THE

TEXTILE MANUFACTURER

YEAR BOOK

1931

All Rights Reserved

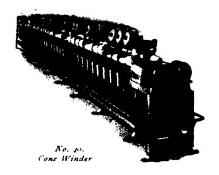*Price in Great Britain, cloth, 3/6 net*

PREFACE

In accordance with our usual practice, many additions have been made to the 1931 " Textile Manufacturer Year Book," whilst revising and retaining the parts covering statistics, technical data, and tables which are offered as a source of reference.

It has been the aim to provide new articles in a form suitable for a handbook on subjects which are not adequately treated in the available standard books, or on subjects in which there is recent development. The doubling section has been extended for this reason by the articles on " Modern Ring Doubling," " Making of Fancy Yarns," " Sewing Cotton Manufacture," and " Loom Driving." Much knowledge, only recently acquired, is covered in the article, " The Properties of the Wool Fibre." A long new section is on " Calico Print-ing," and the subject is approached in a more modern way. The lubrication of yarn for knitting, particularly rayon, is dealt with in a section, " Oiling of Yarn for Knitting." In the search for important economies, the mill power plant is receiving increasing attention, and an article on " Textile Steam Raising Plants " deals with one aspect.

To find space for the new sections, it has been necessary to take out other articles, and a list of these is given on page 194 for reference to the previous edition.

Several sections have been rewritten, notably that on cotton-waste spinning, and minor improvements have been made in various places.

We desire to acknowledge the numerous valuable suggestions which we have received, and we should welcome offers of suitable contributions to the next edition of the " Year Book."

PRINCIPAL CONTENTS

7

CALENDAR, 1931

JANUARY				
S	4	11	18	25
M.......	5	12	19	26
Tu	6	13	20	27
W	7	14	21	28
Th ...1	8	15	22	29
F 2	9	16	23	30
Sa ...3	10	17	24	31

FEBRUARY				
S 1	8	15	22	...
M......2	9	16	23	...
Tu 3	10	17	24	...
W......4	11	18	25	...
Th.....5	12	19	26	...
F......6	13	20	27	...
Sa 7	14	21	28	...

MARCH				
S ...1	8	15	22	29
M...2	9	16	23	30
Tu ...3	10	17	24	31
W...4	11	18	25	...
Th...5	12	19	26	...
F...6	13	20	27	...
Sa . 7	14	21	28	...

APRIL				
S.......	5	12	19	26
M	6	13	20	27
Tu	7	14	21	28
W... ..1	8	15	22	29
Th...2	9	16	23	30
F 3	10	17	24	...
Sa 4	11	18	25	...

MAY				
S.....	3	10	17	24 31
M .	4	11	18	25 ...
Tu ..	5	12	19	26 ...
W .	6	13	20	27 ...
Th ...	7	14	21	28 ...
F....1	8	15	22	29 ...
Sa..2	9	16	23	30 ...

JUNE				
S	7	14	21	28
M ...1	8	15	22	29
Tu ..2	9	16	23	30
W... 3	10	17	24	...
Th.. 4	11	18	25	...
F....5	12	19	26	...
Sa ..6	13	20	27	...

JULY				
S..	5	12	19	26
M	6	13	20	27
Tu ...	7	14	21	28
W......1	8	15	22	29
Th...2	9	16	23	30
F......3	10	17	24	31
Sa......4	11	18	25	...

AUGUST				
S.....	2	9	16	23 30
M....	3	10	17	24 31
Tu..	4	11	18	25 ...
W ...	5	12	19	26 ...
Th...	6	13	20	27 ...
F ...	7	14	21	28 ...
Sa...1	8	15	22	29 ...

SEPTEMBER				
S	6	13	20	27
M	7	14	21	28
Tu...1	8	15	22	29
W...2	9	16	23	30
Th...3	10	17	24	...
F....4	11	18	25	...
Sa ...5	12	19	26	...

OCTOBER				
S.......	4	11	18	25
M	5	12	19	26
Tu.......	6	13	20	27
W	7	14	21	28
Th...1	8	15	22	29
F......2	9	16	23	30
Sa.....3	10	17	24	31

NOVEMBER				
S.....	1	8	15	22 29
M	2	9	16	23 30
Tu ..	3	10	17	24 ...
W	4	11	18	25 ...
Th....	5	12	19	26 ...
F	6	13	20	27 ...
Sa....	7	14	21	28 ...

DECEMBER				
S	6	13	20	27
M	7	14	21	28
Tu .. 1	8	15	22	29
W...2	9	16	23	30
Th...3	10	17	24	31
F.....4	11	18	25	...
Sa . 5	12	19	26	...

BANK HOLIDAYS

Easter Monday, April 6.
Whit Monday, May 25.

Monday, August 3.
Christmas Day and December 26.

POST OFFICE REGULATIONS *

Inland Letters.—Not exceeding 2 oz., 1½d.; and ½d. for each additional 2 oz.

An Inland letter must not exceed the dimensions of 24 in. in length, 12 in. in width, and 12 in. in depth.   In roll form, length 30 in.; diameter 4 in.

Post Cards.—Inland, 1d.; Foreign and Colonial, 1½d.

Printed Papers and Book Post.—For each 2 oz. ½d. up to 2 lb. maximum.

The Registration of any Inland letter, newspaper, or other packet is 3d., and all letters containing coin, posted without registration, will be charged on delivery with a registration fee of 6d., in addition to the ordinary postage.

Registered Letter Envelopes are sold at all Post Offices, and by Rural Messengers, from 5d. to 6½d. each, according to size.   These registered letter envelopes are available for forwarding Foreign registered letters as well as Inland letters.

Newspapers registered at the G.P.O., and published at intervals not exceeding seven days, 1d. for 6 oz.; and ½d. for every additional 6 oz. Limit of weight, 2 lb.; limit of size as for letters.   Packets must be open at both ends.

Inland Parcel Post.—Not exceeding 2 lb., 6d.; not exceeding 5 lb., 9d.; not exceeding 8 lb., 1s.; not exceeding 11 lb., 1s. 3d.   Greatest length, 3 ft. 6 in.; greatest length and girth combined, 6 ft.

Colonial Letter Postage.—To British possessions generally, 1½d. per oz.; and 1d. for each additional oz.

Foreign Letter Postage.—To countries within the Postal Union, 2½d. for the first oz. and 1½d. for each subsequent oz.   To U.S.A., 1½d. per oz. and 1d. for each additional oz.

Foreign Parcel Post.—A Parcel Post service has been established between the United Kingdom and the countries of the Continent of Europe and the British Colonies and Foreign possessions generally.   For rates and other conditions, see the Post Office Guide, published quarterly.

Inland Telegrams.—For twelve words or less, 1s., and 1d. per word afterwards.   Addresses will be charged for.
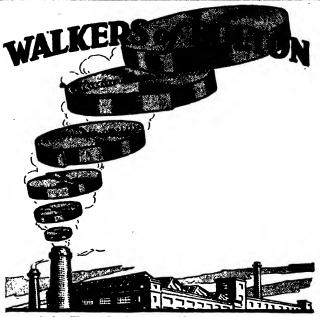
Money Orders (Inland).—For sums not over £3, £10, £20, £30, £40, the charge is 4d., 6d., 8d., 10d., 1s.

Telegraph Money Orders.—Money may be transmitted by means of Telegraph Money Orders, the commission being the same as for Inland Money Orders.   In addition to the commission a charge will be made for the official telegram authorising payment at the office of payment at the ordinary rate for Inland Telegrams, and also a supplementary fee of 2d. for each Order.

Money Orders Payable Abroad.—Foreign orders are issued at varying rates, details of which can be obtained at any Money Order Office.

Postal Orders are issued for 6d., 1s., 1s. 6d., 2s., 2s. 6d. at a cost of 1d. each; from 3s. to 15s. at a cost of 1½d. each; and from 15s. to 21s. at a cost of 2d. each.

INDEX

WASHING AND DRYING
MACHINERY
for

Wool and other
fibres and all
classes of Yarn
in Hanks

including Artificial Silk.

PETRIE & McNAUGHT
Limited

CRAWFORD ST.   **ROCHDALE**

Telegrams   Telephone 2112
  LAVER   PTE. BRANCH EXGE

A108/1976

INDEX TO ADVERTISERS

3

CLASSIFIED BUYERS' DIRECTORY

Guide Classifié pour acheteurs.
Käuferadressbuch in Klassen angeordnet.
Ineicio clasificado para compradores.

ABSORBENT COTTON MACHINERY.

Machines pour la fabrication du coton absorbant.
Maschinen für Herstellung chirurgischer Baumwolle.
Maquinaria para la fabricación de algodon absorbente.

PETRIE & MCNAUGHT LTD., Rochdale.

AIR HEATERS.

Rechauffeurs d'air.
Luftvorwärmer.
Calentadores de aire.

GREEN, E., & SON LTD., Wakefield.
PICKARD, F. HATTERSLEY, & CO., Leeds.

ARTIFICIAL SILK.

Soie artificielle.
Kunstseide.
Seta artificialé.

See RAYON.

ASBESTOS MACHINERY.

Machines pour la fabrication d'amiante.
Maschinen für Asbestherstellung.
Maquinas para la fabricación de amianto.

KENYON, WM., & SONS LTD., Dukinfield, nr. Manchester.

ASBESTOS MATTRESSES FOR BOILERS.

Matelas d'amiante pour Chaudières.
Asbestbelag für Kessel.
Mantas de amianto para Calderas.

KENYON, WM., & SONS LTD., Dukinfield, nr. Manchester.

ASH HANDLING PLANT.

Installations de machines pour escarbilles.
Aschenabfuhranlagen.
Instalaciones de máquinas para cenizas.

RUSCOE, JOHN, & CO. LTD., Albion Works, Hyde, nr. Manchester.

AUTOMATIC FEEDING MACHINES.

Machines automatiques d'alimentation.
Selbsttätige Speisemaschinen
Maquinas alimentadores automaticas.

PETRIE & MCNAUGHT LTD., Rochdale.

AUTOMATIC LOOMS.

Metiers automatiques.
Selbsttätige Webstühle.
Telares automaticos.

BUTTERWORTH & DICKINSON LTD., Burnley.
LIVESEY, HENRY, LTD., Blackburn.

BALING PRESSES.

Presses à emballer.
Ballenpressen.
Prensas embaladoras.

FRASER, D., & SONS LTD., Arbroath.
BRIDGE, D., & CO. LTD., Castleton, Manchester.
CHARLESWORTH, J., Huddersfield.

BALL BEARINGS.

Paliers à billes.
Kugellager.
Cojinetes de bolas.

SKEFKO BALL BEARING CO. LTD., Luton.

BANDING.

Cordes.
Bänder.
Cordones.

HART, THOMAS, LTD., Lambeth Rope Works, Blackburn.
KENYON, WM., & SONS LTD., Dukinfield, nr. Manchester.

BEAMING FRAMES.

Métiers à ensoupler.
Aufbäummaschinen.
Bancos de enjulio.

ASA LEES & CO. LTD., Oldham.
BUTTERWORTH & DICKINSON LTD., Burnley.
CHARLESWORTH, J., Huddersfield.
HOWARD & BULLOUGH LTD., Accrington.
LIVESEY, HENRY, LTD., Blackburn.
PLATT BROTHERS & CO. LTD., Oldham.

BEAMS AND FLANGES.

Ensouples et disques.
Weberbäume und Scheiben.
Plegadores y discos.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.
CHARLESWORTH, J., Huddersfield.

BEARINGS.

Paliers.
Lager.
Cojinetes.

BRIDGE, D., & CO. LTD., Castleton, Manchester.
CROFTS (ENGINEERS) LIMITED, Bradford.
SKEFKO BALL BEARING CO. LTD., Luton.

BELT FASTENERS.

Agrafes pour courroies.
Riemenkrallen.
Corchetes para correas.

BRIERLEY & KERSHAW, LTD., Roach Works, Rochdale.
JONES TEXTILATIES LTD., Blackburn and Manchester.

BELTING.

Courroies.
Treibriemen.
Correas.

WALKER, WM., & SONS LTD., Bolton.
WHITE, JOHN, & SONS LTD., Bingley, Yorks.
WILCOCK BROS., Stamford Works, Ashton-under-Lyne.

BLEACHING AND FINISHING MACHINERY.

Machines pour blanchiment et apprêtage.
Bleich- und Appretiermaschinen.
Maquinaria para blanquear y aprestar.

BENTLEY & JACKSON LTD., Bury.
CHARLESWORTH, J., Huddersfield.
COOPER, C., & SONS LTD., Radcliffe.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
MATHER & PLATT LTD., Park Works, Manchester.
PICKARD, F. HATTERSLEY, & Co., Leeds.
TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley, England.

BOBBINS.

Bobines.
Spulen
Bobinas.

KAY, JOHN, Crown Works, Walker Street, Rochdale.
UNIVERSAL WINDING CO., Manchester.
WILSON BROTHERS BOBBIN CO. LTD., Garston, Liverpool

BOILER MOUNTINGS.

Garnitures pour Chaudières.
Kesselarmatur.
Guarniciones para Calderas.

AULD, DAVID, & SONS LTD., Rochester Street, Glasgow.
HOPKINSONS LTD., Huddersfield.

BOILER AND PIPE COVERING.

Calorifuges pour Chaudières et Tuyaux.
Kessel- und Röhrenbelag.
Calorifugos para Calderas y Tubos.

KENYON, WM., & SONS LTD., Dukinfield.

BRAIDING MACHINES.

Machines à tresser.
Flechtmaschinen.
Maquinas de trenzar.

DOBSON & BARLOW LTD., Bolton.

BRUSHING AND SHEARING MACHINES.

Machines à brosser et à tondre
Burst- und Schermaschinen.
Maquinas de acepillar y tundir.
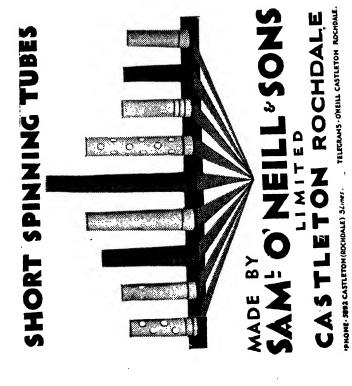
CHARLESWORTH, J., Huddersfield.
MATHER & PLATT LTD., Manchester.

BUNDLING PRESSES.

Presses à emballer.
Ballenpressen.
Prensas de enfardar.

ARUNDEL, COULTHARD, & CO. LTD., Stockport.
ASA LEES & CO. LTD., Oldham.
DOBSON & BARLOW LTD., Bolton.
FAIRBAIRN LAWSON COMBE BARBOUR LTD., Leeds and Belfast.
FRASER, DOUGLAS, & SONS LTD., Arbroath.

CALICO-PRINTING MACHINES.

Machines pour impression de calicot.
Kaliko-Druckmaschinen.
Maquinaria para impression de calico.

MATHER & PLATT LTD., Park Works, Manchester.

CALENDERS.

Calandres.
Kalander.
Calandrias.

BENTLEY & JACKSON LTD., Bury.
MATHER & PLATT LTD., Park Works, Manchester.

CARD CLOTHING.

Garnitures de cardes.
Kardengarnituren.
Guarniciónes de cardas.

KENYON, JAMES, & SON LTD., Derby Street, Bury.

CARD-GRINDING MACHINERY.

Machines pour aiguiser les cardes.
Kardenschleifmaschinen.
Maquinaria de afilar cardas.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.
DOBSON & BARLOW LTD., Bolton.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.

CARDING MACHINERY (COTTON).

Machines a carder (coton).
Krempelmaschinen (Baumwolle).
Maquinaria de cardar (algodón).

ASA LEES & CO. LTD., Soho Iron Works, Oldham.
COOK & CO. (MANCHESTER) LTD., 18 Exchange Street, Manchester.
DOBSON & BARLOW LTD., Bolton.
HETHERINGTON, J., & SONS LTD., Manchester.
HOWARD & BULLOUGH LTD., Accrington.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.
TWEEDALES & SMALLEY (1920) LTD., Castleton, Manchester.

CARDING MACHINERY (JUTE, FLAX, AND HEMP).

Machines à carder (jute, lin, chanvre).
Krempelmaschinen (Jute, Flachs, und Hanf).
Maquinaria de cardar (jute, lino, cañamo).

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.
FRASER, DOUGLAS, & SONS LTD., Arbroath.

CARDING MACHINERY (WOOL).

Machines à carder (laine).
Krempelmaschinen (Wolle).
Maquinaria de cardar (lana).

HAIGH, JOHN, & SONS LTD., Priest Royd Iron Works, Huddersfield.
HETHERINGTON, J., & SONS LTD., Manchester.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.

CARPET-SHEARING MACHINES.

Machines à tondre pour tapis.
Teppichschermaschinen.
Maquinas de tundir para tapices.

CHARLESWORTH, J., Huddersfield.

CARPET-WEAVING MACHINERY.

Messchin pour tissage de tapis.
Teppichwebmaschinen.
Maquinaria de tejer tapices.

PLATT BROS. & CO. LTD., Hartford Works, Oldham.

CHAIN DRIVES.
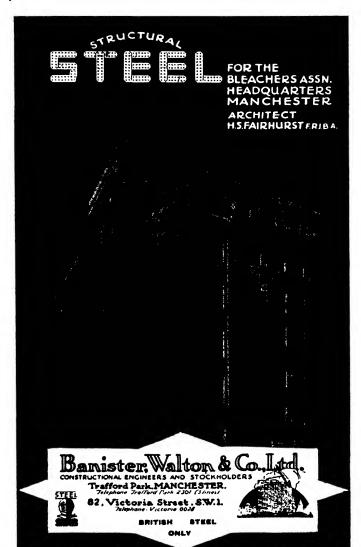
Commandes a chaines.
Kettenübertragungen.
Accionamientos de cadenas.

ANCHOR CHAIN CO. LTD., Oldham.

CHAINS.

Chaines.
Ketten.
Cadenas.

ANCHOR CHAIN CO. LTD., Oldham.

CHEMICAL MANUFACTURERS.

Fabricants de produits chimiques.
Fabrikanten chemischer Produkte.
Fabricantes de productos químicos.

TRAGASOL PRODUCTS LTD., Hooton, Wirral.

CISTERNS.

Citernes.
Zisternen.
Cisternas.

HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.

CLEARER CLOTHS.

Tissus pour nettoyeurs.
Putzwalzentücher.
Panni per cilindri pulitori.

HYDE, ROBERT, & CO., Stalybridge.
KENYON, JAMES, & SON LTD., Bury.

CLOTH-DOUBLING MACHINERY.

Machines à doubler (plier) les tissus.
Tuchfaltmaschinen.
Maquinas para doblar (plegar) les telas.

COOPER, C., & SONS LTD., Radcliffe.

CLOTH - FOLDING AND PLAITING MACHINERY.

Machines à plisser les tissus.
Maquinas para plegar las telas.

COOPER, C., & SONS LTD., Radcliffe.
LIVESEY, HENRY, LTD., Greenbank Iron Works, Blackburn.

CLOTHS.

Drapa.
Tuch.
Paño.

KENYON, JAMES, & SON LTD., Derby Street Mills, Bury.

COMBS (EXPANDING).

Peignes (à expansion).
Kämme (Ausziehbäre).
Peines (a expansion).

JONES TEXTILATIES LTD., Blackburn and Manchester.

CONDENSER BOBBINS.

Bobines de condenseur.
Kondensatorspulen.
Bobinas de condensador.

KAY, JOHN, Rochdale.

CONDENSING PLANT.

Condensateurs.
Kondensatoren.
Condensadores.

FRASER, DOUGLAS, & SONS LTD., Arbroath.

CONSTRUCTIONAL ENGINEERS.

Ingénieurs-constructeurs.
Bauingenieure.
Ingegneri-construttori.

BANISTER, WALTON & CO. LTD., Manchester.

COP AND BOBBIN REELS.

Devidoirs pour faire des écheveaux.
Kötzer- und Spulenhaspel.
Devanadores para hacer madejas.

ARUNDEL, COULTHARD, & CO. LTD., Stockport and Preston.
ASA LEES & CO. LTD., Soho Iron Works, Oldham.
STUBBS, JOSEPH, LTD., Mill Street Works, Ancoats, Manchester.

COP TUBES.

Tubes en papier pour cannettes.
Kötzerhülsen.
Tubos de papel para canillas.

O'NEILL, S., & SONS LTD., Castleton, nr. Manchester.
SWAILES LTD., Oldham.

COTTON SPINNERS AND MANUFACTURERS.

Filateurs et fabricants de coton.
Baumwollspinner und -fabrikanten.
Hiladores y fabricantes de algodón.

KENYON, JAMES, & SON LTD., Bury.

CROPPING AND SHEARING MACHINERY.

Machines à tondre.
Schermaschinen.
Maquinas de tundir.

CHARLESWORTH, J., Huddersfield.
MATHER & PLATT LTD., Manchester.

DERBY DOUBLER ROLLERS.
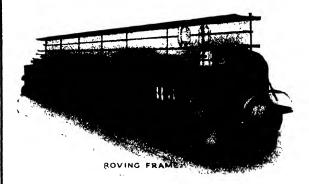
Cylindres pour Réunisseuses Derby.
Cilindros para Máquinas de reunir Derby.

KAY, JOHN, Rochdale.

DOBBIES.

Ratières.
Schaftmaschinen.
Ratières.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.
HODGSON, GEORGE, LTD., Frizinghall Works, Bradford, Yorks.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.

DOBBY LAGS AND PEGS.

Cartons et chevilles pour ratèrs.
Schaftmaschinenkarten und -stifte.
Cartones y clavijas para ratièrs.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.
JONES TEXTILATIES LTD., Blackburn and Manchester.

DOUBLING MACHINERY.

Machines à retordre.
Zwirnmaschinen.
Maquinas de torcer.

ARUNDEL, COULTHARD, & CO. LTD., Sovereign Works, Stockport.
ASA LEES & CO. LTD., Soho Iron Works, Oldham.
BROADBENT, ROBT., & SON LTD., Phœnix Iron Works, Stalybridge.
COOPER, C., & SONS LTD., Radcliffe.
DOBSON & BARLOW LTD., Bolton.
HETHERINGTON, JOHN, & SONS LTD., Manchester.
HOWARD & BULLOUGH LTD., Accrington.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.
SMITH, PRINCE, & SON, Keighley, Yorks.
STUBBS, JOS., LTD., Mill Street Works, Ancoats, Manchester.
TWEEDALES & SMALLEY (1920) LTD., Castleton, nr. Manchester.
UNIVERSAL WINDING Co., Manchester.

DRAWING-IN FRAMES.

Machines à enfiler les fils à travers les lisses.
Einziehgestelle.
Máquinas de pasar hilos a través de los lizas.

NOUVELLE SOCIÉTÉ DE CONSTRUCTION, Guebwiller.
PLATT BROS. & CO. LTD., Oldham.

DRYING MACHINES AND APPARATUS.

Machines et appareils a secher.
Trockenmaschinen und -apparate.
Maquinas y aparejos de secar.

CHARLESWORTH, J., Huddersfield.
MATHER & PLATT LTD., Manchester.
PETRIE & MCNAUGHT LTD., River Street Iron Works, Rochdale.
PICKARD, F. HATTERSLEY, & CO., Leeds.
TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

DUST COLLECTORS.

Collecteurs de poussières.
Staubsammler.
Collectores de polvo.

GOULDIN & CLOUGH, Humboldt Street, Bradford.
HALL & KAY LTD., Ashton-under-Lyne, Manchester.
PICKARD, F. HATTERSLEY, & CO., Leeds.

DYEING MACHINERY.

Machines à teindre.
Färbereimaschinen.
Maquinas de teñir.

AULD, DAVID, & SONS LTD., Rochester Street, Glasgow.
BENTLEY & JACKSON LTD., Bury.
CHARLESWORTH, J., Huddersfield.
COOPER, C., & SONS LTD., Radcliffe.
MATHER & PLATT LTD., Park Works, Manchester.
TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

ELECTRIC BALING PRESSES.

Presses électriques pour balles.
Elektrische Ballenpressen.
Prensas eléctricas para balas.

BRIDGE, D., & CO. LTD., Castleton, nr. Manchester.

ELECTRIC DRIVING.

Transmissions électriques.
Elektrische Antriebsvorrichtungen.
Transmisiones eléctricas.

BROWN, BOVERIE, & CO. LTD., Baden, Switzerland.
CRYPTO ELECTRIC CO. LTD., Willesden, London, N.W. 10.
LANCASHIRE DYNAMO & MOTOR CO. LTD., Trafford Park, Manchester.
MATHER & PLATT LTD., Manchester

ELECTRIC MOTORS.

> Moteurs électriques.
> Elektrische Motoren.
> Motores eléctricos.

BROWN, BOVERIE, & CO. LTD., Baden, Switzerland.
CRYPTO ELECTRIC CO. LTD., Willesden, London, N.W. 10.
LANCASHIRE DYNAMO & MOTOR CO. LTD., Trafford Park, Manchester.
MATHER & PLATT LTD., Manchester.

ELECTRIC MOTOR REPAIRS.

> Reparations de moteurs électriques.
> Reparaturen an elektrischen Motoren.
> Reparaciones de motores eléctricos.

CRYPTO ELECTRIC CO. LTD., Willesden, London, N.W. 10.
LANCASHIRE DYNAMO & MOTOR CO. LTD., Trafford Park, Manchester.

EMERY FILLETING.

> Ruban d'émeri.
> Schmirgelband.
> Cinta de esmeril.

COBDEN, CHADWICK, Oldham.

FANS.

> Ventilateurs.
> Ventilatoren.
> Ventiladores.

GOULDIN & CLOUGH, Humboldt Street, Bradford.
PICKARD, F. HATTERSLEY, & CO., Leeds.
TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

FELT CLOTH MACHINES.

> Machines pour la fabrication de drap de feutre.
> Filztuchmaschinen.
> Máquinas para la fabricación de paño de fieltro.

PICKARD, F. HATTERSLEY, & CO., Leeds.

FERRULES, HOOPS, SHIELDS, ETC.

> Viroles, cercles, protections, etc.
> Zwingen, Bügel, Schoner usw.
> Regatones, aros, protecciones, etc.

WILSON BROS. BOBBIN CO. LTD., Garston, Liverpool.

FINISHING MACHINERY (FOR WOOLLENS AND WORSTEDS).

> Machines à apprêter les lainage et laines peignées.
> Appreturmaschinen (für Woll- und Kammgarnstoffe).
> Macquinaria de apresto (para laverías y estambres).

MATHER & PLATT LTD., Manchester.

FIRE EXTINGUISHERS.

> Extincteurs d'incendie.
> Feuerlöschapparate.
> Extinguidores de incendio.

MATHER & PLATT LTD., Park Works, Manchester.

FIRE PREVENTION APPLIANCES.

> Appareil contre l'incendie.
> Brandverhütungsvorrichtungen.
> Aparajos contra el incendio.

MATHER & PLATT LTD., Park Works, Manchester.

FLANGES (BEAM).

> Brides (d'arbre).
> Scheiben (für Weberbäume.)
> Bridas (del arbol).

BUTTERWORTH & DICKINSON LTD., Globe Works, Burnley.
SCHOFIELD'S FOUNDRY CO., Littleborough.

FRICTION CLUTCHES.

> Marchons à friction.
> Reibungskupplungen.
> Garras de fricción.

BRIDGE, DAVID, & CO. LTD., Castleton Iron Works, Castleton, Manchester.
BROADBENT, THOMAS, & SONS LTD., Huddersfield.
CROFTS (ENGINEERS) LTD., Thornbury, Bradford.
LANCASHIRE DYNAMO AND MOTOR CO. LTD., Trafford Park, Manchester.
MATHER & PLATT LTD., Manchester.

FLAX AND HEMP MACHINERY.

Machines pour le traitement du lin et du chanvre.

Flachs- und Hanfbearbeitungsmaschinen.

Maquinas para lino y cañamo.

ARUNDEL, COULTHARD, & Co. LTD., Stockport and Preston.
FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.
FRASER, DOUGLAS, & SONS LTD., Arbroath.

FUEL ECONOMISERS.

Economiseurs de combustible.

Brennstoffsparer.

Economizadores de combustible.

GREEN, E., & SON LTD., Wakefield.

GAS SINGEING MACHINES.

Machines à gazer.

Gas-Sengmaschinen.

Maquinas de engasar.

ARUNDEL, COULTHARD, & Co. LTD., Stockport and Preston.
MATHER & PLATT LTD., Park Works, Manchester.

GAUGES.

Indicateurs.

Anzeiger.

Indicadores.

HOPKINSONS LTD., Huddersfield.

GAUGE GLASSES.

Verres pour Niveaux d'eau.

Anzeigergläser.

Водомѣрныя стебла.

Vidrios para nivel de agua.

HOPKINSONS LTD., Huddersfield.

GEARING.

Engrenages.

Getriebe.

Engranajes.

BRIDGE, DAVID, & Co. LTD., Castleton Iron Works, Castleton, Manchester.
CROFTS (ENGINEERS) LTD., Thornbury, Bradford.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
SKEFKO BALL BEARING Co, LTD., Luton.

GEARING, CHAIN.

Transmissions à chaines.

Kettengetriebe.

Transmisiones de cadenas.

ANCHOR CHAIN Co. LTD., Oldham.

GRINDING MACHINES.

Machines à affuter.

Schleifmaschinen.

Máquinas de afilar.

CHADWICK, COBDEN, Oldham.
CHARLESWORTH, J., Huddersfield.

GUN COTTON MACHINERY.

Machines pour la fabrication de coton fulminant.

Maschinen zur Herstellung von Schiessbaumwolle.

Maquinas para la fabricación de algodón fulminante.

MATHER & PLATT LTD., Manchester.
PETRIE & McNAUGHT LTD., Rochdale.
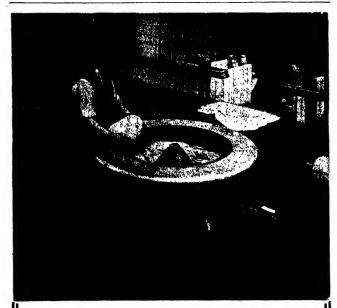
HANK AND HOSIERY DRYING MACHINES.

Séchoirs pour écheveaux et bonneterie.

Trockenmaschinen für Strähne und Strumpfwaren.

Secadores para madejas y calceteria.

CHARLESWORTH, J., Huddersfield.
MATHER & PLATT LTD., Manchester.
PETRIE & McNAUGHT LTD., Rochdale.
PICKARD, F. HATTERSLEY, & Co., Leeds.

4

HANK DYEING AND SCOURING MACHIN-ERY.

Machines a teindre et nettoyer les echeveaux.

Strähnfärbe- und Waschmaschinen.

Maquinas para teñir y limpiar madejas.

BROADBENT, T., & SONS LTD., Central Iron Works, Huddersfield.
CHARLESWORTH, J., Huddersfield.
FARMER NORTON, SIR JAMES, & Co. LTD., Salford.
MATHER & PLATT LTD., Manchester.
PETRIE & McNAUGHT LTD., Rochdale.

HARD FIBRE MACHINERY.

Machines pour le traitement des fibres dures.

Hartfiberbearbeitungsmaschinen.

Máquinas para el tratamiento de las fibras duras.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Leeds.

HIGH DRAFTING.

Etirages élevés.

Strecken mit hohem Verzug.

Estirajes elevados.

ASA LEES & CO. LTD., Oldham.
DOBSON & BARLOW LTD., Bolton.
HETHERINGTON, J., & SONS LTD., Manchester.
HOWARD & BULLOUGH LTD., Accrington.
PLATT BROTHERS & CO. LTD., Oldham.
TWEEDALES & SMALLEY (1920) LTD., Castleton.

HOISTS, LIFTS, AND CRANES.

Elévateurs, ascenseurs et grues.

Aufzüge, Elevatoren und Kräne.

Elevadores, ascensores y grúas.

BROADBENT, THOS., & SONS LTD., Huddersfield.

HOSIERY MACHINISTS.

Machines pour la bonneterie.

Strumpfwarenmaschinenfabrikanten.

Maquinas para boneteria.

UNIVERSAL WINDING CO., Manchester.

HUMIDIFIERS.

Humecteurs.
Anfeuchtmaschinen.
Humidificadores.

MATHER & PLATT LTD., Park Works, Manchester.

HYDRAULIC PRESSES.

Presses hydrauliques.
Hydraulische Pressen.
Prensas hidraulicas.

CHARLESWORTH, J., Huddersfield.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.
PICKARD, F. HATTERSLEY, & CO., Leeds.

HYDRO-EXTRACTORS.

Hydro-extracteurs.
Schleudermaschinen.
Hidro-extractores.

BROADBENT, T., & SONS LTD., Central Iron Works, Huddersfield.

JACQUARD MACHINES.

Machines jacquards.
Jacquardmaschinen.
Máquinas para jacquards.

WALKER, PETER (BLACKBURN), LTD., Burnside Works, Weir St., Blackburn.

JUTE MACHINERY.

Machines pour la préparation du jute.
Jutebearbeitungsmaschinen.
Máquinas para la preparación del yute.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Leeds.
FRASER, DOUGLAS, & SONS LTD. Arbroath.

KNITTING MACHINES.

Tricoteuses.
Strickmaschinen.
Máquinas para tejido de punto.

STIBBE, G., & CO. LTD., Leicester.

KNOTTERS.

Appareils à nouer les fils.
Knotenbildner.
Aparatos para anudar hilos.

STUBBS, JOSEPH, LTD., Manchester.

LAPPETS.

Lapets.
Stickwebstühle.
Orejetas.

ARUNDEL, COULTHARD, & CO. LTD., Stockport and Preston.
BRIERLEY & KERSHAW LTD., Roach Works, Rochdale.

LAYING MACHINES.

Machines à commettre pour cables.
Seilschlagmaschinen.
Maquinas de torcer para cables.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.

LEATHER BELTING.

Courroies de transmission (cuir).
Lederriemen.
Correas de transmisión (cuero).

WALKER, WM., & SONS LTD., Bolton.
WHITE, JOHN, & SONS LTD., Bingley, Yorks.
WILCOCK BROS., Stamford Works, Ashton-under-Lyne.

LOOMS.

Métiers.
Webstühle.
Telares.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.
FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
HUTCHINSON, HOLLINGWORTH & CO. LTD., Dobcross Loom Works, Dobcross, Yorks.
LIVESEY, HENRY, LTD., Blackburn.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.

LOOSE BOSS ROLLERS.

Rouleaux à bosses libres.
Büchsenwalzen.
Rodillos con forros libres.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.
DOBSON & BARLOW LTD., Bolton.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.

LUBRICANTS.

Produits lubrifiants.
Schmieren.
Grasas lubrificantes.

HART, THOS., LTD., Lambeth Rope Works, Blackburn.

MALLEABLE CASTINGS.

Pieces en fonte malleable.
Schmiedbare Gusstucke.
Fundiciones maleables.

BUTTERWORTH & DICKINSON LTD., Globe Works, Burnley.

MECHANICAL DRAUGHT.

Tirage mécanique.
Mechanische Luftzugvorrichtungen.
Tiro mecanico.

PICKARD, F. HATTERSLEY, & CO., Leeds.

MERCERISING MACHINERY.

Machines à merceriser.
Mercerisiermaschinen.
Maquinas para mercerisar.

MATHER & PLATT LTD., Manchester.
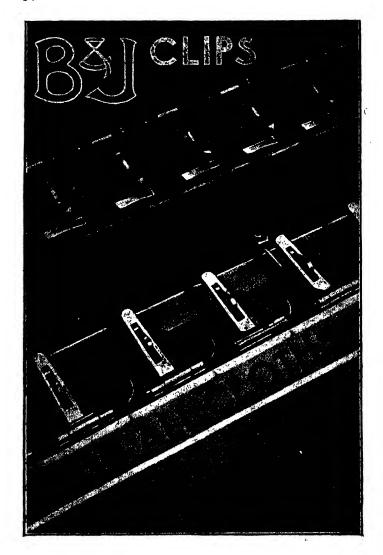
MILL FURNISHERS.

Fournisseurs d'articles pour fabriques.
Fabrikseinrichtungen.
Abastacedores da fábricas.

BRIERLEY & KERSHAW LTD., Roach Works, Rochdale.
HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.
KAY, JOHN, Crown Works, Rochdale.

MILLGEARING.

Transmissions par engrenages.
Rädervorgelege für Fabriken.
Transmisiones de engranajes.

BRIDGE, D., & CO. LTD., Castleton, nr.
Manchester.
CROFTS (ENGINEERS) LTD., Thornbury,
Bradford.

MOTORS, ELECTRIC.

Moteurs électriques.
Motoren elektrische.
Motores eléctricos.

BROWN, BOVERIE, & CO. LTD., Baden,
Switzerland.
CRYPTO ELECTRIC CO. LTD., Willesden,
London, N.W. 10.
LANCASHIRE DYNAMO AND MOTOR CO.
LTD., Trafford Park, Manchester.
MATHER & PLATT LTD., Manchester.

MULES (WOOLLEN).

Métiers self-acting pour la laine.
Mulemaschinen (Wolle).
Selfactinas para lana.
Telai "Self-acting" (automatici)
per lana.

ASA LEES & CO. LTD., Oldham.
HETHERINGTON, JOHN, & SONS LTD.,
Manchester.
PLATT BROS. & CO. LTD., Oldham.
TAYLOR, LANG, & CO. LTD., Stalybridge.

OIL CABINETS.

Armoires à huile.
Ölschränke.
Armarios para aceite.

KAY, JOHN, Crown Works, Rochdale.
KAYE, JOSEPH, & SONS LTD., Leeds.

OIL CANS.

Burettes à huile.
Ölkannen.
Aceiteras.

KAY, JOHN, Crown Works, Rochdale.
KAYE, JOSEPH, & SONS LTD., Leeds.

OIL FEEDERS.

Burettes à huile.
Ölspritzkannen.
Aceiteras.

KAY, JOHN, Crown Works, Rochdale.
KAYE, JOSEPH, & SONS LTD., Leeds.

OILS.

Huiles.
Öle.
Aceites.

STEPHENSON BROS. LTD., Bradford, Yorks.

PAPERMAKERS' FELTS.

Feutres pour fabriques de papier.
Papierfabrikanten, Filze für.
Fieltros para fabricas de papel.

KENYON, JAMES, & SON LTD., Derby
Street Mills, Bury.

PATENT HOPPER FEEDERS.

Appareils d'alimentation à trémie
brevetés.
Patentierte Trichterspeiseapparate.
Aparejos alimentadores patentados
con tolvas.

ASA LEES & CO. LTD., Soho Iron Works,
Oldham.
DOBSON & BARLOW LTD., Bolton.
HOWARD & BULLOUGH LTD., Accrington.
PLATT BROS. & CO. LTD., Hartford
Works, Oldham.
TAYLOR, LANG, & CO. LTD., Castle Iron
Works, Stalybridge.

PICKERS (LOOM).

Taquets (pour métiers).
Treiber (Webstuhl).
Tacos (para telares).

FIELDEN, HOWORTH LTD., Walsden.
WALKER, WM., & SONS LTD., Bolton.
WILCOCK BROS., Stamford Works, Ashton-
under-Lyne.

PICKING BANDS.

Bandes de chasse.
Treiberriemen.
Tira-tacos.

WALKER, WM., & SONS LTD., Bolton.

POWER TRANSMISSION BY CHAINS.

Transmissions à chaines.

Kettenübertragung.

Transmisiones de cadenas.

ANCHOR CHAIN CO. LTD., Oldham.

PREPARING MACHINES.

Machines à préparer.

Vorbearbeitungsmaschinen.

Maquinas de preparar.

ARUNDEL, COULTHARD, & CO. LTD., Sovereign Works, Stockport.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
HATTERSLEY, GEO., & CO. LTD., Keighley.
STUBBS, JOSEPH, LTD., Mill Street Works, Ancoats, Manchester.
TWEEDALES & SMALLEY LTD., Castleton, Manchester.
UNIVERSAL WINDING CO., Manchester.

PRESSES.

Presses.

Pressen.

Prensas.

BRIDGE, DAVID, & CO. LTD., Castleton, nr. Manchester.

PRESSING MACHINES.

Machines à presser.

Pressmaschinen.

Maquinas de prensar.

CHARLESWORTH, J., Huddersfield.
HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.
PICKARD, F. HATTERSLEY, & CO., Leeds.

PRINTERS' BLANKETS.

Blanchets pour imprimeurs.

Drucktücher.

Mantas de impresores.

HYDE, ROBERT, & CO., Stalybridge.
KENYON, JAMES, & SON LTD., Derby Street Mills, Bury.

PULLEYS.

Poulies.

Scheiben.

Poleas.

BRIDGE, D., & CO. LTD., Castleton, Manchester.
CROFTS (ENGINEERS) LTD., Thornbury, Bradford.
FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
SKEFKO BALL BEARING CO. LTD., Luton.

PUMPS.

Pompes.

Pumpen.

Bombas.

MATHER & PLATT LTD., Park Works, Manchester.
TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

RAISING MACHINES.

Machines à aplaner les tissus.

Rauhmaschinen.

Máquinas de cardar pelo de paños.

CHARLESWORTH, J., Huddersfield.

RAYON.

Soie artificielle.

Kunstseide.

Seta artificialé.

COURTAULDS LTD., Coventry.

RAYON FINISHING MACHINERY.

Machines à finir la soie artificielle.

Kunstseide appretiermaschinen.

Maquinas de acabar para seda artificial.

DOBSON & BARLOW LTD., Bolton.
MATHER & PLATT LTD., Manchester.

REED HOOKS.

Passettes.

Blattstecher.

Pasa-hilos.

BRIERLEY & KERSHAW LTD., Roach Works, Rochdale.
JONES TEXTILATIES LTD., Blackburn and Manchester.

REEDS AND HEALDS.

Peignes et lisses.

Rietkämme und Litzen.

Peines y lizos.

JONES TEXTILATIES LTD., Blackburn and Manchester.

RINGS AND TRAVELLERS.

Anneaux et Curseurs.
Ringe und Läufer.
Anillos y Corredores.

COOK & CO. (MANCHESTER) LTD., 18 Exchange Street, Manchester.
EADIE BROS. & CO. LTD., 20 and 21 Victoria Buildings, Manchester.

ROLLER BEARINGS.

Palier à rouleaux.
Kugellager.
Soporte de rodillos.
Sopporti a rulli.

CROFTS (ENGINEERS) LTD., Bradford.
SKEFKO BALL BEARING CO. LTD., Luton.

ROLLER CLOTHS.

Tissus à Cylindres.
Walzentücher.
Panni per Rulli.
Panos para rodillos.

HYDE, ROBERT, & CO., Stalybridge.
KENYON, JAMES, & SON LTD., Bury.

ROLLER COVERING MACHINES.

Machines a couvrir les cylindres de pression.
Walzenüberzugmaschinen.
Maquinas para cubrir cilidros de hilar.

CHADWICK, COBDEN, Oldham.

ROLLER COVERINGS AND LEATHER.

Revêtements et cuir pour rouleaux.
Walzenüberzüge und-leder.
Cubiertas y cuero para rollos.

WALKER, CHAS., & CO. LTD., Leeds.
WILCOCK BROS., Ashton-under-Lyne.

ROLLER MAKERS.

Fabricants de rouleaux.
Walzenfabrikanten.
Fabricantes de rollos.

ARUNDEL, COULTHARD, & CO. LTD., Stockport and Preston.
ASA LEES & CO. LTD., Soho Iron Works, Oldham.
HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.
TWEEDALES & SMALLEY (1920) LTD., Castleton, nr. Manchester.

ROLLER SKINS.

Cuirs pour garnir les rouleaux.
Walzenhäute.
Pieles para rodillos.

CHADWICK, COBDEN, Oldham.

ROPE MACHINERY.

Machines pour fabrication de cordages.
Seilermaschinen.
Máquinas para la fabricación de las cuerdas.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.

ROPES—COTTON DRIVE.

Cables de transmission en coton.
Baumwollene Treibseile.
Cables de algodón para transmisión.

HART, T., LTD., Lambeth Rope Works, Blackburn.
KENYON, WM., & SONS LTD., Dukinfield.

ROVING FRAMES.

Bancs à broches en fin.
Vorspinnmaschinen.
Bancos de husos en fino.

SMITH, PRINCE, & SON LTD., Keighley, Yorks.

RUBBER MACHINERY.

Machines pour caoutchouc.
Kautschukverarbeitungsmaschinen.
Máquinas para caucho.

BRIDGE, DAVID, & CO. LTD., Castleton Iron Works, Castleton, Manchester.

SAFETY BOILER MOUNTINGS.

Appareils de sûreté pour chaudières.
Sicherheitsvorrichtungen für Kessel.
Aparatos de seguridad para calderas.

HOPKINSONS LTD., Huddersfield.

SCUTCHERS.

Batteuses.
Schlagmaschinen.
Agramadoras.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.
DOBSON & BARLOW LTD., Bolton.
HETHERINGTON, J., & SONS LTD., Manchester.
HOWARD & BULLOUGH LTD., Accrington.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.
TAYLOR, LANG, & CO. LTD., Castle Iron Works, Stalybridge.
TWEEDALES & SMALLEY (1920) LTD., Castleton, nr. Manchester.

SECOND-HAND MACHINERY, ETC.

Machines d'occasion, etc.
Gebrauchte Maschinen usw.
Maquinas de lance, etc.

DODD, SAMUEL, & SONS LTD., Lyon Works, Oldham.

SEWING THREAD MACHINERY.

Outillage pour fil à coudre.

Nähzwirnmaschinen.

Maquinaria para hilo de coser.

AYRTON, WM., & CO. LTD., Longsight, Manchester.

SHAFTING, FITTINGS, ETC.

Arbres, accessoires, etc.

Wellen, Garnituren, usw.

Arboles, accesorios, etc.

BRIDGE, DAVID, & CO. LTD., Castleton Iron Works, Castleton, Manchester.

CROFTS (ENGINEERS) LTD., Thornbury, Bradford.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.

FRASER, DOUGLAS, & SONS LTD., Arbroath.

SKEFKO BALL BEARING CO. LTD., Luton.

TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

SHEET-METAL WORKERS.

Fabricantes d'articles en tôle.

Blechwarenfabrikanten.

Fabricantes de articulos de metal laminado.

GOULDIN & CLOUGH, Humboldt Street, Bradford.

KENYON, WM., & SONS LTD., Chapel Field Works, Dukinfield.

SHUTTLES.

Navettes.

Webschützen.

Lanzaderas.

WILSON BROS. BOBBIN CO. LTD., Garston, Liverpool.

SILICATE COTTON.

Coton silicate.

Schlackenwolle.

Algodón silicate.

KENYON, WM., & SONS LTD., Dukinfield, Manchester.

SIZING AND SLASHING MACHINES.

Machines à coller (encolleuses).

Trommel-und andere Schlicht-maschinen.

Máquinas de encolar (engomadoras).

ASA LEES & CO. LTD., Soho Iron Works, Oldham.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.

CHARLESWORTH, J., Huddersfield.

HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.

HOWARD & BULLOUGH LTD., Accrington.

LIVESEY, HENRY, LTD., Greenbank Iron Works, Blackburn.

PLATT BROS. & CO. LTD., Hartford Works, Oldham.

TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

SPINDLE AND FLYER MAKERS.

Fabricants de broches et ailettes.

Spindel- und Flügelfabrikanten.

Fabricas de husos y aletas.

ARUNDEL, COULTHARD, & CO. LTD., Stockport and Preston.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.

BODDEN, W., & SON LTD., Hargreaves Works, Oldham.

COOK & CO. (MANCHESTER) LTD., 18 Exchange Street, Manchester.

DOBSON & BARLOW LTD., Bolton.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.

HOWARD & BULLOUGH LTD., Accrington.

PLATT BROS. & CO. LTD., Hartford Works, Oldham.

RYDER, WM., LTD., Beehive Works, Bolton.

SKEFKO BALL BEARING CO. LTD., Luton.

SMITH, PRINCE, & SON LTD., Keighley, Yorks.
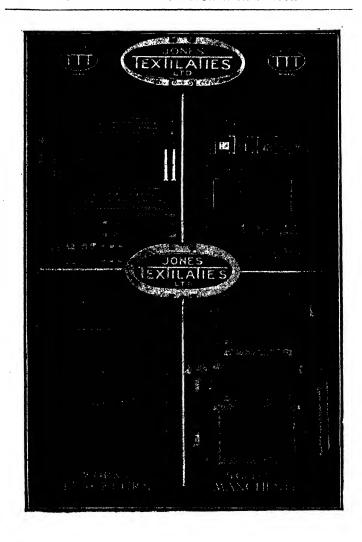
TWEEDALES & SMALLEY (1920) LTD., Castleton, nr. Manchester.

SPINDLE RINGS.

Anneaux pour broches.

Spindelringe.

Anillos para husos.

ARUNDEL, COULTHARD, & CO. LTD., Stockport and Preston.

SWAILES LTD., Oldham Cop Tube Works, Moorhey, Oldham.

SIZE BOILERS.

Bouilleurs pour la colle.
Schlichtekocher.
Aparatos para cocer la pasta.

HIBBERT, JOSEPH, & CO. LTD., Lodge Bank Works, Darwen.

SIZING FLANNEL.

Flanelles à Encollage.
Schlichtflanelle.
Flanella per incollare.

HYDE, ROBERT, & CO., Stalybridge.
KENYON, JAMES, & SON LTD., Bury.

SIZING INGREDIENTS.

Produits à coller.
Schlichtmittel.
Ingredientes de encolar.

TRAGASOL PRODUCTS LTD., Hooton, Wirral.

SOAP.

Savon.
Seife.
Jabón.

STEPHENSON BROS. LTD., Bradford.

SPINNING MACHINERY.

Machines à filer.
Spinnmaschinen.
Maquinas de hilar.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.
DOBSON & BARLOW LTD., Bolton.
DODD, SAMUEL, & SONS LTD., Lyon Works, Oldham.
FRASER, DOUGLAS, & SONS LTD., Arbroath.
HALL & STELLS LTD., Park Works, Dalton Lane, Keighley.
HETHERINGTON, J., & SONS LTD., Manchester.
HOWARD & BULLOUGH LTD., Accrington.
NOUVELLE SOCIÉTÉ DE CONSTRUCTION, Guebwiller.
PLATT BROS. & CO. LTD. Hartford Works, Oldham.
SMITH, PRINCE, & SON LTD., Keighley, Yorks.
TWEEDALES & SMALLEY (1920) LTD., Castleton, nr. Manchester.

SPRINGS.

Ressorts.
Federn.
Muelles.

BRIERLEY & KERSHAW LTD., Roach Works, Rochdale.
JONES TEXTILATIES LTD., Blackburn and Manchester.

SPRINKLERS.

Extincteurs d'incendie.
Nässer.
Rociadores.

MATHER & PLATT LTD., Park Works, Manchester.

SQUEEZING PRESSES.

Presses à exprimer.
Quetschpressen.
Prensas de exprimir.

FRASER, DOUGLAS, & SONS LTD., Arbroath.
PETRIE & McNAUGHT LTD., Rochdale.

STEAM TRAPS.

Purgeurs automatiques.
Kondenswasserabscheider.
Grifos para elagua de condensacion.

AULD, DAVID, & SONS LTD., Rowchester Street, Glasgow.
CHARLESWORTH, J., Huddersfield.
HOPKINSONS LTD., Huddersfield.

STEEL COMBS.

Peignes d'acier.
Stahlkämme.
Peines de acero.

BRIERLEY & KERSHAW LTD., Roach Works, Rochdale.
JONES TEXTILATIES LTD., Blackburn and Manchester.

STOP MOTION TWISTERS (COTTON, JUTE, AND WOOLLEN).

Retordeurs à mouvement d'arrêt (Coton, jute, et laine).
Zwirnmaschinen mit Ausrück-vorrichtung.
Torcedores de movimiento de detención (Algodón, jute y lana).

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.
PLATT BROS. & CO. LTD., Hartford Works, Oldham.

STENTERING MACHINES.

Machines à étirer.
Aufrahmmaschinen.
Macchine di tirare.
CHARLESWORTH, J., Huddersfield.
MATHER & PLATT LTD., Manchester.

TALLOW.

Suif.
Talg.
Sebo.
STEPHENSON BROS. LTD., Bradford,
Yorks.

TEMPLES.

Temples.
Breithalter.
Templazos.
BRIERLEY & KERSHAW LTD., Roach
Works, Rochdale.
JONES TEXTILATIES LTD., Blackburn and
Manchester.

TEXTILE ACCESSORIES.

Accessoires pour fabriques textiles.
**Ausrüstungsgegenstände für Textil-
fabriken.**
Accesorios para fabricas textiles.
BRIERLEY & KERSHAW LTD., Roach
Works, Rochdale.
JONES TEXTILATIES LTD., Blackburn and
Manchester.

THREAD GUIDES.

Guides fil.
Fadenführer.
Guias de hiol.
ARUNDEL, COULTHARD, & CO. LTD.,
Stockport.
BRIERLEY & KERSHAW LTD., Roach
Works, Rochdale.

THREAD MACHINERY.

Machines pour la fabrication de fils.
Zwirnmaschinen.
Maquinas para fabricación de hilos.
ARUNDEL, COULTHARD, & CO., LTD.,
Sovereign Works, Stockport and
Preston.
ASA LEES & CO. LTD., Soho Iron Works,
Oldham.
AYRTON, WM., & CO., Longsight, Man-
chester.
FAIRBAIRN LAWSON COMBE BARBOUR
LTD., Hope Foundry, Leeds.

TUBES.

Tubes.
Röhren.
Tubos.
O'NEILL, SAMUEL, & SONS LTD., Linden
Mill, Castleton, Manchester.
SWAILES LTD., Moorhey, Oldham.

TWINE MACHINERY.

**Machines pour la fabrication de
ficelles.**
Bindfadenmaschinen.
**Maquinas para la fabricación de
bramantes.**
FAIRBAIRN LAWSON COMBE BARBOUR
LTD., Hope Foundry, Leeds.
FRASER, DOUGLAS, & SONS LTD., Arbroath.

TWINE TUBES.

Tubes à ficelle.
Bindfadenröhren.
Tubos de bramante.
O'NEILL, SAMUEL, & SONS LTD.,
Castleton.

VALVES.

Soupapes.
Ventile.
Valvulas.
AULD, DAVID, & SONS LTD., Rowchester
Street, Glasgow.
HOPKINSONS LTD., Huddersfield.
TATTERSALL & HOLDSWORTH'S GLOBE
WORKS AND STORES, Enschede and
Rotterdam (Holland), and Burnley
(England).

VARIABLE SPEED GEARS.

Mécanismes à vitesse variable.
**Veränderliches Geschwindigkeits-
getriebe.**
Engranajes de velocidad variable.
CROFTS (ENGINEERS) LTD., Bradford.

VENTILATORS.

Ventilateurs.
Ventilatoren.
Ventiladores.
GOULDIN & CLOUGH, Humboldt Street,
Bradford.
PICKARD, F. HATTERSLEY, & CO.,
Leeds.

WATER SOFTENERS.

Appareils pour amollir l'eau.
Wasserenthärtungsmittel.
Apparati d'ammollire acqua.
KENNICOTT WATER SOFTENER CO. LTD.,
Wolverhampton.
MATHER & PLATT LTD., Manchester.

WADDING MACHINERY.

Machines pour la fabrication d'ouate.

Wattaerzeugungsmaschinen.

Maquinas para la fabricación de uota.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.

PLATT BROS. & CO. LTD., Hartford Works, Oldham.

WARPING MACHINES.

Ourdissoirs.

Zettelrahmen.

Urdidores.

ARUNDEL, COULTHARD, & CO. LTD., Sovereign Works, Stockport.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.

CHARLESWORTH, J., Huddersfield.

HOWARD & BULLOUGH LTD., Accrington.

LIVESEY, HENRY, LTD., Greenbank Iron Works, Blackburn.

PLATT BROS. & CO. LTD., Hartford Works, Oldham.

UNIVERSAL WINDING CO., Manchester.

WARP-DAMPING DEVICES.

Dispositifs, à humecter les chaines.

Ketten-Anfeuchtvorrichtungen.

Dispositivos humectadores del urdimbre.

MATHER & PLATT LTD., Manchester.

WARP-DYEING MACHINES.

Machines à teindre les ourdissages.

Kettenfärbemaschinen.

Máquinas de teñir les urdimbre.

MATHER & PLATT LTD., Manchester.

WARP-STOP MOTIONS.

Mecanismes d'arrêt pour chaine.

Kettenfadenwächter.

Movimientos paraur dimbres.

MATHER & PLATT LTD., Manchester.

WASHING MACHINES.

Laveuses mécaniques.

Waschmaschinen.

Lavadores mecanicos.

FRASER, DOUGLAS,& SONS LTD.,Arbroath.

PETRIE & McNAUGHT LTD., River Street Iron Works, Rochdale.

TATTERSALL & HOLDSWORTH'S GLOBE WORKS AND STORES, Enschede and Rotterdam (Holland), and Burnley (England).

WASTE BREAKERS.

Effilocheuses pour déchets.

Abfallreisser.

Rompedores de desperdicios.

FRASER, DOUGLAS,& SONS LTD.,Arbroath.

WINDING MACHINERY.

Bobinoirs.

Aufwickelmaschinen.

Devanadores.

ARUNDEL, COULTHARD, & CO. LTD., Sovereign Works, Stockport and Preston.

ASA LEES & CO. LTD., Soho Iron Works, Oldham.

BROADBENT, R., & SON LTD., Phœnix Iron Works, Stalybridge.

BUTTERWORTH & DICKINSON LTD., Globe Iron Works, Burnley.

CHARLESWORTH, J., Huddersfield.

DOBSON & BARLOW LTD., Bolton.

FAIRBAIRN LAWSON COMBE BARBOUR LTD., Hope Foundry, Leeds.

FRASER, DOUGLAS, & SONS LTD., Arbroath.

HOWARD & BULLOUGH LTD., Accrington.

LIVESEY, HENRY, LTD., Greenbank Iron Works, Blackburn.

PLATT BROS. & CO. LTD., Hartford Works, Oldham.
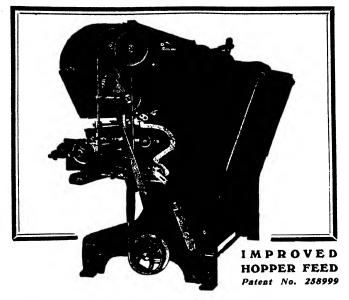
SMITH, PRINCE, & SON LTD., Keighley, Yorks.

STUBBS, JOSEPH, LTD., Mill Street Works, Ancoats, Manchester.

UNIVERSAL WINDING CO., Manchester.

WASTE (COTTON) MACHINERY.

Machines pour la fabrication des
déchets (Coton).
Abfallverarbeitungsmaschinen
(Baumwolle).
Maquinas para la fabricación de
desperdicios (Algodón).

ASA LEES & CO. LTD., Soho Iron Works,
Oldham.
DOBSON & BARLOW LTD., Bolton.
PLATT BROS. & CO. LTD., Hartford
Works, Oldham.
TWEEDALES & SMALLEY (1920) LTD.,
Castleton, nr. Manchester.

WAX RODS FOR WEAVERS.

Verges de cire pour tisserands.
Wachsstäbe für Weber.
Varillas de cera para tejedores.

STEPHENSON BROS. LTD., Bradford,
Yorks.

WIRE HEALDS.

Lisses métalliques.
Drahtlitzen.
Lizos metalicos.

JONES TEXTILATIES LTD., Blackburn
and Manchester.

WOOL CARBONISING PLANT.

Machines à carboniser la laine.
Wollauskohlungsanlagen.
Maquinas para carbonisar lana.

CHARLESWORTH, J., Huddersfield.
PETRIE & McNAUGHT LTD., Crawford
Street, Rochdale.

WOOL-COMBING MACHINERY.

Machines à peigner la laine.
Wollkämmmaschinen.
Maquinas para peinar lana.

PLATT BROS. & CO. LTD., Hartford
Works, Oldham.

WOOL-WASHING MACHINERY.

Machines pour le lavage de la laine.
Wollwaschmaschinen.
Maquinas para lavar lana.

CHARLESWORTH, J., Huddersfield.
PETRIE & McNAUGHT LTD., Rochdale.

WOOLLEN AND WORSTED MACHINERY.

Machines pour la fabrication de
laine et estame.
Woll- und Kammgarnstoff-
maschinen.
Maquinas para la fabricación de
lana y de estambre.

ASA LEES & CO. LTD., Soho Iron Works,
Oldham.
CHARLESWORTH, J., Huddersfield.
HAIGH, J., & SONS LTD., Priest Royd
Iron Works, Huddersfield.
HETHERINGTON, J., & SONS LTD., Man-
chester.
PICKARD, F. HATTERSLEY, & CO., Leeds.
PLATT BROS. & CO. LTD., Hartford
Works, Oldham.
SMITH, PRINCE, & SON, Keighley, Yorks.
UNIVERSAL WINDING CO., Manchester.

YARNS.

Fils.
Garne.
Hilazas.

COURTAULDS LTD., Coventry and London.

A NEW VOLUME in the series of "TEXTILE MANUFACTURER' MANUALS

Practical Ring Spinning

By L. J. MILLS

PRINCIPAL CONTENTS:

PART I.

Chapter I. Cotton Yarn Spinning Principles.
,, II. Ring Frame Construction.
,, III. Ring Frame Spindles.
,, IV. Ring Frame Bobbins.
,, V. Ballooning and Separators.
,, VI. Driving Arrangements.
,, VII. Ring Frame Gearing : Various Makers.

PART II.

Chapter I. Starting Up New Ring Frames.
,, II. Setting Rollers.
III. Roller Gearing Calculations.

Chapter IV. Speed of Spindles. Twist Constants, etc.
,, V. Travellers. Speeds and Counts.
,, VI. Bobbin Building, etc.
,, VII. Changing Counts and Calculations for the same.
,, VIII. Producing Correct Counts.
,, IX. Production.
,, X. Duties of Ring Spinners.
,, XI. Scouring and Drafting.
,, XII. Defective Yarn, & Causes.
,, XIII. Faultily Built Bobbins.
,, XIV. Atmospheric Conditions of Ring Room.
,, XV. Arrangements of Ring Frames and Re-setting.
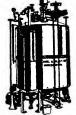
Crown 8vo.   414 Pages.   172 Illustrations.

12s. 6d. net ; by post, **13s.**

Published by EMMOTT & CO. LTD., 65 King Street, Manchester

LONDON : 20 BEDFORD STREET, W.C. 2

THE

TEXTILE MANUFACTURER

YEAR BOOK

CHARACTERISTICS OF COTTON HAIRS

By C. UNDERWOOD, B.A.*

ALTHOUGH the general appearance and character of a cotton fibre are probably familiar to those who are accustomed to handling many millions of them daily, a short discussion of the physical characteristics, and the methods employed in their measurement, might be of interest; for the qualities of a yarn, and ultimately of a fabric, must depend in some way or other upon the properties of the fibres of which the yarn is built up.

The characteristics of cotton hairs may be dealt with under the following headings: Length, convolutions, fineness, strength and rigidity, and colour and lustre, and although it is difficult to discuss any one character without referring to the others, on account of the relationship which exists between them, it will be simpler to treat them separately as far as possible.

Length.—This quality is generally accepted in the trade as being the most important characteristic of the cotton hair; the price of a cotton is governed largely by its "staple," and it is probably true that of two cottons, having all their properties similar except length, the longer will produce the better yarn. Difficulties of investigation arise, however, in that very seldom are two such cottons available for comparison, and owing, perhaps, to the possible correlation of some of the characteristics, cottons practically always differ in more than one respect. In considering the staple length of a cotton, one point should be noted which is perhaps of even greater importance in spinning, viz., the "variability" of length, or, to use the trade

---

* Of the Staff of The British Cotton Industry Research Association.

term, "evenness of staple." It is impossible to obtain a uniform cotton, for not only do the conditions of growth vary in the same field, in the same plant, and even in the same boll, but the hairs on one seed do not all begin to grow at the same moment and probably do not all receive the same amount of nourishment. In Fig. 1 are shown photomicrographs of a cotton seed with one day's growth of
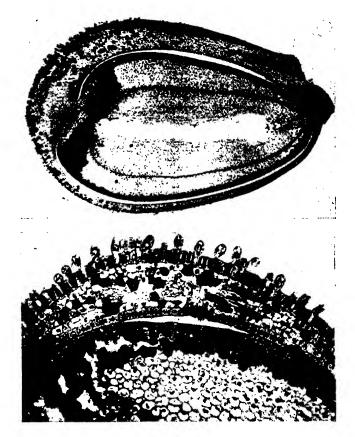
FIG. 1.—COTTON SEED WITH ONE DAY'S GROWTH OF HAIR.
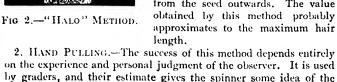
lint. The picture of the whole seeds shows certain portions on which no hairs are yet visible. The more highly magnified photograph shows the variation in length of the stumps of hairs which have just appeared.

FIG 2.—"HALO" METHOD.

The presence of abnormally undeveloped hairs which are easily broken, careless picking, faulty ginning, or inaccurate settings of the machinery, may each be responsible for excessive amount of short fibre and consequent unsatisfactory work.

The four following methods of measuring lint length are used :—

1. "HALO" METHOD.—Used for seed cotton. The hairs on a seed are combed out to form a sort of halo, as indicated in Fig. 2, and the length is estimated from the size of the halo. A rough indication of the variability is given by the variation in density from the seed outwards. The value obtained by this method probably approximates to the maximum hair length.

2. HAND PULLING.—The success of this method depends entirely on the experience and personal judgment of the observer. It is used by graders, and their estimate gives the spinner some idea of the staple length of the cotton he is buying, although the exact significance

FIG. 3.—"BAER" SORTER DIAGRAM.
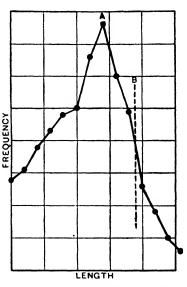
of the grader's figure is unknown except to himself; it is not the maximum length as given by the halo method, and it is generally rather above the " most frequent length," as determined by the method 4 below. The grader usually estimates the variability and qualifies his length figure by adding some such expression as " mixed," " very uneven," etc.

3. BAER SORTER.—The hairs are laid in order of length on a piece of black velvet with their lower ends in the same straight line, so that the upper ends lie on a curve indicating the length and variability of the cotton, as shown in Fig. 3. This method has the advantage of giving at a glance information about the length, etc., of the sample, but it is tedious and requires practice, for it is essential that the hairs are laid out straight and uniformly. It is not suitable for accurate quantitative measurement.

4. BALLS' SLEDGE SORTER.—A complete description of the Balls' sorter is given in a pamphlet, " A New Method for Measuring the Length of Cotton Hairs," by W. L. Balls. The hairs are deposited on a long strip of plush, the short ones at one end, the long ones at the other, the medium length hairs in the middle. By weighing tufts from equal portions of this lot of hairs, the proportions of hairs of various lengths can

FIG. 4.—BALLS' SLEDGE SORTER DIAGRAM.

be calculated and a frequency diagram constructed, as shown in Fig. 4. Such a diagram gives equally as good an indication as the Baer diagram when once its significance is grasped, and is capable of much greater accuracy of interpretation. The "most frequent length" is that length at which the peak A occurs, whilst the grader's staple usually corresponds to the length given by the point B or thereabouts.

Convolutions.—The cause of this characteristic feature of the cotton hair—sometimes spoken of as " natural twist "—has been the

subject of much controversy. It seems to be acknowledged that convolutions are not all of the same type, and that different kinds are probably the result of different causes; generally, however, they may be assumed to be due to some spiral formation or inequality in the structure of the hair. Fig. 5A shows normal convoluted hairs; B, undeveloped hairs with no convolutions; C, an overdeveloped hair, also without convolutions (Fig. 5B and C on p. 6).

Convolutions are related to the shape of the cross-section of the hair, which is usually described in terms of the ratio of the " ribbon-width "—the horizontal distance between the vertical dotted lines

FIG. 5A.—NORMAL CONVOLUTED COTTON HAIRS.

in Fig. 8—to the " wall-thickness," although there is no connection between fineness (see below) and the number of convolutions per centimetre. Convolutions may be caused to disappear by wetting or by boiling under pressure, and are seen to reappear on drying again; reversals in the direction of twist also very often occur, the frequency and distribution of which may modify the spinning qualities of a cotton. The great variation in the number and char-acter of the convolutions of normal cotton hairs (which is apparent in Fig. 5A) makes it extremely difficult, however, to investigate with any degree of success the relationship between the strength and other properties of a yarn and the " natural twist " or frequency of convolutions in the constituent hairs, although attempts have been made to relate the number of convolutions per centimetre to

" clinging power," or the force required to pull a cotton hair through
a pad of similar parallel hairs.

Fineness.—This quality can be expressed in various ways, *e.g.*,
by the area of the cross-section of the hair, the diameter, the wall-
thickness, or the weight of a unit length of hair. With the

FIG. 5B.
UNDEVELOPED HAIRS
WITHOUT CONVOLUTIONS.

FIG. 5C.
OVERDEVELOPED HAIR
WITHOUT CONVOLUTIONS.

exception of " diameter "—which is a very indeterminate character owing to the shape of the normal collapsed cotton hair (see **Fig. 6,** which shows sections of hairs of different types of cotton)—there is a fairly obvious relationship between these quantities and, as the " weight " measurement is the simplest to undertake, fineness is usually expressed in terms of hair weight per centimetre, the assumption being made that the density of cellulose, the principal constituent of the cotton hair, is constant. The results of many measurements on a wide range of samples indicate on the whole a confirmation of the generally accepted idea that long cottons are finer than short ones, although it must be emphasised that this can only be taken as a broad generalisation. Values for hair weight per centimetre of different types of cotton usually fall within certain fairly well defined ranges, and although these ranges overlap in many cases, it is sometimes possible, with the aid of measurements on length, etc., to detect adulterations, such as, for example, the mixing of a long Uppers with a Sakel. The variations within each type are,
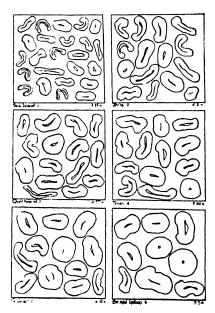
FIG. 6.—SECTIONS OF COTTON HAIRS.

however, too great to admit of this method as a sound means of identification. It is occasionally useful in detecting the presence of immature hairs, which are abnormally thin-walled and thus bring down the mean value considerably if they occur in any quantity. Regarding the effect of fineness on spinning value, the results of spinning tests seem to indicate that of two cottons possessing identical measurable characters, except in so far as one is finer than the other,

the former may be expected to produce the superior yarn. A list of hair weight per centimetre values of most types of cotton is given in a paper by Morton, *J. Text. Inst.*, **17**, 1926, T. 537.

Strength.—The significance of the strength of individual hairs in relation to the quality of the yarn has been the subject of considerable difference of opinion. Until recently it was thought that yarn broke by slippage of the constituent fibres rather than by their actual rupture. Examination of the hairs in broken ends of yarn shows, however, that in many cases a large proportion of the hairs are actually broken. No correlation has been found, on the other hand, between hair breaking load and yarn strength, nor are there any striking connections between breaking load and other hair character-

Fig. 1.—Cotton Hair with Colour in Central Canal.

istics. It would seem reasonable to expect a correlation between wall-thickness or hair weight per centimetre and breaking load, but it must be remembered that the breaking load depends upon the strength of the weakest portion of the hair, and will therefore be considerably influenced by any abnormalities.

Rigidity.—The rigidity of a cotton hair is a measure of the difficulty experienced in twisting a certain length of it through a given angle, and thus can be expected to be intimately connected with spinning quality, since the action of spinning consists in twisting together a number of hairs. There appear to be certain definite relationships between the rigidity of a cotton hair and other factors, such as its strength, mass, length, etc., and the general mill practice of using lower twist constants in calculating turns per inch for finer cottons than for coarser and shorter cottons, since the latter naturally require a greater couple for unit twist than the former, has been confirmed by extensive measurements on various cottons.

Colour and Lustre.—The colour of a cotton may be influenced to a considerable extent by climatic conditions, but it is primarily an inherent characteristic. It is due to the presence in the hairs of " endochrome " or colouring matter. In Fig. 7 the dark-coloured lumps in the central canal of the hair represent the endochrome,

FIG. 8.—SECTIONS OF COTTON HAIRS.

which, however, is not visible in every hair, so that the colour may not be evident on examining individual fibres. American cottons contain very little of this colouring matter and in a healthy state are very faintly cream; some Egyptian cottons and the variety known as Red Peruvian show more intense colouring which may fade on prolonged exposure. In adverse climatic conditions, American cottons may take on a bluish-white appearance which is detrimental to the grade. Colour due to staining is quite distinct from natural colour, as it occurs in patches throughout the bulk. It is caused primarily by the attack of an insect pest known as the Cotton Stainer, or Red Bug, which punctures the boll and inoculates it with a fungus.

SECTIONS OF COTTON HAIRS.
FIG. 9A.   FIG. 9B.

The hairs affected are deeply stained and frequently immature, the development having been arrested. American cotton is not often attacked by this pest, but recent growths in Tanganyika and other cotton-growing countries in Africa seem to be rather susceptible to it.

Lustre.—The governing factor in the lustre of cotton hairs is the shape of the cross-section. Briefly, it has been found that the more
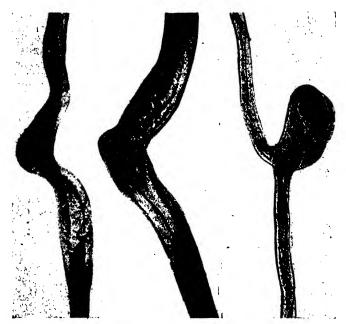
FIG. 10.—ABNORMALITIES IN COTTON HAIRS.

nearly circular is the section of a hair, the greater is its lustre; but that the latter may also be affected by convolutions is evident not only on account of the relationship between this characteristic and the shape of the cross-section, which was referred to in the paragraph on convolutions, but also from the example of immature hairs which are extremely thin-walled, have a very flat, ribbon-like section, and yet are abnormally lustrous. The theory accounts satisfactorily

for the increased lustre effected by mercerisation under tension, in which the hairs swell and become practically circular in cross-section. Fig. 8 shows sections of cottons : A, of low lustre ; B, of high lustre ; and C, mercerised.

This short résumé must include a note on that abnormal condition of cotton known as " immaturity " in which the hair has, for some reason or other, failed to develop, laid down no secondary thickening to its wall, and consequently collapsed on the opening of the boll without convoluting. The converse state of overdevelopment is due to excessive secondary thickening, the central canal of the hair being practically closed up ; collapse is then almost impossible and convolutions are again absent. Fig. 5 shows normal, immature, and overdeveloped hairs ; Fig. 9A shows sections of normal and thick-walled hairs with a group of immature fibres in the centre ; B shows sections of immature fibres.

The former case—" immature," " unripe," or " dead " cotton— is the more frequent and of more concern to the spinner, since it is at the root of many of his troubles. The undeveloped hair, being thin-walled, is comparatively weak ; it is easily broken, firstly in the gin where it gives rise to excessive short fibre and afterwards in the mill. Thin-walled hairs are very liable to form " neps " which resist dyeing and produce spottiness in the fabric, having persisted throughout all previous processes. The presence of im-mature cotton in a sample is indicated frequently by the form of the sorter curves, which show great variability of length, by abnorm-ally low values for both hair weight per centimetre and breaking load, and by the general appearance of the cotton.

Illustrations of other occasional abnormalities, such as kinks and bulges in the hair due, perhaps, to disturbances within the boll during growth, are shown in Fig. 10 on the previous page.

NUMBER OF PERSONS EMPLOYED IN THE COTTON INDUSTRY

According to the Third Census of Production (1924), 517,232 persons were employed in spinning and weaving in the cotton industry, of whom 15,411 were mainly engaged in management, 238,438 were employed in spinning, and 263,383 in weaving. About 64 per cent. of the operatives were women.

The finishing sections employed in 1924 were 107,812, of whom 84,947 were males. The number of management, technical and clerical staff included, was 10,183. These numbers include persons employed in finishing all kinds of goods, cotton, wool, linen, silk, etc.

THE WORLD'S COTTON CROP RETURNS
"Annual Cotton Handbook"
(*In Thousands of Bales*)

Season.			America.	India.	Egypt.	All Others.	Total.
1929-30	-	-	14514	5260	870	7104	27748
1928-29	-	-	15785	5811	1076	6817	29489
1927-28	-	-	14444	5871	911	6501 .	27727
1926-27	-	-	19282	5973	1017	6208	31480
1925-26	-	-	15452	6556	946	6353	29307
1924-25	-	-	14716	6670	935	5410	27731
1923-24	-	-	11327	6330	927	4399	22983
1922-23	-	-	11248	6654	945	4193	23040
1921-22	-	-	11495	6109	764	3498	21866
1920-21	-	-	11355	4921	445	3986	20707
1919-20	-	-	12218	5569	738	4088	22613
1918-19	-	-	11603	3671	718	4919	20911
1917-18	-	-	11912	4000	714	5538	22164
1916-17	-	-	12976	4827	631	5813	24247
1915-16	-	-	12953	5414	728	7663	26758
1914-15	-	-	15067	4753	832	6991	27643
1913-14	-	-	14885	6149	970	7804	29808
1912-13	-	-	14129	4692	969 -	7716	27506
1911-12	-	-	16043	4178	965	6374	27560
1910-11	-	-	12132	4587	984	6324	24027
1909-10	-	-	10651	5317	673	2768	19409
1908-09	-	-	13829	4779	898	2885	22391
1907-08	-	-	11582	4445	908	2916	19851
1906-07	-	-	13550	5197	923	2803	22473
1905-06	-	-	11320	4797	798	2542	19457
1904-05	-	-	13557	4061	843	2172	20633
1903-04	-	-	10124	4471	797	2760	18152
1902-03	-	-	10758	4183	768	2804	17913
1901-02	-	-	10701	4122	864	1052	16739
1900-01	-	-	10425	3377	711	900	15513

COTTON ACREAGE AND YIELD PER ACRE

U.S. Census Bureau

COTTON PRICES

Year.	Egypt.		India.		American.		Average Spot Prices at Liverpool.	
	Acres.	Lb.	Acres.	Lb.	Acres.	Lb.	Mid. American.	F.G.F. Egyptian.
	Thousands.		Thousands.		Thousands.		Pence per lb.	Pence per lb.
1903-4	1,383	466	18,025	79	27,052	174	6·94	8·56*
1904-5	1,491	420	19,918	77	31,215	206	4·91	7·37
1905-6	1,626	363	20,401	88	27,110	187	5·95	9·25
1906-7	1,564	440	22,488	87	31,374	202	6·38	10·37
1907-8	1,664	431	21,680	58	29,660	179	6·19	8·81
1908-9	1,703	393	10,999	74	32,444	195	5·50	8·44
1909-10	1,619	309	20,545	92	32,044	154	7·86	13·12
1910-11	1,664	453	22,596	68	32,403	171	7·84	10·75
1911-12	1,776	412	21,615	61	36,045	208	6·09	9·56
1912-13	1,787	417	22,028	84	34,283	191	6·78	9·70
1913-14	1,789	425	25,020	81	37,089	182	7·28	9·45
1914-15	1,823	353	24,595	85	38,832	209	5·22	7·34
1915-16	1,231	387	17,746	84	31,412	170	7·51	10·42
1916-17	1,718	295	21,745	83	34,085	157	12·33	21·56
1917-18	1,741	359	25,188	64	33,841	160	21·68	30·97
1918-19	1,366	338	21,098	76	36,008	161	19·73	27·85
1919-20	1,633	399	23,353	99	33,566	178	25·31	60·34
1920-21	1,897	336	21,341	68	35,878	125	11·89	30·24
1921-22	1,841	329	18,451	97	30,509	142	11·37	19·75
1922-23	1,868	360	21,077	98	33,036	130	14·92	17·29
1923-24	1,856	354	23,088	88	41,360	157	17·66	21·55
1924-25	1,856	329	24,833	98	40,115	167	13·76	29·82
1925-26	1,998	390	27,960	88	46,053	182	10·77	20·05
1926-27	1,853	386	25,006	79	47,087	155	8·16	15·36
1927-28	1,573	394	23,812	95	40,168	152	11·16	19·38
1928-29	1,405	395	25,874	94	45,326	155	11·14-9·72†	21·85-16·75†
1929-30	1,912	409	25,121	88	45,981		10·65-7·47	17·65-12·20†

* Before 1917 Brown, afterwards Sakel.   † Highest and lowest weekly prices.

COMMERCIAL "GROWTHS" OF COTTON, ETC.

Country of Growth.	Variety.	Approx. Length.	Approx. Diam.		Notes.	Twist or weft up to
U.S.A.	Sea Islands— Edisto	In. 1·8	In.	The best commercial cottons. Silky and regular	All Sea Island cotton varies in colour from a light cream to a creamy colour	400's
West Indies	St Kelts	1·8				400's
	St Vincent	1·8				400's
U.S.A.	Florida	1·7		lightly inferior to above		300's
Polynesia	Fiji	1·6				150's
S. America	Peruvian	1·5		More irregular		150's
	Arizona and California	1·5		Fine and smooth staple		120's
	Long Stapled Uplands	1·2 to 1·5		More variable, but approximates to above	Colour, light cream	W. 120's
	Orleans	1·1		Regular cotton of good colour		T. or W. 70's
U.S.A.	Mississippi	0·99	0·18*	....	These vary in colour from almost white to a slight creamy colour	T. 30's
	Memphis	0·96	0·20*			T. 40's
	Louisiana	1·05				T. or W. 50's
	Arkansas	1·05		Good useful cottons for medium counts, varying in length, strength, and colour		W. 50's
	Carolinas	1·05				W. 50's
	Georgia	1·0				W. 40's
	Uplands	0·95				T. 40's
	Texas	0·95	0·21*	Fine, uniform, and lustrous		W. 40's
	Mobile	0·85				T. 40's
	Sakellarides	1·5				T. or W. 150's
Egyptian	Zagora (Uppers)	1·16		....	New varieties include Maarad (up to 100's), Giya ? (up to 80's), and 310 of Sakel type	T. 70's
	Ashmouni(Uppers)	1·25				T. 70's
	White Abassi	1·25		A very white cotton		W. 70's
	Pilion	1·25				T. or W. 70's
	Soudan	1·3		A useful .... cotton for medium fine yarns		
West Africa	Lagos	1·0		....	....	40's

					Colour		
East Africa	Uganda ·	1·1	1 3/16	Harsh and strong	} Colour, light cream	T.	40's
	Peruvian Rough · Smooth	1·3	1 4/16	Fairly soft		,,	80's
	,, Tanguis	1·2	1 3/16	Useful cottons for medium fine yarns, somewhat harsh	....	W.	80's
			1 4/16			T. or W.	80's
S. American	Brazil—Maranhams ·	1·05	1 3/16	} These cottons vary in strength, but are usually fairly strong and harsh	} Vary in colour from dull white to cream	T.	50's
	Pernams ·	1·15	1 3/16			T.	50's
	Paraibo ·	1·1	1 4/16			T. or W.	50's
	Maceo ·	1·05	1 3/16				40's
	Ceara ·	1·05	1 3/16				40's
	Santos ·	1·0	1 3/16	Softer and weaker than other Brazilian cottons	Dull white	W. ,,	40's
Indian	Western (Dharwar I)	0·89	0·20*	Brownish	} These are some of the "Standard" Indian Cottons tested by the Indian Central Cotton Committee	T.	32's
	Dharwar Amer. (Gadag I.)	0·85	0·15	White		T.	30's
	Surat (1027 A.L.F.)	0·96	0·20	....		T.	32's
	Punjab American (4 F.)	0·80	0·18	....		T.	20's
	Bengals (Aligarh A. 19)	0·70	0·30	....		T.	7's
	Broach (Verum 262)	0·84	0·19	....		T.	20's
	Oomras (Umri Bani)	0·82	0·18	....		T.	24's
	Cambodia (440)	0·90	0·17	....		T.	28's

* Approximate fibre-weight per inch in millionths of an ounce.

LIVERPOOL SPOT PRICES OF COTTON AND YARN—SEASON 1929-30

	Mid. Amer. Per Lb.	F.G.F. Sakel. Per Lb.	32's Twist Amer. Per Lb.	60's Twist Egyptian Per Lb.
	d.	d.	d.	d.
1929 July 26	10·58	17·05	15·25	26·50
Aug. 2	10·65	17·10	15·37	26·50
„ 9	10·16	16·50	15·37	26·50
„ 16	10·10	16·50	15·50	26·50
„ 23	10·32	16·65	15·62	26·50
„ 30	10·58	17·25	15·62	26·50
Sept. 6	10·46	17·50	15·50	26·50
„ 13	10·32	17·65	15·25	26·00
„ 20	10·31	17·20	15·12	26·00
„ 27	10·20	16·50	15·12	26·00
Oct. 4	10·28	16·55	15·12	26·00
„ 11	10·28	15·65	15·12	26·00
„ 18	9·94	15·70	14·75	25·50
„ 25	9·96	15·55	14·75	25·50
Nov. 1	9·88	15·10	14·62	25·50
„ 8	9·56	14·90	14·37	25·25
„ 15	9·56	15·10	14·25	25·25
„ 22	9·76	14·90	14·50	25·50
„ 29	9·59	14·65	14·25	25·50

	Mid. Amer. Per Lb.	F.G.F. Sakel. Per Lb.	32's Twist Amer. Per Lb.	60's Twist Egyptian Per Lb.
	d.	d.	d.	d.
1929 Dec. 6	9·58	14·55	14·25	25·50
„ 13	9·47	14·25	14·12	25·00
„ 20	9·36	13·95	14·12	24·50
„ 27	9·51	14·20	14·12	24·50
1930 Jan. 3	9·53	14·30	14·12	24·50
„ 10	9·58	14·65	13·87	24·00
„ 17	9·49	14·45	13·87	24·00
„ 24	9·40	14·50	13·62	24·00
„ 31	8·85	14·25	13·50	23·50
Feb. 7	8·60	13·75	13·37	23·50
„ 14	8·69	13·70	12·87	23·00
„ 21	8·47	13·50	12·62	22·75
„ 28	8·49	13·55	12·62	22·25
Mar. 7	8·18	13·60	12·37	22·25
„ 14	8·05	13·60	12·25	22·25
„ 21	8·54	13·90	12·37	22·25
„ 28	8·44	14·20	12·50	22·25

	Mid. Amer. Per Lb.	F.G.F. Sakel. Per Lb.	32's Twist Amer. Per Lb.	60's Twist Egyptian Per Lb.
	d.	d.	d.	d.
1930 April 4	8·85	14·20	12·62	22·25
„ 11	8·76	14·05	12·62	22·25
„ 17	8·61	14·25	12·37	22·25
„ 25	8·74	14·30	12·50	22·25
May 2	8·65	14·25	12·50	22·25
„ 9	8·63	14·10	12·37	22·25
„ 16	8·54	13·85	12·37	22·25
„ 23	8·67	13·85	12·37	22·25
„ 30	8·58	13·65	12·37	22·25
June 6	8·34	13·15	12·25	22·25
„ 13	7·98	12·75	12·25	22·25
„ 20	7·81	12·45	11·50	21·75
„ 27	7·74	12·55	11·50	21·75
July 4	7·63	12·25	11·62	21·75
„ 11	7·73	12·45	11·62	21·75
„ 18	7·68	12·40	11·50	21·50
„ 25	7·47	12·40	11·25	21·50

HALF-YEARLY COTTON CONSUMPTION

(International Federation of Master Cotton Spinners' Manufacturers Associations)

(Thousands Actual Bales).

	Half-Year Ending 31st Jan. 1930				Half-Year Ending 31st July 1930				Total, Half-Year Ending			
	American	East Indian	Egyptian	Sundries	American	East Indian	Egyptian	Sundries	July 31, 1930	Jan. 31, 1930	July 31, 1929	Jan. 31, 1929
Great Britain	880	100	167	268	594	88	134	234	1,050	1,415	1,360	1,440
Germany	468	144	38	26	455	127	40	25	647	676	654	724
France	380	100	65	44	348	124	53	57	582	589	614	613
Russia	231	52	27	816	52	61	25	845	983	1,126	1,094	1,058
Italy	355	133	30	15	309	128	22	9	468	533	524	518
Czechoslovakia	171	56	11	6	150	53	7	7	217	244	244	251
Belgium	93	89	4	53	87	91	3	41	222	239	207	245
Spain	130	46	14	18	122	46	19	17	204	208	193	211
Poland	98	12	4	4	86	12	5	4	107	118	105	146
Switzerland	24	5	21	5	22	5	21	1	49	52	52	53
Holland	76	22	—	5	76	22	—	5	103	103	96	94
Austria	39	20	2	2	35	15	2	2	54	63	73	76
Europe Total	3,071	785	384	1,280	2,458	778	332	1,266	4,834	5,520	5,369	5,543
India	25	1,087	4	48	18	1,156	9	72	1,255	1,164	1,018	979
Japan	573	870	22	79	519	827	20	87	1,453	1,544	1,425	1,341
China	130	199	1	763	162	264	2	776	1,204	1,093	1,013	944
U.S.A.	3,157	31	76	25	2,654	30	61	26	2,771	3,280	3,615	3,418
Canada	93	—	7	—	96	—	4	—	100	100	122	106
Mexico	-.	—	—	126	—	—	—	89	89	126	81	83
Brazil	—	—	—	234	—	—	—	180	180	234	221	251
WORLD TOTAL	7,083	2,985	502	2,632	5,940	3,102	435	2,530	12,007	13,202	13,014	12,868

U.K. RAW COTTON IMPORTS
'000 Lb.

	1925.	1926.	1927.	1928.	1929.
Over 1¼ in. Staple.					
From Egypt - -	276,442	283,927	276,331	261,631	235,587
U.S.A. - -	8,028	6,984	6,937	8,521	11,706
Peru - -	7,416	17,486	26,119	14,652	19,081
Sudan - -	14,482	40,775	57,716	45,257	59,443
Total - -	312,758	353,862	373,338	337,873	334,424
Under 1¼ in. Staple.					
From U.S.A. - -	1,217,750	1,062,588	911,612	859,512	824,358
Egypt - -	28,744	29,967	39,957	42,363	60,291
Peru - -	77,294	69,958	81,226	65 697	61 720
Brazil - -	35,839	32,089	20,274	11,559	62 907
British India -	98,294	67,014	48,041	96,328	104,806
Total - -	1,581,435	1,386,420	1,175,001	1 169 707	1,205.854

U.K. EXPORT MARKETS FOR COTTON PIECE GOODS

Destination.		Linear Yards. Thousands.	Value. £'000.	Percentages of Total Exports.	
British India - - -	1927	1,550,696	31,130	37·4	
	1913	3,057,306	34,055		43·2
China, Japan, Hong Kong, etc. -	1927	130,371	4,605	3·1	
	1913	773,242	12,897		10·9
Dutch East Indies - -)	1927	339,290	8,629	8·0	
Ceylon, Straits Settlements)	1913	530,217	7,395		7·6
South America - - -	1927	381.163	11,556	9·2	
	1913	582,146	8,479		8·2
Mexico, Central America)	1927	67,640	1,866	1·6	
West Indies - - -)	1913	167,577	2,146		2·4
United States and Canada -	1927	93,438	4,435	2·2	
	1913	157,065	3,596		2·2
Australia and New Zealand -	1927	217,089	9,143	5·2	
	1913	210,744	4,199		3·0
Europe (excepting Balkans) -	1927	452,123	14,411	10·9	
	1913	388,930	8,007		5·5
Balkans, Near and Middle East -	1927	320,561	7,643	7·7	
	1913	477,604	5,802		6·8
North Africa - - -	1927	263,899	5,368	6·3	
	1913	357,387	4,414		5·1
West Africa - - - -	1927	234,685	6,459	5·6	
	1913	243,161	3,962		3·4
South and East Africa -	1927	115,125	3,641	2·8	
	1913	120,873	1,902		1·7
Totals (all Countries) - -	1927	4,189,110	109,996	100	
	1913	7,075,252	97,776		100

EXPORTS OF COTTON YARNS, THREAD, AND PIECE GOODS FROM THE UNITED KINGDOM

Yearly Average for	Cotton Yarns		Finished Thread		Cotton Piece Goods						Total
	Th. Lb.	£'000.	Th. Lb.	£'000.	Grey. (Th. Linear Yards)	Bleached.	Printed.	Dyed. (Th. Linear Yards)	Coloured.	Total. (Th. Linear Yards)	£'000.
1820-24	26,428	2,718	..	..	142,008		..	151,258	..	346,971	13,518
1825-29	46,331	3,563	..	..	178,424		..	168,547	..	293,266	12,409
1830-34	70,248	4,549	..	..	257,390		..	218,427	..	475,817	12,873
1835-39	99,029	6,615	..	..	326,372		..	308,245	..	629,617	15,405
1840-44	131,605	7,264	..	..	500,991		..	347,242	..	848,233	15,391
1845-49	140,528	6,687	..	..	675,500		..	431,995	..	1,106,795	17,088
1850-54	143,096	6,652	4,571	..	945,672		..	596,947	..	1,542,619	22,322
1855-59	183,206	8,593	4,917	..	1,370,206		..	797,587	..	2,167,793	30,502
1860-64	123,698	8,502	4,980	..	1,338,221		..	739,762	..	2,077,983	36,745
1865-69	151,042	13,555	6,190	..	1,769,167		..	874,492	..	2,643,659	50,832
1870-74	205,477	15,364	8,031	..	2,408,743		..	1,036,767	..	3,445,510	54,855
1875-79	232,281	12,652	11,024	..	2,621,492		..	1,048,292	..	3,669,784	49,877
1880-84	248,883	13,051	14,646	..	3,122,136		..	1,370,828	..	4,492,964	55,330
1885-89	251,890	11,620	18,353	2,761	3,438,907		..	1,394,589	..	4,833,496	50,826
1890-94	235,888	10,311	17,332	3,010	2,166,225	1,243,929	954,474	610,329		4,974,957	50,560
1895-99	242,151	9,250	26,783	3,362	2,134,425	1,293,968	992,900	718,058		5,139,351	48,501
1900-04	161,790	7,897	31,321	3,713	2,012,731	1,415,611	978,790	888,220		5,295,375	56,689
1905-09	216,708	12,448	27,847	4,284	2,159,558	1,660,777	1,087,231	1,094,050		6,001,616	73,149
1910-13	217,353	15,057	22,679	3,885	2,164,193	1,889,202	1,259,276	1,081,482	278,584	6,672,737	89,774
1920-3	160,077	29,774	18,178	9,975	1,116,408	1,262,186	770,895	779,740	200,648	4,041,201	184,344
1924	163,056	27,782	18,096	6,963	1,402,275	1,413,185	748,718	858,046	182,867	4,005,092	154,091
1925	189,531	30,501	18,365	7,616	1,303,130	1,521,974	800,773	831,825	202,722	4,636,920	151,380
1926	168,527	21,781	19,048	7,202	1,121,619	1,284,720	611,699	751,792	171,614	3,922,797	116,608
1927	200,465	23,608	18,159	6,425	1,197,890	1,337,367	656,579	823,722	173,552	4,189,110	109,996
1928	169,207	22,566	18,528	6,867	993,883	1,346,095	625,489	837,595	165,136	3,968,198	107,298
1929	166,637	20,753	18,128	6,713	954,824	1,288,273	542,527	825,722	144,327	3,764,862	99,294

1018 linear yards was equal to 1000 square yards in 1927.

THE WORLD'S COTTON MILLS
"Annual Cotton Handbook"
(According to Latest Known Estimates)

Country.		Mills.	Spindles.	Looms.	Consumption. Bales.	Hands Employed
Great Britain	- - 1930	1734	57711635	703878	2621731	610000
U.S. North	- - 1929	620	16787099	367461	2255403	230000
„ South	- - 1930	957	18875557	352716	4950854	186000
Canada	- - 1929	45	1230734	26764	196854	28500
Germany	- - 1930	300	11260000	250000	1795949	100000
Russia	- - 1929	203	6217000	159100	929174	498980
Poland	- - 1930	66	1642167	42240	292000	62000
Finland	- - 1930	6	266900	6975	32000	7366
Esthonia	- - 1930	4	215000	3500	24000	5500
Latvia	- - 1930	7	73504	1059	13852	3100
France	- - 1930	595	10200000	200000	1215000	200000
Hungary	- - 1930	40	200000	12000	55000	13000
Austria	- - 1930	80	976740	15900	136000	16000
C. Slovakia	- - 1930	86	3655000	110000	510000	120000
Jugo-Slavia	- - 1930	42	130000	9000	40000	15000
Switzerland	- - 1930	64	1531344	26872	103094	28000
Italy	- - 1930	700	5450000	150000	1050000	250000
Spain	- - 1930	400	2100000	75000	400000	130000
Portugal	- - 1930	52	503000	22000	60000	30000
Belgium	- - 1930	228	2156500	54385	345000	39500
Holland	- - 1930	107	1168000	54300	180000	41712
Sweden	- - 1930	33	627000	16000	93000	16000
Norway	- - 1930	15	57218	2999	8000	2800
Denmark	- - 1930	27	98460	5891	22959	3337
Turkey (Eu)	- - 1929	1	10000	..	3500	..
Bulgaria	- - 1929	21	20450	1277	5500	1000
Cyprus	- - 1930	1	2000	..	500	65
Greece	- - 1930	85	225000	2650	40000	12500
Roumania	- - 1930	2	33300	5000	48500	6500
Egypt	- - 1930	1	57000	850	11200	1500
Asia Minor	- - 1927	6	50000	3325	36750	3080
India	- - 1929	334	8807064	174922	2161166	346925
China	- - 1930	120	3664120	29582	2179739	241552
Japan-	- - 1930	258	6836516	77898	2951279	159692
Korea	- - 1930	5	31200	1766	33932	3803
Indo-China	- - 1925	5	90000	500	45000	3000
Brazil	- - 1929	351	2552079	79249	453985	125028
Argentina	- - 1929	5	40500	900	25000	2500
Chile	- - 1916	3	5000	400	..	454
Peru	- - 1928	11	76796	3049	12500	3100
Colombia	- - 1928	16	39640	1927	65000	3285
Ecuador	- - 1928	12	38874	836	12000	2542
Venezuela	- - 1928	8	48800	1900	29000	6000
Guatemala	- - 1929	1	4000	185	5984	500
Mexico	- - 1930	117	791613	29992	160000	34000
Bolivia	- - 1929	2	6000	446	..	..
TOTAL (estimated)	-	7776	166562810	3084694	25610405	3592722

COTTON MARKETING

Raw cotton is a staple product and the markets for it are very highly organised. Almost all the cotton in the international trade is bought and sold on one or other of the numerous contracts of the many cotton exchanges. The exchanges, such as the Liverpool Cotton, Exchange, include in their objects the regulation of the trade, the recording of prices, stocks, and sales, the issue of statistics and other reliable information, arbitration, grading, classification, and standards, the drawing up of contracts, and in many cases the provision of a futures market and other matters.

Growth, grade, and staple are important commercial characteristics of cotton. From the point of view of the spinner buying actual cotton these may be translated together as staple or length of the bulk of the fibres and amount of short fibre, strength, fineness, spinning quality, colour, cleanliness, evenness, etc. The growth usually signifies a certain staple and spinning quality.

Staple is the method of valuing the cotton principally for length and strength. It might also be defined as the whole of those properties which can be determined by handling or pulling the staple as they affect the value for spinning. There are no standards for staple in any growth, though they have been tentatively drawn up and their use suggested by the American authorities for American cottons.

Grade is the relative value of a sample of cotton judged by its appearance without handling, and is determined by such considerations as cleanliness—that is, presence or absence of leaf, motes, or other impurities, colour, bloom, evenness, absence of gin cutting, etc. A bale, or sample of a bale, is referred to the " Standards " kept by the Exchange authorities and copied for the use of members. " Universal Standards " mean standards for grade and colour agreed upon by Liverpool Cotton Association and other markets with the U.S. Department of Agriculture.

The official " spot " quotations (which are determined partly for the purpose of arbitration and future contracts) now include the conception of " fair staple."

American and African varieties are graded under the following names: G.O. (Good Ordinary), S.G.O. (Strict G.O.), L.M. (Low Middling), S.L.M., Mid., S.M., G.M. (Good Middling), S.G.M., M.F. (Middling Fair).

Indian varieties are graded G.F. (Good Fair), F.G.F. (Fully G.F.), Good, F.G., Fine, Superfine, Choice, Superchoice.

Egyptian varieties are graded Fair, Good Fair, Fully Good Fair, Good, Fine, Extra Fine.

Brazilian varieties are graded Middling Fair, Fair, Good Fair.

Peruvian varieties are graded Middling Fair, Fair, Good Fair, Good, Fine.

Futures Contracts.—A futures contract is a contract ostensibly to deliver or receive cotton, in the case of Liverpool American futures, 48,000 lbs. net in a named future month of American middling grade or better or poorer grade with an allowance as officially determined daily and at a basis price officially struck at 12 noon each day, which is the price of the cotton if of basis grade on the day in which it is tendered, providing that the contract actually matures to that point, which is unusual. If cotton is actually delivered it must all be tendered on one contract on the same day in not more than three lots or kinds, and must not be below " fair staple " or usually below low middling grade. There is only a part allowance of 20 per cent. of the value of better staple.

The sale or purchase of a futures contract by a member is registered, and Clearing House arrangements are made whereby the purchase by one member of a contract from any member is set off by a sale to any member, and a balance of sale and purchase of contracts for any particular month frees the individual member immediately from his liability eventually to receive or deliver the specified cotton.

The contract is on " Settlement Terms," whereby the difference between the price mentioned and the value of such cotton as deter- mined officially at 11 A.M. on every following Monday, whilst the contract runs, is paid or received as weekly payments. This is in effect a testing of the solvency each week of every member dealing in so far as it affects the " differences." It is always possible to buy or sell futures at any time when trading is allowed.

The use of futures contracts allows dealing in cotton without capital, and thus by a large volume of transactions in which real cotton is not usually called into question allows a wider market with finer quotations and more sensitive fluctuations. It allows speculation more freely to determine the price of present and future actual cotton. It may be used by spinners or merchants, etc., to offset or " hedge " a sale of actual yarn or cotton on an order for future delivery, balanced by a purchase of futures instead of actual cotton, or a purchase of actual cotton balanced by a sale of futures, in order to hedge the possibility of a fall in value of the cotton bought.

DIMENSIONS OF COTTON BALES

Cotton.	Usual Dimensions of Bales.			Contents. Cubic Feet.	Weight of Bales. Lbs.	Density. Lbs. per Cubic Feet.	Remarks.
	Length.	Width.	Thickness.				
	In.	In.	In.				
AMERICAN— Ordinary or " square " bale	54 to 78	36 to 40	18 to 27	about 26	290 to 878 Usually about 500 lbs.	23 to 30	Thick, open woven jute bagging, easily torn, and not a complete covering for the bale. Generally 7 iron hoops.
EGYPTIAN	52	31	20	about 20	672 to 840 Usually about 750 lbs.	about 38	6 to 11 strong bands, well covered with close woven jute canvas.
EAST INDIAN or SURAT	48	22	18	9 or 10	346 to 531 Av. about 400	about 48	11 or 12 turns of strong hoop iron wrapped spirally. Well covered with close woven jute canvas.
BRAZILIAN— Pressed Unpressed (more usual)	49 34 to 66	22 30 to 33	18 15 to 16	10 ..	367 to 428 100 to 400 Av. 230	up to 45 ..	In bags, with wires, twine, or vegetable ties.
PERUVIAN	30 to 66	24 to 40	20 to 34	..	109 to 504 180 to 200 Usually av. 350	..	Do. Do.
SEA ISLANDS (American)	..	..	..	..	..	..	In bags, and not usually pressed.

TREATMENT OF COTTON PREVIOUS TO
CARDING

The ultimate object in the preparation of laps for the card is the production of a sufficiently clean sheet of cotton that is uniform in thickness, homogeneous, and free from stringiness and nep. It is fairly safe to say that the difficulties in producing a satisfactory lap to-day are much greater than those of twenty years ago, because of the greater variety of raw cotton, greater amount of dirt and leaf, and immature fibres: in some cases notably from the newer fields. Sledded cotton is particularly troublesome in these respects. In addition, there is a definite raising of the standard of cleanliness of cotton for subsequent treatment in the carding room, and a demand for less damage and a more perfect opening of the cotton to ensure improved functioning of the card. There is also a persistent demand for the diminution in the amount of dust in cotton mills generally.

Bale Breaker.—The bale breaker has for its object much more than a mere breaking up of the cotton. It is required to treat the cotton with a uniformly gentle combing action that will ensure a considerable amount of loosening and the removal of much heavy impurity. The construction of the bale breaker has been developed on the lines of a comber rather than that of a beater or breaker. Severe beating not only breaks the fibres but accentuates the tendency to rolling, knotting, and nepping at this stage. Some enterprising managers have coupled two or three breakers together, and have proved this to be a sound commercial proposition because the cotton is sent forward in a more open condition, thereby enhancing the value of stacking and mixings.

Mixing.—Mixing, as distinct from blending, is primarily intended to average out the variations in colour and character of staple that may exist in any bale or mark, quality or growth to be mixed. Two methods are adopted to accomplish this when mixing occurs before the material is passed through the opening machines. One method is to mix the cotton as efficiently as possible in the bale opener and to form it into a stack. The other method differs essentially only in the fact that the cotton from the bale opener is taken directly forward to the opening machines. It was formerly the practice to open the bales separately and form a horizontal layer in the bin, in this way building up a stack of the necessary size and composition. This method, providing that the cotton is taken in vertical section from the face of the stack, results in a fairly satisfactory mixing of the cotton. The use of a modern type of hopper bale opener, however, results in a much better mixing of the material,

by loosening the cotton thoroughly before it is deposited in the mixing stack. The conditioning of the cotton in the stack is expedited and more satisfactorily performed. There is no doubt that the stacking of cotton assists in maintaining uniformity in working conditions and yarn quality.

The practice of having open mixings incurs the expense of providing mixing stalls, overhead lattices or pneumatic apparatus for conveying the cotton from the bale breaker to the mixing stack, extra floor space, extra labour and maintenance charges. Moreover, it is necessary to have a large quantity of cotton on the floor in an exposed state liable to the risk of fire.

The quantity of cotton used in a mixing should always be as large as circumstances will permit, as in that way the advantages of mixing a number of bales together are more fully realised, and there is a better chance of having the work run uniform for a greater length of time.

Whether stacks are being formed or the material is to be passed directly into the opening machines, the arrangements of the bale breaker should be such that a large number of bales (12 to 20) can be conveniently and properly arranged round the feed lattice and fed into the machine in such a way that mixing of the various bales is performed satisfactorily. It is good practice to remove the bands from the bales at least some hours before the cotton is passed into the machine ; this is particularly desirable when stacks are not formed, as it provides an opportunity for the escape of moisture and allows the cotton freedom to regain some of its natural elasticity.

The practice of mixing in the stack was formerly the general rule in all branches of the trade, but during recent years many have discarded it on account of the cost. At present, stack mixing is still generally employed on the better qualities and in the fine spinning mills, and the direct mixing method by those on the medium qualities and on the coarser yarns. The required number of bales of each mark, etc., which is to constitute the mixing are arranged around the machine, within convenient reach of the attendant. The latter is instructed to take a layer from each bale in rotation, and in the prescribed order, and deposit same on the travelling feed lattice. In the hopper the several sorts are tossed about and mixed as well as opened out. The delivery lattice of the hopper bale breaker is arranged to deliver the cotton direct to the stack by means of conveyor lattices or trunks. If stacks are not being formed the cotton may pass forward to the hopper feeder which controls the delivery from the bale breaker, and then direct to the lattice of the small porcupine feeder to the exhaust opener. With this

arrangement the only manual labour required consists in carefully pulling the layers from the selected bales and placing them on the bale breaker lattice. No further handling of the cotton is required until the lap is removed from the opener lap end. Users of this system say that given a careful attendant who conscientiously follows his instructions as to the order of mixing or rota of bales, and who also exercises proper care not to take layers too thick or too thin, then thorough mixings are obtained. They claim that all the advantages of uniformity which result from stacking cotton can be obtained without the trouble, expense, and other incidental objections to the system.

It is the writer's opinion, however, that cotton is all the better for a " resting period." It may be that the aeration which takes place enables the fibres to recover their natural elasticity. The longer the cotton is allowed to lie in some open position the greater will be the opportunity for the cotton recovering its normal condition, after being subject to extreme pressure in the bale. The pneumatic delivery system of cotton is superior to the ordinary mixing lattice. Firstly, owing to flexibility, which allows the hopper breaker to be placed in almost any conceivable position relative to the mixing quarters. Secondly, it allows of the extraction of dust, dirt, and leaf, which means cleaner cotton and cleaner, healthier, and more contented workers. Thirdly, the cotton is more effectively opened, due to the passage through conveyor pipe being in contact with high velocity air current, and, further, by its passage through the delivery boxes. And, fourthly, the pneumatic system is cleaner, there being fewer bearings and parts likely to deposit grease on the cotton.

There are a number of methods by which the cotton may be conveyed from the mixing room to the lap-forming opener; for example, if the mixing room is above the blowing room, a sheet-metal trunk may be used to feed the hopper feeder which is coupled to the opener, or if the mixing room is below, then lattice conveyors may be employed to feed the hopper, or a supplementary hopper feeder may be placed in the mixing room, and by means of a pipe the cotton can be conveyed to a pneumatic conveyor which delivers the cotton to the hopper feeder. In this case the second hopper feeder not only regulates the supply of cotton for the opener by the well-known swing door and regulation motion, but by a system of balance levers and wire connections it automatically starts and stops the first hopper feeder; or an electrical control may be applied. In any system where cotton is conveyed by means of airing pipes it is advisable to consider the introduction of grided dust trunks to give additional cleaning at very little cost.

The foregoing notes presuppose that the cottons to form the mixing are suitable for being mixed together. Obviously, good results cannot attend the mixing of cottons which differ too greatly in length of staple, or in colour. Cottons of a harsh character are mixed with softer staple in order to obtain special effects not otherwise obtainable, but there is a practical limit to the amount of variation between two cottons which will successfully blend together. The general rules are not to mix together cottons which differ too greatly in (1) length of staple; (2) colour; and (3) feel; that is, in softness or harshness. By judicious blending of selected marks or qualities of raw staple, special characteristics can be imparted to the finished yarn, which cannot be obtained in any other way, and which make the yarn more acceptable to the user. The latter is usually willing to pay a little more for yarn which enables him to develop the requisite effect in the knitted or woven products.

Blending Cotton.—The individual characteristics of the various cottons employed must be correctly ascertained if success is to be achieved. The characteristics of the various constituents must be similar or complementary to each other if a satisfactory raw material is to be obtained. It is difficult to ascertain some of the less obvious features of cotton by ordinary means, and much still depends upon the accuracy of judgment of the person making the selection as to whether the best results occur. Regard must obviously be paid to differences in length of staple, variation in length, cleanliness, colour, and fibre strength and thickness in the blending of cotton, if satisfactory manipulation of the material at every process is to be obtained.

A satisfactory system of bale storage, which will facilitate the taking of stock and checking possible errors in the composition of the mixing, is very desirable.

Spraying of Cotton.—The spraying of the cotton by an oil emulsion has received attention recently. The usual procedure is that by an automatic arrangement a mixture of a suitable oil and water is deposited in the form of a fine mist or spray on the cotton in the Hopper bale opener as the machine is at work. The cost of the installation, which is very simple but adequate, and the working costs are very slight. Experience has shown that generally the material works better in its passage through the processes, as a result, if the apparatus is efficiently manipulated. The idea is not new in some branches of the textile trade, and experience in its application to raw cotton may prove it to be of value.

Exhaust Opener.—The use of air as a means of conveying cotton has been so thoroughly investigated during recent years that the

old name of exhaust opener is rapidly becoming a misnomer. How-
ever, it is still a very useful machine in many combinations
of machines. Usually the installation consists of a hopper feeder
coupled to a small porcupine cylinder opener, from whence the cotton
is conveyed through a pipe 8 or 9 in. diameter to the blowing room.
Either direct to a horizontal exhaust opener or, alternatively, through
one or two vertical openers, and even through dust trunks under the
influence of the induced draught of a fan.

Vertical Cylinder Opener.—Is usually included in so-called
exhaust opener installation. It is an extremely adaptable machine,
especially for medium and short staple cottons. It can also be applied
to great advantage in cleaning before being passed to the stack
mixing. A feature of the vertical opener is its extreme simplicity.
Once set carefully little or no skilled attendance is required.

Horizontal Cylinder and Opener.—With the probable exception
of the increasingly successful use of air in the treatment of cotton,
there is no part of the machinery employed that has been so thoroughly
investigated as the horizontal cylinder opener. Changes which have
taken place design to lead to increased cleaning power.

Hopper Feeder.—Is an invaluable machine for ensuring a con
stant and regular supply to the feed apron of the opener.

Beating or Scutching.—The action of the various opening
machines, as regards the severity of the treatment of the material
and their cleaning capacity, is generally known. The points to
which constant attention must be directed are the possibility of
damage to the cotton, the thorough mixing of the material, and the
production of a satisfactorily clean and level lap for the carding
process. Excessive beater speeds or faulty setting of beaters or bars
may result in the production of nep and stringy or over-scutched
cotton. The type of beater employed, the character of the bars,
and the time the cotton remains in the beater chamber must all be
considered in relation to the character of the fibre and the amount
of dirt present. Long or fine stapled cotton is more readily damaged
in opening machines than the shorter and coarser cotton, and the
treatment which may be quite satisfactory for the latter might have
very detrimental effects with the former.

A well-prepared lap is the first essential for satisfactory carding,
and continual attention is necessary to ensure that the finished scutcher
lap is as satisfactory as possible. The work of the scutcher should be
constantly checked to reveal any possible irregularities which may
arise. The character and distribution of the dirt bar droppings
afford reliable evidence as to the correctness or otherwise of the beater

speeds and bar settings, and the distribution and velocity of the air passing in between the beater bars. The beater blades should be kept in good condition so that they will effect satisfactory cleaning with the minimum of damage to the material. The distribution and velocity of the air along the cotton passages should be such that the cotton is properly distributed across the full width of the machine. The cotton passages should be kept clean so that no interference occurs to the free passage of the material. The air current passing through the cages should be adequate to draw the cotton forward in a definite manner whilst allowing the heavier remaining impurities to pass out through the leaf bar; by keeping the bottom cage more or less clear of cotton much dirt, which has just failed to fall out into the leaf box, will pass through the cage surface into the dust flues.

The cages, callender rollers, and lap rollers must be kept clean to preserve as smooth a surface as possible to the sheet of cotton. Equal and adequate pressure on both ends of the calender and slip rollers is necessary to the formation of a well-shaped and uniform lap.

The feed regulator arrangements in a scutcher may normally be relied upon to feed a uniform weight of cotton providing that the cone belt is set in the correct position, that it is kept in an efficient driving condition, and that excessive load in the belt is avoided. To ensure good results, however, it is necessary that the belt be at the position of equal cone diameters when normal thickness of sheet is passing under the feed roller, that the cone belt drives efficiently without being excessively tight, and that undue friction in feed roller and lattice rollers be avoided, and the lattice well mounted and in reasonable driving tension.

Scutcher laps should be frequently examined for irregularity of cleanliness and for evidence of damage to the cotton or inadequate opening. Irregularity in the weight of the lap may be checked by weighing all full laps, occasionally testing them for weight along the whole length, and for uniformity in density by unrolling before a window. The cleanliness and condition of the cotton in the sheet will indicate whether the lap is clean enough for the carding machine, and whether the cotton is being damaged or inadequately opened. The highest possible degree of uniformity in density and thickness of the card lap throughout its whole length and width is very desirable, and such parts as the feed lattice, the cone belt, regular motion, and the uniformity of the opener laps should be frequently examined to allow of this being obtained. Excessive beater speeds, dull beater blades, and faulty setting of beaters and bars may result in the production of nep and flocky cotton.

Scutcher Settings and Faults.—The weight of scutcher laps

vary as follows, according to the class of cotton, requirements of cards, and other factors :—

12's to 16's	-	-	-	- 16 oz. per yd.	
20's ,, 30's	-	-	-	- 15	,, ,,
30's ,, 40's	-	-	-	- 14	,, ,,
50's ,, 60's	-	-	-	- 13	,, ,,
60's ,, 80's	-	-	-	- 12	,, ,,
80's and upwards	-	-	-	11	,, ,, or slightly less.

The width of lap should be $\frac{1}{2}$ to 1 in. wider than card wire.

Setting of scutcher beater to pedal depends upon thickness of sheet of cotton and length and other features of the staple. Egyptian, $\frac{3}{16}$ to $\frac{4}{16}$; American, $\frac{4}{16}$ to $\frac{1}{4}$. Stripping rail just clear.

Setting of beater bars :

varying from $\frac{3}{4}$ in. clearance at start to $\frac{7}{8}$ in. at the end for American.

,,	,,	$\frac{1}{2}$	,,	,,	,,	1	,,	,,	Egyptian.
,,	,,	$\frac{1}{4}$	,,	,,	,,	$\frac{3}{4}$	,,	,,	East Indian.

Regularity of Laps.—All laps doffed should be weighed, and those varying more than 6 oz. from normal weight should be rejected and disposed of by (*a*) returning to feed lattice, or (*b*) feeding a light one with a heavy one to the cards in one set.

Laps should be tested occasionally for uniformity yard by yard, and for uniformity in thickness : in the former case, by unrolling them on the floor and measuring them off by a gauge in uniform short lengths and weighing them, and in the latter, by unrolling before a window so that variation in density or thickness can be observed. The first and last yard of a lap should be rejected in making this test. If laps are coming off adequately regular in weight, the feeding arrangements of the machine may be considered satisfactory. If the distribution of the cotton in the lap is unsatisfactory, the cause is likely to be in the cotton passages, in the cage arrangements, or a result of unsatisfactory air suction. The thorough and systematic testing of finished laps is important, as a lap may be correct in total weight and yet have very serious faults. If a test of a lap along its length reveals a tendency for it to become heavier as the bottom of the lap is approached, it is possible that stretching is occurring as the lap is being rolled up.

Faulty Laps.—Conical laps may be caused by dirty cages, air current stronger on one side of the machine than the other, air inlets in machine sides, under beater bars, unsatisfactory, faulty regulator action, unequal suction down side flues, escape of air round end of cage, unlevel cages, unequal pressure on ends of calender rollers or lap roller.

Uneven Laps.—Interference with air current, excessive friction

in regulator motion, cone belt too tight or too slack, too wide or too narrow, plucking from feed roller, feed lattice slipping, cone belt out of correct position when feed is of normal thickness, very uneven opener laps, heavy driving of feeding parts, badly constructed and dirty bars, cotton passages, and dust flues, insufficient and excessive fan speed.

Lap Licking.—Too much soft waste in mixing, mixing very soft and very harsh cottons, excessive dry or damp cotton, fan draft too strong, insufficient weight on calender rollers, excessive or insufficient pressure on lap roller, too much cotton drawn on bottom cage, dirty cages, or calender rollers.

Damaged Cotton.—Beater too close to feed, excessive beater speed, dirt bars too close to beater.

Dirty Laps.—Grid bars set too close together, excessive fan speed, insufficient beater speed, beater set too far away from feed, beater blade worn, excessive production.

Fatty or Rich Droppings.—Grid bars too widely spaced, air current too weak, excessive beater speed.

HANK ROVINGS AND DRAFTS FOR VARIOUS COUNTS

36's Mule Twist from American Cotton

	Counts.	Draft.
Card - - -	0·14 hank sliver	...
Drawing frame -	0·15 ,, ,,	6·0
Slubbing frame -	0·5 ,, ,,	3·4
Intermediate -	1·5 ,, ,,	5·0 double roving
Roving frame -	4·375 ,, ,,	5·8 ,, ,,
Mule - - -	36's counts	7·6 one end up

COTTON SPINNING MACHINERY PARTICULARS
Draft, Count, Twist, and Production

Hopper Bale Opener.—Floor space, 36-in. machine, 9 ft. × 5 ft. 6 in. Driving pulleys, 14 in. × 3 in. Speed, 300 revs. per min. Production, 2500 to 3000 lbs. per hour. Power, 1½ to 2 I.H.P. Mixing lattices require 1 H.P. for each 90 to 100 ft. of length.

Roving Waste Opener.—Floor space, 10 ft. 6 in. × 5 ft. 6 in. Driving pulley, 12 in. × 4¼ in. Cylinder speed, 650 to 850 revs. per min. Production, from 25 to 28 lbs. per hour of roving waste; and 50 to 90 lbs. per hour of card waste. Power, 3 I.H.P.

Automatic Hopper Feeder.—Floor space, 36-in. machine, 7 ft. 3 in. × 5 ft. Driving pulleys, 10 in. × 3 in. Speed, 300 revs. per min. Production, 700 to 750 lbs. per hour. Power, 1 I.H.P.

Porcupine Opener, or Creeper Feed Table.—Floor space, 9 ft. × 6 ft. Driving pulleys, 16 in. × 3½ in. Production, 800 to 850 lbs. per hour. Speed of beater, 800 to 1000 revs. per min. Power, 1½ to 2 I.H.P.

Openers.—Vertical or Crighton type without scutcher. Floor space: Single opener, 10 ft. 6 in. × 5 ft. 6 in.; double opener, 16 ft. × 5 ft. 6 in. Driving pulleys, 12 in. × 5 in. Speed of beaters, 1000 revs. per min. Production, 800 to 875 lbs. per hour. Power: Single opener, 4 I.H.P.; double opener, 8 I.H.P.

Vertical Opener Combined with Scutcher.—Production, 600 to 800 lbs. per hour, according to the weight of the laps being produced. Floor space, 21 ft. × 6 ft. 6 in. Power, 8 to 9 I.H.P.

Exhaust Opener and Scutcher.—Floor space, 17 ft. 10 in. × 7 ft. 5 in. for 45-in. laps. Production, 600 to 700 lbs. per hour. Power, 8 I.H.P.

Horizontal Opener.—Production, 180 to 450 lbs. per hour, according to the weight of the laps being produced. Floor space: Single opener with lap apparatus, 18 ft. 7 in. × 6 ft. 10 in. for 38-in. laps; single opener with scutcher, 25 ft. 10 in. × 6 ft. 10 in. Power: Single opener, 5 I.H.P.; combined with scutcher, 8 I.H.P.

Scutchers.—Floor space of scutcher with 1 fan and 1 beater and lap machine for 40-in. cards, about 14 ft. × 6 ft. 6 in. With 2 fans and 2 beaters and lap machine for 40-in. cards, about 20 ft. 6 in. × 6 ft. 6 in. Driving pulley, 10 in. × 4½ in. Speed of 2-bladed beater, from 1400 to 1500 revs. per min. Speed of 3-bladed beater, from 900 to 1100 revs. per min. Production, 150 to 300 lbs. per hour, according to the weight of the laps being produced. Power: Single beater, 4 I.H.P.; double beater, 7½ I.H.P.

To find diameter of pulley on beater shaft: Speed of beater × diameter of countershaft pulley for divisor. Revolutions of main driving shaft × diameter of driving drum on main shaft × drum on countershaft for dividend = pulley on beater shaft.

To find speed of fan when driven from beater: Speed of beater × diameter of pulley on beater shaft ÷ diameter of pulley on fan shaft.

To find the pulley on fan shaft: Speed of beater × diameter of pulley ÷ speed of fan.

To find the percentage of loss in cotton when passed through a scutcher: Loss in weight × 100 ÷ weight of cotton put up at feed end.

Carding Engine.—Floor space of card, 40 in. on wire, 10 ft. × 5 ft. 3 in. Driving pulley, 16 in. × 3 in. Speed of cylinder, 160 to 180 revs. per min.

Production
{
15 to 17 lbs. per hour for Indian and Chinese cotton.
14 to 16½ ,, ,, Low American cotton.
12 to 15 ,, ,, Good American cotton.
6 to 10 ,, ,, Egyptian cotton.
3 to 6 ,, ,, Sea Islands cotton.
}

Power, ¾ to 1 I.H.P., according to width on wire.

To find total draft: Lap roller wheel × feed roller wheel × side shaft bevel × doffer wheel × diameter of calender roller ÷ lap roller driving wheel × draft wheel × side shaft driving bevel × calender block wheel × diameter of lap roller.

To find draft between feed roller and doffer: Feed roller wheel × side shaft bevel × diameter of doffer ÷ draft wheel × side shaft driving bevel × diameter of feed roller.

To find length of fillet in feet to cover a cylinder: Diameter of cylinder × width of cylinder × 3·1416 ÷ width of fillet × 12 in.

To find production (calculated) in a given time: Working hours × 60 mins. × revs. per min. of doffer × doffer wheel × calender wheel driving coiler × circumference of coiler calenders × grains per yard of sliver delivered ÷ calender pinion × coiler cannon shaft wheel × 36 in. × 7000 grains.

Sliver Lap Machine.—Floor space, 8 ft. × 5 ft. Driving pulley, 16 in. × 2½ in. Speed of driving pulley, 250 to 300 revs. per min. Production, 40 to 50 lbs. per hour when producing light laps, and 60 to 80 lbs. per hour when producing the heavy laps for the Nasmith comber. Power, ½ I.H.P.

Ribbon Lap Machine.—Floor space, 14 ft. × 4 ft. Driving pulley, 16 in. × 3 in. Speed of driving pulley, 250 revs. per min. Production, 40 to 50 lbs. per hour when producing light laps, and 60

to 80 lbs. per hour when producing the heavy laps for the Nasmith comber. Power, 1 I.H.P.

Combers.—*Heilman.*—Floor space (8 heads 12-in. lap), 18 ft. × 3 ft. 6 in. Driving pulleys, 10 to 15 in. × 3 in. Speed, 300 to 360 revs. per min. to give 80 to 95 nips on single nip machines, and 230 revs. per min. to give 120 nips on double nip machines. Production: Single nip, 8 to 12 lbs. per hour ; double nip, 10 to 15 lbs. per hour. Power, about ¾ I.H.P. for 6 heads.

Nasmith.—Floor space (6 heads 10½-in. lap), 14 ft. × 3 ft. 6 in. Driving pulleys, 10 in.

Speeds
$$
\begin{cases}
335 \text{ revs. (86 nips) for Sea Island.}\\
350 \text{ ,, \quad (90 \text{ ,, }) \text{ ,, Florida.}}\\
370 \text{ ,, \quad (95 \text{ ,, }) \text{ ,, Egyptian and American.}}\\
390 \text{ ,, \quad (100 \text{ ,, }) \text{ ,, coarse work.}}
\end{cases}
$$

Production : A six-head machine at 100 nips per min. with 20 dwt. laps, allowing 15 per cent. for waste, will produce 16 lbs. per hour. Power, about ¾ I.H.P.

To find the production per machine per hour : Nips per min. × amount delivered per nip × 60 mins. × weight of lap per yd. in grains, *less* per cent. of waste × heads per machine ÷ 36 in. × 7000 (grns. per lb.).

Drawing Frames.—Floor space varies according to number of heads and deliveries to each head. Width, including cans if coilers on one side, 4 ft. 6 in. ; if cans zigzag, 5 ft. Driving pulley, 16 in. × 3 in. Speeds, 200 to 300, according to circumstances. Production, 8 to 18 lbs. per hour for finishing delivery. Power, 14 deliveries, 1 I.H.P.

To find the hank drawing : Draft in drawing frame × hank carding ÷ number of ends put up at the frame.

To find the draft, given hank drawing and hank carding : Number of ends put up × hank drawing ÷ hank carding.

To find the hank carding, given hank drawing and draft : Number of ends put up × hank drawing ÷ draft.

To find weight of drawing, given draft, number of ends put up, and weight of carding : Number of ends × weight of carding ÷ draft.

To find draft, given weight of drawing and carding : Number of ends put up × weight of carding ÷ weight of drawing.

To find change pinion when changing from one weight to another : Desired weight × change wheel at present on ÷ present weight of drawing.

To find change pinion when changing the hank : Present pinion × present hank ÷ hank wanted.

To find the draft in a drawing frame : Back roller wheel × crown wheel × diameter of front roller ÷ change pinion × front roller wheel × diameter of back roller.

To find the draft between first and second rollers : Wheel driven by front roller wheel × wheel on second roller × diameter of front roller ÷ diameter of second roller × wheel that drives second roller × front roller wheel.

To find change pinion for a required draft : Crown wheel × back roller wheel ÷ front roller wheel × draft.

To find the calculated production in lbs. per week : Revolutions of front roller per minute × 60 mins. × working hours × circumference of front roller ÷ 810 × 36 in. × hank of sliver.

Flyer Frames.—Floor space : Width of slubbing frame, including the cans, 4 ft. 6 in. ; intermediate and roving frames, 3 ft. Driving pulleys, 12 to 18 in. diameter × 3¾ or 4 in. wide, according to the length of the frame. Gearing occupies about 3 ft. Length, according to the number of spindles.

Power :	Slubbing	spindles	50	per H.P.
	Intermediate	,,	60	,,
	Roving	,,	70	,,
	Fine Jack	,,	80	,,

To find the length of a flyer frame : Number of spindles × gauge + gearing and off end, including pulley.

Driving pulleys, 14 to 18 in. × 3½ in. Speeds, 500 to 1000 revs. of spindle, according to machine and class of cotton. Power, 50 to 80 spindles per I.H.P.

To find the speed of the spindles : Speed of main shaft × diameter of pulley × shaft wheel on frame end × spindle shaft bevel wheel ÷ diameter of pulley on frame end × spindle shaft wheel × spindle foot wheel.

To find speed of front roller : Speed of main shaft × diameter of pulley × twist wheel × frame end cone shaft wheel ÷ pulley on frame end × cone shaft wheel × front roller wheel.

To find the turns per inch : Speed of spindles ÷ length delivered per minute.

To find the draft : Diameter of front roller × back roller wheel × crown wheel ÷ diameter of back roller × change wheel × front roller wheel.

To find the change wheel : Crown wheel × back roller wheel × diameter of front roller ÷ diameter of back roller × front roller wheel × desired draft.

To find the constant number for the draft : Diameter of front roller × back roller wheel × crown wheel ÷ diameter of back roller × front roller wheel = constant number.

To find the hank slubbing : The constant dividend for a given length ÷ the weight in grains of that given length = hank slubbing.

To find the change wheel when changing the hank : Hank being made × change wheel on ÷ hank wanted.

To find the rack wheel when changing the hank : The square of the rack wheel on × hank required ÷ hank being made ; extract square root of quotient.

To find the production in hanks : Speed of spindles per minute × 60 mins. × working hours ÷ turns per inch × 36 in. × 840 yds.

Ring Spinning Frame.—Floor space : Width, 2 ft. 9 in. or 3 ft. Gearing, 2 ft. 8 in. Length, according to the number of spindles and gauge.

To find the length of a ring frame : Number of spindles on one side × gauge + space taken up by gearing and off end, including pulleys.

Driving pulley, 12 to 15 in. diameter × 3¾ to 4¼ in. wide, according to the length of the frame. Pulley speed from 750 to 900 revs. per min. Production varies according to counts. Power : 75 to 80 spindles, twist gauge, 6-in. lift ; and 85 to 90 spindles, weft gauge, per 1 I.H.P.

To find the turns per inch : Front roller wheel × twist carrier wheel × diameter of tin roller ÷ tin roller wheel × twist wheel × diameter of wharve × circumference of front roller.

To find the constant number for the twist : Diameter of tin roller × twist carrier wheel × front roller wheel ÷ tin roller wheel × circumference of front roller × diameter of wharve.

To find the twist change pinion : Constant number ÷ turns per inch.

To find the draft : Counts ÷ hank roving.

To find the hank roving : Counts ÷ draft.

To find the production in lbs. : Circumference of front roller × revs. per minute × 60 mins. × hours worked ÷ 36 × 840 × counts.

Ring Doubling Frame.—Width : 3 ft. or 3 ft. 6 in. Gearing, 2 ft. 6 in. The length is found in similar manner to ring spinning frames. Driving pulleys, 12 to 15 in. diameter × 4 in. wide. The speed of the driving pulleys varies considerably according to the spindle speed required, and on account of the difference in the diameter of the tin roller and spindle wharves. Power : spindles per 1 H.P. on counts when doubled.

SPEEDS OF OPENERS AND SCUTCHERS

		Sea Island.	Egyptian.	American.
		Revolutions per Minute.		
Buckley opener - -	Large cylinder	300 to 350	..	..
Combined Buckley opener	Large cylinder Beater, 2-bladed	.. ..	350 to 400 900 to 1000	450 to 500 1200 to 1500
Crighton opener -	Vertical shaft	..	500 to 800	800 to 1000
Combined Crighton opener	Vertical shaft Beater { 2-bladed { 3-bladed	.. .. ..	.. .. ..	1000 1500* 1000*
Beater scutcher - -	Beater { 2-bladed { 3-bladed	800 to 1000 ..	900 to 1200 ..	1200 to 1500 900 to 1000

*Three-bladed beaters are recommended for machines exceeding 42 in. in width.

REVOLVING FLAT CARD
Revolutions of Main Cylinder per 1 in. of Feed

Sta-ple.	Revs. for High Production.				Revs. for Ordinary Good Carding.				Revs. for Best Quality Carding.
In.	Ind.	Amer.	Egp.	S. I.	Ind.	Amer.	Egp.	S. I.	
⅜	11	...	...	...	12	...	...	...	
⁷⁄₁₆	12	...	...	...	13	...	...	...	
½	13	14	...	...	14	15	...	...	
⁹⁄₁₆	14	15	...	...	15	16	...	...	
⅝	...	16	...	...	16	17	...	...	
1	...	17	18	...	17	18	19	.	10 to 20 %
1⅛	...	18	19	...	...	19	20	...	more revolu-
1¼	...	...	20	23	...	20	21	25	tions per inch
1⅜	...	...	...	24	...	...	22	26	of lap fed.
1½	...	...	...	25	...	...	...	28	
1⅝	...	...	...	...	...	...	...	30	
1¾	...	...	...	...	...	...	...	32	
1⅞	...	...	...	...	...	...	...	34	
2	...	...	...	...	...	...	...	36	

NOTES ON CARDING

Good carding is essential to the production of good yarn. If this process is not satisfactorily carried out, it is impossible to manipulate the fibres properly in subsequent processes, and a cloudy and perhaps a dirty yarn will eventually be produced. Correct alignment of all the working surfaces of the machine with which the cotton comes in contact, and correct clearance of the wire and adjacent surfaces are obviously necessary. The speeds of the various parts should be correctly related to individual conditions and stripping carried out at regular working intervals. Perhaps the most vital factor in efficient carding is the condition of the wire. To maintain this in an efficient state frequent grinding and frequent recovering of the emery grinding rollers is necessary. The satisfactory organisation of routine work in carding machines, such as stripping, grinding, and recovering of grinding rollers, is of vital importance.

Any irregularity in the thickness of the lap or want of alignment of the various surfaces will reduce the general efficiency of the carding process and tend to increase waste losses. The settings should be related to the weight of cotton passing through and to the length and thickness and character of the fibre. All other conditions being equal, a small barrow wheel means more efficient carding, hence the machines should be fully employed, only absolutely necessary stoppages being allowed. The feed roller of a carding machine should hold firmly a thin strip of paper at every point across its width ; if not, plucking of the cotton by the licker-in may occur. The licker-in speed and the distance it is set from the feed plate should vary according to the length and character of the staple, the thickness of the lap, the rate of feed, and the cleanliness or otherwise of the lap. With long, fine staple and a clean light lap, the speed should be low and the setting close. With short, coarse stapled cottons and dirty laps with a high rate of feed the speed should be high. The function of the licker-in is important : it should remove all but the very smallest and lightest impurities, separate out the overhanging fringe of cotton, and remove the fibres in detail for presentation to the cylinder wire. Its function in eliminating impurity is materially effected by the setting of the mote bars, and the character and setting of the under-casing. For short cottons few spaces should be provided in the under-casing, whilst on long cottons an almost continuous bar casing is best. More dirt will be removed if the mote knives are set fairly close, and more fly and dust will escape if the undercasing is set further away.

Adjustments on Card.—The setting of the back plate and flats

must be closer on long and fine cotton if the carding is light, so that the cotton is carried forward to the cylinder under good conditions, and the flats can effectively separate out the fibres, with the minimum of waste, and remove the fine foreign matter and neps. The speed of the flats will be determined by the general conditions as to cotton character, output, and cleanliness of carded sliver required. The front plate should be set so that it permits a very slight connecting strip to come away with the flat strip. The doffer should be set as close to the cylinder as the weight of web will admit, so that it will doff effectively and efficiently.

Faults in Carding.—*Too Fatty Licker-in Droppings.*—Mote knives set too far away from the licker-in and too far apart from each other; excessive licker-in speed.

Too much Fly under Licker-in and Cylinder.—Excessive licker-in speed; licker-in casing set too far away; cylinder under casing set too far away.

Excessively Heavy Flat Strips.—Back plate too far from cylinder; flats too close; flat speed too low; front plate allowing too heavy a connecting strip to form.

Irregular Strip.—Want of alignment of flats or back plate; worn flat chevins, wheels, or ends.

Cloudy Web.—Dirty casing; dirty, dull, or damaged wire; accumulations of fly in casings.

Card sliver wrappings may vary considerably, due to the fact that the scutcher lap, although regular yard by yard, is irregular in much shorter lengths. The high draft at the card may reveal or accentuate this fault, and it is no uncommon thing for carded slivers to wrap 2 to 4 grans per yard up or down from standard weight per yard. In addition to this, the sliver is much lighter after stripping of the cylinder or doffer than immediately before, as these are taking out material at a much higher rate at this time. Flats on cards on the same preparation should be uniform in speed, and remove a uniform percentage of waste. Speeds and settings throughout should be the same on each card on similar qualities and counts. The waste percentage loss should be checked on each machine occasionally, and the character of the waste and fly produced at each point carefully examined. All casings should be thoroughly cleaned at regular intervals, and any bent bars or damaged casings repaired. Licker-in teeth should be kept sharp and otherwise in good condition. Care should be taken that the foundation of the cylinder and doffer wire is not damaged by stripping or burnishing. Flats should be recovered at regular intervals, and if the ends are worn, they should be recut. Card settings must receive methodical and regular attention so

CARD CLOTHING AND SETTING

Carding—Card Clothing.—The several kinds of wire filleting, known as card clothing, is constructed by the leading makers to give standard numbers of crowns per inch, as required by the users. The all-important consideration to the cotton spinner is the number of wire points per square inch the fillet contains, assuming the material itself to be sufficiently good for its intended purpose. As far as the count goes the spinner is directly concerned with carding points, and therefore it is good practice to count the wire points occasionally, by aid of an inch glass, to make sure that the fillet supplied is equal to sample and the counts ordered.   As a considerable amount of misconception prevails concerning the method of "counting cards," it might be useful to state the following rules :—

Each crown represents two wire points, and the clothing is counted on the basis of 10 crowns in each inch width of fillet, and the number of crowns in 4 in. of length.   Thus a fillet with 10 crowns per inch of width and 90 in 4 in. of length will be 90's counts, and will have $90 \times 10 = 900$ crowns in 1×4 in.

When cards are clothed with fillet finer than 100's it is usual to make them with a narrower crown so as to get the points more evenly distributed, and to prevent overcrowding the fillet lengthways. Cards from 110's to 130's usually have 12 crowns in 1 in. of width, and finer cards have a still narrower crown to permit uniform distribution of the wire points.   But even when filleting is made with 12 or other number of crowns per inch, it is counted on the basis given above.   For example, 110's counts with 12 crowns per inch of width will have $110 \times 10 = 1100$ crowns in 1×4 in., i.e., 12 crowns per inch of width and 92 crowns in the standard length of 4 in.   A convenient way of translating the counts of clothing to points per square inch is as follows :—

Counts $\times 5 =$ points of wire per square inch.
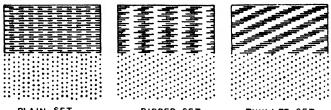
,, $\times 2\cdot5 =$ crowns   ,,   ,,

The table given below gives particulars of the chief counts :—

Counts - - - -	70	80	90	100	110	120	130	140
Crowns per square inch -	175	200	225	250	275	300	325	350
Points ,, ,, -	350	400	450	500	550	600	650	700

There are three distinct methods of setting the wires in the clothing, viz., plain, ribbed, and twill. Illustrations of these three methods are

given herewith : the diagrams show back views of the crowns and also plan views of the density and positions of the wire points. In each case the counts of the fillet is 80's.

PLAIN SET   RIBBED SET   TWILLED SET

The counts of fillet varies according to the class of cotton and the organ on which it is used. The following table is representative of standard practice :—

Class of Cotton.		Cylinder.	Doffer.	Flats.
American	{low - -	100	110	100
	{good - -	110	120	110
Egyptian	{ ordinary -	100	120	120
	{ super. -	120	130	120
Indian	{ low - -	80	90	90
	{ good - -	90	100	100
Brazilian -	- -	90	100	100
Sea Island	- -	130	140	130

Card Setting.—For ordinary work the settings may be as follows :—

Cylinder to doffer -	-	-	7's gauge = $1\frac{1}{3}$ in.
Flats to cylinder (front)	-	-	7's ,, = $1\frac{1}{5}$,,
,, ,, (back)	-	-	10's ,, = $1\frac{1}{50}$,,
Licker-in to cylinder	-	-	10's ,, = $1\frac{1}{50}$,,

For Egyptian cotton the following settings are recommended :—

Cylinder to doffer -	-	-	5's gauge = $2\frac{1}{40}$ in.
Taker-in to cylinder	-	-	7's ,, = $1\frac{1}{3}$,,
Flats to cylinder -	-	-	10's ,, = $1\frac{1}{50}$,,
Doffing comb to doffer	-	-	12's ,, = $\frac{1}{48}$,,
Dish feedplate to taker-in	-	-	10's ,, = $1\frac{1}{50}$,,
Front stripping plate to cylinder -	22's ,, = $\frac{1}{16}$,,

The settings will, however, vary according to the conditions, such as speed of flats, weight being put through, waste desired, etc,

NASMITH COMBER

Length fed by feed roller in inches per nip

$$= \frac{\text{teeth of feed ratchet per nip} \times \frac{3}{4} \times 3 \cdot 14}{47},$$

or, approximately $\quad = \dfrac{\text{teeth of feed ratchet per nip}}{20}$.

Teeth required to be taken by feed ratchet for each nip
$\quad =$ inches required to be fed per nip by feed roller $\times$ 20.

Teeth requir ed to be taken by lap ratchet for each nip
$\quad =$ teeth of feed ratchet per nip.

Lap roller feed per nip in inches

$$= \frac{\text{lap ratchet teeth per nip}}{75} \times \frac{\text{lap draft change}}{80} \times \frac{35 \times 2\frac{3}{4} \times 3 \cdot 14}{47},$$

or, approximately $\quad = \dfrac{\text{lap ratchet teeth per nip} \times \text{lap draft change}}{932}$.

Lap draft $= \dfrac{\text{inches fed by feed roller for each nip}}{\text{inches fed by lap roller for each nip}} = \dfrac{46 \cdot 6}{\text{lap draft change}}$.

If lap draft change $= 42$ (as usual), then lap draft $= 1 \cdot 11$.

If lap draft change $= 41$, then lap draft $= 1 \cdot 14$.

Total draft $=$

$$\frac{47 \times 80 \times 75 \times \text{cross shaft change} \times 88 \times 2\frac{1}{10}}{35 \times \text{lap draft change} \times \text{teeth of lap ratchet per nip} \times \text{draft wheel} \times 63 \times 2\frac{3}{4}}$$

or $8440 \times \dfrac{\text{cross shaft change}}{\text{lap draft change} \times \text{teeth of lap ratchet per nip} \times \text{draft wheel}}$.

Draft wheel

$$= 8440 \times \frac{\text{cross shaft change}}{\text{lap draft change} \times \text{teeth of lap ratchet per nip} \times \text{total draft}}.$$

If lap draft change $= 42$ (as usual), then draft wheel

$$= 201 \times \frac{\text{cross shaft change}}{\text{teeth of lap ratchet per nip} \times \text{total draft}}.$$

If lap draft change $= 41$, then draft wheel

$$= 206 \times \frac{\text{cross shaft change}}{\text{teeth of lap ratchet per nip} \times \text{total draft}}.$$

Cross shaft change may be chosen with any convenient number of teeth to give a suitable lap draft change.

We therefore get the following multipliers for different numbers of teeth fed and different cross shaft changes :—

Lap draft change	42	42	42	42	42	42
Lap ratchet teeth per nip	4	4	4	5	5	5
Cross shaft change	60	66	77	60	66	77
Draft wheel =	$\dfrac{3015}{\text{total draft}}$	$\dfrac{3318}{\text{total draft}}$	$\dfrac{3870}{\text{total draft}}$	$\dfrac{2412}{\text{total draft}}$	$\dfrac{2652}{\text{total draft}}$	$\dfrac{3095}{\text{total draft}}$

Total draft

$$= \frac{840 \times \begin{array}{c}\text{counts}\\\text{of sliver}\end{array} \times \begin{array}{c}\text{grains of lap}\\\text{per yard}\end{array} - \begin{array}{c}\text{percentage}\\\text{of waste}\end{array} \times \begin{array}{c}\text{number of}\\\text{laps up}\end{array}}{7000}.$$

Draft between drawing head and coiler

$$= \frac{88 \times 2\frac{1}{16} \text{ in. (diameter of calendar in coiler)}}{63 \times 2\frac{3}{4} \text{ in. (calendar in drawing head)}} = 1 \cdot 05.$$

Draft between front roller in drawing head and drawing head calendar $= \dfrac{40 \times 2\frac{3}{4} \text{ in.}}{88 \times 1\frac{1}{4} \text{ in.}} = 1.$

Table draft change must keep the sliver on the table tight without tension. The top calendar being fluted, lighter sliver requires a larger wheel.

Guide tin change must keep fleece in tins tight without tension when the index is at 8.

Draft in draw box $= \dfrac{42 \times \text{cross shaft change} \times 88}{\text{guide tin change} \times \text{draft wheel} \times 40}.$

Theoretical production in ten hours per head

$$= \frac{\begin{array}{c}\text{nips}\\\text{per}\\\text{min.}\end{array} \times \begin{array}{c}\text{lap}\\\text{ratchet}\\\text{teeth}\\\text{per nip}\end{array} \times \begin{array}{c}\text{lap}\\\text{draft}\\\text{change}\end{array} \times 35 \times 2\frac{3}{4}\text{in.} \times 3\cdot14 \times 600 \times \begin{array}{c}\text{grains}\\\text{of lap}\\\text{per yd.}\end{array} - \begin{array}{c}\text{per-}\\\text{centage}\\\text{of waste}\end{array}}{75 \times 80 \times 47 \times 36 \times 7000}$$

or the same result from other data :—

Theoretical production in ten hours per head

$$= \frac{\begin{array}{c}\text{nips}\\\text{per}\\\text{min.}\end{array} \times \begin{array}{c}\text{inches fed}\\\text{by feed roller}\\\text{for each nip}\end{array} \times \begin{array}{c}\text{lap}\\\text{draft}\\\text{change}\end{array} \times \begin{array}{c}\text{grains}\\\text{of lap}\\\text{per yd.}\end{array} - \begin{array}{c}\text{percentage}\\\text{of waste}\end{array}}{19600}$$

NOTES ON THE DRAWING PROCESS

The production of a satisfactory drawn sliver is necessary in the production of a satisfactory yarn. The number of slivers doubled, *i.e.*, six to eight at the several heads of drawing, will, if other conditions are satisfactory, ensure the delivery of a sliver of uniform weight. The setting and alignment of the drawing rollers, the condition of the roller surfaces, and attention to the cleaning, lubrication, etc., of the rollers are points of vital importance. Roller clearers of a good type and kept in an efficient state are necessary if the formation of slubs is to be avoided. Stop motions should operate efficiently so that single is prevented and operatives enabled to make satisfactory piecings. The speed of the coiler plate and can-dish should be regulated to the weight and character of the sliver, and the cans kept in good condition, so that the sliver can be laid straight in the can and withdrawn without damage.

The objects of the draw frame process are to lay the fibres parallel along the length of the sliver and to form a sliver of uniform weight and thickness along its whole length. The first-named object is obtained by the drafting action of the rollers, and the second by the repeated folding of a number of slivers together into one.

The parallelising action must be performed under such conditions of roller setting, speeds, etc., and repeated a sufficient number of times to fully achieve the object sought. The conditions of roller setting, relative roller surface speeds and actual delivery speed, and the number of times the operation is repeated will be determined by the features of the cotton, and to some extent by whether the cotton has been combed or otherwise. A harsh strong cotton will usually require more and somewhat different treatment to obtain satisfactory results than a soft weak cotton, and, generally, a combed sliver requires less treatment than a carded one, as the combing process delivers the fibres in a much more approximately parallel condition than the carding machine. In addition, the severe drawing and combing action to which the cotton is subjected in combing processes renders it not only undesirable but unnecessary to treat combed material in drawing machines to any drawing action beyond that necessary to obtain uniformity in weight.

Uniformity in weight and thickness is obtained by the repeated folding of a number of slivers (commonly six) into one, and by this means averaging out individual sliver variation. Although in combed slivers the fibres are more or less parallel when they pass to the drawing frame, they may have, due to the overlap piecing formed in the comber, a type of irregularity in thickness which is:

absent in carded slivers, and to eliminate this satisfactorily more folding may be necessary than would otherwise be the case. It is, however, necessary to remember that any unnecessary drawing action is generally detrimental to the satisfactory manipulation of the material in subsequent operations.

Combed slivers are much weaker than carded slivers as a result of the action of the combing process, hence for such slivers spring bottom cans should always be employed to reduce the strain to which they are subjected in being drawn from, and deposited into, the cans. The employment of an assisting roller at the back of the machine is also useful in this respect, besides assisting in the efficient working of the single preventer motion at the back of the machine.

The single preventer motion on the drawing frame must be kept in an efficient state so as to stop the machine promptly, or otherwise bad piecings or single will be formed. The traverse guides should keep the slivers satisfactorily and uniformly spaced, so that the material will spread evenly and form a web of uniform thickness as it is delivered at the front. The condition, weighting, and setting of the drawing rollers are matters of prime importance in the efficient working of the machines. The alignment of the drawing rollers must be true, or bad drawing is inevitable. The weight on the rollers must be adequate, and care should be taken that no interference with the action of the weight occurs. All front roller weight hooks should be provided with damping springs to prevent vibration of the weights, and the roller surfaces must be kept clean and in good condition.

The diameter of the drawing rollers should be as large as is consistent with adequately close setting, as a larger roller will not only draft more efficiently, but will run more steadily and remain in an efficient condition for a longer period than a smaller one. It is necessary, however, to realise that satisfactory setting to suit staple length is the most important consideration, and roller diameter should be such as to allow this.

The output from the various heads of drawing with equal conditions as to draft, etc., will be least in the first head and greatest in the last head on account of the varying amount of time lost through breakages. To obtain a balanced output from each head, and more efficient drawing, the draft in the first head should be about 10 per cent. below, and in the last head about 10 per cent. above the normal draft.

The clearers in the drawing frame should be kept clean, or a great many slubs will pass forward with the material. The stationary type of clearer requires very frequent picking if faulty sliver is to be avoided, whereas the travelling cloth type of top roller clearer

and the oscillating under clearer almost entirely eliminate the possibility of the formation of slubs and require little attention.

The coiling arrangements should be such that the sliver is not unnecessarily disturbed as it is coiled into and withdrawn from the can, which should be kept in good condition. Light fibre cans are to be recommended, as their use appreciably reduces the amount of labour involved in moving the cans from machine to machine.

Common faults in the drawing process :—

Single.—Long lengths of single occurs chiefly as a result of the single preventer motion not operating properly.

Thin and Thick Places.—Thick places in the sliver may be caused by bad piecings at the back of the machine, and thin places by sluggish action of the single preventer motion at the back, allowing the broken sliver to pass between the rollers or by roller laps.

Uneven Web.—This will occur if the rollers are not kept in an efficient working condition, if they are out of line, or set too close or too open, or if the weighting of the rollers is unsatisfactory.

Bad Coiling.—The sliver may be seriously damaged in coiling if the coiler speed is too high, or if the cams are not kept in good condition, or the canplate is incorrectly set.

Draw frame slivers should be tested at least daily, and care should be taken that the material selected for the test should not be damaged in any way, or erroneous results may be obtained. The variation from standard weight should only be small—though it will vary somewhat according to weight and quality—as it is most important that a high degree of uniformity in the drawn sliver shall be maintained. If this is done, little or no change of draft wheels is required subsequently, except at the spinning machine.

Production per finishing delivery in the draw frame per hour can be obtained as follows :—

$$\frac{\text{Front roller diam. in inches} \times \frac{3\frac{1}{7} \times \text{revs. per min.}}{} \times \frac{\text{mins. per hour}}{}}{\text{Inches per yard} \times \text{yards per hank} \times \text{count or hank.}} - \frac{\text{percentage for stoppage.}}{}$$

i.e., $\dfrac{1\frac{1}{4} \times 3\frac{1}{7} \times 360 \times 60}{36 \times 840 \times \cdot 16} = 17 \cdot 5 - 10 \text{ per cent.} = 15 \cdot 75 \text{ lbs. per hour.}$

In arranging draft in the drawing frames, the draft in the first head should be at least 5 per cent. less than the average, and in the third head at least 5 per cent. in excess of the average to obtain balanced output from each machine in the set. In addition, this will improve the quality of the drawing.

The percentage time lost in drawing frames will increase as the number of deliveries per machine increases.

DRAWING.—*Weighting of Rollers.*—For Indian and American cottons, 20 lbs. on each line of rollers is usual; for Egyptian, front lines, 18 lbs.; back lines, 20 lbs. each; for Sea Islands, 16 lbs. on each line is recommended.

DIAMETER OF DRAWING ROLLERS

Line.	Indian.		Low American.		Middling American.		Egyptian and Sea Island.	
	Top.	Bottom.	Top.	Bottom.	Top.	Bottom.	Top.	Bottom.
1st	$\frac{7}{8}$ in.	$1\frac{1}{8}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{8}$ in.	$1\frac{3}{8}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.
2nd	,,	1 ,,	,,	$1\frac{1}{8}$,,	,,	$1\frac{1}{8}$,,	,,	$1\frac{1}{4}$,,
3rd	,,	$1\frac{1}{8}$,,	,,	$1\frac{1}{4}$,,	,,	$1\frac{3}{8}$,,	,,	$1\frac{1}{2}$,,
4th	,,	$1\frac{1}{8}$,,	,,	$1\frac{1}{4}$,,	,,	$1\frac{3}{8}$,,	,,	$1\frac{1}{2}$,,

The number of drawings varies from 2 to 4 according to the class of cotton and the quality and counts of yarn to be produced. The following is representative of average practice:—

Counts below 16's	-	-	2 drawing processes.
Ordinary American yarns	-	3	,, ,,
Medium Egyptian yarns	-	3	,, ,,
Combed Egyptian yarns	-	3	,, ,,
Combed Sea Island yarns	-	3	,, ,,
Super-carded Egyptian yarns	-	4	,, ,,

SPEEDS AND PRODUCTIONS

Cotton.	Diameter of Front Roller in Inches.	Revs. of Front Roller per Minute.	Hank Drawing.	Lbs. per Delivery in 10 Hours.	Eight Deliveries. Lbs. of Sliver.
Good Egyptian	$1\frac{1}{2}$	275	0·19	112	900
American -	$1\frac{1}{4}$	350	0·15	150	1200
Indian - -	$1\frac{1}{8}$	400	0·13	165	1320

WEIGHT OF SLIVER

Decimal Hank.	Weight of 5 Yds. in Grains.	Weight of 1 Yd. in Grains.	Decimal Hank.	Weight of 5 Yds. in Grains.	Weight of 1 Yd. in Grains.
0·100	415·0	83·0	0·145	287·3	57·47
0·100	397·6	79·5	0·150	277·7	55·55
0·110	378·0	75·6	0·155	268·8	53·76
0·115	362·3	72·5	0·160	260·4	52·08
0·120	347·2	69·44	0·170	245·0	49·01
0·125	333·3	66·66	0·180	231·4	46·29
0·130	320·5	64·10	0·200	207·5	41·50
0·135	308·6	61·77	0·220	189·5	37·90
0·140	297·6	59·52	0·250	166·0	33·20

NOTES ON FLYER FRAMES

In the flyer frames the condition of the rollers, the setting and weighting of the rollers, the efficiency of the clearers, the best distribution of the drafts throughout the set of machines, the amount of twist, and the winding conditions are all very important points. The setting and weighting of the rollers will be chiefly determined by the length and general character of the staple, the hank and the amount of twist in the material, and the best settings can only be determined when individual conditions are known. Clearers of the flat board type require frequent attention if the passage of waste with the material is to be avoided. The distribution of the drafts throughout the series of machines will vary widely according to conditions, but an approximation to the ratio of four, five, and six in succeeding machines is a good basis to work from in medium counts of yarn of carded American quality. On Egyptian qualities the drafts may be higher, and on East Indian qualities lower, but the ratio might be approximately maintained. The winding on conditions on the flyer frames are of the greatest importance, as tight winding at any point in the building of the bobbins will cause stretched roving and irregular yarn. Satisfactory methods of creeling, cleaning, oiling, doffing, and renewal of rollers are necessary if good results are to be obtained.

The objects of the flyer frame processes are to gradually attenuate the strand of cotton fibres produced on the drawing frames, by means of a set of drafting rollers in each machine in the series, so as to produce uniform and satisfactory hank roving of sufficient strength, and wound in a suitable form for the spinning machines.

The number of machines employed is determined by the amount of attenuation required to produce a roving of the required fineness for the count of yarn to be spun. For very coarse yarns it is usual to employ two machines—slubber and roving; for medium yarns, three—slubber, intermediate, and roving; and for very fine yarns, four—slubber, intermediate, roving, and fine jack frame. In order to reduce the irregularity already existing, and to neutralise any irregularity which may be produced, it is usual to double two ends into one in all the machines except the first one, in which machine, owing to the thickness of the sliver and the difficulties arising from the housing of the cans at the back of the machine, doubling is impracticable.

The remarks made in connection with the drawing process regarding the condition of the drawing rollers apply to these machines. The setting between the front and middle lines of rollers should be such that the best results in drawing are obtained. The total roller drafts in each machine should be arranged in progressive order, the amount of draft increasing in each successive machine by about 20 per cent., as, in general, it is found that a higher draft can be efficiently exercised as the weight of the material dealt with decreases.

In the working of these machines careful attention must be paid to every point which affects the uniformity of the material produced. To obtain this end where doubling occurs and bobbins are mounted in a creel in the usual way, half and full bobbins, and the top row bobbins and middle and bottom row bobbins should be paired, this assists in averaging out any irregularity which may occur in winding on and off the bobbins. The winding-on conditions on a flyer frame, if not carefully adjusted, may result in stretched material. The winding-on tension and general conditions will be governed by the manner in which the material is threaded through the flyer, the size of the star and lifter wheel, and by the starting position of the cone belt and initial winding-on tension. It is necessary that the threading of the material through the flyer shall be similar on every spindle in each machine, and that all factors governing winding conditions shall be similar on all machines dealing with material which is similar in character and weight.

The amount of twist put into the material should be adequate for good winding on, for satisfactory unwinding, and for efficient drafting in the next machine. Any excess of twist in excess of that necessary for satisfactory winding on and off is undesirable, as it not only reduces output but necessitates the production of a coarser material to get the weight through, and necessitates wider roller setting and higher draft in the subsequent drafting operations.

DEFECTIVE BOBBINS.—*Unequal Cones.*—Faulty setting of builder cradle and jack screws.

Ridgy Bobbins.—Bobbin rail badly balanced, binding of lifter.

Slattered Ends.—Backlash in gear wheels, worn parts in change motion, change motion binding, badly geared bobbin and spindle wheels.

Soft Bobbins.—Faulty threading of flyer, damaged or bent flyers.

DEFECTIVE MATERIAL.—*Unevenness.*—Faulty setting of rollers, badly worn rollers, roller weights not acting properly.

Stretched Rovings.—Faulty threading of flyer, winding speed too high.

Slubs and Thick Places.—Thick piecings and hard piecings at the back of rollers, dirty roller clearers, waste forming in flyer leg, careless wiping down of flyers and roller beam.

Single and Double.—Breakages at the back and front of the rollers, the variation in thickness of the yarn stage, and the length of the faulty portion produced, will be governed by the point at which the fault occurs.

The material from these machines should be regularly and systematically tested to detect any irregularity in weight. The test should be made from full and nearly empty bobbins. The bobbins from the roving frame should be tested every week, intermediates every three days, and slubbers every two days. Occasionally bobbins from each machine should be tested at intervals, along the whole length, as a check on irregularity in winding tension, which the usual method of testing may not disclose.

The Production of Flyer Frames.—The output may be obtained by calculation when (1) particulars of F.R. speed and diameter and hank are known, and (2) when spindle speed, hank, and twist constant are available.

(1) F.R. speed, 180 revs. per min.; diam., $1\frac{1}{16}$ in.; hank, ·8.

i.e.,
$$\frac{180 \times 19 \times 22 \times 60 \text{ mins. per hour}}{16 \times 7 \times 36 \times 840 \times \cdot 8} = 1 \cdot 665 \text{ per hour.}$$

(Delivery speed of F.R. per min.)

Allowing 30 per cent. lost time, $1 \cdot 665 - 30$ per cent. $= 1 \cdot 163$ lbs. per spindle per hour.

(2) Spindle speed, 1,100 revs. per min.; hank, 6·25; twist constant, 1·1.

$$\frac{1100 \times 60}{(\sqrt{6 \cdot 25 \times 1 \cdot 1}) \times 36 \times 840 \times 6 \cdot 25} = \cdot 1269.$$

·1269 less 6 per cent. for lost time $= \cdot 1183$ lbs. per hour per spindle.

Flyer Frames.—The number of turns per inch for material treated on these frames is obtained by multiplying the square root of the counts by a factor which varies according to the class of cotton. Different factors or twist constants are given by different authorities as shown by the following table :—

Table of Twist Constants for Flyer Frames

Cotton.	Slub.	Int.	Rov.	Jack	Slub.	Int.	Rov.	Slub.	Int.	Rov.	Jack
Sea Island -	0·7	0·78	1·1	0·9	..	..	..	..	..	..	..
Egyptian -	0·9	0·95	1·15	0·95	0·8	0·9	1·0	0·64	0·76	..	0·95
American -	1·15	1·15	1·22	1·05	1·0	1·1	1·2	0·95	1·05	1·15	..
Indian -	1·3	1·2	1·5	..	1·2	1·3	1·35	..	..	..	..

Twist per inch $= \sqrt{\text{counts}} \times$ constant.

Weights for Fly Frame Rollers

Cotton.	Machine.	Front. Pounds.	Middle. Pounds.	Back.
Indian and American	Slubbing	18	24	Saddle and Bridle
Egypt. and Sea Island	,,	16	20	Saddle and Bridle
,, ,,	,,	14	12	Self-Weighted
Indian and American	Intermediate	16	20	Saddle and Bridle
Egypt. and Sea Island	,,	14	18	Saddle and Bridle
,, ,,	,,	12	10	Self-Weighted
Indian and American	Roving	18	24	Saddle and Bridle
Egypt. and Sea Island	,,	10	Self-Weighted	Self-Weighted
Indian and American	Jack	16	20	Saddle and Bridle
Egypt. and Sea Island	,,	8	Self-Weighted	Self-Weighted

APPROXIMATE PROPORTION OF SPINNING SPINDLES TO CARD ROOM AND PREPARATION MACHINERY (NORMAL DRAFT ARRANGEMENTS)

Ring Yarn from Single Roving : American Cotton.	Counts.					
	10	10	20	30	40	50
Ring spinning spindles per :						
Card	200	200	400	600	800	800
Finishing delivery draw frame	200	200	400	600	800	800
Slubbing spindle	10	20	30	40	60	80
Intermediate spindle	..	10	15	20	25	30
Roving spindle	5	5·5	6	6·5	7	7·5

Ring Yarn from Double Roving : Egyptian Cotton.	Counts.			
	50	60	70	80
Ring spinning spindles per :				
Card	500	600	700	800
Finishing delivery draw frame	600	700	800	1000
Slubbing spindle	45	45	45	45
Intermediate spindle	15	15	15	15
Roving spindle	4	4	4	4

Mule Yarn from Single Roving : American Cotton.	Counts.					
	10	10	20	30	40	50
Mule spinning spindles per :						
Card	300	300	500	750	1000	1100
Finishing delivery draw frame	350	350	600	800	1000	1200
Slubbing spindle	25	50	70	90	100	110
Intermediate spindle	..	25	30	35	40	45
Roving spindle	10	11	12	13	14	15

Mule Yarn from Double Roving : Egyptian Cotton.	Counts.											
	50	60	70	80	90	100	110	120	80	90	100	110
Mule spindles per :												
Card	800	900	1000	1100	1200	1300	1300	1300	1100	1200	1300	1300
Finishing delivery draw frame	900	1000	1100	1200	1300	1400	1500	1600	1200	1300	1400	1500
Slubbing spindle	70	80	90	100	110	120	130	140	160	180	200	220
Intermediate spindle	25	27	30	35	40	45	50	55	80	90	100	110
Roving spindle	9	9	9	9	9	9	10	11	25	30	35	40
Jack frame spindle	..	..	..	..	..	..	..	..	9	9	9	9

Name of Machine.	Average Horse-Power Required.	Average Size of Machine Pulleys.	Revs. of Pulley per Minute.
		Dia. Width. In. In.	
Hopper bale opener -	1½	16 × 3	300 to 500
Roving waste opener -	3 to 4	12 × 4¼	800
Porcupine opener -	2	14 × 4½	800
Auto hopper feeder -	1½	12 × 2½	225
Single opener - -	4	14 × 4½	1000
Double opener -	8	14 × 4½ (two)	1000
Exhaust opener -	8	14 × 4½ (two)	900
Single scutcher -	4	12 × 4½	1000 to 1200
Double scutcher -	8	12 × 4½ (two)	1000 to 1200
Carding engine - -	¾	18 × 3½	160 to 180
Sliver lap machine -	½	16 × 2½	200
Draw frame and lap machine - - -	1	14 × 3	262
Combing machines—			
Single nip, 6 heads -	⅝	12 × 3	305
Single nip, 8 heads -	¾	12 × 3	305
Duplex, 6 heads -	½	12 × 3	229
Duplex, 8 heads -	¾	12 × 3	229
Draw frames (for 12 deliveries) - - -	1	18 × 3	200 to 300
Fly frames—			
Slubbing, 90 spindles, 8 in. space - -	2		
Intermediate, 130 spindles, 6½ in. space	2	12 to 16 in. pulleys 3 in. wide	300 to 480
Roving, 160 spindles, 5¼ in. space -	2		
Jack, 200 spindles, 4¼ in. space -	2		
Self-acting mules—			
All classes of cotton -	1 per 100 spindles twist gauge; 1 per 120 spindles weft gauge	16 × 5	rim pulley 600 to 900
Ring frames - -	1 per 75 to 90 spindles	12 × 3	850
Winding frames -	1 per 80 drums	12 × 3	300
Gassing frames -	1 per 80 drums	12 × 3	100 to 120
Reels - - -	⅛	8 × 1½	250
Double bobbin reel -	⅛	7 × 1½	150
Single bobbin reel -	1/16	7 × 1½	125
Bundling press -	1	24 × 3	60
Balling machines -	¼	12 × 2½	80

HIGH DRAFTING

High draft spinning has made enormous progress in recent years, and at the present time its application has become a matter of great importance to the trade. The introduction of the Casablancas system, about sixteen years ago, was chiefly responsible for focussing a large measure of attention on the question, and since then many variations of the usual arrangement, all involving the same principle, have been introduced.

It is not unnatural to expect that there should be doubts as to whether the yarn produced with such high drafts under similar conditions as to cotton, quality, etc., as those exercised in high draft arrangements would be as level and strong as those produced with normal draft under standard conditions. All doubts, however, have been removed by the extensive experimenting and application of such arrangements that have been carried out not only in this country but in almost every cotton spinning country in the world, and it has been amply proved that drafts very much in excess of those which could be employed under the usual conditions can be applied without any detrimental effect on yarn quality.

High drafting may be used to secure a reduction of cost or improvement in quality of the yarn. One method of adaptation of the previous sequence of processes is to eliminate one of the fly frame process, for example, by spinning with high draft from the intermediate bobbin. Another method would be to make a coarser hank roving at each stage, thus increasing the production of the machines and allowing less card room or more spinning room machinery. Yarn possessing superior properties might be obtained by the use of double instead of single roving, and by the more effective control of the fibres during drafting.

The theory underlying the various high draft systems that are now available is that of bringing the shorter fibres in the sliver under better control. It is well known that all varieties of cotton contain a very large proportion of fibres that are shorter than the staple by which it is known and sold. In order to avoid breakage of the longest fibres it is necessary, with the ordinary system of drafting rollers, to adopt settings a little longer than the staple, or just a little less than the longest fibres. But this does not give complete control of the shorter fibres, and in mill practice it strictly limits the draft to about six to eight on single roving, medium counts, or possibly up to a draft of twelve on double roving Egyptian cotton. In the high draft systems this difficulty is overcome by carrying the nip between the second pair of rollers much nearer to that of the front rollers, so as to obtain better

control over the short fibres. In practice this is done by a conveyor belt as in the Casablancas system, or alternatively by the use of smaller rollers in the second lines, and particularly a second top roller, light in weight and of small diameter, or by grooved rollers. This provides means whereby the longer fibres are permitted to slide through amongst the bulk without being nipped or broken in the drafting, as would occur if an ordinary heavy middle top roller were used.

In all high draft systems the amount of short fibre and fly thrown off at the high draft ring frame is increased. Much of this fly can be collected by additional top and underclearers. It is important also that the back roller should give a positive feed of the much heavier roving. A break draft should be able to operate easily by keeping the roving to the minimum of twist.

In any high drafting arrangement it is essential that the mounting of the parts shall be such that correct alignment of the roller surfaces is obtained, and the character of the surface such that irregularities in pressure and speed are eliminated. More skilful adjustment is necessary with such arrangements than with the standard method if the best results are to be obtained. Any irregularity occurring in these respects will have more detrimental effect than with the usual method of low drafting.

The increased number of parts or the small diameter rollers necessary are disadvantages usually inseparable from such arrangements, and will accentuate the difficulties experienced in maintaining efficient working conditions. Experience, however, proves that when those intimately concerned have gained practical experience of them the seeming disadvantages are not of material importance.

As a result of the practical experience gained in the last few years there is a large measure of opinion that the use of light or special types of rollers, as the top roller in the second line, will, with suitable roller diameters, permit drafts very considerably in excess of the normal over a very wide range of conditions as to cotton and hank roving, if roller adjustments and settings are skilfully made.

The various arrangements of rollers were described in the 1929 " Textile Manufacturer Year Book." Those systems where the path of the roving through the rollers is not in a straight line have found little favour. The three-roller arrangement with small diameter second bottom roller and light second top roller is the simplest, but no break draft is present, and if the back top roller is lifted to insert a new roving, the adjacent roving will run through without being drafted. In four-roller systems a middle traverse rod is necessary to reduce the lag of the traverse on the front roller, and the traverse is speeded up.

NOTES ON THE MANAGEMENT OF RING FRAMES

In the ring spinning frame, satisfactory roller setting, the mainten-ance of rollers in good condition, and satisfactory setting of spindles and thread guides are important. The ring should be kept in good working condition, if excessive tension on individual threads is to be avoided. Rollers should be set as close as possible without allowing crackers to form. The spindles should be dead central in the rings, and the thread guides placed so as to set up uniform tension all round the ring. Any rings which are badly worn and cause repeated breakage of the yarn should be replaced, and all the rings re-skimmed after a lapse of years, according to the condition of work. A satis-factory system of banding the spindles, oiling and cleaning rollers, scouring of frames and oiling of spindles, and doffing and gaiting are of the greatest importance in the maintenance of good working conditions and the production of a satisfactory yarn.

Roving.—A ring yarn requires a slightly better cotton than a mule yarn, in order to obtain equal results as regards regularity, etc., due to the inferior system of drawing-out or drafting as found on the ring frames, in comparison with the mule. Crackers cause 95 per cent. of complaints as regards ring yarn, and may be caused by the following cotton defects: Badly mixed cottons, mixings containing an excessive amount of soft waste, unripe fibres, fibres of too widely varying lengths of staple, or neppy cotton, also by overbeaten or badly carded cottons.

It is a good and useful guide, at least in this system, to watch carefully the thickness and feel of the ring bobbins, as it is a sure indication, when they commence to be thick and soft, that the quality of the roving is deteriorating, and other troubles may then be expected. Whilst it may appear exaggerated to state that the quality of the cotton has an appreciable effect on the diameter of the bobbin produced, irrespective of the lift or shaper-wheel used, all practical men will be able to recollect instances where a deteriora-tion in the mixing of a cotton has resulted in the bobbins rubbing in the ring, necessitating the use of a coarser pitched shaper-wheel. Bad ends, slubs, etc., are serious faults to ring yarns, and should be obviated as far as possible in the preparatory processes. The ring frame is at a disadvantage in the detection of these faults, as unless they are sufficiently prominent to be broken down in passage from the rollers to the traveller, it is probable that they will be wound on to the bobbin, only to incite complaint at the next process. The use of double rovings is invaluable in yarn production, but the hank must be sufficiently fine not to require an excessive draft to obtain the

required counts. As regards the amount of draft, no hard-and-fast rule can be given, as this is dependent upon the weighting of the rollers, the diameters of the rollers, and their settings. Unless special measures are taken, the draft should not under any consideration exceed 14. It will be noted that ring-frame machinists have of late years devoted considerable experiments to methods whereby it is possible to treat fluctuating mixings of cotton or fairly high drafts without the risk of causing crackers. In this they have met with undoubted success, as evidenced by the high-drafting systems, or modifications, which are coming very much into favour at the present time.

Travellers.—With regard to travellers, these are a factor which the overlooker cannot afford to neglect. Traveller tables may only be taken as a rough guide, owing to the great and undeniable influence of the mixing of cotton in use, the condition of the rings, and other factors. It is always a wise plan to book the counts of travellers used, along with reference to the various conditions, so as to provide a reliable source of information for future occasions. Care must always be taken that the section of the travellers is correct for the type of ring in use, as serious damage to the yarn will result if the section is too small, whilst too large a section will cause an excessive number to fly off, in addition to winding the yarn slackly on to the bobbin. It is essential for successful production that rings and travellers should be free from any accumulations of fly, etc., which would impede the revolving of the traveller. To assist in obtaining this, the small projections or traveller clearers which are screwed to the ring rail should be correctly set so that they may fulfil their function, whilst the operative should also observe that no dirt is adhering to the traveller when piecing a broken end. Various methods of cleaning the inside of the ring have from time to time been advocated, such as the ring burnishers, where the ring plates may be lifted off the pokers and the insides cleaned without necessitating the removal of the rings from the plate; also the small circular brushes designed to be placed on the spindle, and allowed to revolve inside the ring. The periods of necessity for these operations, however, may only be decided by attention to the individual conditions obtaining.

Spindles.—Slack and oily spindle-bands are a very serious cause of much inferior yarn, and a careful watch must be kept for them. A good quality of banding should always be used, and the bands put on at a regular tension. The tubes in which the spindles revolve should be kept clean, well lubricated with a suitable quality of oil, and any worn or broken tubes should be replaced at the earliest

opportunity. It is necessary at intervals to pump the oil out of the spindle bearings and replace it with a clean supply. As to how often this is required is a matter entirely dependent upon the prevailing conditions, but it should not be treated as an operation of no importance, as spindles running in dirty and gritty oil are sure to result in heavy running, in addition to wearing the tubes excessively. The dirty oil pumped out should be allowed to stand for a few days, when it will be found that all the sediment will have settled at the bottom of the receptacle, leaving the oil clean on top, so that it may be carefully poured off ready for future use. Should any spindles be observed to be wobbling or running erratically, they should be examined to see whether it is the fault of the spindle being strained, the tube or bush being badly worn, or the spring which keeps the tube in position being broken. Failure to attend to these details can only result in a great deal of badly wound, brittle, and uneven yarn. Frequent attention should be paid to the spindle holding-down catches, as should these be inoperative it will entail a large number of strained spindle-bands, due to the spindle being pulled up along with the bobbin during doffing, in addition to that operation taking considerably more time.

Rollers and Scouring.—" Scouring " of the rollers should be done periodically, the length of the periods varying according to the cotton being used and the counts being spun. The date of scouring each frame should be entered up in a book to provide reference to when that machine is again due. Scouring should always be thorough, and the following details and routine should be attended to: It is first necessary to break down all the ends on either one or both sides of the frame, according to whether it is intended to treat the whole frame at one scouring or to deal only with a side at once. For reasons given later, it is usual to scour a whole frame at a time. Having broken down all the threads, the person in charge should attend to ungearing the roller-driving mechanism. The carrier-wheel for transmitting motion from the back to the middle roller should be removed entirely. Some practical men consider it essential to remove the rollers from their stands entirely for this purpose, having provided suitable brackets for clamping on to the roller beam to receive the lines of rollers, one row at a time, for cleaning. Other men consider it is quite possible to meet all requirements without removing the bottom lines of rollers from their accustomed places. The first-mentioned system gives better facilities for cleaning the stands, etc.; but it is also undeniable that it presents a great source of strained rollers, due to the lifting of the whole side length of rollers at once. Should the first method be adopted, it will be

necessary to remove the front roller wheel, the bracket carrying the projecting ends of the back and middle rollers at the gearing end, the crown-wheel, stud, and change pinion, in addition to the radial bracket in which these swivel. At the other end the indicator will need unscrewing from the small bracket which secures it to the roller beam, the cap for holding down the back and middle rollers will require to be removed, and the traverse spring released.

Whilst the overlooker is attending to these details it will be found convenient for a number of the operatives to remove all the top rollers, putting them either on the floor or the creel top, whichever is the more convenient, taking special care to keep them from contact with any oil or greasy deposits. Should the second system find favour, it will only be necessary to remove, in addition to the carrier previously mentioned, the pinion from contact with the back roller wheel (of course, this will already have been removed in order to break down the threads) and the middle traverse guides, for convenience in cleaning the rollers. It will be found to facilitate greatly the turning of the front rollers if the twist-wheel is ungeared. The first real cleaning operation should be the removing of the accumulation of dirt from the roller necks and slides; this will be accomplished by lifting up the roller with a screw-driver or other suitable tool, whilst taking the greatest possible precautions against the roller slipping out of the inclined stand. After this, any dirt which is lying in the flutes of the rollers should be removed with the assistance of a piece of card filleting, suitably mounted on wood. This should be followed by a thorough rubbing with clean, dry cloths. Should any rough places be found, pumice-stone should be applied. A thorough polishing with whitening will greatly assist in preventing the licking of the roving, and should be followed by another thorough rubbing with clean cloths. Next, a small piece of white tallow should be smeared over each roller neck, care being taken that none touches the flutes. At this stage the traverse guides may be replaced and the top rollers put back, the cap bars, of course, having previously received a thorough brushing whilst the regearing is being attended to. Having completed work in this direction, the ring rails may be lifted off, so that the poker slides may be cleaned and the poker bars thoroughly wiped and black-leaded, in order to assist their motion in the slides and prevent any sticking. This done, everything is in readiness for restarting the frame, in the gaiting-up of which it will be found advisable to leave the draft pinion of one side out of gear until all the ends have been pieced-up on the other side, thus causing the soft waste caused by the rovings wrapping round the rollers and clearers prior to being pieced-up to be reduced to a

minimum. Before leaving the subject of scouring, it may be stated that it is advisable to take advantage of the opportunity for the replacement of any broken cap bars or roller stands or slides.

As regards attention to other details, the greatest control should be exercised over the frame tenters with regard to cleanliness of all parts of the machine. The roller beam, weight hooks, thread lappets, separators, and ring rails should be wiped at frequent intervals during the day. No loose waste should be allowed to remain on the clearers, good tenters being trained to remove this immediately after piecing up the thread. The bobbin wires and back traverse guides should be kept clean; the roller ends and necks of the front top rollers should be picked at regular intervals, the frequency being dependent upon the counts being spun and the characteristics of the rovings as regards cleanliness.

In lubricating any parts of the rollers, little and often is a good maxim, the greatest possible care being taken to avoid oil coming into contact with the roving during its passage. It should also be borne in mind that oil ruins roller-covering leather. The lubrication of the tin roller bearings should be undertaken by the jobber and not entrusted to ring spinners, as it is of vital importance that these be kept filled, particularly so when ring lubricating pedestals are in use. At suitable and convenient intervals it is advisable to remove any spindle-bands which may have become wrapped round the tin roller arbors, as these, in addition to being conducive to heavy running and waste of power, are a likely cause of danger by striking fire. A careful watch should be maintained by ring jobbers to see that spindle-bands are put on at regular and very frequent intervals, and to see if any spindles are in need of attention, in this way assuring that a maximum production be obtained. It is often found to be a common fault with banders that, due to ignorance or indifference, a great number of bands are left in the groove above the spindle wharve on replacement. This being of a different diameter to the spindle wharve, will readily be seen to cause irregularities as regards strength and turns per inch.

If there is any impediment to the passage of the traveller, strained yarn and bad spinning will result. It will be found on examining a ring that small grooves appear after running for a number of years in the path taken by the traveller, which, as previously stated, cannot be conducive to good work. It is well to have a definite system for the replacement of these. For example, sufficient new rings may be purchased for a side or a frame at fixed periods. These would all be put into one machine, those taken out being examined, the damaged one being scrapped, and any not showing signs of undue wear used

for general replacements. This method has much to commend it, as, in addition to its being known exactly where the new rings are, it presents a means whereby these accessories may be kept in good condition at an expense spread over a period equalling the life of the frame. This system of replacement may profitably and conveniently be carried also to the spindle bushes. It does not require any explanation, considering the high spindle speed and the constant pull of the band in one direction, that these bushes necessarily become worn, with a result detrimental to the yarn and a high consumption of oil. By effecting the renewal of a complete frame of bushes, it is possible to examine at leisure those taken out, and after destroying any unfit for further use to recondition the others as regards springs, etc., and use them up whenever required.

Lack of any definite system is only too often shown in changing the leather-covered rollers. Of course, the method stated in regard to rings and spindle bushes has much to commend it, although a great number of overlookers prefer to give each tenter a certain number per week, but even so the tenters should put them in systematically. A good way in this case is for the operative to start at one end of a side, and in each succeeding week follow on with her allotted share of recovered rollers, using those taken out in place of any being unfit for further use. Never should a new roller, speaking of loose boss rollers, be allowed to run along with one that has been in use for some time.

Some yarn faults which can only be avoided by constant vigilance and good routine are oil stains and dirty yarn, thick or wiry yarn, thin places in the yarn, soft yarn due to slippage between spindle and bobbin, cracked bobbins, slack spindle bands, etc., slubs, weak and uneven yarn. and piecings required by breakage of ends from innumerable causes.

It is of inestimable value to know the weight per doffing of the various counts, so that in the event of small orders of numbers seldom required, it will be possible to avoid loss by overspinning. The most reliable and simplest method of doing this is to take the average weight of yarn per bobbin multiplied by the number of spindles per frame, this providing a sufficiently accurate guide. Of course, it will be necessary to know the weight per bobbin on various counts, as various numbers will give different weights.

TRAVELLER TABLES FOR RING SPINNING

Yarn Counts.	For 1⅝-in. Rings.	For 1¾-in. Rings.	For 1⅞-in. Rings.	Dia. of Ring.	Size of Traveller.	Dia. of Ring.	Size of Traveller.	Dia. of Ring.	Size of Traveller.
				Inches.		Inches.		Inches.	
4's	14	13	12	2	9	...	...	...	...
6's	12	11	10	2	8	2	8	...	...
8's	10	9	8	2	7	2	7	2	12
10's	8	7	6	1⅞	6	2	6	2	8
12's	7	6	5	1¾	5	1¾	5	2	6
14's	6	5	4	1¾	4	1¾	4	1¾	4
16's	5	4	3	1¾	3	1¾	3	1¾	2
18's	4	3	2	1⅝	2	1¾	2	1¾	1
20's	3	2	1	1⅝	1	1⅝	1	1¾	1/0
22's	2	1	1/0	1⅝	1/0	1⅝	1/0	1⅝	2/0
24's	1	1/0	2/0	1¾	2/0	1⅝	2/0	1⅝	3/0
26's	1/0	2/0	3/0	1⅝	3/0	1⅝	3/0	1⅝	4/0
28's	2/0	3/0	4/0	1⅝	4/0	1⅝	4/0	1⅝	5/0
30's	3/0	4/0	5/0	1⅝	5/0	1⅝	5/0	1⅝	6/0
32's	4/0	5/0	...	1⅝	6/0	1⅝	6/0	1⅝	7/0
34's	5/0	6/0	...	1⅝	7/0	1⅝	7/0	1⅝	8/0
36's	6/0	7/0	...	1⅝	8/0	1⅝	8/0	1½	8/0
38's	7/8	8/0	...	...	...	1½	9/0	1½	9/0
40's	8/0	9/0	...	1½	9/0	1½	10/0	1½	10/0
42's	9/0	10/0	...	...	...	1½	11/0	...	...
44's	10/0	11/0	...	1½	10/0	1½	12/0	...	...
46's	11/0	12/0	...	...	...	...	...	...	...
48's	12/0	13/0	...	1½	11/0	...	...	...	...
50's	13/0	14/0	...	...	...	1½	13/0	...	...
52's	14/0	15/0	...	1½	12/0	...	...	...	...
54's	15/0	16/0	..	...	...	1½	14/0	...	...
56's	16/0	17/0	...	1½	13/0	...	...	...	...
58's	17/0	18/0	...	...	...	...	...	...	...
60's	18/0	19/0	...	1½	14/0	1½	15/0	...	...

The above list is given for American cotton. Indian cotton requires 4 to 5 sizes lighter travellers, and Egyptian and Sea Island cotton 4 to 5 sizes heavier.

PRODUCTION OF RING SPINNING FRAMES

Pulpit may be obtained by (1) timing F.R. speed, or (2) by calculation when spindle speed, turns per inch, and count are known.

(1) By timing of F.R. speed:

Assuming F.R. speed 125 revs. per min., F.R. diameter 1 in., number of spindles per frame 400, and count 36's, then

$$\frac{\text{revolutions of}\atop\text{F.R. per min.}\times 3\frac{1}{7}\text{ diam.}\times {\text{mins. per}\atop\text{hour}}\times {\text{No. of spindles}\atop\text{per frame}}}{\text{Inches per yard}\times\text{yards per hank}\times\text{count}} = {\text{production in}\atop\text{lbs. per hour,}}$$

i.e.,

$$\frac{125\times 1\text{ in.}\times 22\times 60\times 400}{7\times 36\times 840\times 36} = 8\cdot 66\text{ lbs. per hour.}$$

(2) By calculation, if spindle speed, turns per inch, and count are known :

$$\frac{{\text{revs. of spindle}\atop\text{per minute}}\times\text{mins. per hour}\times {\text{No. of spindles}\atop\text{per frame}}}{\text{Turns per in.}\times\text{ins. per yd.}\times\text{yds. per hank}\times\text{count}} = {\text{output in lbs.}\atop\text{per hour.}}$$

Output in other yarns will vary for changes in (*a*) spindle speed, (*b*) turns per inch, and (*c*) count.

In all cases when production is obtained from F.R. speed, an allowance for subsequent shrinkage, if any, should be made, in addition to an allowance of $2\frac{1}{2}$ per cent. for breakages, etc.

TWIST CONSTANTS FOR SINGLE YARNS

The number of turns of twist per inch applied to yarns during spinning is governed chiefly by the purposes for which the yarn is required, and is also influenced by the quality of the cotton. The following is a list of twist constants in regular use, although it should be understood that the figures given are not rigidly adhered to. In practice, slight modifications become necessary to expedite the spinning process.

$$\sqrt{\overline{\text{count}}}\times\text{constant}=\text{turns per inch in the yarn.}$$

Mule Yarn.	Constant.	Ring Yarn.	Constant.
American weft - -	3·25	Soft weft - -	3·25
,, medium -	3·50	Medium weft - -	3·50
,, twist -	3·75	Soft twist - -	3·75
Egyptian weft - -	3·18	Ordinary twist - -	4·00
,, medium -	3·39	Water twist - -	4·25
,, twist -	3·60	Hard ,, - -	4·50
Indian weft - -	3·25	Extra hard twist -	4·75
,, twist - -	3·75	Crêpe twist - -	5·5 to 9

PRODUCTION OF RING SPINNING FRAMES

Twist Yarns—American Cotton								
Counts	Speed of Spindles	Turns per Inch.	Hanks per Spindle per 10 Hrs.	Speed of Spindles	Turns per Inch.	Hanks per Spindle per 10 Hrs.	Speed of Spindles	Turns per Inch.	Hanks per Spindle per 10 Hrs.
4's	...	...	...	4500	8·00	9·12	...	...	...
6's	...	...	...	5500	9·79	9·34	...	...	...
8's	...	...	...	6400	11·31	9·54	...	...	...
10's	6800	12·01	10·12	7150	12·64	9·74	7,500	12·64	11·77
14's	7700	14·21	9·78	8000	14·96	9·58	8,800	14·96	10·61
16's	8300	15·20	9·86	8500	16·00	9·51	8,500	16·00	10·54
20's	8300	16·99	8·91	8500	17·88	8·67	9,000	17·88	9·98
24's	9000	18·61	8·82	8500	19·59	7·90	9,000	19·59	9·11
28's	9000	20·10	8·27	9000	21·16	7·76	9,500	21·16	8·90
32's	9000	21·49	7·73	9000	22·62	7·25	10,000	22·62	8·77
36's	9400	22·80	7·69	9500	24·00	7·23	10,000	24·00	8·26
40's	9700	24·03	7·52	9500	25·29	6·84	10,000	25·29	7·84

Twist Yarns—Egyptian Cotton								
Counts	Speed of Spindles	Turns per Inch.	Hanks per Spindle per 10 Hrs.	Speed of Spindles	Turns per Inch.	Hanks per Spindle per 10 Hrs.	Speed of Spindles	Turns per Inch.	Hanks per Spindle per 10 Hrs.
30's	8500	19·75	7·85	...	...	...	...	...	...
32's	8500	20·40	7·59	...	...	...	...	...	...
36's	8500	21·64	7·16	...	...	...	...	...	...
40's	8500	22·81	6·79	9500	23·7	7·64	...	...	...
42's	8500	23·37	6·75	...	...	...	...	...	...
45's	...	...	...	9500	25·12	7·20	...	...	...
50's	8500	25·50	6·31	9500	26·51	6·46	9500	25·49	7·02
55's	...	...	...	9000	27·78	6·17	9500	26·74	6·69
60's	8500	27·93	5·76	9000	29·02	5·90	9400	27·92	6·34
70's	...	...	...	8500	31·35	5·16	9200	30·16	5·75
80's	...	...	...	8500	32·54	4·97	9000	32·25	5·26
90's	...	...	...	8000	35·55	4·30	...	...	...
100's	...	...	...	8000	37·50	4·06	...	...	...

GENERAL NOTES ON MULE SPINNING

One of the operative spinner's most important duties is surely with regard to cleanliness of the various parts of the machine. To commence from the beginning, the creels should be kept clean, as if fly is allowed to accumulate here it cannot fail to work on to the creel-peg tips and into the steps, causing additional drag to be put on the roving. Only too often does this result in breaking the roving, especially if the cotton is rather below standard or the bobbin is unwinding from its smaller diameters. Operatives should be trained from their earliest associations with the spinning-room that when-ever a fresh bobbin is put into the creel, or a broken one pieced, the creel peg and its step should be freed from any deposits of fly. The pot steps are often found in mules that have been running for some time to have become broken or cracked, a condition seriously impeding the revolution of the peg. Spinners should be encouraged to keep a watch upon these, and to replace immediately any which may have become damaged. By the aid of suitable creel-step extractors this is quite a simple matter.

With conditions likely to cause over-running of the bobbins it is advisable to incline slightly the creels from the vertical, so as to offer the requisite resistance. Failure to attend to this will only result in the operatives blunting the tips of the pegs in order to apply a remedy, and in this manner creating a serious evil should it be necessary at a future time to use a finer hank roving or a greatly reduced rate of unwinding the roving. Facilities should be afforded for the replacement of any damaged pegs, as the practice of patching broken ones up by the use of tubes, pins, or nails is to be condemned. With reference to this, the most common form of damage is breakage of the upper tip during creeling, a condition arising out of the pegs being too long for the spacing of the creels. It will be seen that by attention to the foregoing details much assistance will be rendered in obtaining regularity and minimising bobbin breakages.

In all mules suitable provision is made for guiding and assisting the passage of the roving to the back traverse guide. These should be kept clean, and where small glass forks are employed for this purpose it should be seen to that the roving is passing between these. Only too often is it found, when a bobbin is pieced from the wheel-house, that it will be allowed to pass over the wooden rod which carries the forks. It will be understood that these do not possess a suitable surface for this purpose, and it will even be found that the roving

frequently gets in between the rod and the underside of the glass, at the back side of which a bunch of fibres will very soon collect, these having, of course, been scraped from the roving. These fibres themselves offer a further source of resistance.

Back traverse guides, particularly those of the bird's-eye pattern, form a ready collecting place for loose fly, etc., which will accumulate to such an extent that if it is not removed it will after impose a drag upon the roving, and eventually prevent it from passing through to the drawing rollers. This last is the least of the resultant evils, as, should this occur, it does at any rate obtain the removal of the obstruction. Very often, however, one finds that small portions become detached and pass forward with the roving, thus causing thick places in the yarn. Back traverse guides should be thoroughly picked at least once per week, in addition to the operative removing any accumulations he may see during piecing-up. Also, the small space between the traverse bar and the back portion of the cap bar is another place in which fluke collects. This should be removed with a fine brush at weekly or bi-weekly intervals, according to conditions. Many conscientious operatives will blow this out whilst cleaning the back traverse, or even when walking about the wheel-house. This is, of course, excellent practice; but even so, periodical brushing ensures thorough cleanliness.

The greatest consideration must be paid to the drawing rollers to obtain good work. No hard-and-fast rules can be adhered to as regards the cleaning of these, the deciding factors in this connection being the characteristics of the cottons and the counts being spun. Almost every mill has its own individual practice, but as a rough idea it may be stated that for medium to fine counts the following routine would be considered sufficient: front top rollers once per fortnight, and back and middle top rollers once per month. The efficiency of this system will be materially increased to the advantage of the resultant yarn if operatives will, as the opportunity arises, wipe the cap-bar fingers with a small piece of waste. Should an end be allowed to remain down sufficiently long for the top front roller lap to work into the groove occupied by the weight-hook, this roller should be picked before the end is pieced-up, otherwise it is sure to cause further breakage. All the top rollers should be removed to facilitate the thorough cleaning of the bottom lines and the picking of the back and middle roller necks once every four to six months (one side every four to six weeks). Time spent on this matter is very amply repaid by cleaner yarn, better spinning, and less back and middle roller-laps. A bad method only too often adopted in the removal of back and middle roller-laps is to knock on the top roller

and cause the lap to be cut by the flutes of the bottom roller. If those who practise this were to realise that the damage caused to the flutes is solely responsible for so many additional roller-laps and so much weak yarn, they would themselves immediately condemn it.

Short fibres, etc., form a sheet or lap over the flutes of the back and middle lines of rollers, particularly during damp weather. These may be removed with advantage at every suitable opportunity, and not allowed to remain until that particular side is cleaned through. A prolific collecting place for short fibres is against the roller stands, between the front and middle lines of bottom rollers, quite large accumulations frequently being found. A good spinner will remove these with his finger as soon as they begin to collect, and so prevent any possibility of portions passing forward with the rovings. The necks of the front bottom roller should be kept free from any lap-ends, and the front top roller ends kept as clean as is possible.

A great number of bad ends and thick places are caused through insufficient attention being paid to the top clearers and the dirt-shaft, or, in old pattern mules, its alternative the " crows " or bottom clearers. Where the crows are still in use these should be cleaned of waste whenever it is required, this of course being a very simple matter, as they are in short removable lengths. The pivots especially should be kept clean, as should an accumulation of waste gather on these there is a grave danger of the clearer ceasing to revolve, and very often being the cause of pieces of soft waste becoming attached to the yarn. Where dirt-shafts are employed it is necessary to see that these are always revolving at a uniform speed with the front roller, that they are sufficiently near the roller· to gather the waste, and that the waste collected is not allowed to become hard and matted. This last is another very possible source of bad ends, and if the top of the roller beam is found to be covered with short tufts of waste, it is a sure sign that the dirt-shaft needs to be cleaned. · No rule can be laid down for the length of the intervals for this, but the waste should never be allowed to get in any way hard, or trouble and bad spinning may be expected to follow. The bearings or stands in which the dirt-shaft revolves should be cleaned every time the flukes or waste is removed. Much assistance will be rendered in making this easily practicable if the stands are so set as to allow the shaft to be lifted in its bearings about $\frac{1}{8}$ in. Often, in an attempt to get the shaft as far forward as is possible, this asset will be destroyed, with a very questionable advantage. Top clearers, in addition to causing bad ends, if given insuffient attention, will also cause the top front rollers to require picking more often than usual through the same cause. For example, if an end is allowed

to remain down whilst a lap is formed on the top clearer, should this not be removed at once some portion is sure to work its way on to the rollers. To keep the clearers in good working condition all soft waste must be removed on the piecing-up of the end, and the lap removed from the flannel at frequent intervals. With attention to this, and if the clearers are kept travelling, they cannot fail to do their work efficiently.

Faller wires must be maintained at a fair tension, free from any rough or cut places, and operatives are well advised to run their finger along them as frequently as is convenient, in order to remove fluke. Faller shafts should be oiled about once per week, care being taken not to apply too much oil, which may cause oil-stained cops. Oiling of the fallers should always be done at an early stage after the commencement of a set of cops. Salmon-head levers should be correctly weighted for the counts being spun, and care should be taken that there is no possibility of their touching the floor during the earlier stages of the cop-build.

Correct weighting is vital not only in order to obtain a hard, solid cop; it will also be found that should the weighting be insufficient, erratic carriage of the counterfaller will result, whilst (particularly on fairly fine counts) if the weighting be too great the yarn will be so stretched and strained as to destroy its elasticity. Unlocking should be correctly timed, and in the case of spinning fine numbers, backing-off and locking should be so adjusted as to impose no rough or harsh action upon the yarn. No condition should be permitted which is likely to cause the yarn to break during backing-off or running-up, as such circumstances tend to the broken thread becoming entangled and being wound on along with adjacent threads, which gives rise to subsequent complaint. The most common causes of this evil are: Backing-off friction too keen; spring too tight; winding faller too near to spindle point during outward run; backing-off chain too tight; too much backing-off chain swell at work; fallers locking too deep or drawing up scrolls so set as to cause the mule to commence its inward run at too high a speed. With some types of weight-relieving motions it is possible to obtain, by injudicious setting, such conditions as will cause the weight to be relieved during backing-off, but allow it to act again too severely immediately the mule commences to run in.

Most mules in use at the present time for spinning medium or fine counts are fitted with positive twist motions. In particular, if the motion be driven from the tin roller shaft it is beneficial not only for ensuring regularity of twist, but, with a suitable yarn-easing motion, also for the following reason: Good yarn and good spinning

follow largely upon a thorough study of the prevailing conditions. For instance, suppose a harsh and wiry-fibred cotton has to be spun, it will be of great advantage to cause the carriage to travel out quicker, so that during the time that the carriage gain is operative the yarn will not be increasing in hardness to such a great extent as to cause excessive breakage, the remaining twist being inserted whilst standing at the head, during which time the easing motion would be causing the rollers to deliver sufficient yarn to prevent the ends being twisted down. In the opposite case it is often necessary to deal with a cotton so weak in strength that it is advantageous to insert all the twist during the outward run. If the yarn is pulled out of the nip of the rollers during the outward run, it is a sure indication that the carriage is travelling out too slowly.

When used with discretion, the inclines on the drawing-out scrolls are an invaluable asset, although when used to excess they are a prolific cause of snarls. If the yarn bunches on the spindle-point as the mule reaches the catch, it may be taken that either the inclines are too much in operation or else the cam is opening the roller-box too late. However, should it be found that the mule gets on the catch hard, followed by a number of ends pulling out of the rollers, more incline may successfully be applied. Whilst discussing this subject it may be pointed out that very often mules are allowed to bang on to the catch, especially with a high carriage speed, due to either the non-provision or insufficient use of a strap-relieving motion. Correct use of this motion will also cause less work to be imposed upon the backing-off friction, less damage to the counterstrap selvages, and a consequent easier and quicker change.

Correct bevel applied in correct alignment is an absolute necessity, as is also a reasonable setting as regards topping and distance. Inseparable from these must be considered drag and gain, a correct amount of which must be used with due consideration to counts being spun. A careful study of the capabilities and purposes of these factors will reveal that outside certain limitations inaccuracies of one cannot be corrected by use of another if quality is expected. For instance, if the topping of a mule be too low, this cannot be corrected either by the application of more drag or by less bevel, without creating further faults. A thorough explanation requires too much detail to be discussed at this juncture, but it is perhaps sufficient to state that the correct remedy may be arrived at by application of the following : If the yarn is found to break excessively during the earlier stages of the outward run, it is safe to assume that the carriage is set too high, whilst should the breakages be found to be most numerous after this period the remedy will be to decrease the amount of gain.

If on examination it is found that the threads are broken (whilst the mule is travelling out) on the length of the spindle-blade, the bevel is insufficient. Care must be taken, however, not to confuse the latter trouble with too late unlocking, which would have the same effect, except that breakage of the threads would occur as the mule terminated its inward run. It must not be considered, however, that the application of one of the former will prove a remedy for any or all cases of bad spinning, as many factors will contribute to this, amongst which are: Excessive speed, insufficiently good cotton, strained rovings, winding too tightly, lack of cleanliness, etc.

PRODUCTION FROM SELF-ACTING MULES

The production obtained from self-acting mules may be taken approximately as given below. In calculating these productions, assuming average speeds and allowances for doffing, breakages, etc., but for all yarns, without weft yarns, 7 to 10 per cent. more output.

Counts of Yarn.	Turns of Twist per Inch.	No. of Draws per Min.	Draw or Stretch	Production in 10 Hours.		Kind of Cotton.	Loss to be Allowed for Doffing and Breakages.
				Hanks.	Lbs.		
			In.				Per cent.
16's	15·0	5·25	66	6·26	0·39	American	7½
20's	16·77	5·25	66	6·26	0·31	,,	7½
24's	18·37	5·0	66	6·00	0·25	,,	7
30's	20·54	4·85	64	5·63	0·188	,,	7
36's	22·5	4·65	64	5·43	0·150	,,	6½
40's	23·71	4·5	64	5·26	0·131	,,	6½
44's	24·87	4·25	64	4·99	0·113	,,	6
50's	26·51	4·0	64	4·70	0·094	,,	6
56's	27·68	4·0	64	4·70	0·083	,,	6
60's	28·65	4·0	64	4·70	0·078	,,	6
60's	27·88	3·25	63+3	3·98	0·066	Egyptian	5
70's	30·11	3·0	63+3	3·67	0·052	,,	5
80's	32·20	2·75	63+3	3·37	0·042	,,	5
90's	34·15	2·5	63+3	3·08	0·034	,,	4½
100's	36·0	2·5	60+3	2·94	0·029	,,	4½
110's	37·75	2·25	60+3	2·66	0·024	,,	4
120's	39·43	2·15	60+3	2·54	0·021	,,	4

NOTE.—The productions for 60's to 120's from Egyptian cotton are calculated for mules with about 3 in. of roller delivery motion whilst winding on. The productions are calculated by Platt Bros. & Co. Ltd.

For finer counts from good Egyptian and Sea Islands cottons the productions are not given, as these might prove misleading, owing to the varying conditions as to turns of twist per inch in the yarn, and other circumstances.

{

Calculations for Production of Cotton Mules.—The output of cotton mules may be ascertained in several ways.

If a timing of the actual running can be made, the following method No. 1 will indicate the output. If, however, an actual timing cannot be made, but the time occupied in backing-off and winding-on, and adequate particulars as to speed of spindle, gearing particulars, turns per inch, etc., be known, the methods **2, 3, and 4** may be employed according to circumstances.

No. 1.—

$$\frac{\dfrac{\text{Secs.}}{\text{per min.}} \times \dfrac{\text{mins.}}{\text{per hour}} \times \dfrac{\text{length in ins.}}{\text{produced per draw}} \times \dfrac{\text{number of spindles}}{\text{per mule}}}{\text{Seconds per draw} \times \text{inches per yard} \times \text{yards per hank} \times \text{count}}.$$

Assuming 14 secs. per draw, length of yarn produced **per draw 67** in. (64-in. draw and 3-in. roller delivery whilst **winding-on**), number of spindles per mule 1,200, and count 50's,

then $\qquad \dfrac{60 \times 60 \times 67 \times 1200}{14 \times 36 \times 840 \times 50} = 14 \cdot 1$ lbs.

14·1 lbs., less 2½ per cent. allowance for breakage, etc.=13·75 lbs. per hour per mule.

If the time occupied in backing-off and winding-on is known, **and** other necessary particulars available, the output may be calculated as follows :—

No. 2.—If all the twist is put in at a uniform spindle speed during the outward traverse of carriage, then

$$\frac{\text{seconds per minute} \times \dfrac{\text{mins.}}{\text{per hour}} \times \dfrac{\text{length of yarn}}{\text{spun per draw}} \times \dfrac{\text{number of}}{\text{spindles in mule}}}{\left(\dfrac{\text{turns per in.} \times \text{ins. spun per draw} \times 60}{\text{spindle speed per minute}} + \dfrac{\text{secs. occupied in}}{\substack{\text{backing-off and} \\ \text{winding-on}}} \right) \times \dfrac{\text{inches}}{\text{per yd.}} \times \dfrac{\text{yds. per}}{\text{hank}} \times \text{count}}$$

Assuming spindle speed 10,000 per min., turns per inch 24, inches spun per draw 67 (64-in. draw ×3-in. roller delivery whilst winding-on), 4 secs. for backing-off and winding, numbers of spindle in mule 1,200, and count 50's,

then $\qquad \dfrac{60 \times 60 \times 67 \times 1200}{\left(\dfrac{24 \times 67 \times 60}{10000} + 4 \right) \times 36 \times 840 \times 50} = 14 \cdot 02$ lbs.

14·02 lbs., less 2½ per cent. for breakages, etc., 14·02 − ·35
= 13·67 lbs. per hour.

No. 3.—If a single spindle speed machine twisting at the catch, the output may be calculated as follows :—

$$\frac{60 \times 60 \times \text{length in inches spun per draw} \times \text{number of spindles}}{\left(\begin{array}{c}\text{time occupied} \\ \text{in twisting}\end{array} + \begin{array}{c}\text{time occupied in backing-} \\ \text{off and winding-on}\end{array}\right) \times 36 \times 840 \times \text{count}}.$$

Assuming spindle speed 9000 revs. per min., revolutions of spindle to one of rim shaft 13, revolutions of rim shaft per draw 150, $4\frac{1}{2}$ secs. for backing-off and winding-on, and count 80's,

then $\dfrac{13 \times 150 \times 60}{9000} = \begin{cases} 13 \text{ secs. for twisting per draw} + 4\frac{1}{2} \text{ secs. for} \\ \text{backing-off and winding-on} = 17\frac{1}{2} \text{ secs. per draw.} \end{cases}$

If length of stretch is 61 in. with 3-in. roller delivery motion, number of spindles 1,200.

$\therefore \quad \dfrac{60 \times 2 \times 60 \times 64 \times 1200}{35 \times 36 \times 840 \times 80} = 6\cdot53 - 2\frac{1}{2} \text{ per cent.} = 6\cdot37 \text{ lbs. per hour.}$

No. 4.—In the case of a mule with a double spindle speed arrangement, with a lower spindle speed of 6000 revs. per min. during traverse of carriage, when $\frac{7}{10}$ of total twist is inserted, and a higher spindle speed of 9000 revs. per min. in operation during twisting at the catch.

Assuming length of draw 60 in., 3-in. roller delivery motion, count 150's, turns per inch 33, time for backing-off and winding-on 5 secs., number of spindles 1200,

then secs. at lower speed $\quad \dfrac{7 \times 63 \times 33 \times 60}{10 \times 6000} = 14\cdot553$

Secs. at higher speed $\quad \dfrac{3 \times 63 \times 33 \times 60}{10 \times 9000} = 4\cdot160$

Secs. backing-off and winding-on $\quad = 5\cdot000$

Total time per draw $= 23\cdot713$ secs.

$\therefore \quad \dfrac{60 \times 60 \times 63 \text{ in.} \times 1200}{23\cdot713 \times 36 \times 840 \times 150} = 2\cdot53 - 2\frac{1}{2} \text{ per cent.} = 2\cdot47 \text{ lbs. per hour.}$

SPINNING MILL TESTING

The systematic and correct testing of the material at every point is of vital importance in the spinning mill in disclosing any irregularity at the earliest possible moment, so that defects can be remedied. When the results of testing are accurately recorded and tabulated in a suitable way, they serve as a reliable index of the work of the mill and locate at once the cause of any variation from the normal standard.

All spinners are alive to the necessity of maintaining uniformity, and the difficulty of maintaining the highest possible standard in this feature of the yarn, owing to unavoidable irregularities in the cotton. In order to keep variation within reasonable limits it is necessary to exercise constant vigilance, and this finds its best expression in methodical and correct testing at every stage.

The aim of the spinner is to produce a clean and even yarn of good appearance, with a suitable amount of twist and of correct count and strength. The most desirable feature of any yarn of whatever quality is maintenance of the standard in all respects, and that the standard may be maintained in successive deliveries. The manufacturer or doubler, using such yarn, knows its uniformity in general quality, and when this is the case the maximum in both output and quality can be maintained. The value of a yarn as a raw material is seriously depreciated if variation in any of its features occurs in successive deliveries. It is therefore a direct economic advantage to all concerned to secure as uniform and reliable a yarn as care and vigilance can produce. When such is the case, the user of the yarn can get maximum output and maintain good working conditions in every department of the mill and reduce costs of production to a minimum.

The system of testing must commence with the raw material, and it is important that the cotton obtained for any particular purpose shall be obtained at the right price, and be suitable for the yarn to be produced. If cotton is unsuitable, even though there may be a slight saving in first cost, the use of such cotton may, if working conditions deteriorate and increased waste loss and inferior yarns result, easily prove to be uneconomical.

The examination of the bales after they are opened round the bale breaker is a necessity to avoid the passing forward of cotton into the mixing which is obviously below the standard or unsuitable in any way. It is necessary occasionally to make a thorough test of the various marks of cotton in use to ensure that the general quality of

the mark is being maintained and to find out if waste losses are increasing. The ordinary mill machines do not lend themselves to making such tests readily, but nevertheless it should be done, as a mark of cotton may gradually and almost imperceptibly deteriorate in quality, and such a test made at intervals will indicate this. Such testing will reveal not only recoverable waste but also give the amount of invisible loss, which is less easy to judge than the actual weight of actual coming out which is recoverable. The moisture content of the cotton in bale should also be carefully checked, as damp cotton represents not only a direct and important loss, but it interferes with the efficient work of the opening machines.

When mixings are being put down the bales must be examined, so that false packs, wet or sandy bales, may be detected. It is good practice to employ mixing cards on which the particulars of every mixing, such as the mark of bales, number of bales of each mark, are entered, and these instructions made out in duplicate, so that one copy can be kept in the mill and the other in the office. The cost and labour of such a procedure are insignificant, and the result is not only useful in the way indicated, but also in that it impresses the person making the mixing with the importance of the operation and the need for care in making mixings.

When the testing of the raw material has been satisfactorily carried out, the next important point, where testing should be carried out, is the finisher scutcher lap. Examination of the laps will reveal whether the material has been adequately opened out and cleaned, and whether the cotton has been over-treated, and indicate whether beater speed, settings of beater and bars and fan speed, and the general opening and cleaning agents in the machine are functioning satisfactorily.

Scutcher laps should be tested for total weight, for weight in yard or two-yard lengths, and for uniformity in density and thickness through the sheet. Every finished lap doffed should be weighed—preferably on a beam scale, as a spring balance is more liable to error—to check the general working of the regulator motion and other irregularities which may occur at the feed of the machine, and any lap varying more than, say, 2 oz. or so above or below the normal weight rejected. Such laps may be returned to the feed lattice of the machine or, preferably, disposed of by feeding a light one and a heavy one together on a set of cards feeding the same set of drawings. The testing of laps along their whole length, by weighing two-yard lengths, will indicate whether any stretching of the sheet occurs as the lap is being rolled up. This is a fault which is indicated by the excessive softness of the lap and by its irregular

shape, and is a fault which is likely to arise if very soft cottons are being dealt with, or waste is being put into the mixing. When this test is being made, the first and last yards of the lap should be rejected as they may vary from standard, as the tension on the sheet on these lengths may be uncertain. The test for uniformity in density and thickness of the lap may be made by unrolling the lap before a window, and examining the lap with the light behind; any irregularity in this respect is usually associated with the distribution of the cotton at the feed and the efficiency of the air current in distributing the material uniformly in the cages. To avoid the possibility of mixing where laps of several different qualities are made, it is a good plan to dust the ends of the lap with coloured powder, so that laps of each quality can be readily identified. The desirability of entering up the weight of every lap made of the different qualities deserves consideration, as it offers a means of checking losses occurring up to this point and subsequently.

It is necessary occasionally to test the weight of the carded sliver, though a considerable variation in weight is inevitable arising from stripping, etc., but such testing taken at a suitable time between the intervals of stripping is useful. Periodical testing of waste losses at various points in the carding machine should also be made as a check, not only on the cotton and amount of impurity present, but also on the settings and general efficiency of the machine. The amount and character of the flat strips, and the cleanliness and appearance of the card web, are matters that require continual attention, as they fairly readily indicate variation from normal conditions.

Frequent and systematic testing at the last head of drawing is very important, as it provides perhaps the best point in the whole mill for testing, for any loss subsequent to this point is likely to be inconsiderable and steady. If, therefore, a high degree of uniformity is obtained at this point, it is not likely to be seriously affected by subsequent operations. With a satisfactory degree of uniformity maintained at this point, the necessity for changing pinions at any subsequent machine, except the spinning machine, should be avoided. The draw frame sliver should be tested at least daily, and the material selected carefully handled to avoid any damage to it before the test is made. It is necessary also to check the possibility of stretching of the material when being deposited and withdrawn from the bottom of the ordinary sliver can. For combed and fine slivers, spring bottom cans should be employed to reduce this possibility to a minimum. Any variation in weight of the drawn sliver should be immediately remedied, but care should be taken to discount any temporary factor, such as atmospheric conditions, before pinions

are changed. The variation allowed from standard weight should not exceed a given percentage of total weight, say, 2 or 3 per cent., and a record should be kept of all wrappings from each machine, and each quality for reference and comparison. If differences in weight from machines dealing with similar material occur, it will indicate some local disturbance which should receive immediate attention. The uniformity of the web on the drawing frame should receive constant attention, as this will indicate the efficiency or otherwise of the drafting operation.

Testing of the material from the fly frames is necessary to indicate whether any irregularity in the drafting or in the winding-on of the material occurs. The winding-on arrangements on these machines require careful adjustment if stretching and consequent variation in thickness is to be avoided. Slubbers should be wrapped three times per week, intermediates twice, and roving frames weekly, tests being made from full and nearly empty bobbins taken from the same spindles. If, as should be the case on all frames on the same counts and quality, similar change wheels are employed, any variation occurring on an individual machine indicates some local defect to which attention can be paid. As with the drawing frame testing, changes due to known causes, such as atmospheric changes, etc., must be discounted. This regular, systematic, and intelligent testing of the material will indicate irregularities in the drafting and winding-on in these machines, and with the necessary degree of uniformity at the draw frame maintained will reveal defects and localise it.

The tests from the yarn record the measure of success attained in the provision of suitable cotton and its manipulation. It should be tested daily. Some prefer to test direct from the spindle and from bobbins which have been creeled immediately previously, some from the full caps or bobbins as they arrive in the warehouse, and some test in both ways. The testing of the yarn from the spindle from newly creeled bobbins has much to recommend it, as it ensures a closer check on recent card-room output. Warehouse testing of the full cop should, however, occur, as it is the material to be sent out and from which subsequent tests will be made. Yarn tested direct from the spindle will usually be 3 to 5 per cent. lighter and 4 to 6 per cent. weaker than the same yarn when conditioned. The usual yarn test is to wrap four cops or bobbins, a lea from each, obtain the strength and weight of each lea separately, and in the record relate the strength and counts of each. The testing book should show the number of tests from each count and quality tested, so that comparisons with past records in similar yarns can readily be made.

A system to be recommended, not only with this general yarn testing, but at previous tests, is to work out the percentage of tests which fall outside a certain variation and indicate this, which will be a valuable index of the efficiency of the whole of the mill operations. The amount of variation allowed will vary with the general character of the yarn, but such a method will indicate in a very clear manner whether the general quality of the yarn is being maintained or otherwise.

Further testing of the yarn must be made by subjecting it to examination for cleanliness and general appearance by winding it on a blackboard or drum, machines for both purposes being in use, and also by testing it on the single-thread tester which will indicate variations, in short lengths, of strength and stretch clearly. The value of the single-thread tester is that it reveals irregularity which the lea tester does not disclose, and the relation between single thread and lea strength can be related. Since the lea test is the ultimate load that 160 threads will carry, it might be assumed that in a perfect yarn it will be 180 times that of the single thread. As perfect yarn does not exist, the lea test will always be less than 180 times single thread strength, but the percentage of one to the other will be an index of the uniformity in the strength of the yarn along its whole length. If the lea test shows 75 per cent. of 180 times single thread strength, the yarn may be described as good; if the lea strength falls below 55 per cent., it can be regarded as an inferior yarn if the turns per inch are approximately normal for twist yarn.

RAYON STAPLE FIBRE

Staple fibre consists of rayon which has been produced as continuous filament yarn, and subsequently guillotined into definite lengths. These lengths are similar to the staple length of cotton, or wool, as the case may be, and the staple fibre is then processed and spun into a thread in a similar manner to cotton or wool. Staple fibre may be produced by any of the commercial processes by which rayon is manufactured, but the greater proportion is made by the viscose process on account of the lower cost of production.

The major part of the staple fibre on the market at the present time is sold under the registered trade names of the producers, some of the principal varieties being as under:—

TABLE I

Process.	Trade Name.	Producer.
Viscose	Fibro	Courtaulds Ltd.
,,	Vestra	I. G. Faibrenindustrie, A.G.
,,	Seris	La Soie de Chatillon
,,	Chatilaine	,, ,,
,,	Sniafil	Suia Viscosa
Acetate	...	British Celanese
Cuprammonium	...	Bemberg

Staple fibre is usually worked up in a similar way to cotton and possesses definite characteristics of its own. While it retains much of the characteristic brightness of rayon, this is in a subdued form, giving a fabric of pleasing appearance and of similar lustre to that of natural silk. The yarn is softer and warmer than rayon yarns, and with a fuller handle and greater elasticity. There is a growing use of staple fibre, and large weights are now being spun on plant previously employing cotton. Staple fibre must be regarded as a new textile with distinctive characteristics of its own, and not as a substitute for cotton or wool. As such, it is apparent that it will find many applications, and this new textile bids fair to become of definite importance.

MANUFACTURE OF STAPLE FIBRE

The shortage of all textiles in the Central European Powers during the War compelled attention to every possible source of home production, and consequently staple fibre was manufactured on a fairly extensive scale. This was, however, essentially a war production, and the importance of staple fibre as a distinctive textile has been of more recent date.

While staple fibre may be produced by any process for rayon, as it is essential that the cost should approach as nearly as possible to that of cotton, the cheaper viscose process is utilised much more than either cuprammonium or acetate methods. Modern methods of production follow the usual lines up to the preparation of the viscose, except that, as there is not the same imperative necessity for uniformity as in the case of rayon yarn, simplification of control and the shortening of mercerising and ripening periods are permissible. (For manufacture of rayon, see page 282).

The spinning of viscose solution for staple fibre is accomplished on special machines having much greater productions than is

possible for continuous filament yarns. Heavy threads having a total denier of 1,500 or over, and with 500 or more filaments, are the usual practice. These threads may be collected upon a rigid swift mounted in the position occupied by the glass godet roller on a viscose rayon spinning machine. Alternatively the yarn may be collected in centrifugal spinning pots of large capacity, and revolving at a relatively low number of revolutions per minute.

The speed of spinning is usually higher than for continuous filament yarn, and may be about 75 metres per minute. This factor is a further influence in obtaining a high production, which is commonly ten times that of a continuous filament spinning machine, producing yarn of average denier. The requirements of staple fibre also permit the employment of more simple and cheaper coagulation baths than are usual for rayon yarns.

Compared with rayon, therefore, the production of staple fibre presents less technical difficulty and easier control, coupled with very high productions per spindle or swift. These factors assist in materially reducing the cost of production, especially as the finishing processes are characterised by the same simplification.

After spinning, the staple fibre yarn, in common with other viscose yarn, requires treatment for the removal of acid, and sulphur, and finally, bleaching, washing, and drying. The necessity for regularity of treatment, which is vital in viscose yarn, is not, however, so important for staple fibre. The ventilation, humidification, and air control plants which are an expensive item in viscose rayon plant, are only required in simplified form, and the processes of sorting, grading, and conditioning are eliminated entirely. After spinning, the yarn is removed from the swifts, or from the spinning pots, and may be washed free from acid, desulphurised, bleached, and dried in the form of hanks cut through once and of a length corresponding to the circumference of the swift.

The staple fibre may be marketed in this form and guillotined by the user, or, as is more commonly the case, may be sold already cut to the desired staple length. In this case the yarn may be guillotined directly after spinning, and before the processes of washing and bleaching are performed.

Characteristics of Staple Fibre.—The denier per filament of modern staple fibre is between 2 and 3 deniers. This shows a considerable improvement in the fineness of the material from about 6-8 deniers per filament, which was usual only two or three years ago.

The denier of cotton is between 1·5 and 2 deniers, but as staple fibre is not a hollow filament yarn the area of cross section of the latter is not usually any greater than that of cotton.

Average diameters of typical cotton and staple fibre filaments showed as follows:—

TABLE II

Sudan Cotton	-	-	-	-	- ·0177	mm. diameter.
Sakel Cotton	-	-	-	-	- ·0168	,, ,,
South African Cotton	-	-	-	- ·0198	.,	,,
Viscose Staple Fibre (British origin)	-			- ·0179	,,	,,
,, ,, ,, (Foreign origin)				- ·0182	,,	,,
Acetate Staple Fibre	-	-	-	- ·0218	,,	,,

Staple fibre, being a " solid " filament, possesses a higher specific gravity than cotton.

The length of staple employed in Lancashire mills is usually between 1¼ and 2 in., 1½ and 1¾ in. being usual staple lengths. Worsted mills, however, employ staple lengths up to 8 in.

Staple fibre, as produced, is naturally a straight filament without any convolutions such as are present in cotton. These convolutions materially assist in processing as well as increasing the tenacity of the yarn. It is desirable that this effect should be produced in staple fibre, and consequently the latter is frequently " curled " or " crimped." This may be achieved during the finishing of staple fibre after coagulation, and materially facilitates the scutching and carding of the material. A great deal of experimenting is proceeding with the object of imitating a wool feel or greater power of cohesion by depositing materials in or on the fibre, by rotating or otherwise moving nozzles, pulsating coagulation baths, and the like.

Manufacture of Yarn from Staple Fibre.—The processing of staple fibre of lengths somewhat similar to cotton generally follows similar lines to those employed for cotton, the processes being as follows:—

TABLE III

OPENING.—Hopper feeder and single scutcher.

CARDING.—

COMBING.—(Used for finest counts only.)

DRAWING.—1st drawing, 2nd drawing.

FLY FRAMES.—Slubber, intermediate, rover.

SPINNING.—Mule, or ring frame (high draft system).

The machines necessary for carrying out the above processes are generally similar to those usually employed for cotton yarns of fine or medium counts, one main difference in the preparation machines being on account of the much cleaner condition of staple fibre than of cotton. There is also a much greater uniformity of staple length, obviating the necessity, present with cotton, of removing short fibres.

The scutcher is modified by the substitution of an 18-in. porcupine in place of the usual beater, and by the removal of the dust bars. In place of the latter, the bar circle and passage to the cages is made from perforated sheet steel. In the card the mote knives under the licker-in are unnecessary, blank undercasings being applied in their place. The flats are run " dead slow," and in one method reversed and the strips conveyed back to the cylinder by stripping worker rollers. Fine wire clothing is used throughout. Without the exception of these modifications, standard machines may be employed, while for the subsequent processes of combing, drawing, fly frames, and spinning, no variations from standard are required apart from ordinary modifications of roller setting.

The fibre may have a tendency to " lick " in drawing. In the fly frames winding tension must be correct to avoid the necessity of piecings, which are difficult.

Gentle treatment is required throughout, and on the mule it may be desirable to increase the spindle bevel to ease the insertion of the twist at the spindle point.

It should be noted that the requirements of humidity control are more exacting than for cotton, particularly in the processes subsequent to carding. A moist and warm atmosphere is required. This fact is due to the greater degree of electrification of staple fibre than cotton, the individual filaments showing a marked mutual repulsion. In this respect viscose fibre behaves more nearly like cotton than does acetate. This is not unexpected, remembering the composition of the three fibres.

An aspect of the economic importance from a national standpoint of the use of staple fibre is that the only raw material which must be imported into this country is wood pulp, at a cost of say, 2d. per lb., only a fraction of the cost of cotton.

The use of staple fibre as compared with the older textiles is still very small, although an exceedingly rapid advance has been made in its use, particularly in the fine-cotton areas of Lancashire. The employment of rayon in the form of staple fibre is a fact of great significance, and there are immense possibilities. While rayon yarns are excellent in feel, they have been deficient in heat-insulation properties. The use of rayon in staple lengths which are worked up in a similar way to cotton, for instance, may provide a satisfactory warm and light fabric. In addition, staple - fibre yarns are hard-wearing : they form an ideal material for clothing purposes, and there can be little doubt that upon these grounds very great strides in the use of this new material may be made.

COTTON WASTE SPINNING

The waste of cotton mills is seldom used up in the cotton mill itself, though the better classes, such as roving waste and roller laps, are usually sent back to the mixings.   As a rule, waste merchants buy up the waste of a number of mills, contracting for the waste made in a given period, say three to twelve months, at a price which covers the whole period of the contract.   The waste merchant collects the waste, and puts it into a condition which will ensure him the greatest profit.

There are many different kinds of cotton waste, according to the kind and amount of treatment which the fibres have received in the previous manufacturing processes, and according to the treatment to which they must be subjected before they are rendered suitable for respinning.   The great diversity of treatment in manufacturing processes which cotton undergoes before it falls out as waste, naturally brings out a multiplicity of different characteristics.   The waste as it arrives at the waste mill calls for treatment to suit the necessities for opening and cleaning, and these processes must obviously be of a kind to bring out still more those characteristics which the particular waste may show already to some extent, and which may be very valuable for some purpose or another.   Thus, soft wastes of certain types are of a character to render them particularly suitable as weft, giving body to the fabric.   It will thus be clear that the full value can be got out of any waste only if the processes for opening, cleaning, and so on, right up to spinning and manufacturing, are best adapted to bring out still more the desirable peculiarities of the stock.

The greatest divergences between the various processes are in the opening and cleaning processes.   Thread waste must naturally be resolved into single fibres before the material can be submitted to a spinning process —whilst soft waste does not present the same difficulty in this respect, but usually requires to be more thoroughly cleaned, as it contains a great deal of undesirable impurities and admixtures which must be eliminated in the cheapest manner without detracting from the commercial value of the material.   It may be stated, therefore, that soft waste requires more " cleaning " whilst hard waste requires more " opening."

There are also certain mixed wastes, such as roller laps from ring frames and self-acting mules, which are chiefly composed of untwisted fibre masses, but also contain a fairly high proportion of hard threads which must be picked out of the material.   This leaves a soft waste which is then of such a high quality that it never gets into the waste mills at all—it is added to the cotton again and respun along with it. The same is the case with the ordinary roving waste which seldom finds its way into a proper waste mill.

Card Waste.—The waste emanating from revolving flat cards is generally free from oil. Flat strips often contain as much as 50 per cent. and sometimes more of good fibre, the spaces between the flats being filled with good fibre; but these strips also contain a large amount of foreign matter and many impurities which should have been taken out under the licker-in if the knives and undercasings of the latter were properly adjusted.

As a rule, American strips are fairly strong, and they are therefore largely used in the manufacture of twines, ropes, and nettings.

Egyptian strips are sometimes mixed with wool, the yarn thus obtained being largely used by manufacturers of low woollen goods. Many mills also reclaim the long staple from these strips, obtaining sometimes a yield of 50 per cent. of fibres of such a length that the resultant yarn is in some cases stronger than that of the same counts made from the cotton from which the waste was derived. The yarn made from reclaimed strips, however, is rougher in appearance, and it also contains nep, which renders the use of such yarn quite unsuitable for many purposes.

Cylinder strips are cleaner than flat strips, but they are also shorter. On the other hand, they are dirtier and longer than card fly.

Doffer strips are about the same as cylinder strips.

Cylinder fly is the cleanest card waste, but is also the shortest.

The fly from the floor between cylinder and doffer is rather dirtier than the fly under the cylinder itself.

Licker-in droppings consist principally of the seeds and husks left in the laps after the last scutcher passage; they also contain some short fibres.

Spinners' Sweepings are the lowest class of cotton waste. They are also called "oily waste." They consist chiefly of fly and all kinds of twisted and partially twisted waste picked up from the floor of the preparation and spinning rooms, the bulk coming from the floor near the drawing frames.

The winding, warping, and weaving departments yield some classes of waste which will spin into yarns characteristic for their softness and good cover, suitable for quiltings, bed covers, towels, etc. Sized thread waste is much less valuable, and often something of a problem. Engine-cleaning waste is often a use to which it can be put, though this material is not particularly suitable for that purpose.

Engine-cleaning waste is composed of the thread waste which cannot be respun by any advantageous process. This class of waste is roughly pulled so as to allow of its being conveniently handled.

Soft Waste as a class comprises such kinds of waste as strips, crow laps, stockings, clearer waste, cage fly, card-room sweepings, spinners' sweepings, blowing-room sweepings, droppings from the blowing room, and so on. It must be taken to include also the more valuable wastes, such as roving waste and comber waste.

The lower classes of soft waste are particularly suitable for the production of yarns having " body," as desirable for weft in sheetings, flannelettes, towels, quilts, and the like. They are also valuable for the manufacture of wadding and even gun-cotton. In the latter case the employment of the most suitable opening and cleaning machinery is of the utmost importance.

To a great extent, the machinery for the preparatory treatment of soft waste has become standardised, the following machines being usually met with for the purpose.

The Willow, as the characteristic opening and cleaning machine for soft waste, is in use for the most diverse purposes. Its chief organ is a large cylinder with very strong spikes revolving at a fairly high speed and beating the material in the free flying state against sets of grid bars. The kind and setting of the grid bars must be suited to the work in hand, and this kind of machine is therefore often made with interchangeable bars. The type of feed and the general mechanism varies very much according to requirements, and the opened and cleaned soft waste is generally delivered loosely on the floor, ready for a second treatment of the same kind, if required. There are also automatic deliveries of various kinds. The waste made by this machine, i.e., the dust, is automatically removed by a scroll and elevator and automatically placed in a bag. Some improved types with special feeding devices are capable of turning out productions amounting to 30,000 lb. per week.

The Waste Shaker is a machine with a less severe action. It has a number of rods projecting radially from a revolving shaft and beats the material inside a large cylinder composed entirely of meshed grids. This machine shakes the dirt out of opener and scutcher droppings and out of card waste and has the advantage of treating the material so gently that there is no danger of damaging the staple.

The Crighton Opener has its working organs arranged in the fashion of a large inverted cone. The vertical opening cylinder, with steel blades fastened on steel plate discs in a number of heights, rotates at a high speed in a conical cage made up of grids with suitable openings to allow the dirt to fall out. The dirt is flung against the grids by the blades of the beater, the fibres being prevented from escaping by a strong current of air which is made to enter the conical cage through the same openings. The Crighton opener is also the

standard machine for dirty cottons. It is often used as a double machine, double Crighton opener, with double cylinders, one arranged behind the other, and with dampers allowing the material to be treated in both cylinders, or in one of them only, at will.

Thread Extractor.—Some soft wastes such as roller laps and spinners' sweepings require previous treatment in a machine allowing hard threads to be extracted from them, and thread extractors are employed for this purpose. The soft waste remaining after the extraction of the hard ends from roller laps is usually of good quality, consisting almost wholly of good long fibres ; this waste is therefore very valuable, and as a rule it is utilised in the spinning mill itself, to be spun along with the cotton from which it was originally derived.

In the usual type of thread extractor there is a tray for receiving the roller laps and sweepings, arranged on the top of the machine in a convenient position to allow hard matter to be picked out rather than letting it pass into the machine itself along with the waste, where it might do serious damage. The waste goes down into the machine through a funnel, whence it drops on one of three spiked rollers rotating at a high speed and interlocking in such a way that the hard threads wind on to the spiked shafts, whilst the soft waste is exhausted by a fan and delivered on to the floor by cages. A hood is suitably arranged above these cages so as to deflect the soft waste in such a direction that it is deposited on the floor without flying about and settling as fly and fluff on the machinery. The machine is stopped from time to time, the cover is lifted, and the hard waste can then be cut off from the shafts by means of a knife. Each shaft carries a groove, along which the knife is passed to facilitate the cutting of the waste. The cover is then closed and the machine can be restarted again to treat a further lot of roller laps or sweepings.

Grids are arranged below the spiked rollers to allow dirt to fall out. The cages are not connected to an exhaust fan, but a fan in the machine blows the fibres towards the cages, allowing the air to escape, whilst the soft waste falls out undisturbed by air currents when the cages have come round to a suitable position for the waste to be out of the way of the air currents.

Hard Waste is quite different in character from soft waste. It comprises principally the following kinds : Cop bottom waste, ring frame waste, reelers' waste, winders' waste, weavers' cop bottoms, hosiery waste and some similar kinds.

The great difficulty with broken-up hard waste is to get all the hard ends out, particularly the short bits of thread. The finer the counts, the more difficult it is to get all the hard ends out. In fact, the difficulties become well-nigh insuperable as the counts become finer,

though in recent years special devices have been introduced which go a long way towards getting out every vestige of hard ends, under favourable conditions. As a general rule, the hard-waste opener itself cannot be relied on to reduce the hard waste to soft material having no hard ends, and it is therefore necessary to get out the hard ends by suitable appliances to the card. The devices for this purpose are generally applied to or near the licker-in of the card.

Preparing Machine for Hard Waste.—The preparing machine, sometimes also called " combing machine," is employed for loosening cop bottoms, mule waste, ring frame waste, winders' waste, warpers' waste, and similar entangled hard waste, previous to its treatment in a hard waste breaker, thus saving the lagging of the hard waste breaker.

The entangled hard waste is placed on a lattice feeding creeper which feeds it into a pair of feed rollers, from which it is combed away by the strong steel teeth of the large cylinder. The steel teeth of the doffer then take the waste from the large cylinder. The waste is drawn from the doffer by a pair of fluted rollers which deposit the combed and prepared waste on the floor. A lap head is sometimes attached to the delivery end of this machine. The production of this machine is about 50,000 lb. per week. It is only used in large mills, as it would not pay to put it down in small plants, on account of its first cost. The running-down machine of the cleaning waste trade is the identical machine, but engine waste is afterwards finished on an ordinary engine-cleaning waste machine.

The Hard Waste Breaker is used for the purpose of reducing hard waste such as cop bottoms and other hard thread waste to individual fibres. The same machine is also used for preparing cotton waste for gun cotton. The hard thread waste is advantageously prepared on the preparing or combing machine previously described, but this machine will only pay where large quantities are to be coped with.

The hard waste breaker has a number of cylinders covered with lagging carrying spiked teeth, the lagging and pinning becoming successively finer and finer towards the delivery end of the machine. The material is fed into the machine by a feed lattice presenting it to a pair of feed rollers which in turn feed the material to the first cylinder. The first cylinder throws the material on to revolving cages which in their turn convey the material to the nip of the next pair of feed rollers preparatory to the next cylinder. This operation is automatically repeated until the material has passed through the whole machine. The hard waste breaker is generally made with six

cylinders, but eight cylinders are sometimes employed for the finer grades of hard waste. In the multiple-cylinder machines, the fineness of the teeth in the lagging can be adapted to the degree of opening which the waste has to undergo.

Waste Mixings.—The waste mixings must take account of the colour and the length of the staple. Each stack should contain sufficient raw material for about one month's working, to ensure the maintenance of an even quality. When preparing the mixings, the waste should be distinguished as suitable for (1) greys, or (2) blends or mixings of wastes of various colours. In goods for raising, the staple should be fairly long and the material regular. Certain kinds of Indian cotton are advantageously used in such mixings.

Ordinary counts of mule condenser yarn may be made up as follows : 4's to 7's counts from weavers' cop bottoms with about 20 per cent. of reelers' waste.

7's to 10's counts require about a quarter of the weight of comber waste to be put into the material at the scutcher.

10's to 14's counts require about one-half comber waste, which is easily mixed behind the card, if laps are put up at the card.

Higher counts than 14's are generally spun from comber waste only, though much can be done with discrimination.

Low qualities do not require the same qualities as those mentioned above. In fact, counts up to 10's can be spun from any hard waste, if required, whilst up to 16's is often spun from half-card waste with one-half strips.

Mixings for Jumbo Spinning.—The coarsest kind of spinning. is called jumbo spinning. This requires yarns with very little twist as suitable for cotton blankets. The counts are usually 40 to 110 yards per ounce. The mixings vary according to the purposes for which the yarn is required. A mixing for yarns for grey cotton blankets may contain about 70 per cent. of bleached waste, and the rest stockings or good clearer waste and strips in about equal proportions. For dyed cotton bankets, darker waste may be used, say half card-room sweepings, and the rest made up of blowings and low strippings in about equal proportions.

Mixings for Bump Yarn.—This yarn ranges in counts from about 40 to 200 yards per ounce. It is used principally for quiltings and the composition of its raw material is somewhat on the following lines:—Grey yarn : blowings, strips, cotton pickings, willowed fly. Dark yarn : card-room sweepings, droppings, and Indian waste.

Somewhat finer waste yarns of coarse description, say up to 3's, may be made from scutcher waste with about 40 per cent. of a better class of card waste.

WASTE MACHINERY

Machines for preparing soft waste which have been mentioned are the willow, shaker, and Crighton, and for hard waste, the pulling machine and the hard-waste breaker.   After such treatment the material may be blended, and soaped or oiled, and a further sequence might be hopper feeder, " fearnought," or other blending or pickering machine, and soaping or oiling apparatus.   Rags may have been originally treated by a rag shaker, rag-tearing machine, or Garnett opener.   There is a large variety of machines.   Further machines are as follows :—

Scutcher.—This machine is used in the cotton-waste trade chiefly for the purpose of thoroughly blending the material and forming it into a lap of even density, so as to feed the material evenly into the breaker card.   The waste scutcher is fitted with one beater only, to avoid too violent treatment of the fibres.   In the cotton-waste trade the scutcher is now almost restricted to large installations using waste of a better class.   Scutcher laps containing cotton waste will often give trouble by licking and not unrolling properly.   It is therefore usually better to make the scutcher deliver on the floor, and to feed the loose material into a hopper behind the card, unless there are important reasons against the employment of hopper feeders.

· **Hopper Feeders**.—When employing hopper feeders, it is important that these are really suitable for the purpose, for the mechanisms of hopper feeders differ greatly in the kind of spikes, and particularly in the surplus stripping arrangements, and the weighing devices which must take account of the state in which the material is fed.   In usual cases this will be of little importance, but there are exceptions where these details must be considered.

The Breaker Card is the first of the set of two cards which are regularly employed in the manufacture of cotton-waste yarns.   It is generally fitted with a special feeding apparatus with saw-tooth rollers which are intended to prepare the material for the carding organs proper, separating it into very little tufts to relieve the card clothing.   In the card itself, the material is suitably placed on the card-wire surface of a large cylinder or " swift " which takes it round · a number of times, to be carded by the action of the wire points on the large swift and on the rollers arranged on its surface.   In cotton-waste manufacturing, " roller " cards are invariably used, because

they leave the material in the peculiar state of springiness which is desired in waste yarns, which are employed less where smoothness of the yarn is desired than where body is called for. If flat cards were used, the material would lose covering power and not give the desired body to the cloth.

The Finisher Card has the same carding organs as the breaker card, but these are covered with finer wires, and the feed and delivery are different.

Finisher Card Feed.—The Derby doubler system requires the breaker card to deliver a number of slivers into card cans, the slivers being combined into laps in the Derby double. The laps made on the latter machine are then fed into the finisher card. The Derby doubler system can best be characterised by specifying a standard set of machines which may be arranged somewhat on the following lines :— ·

Breaker card 48 in. wide, producing about 160 lb. in 8 hours.

Derby doubler 23 in. laps from 60 cans, about 1,200 lb in 8 hours.

Finisher card, production according to counts, 80 to 130 lb. in 8 hours.

The finisher card may have a doffer clothed with rings and leather dividers about $\frac{1}{4}$ in. wide, about 26 rings in the width of the card for 5's counts, and up to about 40 rings for 10's counts. A doffing comb and groove roller precede the leather rubbers, which impart a false twist to the sliver which is then wound on to condenser bobbins.

Other Types of Feed do away with the can delivery and with the Derby doubler. When they are employed, the Scotch feed or · some other feeding device is used, in such a fashion as to make a direct connection between the breaker and finisher cards, doing away with the labour connected with the can delivery of the breaker card, the Derby doubler, and with the lap feed of the finished card, besides saving space and trouble.

The Scotch Feed is an automatic connection between the breaker and finisher cards. It is usually arranged so that the connection is made over an overhead lattice, chiefly to afford ample passage about the cards.

Finisher Card Delivery.—The preparation system of cotton waste spinning requires coiler delivery. It is only used for comparatively hard twisted wastes. The resultant yarn is not of a very high quality, for it is uneven ; not so round as condenser yarn ; and lacks the smoothness of the condenser yarn. Any hard waste of fairly good quality is suitable for the system, so long as the material is not too short.

As an example, the following plan for producing 16's to 20's weft from hard waste may be given :—

Crighton opener delivering on to floor.

Single scutcher to be used as breaker and finisher, and to make laps 46 in. wide for cards 48 in. wide.

Breaker card 48 in. wide, for two laps up.

Derby doubler for 60 cans, to make laps $23\frac{1}{2}$ in. wide.

Finisher card 48 in. wide, with six coilers.

Slubber for bobbins 8 in. lift × 4 in. diameter for 4's counts, requiring a modified intermediate frame to be used for the purpose

Ring spinning frame of $1\frac{3}{4}$ in. gauge.

The Coiler System of waste spinning is often adopted where a strong waste yarn is required, and where at the same time there is no necessity for a full and oozy character of the yarn. Consequently hard waste is the given raw material, though soft waste is also often spun by this system where strength is required rather than evenness, such as in the case of yarns for weft in towels, cretonnes, and other weaves. The important feature of this system, that it preserves the strength of the fibre to a high degree, is also the reason for its adoption in the manufacture of yarns for twines and ropes, though of course waste is only used in the lower qualities of such.

The cheapness of manufacture by the coiler system is in all cases a factor which is by no means negligible, and often decides the question. Moreover, attendance on the machine is easier. For hard waste it may be considered the approved system where a strong yarn is required rather than an even one, and also for counts, say above 10's. To characterise the system, the sequence of machines may be here stated for a standard plant for a yarn made from hard waste, say counts 3's to 16's, as follows :—

Hard waste pulling machine.

Hard waste breaker with soaping attachment.

Single beater scutcher with hopper feed and lap machine.

Single cylinder breaker card with coiler attachment.

Derby doubler.

Single cylinder finisher card with four coilers for 9-in. cans.

Slubbing frame.

Mule or ring frame.

The Slubbing Frame of the type used in cotton spinning is often used for coarse counts. The machine is fitted with a large diameter tin roller at the back to assist in lifting the slivers out of the cans without breaking. The slivers then pass to drawing rollers for the attenuation of the sliver, and thence to the flyer spindles for twisting and winding on to slubbing bobbins. The yarn is then sometimes ready

for winding into tubular cops, and in other cases it passes to a mule or a ring frame.

The mule employed in spinning waste prepared by the coiler system is practically identical with the self-acting cotton mule, though the gauge of the spindles is rather wider. The draft is " roller draft " rather than carriage draft or gain.

The ring frame, which may be employed instead of the mule, is also very similar to the ring spinning frame employed for cotton yarn.

The Condenser System of waste spinning is the approved system for producing a full and level yarn from practically any kind of cotton waste. To characterise the system, the sequence of machines may be here stated for a standard plant for a yarn made from hard waste for, say, 5's to 10's, the hard waste to be spun into a full and level yarn :—

Hard waste pulling machine.

Hard waste breaker with soaping attachment.

Single beater scutcher with hopper feed and lap machine.

Single cylinder breaker card with coiler attachment.

Derby doubler.

Single cylinder finisher card with condenser.

Mule.

The condenser is the feature of this system. The condenser is attached to the finisher card for the purpose of dividing the carded web into a large number of narrow strips of web, rather than a limited number of fairly wide strips as in the coiler system. The various strips of web taken off by the condenser should be of practically even weight for a given length, according to the desired counts. This demand of even weight creates problems of rather difficult solution in some of the more elaborate condensers for special purposes. What the condenser has to do is :—

(1) To split up the web into a number of strips of even weight;

(2) To rub each strip so as to enable it to carry its own weight, over a short distance at least ; and

(3) To wind a number of such rubbed ends side by side on one or more long bobbins called condenser bobbins.

The condenser bobbin is driven by surface contact from a drum, so as to maintain a uniform speed of winding on.

The Ring Doffer Condenser in its usual form requires the doffer to be clothed with rings of card clothing having between them leather dividing rings about ¼ in. wide to keep the slivers separate. The number of rings is governed by the desired counts of yarn, the usual number being between eight and thirty-six for counts ranging from about 1's to 10's. The doffing comb takes off the divided slivers,

which are then drawn off by a pair of endless rubbing leathers, being kept separate on their passage thither by grooved dividing rollers between which they pass. The rubbers roll the individual slivers into thin slubbing, condensing them at the same time, hence the name condenser for the attachment. From the rubbers, the slubbing emerges to be wound on to a slubbing or condenser bobbin. The ring doffer condenser is gradually disappearing, but it is still used by mills specialising in better classes of waste yarn from cop bottom and comber waste.

The Tape Condenser has a very immediate advantage over the ring doffer condenser in the matter of production, as the doffer is set " full," the doffing comb stripping the web in a single sheet over the whole card. This wide web enters a system of tapes which is guided over rollers in such a way that they split the web up into single slivers, each of which is taken by its leather tape to one of a number of sets of rubbers, and thence to the condenser bobbins. There are usually two, three, or four heights of condenser bobbins, according to the number of slivers, the slubbing being wound on in such a fashion and gauge as to be suitable for the gauge of the spindles of the subsequent spinning machine.

The Waste Mule.—The self-acting billey is the usual machine for spinning condensed sliver into yarn. The system is in practical use for yarns from 40 yards per ounce up to 16's and higher. For soft waste, this machine has two lines of bottom rollers and one line of top rollers. When spinning short material, the slubbing is generally delivered at a uniform rate of speed throughout the draw, the carriage speed being also maintained uniform. Thus there is a constant and fixed draft between rollers and spindles. During the outward run of the carriage, the spindles should not put in more twist than is necessary to allow the yarn to carry its own weight; any excess will interfere with the subsequent carriage drafting. When putting in the first twist, short material will contract owing to the comparatively great number of turns per inch which must be put in to prevent the yarn from breaking whilst the carriage is running out. Longer material will require a less amount of twist during the outward run of the carriage, and it will therefore allow some tension, and for that very reason show some gain from the very beginning. The amount of twist which is put into the yarn during the outward run of the carriage not only depends on the actual speed of the spindles, but is chiefly dependent on the speed of the roller delivery and on the speed of the carriage, the latter depending on the necessities of easy piecing.

Where the quality of the material allows, the spindles may be

12

stopped entirely for the first few inches of the outward run of the carriage and, in certain cases, this becomes necessary, say where the yarn would otherwise receive so much twist that it would interfere with the carriage drafting when the roller delivery is stopped.

The spindle speed during the outward run of the carriage is fairly low, and the extra twist which is put into the yarn at the end of the outward run of the carriage requires the spindles running at about double the speed, to save time, and to increase the production.

When spinning short material the delivery of the rollers is only interrupted when the carriage is in its outward position. In other cases it is stopped somewhere within the last 10 in. from the end of the outward run, the yarn being afterwards drawn out by the carriage continuing its outward course. The amount of stretching which the yarn will stand depends on the quality of the material. Where Indian cotton is spun on waste mules, for the production of a yarn of woollen character, the roller delivery is often restricted to two-thirds of the total stretch, or sometimes even less than that.

Whilst coarse counts are generally spun with " gain " or " carriage draft " only, the slubbing for counts above 6's often receives a preliminary roller draft of 1·2 to 1·6, allowing a coarser slubbing and therefore a higher production to be obtained.

Waste yarn spun by the preparation system requires leather-covered and weighted top rollers for a practically positive draft, which is given between roller nips set at a comparatively short distance from each other. A high carriage draft would render the evenly-prepared yarn uneven. This is the reason why also in some special systems of condenser spinning roller drafting is resorted to in the spinning frame.

A carriage retarding motion, to start the delivery of the slubbing slightly in advance of the outward run of the carriage, is sometimes employed to prevent cut yarn. The speed of the outward run of the carriage is largely controlled by the necessity of affording time for piecing, and the spindle speeds must needs follow suit.

The double spindle speed allows the use of a greatly accelerated speed towards the end of the outward run of the carriage after the " gain " has been put in by the carriage. The second or higher speed may be put in at the end of the outward run, by the camshaft change, or special mechanism may be provided to increase the spindle speed at any time during the outward run, say after two-thirds or more of the outward run of the carriage.

The treble spindle speed is often used when spinning counts above 4's, where a very uniform yarn is desired. In this case, mechanism is provided to reduce the speed of the spindles for the first 18 in. or 24 in.

of the outward run, to allow the carriage gain to develop its evening influence to the highest degree which is possible under any given circumstances. The second speed, which comes into use after the first 18 in. or 24 in. of outward run, then consolidates the yarn more and more, to give way afterwards to the third speed towards the end of the outward run.

The carriage receding motion is used at the end of the outward run, to prevent the yarn from breaking when the final twist is put in, seeing that the yarn contracts under the influence of the added twist.

A roller reversing motion is sometimes used for very soft spun yarn and short material. This motion is intended to prevent breakage of the ends near the rollers. The idea is to turn the rollers back a little when the carriage has run out; the rollers then hold the twisted yarn during winding, and breakage of ends near the roller nip cannot take place so easily.

Continuous Spinning Systems for Cotton Waste

The following continuous spinning systems are applicable to the manufacture of a soft waste yarn, with the exception of the ring frames :—

1. **Special Roving Frame.**—This machine greatly resembles the speed frame of the cotton mill, but the bobbin creel is replaced by a condenser bobbin creel. Moreover, there is only one line of fluted bottom rollers and one line of plain solid top rollers. The machine is used for spinning soft waste for sponge and cleaning cloth weft as well as mop and wick yarns.

2. **Chapon Frame.**—For soft wefts of very coarse counts, such as required for blankets, sponge, and cleaning cloths, this machine is now used in preference to the roving frame described above. In this machine the condenser bobbins are put up in a condenser bobbin creel, on surface drums, and it is wound on to a positively driven spindle, a tubular cop being formed in a stationary cup like that of a solid cop winder.

3. **Ring Frame.**—This machine is similar to that used in the cotton trade, but the creel may be either fitted with sheet-metal surface drums to take the condenser bobbins, or the slubbing cheeses are placed separately on small tin tubes with a large bottom flange and which rotate freely on vertical pegs. Either arrangement is only suitable for hard twisted yarn, and requires good raw material. Four-line roller systems may be used in drafting, and a false twist tube is used in the " tube frame." There are also special frames on the market.

Examples of Waste Plants

Example 1.—The following is an example of a waste plant for 2's to 3's counts from low oily waste, for a production of about 300 lb. per hour :—

1 Waste shaker of small size for cleaning sweepings, opener, and scutcher droppings, etc.

1 Willow of the usual standard type, 56 in. wide.

1 Single breaker scutcher to make laps 46 in. wide, with two-bladed beater with hopper feeder and lapping apparatus.

1 Single finisher scutcher for 3 laps up, with regulator.

10 Breaker cards 48 in. wide with lattice feed table for 2 laps, with side drawing for cross feed. Small diameter doffer.

10 Finisher cards with cross feed and with tape condenser for 50 good ends and 2 waste ends, the good ends on 2 bobbins of 25 threads each.

4 Self-acting mules of 575 spindles each, standing in $1\frac{7}{8}$-in. gauge, 72-in. stretch, with treble speed motion to change at any part of the draw.

Example 2.—Waste yarn of 4's to 10's counts from low cotton waste requires the following machinery for, say, 70 lb. of 7's counts per hour :—

1 Willow of the standard type, 56 in. wide.

1 Single beater scutcher for 46-in. laps, with 3-bladed beater, pedal regulator and lapping apparatus.

6 Breaker cards 48 in. wide on the wire, with feed table for 2 scutcher laps, and with side drawing for Scotch feed. ·

6 Finisher cards with Scotch feed with suitable condenser.

2 Self-acting mules of 540 spindles each, standing in $1\frac{3}{4}$-in. gauge, and arranged for treble speed.

Example 3.—8's to 12's weft may be spun by the Derby doubler system somewhat on the following lines, the machines specified being those necessary for a production of about 60 lb. of 10's per hour :—

1 Single scutcher to make laps 46 in. wide, the machine to serve as breaker as well as finisher.

4 Breaker cards 48 in. wide for 2 laps, one behind the other.

1 Derby doubler for 60 cans, to make laps $23\frac{1}{2}$ in. wide.

5 Finisher cards for 4 Derby doubler laps, with tape condenser for 64 good ends and 2 waste ends, the bobbins having 32 ends each.

2 Self-acting mules of 608 spindles each, $1\frac{1}{2}$-in. gauge, double speed, three pairs of rollers, fluted bottom rollers, leather-covered top rollers, saddle, and lever weighting.

COTTON YARN DOUBLING

The term doubling is applied to the operation of twisting together two or more yarns. The single yarns are usually, but not necessarily, of the same count, twist, quality, and colour.

Fancy Doubled Yarns.—When doubled yarns are produced comprising singles, which vary in the foregoing characteristics, the object is to obtain some special effect, and the result is a "fancy" yarn. The most common of these fancy yarns are designated by the following terms :—Chain, slub, corkscrew, loop, knop, knickerbocker, grandrelle, and mock grandrelle.

OBJECTS OF DOUBLING

Strength.—It is not advisable to say, without qualification, that one of the objects of doubling is to attain greater strength. This is a point about which there is much misconception. It is a fact that it requires an exceptionally well-doubled yarn to register a strength even approximating to that of the single yarn strengths added together. The reason for this apparent loss in the strength of doubled yarns is that it is a practical impossibility to arrange two or more threads together, so that each bears an equal share of the total stress which is induced when the resultant thread is put under tension. There are, broadly, two reasons for this :—

1. Difference in the construction of the single yarns.

2. Difference in the tension to which the single yarns are subjected during the operation of laying them alongside each other for doubling.

The second of these reasons is a straightforward case of mechanical manipulation. What it really amounts to is that one yarn is virtually longer than the remainder, and does not pull tight enough to bear its correct share of the stress when tension is applied to the doubled yarn. It is therefore clear that rupture will occur among the components consecutively instead of simultaneously.

The first reason is by no means so apparent, and brings to light a feature which is often overlooked.

A practical example will make the point clear. Assume two single yarns to be doubled together, which differ in the amount of their twists. This often happens, and may be said to be always the case to some degree. Suppose the doubled yarn thus constructed to be subjected to pull. It would at first appear that the softer twisted, and therefore the weaker, would be the first to rupture. The opposite is the case. The softer twisted yarn would elongate considerably before rupture, but this would not apply to the harder twisted yarn, which

would resist elongation. The stronger yarn would, therefore, break first. This explains why hard-twisted yarns are unsuitable for certain purposes. A given yarn will register better on the strength tester than another which is softer twisted, but it does not show the same powers of elongation before break. In this way the impression is often conveyed that a yarn is weakened through added twist, although it is, in fact, stronger. The actual condition is that if the yarn is needed to stand a sudden shock it will fail quicker than a softer twisted one which elongates and resists rupture until the shock has passed, which possibly does not occur again throughout the life of the thread.

The term elongation must not be confused with elasticity. Elasticity signifies the additional property of being able to return to the original size after elongation. Thus elasticity, although a desideratum, is not necessary to illustrate the point at issue.

A synthesis of the foregoing enables one to determine exactly the properties in a single yarn which are chiefly to be sought when it is desired to construct a doubled yarn. They are : Uniformity in count, twist, tensile strength, and elongation before rupture. This means absence of such faults as snarls and soft places which pull out and throw the pull on other component yarns. The consideration of appearance also demands uniformity in the characteristics enumerated.

Referring back to the objects of doubling, it can now be fairly assumed that it is not within practical possibilities to expect, in the doubled yarn, additional strength over and above the sum total of the individual single yarn strengths.

It will be noticed that nothing has been said regarding a comparison between the relative strengths of the following :—

(a) A doubled yarn.

(b) A single yarn of equivalent resultant counts.

That is, a comparison between, say, 10's single and 40's fourfold.

There is no doubt that the latter will be the stronger. The reason is that twist is more thoroughly carried through the mass of fibres by the piecemeal method than when it is done at one operation. And the strength of a yarn depends on the interlocking effect of its naturally-twisted fibres, which effect is only brought to its maximum efficiency by judicious twisting. By inserting twist, also, there is a purely frictional element introduced, *i.e.*, it is possible to form smooth fibres into a yarn by the effect of twist forcing those fibres into contact with one another, and thus causing them to resist the action of sliding past each other.

In addition to the foregoing conclusions relative to strength, the objects of doubling are to obtain greater compactness or density, to stabilise the twist, and to promote smoothness.

Compactness.—This is desirable in practically all the goods in which doubled yarns are used. Although the resultant yarn may be weaker than the sum of the singles, still one which is compact, that is one which possesses solidity to a marked degree, will be stronger per unit of cross-sectional area than an equivalent count of single yarn. This property is particularly desirable in warp yarn, and more especially so in the side ends, which bear a greater strain than the main body of the warp. A good wearing cloth, and one which will offer the greatest resistance to tearing, can obviously only be constructed with a compact warp if fineness of texture is to be maintained. This is quite apart from considerations of loom manipulation, in which there is trouble if the warp yarns have an oozy inclination. In sewing threads the advantage of strength with small diameter is very obvious

Stability of Twist.—This means resistance to the tendency for the twist to run, and is, of course, specially desirable when, in the course of its use, the thread is often broken, *e.g.*, in sewing thread.

Smoothness.—In very many ways this property is of great advantage. With the possible exception of weft yarn, which is used chiefly as a filler, *i.e.*, to obtain cover in the cloth, smoothness is a desirable characteristic of all yarns. This is proved by the methods adopted—preparing, sizing, and polishing—to obtain smoothness from independent agents. Smoothness attained in the grey yarn has the advantage over these artificial agencies, in that loss of flexibility is avoided.

Polish and size stiffens the thread as well as increases its diameter. Moreover, the tendency is for polish and size to rub off when subjected to a chafing action, such as is obtained at the reed of a loom. Under this heading of smoothness may also be included the shrouding of knots and faults in the single yarn. In a good quality doubled yarn it is very difficult to detect the position of a piecing or slub in the single.

Explanations as to how the foregoing objects are attained are so interdependent that a comprehensive explanation will serve. It is possible, without attempting to put forward the theories which are expounded in explanation of the doubling action, to realise graphically its value.

To do this take two extreme cases : A card sliver is, say, 33 grains per yard. This is equivalent in counts to 0·25's, or four times

coarser than 1's. Assuming this to be twisted with a twist constant of 3, the turns per inch would be $\sqrt{0.25} \times 3 = 1.5$. It would be possible to twist this so-called yarn a little harder, but not without causing the usual effect of snarling.

Compare this product with a yarn spun into 10's counts from the same card sliver, and doubled forty-fold. Ignoring contractions, it will have the same resultant counts. What has happened is that the card sliver has been subdivided into forty separate strands. Each of these strands has been twisted, say, to the extent of $\sqrt{10} \times 3 = 10$ turns per inch, approximately. Forty of these strands are then united, so that there are 400 twists in 1 in. of the doubled yarn, each twist having its interlocking and anti-sliding effect. This disposes of the question of strength attainment.

With regard to compactness, this is also obvious, as the diameter reducing effect of twist is many times multiplied in the case of the doubled yarn. The stabilising of twist is also perfectly apparent, as it is inconceivable that the twist can run out of forty single yarns having the locking effect of the doubling twist, which naturally runs in as the singles tend to untwist.

The last object, that of smoothness, is attained by the enhanced bonding effect on the fibres, which keeps the ends to the body of the thread. Loose fibre ends cannot show in the doubled yarn, as they are subjected to minute subdivisions of twist which are entirely absent in the single yarn. Further, faults and piecings in the doubled yarn are distributed so indiscriminately throughout its structure as to be almost imperceptible, whilst for the faults and piecings in the single yarn there is no such protective shrouding.

Purposes for which Doubled Yarns are Used.—So far as cloth is concerned doubled yarn is used in those cases where the weave imposes extra strain on the threads, as in leno fabrics, cords, corduroys, fustians, etc. ; in those fabrics such as grandrelles and other cloths subjected to hard wear in use ; as effect threads in figured fabrics ; for selvage threads and other purposes where greater strength is required than is obtainable in single yarn of corresponding size or counts. The resistance to bursting pressure and rough road usage of tyre fabrics, the resistance to tearing and wind pressure of sail and aeroplane cloths, necessitate the use of special classes of folded yarns in which the strength qualities are developed to the maximum. Various kinds of lace require doubled yarns of high quality. In the manufacture of heald yarn, sewing thread, nettings, twine, etc., strong compact and even thread is necessary, and for these reasons doubled

yarn is used. Crochet yarns must also be strong and even; compactness is not primarily sought. The special method of doubling causes these yarns to be slightly fuller or softer than sewings.

Variations in Machinery.—Since doubled yarns are included in such a variety of goods, the quality required naturally varies, and consequently no hard and fast rules can be cited as to the procedure of manufacture. The differences arise chiefly in the method of preparing the yarn for the doubling frame, but the method of doubling is also liable to variation.

The following tabulations will be found useful in demonstrating the many combinations which are possible from the spinning cop or bobbin to the doubled yarn :—

Systems of Doubling Winding Frames

Type of Creel.	Type of Bobbin on to which the Yarn is Wound.	Type of Traverse and Shape of Finished Spool.	Type of Drive for Winding Bobbin.
To hold the desired number of mule cops, ring bobbins, or doubler bobbins. To unwind over the nose or from the side. If from the side, bobbins or cops mounted on ordinary spindles or Rabbeth spindles.	Double - flanged bobbins or (another name) warpers' bobbins. Paper or wood tubes. Single - flanged bobbins.	Quick traverse; parallel wind. Quick traverse; conical wind. Slow traverse; barrel-shaped wind. Slow traverse; parallel wind. Variable traverse; bottle-shaped bobbin. Traverse mechanism may be :— (a) Mangle wheel. (b) Cam. (c) Hill & Brown split drum.	Single drum. Double drum. Upright spindle; "Rabbeth" type. Horizontal spindle; "Universal" method.

It will be seen from the foregoing that there are almost innumerable systems of winding and rewinding. Often doublers will employ different methods for exactly the same class of work. There is still greater diversity in reeling the doubled yarn, and after dyeing, etc., rewinding on to bobbins or spools suitable for the next process. The above does not include such minor modifications as length of traverse.

Systems of Doubling Frames

Type of Creel.	Type of Bobbin on to which the Yarn is Doubled.	Type of Build.	System of Doubling.	Class of Machine.	Spindle Drive.
Upright or vertical creel, *i.e.*, creel pegs vertical or nearly so. Various number of decks.	Paper tubes.	Parallel.	English dry.	Ring.	Band.
	Double-headed bobbins.	Taper.	English wet.	Flyer.	Tape.
Porcupine creel. Various number of heights.		Cop build.	Both the above with various methods of threading.	Twiner with stationary creel.	Belt.
Desk creel.	Single-headed bobbins.				Rope.
Creel suitable for cops or bobbins, unwinding over nose or from side.			Scotch wet.	Twiner with moving creel.	
Horizontal creel; axis of pegs parallel to axis of rollers.					
Creel to carry small beams on which ends are wound like warp beams.					

It must not be understood from the foregoing that it is possible to have any combination, although this is almost correct. For example, a ring doubling frame may be on the wet or dry principle; it may have any type of build and any type of creel, but its spindles are in no case driven by belts.

A few typical systems may now be given as examples of general procedure :—

Example I.—Two- or Three-Fold Warp—Plain or Gassed

Single : Mule cops, soft spun twist way. Wound two- or three-fold on quick traverse drum winder. Twisted weft way on wet or dry ring doubler. Rewound on to warpers' bobbins and cleared of lumps and bad ends. (Or, if for gassing, rewound on vertical spindle machine and gassed.) Made into beams at the warping frame.

If for export, it will not be beamed but wound on paper tubes convenient for the warpers' creel.

Example II.—Three-Cord Sewings

Single : Flyer throstle, ring or mule twist. Wound single on the vertical spindle winding frame. Twisted weft way from the single wound bobbins, *i.e.*, three creel bobbins to each spindle. Wound on bobbins for reeling, or reeled direct from doubler bobbins.

Delivered to dyer, etc.

Three-Cord Sewings (Alternative System)

Single as above.

Three ends wound together on the drum winder. Twisted weft way from the double-flanged bobbins, one bobbin to each spindle.

It is claimed that, for ring yarn especially, a stronger doubled yarn is obtained by the former system. This is because the three ends are laid side by side at a slower speed in the doubling frame than at the winding frame, and consequently there is less danger of inequality of tension by over-running.

EXAMPLE III.—Four-Cord Sewings

Twist way single yarn wound two-fold from cops or bobbins on the drum winder.

Twisted on the doubling frame the same way as spun. This is termed the preparing twist.

Rewound on the doubler winder on to double-flanged bobbins—two strands together.

Twisted weft way on the wet doubling frame (finishing twist).

EXAMPLE IV.—Six-Cord Sewings

Exactly as above, except that at the finishing doubler three strands of two-fold are twisted together. All sewings are polished.

EXAMPLE V.—Six-Cord Crochet

Twist way single yarn wound two-fold from cops or bobbins on the drum winder.

Twisted weft way on the doubling frame.

Rewound three strands together.

Twisted twist way on the doubling frame.

Crochet yarns are not polished, thus the cotton used must receive consideration as regards appearance.

Winding before Doubling.—This question devolves itself into the advantages of having a winding bobbin, viz., double headed, quick traverse or single headed, in the creel of the doubling frame. Imagine the doubling frame creel to contain ring bobbins, mule cops, or doubler bobbins, the following conditions would prevail :—

1. There is no drafting in the doubler, consequently the yarn is being uncreeled at a quick rate, particularly on coarse work.

Since piecings would be frequent, it follows that there is :—

(a) Detrimental effect on the yarn due to cork screwing, unless the piecing is performed very carefully.

(*b*) A necessity for more operatives per unit number of spindles with cramped working conditions due to other operatives often being necessary in the same alley for doffing, cleaning, greasing, banding, etc. Also conditions in the doubling rooms are such that the staff should be kept to the absolute minimum.

(*c*) A considerable stock of bobbins or cops on the creel tops. This is an inconvenient form for yarn to be stored, and there is considerable danger of mixtures when two sides of the same frame are on different work.

(*d*) A limiting of production in the doubling rooms, due to ends running out and the creation of waste, since there is no really satisfactory stop motion, particularly on low gauge frames.

2. Inequality of tension in individual ends feeding the same doubler spindle. The comparatively rapid changing of diameter in the material on the bobbin or cop is responsible for this. This objection would not be so pronounced in the case of doubler bobbins with parallel build feeding the finisher doubler.

3. The passage through of bad piecings, slubs, pieces of adhering seed, etc., the arrangement of any method of clearing at the doubling frame would so limit operating space and production as to be out of the question.

Winding before the preparing doubler and rewinding before the finishing doubler has for its objects the avoidance of the adverse conditions quoted. The first condition is very simply overcome by transferring to large capacity bobbins the contents of several cops, ring bobbins, or doubler bobbins. Secondly, inequality of tension is considerably reduced, if not entirely eliminated, by the provision of a yarn container which holds, say, 1¼ lbs. of yarn, and which, therefore, only slowly reduces in diameter in the doubling frame creel. Lastly, the process of winding clears the yarn of loose impurity by such provisions as flannel-covered boards and snick plates. Also weak places fail during winding, and are thereby removed. Anything not loose and not weak, such as snarls, knots, or bad piecings, are caught in the snick plates, and brought to light by breakage.

General Process Principles, Construction and Action of Winding and Doubling Machinery.— Single is received in the winding room either from outside spinners or from the spinning room of the same or an adjacent mill. If yarn is from the same mill it is received in sets. Yarn from outside spinners, whether ring or mule, is received in cases or skips. From the doubler's point of view cases are preferable, as the cops retain their shape, and consequently there

is less waste from bad skewering. Skips are used because they are cheaper in first cost and less liable to damage from rough usage.

When yarn is spun on the premises it reaches the winding room in complete sets or doffings from the ring frame. These sets are generally contained in doffing skips or tins. In the case of mule cops one box or skip would contain a doffing from half a side (long or short).

Counts and strength of incoming yarn should be regularly tested, compared with a standard list (which is often a little more elastic than the buying specification), and passed or condemned. The same standards are not necessarily insisted upon for the same count as they may be for different purposes. For example, yarn for 6-cord sewings need not show the same pull as single for 3-cord sewings, as the former may contain less twist. A typical standard list is given. It will be noted that only a minimum count is given; this is because spinners, in their own interest, see that they do not spin yarn which is finer than the count specified.

APPROVAL LIST

Minimum Lbs. Pull on 1-Lea Tester

Nominal Counts.	Counts not to be Coarser than :	Average Strength of 7 Cops not to be Less than :	
		For 3-Cord.	For 6-Cord.
20	19	100	...
22	21	90	...
24	23	83	...
26	24½	77	...
28	26¼	68	60
30	28	64	56
32	30	60	52
36	34	56	48
40	37½	50	42
46	43½	45	38
50	47	42	36
60	57	37	33
70	66	33	29
80	76	30	26
100	96	24	21
110	106	22	19

DOUBLER WINDING

Upright Spindle Winder.—If only one end is required on each bobbin, the most suitable machine to use is the upright spindle winding frame.   Double-flanged bobbins would be used.   This machine has a slow traverse, and the shape of the full bobbin may be cylindrical or slightly barrelled.   The most favoured shape of full bobbin is as shown in Fig. 1.   This is done by having quick changes at the ends of the traverse and by having the length of traverse rather shorter than the distance between the flanges.   The object is to avoid the evil shown in Fig. 2, which results in waste through the yarn rubbing off the flanges during transit and creeling.
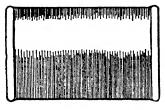
FIG. 1.   FIG. 2.

The upright spindle winder has one outstanding fault as compared with the drum winders; its winding speed is not constant.   The bobbins receive their rotary motion from spindles of the Rabbeth type.   There are two rows on each side.   The spindles are driven from a tin roller, and the wharves on the front and back row may be $1\frac{1}{4}$ and $1\frac{1}{2}$ in. respectively.   The fault mentioned above is modified by transferring half-filled bobbins from the front row to the back row of spindles, where the speed is reduced by one-sixth.   Usual spindle speeds are 600 and 500 revs. for front and back rows respectively.

The bottle-shaped bobbin is made on the upright spindle winder, and is usually employed when the yarn is to be unwound at a rapid rate over the end of the bobbin.

This machine is suitable for the fitting of a central travelling apron to take away and deposit into a skip empty ring bobbins.   There is no stop motion applied to the upright spindle winder.   The winding-on spindles should be pumped and oiled every twelve weeks.

Slow Traverse Drum Winder.—This machine is the one most generally used for winding two or more ends together in preparation

for either the preparing or finishing doubler. Since the bobbins are driven by the drum's frictional contact with the yarn, the winding speed is kept constant throughout. The points to be watched in this machine are :—

1. The maintenance of equal tension in the individual ends.
2. Correct adjustment of the snick plates.
3. The efficiency of the stop motion.
4. The building of a well-shaped bobbin.

The first is usually obtained by having tension guides which are adjustable. The tension should be so set as to be as light as possible consistent with keeping the detector wires steady. Insufficient tension means a vibrating detector wire and frequent knocking off. It is also important to set the creel spindles correctly if the yarn is pulled off over the nose. This is most satisfactorily done by passing the yarn over the drag rod and noting whether the spindle point is cleared all round. Practically, this is simply a method of setting the spindle so that a prolongation of its axis is tangential to the surface of the drag rod or its equivalent. It is obvious that the foregoing conditions are not necessarily fulfilled by merely setting the spindle point vertically under the point of contact with the drag rod periphery.

The snick plates are important. They should be set by leaf gauges to a correct distance for the particular count. If the means of adjustment is accessible, winders will open the snick plates to improve production. A good method is to have the locking screws so placed that a special box key is necessary to get at them ; this method is less cumbersome than padlocking.

In order to be efficient, a stop motion should operate so quickly that the bobbin is stopped before the broken end is wound on. For this reason extra runners are often favoured which gives the yarn a greater distance to travel to the bobbin after the bobbin holder has been thrown forward.

A well-shaped bobbin is essential if waste is to be kept down. Sometimes overlookers are handicapped by poor quality bobbins, i.e., those with flanges which are twisted. Under these circumstances a good build is impossible. In any case it is important that the traverse motion be kept in good condition. Any of the following mechanical faults will cause badly-built bobbins: Ridged cams, cam bowls worn down or containing flats, loose connections at the lever joints, and thread guides which are too open or which are nicked. Guides should be as near as possible to the winding-on point.

This type of winder may be belt or motor driven. In one type of

machine, if belt driven, the fast and loose pulleys are on the drum shaft, and there is another drive down to the double worm driving the cam. When motor driven, the motor shaft is connected direct to the worm shaft which would have a single worm to get the necessary speed reduction. There would then be a separate drive up to the drum shaft.

Quick Traverse Drum Winder.—This type dispenses with flanged bobbins. The yarn is wound either in parallel or conical tubes, generally the former. Quick traverse winders are broadly of two types, according to the method of giving the traverse. In the first type a cam motion is used which controls the traverse of all heads alike. For small lots this is a disadvantage, and it is overcome in machines of the Hill and Brown type, where split drums control the traverse at each head. The length of traverse and its shape can be controlled independently on each individual cheese.

Advantages of the quick traverse drum winder are more pronounced when the yarn has to be transported, since the tare weight, both ways, is practically eliminated. It also places the yarn in a form which can be wound over the end if necessary, and which is convenient for dyeing in cheese form. For ordinary doubler winding, however, the double-flanged bobbins form a better protection for the yarn. It should not be overlooked that, in the production of conical bobbins, there is a loss of winding speed at the small end.

Notes on Winding Generally.—In winding from ring bobbins over the nose there is a tendency for snarls to be formed, particularly if the yarn contains any more than weft " turns." Tightly wound two- and three-fold warp yarn should not be stocked for long periods on flanged bobbins, as there is a considerable end thrust exerted which often forces off the bobbin ends. Fine two-folds, say from 120's up, are usually doubled direct from cops. Fine three-folds are usually wound first, since they cannot be doubled direct without much waste, failing the provision of a doubling frame stop motion.

Winding for high doublings with an awkward number, such as fifteen-fold for netting, should be specially regulated. Two-fifths of the total weight would be wound two-fold, and three-fifths three-fold. These would be placed one of each to a doubling spindle and twisted five-fold. In this way the size of knots is kept down and, when piecing, the tension of the remaining ends on the same winder's bobbin is less liable to be disturbed.

Waste in cop winding needs careful supervision by the overlooker. If he is too strict, winders will not disclose all their waste. It should

be examined more from the point of view of detecting mechanical faults or faulty cops than to attach the whole blame to the winder. If a winder consistently makes much waste in spite of changes in quality and changing over of frames, it rests with the overlooker to decide whether or not it denotes conscientious operation.
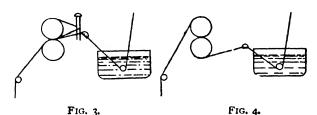
Overfilling of flanged bobbins needs continual checking.

Stabbing or bad skewering is more often caused by faulty skewers and distorted cops than by bad manipulation of the winder.

Close watch should be kept for " double," since no mechanical contrivance can absolutely prevent it.

Rewinding, *i.e.*, the transfer of yarn from preparing double bobbins to doubler-flanged bobbins for the finisher doubler is a similar operation to cop or ring bobbin winding. The chief differences are the provision of a suitable creel peg and anti-ballooning plates for the doubler bobbins.

For knittings the yarn is doubled " single throw," *i.e.*, at one operation.

FIG. 3.   FIG. 4.

DOUBLING

The Ring Doubler.—This is the most common type of doubling frame. It is constructed on very similar lines to a ring spinning frame. with the omission of the drafting agents. The two broad types of ring doublers are :—

1. Wet doublers.
2. Dry doublers.

Each of these types has different methods of roller arrangement.

WET DOUBLERS.—English No. 1 Method (Fig. 3) is usually employed on fine work.

English No. 2 Method (Fig. 4) is a fairly general arrangement.

American Method (Fig. 5) is used on these classes of work where heavy drag is required.

I 3

RING DOUBLING: SIZES OF RINGS

Diameter of Ring.	Spindle Speed.	3-Cord.	2-Ply Preparing for 4-Cord and 6-Cord.	4-Cord Finishing.	6-Cord Finishing.	Crochet Preparing.	Crochet Finishing.
2¼ in.	5500	20-24	...	28-32	30-50	10-16	10-50
2 in.	6500	28-40	28-32	36-50	55-80	18-32	60-80
1¾ in.	7000	50-80	36-60	60-80	100-130	36-60	...
1½ in.	7500	...	70-120	...	...	70-80	...

however, double fine yarns without injury. Owing to the comparatively large gauge of these frames, a satisfactory stop motion can be installed which operates on roller and spindle. Flyers are screwed on—not of the pin and slot principle adopted in fly frames—since the pull on the yarn tends to lift the flyer. Spindles may be adapted to run either twist or weft way by the provision of a double screw at the top.

The outstanding disadvantage of a flyer doubler is that the flyer must pull the bobbin round more rapidly as it fills. This is counteracted by the increased diameter affording the yarn greater leverage. The result is an indeterminate tension. This variation is supposed to be catered for by the provision of a means for regulating the drag on the bobbin. At the best these provisions are crude and are left to the discretion of the operative. In addition to the foregoing, the bobbins are subjected to wear in the bore as they revolve at a different speed from the spindles and traverse them vertically.

Work produced from this machine is of good quality if attention is paid to spindle bands or belts. Care must also be exercised in piecing the single ends to avoid corkscrewed yarn.

Flyer doubling is preferred for lace, because of the compact thread which can be produced by the use of the drag band. This method of inserting drag or tension would have its equivalent in a heavier traveller at the ring doubler, but the use of a heavy traveller has so many attendant disadvantages as to preclude its use.

Twiner Doubler.—This machine is the counterpart of the mule in the same way that the flyer doubler is of the flyer throstle and the ring doubler of the ring spinning frame. There are two types of twiner :—

1. The Yorkshire twiner, in which the spindles do not move through space—the opposite to the spinning mule.

2. The French twiner has a stationary creel, and the spindles move through space as in the case of the mule.

The twiner can be made to accommodate most classes of work which are possible on the ring doubler. The advantage of the twiner is that wet doubling can be performed without the use of ring grease. A cleaner yarn is the result. Also the twiner, in common with the mule, inserts twist more uniformly than a machine of the ring and traveller type. The twiner carries with it the disadvantages of the mule, viz., the necessity for skilled operatives and the absorption of more floor space.

Twist.—There is no such condition as standard twists in doubling. Often customers specify their own twist. In setting out twists it should be clearly understood whether the turns are calculated on the twisted or untwisted length. Also the requisite allowance should be made for the diameter of the spindle band and slippage. In addition, there is often a variation amounting to one tooth on the twist wheel between the negative and positive side of a double tin roller frame with one roller " negatively " driven. It must also be borne in mind that there is a considerable amount of stretch in some of the later processes, *e.g.*, winding, reeling, and gassing. In any case, when a frame is changed, the twist should be checked on a twist counter very soon after starting up, as this also brings to light any possible error in the twist wheel. If one test shows a shortage of twist, another should be taken, as there is often a variation of 10 per cent. between one spindle and another.

A good average multiplier ($\sqrt{\text{counts}} \times$ multiplier $=$ turns per inch) is 4·2 for two-fold warps, 3-cord sewings, and preparing 4 and 6-cord sewings. From this basis the following general rules will enable a fairly good idea to be formed of prevailing practice :—

1. Coarser counts require a higher multiplier.

2. Six-cord finishing has a slightly lower multiplier than 4-cord finishing.

3. In sewings, the finishing multiplier is higher than the preparing multiplier.

4. In crochet, the finishing multiplier is lower than the preparing multiplier.

5. Nettings have a comparatively low finishing twist, as the product must be pliable.

NOTES ON MODERN RING DOUBLING

Principles which should be observed in any doubling process are : uniformity of tension ; facility to obtain any desired elongation ; regularity of twist ; facility to obtain any desired twist ; cleanliness.

The ring doubling frame has largely superseded the flyer and twiner frames on account of its increased productive capacity, and the following remarks concern only this method of doubling. The yarn to be doubled may be in the form of cop, ring bobbin, winders bobbin, ply bobbin, single or ply cheese, or beam, and is placed in a suitable creel from which it traverses around rollers to a guide eye, thence through the traveller to the doubled yarn bobbin.

The Creel.—The creel is a more important adjunct than is generally imagined, for through maladjustment of this part cork-screwed yarn can easily be produced. The important point is that all the threads should be at the same tension. This is not easy of accomplishment when doubling from single-end bobbins or cheeses, owing to the relative weights of yarn to bobbin or centre giving varying tensions in the yarn between full and empty bobbin or cheese.

The tension in the thread as it is pulled off depends on two factors : (1) the effective radius at which the tension is applied in rotating the bobbin ; and (2) the friction of the creel peg in its bearing, which is determined by the weight of bobbin and of yarn. The weight of yarn decreases as the pulling-off radius decreases, and the two factors compensate to allow less variation of tension. However, there is a best weight of bobbin or centre for any set of conditions, and this can be calculated so as to give optimum results. What should be done is to arrange the weights and radii of peg and empty package, and possibly shape and dimensions of bobbin, to give the best effect upon evenness of tension. Better tension may be obtained by using a cheese-shaped bobbin (*i.e.*, with cone ends) similar to a roving bobbin.

Some of the troubles with creels are : bobbins sticking on the pegs ; bobbins overrunning ; threads fouling each other ; threads breaking without causing the doubled thread to break ; stoppage of frame for creeling ; waste on bobbins, or yarn left on bobbins.

The beam creel has, on the whole, perhaps fewer faults than the porcupine creel, but it has one or two which do not apply to the latter creel. The beam must be perfectly level, otherwise the amount of yarn being delivered will vary at the different parts of the beam. This has to be particularly watched at the positions near the flanges. Then, again, when an end breaks between the beam and the rollers, a lapper is formed on the beam and a certain amount of skill is

required in cutting off the lapper and repairing same. The method of doubling from beams is cheaper than from bobbins, owing to the larger amount of yarn handled at one operation, and there being no bobbin pieces and less waste. Of course, there is the extra cost of beaming to offset this reduced cost.

Rollers.—The yarn is drawn from the beam or bobbins by rollers, and some attention should be given to these rollers to ensure the take-off being as positive as possible. The weight of the top roller and the arc of contact the yarn makes with the rollers are important points—so much so that the system of three lines of rollers is gaining in favour. In this method the yarn is passed under the front and back bottom rollers, and over the top roller, so that the latter tends to be pulled between the other two, this resulting in a very efficient take-off.

With the two-line system there are numerous methods of threading the yarn, each claiming some particular advantage; but there is one kind of yarn which, perhaps, needs special mention—namely, very hard-twisted yarn. If this is threaded so as to pass from the top roller to the lappet, it runs off the roller into the roller neck when the frame is stopped, resulting in dirty and faulty yarn. As a consequence, it is usual to thread the yarn so that it passes from the bottom roller to the lappet. But even so there is often trouble from the same cause. This trouble is eliminated with the three-line system. Another point which often escapes notice is the fact that knots, especially in the cabling process, frequently wedge between the rollers in the two-line system, and cause the yarn to be over-twisted to such an extent that it either breaks or produces sufficient tension to pull the knot through the rollers. This fault is very easily overcome by the use of knurled or fluted bottom rollers, or by the three-line roller system.

Wet Doubling.—The troughs should be arranged so that the water whi ch drops off the rollers should drop back into the trough and not on to the roller beam and then on to the bands, with deleterious results. The glass rods should always be partly or wholly immersed in the water, preferably the latter, as in the former case it often happens that the water in the trough becomes rather low, and the yarn does not touch the water. Hence the yarn is dry-doubled instead of wet-doubled, and when mixed with wet-doubled yarn subsequently very serious results ensue.

Rings and Travellers.—The number of shapes and types of travellers which have been patented and used is legion. Most of these, though, have either been discarded or gone into disuse in favour of the standard ear-shaped or C-shaped types.

The travellers appear to vary slightly in hardness, and this is probably the cause of the variation in wear, and the consequent variation in tension, due to the difference in the amount of friction.

The yarn is led from the lappet-guide under the traveller on to the bobbin. As the bobbin rotates, the traveller is pulled round in the same direction by the yarn. The rapid revolutions cause the traveller to fly outwards and exert a pressure against the ring. The friction set up by moving the traveller round the ring is thus greater the heavier the traveller, or the greater the number of revolutions per minute. This friction has to be overcome by the tangential component of the tension in the yarn. It will be seen, therefore, that since the tangential force required is the same for full and empty bobbins, the tension in the yarn will have to be much greater when doubling on to the empty bobbin. One fact which counterbalances this defect, however, is that the rings are usually lubricated at the beginning of a sett, and this reduces the friction of the traveller and ring, and hence reduces the tension in the yarn, making it approximate to the tension on a full bobbin.

The indefinite method of lubricating the rings is certainly a factor in the variation of tension of the different threads during doubling, and should therefore be given more consideration than is generally the case. Another point in this connection which is worthy of consideration is the consistency of the lubricant for winter and summer conditions, requiring to be more viscous in summer than in winter.

Traveller Tension Testing.—One of the most important points in cabling is to double yarns from all spindles at the same tension, so that when the yarns from the different spindles are subsequently used collectively, each thread takes its due proportion of stress. If the component threads are not doubled at uniform tension, corkscrewed yarn will result in cabling. With ring-and-traveller method perfection in this respect is well-nigh impossible, but it should be the aim of every manager to attain as nearly as possible to the desired state. To this end it is desirable that the relative tensions should be tested, and it is not very difficult to institute a simple expedient for testing the tensions of the yarns on the different spindles. The rings themselves vary in frictional resistance, and it is found in practice that different rings require different weights of travellers. This causes endless trouble and tedious testing, but it is suggested that it is well worth carrying out to obtain optimum results.

Plate Washing.—It is necessary to wash the rings and plates periodically to rid them of the dirty grease and foreign matter, especially when wet-doubling. There are several methods which

present themselves for consideration, the simplest being a bath of water and soap heated with steam. A recent innovation is the Meynall's burnishing machine. Another method depends on dissolving the grease by a heavy vapour, then recovering the grease. It is found, however, that the grease after recovery is hardly fit for use on ring plates.

Ring Sections.—Recently there have come into use rings of different sections, notably the deep-sectioned ring, both plain and grooved. These naturally necessitate different travellers. The grooved ring is supposed to retain the grease, so that it is used as required. But it is very questionable whether this is as good as the plain sectioned ring. Apparently the rings become dirtier with the grooved ring than with the plain ring. Again, it is observed that with plain rings the grease, if of proper consistency, is retained near the top of the traveller for a very long time—practically until the time for re-greasing—so that, on the whole, plain sectioned rings are preferred.

Another type of ring is grooved, and a hole drilled from the front of the ring to enter the groove. A felt pad is inserted in the front of the plate, so that when the pad is oiled the oil percolates through the hole to the groove, and thence to the traveller. This appears to be promising if an oil can be obtained with the same lubricating properties as grease.

Driving of Spindles.—Ring doubling frame spindles are usually of the self-contained type, with the exception of the very heavy doubling frames, where a plain spindle, supported by bolster and footstep, is used.

The general method of driving is by either tubular or solid cotton band from one or two tin rollers, the latter being more usual, since it allows of a 4 to 6 in. narrower frame, and less trouble due to bands coming off the spindle wharves. There is, however, a slight loss of twist on the negatively driven side.

Wet-doubling causes a lot of trouble with the bands, owing to the water being thrown on to the bands from the rotating yarn, and in many cases water running from the troughs on to the bands. This causes the bands to contract, and ultimately to break. Tubular bands treated with cutch dye have been found to be advantageous, as also have solid bands treated with rubber latex. The rubber also gives a better grip, and hence a more efficient drive. Tape driving is rapidly gaining favour. The use of one tin roller and a jockey pulley allows of a constant tension of driving tape. This tension, being governed by the weighted jockey pulley, removes the danger of

bands being put on too tightly, with resulting heavy wear of bearings and high power consumption. Owing to the long life of tapes, the cost is less than that of bands, and since fewer spindles are stopped, due to fewer tape breakages, the efficiency of the frame is increased.

On light doubling frames one tape drives two spindles on each side, while on heavy frames one tape drives only one spindle on each side. Wherever possible the latter method should be adopted, owing to the more efficient drive.

Wrong Foldings.—It is suggested that whenever plied yarns are being doubled the same number of ends should be run on the ply winder, *e.g.*, if a five-fold yarn is to be doubled from ply-wound cheeses, the cheeses should be five-ply cheeses, and not one three-ply and one two-ply cheese. The latter make for wrong foldings in the doubled yarn.

Specifications.—The modern tendency is to ask for yarns to be supplied to some particular specification. In a doubled yarn the particulars specified are resultant count, folding, strength, twists, and elongation at a certain load or at break. The testing machines required for these are : balance, twist tester, strength-testing machine, with or without autographic recording device. The maximum strength depends naturally upon the type of fibre, but as regards doubling, it depends upon the absolute uniformity of length of single yarns per unit length of doubled yarn. The elongation is determined by the weight of traveller and the tension of any subsequent operation, such as winding, etc.

THE MANUFACTURE OF SEWING COTTON

Threads.—Sewing cotton may consist of 3, 4, 6, or even more yarns of counts, ranging from about 16's to 130's. Three or four fold yarns which may not be combed are usually one-throw, in which folding twist is in the opposite direction to the singles. Six-fold thread is cable-laid ; the singles are doubled in the same direction, and the three doubled threads are then twisted in the opposite direction. The threads are usually knotless or free from bunch knots.

Doubling.—The yarn is usually multiple-wound on the stop-motion doubling winding machine, and wet-doubled on the English or Scotch type of ring doubler, or in some cases still on the flyer frame. If the thread is to be cabled, it is then again wound on a doubler winding machine—this system giving more even tension of the components and avoiding bunch knots—but it may be put singly in the creel of the twister. In some cases, it is wound on to

beams, and it may have been passed through a clearing frame. The thread is then again twisted on a suitable rung or flyer twister. The cord is then reeled into 54-in. hanks and linked together to form a continuous chain, or it may be wound on warpers' bobbins and made into a chain warp on a chaining and linking machine.

Bleaching and Dyeing.—The chain may be kier-boiled with caustic soda, and then washed and plaited into a cistern and chemicked with bleaching powder solution. It is then soured, washed, and again soured and washed. The whole process may then be repeated. The thread is then hydro-extracted and treated in wash stocks with hot soap solution, after which it is blued if required white, and again hydro-extracted. If the thread is to be dyed, the bleaching process may be shortened. The dyeing is carried out in dye-vats. The final processes are stove drying and cooling.

Polishing.—The threads may be polished in hanks, warps, beams, or from bobbin to bobbin. The thread is drawn by squeezing rollers through the polishing mixture or size of various composition, usually chiefly farina, paraffin wax, and olive oil soap, which also increases the weight of the threads. The fibres are laid by brushes, and the contact is adjustable. In bobbin-to-bobbin machines the thread is drawn through flannel-covered drawing-off rollers, whose speed can be adjusted to control the tension.

Spooling or Balling.—Automatic spooling machines are used where there is continuous production of one size of thread wound with a certain length on one spool. The empty spools are fed automatically to the spindles, and winding commences. When full, the winding stops, the spools are nicked and the thread caught, and the spools automatically doffed. On semi-automatic machines a full-stop motion is fitted. Different counts or shapes can be wound on each head. The attendant has to start the winding, nick the spool, and fasten the thread. The spools are then ticketed and parcelled in dozens.

For balling, fully or semi-automatic machines may be used. The Baines fully automatic winds any predetermined shape and length of ball, places a ticket in place, and holds it until the edges are covered, stops, cuts and secures the end, and recommences winding. For small quantities the semi-automatic would be used.

THE MAKING OF FANCY YARNS

Fancy yarn, otherwise known as " novelty " or " effect " yarn, may be described as any single or folded yarn possessing features which are specifically distinct from the ordinary commercial yarn, where uniformity in colour, thickness, twist. strength, and elasticity are the important features. Some yarn possessing these normal features may be, however, described as fancy yarn, if it is formed from different kinds of fibre or yarn, or similar fibre or yarn of different colours. The production of fancy yarn for the ornamentation of cloth, for knitted goods, or for general decorative purposes has increased considerably in recent years, but there is still a very wide field open for exploitation.

The more common fancy yarns now in use may be classified as follows :—

1. Spiral or Corkscrew Yarn.
2. Covered Yarn.
3. Snarl Yarn.
4. Loop Yarn.
5. Slub and Flake Yarn.
6. Knop or Spot or Bead Yarn.
7. Chain or Gimp Yarn.

These may all be classed under two main types. In the first, which includes 1, 2, 3, 4, and 7, the essential feature in construction is the combination, by twist, of yarns of varying count, twist, character, and length, and in the second, which includes 5 and 6, the employment of intermittent or variable delivery speed, though this is not essential in making 6, as an oscillating guide, operated on the lines shown in Fig. 6, may be employed instead of an intermittent feed.

Besides the classes of fancy yarn just enumerated, very many others, ranging from slight variations from yarn of normal construction to elaborate combinations of several types, are produced. In addition to these, there are other types of yarn made which may be described as fancy yarn, such as chenille, printed yarn, etc.

As in general the strength of a fancy yarn is dependent on the strength of the ground yarn, it is obviously important that this shall have the necessary strength, etc., to resist breakage. For this reason two singles are frequently employed to form the ground thread. In addition to serving this purpose, the yarn forming the ground should, as far as possible, contribute to the production of effect, and to the formation of a resultant yarn which will pass satisfactorily through subsequent processes.

The effect yarn should be selected primarily for effect, but consideration should also be given to the relative character of the ground and the material employed for effect, so as to facilitate satisfactory processing, and so that maximum effect, together with utility, is obtained.
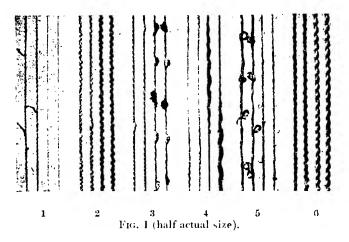
To ensure the satisfactory formation of some types of fancy yarns, or their successful passage through manufacturing or finishing processes, it may be necessary to introduce a binding or tie thread. In such a case, the tie yarn may either be introduced at the final twisting operation in the making of the fancy yarn, or in a subsequent operation, so as to avoid interference with the proper construction of the yarn. The binding thread may be so used as to add its strength to that of the ground thread.

The methods by which fancy yarns are produced vary widely. Some of them can be made on ordinary spinning or doubling machines, without any alteration, and some by slight modification of the rollers or the roller driving ; the yarns so produced can be made relatively cheaply. In making many of these yarns, it is, however, necessary to employ a special type of machine known as a " fancy " doubler. Such machines vary in construction, some being built to produce those yarns in which no drafting action is required, and others in which every type of yarn enumerated can be produced. In the former case, two separate pairs of rollers, mounted at different heights, for convenience, are often employed, provision being made for a very wide range of twist, and for variable or intermittent speed of one pair of rollers. In the latter case, two or more pairs of rollers are mounted close together on a roller beam, giving facilities for the drafting of suitable material, in addition to providing almost unlimited facility for variation of twist and delivery, as shown in Fig. 2. In both cases, suitable stationary or oscillating guide bars for the yarn may be employed.

Fancy yarns made on a spinning machine are usually produced by varying the draft in the drawing rollers from no draft to the normal amount or, in some cases, to an amount in excess of the normal. The draft may vary gradually between two extremes to produce a yarn with corresponding changes in thickness, or the draft may change suddenly to produce more clearly defined changes in thickness.

A single yarn of variable thickness can be produced by driving the back and middle rollers at a variable speed, as by eccentric wheels, and a single slub, by any means which will give occasional accelerated motion to the back and middle rollers, but in both cases the amount of variation in thickness, and the spacing of the thick or thin places,

will be governed by the general conditions in the spinning machine. In addition, for some purposes, single yarn which is as irregular as possible is produced on a spinning machine, without any mechanical alterations. In this case the irregularity may result from the character

FIG. 1 (half actual size).

of the material, the method of preparation of the rovings, and the roller settings.

Spiral or Corkscrew Yarn is shown at No. 6, Fig. 1. It may be produced in a variety of ways, some of which are as follows :—

(a) By twisting together yarns of different count.

(b) By twisting together yarns of varying twist.

(c) By twisting together yarns of opposite twist.

(d) By twisting together yarns of unequal delivery.

(e) By twisting together yarns of different character.
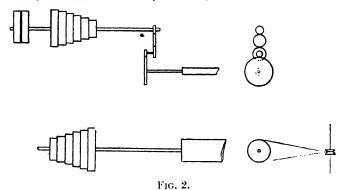
If coloured yarn is employed, the prominence of the spiral may be accentuated or reduced.

Within reasonable limits all these yarns except (d) may be produced fairly successfully on an ordinary doubling frame, without any special provision, and (d), within limits, may be produced on a similar machine fairly successfully if suitable top rollers, such as grooved rollers, are employed. The use of two lines of delivery rollers and a fixed guide bar, shown in Fig. 3, is, however, advantageous, as it ensures more satisfactory control of the material, and permits

the satisfactory folding of yarns of more widely varying character than otherwise. In the production of such yarn it is frequently advisable to wind the singles on to separate bobbins or cheeses, on account of difficulties which may arise in doubler winding yarns varying in count, twist, and character.

Particulars of methods of production may be as follows [*Note.*— T.W.=twist-way twist, *i.e.*, anti-clockwise or in doubling parlance " right " direction of twist ; W.W.=weft-way twist or reverse] :—

(*a*) Assuming 9's T.W. (9 t.p.in.. *i.e.*, 3 $\sqrt{\text{counts}}$) and 36's T.W. (18 t.p.in., *i.e.*, 3 $\sqrt{\text{counts}}$) are folded with 9 t.p.in. W.W. In the folded yarn the 36's retains 9 t.p.in. T.W., whilst the 9's is left devoid

FIG. 2.
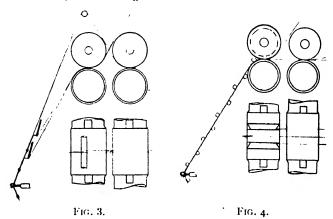
of original twist, causing it to form a spiral round the 36's on account of its thickness and softness, and also, because its lack of twist will cause it to stretch and lengthen when delivered from the rollers and wind slackly round the 36's, though both are delivered from the same rollers.

(*b*) If two singles of 16's T.W., one 10 t.p.in., *i.e.*, 2·5 $\sqrt{\text{counts}}$, and the other 20 t.p.in., *i.e.*, 5 $\sqrt{\text{counts}}$, are twisted together with 10 t.p.in. W.W., a spiral yarn will be produced, as the softer twisted single will have all its original twist removed, causing it to become very soft and thick and to lengthen and stretch when delivered, and form a spiral round the other which is harder, as half the original twist remains in it.

(*c*) If a 20's T.W. spun single and a 20's W.W. spun single are folded together in either direction so that one of the singles is left almost devoid of original twist, the other will be harder twisted to a

corresponding amount.   The result will be that one single will
contract and become harder, whilst the other will extend, due to the
removal of twist, and will become softer, and stretch, causing it to
wind slackly round the other and form a spiral yarn.

(d) If two singles which are similar in every feature are delivered
at different speeds and twisted together, a spiral yarn will be formed,
as the single which is delivered at the higher speed will wind slackly
round the tighter single.   The prominence and pitch of the spiral
will be affected by the amount of twist inserted in folding and the
relative length of each single delivered.

FIG. 3.   FIG. 4.

(e) If two singles of approximately equal thickness, made from
material of widely differing characteristics, such as cotton and linen,
cotton and filament artificial silk, cotton and worsted, or other suitable
combinations are twisted together, a spiral effect yarn may be pro-
duced.   This will occur, although both yarns are delivered at the
same speed, on account of the differences in the stiffness or rigidity
of the yarns.   In such combinations, the thickness, amount and
direction of twist, and the character of the singles employed need
to be carefully determined to produce a yarn of utility with the desired
characteristics.

As the slackly wound yarn in a spiral yarn contributes little or
nothing to the available strength of the finished yarn, it is essential
that the tighter or ground yarn in the finished thread should have
adequate strength, and be suitable in other ways for its ultimate

purpose. On this account, the amount of twist remaining in a single ground yarn needs to be carefully considered in producing many of the twofold spiral yarns.

In producing spiral folded yarn, the prominence of the spiral can be widely varied, not only by the methods indicated, but by a combination of such methods. For example, if 4's single cotton, 6 t.p.in. T.W., i.e., $3\sqrt{\text{counts}}$, and 25's single cotton with 15 t.p.in. W.W., i.e., $3\sqrt{\text{counts}}$, are folded together with 6 t.p.in. W.W.. the former having a delivery speed one and a half times that of the latter, a much more pronounced spiral yarn would be produced than if two singles, similar in every respect, but respectively delivered at the speed indicated, were used.
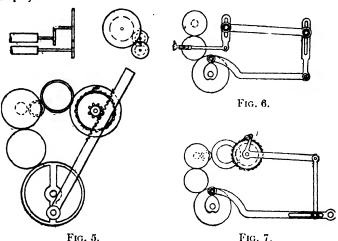
Covered Yarn.—This yarn is merely a variation of a spiral yarn, in which the ground yarn is almost, or completely, covered by a yarn coiling round it. It can be produced by the arrangement shown in Fig. 3 if yarns of suitable character, thickness, and twist are used, the correct relative speed of delivery of ground and covering yarn are determined, and the amount of twist used in the folding is suitably arranged.

Semi-covered Yarn.—This yarn can be produced in the same way as the covered yarn, except that the excess speed of the coiling yarn over ground yarn is reduced, and the bar guide under which it passes is oscillated. The movement of the bar in a downward direction is so much less than the ground yarn that the coiling yarn completely covers it during this period, whilst during the rise of the bar a spiral length of yarn is formed.

Snarl Yarn.—This type of yarn, shown at 1, Fig. 1, may be produced by inserting twist of an adequate amount, and in the proper direction, into two yarns delivered at widely varying speeds, providing the material employed to form the snarl is suitable in character and in the amount and direction of twist, and is delivered at the necessary speed. An arrangement of rollers, etc., which may be employed for producing this type of yarn is shown in Fig. 4.

A snarl yarn made from cotton yarns may be produced by twisting together weft-way, two single twist-way yarns, and delivering a weft-way, hard twisted single at about twice the speed of the two singles forming the ground. As the yarns are delivered from the rollers, the folding twist will operate to form a normally constructed ground yarn, whilst adding twist to the slackly delivered yarn, causing it to become very highly twisted so that it readily forms a snarl. The amount of twist in the singles employed, the count of the singles, the relative rate of delivery of the ground yarn and the yarn

forming the snarl, and the amount of twist put in during the operation are all interrelated, and must be taken into account in the making of snarl yarn. This type of yarn cannot only be produced from cotton, but from filament artificial silk, spun artificial staple silk, and worsted yarn, or any of these in combination, provided that the correct relative length of each is delivered and yarns of suitable count and twist are employed.

FIG. 6.

FIG. 5.

FIG. 7.

Loop Yarn.—Loop yarn, shown at 5, Fig. 1, may also be produced by the arrangement in Fig. 4 if fairly stiff yarn with suitable twist is employed to form the loop. The conditions for the production of this yarn vary so little from those required for a cotton snarl yarn that the mere substitution of a fairly stiff yarn, such as mohair, for the cotton yarn forming the snarl will often produce it, as the excess length of the mohair yarn will form a loop, whereas the cotton yarn being very much softer will form a snarl. This type of yarn can also be produced by employing filament artificial silk or worsted yarn to form the loop, providing the length of such yarn delivered, the thickness, and the amount and direction of twist are suitable, and the amount and direction of twist in the folding are correct. The size and frequency of the loops will vary with the relative rate of delivery of the ground yarn and the yarn forming the loop, and by the character, count, and twist in the yarns employed, as well as by the folding twist.

Knop Yarn.—Knop or bead yarn, shown at No. 3, Fig. 1, may be formed by the use of two pairs of rollers and a fixed or moving guide for the yarn forming the knop. An arrangement of rollers for producing this type of yarn is shown in Fig. 3. Intermittent delivery of the ground yarn from the second line of rollers may be obtained by means of a spaced pinion, or by either of the alternative arrangements for driving the second line of rollers shown in Figs 5 and 7.

In using a fixed guide for the knopping thread, a spaced wheel, or the mechanism shown in Figs. 5 and 7, may be employed to drive the second line of rollers, the rate of delivery from the front line being slightly in excess of that of the second line. The intermittent delivery
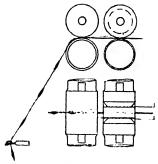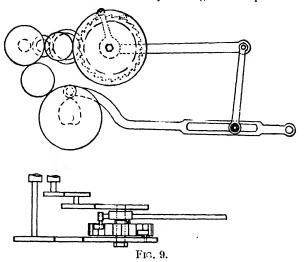
FIG. 8.

of the ground yarn causes the knopping yarn, which is continuously delivered and passed under the fixed guide, to wind in a bead or knop at intervals on the ground yarn.

An alternative method is to have similar threading of the yarns, as in Fig. 3, but to deliver both yarns continuously. The knopping yarn, which is delivered at a slightly higher rate than the ground yarn, is passed underneath a bar to which is imparted an up and down motion derived from a cam, as shown in Fig. 6. The movement of the bar, which should be in contact with the ground yarn, should, during its descent, be equal to that of the ground yarn; so that it will guide the yarn on at the same point during this period, and form a bead or knop, whilst during the ascent of the bar, a folded yarn of approximately normal features will be formed. In either method a double knop may be formed by the use of two bars, each controlling a separate yarn.

This type of yarn may be made from cotton, filament artificial silk,

spun staple artificial silk, or worsted, if the count of the yarns, the amount and direction of twist in the single and the folding, and other particulars, such as rate of delivery, are satisfactorily arranged.   The size of the knops and the spacing between them will, if intermittent delivery of the ground yarn is employed, be affected by the length of yarn delivered between each dwell of the ground yarn, and the amount of dwell, and in the other method by the length of sweep of the bar.

Fig. 9.

The first method is more suitable for making fine knop yarns, though the production is low as compared with the second method, which will permit greater intervals between the knops, and is more suitable for the coarser and stronger yarns.

Slub Yarn.—Flake or slub folded yarn, shown at No. 4, Fig. 1, can be produced by an arrangement of rollers as shown in **Fig. 7.** When two separate ends are employed to form the ground yarn, the slub should emerge from the front rollers between them. If grooved top rollers are employed in the second line, the ground ends should be brought through the grooves, as they help to control the soft material as it is subjected to the drafting action between the middle and front pairs.

The intermittent movement of the second line of rollers necessary to produce this type of yarn may be obtained in several ways: (*a*) by an ordinary spaced pinion; (*b*) by a crank drive arrangement shown

in Fig. 5; (c) by a cam drive arrangement, as shown in Fig. 7, or by a combination of driving, as shown in Fig. 9.

By employing an arrangement of driving on the lines shown in Fig. 9, a continuous but very slow speed drive to the second roller can be obtained, so that the thick material is drafted, and the accelerated speed necessary to deliver a thick undrawn piece of slubbing obtained from a cam. Arrangements (a), (b), (c), will produce a detached slub, unless the dwell in the second line is too brief to allow the thick material to be entirely detached by the drafting action of the front rollers. Much less difficulty is experienced in producing and processing the type of yarn in which the thick material is not entirely detached, as the trouble arising from inadequate binding of the detached ends of the thick material is avoided.

The thickness and frequency of the thick portions will be affected by the thickness of the material employed, the length fed, and the relative speed of front to second line of rollers when the thick material is being delivered.

Chain or Gimp Yarn, shown at 2, Fig. 1, may be produced by twisting together a fine and a coarse yarn, as previously indicated, to form a prominent spiral yarn, and subsequently twisting the yarn thus formed with another fine yarn, the twist in the second doubling being opposite to the twist in the spiral yarn.

To produce this type of yarn, an arrangement such as shown in Figs. 3 or 4 may be employed, the coarse yarn in the first folding being delivered at about twice the speed of the ground and forming a pronounced spiral yarn. The thickness, twist, and character of the two yarns employed, and the relative length of each delivered, as well as the amount of folding twist, must be regulated so that the thick yarn is just taken up and coiled regularly on the ground yarn.

If a spiral yarn made, as just described, from two single 60's T.W. cotton, and 4's T.W. cotton with 12 t.p.in. W.W. is folded with two single 60's with 6 t.p.in. T.W. and both delivered at the same speed, a chain or gimp yarn will be produced.

Intermittent Chain Yarn, which is a variation of the above, can be produced under similar conditions, except that motion is given to the bar, Fig. 2, under which the coarse end in the first operation is passed. If the movement of the bar, operated as shown in Fig. 6, is such that during its descent it moves somewhat slower than the ground yarn, the coarse yarn will be laid in a close spiral, whilst during its ascent it will be laid in an open spiral. A subsequent folding with a fine yarn, as described above, will produce an intermittent or variable chain yarn.

YARN COUNTING OR NUMBERING SYSTEMS

In all classes of yarns it is necessary to have a system of numbering, by which the different sizes or thicknesses of the threads may be designated, and to provide a means of calculating the quantities of yarns required in manufacturing processes.   There is a great variety in the yarn numbering systems in use in different districts, not only in respect of different fibres, but also in respect of the same fibre.   All systems, however, fall into one of two distinct classes, viz.—(1) Fixed weight systems and (2) fixed length systems.   In the first of these, the count is determined by the length in yards contained in a given weight ; generally stated as the number of hanks or leas of a given length contained in a fixed weight, so that coarse (thick) yarns have low numbers, and the finer or thinner the yarn the *higher* the number.   In the second or fixed length system the count is determined by the weight of a fixed length of yarn, and the finer the yarn the *lower* the number or count.

Cotton Yarn.—The hank is 840 yds., and the number of such hanks in 1 lb. avoirdupois is the count of the yarn.   Thus, $20 \times 840 = 16,800$ yds. in 1 lb. = 20's counts.   In folded cotton yarns the number of threads twisted together is indicated along with the count of the original singles.   Thus, 2/40's means that two threads of 40's are twisted together, and the resultant count is 20's.

Very coarse cotton yarn below 1's is called bump yarn, and the counts are reckoned by the number of yards contained in 1 oz. avoirdupois.

Continental System.—The hank is 1000 metres (1093 yds.), and the number of hanks in $\frac{1}{2}$ kilogram is the count.

International Metric System.—The hank is 1000 metres, and the number of hanks in 1 kilogram is the count.   *Note.*—This system of yarn numbering is also applicable to all other fibres.

Worsted Yarn.—The hank is 560 yds., and the number of such hanks in 1 lb. is the count of the yarn.

Woollen Yarn.—*Aberdeen Scale.*—The spindle is 14,400 yds., and the number of pounds a spindle weighs is the count of the yarn.   No. 1's, or "1 lb. yarn," is 14,400 yds. to the pound.

Alloa Scale.—Also used in Stirling, Kilmarnock, and elsewhere. The cut is 240 yds.   48 cuts = 11,520 yds. make a spindle.   The number of such spindles in 24 lbs. is the count of the yarn.

American Cut.—The cut is 300 yds., and the number of cuts in 1 lb. is the count.

American Grain.—The weight in grains of 20 yds. is the count.

American Run.—The run is 100 yds., and the number of runs in 1 oz. is the count.

Dewsbury Scale.—The yards per ounce indicates the counts.

Galashiels Scale.—The cut is 300 yds., and the number of cuts in 24 oz. is the count of the yarn. A spindle is 48 cuts = 14,400 yds. A slip is 12 cuts.

Halifax Rural District Scale.—The weight in drams of 80 yds. of yarn is the count. If 80 yds. of yarn weigh 10 drams, the yarn is 10's counts, and is spoken of as 10-dram yarn.

Hawick Scale.—The cut is 300 yds., and the number of cuts in 26 oz. is the count of the yarn. A spindle is 48 cuts = 14,400 yds. A slip is 12 cuts.

Leeds and Huddersfield Scale.—The number of yards in 1 dram indicates the counts. Thus, 30's skein wool means that 30 yds. will weigh 1 dram.

West of England Scale.—The snap is 320 yds., and the number of snaps in 1 lb. is the count.

Yorkshire Skein.—The skein is 1536 yds., and the number of skeins in 6 lbs. indicates the counts. Therefore 1's yarn will have $1536 \div 6$ = 256 yds. per lb., and an alternative method of counting would be to take the number of skeins of 256 yds. each in 1 lb. as the count, but seeing that there are 256 drams in 1 lb., then obviously the number of yards which weigh 1 dram also equals the count.

Linen Yarn.—*Wet Spun.*—The hank or lea is 300 yds., and the number of these in 1 lb. is the count of the yarn. A spindle is 48 leas = 14,400 yds. A bundle is 200 leas = 60,000 yds.

Dry Spun.—The lea is 300 yds. ; 12 leas make 1 Irish or Scotch hank, and 4 hanks (48 leas) = 14,400 yds. = 1 spindle. The weight in lbs. of 1 spindle (14,400 yds.) is the count. Thus if 14,400 yds. weigh 10 lbs., the grist or count of the yarn is 10's.

Jute and Heavy Flax Yarns are reckoned on the same basis as given for dry spun linen.

Hemp Yarn.—Fine hemp is reckoned on the same basis as linen (wet-spun), but coarser hemp, which constitutes the majority, is spun on the same system as jute.

Ramie Yarn.—The hank is 1000 metres. The count is the number of hanks in 1 kilogram.

Raw Silk.—*Denier System.*—Authorities differ considerably as to the length of the hank and the weight of a denier. We follow the rule of the London Silk Conditioning House, which is an acknowledged authority in all disputes. The hank is 400 French ells = 476 metres = 520 yds. 533⅓ deniers make 1 oz. avoirdupois. The number of deniers that one such hank weighs is the count of the yarn.

Dram System.—The hank is 1000 yds., and the number of drams that such a hank weighs is the count of the yarn.

Ounce System.—The hank is 1000 yds., and the number of hanks weighing 1 oz. is the count. Thus, if 30 hanks (30,000 yds.) weigh 1 oz., the count is 30's.

Spun Silk is reckoned on the same basis as cotton in all single yarn, but in folded yarns the number of threads in the folded yarn is written after the actual count of the resultant yarn. Thus, 60/2 means that the yarn is actually 60's counts and is composed of two threads of finer counts.

Union Yarns, composed of varying proportions of cotton and wool, are generally counted on the same basis as cotton yarns. The count is the number of hanks of 840 yds. each contained in 1 lb.

Rayon Yarns.—The system of numbering silk and rayon yarns is that laid down by the Paris Conference in 1900. This system is based on a unit length of 450 metres and a unit weight of 0·5 decigramme. The denier counts is the weight in half-decigrammes of 450 metres of yarn. The equivalent counts in cotton, linen, and worsted are given below.

By calculating the metric equivalents, a conversion dividend is found. The denier or counts is divided into 5315, used as a

Silk and Rayon Denier.	Cotton.	Worsted.	Linen.
30	177·2	265·7	496·0
40	132·9	199·3	372·1
50	106·3	159·4	297·6
60	88·6	132·9	248·0
70	75·9	113·9	212·6
80	66·4	99·6	186·0
90	59·0	88·6	163·2
100	53·2	79·7	148·8
110	48·3	72·5	135·3
120	44·3	66·4	124·0
130	40·9	61·3	114·5
140	37·9	57·0	106·3
150	35·4	53·2	99·2
160	33·2	49·8	93·0
170	31·3	46·9	87·5
180	29·5	44·3	82·7
200	26·6	39·9	74·4
240	22·1	33·2	62·0
280	19·0	28·5	53·2
300	17·7	26·6	49·6

YARN COUNTS CONVERSION FACTORS

KNOWN COUNTS IN	MULTIPLIERS TO GIVE EQUIVALENT COUNTS IN—				
	Cotton and Spun Silk	Worsted	Woollen (Yks. Skein)	Woollen (West of England)	Linen (Wet Spun)
Cotton and Spun Silk	1	$\frac{3}{2}$ or 1·5	$\frac{105}{32}$ or 3·28125	$\frac{21}{8}$ or 2·625	$\frac{14}{5}$ or 2·8
Worsted	$\frac{2}{3}$ or ·6667	1	$\frac{35}{16}$ or 2·1875	$\frac{7}{4}$ or 1·75	$\frac{28}{15}$ or 1·8667
Woollen (Yks. Skein)	$\frac{32}{105}$ or ·3048	$\frac{16}{35}$ or ·4571	1	$\frac{4}{5}$ or ·8	$\frac{64}{75}$ or ·8534
Woollen (W. of Engl'nd)	$\frac{8}{21}$ or ·381	$\frac{4}{7}$ or ·5714	$\frac{5}{4}$ or 1·25	1	$\frac{16}{15}$ or 1·0667
Linen (Wet Spun)	$\frac{5}{14}$ or ·3571	$\frac{15}{28}$ or ·5357	$\frac{75}{64}$ or 1·1719	$\frac{15}{16}$ or ·9375	1

constant. In similar manner constants for other yarns may be ascertained, five of the principal ones being as follows:—

Cotton constant	5315
Worsted constant	7972
Linen constant	14882
Woollen (Yks. skeins) constant	17439
Woollen (W. of England) constant	13952

Artificial Silk Drawback.—For the declaration for drawback purposes of the artificial silk content of piece goods, artificial silk and cotton, the weight of cotton is to be ascertained as follows:—

Warp

$$\frac{\text{Ends of warp} \times \text{warp length in yards}}{840 \times \text{count of warp}} = \text{weight of warp in lb.*}$$

* Weight in lb. to two places of decimals.

Weft

$$\frac{\text{Picks per inch of cloth} \times \text{actual reed width in inches} \times \text{length of cloth in yards}}{840 \times \text{count of weft}} = \text{weight of weft in lb.*}$$

* Weight in lb. to two places of decimals.

The weight of artificial silk is to be ascertained in the same way, the denier counts being normally converted to cotton counts by the use of the constant 5314.

YARN COUNTS CONVERSION FACTORS

KNOWN COUNTS IN	MULTIPLIERS TO GIVE EQUIVALENT COUNTS IN—				
	Raw Silk Artific'l Silk (Denier)	Silk (Dram)	Woollen (Sowerby Bridge)	Woollen (U.S.A. Grain)	Jute and Hemp
Raw Silk Artificial Silk (Denier)	1	·0577	·0046	·03169	·0032
Silk (Dram)	17·333	1	$\frac{2}{2 \cdot 5}$ or ·08	$\frac{3 \cdot 5}{6 \cdot 4}$ or ·54	$\frac{9}{1 \cdot 6 \cdot 0}$ or ·0563
Woollen (Sow'by Bridge)	216·667	$\frac{2 \cdot 5}{2}$ or 12·5	1	6·8359	$\frac{4 \cdot 5}{6 \cdot 4}$ or ·7031
Woollen (U.S.A. Grain)	31·695	$\frac{6 \cdot 4}{3 \cdot 5}$ or 1·828	·1463	1	$\frac{1 \cdot 8}{1 \cdot 7 \cdot 5}$ or ·1029
Jute and Hemp	308·148	$\frac{1 \cdot 6 \cdot 0}{9}$ or 17·778	$\frac{6 \cdot 4}{4 \cdot 5}$ or 1·422	$\frac{1 \cdot 7 \cdot 5}{1 \cdot 8}$ or 9·7223	1

Example. — 32's Worsted = ·2 × $\frac{7 \cdot 8}{1 \cdot 8}$ = 70's Woollen (Yorkshire Skein).
20's Silk (Dram) = 20 × 17·333 = 346·67 Raw Silk (Denier).

YARN COUNTS CONVERSION CONSTANTS

The constants given below *are not multipliers* as in the preceding tables.

To obtain equivalent counts, find the denominations of the known and unknown counts in the two headings. The constant found at their

intersection, divided by the known counts, will give the equivalent counts in the other denominations.

Thus, to convert 40's Yorkshire Skein to Woollen (Sowerby Bridge) we have $\frac{80}{40} = 2$'s Woollen.   Again, 4's Jute $= \frac{48}{4} = 12$'s Linen.

	Raw Silk Artific'l Silk (Denier)	Silk (Dram)	Woollen (Sowerby Bridge)	Woollen (U.S.A. Grain)	Jute and Hemp
Cotton and Spun Silk	5315	304·8	24·38	166·7	17·14
Worsted	7972	457·1	36·57	250	25·71
Woollen (Yks. Skein)	17439	1000	80	546·9	56·25
Woollen (W. of Engl'nd)	13952	13867	64	437·5	45
Linen (Wet Spun)	14882	853·3	68·26	466·7	48

DIAMETERS OF WORSTED YARNS

From Diameter of yarn in inches $= \sqrt{\text{Counts}} \times 1/21\cdot3$.

The figure against the counts gives the approximate number of threads which, when laid side by side, will occupy 1 inch.

Counts.	No. of Threads.	Counts.	No. of Threads.	Counts	No. of Threads.	Counts.	No. of Threads.	Counts.	No. of Threads.
1	21·3	12	74	26	109	48	148	70	178
2	30·1	13	77	28	113	50	151	72	181
3	36·9	14	80	30	117	52	154	74	183
4	42·6	15	82	32	120	54	157	76	186
5	47·6	16	85	34	124	56	160	78	188
6	52·2	17	88	36	128	58	163	80	191
7	56·3	18	90	38	131	60	165	90	202
8	60·2	19	93	40	135	62	168	100	213
9	64·0	20	95	42	138	64	170	110	224
10	67·4	22	100	44	141	66	173	120	234
11	71	24	104	46	145	68	176	...	...

DIAMETERS OF WOOLLEN YARNS (YORK-SHIRE SKEIN)

From Diameter of yarn in inches $= \sqrt{\text{Counts}} \times 1/13 \cdot 5$.

The figure against the counts gives the approximate number of threads which, when laid side by side, will occupy 1 inch.

Counts.	No. of Threads.	Counts.	No. of Threads.	Counts.	No. of Threads.	Counts.	No. of Threads.	Counts.	No. of Threads.
1	13·5	11	44·8	21	61·9	31	75·3	42	87·6
2	19·1	12	46·8	22	63·4	32	76·4	44	89·6
3	23·4	13	48·7	23	64·9	33	77·6	46	91·6
4	27·0	14	50·5	24	66·1	34	78·9	48	93·6
5	30·2	15	52·3	25	67·5	35	80·0	50	95·6
6	33·2	16	54·0	26	68·9	36	81·1	52	97·5
7	35·8	17	55·7	27	70·2	37	82·2	54	99·3
8	38·2	18	57·4	28	71·5	38	83·4	56	101
9	40·5	19	58·9	29	72·9	39	84·5	58	103
10	42 8	20	60·5	30	74·0	40	85·5	60	105

DIAMETERS OF COTTON YARNS

From Diameter of yarn in inches -- $\sqrt{\text{Counts}} \times 1/26$ 1.

Counts.	No. of Threads	Counts.	No. of Threads.	Counts.	No. of Threads.	Counts.	No. of Threads.	Counts.	No. of Threads.
1	26·1	17	108·0	46	177	78	230	140	309
2	36·8	18	111·0	48	181	80	234	144	313
3	45·2	19	114·0	50	185	84	239	148	318
4	52·2	20	117·0	52	188	88	245	152	322
5	58·4	22	122·5	54	192	92	250	156	326
6	64·0	24	128	56	196	96	256	160	330
7	69·0	26	133	58	199	100	261	180	350
8	73·9	28	138	60	202	104	266	190	360
9	78·3	30	133	62	206	108	272	200	370
10	82·7	32	147·5	64	209	112	277	220	388
11	86·6	34	152	66	212	116	281	240	405
12	90·5	36	157	68	216	120	286	260	422
13	94·1	38	161	70	219	124	291	280	437
14	97·8	40	165	72	222	128	295	300	453
15	101·0	42	169	74	225	132	300	...	...
16	104·5	44	173	76	228	136	304	...	...

WEIGHTS OF COTTON YARN

1 lea = 120 yds.

	1 Lea.			2 Leas.			4 Leas.			7 Leas		
Counts.	Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs	Oz	Dwt.	Grs.
1	2	5	5·00	4½	1	7 25	9	2	14·50	16	0	0·00
2	1	2	14·50	2	5	5·00	4½	1	7·25	8	0	0·00
3	½	4	18·58	1½	0	10·41	3	0	20·83	5	6	1·83
4	½	1	7·25	1	2	14·50	2	5	5·00	4	0	0·00
5	0	8	8·00	½	7	13·25	1½	5	23·75	3	3	15·50
6	0	6	22·66	½	4	18·58	1½	0	10·41	2½	3	0·91
7	0	5	22·86	½	2	18·96	1	5	13·93	2	5	5·00
8	0	5	5·00	½	1	7·25	1	2	14·50	2	0	0·00
9	0	4	15·11	½	0	3·47	1	0	6·94	1½	5	1·53
10	0	4	4·00	0	8	8·00	½	7	13·25	1½	1	19·75
11	0	3	18·91	0	7	13·82	½	6	0·88	1	8	6·86
12	0	3	11·33	0	6	22·66	½	4	18·58	1	6	1·83
13	0	3	4·92	0	6	9·84	½	3	16·94	1	4	4·96
14	0	2	23·43	0	5	22·86	½	2	18·96	1	2	14·50
15	0	2	18·66	0	5	13·33	½	1	23·91	1	1	5·16
16	0	2	14·50	0	5	5·00	½	1	7·25	1	0	0·00
17	0	2	10·82	0	4	21·65	½	0	16·54	½	8	1·01
18	0	2	7·55	0	4	15·11	½	0	3·47	½	7	2 14
19	0	2	4·63	0	4	9·26	0	8	18·52	½	6	5·67
20	0	2	2·00	0	4	4·00	0	8	8·00	½	5	11·25
21	0	1	23·62	0	3	23·24	0	7	22·47	½	4	18·58
22	0	1	21·45	0	3	18·91	0	7	13·81	½	4	3·43
23	0	1	19·48	0	3	14·95	0	7	5·91	½	2	13·60
24	0	1	17·66	0	3	11·33	0	6	22·66	½	3	0·91
25	0	1	16·00	0	3	8·00	0	6	16·00	½	2	13·25
26	0	1	14·46	0	3	4·92	0	6	9·84	½	2	2·48
27	0	1	13·03	0	3	2·07	0	6	4·15	½	1	16·51
28	0	1	11·71	0	2	23·43	0	5	22·86	½	1	7·25
29	0	1	10·48	0	2	20·96	0	5	17·93	½	0	22·63
30	0	1	9·33	0	2	18·66	0	5	13·33	½	0	14·58
31	0	1	8·26	0	2	16·51	0	5	9·03	½	0	7·05
32	0	1	7·25	0	2	14·50	0	5	5·00	½	0	0·00
33	0	1	6·30	0	2	12·60	0	5	1·21	0	8	20·12
34	0	1	5·41	0	2	10·82	0	4	21·65	0	8	13·88
35	0	1	4·57	0	2	9·14	0	4	18·28	0	8	8·00
36	0	1	3·78	0	2	7·55	0	4	15·11	0	8	2·44
37	0	1	3·02	0	2	6·05	0	4	12·11	0	7	21·19
38	0	1	2·31	0	2	4·63	0	4	9·26	0	7	16 21
39	0	1	1·64	0	2	3·28	0	4	6·56	0	7	11·49
40	0	1	1·00	0	2	2·00	0	4	4·00	0	7	7·00
41	0	1	0·39	0	2	0·78	0	4	1·56	0	7	2·73
42	0	0	23·80	0	1	23·62	0	3	23·24	0	6	22·66
43	0	0	23·25	0	1	22·51	0	3	21·02	0	6	18·79
44	0	0	22·72	0	1	21·45	0	3	18·91	0	6	15·09

WEIGHTS OF COTTON YARN—contd.
1 lea = 120 yds.

Counts	1 Lea.			2 Leas.			4 Leas.			7 Leas.		
	Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs.	Oz	Dwt.	Grs.	Oz.	Dwt.	Grs.
45	0	0	22·22	0	1	20·44	0	3	16·89	0	6	11 55
46	0	0	21·74	0	1	19·48	0	3	14·95	0	6	8·17
47	0	0	21·28	0	1	18·53	0	3	13·10	0	6	4·93
48	0	0	29·83	0	1	17·66	0	3	11·33	0	6	1·83
49	0	0	20·41	0	1	16·81	0	3	9·63	0	5	22·86
50	0	0	20·00	0	1	16·00	0	3	8·00	0	5	20·00
51	0	0	19·61	0	1	15·21	0	3	6·43	0	5	17·25
52	0	0	19·23	0	1	14·46	0	3	4·92	0	5	14·61
53	0	0	18·87	0	1	13·73	0	3	3·47	0	5	12·07
54	0	0	18·52	0	1	13·04	0	3	2·07	0	5	9·63
55	0	0	18·18	0	1	12·36	0	3	0·73	0	5	7·27
56	0	0	17·86	0	1	11·71	0	2	23·43	0	5	5·00
57	0	0	17·54	0	1	11·09	0	2	22·17	0	5	2·81
58	0	0	17·24	0	1	10·48	0	2	20·96	0	5	0·69
59	0	0	16·95	0	1	9·90	0	2	19 79	0	4	22·64
60	0	0	16·66	0	1	9·33	0	2	18·66	0	4	20·66
61	0	0	16·39	0	1	8·79	0	2	17·57	0	4	18·75
62	0	0	16·13	0	1	8·26	0	2	16·51	0	4	16·90
63	0	0	15·87	0	1	7·74	0	2	15·49	0	4	15·11
64	0	0	15·62	0	1	7·25	0	2	14·50	0	4	13·37
65	0	0	15·38	0	1	6·77	0	2	13·54	0	4	11·69
66	0	0	15·15	0	1	6·30	0	2	12·60	0	4	10·06
67	0	0	14·92	0	1	5·85	0	2	11·70	0	4	8·48
68	0	0	14·70	0	1	5·41	0	2	10·82	0	4	6·94
69	0	0	14·49	0	1	4·98	0	2	9·97	0	4	5·45
70	0	0	14·18	0	1	4·57	0	2	9·14	0	4	4·00
71	0	0	14·08	0	1	4·17	0	2	8·34	0	4	2·59
72	0	0	13·89	0	1	3·78	0	2	7·55	0	4	1·22
73	0	0	13·70	0	1	3·40	0	2	6·79	0	3	23·89
74	0	0	13·51	0	1	3·03	0	2	6·05	0	3	22 59
75	0	0	13·33	0	1	2·66	0	2	5·33	0	3	21·33
76	0	0	13·16	0	1	2·31	0	2	4·63	0	3	20·10
77	0	0	12·99	0	1	1·97	0	2	3 95	0	3	18 91
78	0	0	12·82	0	1	1·64	0	2	3·28	0	3	17·74
79	0	0	12·66	0	1	1·31	0	2	2·63	0	3	16·61
80	0	0	12·50	0	1	1·00	0	2	2·00	0	3	15·50
81	0	0	12·34	0	1	0·69	0	2	1·38	0	3	14·42
82	0	0	12·19	0	1	0·39	0	2	0·78	0	3	13·36
83	0	0	12·05	0	1	0·09	0	2	0·19	0	3	12 3·
84	0	0	11·90	0	0	23·81	0	1	23·62	0	3	11·33
85	0	0	11·76	0	0	23·53	0	1	23·06	0	3	10·35
86	0	0	11·63	0	0	23·25	0	1	22·51	0	3	9·39
87	0	0	11·49	0	0	22·99	0	1	21·98	0	3	8·46
88	0	0	11·36	0	0	22·73	0	1	21·45	0	3	7·54

WEIGHTS OF COTTON YARN—*contd.*

1 lea = 120 yds.

Counts	1 Lea.			2 Leas.			4 Leas.			7 Leas.		
	Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs
89	0	0	11·23	0	0	22·47	0	1	20·94	0	3	6·65
90	0	0	11·11	0	0	22·22	0	1	20·44	0	3	5·78
91	0	0	10·99	0	0	21·98	0	1	19·95	0	3	4·92
92	0	0	10·87	0	0	21·74	0	1	19·48	0	3	4·08
93	0	0	10·75	0	0	21·50	0	1	19·01	0	3	3·77
94	0	0	10·64	0	0	21·27	0	1	18·55	0	3	2·47
95	0	0	10·52	0	0	21·05	0	1	18·10	0	3	1·68
96	0	0	10·41	0	0	20·83	0	1	17·66	0	3	0·91
97	0	0	10·31	0	0	20·62	0	1	17·24	0	3	0·16
98	0	0	10·20	0	0	20·41	0	1	16 81	0	2	23·43
99	0	0	10·10	0	0	20·20	0	1	16·40	0	2	22·71
100	0	0	10·00	0	0	20·00	0	1	16·00	0	2	22·00
102	0	0	9·80	0	0	19·61	0	1	15·21	0	2	20·63
104	0	0	9·61	0	0	19·23	0	1	14·46	0	2	19·30
106	0	0	9·43	0	0	18·87	0	1	13·73	0	2	18·04
108	0	0	9·26	0	0	18·52	0	1	13·04	0	2	16·81
110	0	0	9·09	0	0	18·18	0	1	12·36	0	2	15·63
112	0	0	8·93	0	0	17·86	0	1	11·71	0	2	14·50
114	0	0	8·77	0	0	17·54	0	1	11·09	0	2	13·40
116	0	0	8·62	0	0	17·24	0	1	10·48	0	2	12·34
118	0	0	8·47	0	0	16·95	0	1	9·90	0	2	11·32
120	0	0	8·33	0	0	16·66	0	1	9·33	0	2	10·33
122	0	0	8·19	0	0	16·39	0	1	8·78	0	2	9·38
124	0	0	8·06	0	0	16·13	0	1	8·26	0	2	8·45
126	0	0	7·93	0	0	15·87	0	1	7·74	0	2	7·55
128	0	0	7·81	0	0	15·62	0	1	7·25	0	2	6·69
130	0	0	7·69	0	0	15·38	0	1	6·77	0	2	5·84
140	0	0	7·14	0	0	14·28	0	1	4·57	0	2	2·00
150	0	0	6·66	0	0	13·33	0	1	2·66	0	1	22·66
160	0	0	6·25	0	0	12·50	0	1	1·00	0	1	19·75
170	0	0	5·88	0	0	11·76	0	0	23·53	0	1	17·18
180	0	0	5·55	0	0	11·11	0	0	22·22	0	1	14·89
190	0	0	5·26	0	0	10·52	0	0	21·05	0	1	12·84
200	0	0	5·00	0	0	10·00	0	0	20·00	0	1	11·00
210	0	0	4·76	0	0	9·52	0	0	19·05	0	1	9·33
220	0	0	4·54	0	0	9·09	0	0	18·18	0	1	7·82
230	0	0	4·35	0	0	8·69	0	0	17·39	0	1	6·43
240	0	0	4·16	0	0	8·33	0	0	16·66	0	1	5·16
250	0	0	4·00	0	0	8·00	0	0	16·00	0	1	4·00
260	0	0	3·84	0	0	7·69	0	0	15·38	0	1	2·92
270	0	0	3·70	0	0	7·40	0	0	14·81	0	1	1·92
280	0	0	3·57	0	0	7·14	0	0	14·28	0	1	1·00
290	0	0	3·45	0	0	6·89	0	0	13·79	0	1	0·14
300	0	0	3·33	0	0	6·66	0	0	13·33	0	0	23·33

WRAPPING TABLE

The following table shows the nearest count for the weight in grains of 1 lea.

In many mills it is the practice to take the average of 4 or 7 leas in order to ascertain the counts. A better plan is to ascertain the counts of each lea separately and take the average.

The count of cotton yarn is the number of hanks (840 yds.) to the lb. (7000 grs.).

In testing for count the usual practice is to measure off 1 lea (120 yds. or ⅐ hank) and to find the number of leas to ½ lb., or 1000 grs., *i.e.*, if 1 lea weighs 20 grs., then the count is $\dfrac{1000}{20} = 50$.

When the lea has been measured off on the wrap reel it is usual before weighing it to test it for breaking strength on the lea strength tester.

Grs.	Counts.	Grs	Counts.	Grs.	Counts.	Grs.	Counts.	Grs.	Counts.
4	250·00	12¼	81·62	20½	48·78	28¾	34·78	44	22·72
4¼	235·29	12½	80·00	20¾	48·14	29	34·48	44½	22·47
4½	222·22	12¾	78·42	21	47·62	29¼	34·18	45	22·22
4¾	210·53	13	76·92	21¼	47·06	29½	33·89	45½	21·97
5	200 00	13¼	75·46	21½	46·51	29¾	33·60	46	21·74
5¼	190·48	13½	74 07	21¾	45·98	30	33·33	46½	21·50
5½	181·82	13¾	72·72	22	45·45	30½	32·78	47	21 27
5¾	173·91	14	71·43	22¼	44·94	31	32·25	47½	21·05
6	166 67	14¼	70·16	22½	44·44	31½	31·74	48	20·83
6¼	160·00	14½	68·96	22¾	43·94	32	31·25	48½	20·62
6½	153·85	14¾	67·78	23	43·47	32½	30·77	49	20·41
6¾	148·15	15	66·66	23¼	42·10	33	30·30	49½	20·20
7	142·86	15¼	65·56	23½	42·55	33½	29·85	50	20·00
7¼	137·93	15½	64·51	23¾	42·10	34	29·41	50½	19·80
7½	133·33	15¾	63·48	24	41·66	34½	28·98	51	19·61
7¾	129·03	16	62·50	24¼	41·24	35	28·57	51½	19·42
8	125·00	16¼	61·72	24½	40·81	35½	28·17	52	19·23
8¼	121·21	16½	60·60	24¾	40·40	36	27·77	52½	19·05
8½	117·65	16¾	59·70	25	40·00	36½	27·39	53	18·87
8¾	114·29	17	58·82	25¼	39·60	37	27·02	53½	18·69
9	111·11	17¼	57·96	25½	39·21	37½	26·66	54	18·52
9¼	108·11	17½	57·14	25¾	38·84	38	26·31	54½	18·35
9½	105·26	17¾	56·34	26	38·46	38½	25·97	55	18·18
9¾	102·56	18	55·55	26¼	38·10	39	26·64	55½	18·02
10	100·00	18¼	54·78	26½	37·73	39½	25·31	56	17·85
10¼	97·56	18½	54·05	26¾	37·38	40	25·00	56½	17·69
10½	95·24	18¾	53·32	27	37·03	40½	24·69	57	17·54
10¾	93·02	19	52·63	27¼	36·70	41	24·39	57½	17·39
11	90·91	19¼	51·94	27½	36·36	41½	24·07	58	17·24
11¼	88·88	19½	51·28	27¾	36·04	42	23·81	58½	17·09
11½	86·95	19¾	50·62	28	35·71	42½	23·53	59	16·95
11¾	85 ·0	20	50·00	28¼	35·38	43	23·25	59½	16·80
12	83·33	20¼	49·38	28½	35·08	43½	22·99	60	16·66

WRAPPING TABLE—contd.

Grs	Counts.	Grs.	Counts.	Grs.	Counts	Grs.	Counts.	Grs.	Counts.
60½	16·53	78½	12·74	96½	10·36	114½	8·73	132½	7·54
61	16·39	79	12·66	97	10·31	115	8·69	133	7·52
61½	16·26	79½	12·58	97½	10·25	115½	8·65	133½	7·49
62	16·13	80	12·50	98	10·20	116	8·62	134	7·46
62½	16·00	80½	12·42	98½	10·15	116½	8·58	134½	7·43
63	15·87	81	12·34	99	10·10	117	8·55	135	7·41
63½	15·75	81½	12·27	99½	10·05	117½	8·51	135½	7·38
64	15·62	82	12·19	100	10·00	118	8·47	136	7·35
64½	15·50	82½	12·12	100½	9·95	118½	8·43	136½	7·32
65	15·38	83	12·05	101	9·90	119	8·40	137	7·30
65½	15·26	83½	11·97	101½	9·85	119½	8·37	137½	7·27
66	15·15	84	11·90	102	9·80	120	8·33	138	7·25
66½	15·04	84½	11·83	102½	9·75	120½	8·29	138½	7·22
67	14·92	85	11·76	103	9·71	121	8·26	139	7·19
67½	14·81	85½	11·69	103½	9·66	121½	8·23	139½	7·17
68	14·70	86	11·62	104	9·61	122	8·19	140	7·14
68½	14·60	86½	11·56	104½	9·57	122½	8·16	140½	7·11
69	14·49	87	11·49	105	9·52	123	8·13	141	7·09
69½	14·39	87½	11·43	105½	9·47	123½	8·09	141½	7·07
70	14·28	88	11·36	106	9·43	124	8·06	142	7·04
70½	14·18	88½	11·30	106½	9·39	124½	8·03	142½	7·02
71	14·08	89	11·23	107	9·34	125	8·00	143	6·99
71½	13·98	89½	11·17	107½	9·30	125½	7·97	143½	6·97
72	13·89	90	11·11	108	9·26	126	7·93	144	6·94
72½	13·79	90½	11 05	108½	9·21	126½	7·90	144½	6·92
73	13·70	91	10 99	109	9·17	127	7·87	145	6·89
73½	13·60	91½	10 93	109½	9·13	127½	7·84	145½	6·87
74	13·51	92	10·87	110	9·09	128	7·81	146	6·85
74½	13·42	92½	10·81	110½	9·05	128½	7·78	146½	6·83
75	13·33	93	10·75	111	9·01	129	7·75	147	6·80
75½	13·24	93½	10 69	111½	8·97	129½	7·72	147½	6·78
76	13·16	94	10·63	112	8·93	130	7·69	148	6·75
76½	13·07	94½	10 58	112½	8·89	130½	7·66	148½	6·73
77	12·98	95	10·52	113	8·85	131	7·63	149	6·71
77½	12·90	95½	10·47	113½	8·81	131½	7·60	149½	6·69
78	12·82	96	10·41	114	8·77	132	7·57	150	6·66

FRENCH COTTON COUNTS.—The French system of numbering cotton yarns is metric, and the counts is the number of hanks of 1000 metres which weigh 500 grms.   To reduce English counts to French, divide the English counts by 1·18 (or multiply by 0·849). Multiply French counts by 1·18 to convert to English.

15

BREAKING STRENGTH OF COTTON YARNS

Those who are not very well informed in regard to the intricacies and the technicalities of cotton spinning are apt to think it should be quite an easy matter to compile a table of breaking strengths for cotton yarns.   As a matter of actual fact, it is almost impossible to compile tables that would be dependably correct for all the varying qualities and counts of cotton yarns in common use.   Many years ago the Draper Co., Hopedale, Mass., U.S.A., compiled tables of breaking strengths of yarns spun from American cotton.   The tables contained average figures from tests obtained from several hundred American mills, from which was evolved the following formula :—

$$\frac{1900 + \text{counts}}{\text{counts}} = \text{standard breaking weight in pounds.}$$

Utilising this rule, the strength of 20's yarn would be—

$$1900 + 20 \div 20 = 96 \text{ lb.}$$

Another rule is to divide the counts of the yarn into 1800, and to the quotient thus obtained add 3 lb.

Example.—1800 ÷ 20's counts = 90 + 3 = 93 lb. breaking weight.

The determination of a single constant that will serve for all qualities is exceedingly difficult and is probably impossible.   The value of the constant will change with the length of staple, the character of the cotton, the counts, and whether the yarn is carded or combed.   The National Association of Cotton Manufacturers (U.S.A.) has recently published two tables, one for carded yarns and the other for combed yarns.   These tables have been prepared by F. P. Sheldon & Sons, and are as follows :—

BREAKING STRENGTH OF CARDED COTTON WARP YARNS

Counts	Length of Staple in Inches.					Counts	Length of Staple in Inches.				
	⅞	1	1⅛	1¼	1⅜		⅞	1	1⅛	1¼	1⅜
10	150·5	186·5	218·5	254	..	40	25·5	35·5	44	52·5	62
12	125	153·5	181·5	210	248	42	23·5	33	41	49	58·5
14	106	130	154	178	205	44	22	30·5	38·5	46	55
16	90	111·5	133	155	176·5	46	20	28·5	36	44	52
18	78	97·5	116·5	137	156	48	18·5	27	34	41·5	48·5
20	68	85·5	103·5	122·5	140·5	50	17	25	32	39	46·5
22	59·5	76	92	109	123·5	52	16	23·5	30	37	44·5
24	53	69	83	98·5	111·5	54	15	22	28·5	35	42·5
26	47·5	62·5	76	89	102	56	13·5	20·5	26·5	33·5	40·5
28	43·5	57·5	70	81·5	93	58	12·5	19	25	31·5	38·5
30	40	52·5	64·5	75	86	60	11·5	17·5	23·5	30	36·5
32	35·5	48	60	69	80	62	11	16·5	22	28	34·5
34	33·5	44·5	55·5	64	75	64	10	15·5	21	26·5	33
36	30·5	41	51	60	70	66	9	14	19·5	25	31
38	28	38·5	47·5	56	66	68	8	13	18	23·5	29·5

$$\text{Strength of yarn in pounds} = \frac{1600 \ (1 + \text{or} - 0 \cdot 11a + \text{or} - 0 \cdot 01b)}{c}.$$

$a =$ Difference in sixteenths of staple over or under 1 in. Use +
   sign when over, − when under.

$b =$ Difference in number of yarn above or below 28's. Use − sign
   when over 28's, + sign when below 28's.

$c =$ Yarn count.

The above table represents the breaking strength found by testing
a great many samples of yarn, using the 120 yard skein after condition-
ing in an atmosphere containing 70 per cent. relative humidity.

BREAKING STRENGTH OF COMBED WARP YARN

Counts	Length of Staple in Inches.					Counts	Length of Staple in Inches.				
	$1\frac{1}{4}$	$1\frac{1}{3}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$		$1\frac{1}{4}$	$1\frac{1}{3}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$
20	113	132·5	151·5	170	189	70	26	31	36·5	41·5	
22	100	119	136·5	152·5	173	72	24·5	30	35	40	
24	90	108·5	125	139·5	157	74	23·5	28·5	33·5	38·5	
26	83	98·5	114	128	143·5	76	22·5	27·5	32	37·5	
28	76·5	90	105	117·5	133	78	21·5	26·5	31	36	
30	70·5	82·5	96	108	121·5	80	20·5	25·5	30	34·5	
32	64·5	76·5	89	100	112	82	19·5	24·5	28·5	33	
34	60	71	82·5	94	105	84	18·5	23	27·5	31·5	
36	56	66·5	77·5	88	99	86	17·5	22	26·5	30·5	
38	52	61·5	72·5	82	92·5	88	17	21	25·5	29·5	
40	48	57·5	68	77·5	87	90	16	20	25	28·5	
42	45	54	64	73	82	92	15·5	19·5	24	27·5	
44	42	51	60	68·5	77·5	94	15	18·5	23	27	
46	39·5	48	57	65	73·5	96	14	17·5	22	26	
48	37·5	45·5	53·5	61·5	69	98	13·5	17	21	25·5	
50	35	43	51	58·5	65·5	100	12·5	16·5	20	24·5	
52	33	40·5	48	55·5	62	102	12	15·5	19·5	23·5	
54	31	38·5	46	52·5	59	104	11·5	15	19	22·5	
56	29·5	36·5	43·5	50·5	56·5	106	11	14·5	18	22	
58	28	34·5	41	47·5	53·5	108	10·5	14	17·5	21·5	
60	26·5	32·5	39·5	45·5	51	110	10	13·5	17	20·5	
62	25	31	37·5	43·5	49	112	9·5	12·5	16·5	19·5	
64	24	29·5	35·5	41·5	47	114	9	12	16	19	
66	22·5	28	34	39·5	45	116	8·5	11·5	15·5	18·5	
68	21·5	27	32·5	38·5	43·5	118	8	11	15	17·5	

$$\frac{1750 \ (1 + 0 \cdot 11a \pm 0 \cdot 01b)}{c} = s.$$

$s =$ Strength in pounds. $a =$ Difference in sixteenths of staple over 1 in.
$c =$ Counts. $d =$ Difference in number of yarn above or below 28's.
   Use − sign when over and + sign when under.

NOTES ON COTTON WEAVING AND PREPARING MACHINERY

Winding Machinery.— *Vertical Spindle Winder.*—Made with any number of spindles up to 300. Floor space for a 200-spindle machine, 2 rows on each side, 5-in. gauge, 22 ft. 8 in. × 5 ft. 6 in. Spindle speed, 480 to 900 revs. per min. Production, variable from 240 to 600 hanks per spindle per week. Average, about 15 to 18 lbs. per week of 32's T. Power, ¾ to 1 H.P. for 200 spindles.

Drum Winder.—Floor space, 33 ft. × 4 ft. 6 in. (50-drum machine). Speeds, drum to make 150 to 200 revs. per min. on 24's single.

WARPING MACHINERY. — *Beam Warper.* — Floor space, 9/8's machine, 16 ft. 6 in. × 7 ft. 6 in. Speed, 40 revs. per min. Production, suitable for 90 to 100 looms. Power, ⅓ I.H.P.

Mill Warper.—Floor space varies from 19 ft. × 12 ft. for a mill 12 yds. in circumference, to 27 ft. × 20 ft. for a mill 20 yds. in circumference. Made in sizes 12, 14, 15, 16, 18, and 20 yds. in circumference. Height of staves, 6 ft., 6 ft. 6 in., 7 ft., 7 ft. 6 in., and 8 ft. Average creel, 17 chases each to hold 18 bobbins = 306 ends. Speed, about 170 yds. per minute. Power, ½ H.P.

Sectional Warper.—Floor space, 21 ft. × 7 ft. 6 in. Speed, 100 revs. with 14-in. pulley. Production, suitable for about 50 looms. Power, ½ H.P.

Yorkshire Dressing Frame.—Floor space, 21 ft. × 8 ft. Speed, about 100 revs. per min. Production varies considerably. Power, ½ I.H.P.

SLASHER SIZER.—Floor space, 9/8's machine, 35 ft. × 9 ft. Speed, 180 revs. per min. Production, suitable for 300 looms on medium yarns. Power, 1¼ I.H.P.

The following are the standard sizes of slasher sizing machines :—

9/8,	suitable for looms up to 50 in. reed space.			
6/4	,,	,,	,, 56	,, .,
7/4	.,	,,	,, 62	,, ,,
8/4	,	,,	,, 68	,, ,,
9/4	,,	,,	,, 74	,, ,,

To find the length of mark in yards :—

$$\frac{\text{Bell wheel} \times \text{circumference of measuring roller} \times \text{stud wheel.}}{\text{Tin roller wheel} \times 36}$$

The two factors, bell wheel and circumference of measuring roller, are

constant, and multiplied together $=648$, which is equivalent to 18 yards.
Therefore the ratio $\dfrac{18}{\text{Mark in yards}} = \dfrac{\text{Tin roller wheel}}{\text{Stud wheel}}$, and this gives a very ready means of finding the two change wheel.

CHANGE WHEELS FOR SLASHER SIZING MACHINES

This table gives a few of the tin roller wheels and stud wheels to use for the lengths of marks given, using a tin roller 14·4 in. in circumference, and a bell wheel of 45 teeth.

Length of Mark in Yds.	Stud Wheel.	Tin Roller Wheel.	Stud Wheel.	Tin Roller Wheel.	Stud Wheel.	Tin Roller Wheel.
10	20	36	30	54	40	72
10½	21	36	35	60	56	96
11	22	36	33	54	55	90
11½	30	47	46	72	69	116
12	20	30	32	48	40	60
12½	25	36	50	72	66	95
13	39	54	52	72	65	90
13½	24	32	42	56	60	80
14	35	45	42	54	70	90
14½	33	41	58	72	66	82
15	25	30	40	48	50	60
15½	37	43	56	65	86	100
16	24	27	40	45	64	72
16½	44	48	55	60	66	72
17	34	36	50	53	84	89
17½	35	36	70	72	100	103
18	30	30	40	40	60	60
18½	36	35	72	70	75	73
19	58	50	76	72	96	91
19½	52	48	65	60	92	85
20	40	36	60	54	80	72

LOOMS.—*Plain Loom.*—Floor space (40-in. loom), 7 ft. × 4 ft. Speed, 200 picks per min. Power, ¼ I. H. P.

Northrop E Model for light cotton goods. Sizes, 28 in. to 60 in. Standard, 40 in. reed space. Speed, 180 picks per min. Floor space, 4 ft. 2 in. × 7 ft. 3 in. Power, ¼ H. P.

Northrop T Model for medium cotton goods, flannels, coloured goods, etc. Sizes, 28 in. to 60 in. Standard, 40 in. reed space,

Speed, 180 picks per min. Floor space, 4 ft. 2 in. × 7 ft. 5 in. Power, ¼ H.P.

Northrop H Model for moleskins, heavy drills, etc. Sizes, 30 in. to 72 in. Standard, 36 in. reed space. Speed, 170 picks per min. Floor space, 4 ft. 4 in. × 7 ft. 5 in. Power, ⅓ H.P.

Northrop Sheeting Loom.—Sizes, 30 in. to 110 in. Standard, 80 in. reed space. Speed, 115 picks per min. Floor space, 4 ft. 9 in. × 12 ft. Power, 1 to 1¼ H.P.

FOLDING OR PLAITING MACHINE.—Floor space (40-in. cloth), 6 ft. × 6 ft. Speed, 220 revs. per min. = 75 folds. Power, ½ I.H.P.

CLOTH PRESS.—Floor space, 6 ft. × 2 ft. 6 in. Speed, 80 revs. per min. Power, ¾ to 1 I.H.P.

LOOMS.—Speed of looms : —

42 in. reed space, plain loom, 180 to 210 picks per min.

,, ,, box loom (drop), 150 to 160 picks per min.

,, ,, . ,, (circular), 160 to 180 picks per min.

,, ,, dobby loom, 160 to 200 picks per min.

,, ,, jacquard (single lift), 120 to 140 picks per min.

,, ,, ,, (double lift), 150 to 200 picks per min.

,, ,, Northrop, 180 picks per min.

To find the production of a loom in yards :—

$$\frac{\text{Time of runs in hours} - \text{stoppages} \times 60 \times \text{picks per minute}}{\text{Picks per inch in cloth} \times 36}.$$

To find the dividend of a loom :—

$$\frac{\text{Rack wheel} \times \text{stud wheel} \times \text{beam wheel}}{\text{Pinion wheel} \times \text{circumference of beam in } \frac{1}{4} \text{ in.}} + 1\frac{1}{2} \text{ per cent.}$$

$$\frac{\text{Dividend}}{\text{Change wheel}} = \text{Picks per } \frac{1}{4} \text{ in.}$$

$$\frac{\text{Dividend}}{\text{Picks per } \frac{1}{4} \text{ in.}} = \text{Change wheel.}$$

The following are a few of the trains of wheels in common use :—

Rack wheel - -	50	59	50	60
Stud - - -	100	120	120	120
Beam - - -	75	75	100	75
Pinion - - -	12	15	18	15
Cir. of beam in ¼ in.	60	60	64	60
Dividend - -	528	507	528	609

TABLES OF CHANGE WHEELS

DIVIDEND 507

Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.
13	39·00	29	17·48	45	11·26	61	8·31	77	6·58
14	36·21	30	16·90	46	11·02	62	8·17	78	6·50
15	33·80	31	16·35	47	10·78	63	8·04	79	6·41
16	31·68	32	15·84	48	10·56	64	7·92	80	6·33
17	29·82	33	15·36	49	10·34	65	7·80	81	6·25
18	28·16	34	14·91	50	10·14	66	7·68	82	6·18
19	26·68	35	14·48	51	9·94	67	7·56	83	6·10
20	25 35	36	14·08	52	9·75	68	7·45	84	6·03
21	24·14	37	13·70	53	9·56	69	7·34	85	5·96
22	23·04	38	13·34	54	9·38	70	7·24	86	5·89
23	22·04	39	13·00	55	9·21	71	7·14	87	5·82
24	21·12	40	12·67	56	9·05	72	7·04	88	5·76
25	20·28	41	12·36	57	8·89	73	6·94	89	5·96
26	19·50	42	12·07	58	8·74	74	6·85	90	5·63
27	18·77	43	11·79	59	8·59	75	6·76	91	5·57
28	18·10	44	11·52	60	8·45	76	6·67	92	5·50

DIVIDEND 609

Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.
13	46·84	29	21·00	45	13·53	61	9·98	77	7·90
14	43·50	30	20·30	46	13·23	62	9·82	78	7·80
15	40·60	31	19·64	47	12·95	63	9·66	79	7·70
16	38·06	32	19·03	48	12·68	64	9·51	80	7·61
17	35·82	33	18·45	49	12·42	65	9·36	81	7·51
18	33·83	34	17·91	50	12·18	66	9·22	82	7·42
19	32·05	35	17·40	51	11·94	67	9·09	83	7·33
20	30·45	36	16·91	52	11·71	68	8·95	84	7·25
21	29·00	37	16·45	53	11·49	69	8·82	85	7·16
22	27·68	38	16·02	54	11·27	70	8·70	86	7·08
23	26·47	39	15·61	55	11·07	71	8·57	87	7·00
24	25·37	40	15·22	56	10·87	72	8·45	88	6·92
25	24·36	41	14·85	57	10·68	73	8·34	89	6·85
26	23·42	42	14·50	58	10·50	74	8·23	90	6·76
27	22·55	43	14·16	59	10·32	75	8·12	91	6·69
28	21·75	44	13·84	60	10·15	76	8·01	92	6·62

TABLES OF CHANGE WHEELS

DIVIDEND 528

Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.
13	40·61	29	18·20	45	11·73	61	8·65	77	6·85
14	37·71	·30	17·60	46	11·47	62	8·51	78	6·76
15	35·20	31	17·03	47	11·23	63	8·38	79	6·68
16	33·00	32	16·50	48	11·00	64	8·25	80	6·60
17	31·05	33	16·00	49	10·77	65	8·12	81	6·51
18	29·33	34	15·52	50	10·56	66	8·00	82	6·43
19	27·78	35	15·08	51	10·35	67	7·88	83	6·36
20	26·40	36	14·66	52	10·15	68	7·76	84	6·28
21	25·14	37	14·27	53	9·96	69	7·65	85	6·21
22	24·00	38	13·89	54	9·77	70	7·54	86	6·14
23	22·95	39	13·53	55	9·60	71	7·43	87	6·06
24	22·00	40	13·20	56	9·42	72	7·33	88	6·00
25	21·12	41	12·87	57	9·26	73	7·23	89	5·93
26	20·30	42	12·57	58	9·10	74	7·13	90	5·86
27	19·55	43	12·27	59	8·94	75	7·04	91	5·80
28	18·85	44	12·00	60	8·80	76	6·94	92	5·74

DIVIDEND 634

Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.	Wheel.	Picks per ¼ in.
13	48·77	29	21·86	45	14·08	61	10·39	77	8·23
14	45·28	30	21·13	46	13·78	62	10·22	78	8·12
15	42·26	31	20·45	47	13·48	63	10·06	79	8·02
16	39·62	32	19·81	48	13·20	64	9·90	80	7·92
17	37·29	33	19·21	49	12·93	65	9·75	81	7·82
18	35·22	34	18·64	50	12·68	66	9 60	82	7·73
19	33·36	35	18·11	51	12·43	67	9·46	83	7·63
20	31·70	36	17·61	52	12·19	68	9·32	84	7·54
21	30·19	37	17·13	53	11·96	69	9·18	85	7·45
22	28·81	38	16·68	54	11·74	70	9·05	86	7·37
23	27·56	39	16·25	55	11·52	71	8·93	87	7·28
24	26·41	40	15·85	56	11·32	72	8·80	88	7·20
25	25·36	41	15·46	57	11·12	73	8·68	89	7·13
26	24·38	42	15.09	58	10·93	74	8·56	90	7·04
27	23·48	43	14·74	59	10·74	75	8·45	91	6·96
28	22·64	44	14·40	60	10·56	76	8·34	92	6·89

NOTES ON THE SIZING OF COTTON WARPS

The primary reasons for the sizing of cotton warps are :—

1. To bind together the fibres composing the yarn, and thereby to increase its tensile strength, so as to enable it to withstand the strain of the shedding and take-up motions of the loom.

2. To lay down loose projecting fibres, and to give each thread a smooth, well-lubricated surface. This is necessary in order to minimise the chafing action of the harness and reed.

In addition, sizing is often made the means of imparting to the cloth certain definite qualities, such as :—

1. Characteristic " feels " and appearances.

2. Certain colours, *e.g.*, Egyptian tints on American yarn, or very white effects on ordinary grey yarn.

3. Considerable weight in excess of that required to give good weaving qualities.

Sizing materials may be divided into five distinct classes, according to their respective functions when mixed in the size.

Adhesive Substances.—The term explains itself. The chief of these are :—Various starchy substances—wheaten flour, wheaten starch, sago flour, rice flour, tapioca flour, maize flour, and farina (potato starch). More or less altered starches—corn starches, soluble starches, gloy, and dextrine. Gums—gum arabic, gum tragacanth, " gum tragasol." Various seaweed preparations. Irish moss.

Starches from various plants exhibit different sizing properties. They behave differently in boiling, in adhesive properties, and in stability of the viscosity during storage. Cooked starch pastes of maize are the most and of farina the least stable.

Emollients or Softeners.—These are used to give suppleness, and also to provide " lubrication " for the yarn. Suppleness is given by fats and fatty oils, such as tallow, palm oil, castor oil, olive oil, cotton-seed oil, etc., and also glycerine. Substances used to give a smooth, polished surface to the yarn include various soaps, and waxes and wax-like fats, such as paraffin wax, beeswax, Japan wax, spermaceti.

According to recent work by the Shirley Institute, it appeared that reductions or even the elimination of fat in pure sizing would not be attended by any interference with loom efficiency. Also, in this

particular case, by exercising careful control in sizing and reducing the average amount from 16 or 17 per cent. to 12 per cent., considerable improvement in weaving and in costs resulted.

Deliquescents.—Substances which readily absorb moisture are used to prevent the starchy adhesives from becoming too dry and brittle, and to counteract the drying action which always results from the actual working processes. The ideal aimed at is to maintain the percentage of moisture in the sized yarn at as nearly as possible the moisture content of the natural cotton, i.e., 8 to 9 per cent.

The deliquescents in general use are magnesium chloride, calcium chloride, and glycerine. Zinc chloride is also strongly deliquescent up to a point, but is used in sizing, not on account of this property, but as an antiseptic. It is not so good as the other deliquescents mentioned, and is very much higher priced.

Weight-giving Substances.—China clay is in a class by itself. Other insoluble substances are French chalk and barium sulphate. A few soluble salts are also used, chiefly Epsom salts, magnesium chloride, and zinc chloride. The two latter have special functions other than that of giving weight, but are often used in some excess for this purpose.

Antiseptics.—Some kind of antiseptic substance is absolutely necessary in all sizes containing deliquescents, as moist starch is a very suitable pabulum for the growth of fungi (mildews). Sizes containing any nitrogenous matter, e.g., the gluten of wheaten flour, require much more antiseptic than size made up with pure starches. Whether a size contains deliquescents or not, it is *advisable* to use antiseptics in sufficient quantity to protect the cloth against unforeseen, but by no means unusual, conditions.

The number of antiseptics which have been tried and used at various times is very large. The following are the principal ones :—

Inorganic Substances.—Zinc chloride, zinc sulphate, copper sulphate, sodium fluoride, sodium silicofluoride, and boric acid.

Organic Substances.—Phenol (carbolic acid) and sodium phenate, cresylic acid, salicylic acid, thymol, and formolin. Glycerine is also a mild antiseptic. The British Cotton Research Association have patented the use of salicylanilide or derivatives as an antiseptic in sizing and finishing cotton, and they supply a sodium salt of one of these under the name " Shorlan."

The value of present methods and ideas in sizing is being called in question, and there are several new processes in the experimental stage in which starch paste is not used.

LOOM DRIVING

By W. A. HANTON, M.Sc. (Tech.)

The problem of getting a satisfactory drive for the power-loom is one that has long exercised the minds of textile engineers. The matter is one of some importance, for the nature of the drive has a decided effect on the production of the loom, both in quality and in quantity; it is also one of considerable difficulty, due to the intermittent running and varying load of the loom, and to the need, in non-automatic looms at least, for frequent stopping and starting. The drive must enable the loom to be started and stopped quickly and easily, and must be capable of keeping the loom running satisfactorily. It should also be clean and free from danger to the weaver; it should offer the minimum obstruction to light, and it should be reasonable in cost and upkeep.

In most respects the individual electric drive is the best, although, as will be evident later, it does not fulfil all the claims often made for it; and its first cost is high, particularly when considered for existing weaving sheds already fitted with overhead driving-shafts. Because of this, many attempts have been made, and are still being made, to secure some of the advantages claimed for the individual drive, particularly higher production through better running of the loom, by some cheaper appliance. An example of this is the " Speedwell " pulley drive, in which the fast and loose driving pulleys of the loom are mounted on an eccentric bush, fixed to the crankshaft, with the result that when on the fast pulley the belt is alternately tight and slack, and the driving radius at which the belt acts is continually varying. The claims of better and higher production from this deliberate introduction of a variation in the driving torque applied to the loom seem to be diametrically opposed to the claims of the advocates of the individual motor drive that these advantages result from the steadier running of the loom with the motor drive. A closer investigation, however, reveals a distinct similarity between the two methods.

Driving Systems.—Loom drives may be classified in three main groups: (1) Ordinary lineshaft drives, generally from overhead shafting, which is driven by a steam engine or large electric motor, power being transmitted to the loom by a belt through fast and loose pulleys, or, occasionally, through a clutch. (2) The individual motor drive, with power transmitted from motor to loom by belt or rope, wheel gearing or a chain. Generally, motor and loom start

together, the starting switch being operated direct from the starting handle. Occasionally the motor is kept running, and the loom started and stopped by a clutch, whilst a third method is to use a centrifugal clutch on the motor shaft, which enables the motor to reach nearly full speed before the clutch engages with the loom drive and begins to accelerate the loom. (3) Lineshaft drive, with " Speedwell " eccentric pulleys or other device to vary the speed of the crankshaft.

A quick start-up of the loom is necessary in order that the two important operations of beating-up and picking may be carried out, on the first pick, at the full speed of the loom. If the loom is under speed at the beat-up, a crack is liable to be made in the cloth. There is always a certain amount of slackness at the connecting-arm bearings, and if the loom is under speed, the reed does not reach quite so far forward as at normal speed. Again, if the loom speed is low when the first pick is delivered, the pick will be weaker than normal, and to enable the shuttle to get home without the loom " banging-off " the pick will have to be made stronger. This will result in extra wear and tear on the picking parts, or even in some reduction in the running speed of the loom, for it is most probably the shuttle speed that generally limits the speed of the loom.

The loom is usually started with the cranks between the back and top centres, although sometimes an earlier starting position is used— say, midway between bottom and back centres. To get up full speed for the beat-up, the drive should, therefore, be capable of accelerating the loom to full speed in from 180° to 225° of crankshaft movement. If up to speed for the beat-up, the loom will, of course, be at full speed for the pick.

Quickness in stopping is also desirable, so that the loom will not overrun much when stopping. This is not quite so important as a quick start, since a brake is often used to assist in the stopping, and can generally be adjusted to bring the loom to rest in the desired position. At the same time many looms are so arranged that the brake is not applied when the loom is stopped by the weaver. It is easier to stop the loom in the best position for changing the shuttle and re-starting the loom if no brake is applied, and if, as often happens, some adjustment of the loom position has to be made before starting, this is more quickly done if no brake has to be released.

During normal running of the loom the speed has a large cyclical variation due to the varying load. The chief distributing factors are the slay and the picking, but whereas the moving of the slay is causing disturbance at all times during the cycle, the effect of the pick is felt only during the short time the picking parts, and especially the shuttle,

are being accelerated. For example, in a 40-in. plain loom, running at 200 picks per minute, the average power required would be about 0·3 H.P., or 50 ft.-lb. per revolution of the crankshaft. Of this, 20 ft.-lb. at least would be spent on picking, this being done in about 30° of the crank movement, round about the bottom centre. The remaining 30 ft.-lb., mainly spent in overcoming friction at the shaft bearings, etc., would be distributed fairly evenly throughout the revolution. But, in addition, the slay is alternately taking work from the drive and giving it back again. Thus, from beat-up to bottom centre the slay would require an additional 16 to 20 ft.-lb., so that during this period the drive has to do more than twice as much work in accelerating the slay as in driving the rest of the loom, and it is at the end of this period, when the loom speed has fallen somewhat, that the work of picking has to be done, lowering the speed still further. From bottom centre to back centre the slay is slowing down and is giving back its 16 to 20 ft.-lb. of energy, thus helping to drive the loom; in fact, it will be evident that during this period the slay alone is quite capable of keeping the loom going, and hence the loom generally speeds up. The slay again acts as a brake from back centre to top centre, and speeds up the loom from top centre to beat-up. The loom speed is consequently high at beat-up and at the back centre, whilst it reaches its minimum after the pick, somewhere about the bottom centre.

These high and low speed periods do not come at the most desirable times. Thus, a high speed is desirable near the bottom centre to get a good pick, but in fact the speed at that time is low. Again, whilst the shuttle is passing through the shed, from shortly after bottom centre to a little after back centre, the loom speed should preferably be low, to give the shuttle as long as possible to get across; but the actual conditions are the reverse of this, for the loom speeds up as the shuttle is crossing. The extent of the speed variation, as will be seen later, depends mainly on the type of drive.

Information on the time required for the start and on the speed variation when running is not very reliable. In the *Journal of the Textile Institute*, vol. xix., No. 6, June 1928, p. T. 268, it is calculated that the time of acceleration of a 100-in. reed space plain cotton loom, individually driven by a 1-H.P. motor, is about 82° of the crankshaft revolution, starting from the back centre, motor and loom being assumed to start together. The speed variation of the loom is also calculated to be less than 2½ per cent. above and below the normal speed, and it is stated that calculations for a 40-in. loom show speed variation of less than 1½ per cent. above and below normal speed

(p. T. 276). In a further article in the same journal, vol. xx., No. 10, October 1929, p. T. 296, the speed variations as usually found in practice are stated to be about 10 per cent. above and below normal for ordinary lineshaft drive, and 1 to 2 per cent. for individual motor drives.

It seems likely, from some test results to be given later, that the calculated time for loom acceleration, as quoted above, is much less than the normal starting time. Although it is generally claimed, and seldom contradicted, that the individual motor drive gives a very quick start-up and also a quick stop, as compared with other methods of driving, this is certainly not correct, especially when motor and loom start together, as they generally do. Again, it is probable, as will be shown later, that the speed variations quoted, although generally accepted as about correct, are all considerably too low. Speed variations have generally been estimated from a tachograph record, the tachograph being generally driven by belt from the shaft or machine of which the speed variation is required. The recording pen of the tachograph is operated by a governor ball mechanism, any change in speed causing a change in the governor ball position, and a corresponding change in the position of the pen. It is practically certain that the belt which drives the instrument cannot transmit, without considerable slip, variations of the extent found in the speed of a loom crankshaft—variations of from 10 to 15 per cent. above to 10 to 15 per cent. below normal occurring in less than one-tenth of a second. In addition to errors due to belt slip, the effects of inertia in the instrument itself are almost certain to render the results unreliable.

In order to find out, by experiment, the approximate time of acceleration, a number of tests were recently made on looms driven by different methods. The apparatus used was a modification of the Fletcher trolley acceleration apparatus which is commonly used for mechanics' laboratory experiments, and the same appliance was used to estimate the approximate speed variation of the looms when running normally.

A brush at the free end of a spring lever is caused to vibrate by deflecting and releasing it, and the vibrating brush is used to trace out a wave curve on a paper strip fixed round the rim of a pulley on the loom crankshaft. The brush vibrates at a constant rate, and consequently the distances between successive waves are the distances moved by the pulley rim in equal time intervals, from which the average speed of the crankshaft in successive equal time intervals can be calculated and a speed curve can then be plotted. The

TABLE I

No.	Make of Loom.	Type.	Reed Space. In.	Speed, Picks per Minute.	Method of Driving.
1	Butterworth and Dickinson	Pickles' ideal loom, with Whittaker weft replenisher	41	184	Individual belt drive, ½ h.p. a.c. motor.
1 (a)	,,	,,	..	,,	Fast-and-loose-pulley drive from lineshaft.
2	,,	5-shaft cross rod.	..	160	Fast-and-loose-pulley drive from lineshaft.
2 (a)	,,	,,	..	,,	Speedwell pulley drive from lineshaft.
3	Northrop	Cop-changing automatic.	46	158	Individual gear drive, ½ h.p. a.c. motor.
4	Hattersley	Shuttle-changing automatic.	32	161	Friction clutch drive from lineshaft.
5	Ruti	Cop-changing automatic.	45	154	Friction clutch with belt drive from ½ h.p. a.c. running motor.
5 (a)	,,	,,	,,	,,	Belt drive from ½ h.p. a.c. motor. Loom and motor start together.

apparatus is cheap and easy to use, and the method has the merits of simplicity and directness. The speed curve obtained in this way is only approximately correct, but, on the other hand, the errors should be small if care is taken.

It was not possible to carry out all the tests on the same loom, but as far as possible, the tests were arranged to give a fair comparison between the various drives. The looms and methods of driving were as shown in Table I., all the looms weaving about the same weight of cloth.

Test Results.—1. *Speed Variation.*—The variation in speed of the looms during steady running is shown in Fig. 1, in which all the speed curves are drawn to the same scale. The approximate extent of the speed variation is also given in Table II.

2. *Starting Time.*—The diagrams in Fig. 2 show the starting times for the looms, the left-hand diagrams showing the time, in seconds, spent in accelerating to full speed, whilst the right-hand diagrams show the angular movement of the crankshaft during the acceleration, the latter being the more important of the two. The approximate values of these times are also given in tabular form in the last two columns of Table II.

3. *Stopping Time.*—This test was carried out only on the Pickles Ideal Loom No. 1, with the motor drive and also with the ordinary lineshaft drive. The diagrams in Fig. 3 show the relative times of stopping, in revolutions of the crankshaft, after the weft fork acts. These times are approximately three revolutions of the loom crank-shaft for the motor drive and one and a half revolutions for the line-shaft drive, no alteration of the brake being made between the tests.

Results.—The speed variations will be seen to amount to 10 to 15 per cent. for individual motor drives, and to 25 to 30 per cent. or more for lineshaft drives. The steadier running with the motor drive is due mainly to the flywheel effect of the motor and of the compara-tively heavy driving pulley or gearwheel on the crankshaft. An equally steady speed could almost certainly be got with the lineshaft drive if a flywheel of weight equivalent to the motor rotor were fixed to the loom crankshaft. The fixing would preferably be of a frictional nature to allow of a certain amount of slipping during stoppage, and also during starting. Even then it is by no means certain that the increased difficulty of stopping and starting will be balanced by any real improvement in the running of the loom. The speed variation will certainly be reduced, but it has yet to be definitely proved that the speed variation is detrimental to weaving.

The effect of the motor drive, as compared with the lineshaft drive,

FIG. 1.

16
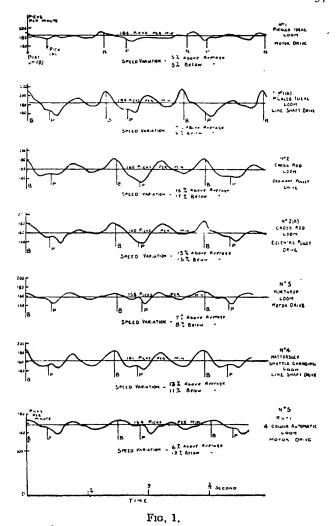
TABLE II

Loom-Speed Variation and Times for Loom Acceleration

No.	Loom.	Drive.	Average Speed, Picks per Minute.	Maximum Speed, % above Average.	Minimum Speed, % below Average.	Total Speed Variation, % of Average.	Approx. Time to Reach Full Speed.	
							Seconds.	Degrees of Crank Rev.
1	Pickles Ideal	Individual motor-belt	184	5	5	10	0·74	410
1 (a)	,,	Lineshaft	184	17	15	32	0·42	216
2	Cross rod	Lineshaft (ordinary pulleys)	160	15	17	32	0·38	180
2 (a)	,,	Lineshaft (Speedwell pulleys)	160	13	15	28	0·52	270
3	Northrop	Individual motor-gear	158	7	8	15	0·55	315
4	Hattersley	Lineshaft clutch	161	13	11	24	0·27	153
5	Ruti	Individual motor-belt (clutch start)	154	6	12	18	0·32	185
5 (a)	,,	Individual motor-belt (loom and motor start together)	154	,,	,,	,,	0·77	360
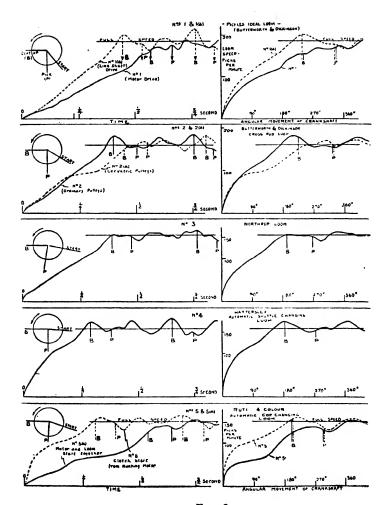
FIG. 2.

on the speed, about the time of picking, of the Pickles Ideal Loom (Nos. 1 and 1 (*a*)) is shown in Fig. 4. The speed with the lineshaft drive is about 4 per cent. lower when the pick is delivered, but some
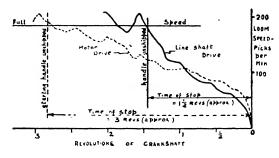
FIG. 3.

3 per cent. higher, on the average, whilst the shuttle is passing. The effect of the lower speed when the pick is delivered can be counteracted by setting the pick a little stronger so as to give the same shuttle speed as the motor drive, and the wear and tear, etc., on the
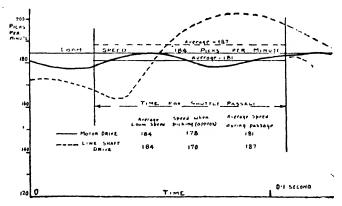
FIG. 4.

picking parts should be practically the same in both cases. It is true that the slightly higher loom speed during the shuttle passage, with the lineshaft drive, will probably need a higher shuttle speed and yet stronger pick, but, on the other hand, the loom, when motor-driven, does not start up so quickly, and may require a strengthening of the pick to ensure that the shuttle gets home properly on the first pick.

An examination of the effect of the Speedwell pulley drive, as seen in Fig. 1, shows a somewhat similar result to that got by the motor drive, though not nearly so marked. The tightening of the belt at the picking time again speeds up the loom as compared with the ordinary lineshaft drive, and again the speed is somewhat reduced when the shuttle is passing. But here, also, the steadier running with the Speedwell pulley drive is accompanied by a slow start. The belt is comparatively slack during the acceleration period, with the result that the loom is not up to speed for the beat-up.

The starting period for the looms tested averages about 180° of crankshaft revolution with lineshaft drive, and about 360° with individual motor drive, when loom and motor start together. The claim is frequently made that this latter method of driving gives a very quick start because of the high starting torque of the motor; but although the motor has this high starting torque, most of it is needed for accelerating the motor itself, leaving a comparatively small torque available for the acceleration of the loom. The calculated value, quoted above, of 82° of crankshaft revolution for a loom of 100 in. reed space, driven by individual motor in this way, would appear to be very much too low. This seems to be due mainly to underestimation of the masses, etc., of the loom parts. The effective weight of the moving parts of the loom, for example, is given as 8 lb., referred to the motor speed of 960 r.p.m. and radius of gyration of 1·9 in. The work done in accelerating these parts to the full loom speed of 115 picks per minute is equal to the energy stored at full speed, which works out to about 32 ft.-lb. But a test on the crank and bottom shafts only of a much narrower loom—34 in. reed space—showed about 43 ft.-lb. at 115 picks per minute, and the energy would certainly be much higher than that for a loom of 100 in. reed space.

The acceleration period for the individual motor drive can be much reduced by keeping the motor running, and stopping or starting the loom by means of a clutch. The result for the Ruti loom, when driven in this way (No. 5, Table II.), is an acceleration period of about 185°, as against 360° when loom and motor start together (No. 5 (a)). It is not desirable, however, to keep the motor running

continuously, because of the increase in the current costs, but a start which is nearly as quick will be got by using a centrifugal clutch coupling between motor and loom, this type of coupling allowing the motor to get up to about 70 per cent. of its speed before applying any torque to the loom. This method of driving should combine the advantages of economy in current with full loom speed for the first beat-up, whilst it will also make the stopping of the loom easier.

The stopping of the loom is naturally more difficult with the motor drives than with the lineshaft drive, for even with a centrifugal coupling about half the energy in the motor has to be got rid of before the clutch slips, and it must be remembered that there is far more energy in the motor at full speed than in the loom it drives. Even with the aid of a brake it is more difficult for the weaver to stop the motor-driven loom in a suitable position for changing the shuttle.

In conclusion, it would appear that to get the best results from the individual motor drive the motor should be running at full speed, or nearly so, before the loom starts. The motor certainly keeps the loom running comparatively steadily, but whether extra production results from this, as distinct from the reduction or elimination of belt slip, is a matter that requires further investigation.

A clutch drive gives a quicker start than fast and loose pulleys, but, except for very high-speed looms, the latter method gives a reasonably quick start and is less trouble in working. The eccentric, or Speedwell, pulley drive steadies the running of the loom to some extent; but, again, further investigation is required on the effect of this on the production.

STANDARD WEAVES FOR COTTON GOODS

Plain Weave.—The best known and by far the most used of all weaves, is that variously known as the plain, calico, or tabby weave. It results from the simplest possible scheme of interlacement, each thread passing alternately over and under successive picks of weft in regular order, and interlacing in exactly opposite manner to its neighbour, as illustrated in Design 1, which represents a sketch of a plain cloth, and in Design 2, which gives a point paper plan of the weave.

1   2
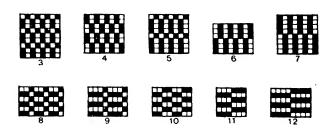
No attempt can be made here to indicate a tithe of the infinite variety of fabrics made from the plain weave, which range from the flimsiest cheese cloths, fine lawns and muslin, to heavy blankets and coarse canvas.   In addition to these, there are infinite varieties of cloths in the plain weave, ornamented by the introduction of threads which vary in thickness, colour, material, twist, or turns per inch, either in the warp or weft, or in both.   Variable spacing of the warp or weft threads in the same cloth, using two or more warp beams which are tensioned differently, utilizing mechanism in the loom which causes the threads to form zigzag lines in the cloth, are additional well-known means of ornamenting cloths made in the plain weave.

The squared paper, shown in Design 2 and succeeding illustrations, is variously known as design paper, point paper, and draft paper, and forms a convenient medium for recording the manner in which the threads interlace.   The vertical spaces are each taken as representing one warp thread, or more than one in those cases where more than one thread is placed in the same eye of the harness.   The horizontal spaces are each taken as representing one weft thread.   Marks in the squares can optionally represent the warp passing over the weft or the weft passing over the warp, but in all the weaves given herewith, filled in squares will represent warp threads raised over the weft ; and conversely, white or blank spaces will represent weft passing over the warp.

Repp or Rib Weaves.—The true repp is made in the plain weave so far as intersections of the warp and weft are concerned, but in appear-

ance the cloth presents a regular series of prominent cords extending across the cloth from selvage to selvage, and alternating with equally decided hollows. This is effected by arranging both warp and weft, one end coarse and one end fine alternately, and arranging the picking so that all the coarse threads are lifted above the coarse picks, and all the fine ends over the fine picks. The coarse ends are warped on a separate beam from the fine ends, and are less tightly tensioned than the latter.

Comparatively few looms are equipped to change the weft after the insertion of each pick, and large quantities of repps are made in which coarse and fine warp ends alternate, but the weft is all one count.
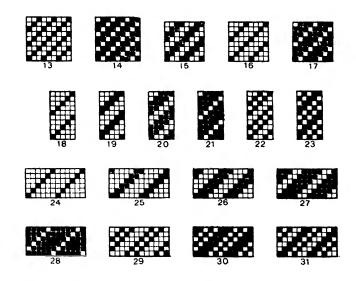
Other variants include those in which two or more picks are placed in the same shed, as illustrated in Designs 3 to 7. Ribs running in a longitudinal direction, that is, in the same direction as the warp, are produced by the Designs 8 to 12 inclusive.

Twill Weaves.—The twill order of interlacing produces diagonal lines in the cloth. It embraces a very large variety of weaves, in which, according to the designer's fancy or to produce a desired effect, (1) either the weft or the warp can be made to predominate on the face of the cloth in uniform straight diagonal lines ; (2) straight diagonal lines of varying prominence can be made according to the number of ends (or picks) in the floats ; (3) straight diagonal lines can be made in which both warp and weft appear in suitable contrast ; and (4) an infinite variety of diagonal fancy effects can be developed in either warp or weft, but most frequently in both.
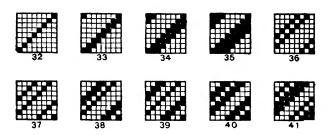
The simplest twill is the 1-and 2 twill, variously known as the "Cashmere," "Jean," "Genoa," and by other names. It is made with the weft predominating as in Design 13, or with the warp predominating as in Design 14. The 2-and-2 four-end twill weave, Design 15, is probably more used than any of the other twills. It is

known by a large number of special terms, such as "Harvard," "serge," "blanket," "sheeting," etc. The 1-and-3 twill can be made, as in Design 16, to give a weft face, or with the warp predominating as in Design 17. Owing to the fact that there are fewer intersections in twill weaves than in plain cloth, it becomes possible to put in more ends and picks per inch, and so build up heavier fabrics than is possible with the plain weave with the same count of yarns, hence the use of twill weaves for sheetings, blankets, heavy shirtings, and like fabrics.

The 5-end twill admits of several variations as illustrated in Designs 18 to 23. Variations of the 6-end twill are shown by the Designs 24 to 31. In straight twills the number of ends in a single repeat of the weave is the same as the number of picks. Designs 32 to 41 show some of the 8-end twill weaves. In deciding upon the extent to which the warp or weft shall predominate, due regard must be paid to the character and qualities of the materials to be used. In all cases the respective lengths of the warp and weft floats must be governed by the effect which it is desired to produce in the finished cloth, having due regard to the preservation of a desirable amount of firmness in the weave.

As the number of threads in a single repeat of the weave increases, the possible variations and the scope for fancy effects is greatly increased, but lack of space prevents us giving more examples of twill weaves, and readers are recommended to consult works on textile design for further examples of twill weaves. Elongated or stepped twills, corkscrew twills, broken twills, transposed twills, zigzag twills, waved

32   33   34   35   36

37   38   39   40   41
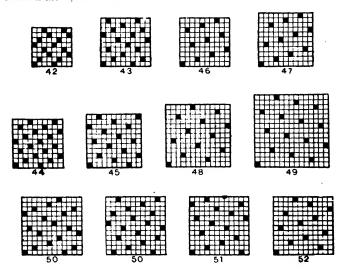
twills, curved twills, are some of the best known varieties of fancy twill weaves, and most of them can be used with telling effect for the ornamentation of grounds and ornament in brocade fabrics.

Sateen Weaves.—The sateen class of weaves is extensively employed in a large variety of both fancy and plain or unornamented fabrics. Each thread floats over or under all but one pick in each repeat of the weave, and these points of intersection are distributed in such manner as to minimize the occurrence of decided twill lines on the face of the fabric, and present as nearly as possible a solid warp or weft surface. In plain sateen fabrics, that is those without ornamentation, the smooth solid appearance obtained by floating the warp or weft so largely on the surface of the cloth, is very frequently emphasized by having considerably more ends than picks per inch in the case of a warp-faced sateen, and more picks than ends per inch in the case of a weft-faced sateen. A preponderance in picks over ends involves a low loom production, so that weft-faced sateens are more expensive to produce than warp-faced sateens.

In constructing sateen weaves, the intersections or binding points, besides being arranged in regular sequence, should be evenly distributed, and if possible be arranged equidistant from each other, in order to ensure an even distribution of warp and weft and eliminate marked lines of twill as much as possible. Neither of these two conditions can be satisfied by either the 4-end sateen, Design 42, or the 6-end sateen, Design 43, and for those reasons they are known as irregular or broken
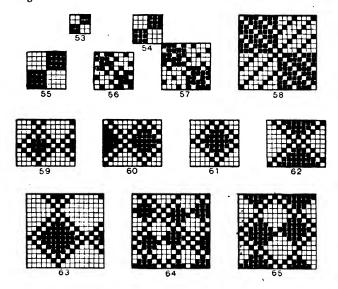
sateens, as distinguished from regular sateens in which the binding
points are arranged in regular order. ❦ Probably the 5-end sateen
illustrated in Design 44 is the most used of any of the sateen weaves,
and perfectly satisfies the condition requiring even distribution of the
binding points.❦ The 8-end sateen, Design 45 ; 10-end, Design 46 ; 11-
end, Design 47 ; 13-end, Design 48 ; and 15-end, Design 49, are other
regular sateens which give even distribution of the binding points.
The 7-end and 9-end sateens are seldom used, as it is not possible to
arrange the intersections equidistant, and a too pronounced wale is
visible in the woven cloth.

42   43   46   47

44   45   48   49

50   50   51   52

Besides their use as ground weaves, the sateen weaves are extremely
useful in other respects.   They frequently form the bases on which
crêpe weaves are built up, they also form the bases of large numbers of
textile designs, notably in the orderly arrangement of spot designs, and
in the distribution of the most prominent figures or masses of ornament
in all-over designs.   In this respect the broken or irregular sateens
often provide more suitable dispositions than regular sateens, as spots
and other objects can be evenly distributed without the oft-times fatal
objection of having the objects exhibiting pronounced lines diagonal or
otherwise.   Besides the 4-end and 6-end sateens shown in Designs 42

and **43**, other useful arrangements are the 8-end broken sateen, two arrangements of which are shown in Designs 50 ; the 10-end, Design **51** ; and the 12-end, broken sateen, Design 52.
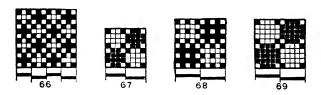
Dice Weaves.—Dice checks are produced by combining units or groups of warp and weft threads on the counter-change principle, as exemplified in Designs 53 to 58. The simplest dice weaves are those known also as matt weaves, shown in Designs 53 to 55. The more elaborate dice weaves are generally made by combining two opposite sateen weaves, as in Designs 56 and 57, or opposite twill weaves, as in Design 58.

Honeycomb Weaves.—The characteristic feature of honeycomb weaves is the formation of ridges and hollows which give a cell-like appearance in the woven cloth. Both the warp and weft are floated in diamond formation, with the addition of a single stitch or more of calico to add firmness to the texture. The weaves are utilized largely in the manufacture of towelling, bed-covers, quilts, and in fancy textures in combination with other weaves. Honeycomb weaves may be arranged as in Designs 59 and 61, where the weft diamond is larger than

the warp diamond, or as in Designs 60 and 62, where the warp diamond
is the same size as the weft diamond. In Design 60 two additional
picks are required as compared with Design 59, and in Design 62 two
additional ends and one more stave are required as compared with
Design 61. Design 63 shows the 12-end honeycomb, and Designs 64
and 65 show the 12-end and 16-end Brighton honeycombs respectively.
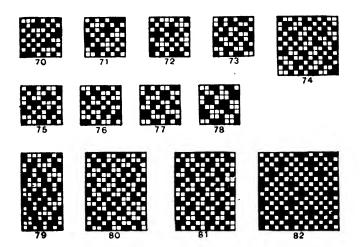
Imitation Lace or Mock Leno Weaves.—This is an interesting
class of weaves used principally for the decoration of fabrics, and
productive of lace-like openwork or perforated effects in the woven
cloth. In light weight brocades, mock leno weaves are frequently used
in the development of the ornament or ground, but the best mock leno
effects are only obtained when the denting of the ends in the reed is
arranged in conformity with the weave. The threads are arranged in
groups, and the outside threads of each group are made to interweave in
exactly opposite manner to the outside thread of the next group.
Arranged in this manner the threads composing each group tend to

66   67   68   69

crowd together, and leave a crack or open space between each group.
This effect is more pronounced when the threads composing each group
are placed in the same dent as indicated beneath the Designs 66 to 69,
which illustrate the 3 and 3, 4 and 4, 5 and 5 mock leno weaves
respectively. Sometimes the open effect is still more accentuated by
leaving a dent empty between each group of threads.

Crêpe Weaves.—Perhaps of all weaves the crêpe weave is least
capable of a precise definition. The name is frequently indiscriminately
applied to mixed weaves that are not obviously twill, satin, or of other
clearly pronounced type. It is correctly applied to broken-up weaves
which cover the cloth with variegated minute spots. Crêpe weaves can
be developed with either the weft or the warp in preponderance, or
with weft and warp both showing on the surface. The weaves are
used alone, as well as in combination with other weaves, and are very
frequently employed in the ground portion of brocade fabrics. Crêpe
weaves can be constructed in a variety of ways. Those made by a
haphazard arrangement of dots and blanks are almost invariably faulty

in some respect. The best results are obtained by first arranging
foundation dots in some predetermined order, the irregular sateens
being particularly valuable for this purpose, and then adding dots to
give a satisfactory mingling of the warp and weft, care being taken not
to let either warp or weft floats exceed the proper degree of boldness
consistent with the fineness of the fabric, or the quality of the material
being used. Useful effects can sometimes be obtained by reversing a
section of a simple weave, and then suitably filling up the remaining
spaces. Another method is to impose one weave on the top of another
weave, but special care should be exercised in this method, or undesirable

twill lines will be produced. The suitability or otherwise of crêpe
weaves depends very largely on the make of cloth or texture to which
it is applied, and the Designs 70 to 82 illustrate a few representative
weaves which have given satisfactory results in the woven fabric.

In constructing new crêpe weaves it is extremely difficult to judge
correctly, from the point paper design, whether the weave will prove satis-
factory or not when applied to the particular make of cloth for which it is
intended. In all cases, therefore, it is advisable to try crêpe weaves
in the actual cloth before deciding on their use. Crêpe weaves which
look quite good on point paper, often show in the woven cloth faulty
lines or groupings of floats which are obtrusive and which greatly
impair the general effect.

WEAVING PARTICULARS FOR TYPICAL COTTON FABRICS

Note.—All reeds named are Stockport count, *i.e.*, the number of dents in 2 inches. Where the reed is not stated, the number of ends per inch is substituted. The widths given are those in regular demand.

Style.	Width in Inches.	Reed, or Ends, per Inch.	Counts of Warp.	Picks per Inch.	Counts of Weft.	Weave.	Remarks.
Alhambra quilting	..	56/3	2/26's figure, 2/40's binding	36	6's condenser	..	..
„ „	..	58/3	16's figure, 2/40's binding	24	2¼'s soft	..	..
Apron check	46	48/4	36's	44	24's grey, 28's dyed,	Plain	Colours fast to washing
Bafts	27/28	56 to 68 ends	(2 in 1 eye) 18's to 20's	56 to 68	20's to 32's	„	Heavy-sized, 100 to 140 per cent.
Beaverteen	27/42	32 ends	2/18's	280	18's	..	..
Bedford cord	27/28	92 „	24's	80	48's	..	..
Blue dungaree	27/28	44/3	18's blue	48	20's blue	⅔-twill	..
Brocade	27/28	120 ends	2/90's	68	24's	..	..
„	27/28	68 to 140 ends	30's to 60's	56 to 108	30's to 80's	..	..
Cantoon	..	54 ends	2/20's	400	20's	Plain	..
Check zephyr	..	70/2	40's	68	40's	„	Heavy-sized, 100 to 110 per cent
Domestics	22/36	48 to 68 end's	18's to 24's	48 to 64	20's to 32's	⅔-twill	Checks of different sizes. All ½ colour.
Dress cloth, black and white	55	64/2	1s's white, and sulphur black	66	18's grey cop and sulphur black	..	..
Flannelette	34	60/2	30's	48	14's soft rove	⅔-twill or plain	..
„	84	44/4	28's (2 in 1 eye)	42	18's grey cop		..
Flour and grain-bag cloth	31/38	44 to 56 ends	16's to 20's	44 to 56	16's to 22's	Plain	Heavy-sized, 100 to 140 per cent.
Fustian	..	40/2	2/60's	400	26's	..	..

Weaving Particulars for Typical Cotton Fabrics—continued

Style.	Width in Inches.	Reed, or Ends, per Inch.	Counts of Warp.	Picks per Inch.	Counts of Weft.	Weave.	Remarks.
Gaberdine (showerproof)	56	54 4	2/36's (2 in 1 eye)	56	2/40's	⅔-twill	Self-colours, fast to washing
Grandrelle shirting	28¾	54/3	18's white, 20's colour,	62	14's grey cop	5-shaft warp satin	Indigo blue and washing colours
,, ,, ,,	28¾	42/5	2/40's grandrelle 20's white,	48	10's grey cop	,,	,,
,, ,, ,,			22's colour, 2/40's grandrelle 32's				
Gingham	28¾	68/2	32's	64	40's grey and dyed	Plain	Colours fast to washing
Handkerchiefs, coloured and cord borders	54 3 in width	62/2	44's Eg. grey, 40's colour,	70	44's Amer. grey cop.	..	Bleaching colours
,, ,,	40 2 in width	92/2	2/30's grey cord 62's Eg. grey, 40's colour,	80	54's Amer. grey cop.	..	,,
,, ,,			2/16's grey cord				
Harvard shirting	28¾	64/2	20's	60	18's	⅔-twill with stitch effects	Indigo blue and washing colours
,, ,,	28¾	66/2	22's	46	9's grey cond. cop 20's	,,	..
Honeycomb quilting	..	76 ends	2/40's	64	20's	..	..
Imitation chamois duster	26 in. wide. 24 in. long.	50/2	36's	38	8's cond. yellow 10's cond red	..	Yellow ground, red borders, surface raised
Imperial sateen	..	68 ends	16's	150	yellow 16 s	5-end sateen	..
Leno brocade	28	62	24's	70	50's	.	..
,, (cellular shirting)	28/46	30/0½/4	2/40's mercerized, 2/30's ground, 2/20's crossing	40	20's	..	..

Weaving Particulars for Typical Cotton Fabrics—*continued*

Style	Width in Inches.	Reed, or Ends, per Inch.	Counts of Warp.	Picks per Inch.	Counts of Weft.	Weave.	Remarks.
Matelasse	..	80/3	2/70's face, 2/50's back	{ 80, 40 }	face } 2/60's, back	..	..
Matt shirting	..	56 ends	24's	52	16's	..	..
„	..	84 „	32's	40	12's	..	..
Mexican	27/31	58 to 64 ends	20's to 22's	56 to 64	32's to 42's	..	Heavy-sized, 100 per cent.
Micheline quilting	..	60/3	20's figure, 36's binding	32	ground 14's, figuring 6's	..	..
Moleskin	..	38 ends	3/24's	400	14's	..	..
Nurse cloth	29½	68/2	20's	64	20's	Plain	Colours fast to washing
„	various	58/4	40's (2 in 1 eye)	62	38's coloured	„	„
„	various	66/2	20's	56	24's coloured	Plain (2 ends as 1)	Stitch effects
Oxford shirting	28	80/2	30's	44	16's hank	..	..
Piques	28	100/3	32's face, 2/40's back	{ 120, 60 }	face 40's, back 20's	..	..
„	28	40/3	40's face	{ 28, 140 }	cutting } 50's face, back 20's soft	..	..
Plains, grey	40	72 ends	30's back	28	38's	Plain	..
„	36	72	32's	72	32's	„	..
„	36	64	32's	72	28's	„	..
„	36	68	28's	64	20's	„	..
„	36	64	20's	68	20's	„	..
„	34	64	20's	64	42's	„	..
„	32	64	36's	64	54's	„	..
„	36	56	36's	64	16's	„	..
„	38	50	24's	58	16's	„	..
„	38		32's			„	..

Weaving Particulars for Typical Cotton Fabrics—continued

Style.	Width in Inches.	Reed, or Ends, per Inch.	Counts of Warp.	Picks per Inch.	Counts of Weft.	Weave.	Remarks.
Sateens, grey	31½	80 ends	38's	116	38's	5-end satin	
,, ,,	31½	72 ,,	38's	104	38's	,,	
,, ,,	31½	72 ,,	38's	116	38's	,,	
,, ,,	40½	72 ,,	36's	116	38's	,,	
,, ,,	56	72 ,,	38's	116	50's	,,	
Sateen skirtings and suitings	32	96/2	60's	160	18's	,,	Heavy-sized, 100 to 140 per cent.
,,	30	44/5	20's	68	18's	,,	Sized up to 70 per cent.
,,	30	48/5	22's	68	26's	,,	
Sheeting, grey	54/80	56 to 68 ends	17's to 22's	56 to 64	20's to 32's	..	
Shirting, grey	37/39	56 to 72 ends	26's to 32's	56 to 72	26's to 42's	Plain	
,, cord		60/1/2 ends	32's and 3/18's	68	40's	‡twill face, 8-end satin back	
Suiting, heavy	40	58/4	2/32's and 2/40's	60	12's	..	
Swansdown		60 ends	18's	120	20's	..	
Tartan dress cloths	39	68.2	36's white, 36's colour	60	40's grey cop, 44's colour	Clan tartan designs	Colours fast to washing
T cloths	24/31	48 to 66 ends	18's to 22's	48 to 60	24's to 32's	..	Heavy-sized, 100 per cent.
Terry towel (3-pick)		24/2	16's ground, 14's pile	34	12's	..	
Toilet quilting, 3-pick, 2-shuttle		80/3	42's face, 2/40's back	100 / 50	face 50's, wadding 10's	Loose back	
,, ,, 4-pick, 1-shuttle		56/3	18's face, 18's back	56 / 28	face 9's, back 9's	Stocking back	
,, ,, 5-pick, 2-shuttle		78/3	2/80's face, 2/50's back	80 / 40 / 80	back 40's, wadding 24's	Fast back	

Weaving Particulars for Typical Cotton Fabrics—*continued*

Style.	Width in Inches.	Reed, or Ends, per Inch.	Counts of Warp.	Picks per Inch.	Counts of Weft.	Weave.	Remarks.
Twill, grey	40½	72 ends	36's	80	38 s	⅜ twill	..
,, ,,	38	80 ,,	36's	120	38 s	,,	..
,, ,,	38	54 ,,	36's	96	28 s	,,	..
,, ,,	34	56 ,,	36 s	98	38 s	,,	..
,, ,,	34	60 ,,	36 s	100	44's	,,	..
,, ,,	29	64 ,,	32 s	64	20's	⅜ twill	..
,, ,,	31½	80 ,,	32's	132	36 s	¼ twill	..
,, ,,	56	72 ,,	36's	132	33's	,,	..
,, ,,	40½	72 ,,	36's	120	38 s	⅝ twill	..
,, ,,	36/40	72 ,,	36 s	72	33 s	,,	..
,, ,,	40½	72 ,,	36's	98 to 120	38 s	,,	..
Velveteen	..	72/2	2/80's	500	50's	..	..
Welt (piqué)	..	60/3	36's face, 30's back	120	20's	..	..
,, ,,	..	60/3	40's face, 36's back	144 / 18 / 64 / 64 / 80	face 40's Am., wadding 16's / 16's / 12 s / 18's	..	..
Wigan, plain	28 to 112	58 ends	16's	16		Plain	Pure-sized
,, heavy twill	22 to 112	68 ,,	18's	64	12 s	Twill	,,
,, light twill	28 to 112	58 ,,	24's	80	18's	,,	,,
Zephyr	23½	88/2	36's	90	32's white	Plain	Colours fast to bleaching
,, shirting	22½	80/2	36's grey, 40's bleach col., 2/32 s grey cord	90	40's grey cop	,,	,,

ANALYSIS AND COSTING OF FABRICS

The analysis of a woven fabric is strictly an examination into its con-struction for the determination of the particulars of make, or in other words the determination of the data which will permit any given sample to be duplicated.   In all branches of woven textiles a tremendous amount of business is done against small quality samples supplied to the manufacturer by the merchant or distributor.   The manufacturer is perforce compelled to analyse the sample in order to obtain the requisite weaving particulars.   But with ordinary care and the assistance of suit-able measuring and weighing instruments, an experienced analyst is able to determine with sufficient accuracy the counts of the yarns, setting and other particulars of make required to duplicate any given sample.   From these particulars, it is a simple arithmetical process to calculate the cost of the material, and up to this point the analysis pro-ceeds upon safe and well understood principles.   To the cost of the material, however, there must be added the cost of transforming the several yarns into fabric of the desired pattern, character, and finish. Now, while some manufacturers have gone to considerable trouble to reduce this important feature of costing to an exact science, the majority of manufacturers still rely upon empirical methods, which do not truly indicate exact conversion costs.   It is possible to calculate with accuracy the actual cost of the weaving, and many manufacturers adopt the practice of assuming all other expenses to be equal to a certain propor-tion of the weaving charges.   Obviously, their bargaining position is greatly weakened as compared with manufacturers who know the precise cost of making any given quality of cloth/ In this place, however, it is not possible to develop, or even indicate, a system which will serve the interests of textile manufacturers in general, owing partly to the great diversity of fabrics, the wide differences in the character of different yarns, and the equally wide diversity of methods and machinery for preparing such yarns for the loom.

    1. Counts of warp and weft.
    2. Number of ends and picks per inch.
    3. Weight of each kind or colour of warp, and weft.
    4. Character or quality of each kind of warp, and weft.
    5. Character or quality of each colour (if any).
    6. Design, heald or harness draft, and lifting plan.
    7. Length and width of the cloth usually specified on the order).
    8. Length of the warp or warps and width in the reed.
    9. Counts of the reed and manner of denting.
    10. Class of finish.
    11. Particulars of the selvages required.

Dealing with the question of analysis first, in order to be able to reproduce a cloth, the foregoing particulars must be ascertained :—

With the exception of item No. 7, and possibly No. 11, all the data specified may have to be determined by inspection and measurement from the sample submitted.

1. After first determining which series of threads forms the warp, and legibly marking same to prevent future error, the counts of the warp and weft may be ascertained in the manner described on page 183, under "Notes on Testing Yarn." Particular care should be taken to ascertain whether more than one count of yarn is used in either the warp or the weft, and whether any of the warp threads or picks are two or more fold yarns.

2. The number of ends and picks, as a rule, may be readily counted by the aid of any one of the standard pick counting glasses. Where the size of the sample permits, it is advisable to count both the warp threads and picks in several places, so as to minimize the risk of errors arising from weaving faults which may be present in the sample. In those cases where the compactness of the threads or intricacies of the weave makes it difficult to see all the threads or picks, a good plan is to count the number of ends or picks in one repeat of the pattern, and then count the number of patterns to an inch or other convenient unit of measurement.

3. The weight of each kind or colour of material may be calculated in the following manner—

$$\frac{\text{Ends per inch} \times \text{width in inches} \times \text{warp length in yards}}{840 \times \text{counts of warp}} = \frac{\text{weight of}}{\text{warp in lb.}}$$

$$\frac{\text{Picks per} \atop \text{inch} \times \text{reed width} \atop \text{in inches} \times \text{length of cloth} \atop \text{in yards}}{840 \times \text{counts of weft}} = \text{weight of weft in lb.}$$

These calculations give the actual weight of the material in the piece, but due allowances must also be made for waste in both warp and weft. In the majority of cases 5 per cent. is an ample allowance for waste, which in the case of cotton is equal to 42 yds. per hank, and for convenience of calculation the number of yards per hank is then taken as 800 yds. Where the percentage of waste is other than 5 per cent. it should still be taken as a proportion of the yards per hank, and the number so obtained used as a divisor. If, for instance, previous experience has shown that a particular class of cotton weft makes 8 per cent. of waste, the yards per hank would then be $840 - 67\frac{1}{2} = 772$ yds. With other classes of yarn, e.g., worsted, woollen, linen, silk, etc., the appropriate hank factor should be calculated to allow for the proper

percentage of waste.   In some mills the warp length is used instead of the cloth length in calculating the quantity of weft, and the difference is assumed to cover the amount of waste.   This is bad practice and leads to inaccurate results, as the difference between the warp length and the cloth length may bear no relation to the amount of waste.

4. The character and quality of each kind of warp and weft can only be determined by inspection and comparison with similar known qualities of yarns.   It affords scope for the exercise of trained and experienced judgment, although the matter is to some extent determined by the cost of the ultimate fabric.

5. The character and quality of the colour or class of dye is necessary in many cases, the final determination being usually influenced by previous knowledge of the style and the price of the cloth.

6. Design, heald or harness draft, and lifting plan, are obtained in the usual manner, from an inspection of the interlacement of the warp threads with the weft.

7. The length of the piece and the width of the cloth on the counter are usually specified on the order.

8. The length of the warp and width in the reed are determined in a similar manner by measurement of threads extracted from the sample submitted, as both items are dependent upon the amount of contraction the yarns undergo in being woven into cloth.   A convenient measured length of the cloth sample is cut, and a number of threads extracted. Each thread is taken in turn, and its length carefully measured after the waviness has been carefully smoothed out.   Sufficient threads are measured to give a reliable average.   Assuming that threads measuring 3 in. in the cloth were found to be $3\frac{1}{4}$ in. long when straightened out, then the warp contraction is approximately 6 per cent., and this percentage added to the cloth length gives the length of the warp. Similar procedure is adopted with the weft, and the percentage of contraction added to the cloth width gives the reed width.

9. The count of the reed is determined by the number of ends per inch in the finished cloth, after due allowance has been made for the contraction from reed width to cloth width on the counter.   Assuming for instance weft contraction of 5 per cent. and a cloth to have 84 ends per inch required to measure 30 in. on the counter, then the reed width would be $30 + 5$ per cent. $= 31\frac{1}{2}$ in. and the reed would have $84 - 5$ per cent. $= 80$ threads per inch.   The order of denting may very often be seen quite clearly by holding the sample up to the light, as the reed marks are not always obliterated even by the finishing operation.   In other cases the requirements of the weave and past experience of similar fabrics are safe indications of the number of ends to be placed in each dent.

10. In those cases where the cloth is delivered to the buyer in the loom state, the question of finish is no concern of the manufacturer. In other cases, the class of finish is generally specified on the order. Where this is not done previous experience of the analyst is depended upon to adjudge same correctly.

11. Where special selvages are required it is either specified on the order, or a cutting supplied with a portion of the selvage attached. Special selvages made of two-fold or other special yarns materially affect the cost of the fabric, and should never be ignored in the costing. Instead of having a separate calculation for the selvage, some manufacturers reckon each two-fold end of the selvage as being equal to two ends of the ground warp.

In order to ascertain the cost at which a fabric can be sold, the value of the materials used and the cost of converting such material into cloth, must be taken into consideration.   While the aggregate conversion costs of one manufacturer will probably not differ greatly from those of other manufacturers engaged in the same class of work, there are great differences of detail, and the manner in which certain of the expenses are allocated to different qualities of cloth.   Most of these expenses are covered by the following list :—

1. Value of materials, viz., yarns, sizing, etc.
2. Wages paid for :—
    (a) Weaving.
    (b) Preparing for weaving, *i.e.*, winding, warping or beaming, slashing, looming, loom tackling or jobbing.
    (c) Cloth examining and to warehouse staff, office staff, engineer, mechanics, labourers, etc.
3. Working expenses :—
    (d) Depreciation of machinery and buildings.
    (e) Interest on loan capital, bank commission, etc.
    (f) Repairs to buildings, machinery, renewals of machinery accessories, belts, oils, etc.
    (g) Rates, rents, insurance and similar charges.
    (h) Fuel, lighting, and water.
    (i) Cartage expenses and cost of goods transport.
4. Discount.

An approximate idea of the manner of arriving at the selling price of any given sample of cloth is afforded by the following examples of typical fabrics.   In all cases it is presumed that the counts of yarn and all other weaving particulars have been correctly ascertained by analysis or otherwise.

Example 1.—Plain Grey Cotton Cloth

Cloth to be 37 in. wide, 78 yds. long, 72 ends per inch of 30's warp and 76 picks per inch of 32's weft. The warp shrinkage is found to be 6 per cent., therefore the warp length would be 78 + 6 per cent. = 82·5 yds. The weft shrinkage is found to be 4 per cent., therefore the reed width = 37 + 4 per cent. = 38·5 in. Allowing 40 yds. per hank for waste in both warp and weft, the weight of material required would be :—

$$\frac{\overset{\text{Ends per inch.}}{72} \times 37 \times \overset{\text{Warp Length.}}{82\cdot5}}{800 \times 30} = 9\cdot16 \text{ lbs. weight of warp}$$

$$\frac{\overset{\text{Picks.}}{76} \times \overset{\text{Reed Width.}}{38\cdot5} \times \overset{\text{Cloth Length.}}{78}}{800 \times 32} = 8\cdot91 \text{ lbs. weight of weft.}$$

The weaving price for this cloth woven in a 43 in. loom would be (under the uniform list) :—

2d. per pick.
19 picks per ¼ in.

38 = price for 100 yds.
less   0·95 = 2½ per cent. for width of loom.

37·05
plus   1·48 = 4 per cent. for reed.

38·53
  78

30·05 = price for 78 yds.
plus 34·55 = 115 per cent. added to list prices.

64·60 = weaving price.

The total cost of this cloth would therefore be :—

30's warp, 9·16 lbs. at 30d. per lb.	- -	274·8d.
32's weft, 8·91 lbs. at 30d. per lb.	- -	267·3d.
Weaving - · - ·	-	64·6d.
All other expenses (assumed) to equal cost of weaving · · · ·	-	64·6d.

Cost per piece =   671·3d. = £2. 16s. 0d.

Example 2.—Fancy Shirting

In costing fancy cloths, the expenses are taken more in detail, because the system of warp preparation is usually much more elaborate than in the case of plain grey goods. It is also customary to quote the price per yard. The following is given as an example : A fancy shirting is 28 in. wide, 66 yds. long, 48 picks per inch, 18's bleached cop, 37 dents per inch, 29½ in. reed width, 30's white and coloured warp, 2/60's white mercerized :—

WARP PATTERN

Dents.	Ends.	
2	6	white mercerized
1	2	white.
3	6	$\left\{\begin{array}{l}1 \text{ white}\\1 \text{ green}\end{array}\right\}$ 3 times.
1	2	white.
1	2	black.
16	32	white.
1	2	black.
1	2	white.
3	6	$\left\{\begin{array}{l}1 \text{ green}\\1 \text{ white}\end{array}\right\}$ 3 times
1	2	white.
30	**62**	

$37 \times 29\frac{1}{2} = 1092 + 4 = 1096$ dents.
16 ends 2/50's selvage in   8 dents.
30×36 patterns in   1080   „
16 ends 2/50's selvage in   8   „

Total,   1096

	Ends per patt.		
White mercerized	6×36 patterns		= 216
White	46×36 „	+64 to cover selvage	=1720
Green	6×36 „		= 216
Black	4×36 „		= 144

Total ends = 2296

Weight of warp yarn, allowing 40 yds. per hank for waste :—

$$2/80\text{'s white mercerized } \frac{216 \times 70}{800 \times 40} = 0.4725 \text{ lb.}$$

$$30\text{'s white } \frac{1720 \times 70}{800 \times 30} = 5.016 \text{ „}$$

$$30\text{'s green } \frac{216 \times 70}{800 \times 30} = 0.63 \text{ „}$$

$$30\text{'s black } \frac{144 \times 70}{800 \times 30} = 0.42 \text{ „}$$

Weight of weft yarn, allowing 40 yds. per hank for waste :—

$$\frac{29.5 \times 66 \times 48}{800 \times 18} = 64.9 \text{ lbs.}$$

Taking the weaving price according to the Colne list, and knowing that the cloth was woven on 13 staves, for which allowance must be made, in addition to 6 per cent. for fine reed, the weaving price would be :—

d.

1·5   per pick (Standard).

plus   0·09 = 6 per cent. for fine reed.

———

1·59

plus   0·254 = 16 per cent. for shaft work.

———

1·844

12 = picks per quarter-inch.

———

22·128 for 70 yds. warp.

Weaving price : 22·128d. per piece.

Assuming a warp of 10 pieces the proportionate warp-dressing price according to the Colne and district list is 21·7d., and the proportionate drawing price is 5·11d. The dyeing and sizing of the warp will be taken at an average price of 9d. per lb. ; bleaching and sizing warp at 2½d. per lb. The cost of finishing the cloth, raised back, will be taken at ½d. per yd., whilst expenses will be taken as equal to weaving, seeing that warp dressing, drawing-in, and sizing have been separately dealt with. The summary stands thus :—

Warp { 2/60's mercerized, 0·4725 lb. at 72d. per lb.	-	34·02d.
{ 30's grey, 6·07 lbs. at 30d. per lb. -	-	182·10d.
Dyeing and sizing, 1·05 lb. at 9d. per lb. -	-	9·45d.
Bleaching and sizing, 5·016 lbs. at 2·5d. per lb.	-	12·54d.
Dressing - - - - -	-	21·70d.
Drawing - - - -	-	5·11d.
Weft, 649 lbs. at 32d. per lb. -	-	207·68d.
Weaving - - - -	-	22·12d.
Expenses - - - -	-	22·12d.
Finishing 66 yds. at ½d. per yard -	-	33·00d.

Total cost -   549·84d.

549·84d. ÷ 66 = 8·33d. per yard.

NOTES ON TESTING YARN FOR COUNTS

In estimating the unknown counts of yarn from a given sample for quotation purposes it is essential to take pains to arrive at a correct result. A number of methods are available, but in all cases the reliability or otherwise of the results depends to a great extent upon the degree of skill exercised in making the tests. If a large piece of cloth is available in the unfinished state, a good method is to cut a number of threads, say 30 in. long, although other lengths will serve, and after weighing them accurately, obtain the counts by calculation from the weight of the measured length.

For small patterns a small yarn balance is available, and with this system the threads are cut into short lengths to the size of a templet. The number of such threads required to make a balance indicates the counts. In other cases where small patterns have to be tested, a number of threads are cut to a predetermined length and weighed against a fixed weight, the number of threads required again indicating the counts.

Good judgment is required to determine when it is quite safe to use the system of weighing, as in the case of finished cloths particularly, and sometimes with unfinished cloths, the results are liable to be vitiated by the presence of an uncertain quantity of filling or weighting. The only alternative in such cases is to wash out all impurities, and even then some little doubt arises as to whether all the weighting has been washed away, or if that is made certain by a very vigorous scouring, whether or not some fibres have been removed.

Actual mill practice varies considerably. In some cases one or other of the weighing tests is made to serve, and such methods have at least the advantage of being fairly quick. In other cases, the counts is first obtained by twisting the unknown yarn, against yarn of a known count, and the result verified by weighing. In other cases the counts of the unknown yarn is determined solely by twisting it with similar yarn of a known count. A great aid towards securing reliable results, is to test the unknown yarns against yarns of similar count, taken from cloths which agree in respect of colour, weave, number of picks per inch, style of finish, etc. For this purpose, it is strongly recommended that a collection of finished and unfinished cloths made from yarns of known counts should be kept at hand. The collection should cover as wide a range as possible, so that in all cases unknown yarns may be compared with known yarns of like character.

The actual procedure is as follows : Prejudging that the unknown

count is about, say, 32's, that number of threads is abstracted from the unknown cloth.   Then 32 threads of 32's of the same colour and finish are taken from a known cloth.   The two sets of threads are then linked together as shown in the diagram herewith, where A represents the known counts and B represents the unknown counts.

The two sets of threads are twisted fairly tightly and as uniformly as possible.   Threads of the unknown counts are added or removed until it is adjudged that the two are equal in thickness.   If the number of threads taken of the known counts equals the counts in number, then the number of threads in the set of threads of the unknown counts equal the counts of the threads in the sample.   If, however, the number of threads of the known counts taken for some reason does not equal the counts, then the following rule must be used :—

$$\frac{\text{Strands of yarn in B} \times \text{known counts}}{\text{Strands of yarn in A}} = \text{counts of unknown yarn.}$$

Other useful rules for use when estimating the counts of cotton yarns and only short lengths of yarn are available, are as follows :—

0·2314 × number of inches that weigh 1 grain = counts.

The number of threads each 4·32 in. or $4\frac{5}{16}$ in. long that weigh 1 grain = counts.

$8\frac{1}{3}$ × number of yards weighed ÷ weight in grains = counts.

Number of yards weighed ÷ 0·182 × weight in grains = counts.

A quick method of ascertaining the counts of cotton yarn on a cop or bobbin is to wrap six turns, equalling 9 yds., and divide the weight in grains of this length into 75.   Thus :—

$$\frac{75}{\text{Weight in grains of 9 yds.}} = \text{counts.}$$

This length (9 yds.) might be taken as a standard length for wrapping, and provides an easy method of ascertaining the counts, though there is no reason why any other suitable length should not be taken, and a constant found by calculation for that length as follows :—Suppose the length most suitable is 10 wraps or 15 yds., then

$$\frac{15 \times 7000}{840} = 125,$$

and this number is the constant numerator, which, if divided by the weight in grains of the standard lengths, gives the counts.

WORSTED YARNS.—For worsted yarns in which the hank constant is 560, suitable constants for purposes similar to those given for cotton are :—

0·3472 × number of inches that weigh 1 grain = counts.

The number of threads each 2·88 in. long that weigh 1 grain = counts.

12·5 × number of yards weighed ÷ 0·08 × weight in grains = counts.

In wrapping worsted yarns constants similar to those given for cotton may be employed, the standard numerator for 9 yds. being 112·5, though 12 yds. gives a better number to deal with in calculations (150).

LINEN YARNS.—Similar constants for linen yarns in which the system factor is 300 are as follows :—

0·648 × number of inches that weigh 1 grain = counts.

The number of threads, each 1·543 in. long, that weigh 1 grain = counts.

Number of yards weighed ÷ 0·043 × weight in grains = counts.

The constant numerator, if 12 yds. are wrapped, is 280 ; this, if divided by the weight in grains of the standard length, will give the counts.

YARNS IN COMMON USE

Angola Yarn is composed of a low quality of wool (shoddy) and cotton scribbled together. About 20 per cent. is the usual proportion of cotton, which is included in the blend chiefly to improve its spinning properties, but sometimes these proportions are varied according to requirements. The yarn is principally employed as weft in the manufacture of warp-faced worsted fabrics.

Angora Yarn is spun in France of the silver-grey fur of the Angora rabbit. It is very soft and will not felt, and is used for knitted sporting goods.

Artificial Silk is entirely of vegetable origin, and consists of cellulose obtained from wood pulp or cotton formed into fine threads. It is now used in a large variety of fabrics, generally as special figuring threads either warp or weft, as weft in "lustre" fabrics, in trimmings, or in combination with the other textile threads.

Bead Yarns comprise threads to which an actual bead is fastened, or to which hardened gelatine of a bead-like form has been attached.

Botany Twist Yarns are spun from 56's to 70's Botany tops, and are used for the Huddersfield coating trade and the Bradford dress-goods trade.

Bourette Yarn is a heavy, fancy yarn spun from the carded short fibres of waste silk, with tufts or nubs of wool or hair occurring at intervals.

Bump Yarn is spun from low-class cotton waste into coarse thick yarn with a little twist. It is used as wadding weft for toilets, quiltings, etc.

Camlet Yarns are made from lustrous wool (Lincoln or Leicester).

Chain or Diamond Yarn is a three-fold yarn in which a thick soft thread is twisted with another thread of finer count and medium twist. These are twisted again in the reverse direction with a third and finer thread.

Chappe Silk Yarns are spun from inferior cocoons and silk spinners' waste. They are used in the manufacture of velvets.

Chenille Yarn is a composite thread produced by the weaving process. The warp threads interweave on the gauze principle, with weft in one or more colours. After weaving, the floats of weft between each group of warp threads are cut, thus producing continuous lengths of yarn with a projecting fluffy or pile surface. This yarn is then used as weft in chenille table covers, hangings, and like fabrics.

Cloud, Flake, or Slub Yarns (Cotton) are produced by twisting a fine thread with another thread in which at intervals a soft place termed a slub, flake, or nep, has been formed.

Coloured Mixture Yarns are made by running together, in the first process of drawing, tops of different colours, the final yarn having the differently coloured fibres thoroughly intermingled.

Condenser Yarns are spun from good-class cotton waste, counts 5's to 10's, used for weft in low-class shirtings, quiltings, etc.

Continental Mule Spun Yarn is a type of Botany yarn combed and drawn by the French method, and spun on the mule.

Cord Yarns for thick carriage rugs are spun from low coarse Scotch wool.

Cord Yarns (Cotton) prepared as single, 2, 3, 4, or more fold are thick yarns frequently used to ornament fabrics made with a ground of finer threads.

Cord Yarns (Silk) are thick yarns used to ornament silk fabrics, and are made by running the required number (up to about 20) of cotton threads together without twist, and then twining a silk thread around the cotton core so closely as to entirely cover the cotton.

Corkscrew Yarn (Cotton) is made by twisting together two yarns of unequal diameters, yarns which may be delivered at unequal rates, yarns which contain unequal twist, or yarns which are twisted in opposite directions.

Crêpe Yarns (Cotton) are usually made 6- or 9-fold, and are very hard twisted. Another class of crêpe yarn which is single, and also very hard twisted, is used for warp and weft in crêpe fabrics.

Crêpe Yarns (Worsted) are hard-twisted Botany yarns employed as weft in the production of crêpe-de-chines, and similar fabrics.

Crewel Yarns for knitting are spun from fine cross-bred wools.

Curl Yarn is made by twining a comparatively thick thread around a much finer ground thread so as to form a succession of curls or loops along the surface of the yarn.

Diamond Yarn consists of a thick core thread, around which two fine threads—usually of a different colour—are twisted in opposite directions, thus producing a diamond pattern effect.

Fingering Yarns are spun from fine cross-bred wools in hard, medium, and soft twists.

Gassed Yarns are yarns which have been passed through a flame, or over hot singeing plates, to remove the projecting fibres from the surface of the thread, and make it smooth, round, and bright. They are used principally for sewing thread, lace manufacture, yarns for mercerizing, and as coloured threads in high-class shirtings.

Genappe Yarns are made from lustre wools (Lincoln or Leicester), which are singed after doubling to secure a smooth surface free from loose fibre.

Gimp Yarn is produced in a manner similar to spiral yarn, but additional twisting is required.

Grandrille Yarns are evenly twisted yarns of different colours but usually similar counts.

Heald Yarns (Cotton) are made from Egyptian cotton, and doubled into threads of varying thickness, 6, 9, 12, and 16-fold being the most used.

Heald Yarns (Woollen) are made from long lustre wools.

Hosiery Yarns (Worsted) are made from fine botany tops (70's quality).

Hosiery Yarns (Cotton) are soft spun yarns with less than the standard number of turns per inch.

Knop Yarn is a two-fold yarn produced on a machine with an intermittent motion, which stops the progress of the yarn while one single twists around the base yarn to form a knop.

Knickerbocker Yarn is generally produced in two or more colours, and is made in a similar manner to cloud yarns, except that the spotting material is flecked with colour during carding.

Lace Yarns are produced from good Egyptian and Sea Island cotton.

Loop or Curl Yarns are produced by twisting a coarse firm thread around two ground threads, and then again twisting the whole around a binding thread.

Marl Yarns are worsted yarns in two or more colours, which are combined in the later drawing process, or in the final spinning process.

Melange Yarn is a mixture worsted coloured yarn produced from tops on which the colour has been printed at intervals.

Mercerized Yarn is cotton yarn treated, while in a state of tension, with caustic soda, which imparts to the yarn a bright lustre. These yarns are sometimes gassed before mercerizing.

Merino Yarns are spun from a mixture of cotton and wool, sometimes in equal proportions, usually about seven parts cotton to three parts wool. These are used as weft in union and other shirtings.

Mock Grandrelle Yarn is single yarn spun from double roving, one being white or grey and the other coloured.

Mungo Yarn is obtained from milled goods, chiefly fragments of cloth, which short-stapled fibre is mixed with longer wool or with cotton.

Organzine or Warp Silk contains from three to eight cocoon threads lightly twisted together.

Paper Yarns are produced from strips of paper which are first moistened and then twisted into a round thread. They are used as weft for quiltings, domestics, trimmings, for making sacking, and for carpets.

Sewing Thread (Cotton) is made from finest Egyptian and Sea Island cotton, usually six-fold.

Shoddy Yarn is spun from wool recovered from old long-staple materials.

Snarl Yarn is made from very hard twisted yarn, which is allowed to form " kinks " or curly places in the thread at the desired intervals.

Spiral Yarn is produced by twisting a fine thread around a thick soft single, or the thick thread may be twisted around the fine hard-twisted single.

Textilose is spun from low cotton waste in conjunction with strips of paper. Used as a substitute for jute in bag-making.

Tram or Weft Silk contains 2, 3, or 4 cocoon threads simply run together without twist.

Vigogne Yarns are spun from a mixture of wool and cotton.

Vigoureux Yarn is a fancy coloured worsted yarn made from sliver which is printed—generally in one colour—prior to the spinning process.

Voile Yarns (Cotton) are evenly spun hard twisted yarns used for both warp and weft of voile fabrics. Single as well as two-fold voile yarns are now in common use.

NOTES ON HEALD KNITTING

The term "counts of healds" indicates the number of heald eyes per inch on all the staves constituting a set; it should not be confused with the number of heald eyes per inch per stave. For example, from shafts each containing 20 heald eyes per inch, the following sets of healds could be made : Three shafts, 60's counts ; four shafts, 80's counts ; five shafts, 100's counts, and so on. Before the counts of healds to be used in weaving any specified cloth can be ascertained, the draft, method of denting the warp threads, and the counts of reed, must be known. In cloths such as plains, twills, sateens, etc., where, in one repeat of the draft, the same number of healds are required on each shaft (the denting also being regular and the ends drawn singly through the healds), the counts of healds to use will be equal to the ends per inch in the reed. For example : A warp has to be drawn 80 ends per inch in the reed, and has to be woven in plain, three-shaft twill, four-shaft twill, and five-shaft sateen. The plain would be drawn on four shafts, thus : 1, 3, 2, 4 ; and would require 20 heald eyes per inch per shaft, or a set of four shafts 80's counts. The three-shaft twill would be drawn in on six shafts (to prevent overcrowding the healds), thus : 1, 3, 5, 2, 4, 6 ; or 1, 2, 3, 4, 5, 6 ; and would require 13⅓ healds per inch per shaft, or a set of six shafts 80's counts. The four-shaft twill would be drawn in on four shafts, thus, 1, 3, 2, 4 ; or 1, 2, 3, 4 ; and would require, like the plain, a set of four shafts 80's counts. The five-shaft sateen would be drawn in on five shafts, thus : 1, 2, 3, 4, 5; and would require 16 healds per inch per shaft, or a set of five shafts 80's healds.

The best weaving conditions are obtained when the "counts" of the healds exactly coincides with the counts of the reed, as in such circumstances the warp ends occupy exactly the same width in the healds as in the reed. This allows the warp ends to pass through both the healds and the reed in a straight line, and therefore minimizes side-chafing of the ends during the weaving process. In practice, however, it is not always possible to attain this ideal condition, as the actual counts of healds required are not always used. In a few cases coarser counts than required are used, and this causes the warp ends to stand wider in the healds than in the reed, with the consequence that the reed will chafe the ends, particularly those nearest the selvage. Healds of finer counts than actually required are often used, and the spare healds dropped or left empty in a predetermined regular order. In such cases the drawer-in is expected to drop the healds in such manner as to keep the warp ends as nearly as possible in a straight line. But healds left empty frequently prove a source of trouble to weavers, and involve a

great risk of wrong drafts.   Moreover, if the healds used are very much finer than required, the spare healds interfere with the free passage of the yarn.

Apart from the above, faults sometimes occur in the knitting of healds, which greatly interfere with the gaiting and good weaving of the warp. Some of the most common faults noted are as follows :—

Rough Healds, caused by using lumpy heald twine, faulty sizing, varnishing or drying of the healds.   The healds and eyes should be perfectly smooth and free from all projections.   When healds are rough or sticky, the gaiting of the warp is often facilitated by freely dusting the healds, when in the loom, with French chalk ; but as only a small quantity of chalk remains on the healds, the remainder being lost on the floor, this is a very wasteful method.   Some firms have a wooden trough constructed, into which about one hundredweight of French chalk is placed.   If healds, when received from the knitter, are sticky or inclined to roughness, they are bent by taking hold of the top and bottom staves, and the eyes and those parts of the healds which have to come into contact with the warp are worked well into the French chalk.

"*Necked*" *Healds.*—This fault is caused by undervarnishing or sending the healds out before they are properly set.   If undervarnished, the healds will not be durable ; if "necked"—*i.e.*, the bottom loops of the healds all loose—there will be considerable trouble with the gaiting of every warp.   Because, when the healds are tightened up in the loom, a large number of warp ends will become fast between the bottom of the heald eye and the bottom loop of the heald, and as soon as weaving is commenced most of these ends will be broken out.   When a new set of healds is received it should be tested by bending over a few healds ; this should not result in any breaking loose at the eye.

Healds Dropped in the Knitting.—The greatest fault in healds of this description is where one shaft only is particularly faulty.   The warp ends when drawn through the healds of the faulty shaft will stand wider than the ends on the other shafts, thus causing them to be all askew in the healds.   In an ordinary set the healds should be knit the same width on each shaft, and should start and finish together, so as to ensure the warp ends passing through the healds straight.   Healds stuck together with varnish, closed eyes, healds dropped in pattern healds, are all faults which cause increased labour and loss of time to the drawer-in.

Special care should be taken of the healds when in the loom, or their working life may be considerably curtailed.   They should not be too tightly strung up.   The separate shafts should rise and fall clear of each other.   The back shafts should be clear of the sley cap when the latter is thrown back.   If the healds are touched by the crank or sley at each

pick, a sawing action is set up between the healds and the warp ends, the effect of which is to reduce considerably the durability of the healds. Connections between the shedding mechanism and the healds should be made at the proper places on each shaft; knots in the cords used in these connections should be so adjusted that there will be no danger of their rubbing against the healds when in motion.   If heald hooks are used in the shafts they should not project so as to touch the healds on adjoining shafts.

The counts of the yarn from which healds are knit influences good weaving to a considerable extent, and it is very important that the thickness of the heald yarn, as well as the size of the heald eye, should be exactly suited to the counts of the warp, the class and quality of the material used, and the number of ends per inch in the cloth which the healds have to weave.

For average work, the question of the counts of heald yarn may safely be left to the heald knitter, who, on knowing the counts of the healds to be knit and the counts of the warp yarn, is able to make the right selection.   Some mill managers and designers, however, prefer to specify the counts of the heald yarns to be used, as only they can be fully aware of any modifying circumstances which might influence the right choice of the counts of the heald yarn to be used.   In general, it may be stated that heald yarn too fine will not be durable for coarse counts or heavy work.   Or, if the heald eyes are too small, lumps and knots will not be able to pass through, and thus a larger percentage of yarn breakages will occur.   If the cloth has to contain a large number of ends per inch of coarse counts and too coarse twine is used, there will be considerable friction between the warp and the healds, and additional strain placed on the shedding mechanism.   Twine too coarse and too numerous or crowded clumsy heald eyes are very unsuitable for fine counts.

The yarn used for making cotton healds is made from folded Egyptian yarns of good quality.   Twelve-fold, 16-fold, and 20-fold are the most common folds, although others are in regular use.   As a guide to the selection of the correct counts of heald yarn the following table may be taken as thoroughly representative of sound practice.   It gives suitable heald yarn counts to use for weaving grey goods.   For coloured warps it is advisable to use heald yarns somewhat finer than for grey warps, and two moves to the right in the table is recommended, viz. : for 20's twist use the counts given in col. C ; for 32's twist use col. D ; for 44's twist and upwards use the counts given in col. E.   For the convenience of those who enumerate their healds by the number of heald eyes per inch, the number of stitches per inch is given in col. 3.   The counts of

healds in col. 2 is the total number of stitches on all the four staves in a plain set.

Counts of Yarn Used in Knitting Cotton Healds

	Counts of Healds.	Stitches per Inch.	Counts of Warp Twist.				
			20's	32's	44's	60's	80's
			A	**B**	**C**	**D**	**E**
1	40's to 50's	10 to 12·5	20/40's	15/40's	16/50's	16/60's	16/70's
2	51's to 60's	12·25 to 15	18/40's	15/40's	16/50's	16/60's	16/80's
3	61's to 70's	15·25 to 17·5	15/40's	16/50's	16/60's	16/70's	12/70's
4	71's to 80's	17·75 to 20	15/40's	16/50's	16/60's	16/70's	12/80's
5	81's to 90's	20·25 to 22·5	16/50's	16/60's	16/70's	16/80's	12/90's
6	91's to 100's	22·75 to 25	16/50's	16/60's	16/70's	16/80's	12/90's
7	101's to 110's	25·25 to 27·5	16/60's	16/70's	16/80's	12/70's	12/100's
8	111's to 120's	27·75 to 30	16/60's	16/70's	16/80's	12/80's	12/100's

Systems of Numbering Reeds

District	System of Counting.	Factor.
Huddersfield	Number of dents in 1 in. - - -	1
Radcliffe -	,, ,, ,, - - -	1
U.S.A. -	,, ,, ,, - - -	1
Stockport -	,, ,, 2 in. - - -	$\frac{1}{2}$
Blackburn -	Number of beers of 20 dents in 45 in.	$\frac{4}{9}$
Bolton -	,, ,, ,, 24¼ ,,	$\frac{80}{97}$ or 0·82474
Bradford -	,, ,, ,, 36 ,,	$\frac{5}{9}$
Dewsbury -	,, ,, ,, 90 ,,	$\frac{18}{9}$
Leeds - -	,, ,, ,, 9 ,,	$\frac{18}{9}$
Irish - -	Number of hundreds of dents in 40 in.	$\frac{5}{2}$ or 2·5
Macclesfield	,, ,, ,, 36 ,,	$\frac{25}{9}$
Scotch -	,, ,, ,, 37 ,,	$\frac{100}{37}$ or 2·702
Metrical -	Number of dents in 1 centimetre -	$\frac{100}{39}$ or 2·53969
,, -	,, ,, 1 decimetre -	$\frac{10}{39}$ or 0·25397

Note.—Any count of reed may be converted into dents per inch by multiplying by the constant factor given in the third column. Dents per inch, divided by the constant factor, equals the equivalent reed in any other denomination.

REED TABLE

Dents per Inch.	Stockport.	Blackburn.	Bolton.	Bradford.	Leeds.	Irish.	Macclesfield.	Scotch.	Dents per Centimetre.
20	40	45·00	24·25	36·0	9·47	8·0	7·20	7·40	7·874
21	42	47·25	25·46	37·8	9·95	8·4	7·56	7·77	8·267
22	44	49·50	26·67	39·6	10·42	8·8	7·92	8·14	8·661
23	46	51·75	27·88	41·4	10·89	9·2	8·28	8·51	9·055
24	48	54·00	29·10	43·2	11·37	9·6	8·64	8·88	9·449
25	50	56·25	30·31	45·0	11·84	10·0	9·00	9·25	9·842
26	52	58·50	31·52	46·8	12·32	10·4	9·36	9·62	10·236
27	54	60·75	32·73	48·6	12·79	10·8	9·72	9·99	10·630
28	56	63·00	33·95	50·4	13·26	11·2	10·08	10·36	11·023
29	58	65·25	35·16	52·2	13·74	11·6	10·44	10·73	11·417
30	60	67·50	36·37	54·0	14·21	12·0	10·80	11·10	11·811
31	62	69·75	37·58	55·8	14·69	12·4	11·16	11·47	12·205
32	64	72·00	38·80	57·6	15·16	12·8	11·52	11·84	12·598
33	66	74·25	40·10	59·4	15·63	13·2	11·88	12·21	13·000
34	68	76·50	41·22	61·2	16·11	18·6	12·24	12·58	13·386
35	70	78·75	42·40	63·0	16·58	14·0	12·60	12·95	13·779
36	72	81·00	43·65	64·8	17·05	14·4	12·96	13·32	14·173
37	74	83·25	44·86	66·6	17·53	14·8	13·32	13·69	14·567
38	76	85·50	46·07	68·4	18·00	15·2	13·68	14·06	14·960
39	78	87·75	47·28	70·2	18·47	15·6	14·04	14·43	15·354
40	80	90·00	48·50	72·0	18·95	16·0	14·40	14·80	15·748
41	82	92·25	49·71	73·8	19·42	16·4	14·76	15·17	16·141
42	84	94·50	50·90	75·6	19·99	16·8	15·12	15·54	16·535
43	86	96·75	52·13	77·4	20·37	17·2	15·48	15·91	16·930
44	88	99·00	53·55	79·2	20·84	17·6	15·84	16·28	17·322
45	90	101·25	54·56	81·0	21·32	18·0	16·20	16·65	17·715
46	92	103·50	55·71	82·8	21·80	18·4	16·56	17·02	18·109
47	94	105·75	56·98	84·6	22·26	18·8	16·92	17·39	18·503
48	96	108·00	58·20	86·4	22·73	19·2	17·28	17·76	18·896
49	98	110·25	59·41	88·2	23·20	19·6	17·64	18·13	19·290
50	100	112·50	60·62	90·0	23·68	20·0	18·00	18·50	19·685

CLEAR SHELLAC VARNISH.—To get an absolutely clear solution of shellac has long been a desideratum with those who have occasional need of the medium of cements, etc.   It may be prepared by making an alcoholic solution of shellac in the usual way; a little benzole is then added, and the mixture well shaken.   In the course of from twenty-four to forty-eight hours the fluid will have separated into two distinct layers—an upper alcoholic stratum, perfectly clear, and of a dark red colour, while under it is a turbid mixture containing the impurities. The clear solution may be decanted or drawn off with a pipette.

SECTIONS AND SPECIAL ARTICLES IN 1930 YEAR BOOK OMITTED IN 1931 EDITION

WOOL SUPPLIES

The world's production of wool has been recently estimated at about 3,620,638,000 lbs., compared with an average annual production of 3,248,477,000 lbs. in the pre-war years 1909-13.

For all practical purposes the wool produced may be divided into three broad classifications—namely, merino, crossbred, and low. Merino wools in quality are 60's, 64's, 70's, and 80's, Bradford descriptions. Finer qualities still are produced, such as 90's, and even finer, but they constitute a negligible quantity of the total. Crossbreds range from 32's to 58's qualities, and in the wool trade embrace all qualities other than merino. Low wools fall into a class by themselves ; they include East India wools, and are used in the manufacture of carpets, rugs, etc.

A further distinction is drawn between combing wools, *i.e.*, wools used in the worsted trade ; and clothing wools, *i.e.*, wools used in the woollen trade.

There are twenty-four registered pure breeds of sheep in the United Kingdom, and the wool produced ranges from 28's quality grown on the blackfaced breed, to 58's quality grown on the Southdown.

All wools may be divided into three main classes—namely, long, medium, and short, and the essential differences may be summarised as follows :—

	Long Wools.	Medium Wools.	Short Wools.
Length - -	8 in. and upwards	5 to 8 in.	1 to 5 in.
Lustre - - -	Lustrous	Demi-lustrous	Non-lustrous.
Colour - -	Yellowish	Fairly white	White.
Fineness - -	1/400 to 1/700 in.	1/600 to 1/900 in.	1/900 to 1/2000 in.
Softness - -	Fairly hard	Fairly soft	Soft and very soft.
Elasticity - -	Fairly elastic	Elastic	Very elastic.
Waviness - -	Fairly straight	Fairly wavy	Very wavy.
Felting property -	Indifferent	Good	Very good.

In British wools the long classes comprise chiefly Lincoln, Leicester, Border-Leicester, Cotswold, Devon, and the Blackfaced type. In the medium classes there are Cheviot, Romney Marsh, and Irish. Among the shorter wools are Southdown, Dorset, Wiltshire, Shropshire, Oxford, Hampshire, and Suffolk Downs.

DEFINITIONS OF WOOL TERMS

Lamb's Wool.—Up to seven months old, approximately.

Hog.—First clip off sheep, about one year old.

Teg.—Same as hog, in shorter wools. Both hogs and tegs are naturally finer and longer than wethers, and are thus classed about four qualities higher.

Wether.—After first clip.

Ram and Ewe are, of course, male and female respectively, the former producing longer and stronger wool.

Comeback refers to the wool from a sheep which after crossing and recrossing comes back nearly to the original breed or type.

Super is finer than **Selected**, and **Pick** finer than **Super.**

Colonial and Other Crossbred Wools

32's-40's : **Coarse Crossbreds.**—12 in. downwards, fairly strong and lustrous, harsh, felting indifferent ; yield 60-90 per cent.

40's-50's : **Medium Crossbreds.**—10 in. downwards, very strong and lustrous, fairly fine and soft, fair felting properties ; yield 55-65 per cent.

50's-58's : **Fine Crossbreds.**—6 in. downwards, very strong, fair lustre and good colour, soft handle, good felting properties ; yield about 50-60 per cent.

Colonial and Other Merino Wools

58's-64's : **Strong Merinos.**—4 in. downwards, very strong, good white colour, very soft handle, very good felting properties : average yield 48-50 per cent.

64's-80's : **Fine Merinos.**—3 in. downwards, very strong and white, extra soft, with best felting properties ; average yield 45-50 per cent.

British Wools

28's-32's : **Mountain Types.**—Scotch blackface wethers and hogs ; Irish, Scotch, and Herdwick ewes and wethers.

32's-36's : **Mountain.**—Irish mountain, best Scotch cross wethers, and hogs. **Lustres.**—Lincoln wethers and hogs, Nottingham wethers, Yorkshire wethers. **Demi.**—Deep Radnors.

36's-40's : **Lustres.**—Nottingham hogs, Leicester wethers and hogs, Ripon wethers, Devons, Yorkshire hogs. **Demi-lustres.**—Selected Irish wethers, super Staffordshire wethers. **Demi.**—Welsh fleeces, seconds.

40's-44's : **Lustres.**—Ripon hogs, North wethers. **Demi-lustres.**—Irish wethers (pick and super), Irish hogs (selected), Kent wethers (selected), super Staffordshire hogs. **Demi.**—Welsh fleeces best, Lonk ewes and wethers, Cheviot wethers.

44's-46's : **Demi.**—North hogs, Irish hogs (pick and super), Kent tegs (selected), half-bred hogs, Norfolk half-bred hogs, fine Radnors, Cheviot hogs (super).

46's-50's : **Demi.**—Pick Shropshire hogs and wethers, selected Welsh Eastern Counties Down ewes and tegs, Hampshire and Oxford Down ewes and tegs.

50's-58's : **Demi.**—Wiltshire and Dorset Down tegs and ewes, Southdown tegs and ewes.

Summary

Mountain Wools.—Length 8 in. to 1½ in., strength deficient, no lustre, colour according to soil ; handle harsh, brittle, non-felting, more or less kempy ; yield 55-70 per cent. according to soil ; fineness 28's to the best of 50's quality.

Lustre Wools.—Length up to 16 in., very strong and firm, high lustre, colour according to soil, non-felting ; yield 60-75 per cent. according to soil : fineness 28's up to 44's quality.

Demi-lustre—*e.g.*, a cross between Lincoln (pure lustre) and Shropshire (non-lustre).—Length up to 8 in. or 10 in., strong and firm, " softish " handle, felting indifferent ; yield 60-70 per cent. ; fineness up to 48's quality.

Half-breds.—Same characteristics as Demi.

Demi (in the sense of non-lustre).—Length up to 4 in. or 5 in., comparatively strong, soft handle, felting fairly good ; yield 60-68 per cent. ; fineness up to 54's quality, except Southdowns, which go up to 58's, and are the best.

Sheep in the United Kingdom

·The following shows the number of sheep in the United Kingdom and the estimated wool production :—

Year.	Number of Sheep.	Wool Production.	Wool Exported.	Left for Home Consumption.
		Lbs.	Lbs.	Lbs.
1913	27,629.206	125,122,000	28,662,000	96,460,000
1917	27,850,252	125,176,066	8,781,200	116,394,866
1918	27,062,681	119,736,277	2,333,300	117,402,977
1919	25,047,694	115,658,564	18,462,900	97,195,664
1920	23,328.790	104,856,600	22,170,100	82,686,500
1921	24,160.826	101,100,000	35,334,900	65,765,100
1922	23,816,000	102,900,000	61,359,700	41,540,300
1923	24,184,000	102,300,000	57,920,900	44,379,100
1924	25,366,000	104,477,000	52,314,300	52,162,700
1925	26,527,800	109,753,800	53,690,900	56,062,900
1926	27,580,000	113,684,000	54,395,000	59,289,000
1927	28,328,000	117,822,000	62,021,000	55,811,000
1928	27,865,600	118,816,000	48,195,400	70,620,600
1929	27,691,000	117,070,000	51,983,000	65,087,000

PRICES OF BRITISH FLEECE WOOLS DURING 1930

The following shows prices ruling in Bradford for certain descriptions of British wool during 1930 :—

Quotations, in pence per lb., are those ruling on the last Thursday in each month for good, well-classed, selected, and well-washed fleeces.

Description.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
Lincoln hogs	18¾	13½	12½	12½	12	11¼	11	10½	10¼	9½	9	9
Lincoln wethers	13	13	12	12	11½	10½	10¼	9¼	9½	9	8	8
Nottingham hogs	14	13½	12½	12½	12	11¼	11	11	10	9½	9½	9½
Nottingham wethers	13½	13	12½	12	11½	10¼	10½	10	9¾	9	8	8
Ripon hogs	15	15	14	14	13	12¼	12	12	12	11	11	10½
Ripon wethers	14	14	13	12½	12	12	11½	10¾	10¼	10	9	9
Yorkshire hogs	14	13½	12½	12½	12	11¼	11	10¾	10	9½	9½	9¼
Yorkshire wethers	13½	13	12	11¾	11½	10½	10¼	10	9¾	9	8	8
North hogs	14¼	13½	12½	12½	12	11½	11¼	11	10¾	9½	9	9
North wethers	13½	13	12	12	11½	11	10¾	10¼	10	9	8½	8½
Irish hogs, pick and super	14½	13	12½	12	12	12	11½	11	10½	10	9½	9½
Irish wethers, pick and super	14	13	12½	12	12	11½	10¾	10¼	10	9½	9	9
Best Kent tegs	15¼	14½	14	13¼	12½	12	11½	11	11	10	9½	9½
Best Kent wethers	13½	12½	12	11	11	11	10½	10½	10	9	8½	8½
*Cheviot hogs, North	14	13½	12	12	12	11¾	10	10	9½	9	8½	8
*Cheviot wethers, North	13	12½	11	11	11	10¾	10	9½	9	8½	8	7¾
Half-bred hogs (Mid. Counties)	14	13½	12	11½	11	11	11	10¾	10½	9½	8¾	8
Half-bred wethers (Mid. Counties)	13½	13	11½	11½	11	10½	10¼	10½	10¼	9	8½	7½
Norfolk half-bred hogs	14	13½	12	12	11½	11	11	10¾	10½	9½	8¾	8
Norfolk half-bred wethers	14	13	12	11½	11	10½	10½	10	10	9	8½	7½
*Scotch Cross hog	10	9½	8½	8½	8½	8½	8	7¼	7½	6½	6½	6½
Southdown tegs and ewes	18½	18¼	17	15¾	15¾	15½	16½	16¼	15¼	14	14¼	13¼
Pick Shrop. h. and w.	16	15¾	15	14½	14¼	14	14	14	13½	12½	11½	11
Hampshire Down t. and e.	16	15½	14	14	14	14	14	14	13	12	11	10¾
Dorset Down t. and e.	18	17¾	16½	15½	15	15	15	15	14½	13½	13¼	13
Eastern Counties Down t.	15	15	14½	13¾	13	13	13	12½	12	10¾	10	9¾
Eastern Counties Down e.	15	15	14¼	13¾	13	13	13	12½	12	10¾	10	9½
Welsh fleeces, selected	12	12	11	11	10½	10½	10	9¾	9	8	7½	7
Radnors, pick and fine	12½	12	11½	11	10¼	10½	10	9¾	9½	8½	7	7
*Herdwick e. and w.	10	10	9½	9	8½	8	7	6	6	5	5	4¾
*Blackfaced Scotch	11½	11½	10½	10	9	9	7¼	6	5¾	5½	5½	5½

* Unwashed.   h. = hogs.   w. = wethers.   t. = tegs.   e. = ewes.

COLONIAL AND FOREIGN WOOLS

The finest merino wool is grown in Australia, Tasmania, and in increasing quantities in South Africa.   The merinos of Australia show good length, colour, soundness of staple, elasticity, fineness, softness, and felting property.   Merinos are grown in three main types—namely, fine, medium, and strong, and they are used in the production of the finest worsteds, woollens, and hosieries.   The best commercial types are 64's and 70's, and these wools are wanted in increasing quantities.

Crossbreds are produced in Australia, New Zealand, and South America.   Of the New Zealand clip, about 98 per cent. is crossbred wool and only 2 per cent. merino.   Of the South American clip, about 70 per cent. is crossbred and 30 per cent. merino.

Crossbreds can be divided into three classes—namely, fine, medium, and coarse.   The first cross of the merino with a mutton sire, say, Lincoln, Leicester, or even Romney, produces a sheep growing 50's to 56's wool ; the second cross of the half-bred ewe produces medium wool of, say, 46's to 48's quality ; and a third cross produces a full blood coarse crossbred with a quality ranging around 40's to 44's.   The pure Lincoln and Leicester wools produce wool of 36's to 44's quality, while pure Romney Marsh wool is 46's to 48's.   A very useful class of fine crossbred wool comes under the category of " comeback," this wool being 56's to 58's quality, while often the comeback wool produced in Victoria and Tasmania will scale 60's quality.   The crossbreds from South America are excellent for many purposes, but, as already indicated, are usually of the Lincoln type, and are not quite equal in point of handle and spinning value to those of Australia and New Zealand, though there has been a marked improvement in the general character of South American crossbreds during the past dozen years, owing to the large importations of stud sheep from England.

The following are the leading descriptions of wool made in Australia when the fleeces are classed after shearing :—

Super or AA Combing.—Represents the longest, brightest, and lightest conditioned sound fleeces.

First or A Combing.—Represents shorter, heavier conditioned, and less attractive fleeces of the same quality.

Average or B Combing.—Represents the shorter, heavier conditioned and less attractive fleeces of rather strong quality.

Combing or C Combing.—Represents all the extra heavy conditioned and very fatty fleeces from the above lines.

Broken Fleece.—Usually contains the tender stapled fleeces from the above lines.

Super or AA Lambs.—Represent the lightest, brightest, longest, and best lambs.

A Lambs.—Shorter and heavier in condition.

Necks.—The portion from the neck of the animal adjoining the shoulder.

A Pieces.—Lightest, brightest, and best conditioned.

Pieces.—Heavier in condition and the outer edges of the skirted fleece.

Stained Pieces.—Represent that portion of the fleece stained by urine, dung, etc.

A Bellies.—Earthy, stumpy, and short wasty tender wool from the belly of the sheep.

A Locks.—Represent the lightest conditioned trimmings of the fleece.

Locks.—Heavy conditioned, short, and second cuts ; should be free of dags.

The following statistics relating to sheep and wool production in Australasia are compiled by Dalgety & Co. :—

Sheep Returns

States.	1929.	1928.	1927.	1926.
New South Wales	50,750,000	50,515,000	48,920,000	54,630,000
Victoria -	17,427,203	16,498,222	15,527,447	14,863,000
Queensland	19,975,752	18,509,201	16,642,385	16,965,481
South Australia	6,186,252	7,079,947	7,542,345	7,450,000
West Australia	9,556,823	8,927,929	8,447,480	7,436,312
Tasmania -	2,000,000	1,900,000	1,860,000	1,619,075
Commonwealth	105,896,030	103,430,299	98,939,657	102,963,868
New Zealand	30,637,390	29,051,382	27,133,810	25,379,071
Australasia	136,533,420	132,481,681	126,073,467	128,342,939

	Australia.	New Zealand.	Australasia.
1925 - - -	96,343,098	24,904,993	121,248,091
1924 - - -	87,669,311	24,547,955	112,217,286
1923 - - -	81,035,356	23,775,776	104,811,132
1922 - - -	84,691,864	23,081,439	107,773,303
1921 - - -	82,921,391	23,285,031	106,206,422
1920 - - -	76,823,350	23,919,970	100,743,320

The net production of wool for the Commonwealth and New Zealand in bales for the last four seasons has been as follows :—

Net Production

States.	1929-30 Production.	1928-29 Production.	1927-28. Production.	1926-27 Production.
	Bales.	Bales.	Bales.	Bales.
New South Wales	1,450,000	1,485,000	1,430,000	1,495,000
Victoria - -	491,000	500,000	405,000	446,668
Queensland - -	463,000	419,000	374,000	348,000
South Australia -	213,000	228,000	247,000	222,570
Western Australia	200,000	180,000	176,000	160,000
Tasmania - -	50,000	50,877	41,000	40,200
Commonwealth -	2,867,000	2,862,877	2,673,000	2,712,438
New Zealand -	715,000	698,000	665,000	587,000
Australasia - -	3,582,000	3,560,877	3,338,000	3,299,438

Australasian Sales, Weights, and Values

Season.	Sales.	Average Net Weight.	Gross Value.	Average per Bale.		
	Bales.	Lbs. per Bale.	£	£	s.	d.
1929-30	2,979,223	308·5	39,054,959	13	2	2
1928-29	3,221,327	316·1	69,339,438	21	10	6
1927-28	2,955,585	311·3	73,877,862	24	19	11
1926-27	2,993,933	319·5	64,818,586	21	13	0
1925-26	3,146,916	316·9	65,980,862	20	19	4
1924-25	2,050,545	327·3	69,083,182	33	13	10
1923-24	2,202,037	322·7	64,929,298	29	9	9
1922-23	2,409,281	322·9	54,169,743	22	9	8
1921-22	2,694,139	327·2	41,504,090	15	8	1
1920-21	990,050	330·5	15,475,014	15	12	7
1919-20	2,626,005	324·4	59,819,005	22	15	7
1918-19	2,658,747	331·1	60,346,547	22	13	11
1917-18	2,488,862	331·3	55,806,998	22	8	5
1916-17	2,216,581	327·3	47,951,729	21	12	8
1915-16	1,807,979	322·7	29,903,532	16	10	10
1914-15	1,544,799	329·1	19,742,546	12	15	7
1913-14	1,968,578	327·2	26,079,536	13	4	11
1912-13	1,804,801	321·2	24,642,643	13	13	1

Australasian Merino and Crossbred

Description.	Total, 1928-29.		Total, 1929-30.	
	Bales.	Per Cent.	Bales.	Per Cent.
Merino - - - -	2,181,778	68	2,131,066	72
Crossbred and all strong wool breeds	1,039,549	32	848,157	28
	3,221,327	...	2,979,223	...

Proportion of Fleece and Lambs

Description.	Total, 1928-29.		Total, 1929-30.	
	Bales.	Per Cent.	Bales.	Per Cent.
Fleece, etc. - - - -	3,068,788	95	2,830,227	95
Lambs - - - -	152,539	5	148,996	5
	3,221,327	...	2,979,223	...

Distribution of Australasian Purchases

(Figures supplied by Buyers)

Destination.	Total, 1929-30.		Total, 1928-29.	
	Bales.	Per Cent.	Bales.	Per Cent
United Kingdom - - -	812,384	27	891,765	28
France - - - -	702,652	24	672,894	21
Germany and Austria - -	418,009	14	452,228	14
Belgium and Holland - -	246,139	8	313,546	10
Japan, China, and India -	342,323	11	365,319	11
United States and Canada -	76,408	3	105,687	3
Italy and Switzerland - -	143,413	5	139,811	4
Russia, Norway, Sweden, Poland, Czecho-Slovakia, and Spain	31,105	1	65,372	2
Local manufacturers - -	206,790	7	214,705	7
Totals - - -	2,979,223	...	3,221,327	...

IMPORTS OF WOOL
'000 Lbs.

	Merino.		Crossbred.		Other Sorts.	
	Greasy.	Scoured.	Greasy.	Scoured.	Greasy.	Scoured.
1926	312,051	17,635	208,075	30,389	183,001	56,997
1927	301,612	21,259	229,439	35,493	160,804	68,211
1928	322,112	19,676	279,516	27,152	51,937	66,530
1929	380,937	29,042	276,039	313,689	214,681	62,000

Exports of British Wool
'000 Lbs.

	Greasy.	Scoured.	Sliped or Pulled.	Wool Waste.
1926	24,453	16,436	4,819	13,277
1927	25,050	17,525	5,730	17,293
1928	21,474	13,436	4,570	17,597
1929	21,420	14,498	3,860	15,402

Imports of Alpaca, Mohair, etc.
'000 Lbs.

	Alpaca, Vicuna, and Llama.	Mohair.	Camel's Hair.
1925	5,516	13,413	4,909
1926	5,176	11,069	2,337
1927	6,459	20,396	5,922
1928	4,894	14,537	4,620
1929	4,831	12,721	4,944

Wool Waste, Noils, and Woollen Rags

IMPORTS

	Wool Waste.	Noils.	Rags Pulled.	Rags not Pulled.
	'000 Lbs.	'000 Lbs.	Cwt.	Cwt.
1925	1,755	1,362	11,137	642,971
1926	1,927	1,583	19,651	512,679
1927	2,516	1,823	12,499	409,219
1928	3,250	1,946.	11,825	399,753
1929	2,478	1,724	6,816	466,199

EXPORTS

	Noils.	Rags Pulled.	Rags not Pulled.	Value Raw Wool, etc., and Rags.
	'000 Lbs.	Cwt.	Cwt.	£
1925	15,141	87,781	205,864	11,503
1926	13,808	56,241	200,889	8,453
1927	18,821	66,241	232,710	10,471
1928	20,459	63,677	276,632	10,282
1929	17,101	60,827	237,778	9,621

U.K. IMPORTS OF PRINCIPAL WOOL TEXTILE PRODUCTS

	Average. 1909-13.	1925.	1926.	1927.	1928.	1929.
	'000 Lbs.	'000 Lbs.	'000 Lbs.	'000 Lbs.	'000 Lbs.	'000 Lbs.
Merino tops - -	..	340	603	685	1,066	2,131
Other tops - -	..	1,909	1,579	2,014	2,218	1,565
Woollen yarns - -		14,782	15,792	16,032	15,466	18,026
Worsted yarns - -	28,121	309	1,399	1,768	2,202	2,197
Hair, etc., yarns - -		54	56	134	210	266
		'000 Sq. Yds.				
Woollen tissues (sq. yd.)—						
16 oz. and over - -		820	806	737	846	804
12 to 16 oz. - -		3,196	2,614	2,753	2,132	1,849
8 to 12 oz. - -		46	57	55	76	70
Under 8 oz. - -	71,292	7,910	11,539	9,884	7,714	6,748
Worsted tissues -						
12 oz. and over - -		46	38	88	58	34
Under 12 oz. - -		11,207	7,547	7,976	8,125	6,334
Mixtures, "woollens"—						
16 oz. and over - -	..	126	364	595	501	494
12 to 16 oz. - -	..	1,152	1,263	1,354	1,564	1,575
8 to 12 oz. - -	..	2,054	2,083	3,106	3,781	4,052
Under 8 oz. - -	..	1,498	1,197	1,517	2,129	1,741
Mixtures, "worsteds"	..	400	390	1,028	828	734
Damasks, tapestries -	..	518	750	1,158	562	1,090
Plushes - - - -	..	327	346	376	817	495

U.K. EXPORTS OF PRINCIPAL WOOL TEXTILE PRODUCTS

	Average. 1909-13	1925.	1926.	1927.	1928.	1929.
			'000 Lbs.			
Tops - - - -	41,851	32,041	33,622	41,952	34,425	32,736
Woollen yarns - -	127,494	5,971	5,371	6,573	7,461	7,898
Worsted yarns - -	..	38,756	31,806	45,316	41,491	38,797
Alpaca, nohair, cashmere yarns	..	8,059	6,336	9,007	8,880	7,927
Hair, etc., yarns - -	..	4,627	3,818	8,234	8,180	8,989
			'000 Sq. Yds.			
Woollen tissues - -	127,494	132,174	119,357	130,916	128,339	108,186
Worsted tissues - -	98,405	47,302	42,950	39,979	42,111	47,281
Flannels and delaines -	5,441	5,858	4,428	5,546	4,085	4,056
Mohair, alpaca, cashmere	..	764	997	1,387	2,722	2,396
Wool pile - - -	..	1,324	1,298	1,353	1,217	1,042
Blankets ('000 pairs) -	972	1,138	1,145	1,134	1,179	895
Damasks, etc. - -	..	320	391	344	262	243
Carpets and Rugs -	..	2,153	2,196	2,200	1,838	837
			'000 £			
Total value manufactures :	..	58,934	51,312	56,755	56,897	52,885

Argentine Wool Exports

The following shows shipments of Argentina wool to overseas destinations for four years. The Argentine wool year dates from 1st October to 30th September, and the average weight of a bale is about 1000 lbs greasy and 800 lbs. scoured :—

Destination.	1929-30.	1928-29.	1927-28.	1926-27.
	Bales.	Bales.	Bales.	Bales.
Dunkirk - -	54,743	57,292	69,562	78,159
Antwerp - -	52,936	62,878	40,755	33,939
Hamburg - -	66,389	76,005	73,841	75,308
Bremen - - -	6,490	5,005	16,855	22,067
Genoa - - -	20,746	25,671	20,775	15,802
United Kingdom -	72,479	62,554	63,808	79,182
United States	33,861	39,740	23,083	30,261
Bordeaux -	322	40	47	101
Havre - -	568	739	359	802
Marseilles - -	1,087	272	134	2,050
Barcelona - -	1,105	804	1,705	464
Amsterdam - - }	} 2,061	} 1,918	} 1,205	} 3,072
Rotterdam - -				
Trieste - - -	1,350	1,354	968	2,821
Various - - -	7,522	8,497	9,640	7,575
Totals	321,659	342,769	322,737	351,603

Uruguayan Wool Exports

The following shows the shipments of Uruguayan wool to overseas destinations for four years :—

Destination.	1929-30.	1928-29.	1927-28.	1926-27.
	Bales.	Bales.	Bales.	Bales.
Dunkirk	24,261	17,537	20,706	21,876
Antwerp	14,995	16,139	18,774	11,655
Hamburg	29,764	31,569	21,903	40,496
Bremen	841	3,417	4,291	1,075
Genoa	13,851	12,819	11,254	12,202
United Kingdom	34,036	9,000	35,479	14,949
United States	13,587	20,578	6,927	14,786
Bordeaux and Marseilles	1,602	493	645	931
Amsterdam and Rotterdam	1,610	2,067	1,758	1,418
Havre	311	688	326	496
Trieste	3,135	1,891	857	1,929
Various	5,047	3,382	721	1,133
Totals	143,040	119,580	123,641	122,946

South African Wool Exports

The following comparative statement shows the exports of wool from the Union of South Africa for four years :—

Destination.	January to December.			
	1929.	1928.	1927.	1926.
	Lbs.	Lbs.	Lbs.	Lbs.
Scoured :				
United Kingdom	4,000,324	4,311,204	4,222,502	3,854,250
Belgium	248,880	138,751	109,935	166,748
France	95,444	128,466	235,472	257,007
Holland	25,590	76,016	56,352	47,512
Germany	1,336,888	1,114,701	907,692	657,804
United States	652,917	584,174	804,432	891,654
Canada	200,479	187,469	110,419	141,511
Italy	134,436	83,892	10,958	..
Japan	13,198	3,908	9,706	10,696
Denmark	1,903	..	..	..
Hong Kong	15,331	1,014	..	..
Sweden	5,942	..	..	..
Spain	..	..	..	12,201
China	..	..	..	1,750
Totals	6,731,332	6,629,595	6,467,558	6,041,133
Grease :				
United Kingdom	111,518,568	105,152,935	106,010,490	94,307,636
Belgium	25,286,084	24,461,418	25,411,672	18,884,234
France	67,179,064	55,149,513	60,709,814	42,216,579
Holland	1,920,444	5,127	266,100	4,383,072
Germany	55,880,126	47,871,363	46,879,819	30,459,949
United States	2,356,523	2,883,399	5,035,213	7,037,009
Italy	14,011,100	9,941,133	8,450,647	7,026,403
Sweden	618,198	508,475	204,136	851,780
Spain	1,010,835	904,006	495,229	319,608
Canada	366,176	..	10,639	15,405
Japan	..	..	369,950	152,686
Australia	..	..	8,182	..
Switzerland	..	..	14,556	..
Totals	280,147,118	246,877,369	253,866,456	205,654,361

WOOL COMBING TARIFF

The following combing tariff came into operation on January 13, 1930 :—

MERINOS

(All above 56's quality)

	Per Lb. d.
Tearing 10 to 1 and over · · · · ·	$3\frac{1}{2}$
Tearing 5 and under 10 to 1 · · · · ·	$3\frac{3}{4}$
Tearing 4 and under 5 to 1 · · · · ·	$4\frac{1}{4}$
Tearing 3 and under 4 to 1 · · · · ·	$4\frac{3}{4}$
Tearing 2 and under 3 to 1 · · · · ·	$5\frac{1}{2}$
Tearing under 2 to 1 · · · · · ·	$6\frac{1}{4}$
Burring · · · · · · · ·	$\frac{1}{2}$ extra
Gilling in · · · · · · ·	$\frac{1}{2}$ extra

CARDING CROSSBREDS

56's.

Tearing 7 to 1 and over · · · · ·	3
Tearing 5 and under 7 to 1 · · · · ·	$3\frac{1}{2}$
Tearing under 5 to 1 · · · · · ·	4
Burring · · · · · · · ·	$\frac{1}{4}$ extra
Gilling in · · · · · · ·	$\frac{1}{2}$ extra

50's and below.

Tearing 7 to 1 and over · · · · ·	$2\frac{1}{2}$
Tearing 5 and under 7 to 1 · · · · ·	3
Tearing under 5 to 1 · · · · · ·	$3\frac{1}{2}$
Burring · · · · · · · ·	$\frac{1}{4}$ extra
Gilling in · · · · · · ·	$\frac{1}{2}$ extra
Carding, Backwashing, and Gilling only · · ·	$2\frac{1}{8}$

PREPARING

All qualities · · · · · · ·	2
Burry and Seedy Wools · · · · ·	$\frac{1}{2}$ extra
Gilling in · · · · · · ·	$\frac{1}{2}$ extra

WOOL CARBONISING TARIFF

The following tariff was issued by the Wool Carbonisers' Federation to come into operation on and after February 1, 1930:—

WOOL

Per Lb. on Weight Returned.

Producing up to 30 %	-	4¾d.
,, from 30 to 55 %	-	3¾d.
,, ,, 55 ,, 75 %	-	3¾d.
,, ,, 75 ,, 100 %	-	3½d.

NOILS

Crossbred Noils, 50's quality and under	- 2½d.
Over 50's quality to 58's, inclusive	2¾d.
,, 58's ,, ,,	- 3½d.

CARD WASTE AND BURRS

Per Lb. on Weight Returned.

Producing up to 30 %	-	4¼d.
,, from 30 to 40 %	-	3½d.
,, ,, 40 ,, 60 %	-	3¼d.
,, ,, 60 ,, 75 %	-	3¼d.
,, ,, 75 ,, 100 %	-	3d.

SCOURING AND DRYING TARIFF
(Australasian, Cape, South American, and British Wools)

Per Lb. on Greasy Weight Received.

Producing up to 35 %	. . . . .	¾d.
,, above 35 % up to 60 %	. . . .	⅞d.
,, ,, 60 %	. . . . .	1d.

All Asiatic, East Indian, skin wool pulled in lime or by chemical process, Scotch fleece, blackfaced, and all cotted wools, 1⅛d. per lb. on the greasy weight received.

PRICES OF TOPS IN OIL DURING 1929
(The quotations, in pence per lb., are those ruling on the last Thursday in each month except Dec.)

Merino.

	Jan. d.	Feb. d.	Mar. d.	Apr. d.	May d.	June d.	July d.	Aug. d.	Sept. d.	Oct. d.	Nov. d.	Dec. d.
70's Warp	32½	31½	29	30½	32½	31	31½	31½	30½	29	28½	27
70's Average	31½	30	28	29½	31	30	29¾	29½	28¾	27½	27	25
64's Warp	29½	29	27	28½	30	28½	28½	28½	27½	25	24½	23
64's Average	28½	28	26	27½	29	27½	27½	27½	26½	24	23½	22
60's Super	27	26½	25	26	27½	26½	26½	26	25	22¾	22	20½
60's Ordinary	26	25½	24	25	26½	25½	25	24	22	21	19½	
Cape (12 months)	31	30	29	31	32	30½	30½	30½	29	38	27½	26
Cape Average	29	28	26½	28½	29½	29	28½	28½	26	24½	25	23

Crossbred Colonial Carded.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
68's Super Comeback	25	24½	22½	23½	25	24	23	22½	21½	19	18	18
58's Average	24	23½	21½	22½	24	22½	22½	21¾	20½	18½	17½	17
56's Super	22½	21½	20½	21½	22½	21½	20½	19½	18½	16½	15½	15½
56's Average	21½	20½	19½	20½	21½	21	19½	18½	17¾	16	15	14½
50's Super	19	18	17	17¾	18½	18	17½	16½	16	14	13	13
50's Average	18	17½	16½	17½	18½	17½	16½	16	15½	13½	12½	12½
48's Average	16	16	15½	16	17½	16	15½	15	14½	12½	11	11
46's Average	15½	15½	14½	15½	16¼	15½	14¾	14½	13¾	11¾	10½	10½
44's Average	15	15	14¾	15	16	15½	14½	14½	13½	11¾	10½	10
40's Average	15	15	14¾	15	16	15½	14½	14¾	13¼	11½	10	10

Crossbred Colonial Prepared.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
50's Average	19	18	16½	17¼	18	17½	17	17	15½	14	13	12½
48's Average	16½	16	15	16	16½	16	15½	15	14½	12½	11	11
46's Average	15½	15½	14½	15½	16½	15½	15½	15	14	11¾	10½	10½
44's Average	15½	15½	14½	15½	16½	15½	14½	14½	13½	11½	10	10
40's Average	15	15½	14¾	15	16	15½	14¾	14½	13½	11½	10	10
36's Average	15	15½	14½	15	16	15½	14¾	14½	13½	11½	10	10

English Tops.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
58's Down	25½	25	22½	23	24½	24	23¾	23	22	20	19	18½
50's Pure Shrop.	22	21½	20	20	20	20	19½	18¾	17½	16	15½	15¼
46's Prepared Average	16½	16½	15	15	16	16	15½	15	13½	12½	12	12
Lustre Wether, Bulk	17	17½	17	17	17½	16½	16½	15½	14	13	12	12
36's Devon	17	16	15½	15½	16	15½	14½	14½	13½	11½	11	10
32's Scotch, white (4's)	19½	19	18	17½	16½	16	15	14	12½	12½	12	12

WOOL VALUES AT THE LONDON SALES

The following shows the course of values at the close of the colonial wool auctions in London, the quotations being first cost, clean, without oil, in pence per lb. :—

	1929						1930						1914
	Jan. 30.	Mar. 21.	May 15.	July 23.	Oct. 4.	Dec. 4.	Feb. 6.	Apr. 9.	May 30.	July 23.	Oct. 7.	Dec. 13.	July.
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
70's super fleeces	46	43¼	42	40	34	35	30	28	30	28½	27	24	32
60/64's good medium fleeces	44	39	36	33	27	29	24	23	25	23	21	19	30
64's good pieces	42	40	37	33	27	29	24	23	26	24	22	19	28
58/60's good medium fleeces	40	37	34	30	26	27	22	20	22	20	17	15	29
56's fine crossbred fleeces	34	31	29	27	23	25	20	17½	19	18	15	13	26
46's crossbred fleeces	25	21¼	21	20	18	19	15½	14	15½	13	10¼	9½	17
44's crossbred fleeces	24	21	20	19	17¼	18¼	15	13¼	15	12½	10	9	16
36/40's crossbred fleeces	21	20	19	19	17	18	14½	13	14	12	9¼	8¼	15½
Capes—													
10/12 months' combing Capes	43	40	40	36	30	31	26	26	28	26	24	21	27
6/7 months' clothing Capes	38	35	35	32	26	27	22	22	22	20	18	16	24

WEIGHT AND VOLUME OF WATER

1 imperial gallon = 277·274 cub. in.
1 imperial gallon = 0·16045 cub. ft.
1 imperial gallon = 10 lbs.
A cubic inch of water = 0·03616 lb.
A cubic inch of sea water = 0·037037 lb.
A cubic foot of water = 62·32 lbs.
A cubic foot of sea water = 64·00 lbs.
A cylindrical foot of water = 48·96 lbs.
A cylindrical inch of water = 0·0284 lb.
A column of water 12 in. long, 1 in. square = 0·434 lb.
A column of water 12 in. long, 1 in. diameter = 0·340 lb.
The capacity of a 12-in. cube = 6·232 gallons.
The capacity of a cylindrical inch = 0·002832 gallon.
The capacity of a cubic inch = 0·003606 gallon.
The capacity of a sphere 12 in. diameter = 3·263 gallons.
The capacity of a sphere 1 in. diameter = 0·00188 gallon.
1 imperial gallon = 1·2 United States gallon.
1 imperial gallon = 4·543 litres of water.
1 United States gallon = 231·0 cub. in.
1 United States gallon = 0·83 imperial gallon.
1 United States gallon = 3·8 litres of water.
1 cub. ft. of water = 6·232 imperial gallons.
1 cub. ft. of water = 7·476 United States gallons.
1 cub. ft. of water = 28·375 litres.
1 pint of water = 34·672 cub. in.
1 pint of water = 568·24 cub. centimetres.
1 litre of water = 0·22 imperial gallon.
1 litre of water = 0·264 United States gallon.
1 litre of water = 61·0 cub. in.
1 litre of water = 0·0353 cub. ft.
1 litre of water = 2·2046 lbs.
1 oz. of water = 1·729 cub. in.
1 oz. of water = 23·349 cub. centimetres.
1 lb. of water = 27·68 cub. in.
1 lb. of water = 453·6 cub. centimetres.
1 lb. of water = 0·09978 gallon.
1 ton of water = 35·881 cub. ft.
1 ft. head = 0·434 lb. per sq. in.
1 lb. per square inch = 2·31 ft. head.

MODERN WOOL SCOURING PRACTICE

In their natural state all wools are more or less associated with adhering substances which, before being converted into tops and yarns, have to be removed. The processes by which this removal is accomplished may vary, according to the nature and condition of the adherent or encrusting substance that the wools contain. Generally speaking, these substances can be divided into two distinct groups, known respectively as natural and foreign impurities.

The Natural Impurities consist chiefly of suint or natural sweat and wool fat. The extent to which these natural impurities are present in wools varies very largely according to the nature of the wool and the climatic conditions under which the wool has been grown.

The Foreign Impurities to which wools are liable may consist of either vegetable or mineral substances whose compositions must, like the natural impurities, be thoroughly understood when the processes necessary for their removal are being considered.

Wool Fat may be said to be part and parcel of the structure of wool fibres. It is insoluble in water, and unlike the majority of animal and vegetable oils, will not saponify with alkali.

Wool Sweat or Suint, consisting as it does chiefly of potash salts, is very soluble in water, with which it most readily combines to form a detergent which in itself has many cleansing properties. The continental process of steeping wool before actual wool scouring takes place is based upon this fact, as the potash salts are much more easily recovered in this state than when other scouring materials have been added.

The real extraneous impurities which those responsible for cleansing wool have to contend with are the natural wool suint or sweat, and the vegetable and mineral foreign substances. So far as the wool scourer is concerned, he can only deal effectively with the wool suint and those impurities which are soluble or rendered harmless by soap and water.

It is utterly impossible in the ordinary wool scouring process to successfully cope with vegetable impurities, as these, being for the most part insoluble in water, cannot, unless they can be loosened from the wool by agitation, be got rid of except by chemical decomposition such as is provided in up-to-date chemical carbonisation plants.

The natural grease or yolk can only be dissolved by such volatile solvents as benzene, naphtha, ether, carbon bisulphide, and ethylene

trichloride. Wool fat does not form soluble soaps with alkali, but it readily emulsifies, and upon this fact is based the processes of ordinary wool scouring without necessitating the use of volatile solvents if this process is not considered a desirable treatment. It must be emphasised at this point that it is only the external yolk which the wool scourer must remove, and he must leave, undisturbed, the interior fats of the fibre. Anything that may be done to affect the internal yolk will materially impair the nature of the wool fibre. The latter may easily be rendered harsh and lacking in suppleness, which, when once removed, cannot be restored by any subsequent process, and may result in a poor spin and a reduction of quality.

Taking a broad view of the process of wool scouring, it involves the removal of all foreign and natural impurities possible to render the wool comparatively clean for being dealt with in any subsequent operation. To accomplish this object the wool scourer must employ methods that are mechanically and chemically efficient, and whilst endeavouring to make the process of wool scouring as economical as possible, he must exercise such care as will render the wool clean and of good colour without in any way damaging any of the wool's physical qualities.

The emulsion system of wool scouring necessitates the use of water, heat, soap, and alkali, and upon the proper and skilful use or otherwise of these detergents depends the good or bad results in the condition of the wool scoured.

Water.—The water used for scouring purposes is of exceptional importance, and varies considerably in different districts. In making a selection of water it should be carefully examined for its purity and its condition as regards the extent to which calcium and magnesium salts are present. Water may possess such foreign impurities as decayed vegetation collected by the water as it flowed along its course down the country-side. The leaves from trees and the decayed herbage from the sides of the stream all contribute to impart impurities to water either in a suspended form or in a more or less state of solution. Perhaps one of the worst vegetable impurities found in water is the tannic juice extracted from oak vegetation, and few scourers in the country districts have been entirely free from trouble caused by this impurity, and especially in the scouring of white pieces.

Impurities that are present in a suspended form can be got rid of by filtration, but all impurities that are dissolved in the water must be treated by such agents as will nullify their effect upon the material to be scoured and the emulsion by which this takes place.

Hardness of Water.—The presence of magnesium and calcium salts in water increase or decrease the quality of " hardness," according as to whether they are present to a larger or lesser degree. In order to establish a system of identification as to the condition of water from a quality point of view, it is spoken of as being of so many degrees of " hardness," according to the number of grains of calcium or magnesium carbonate per gallon of water. Thus a water of 10° " hardness " would indicate a water possessing 10 grains of calcium per gallon. Carbonates, sulphates, and chlorides of these salts would form the basis for identification, but the " hardness " thus determinated may necessitate a further qualification as to whether the water is " temporary hard " through the presence of carbonates of these salts, or " permanently hard " owing to their existence in the form of sulphates and chlorides.

A water, say, that is tested and found to be 10° " hardness " may be quite suitable for scouring purposes even though its condition would be spoken of as " hard." The reason for this observation is due to the fact that it may be composed of, say, 6° "temporary hardness " and 4° of "permanent hardness," and as the carbonates of lime can be dissolved by boiling, the water would not be altogether unsuitable.

It is estimated that 1° of hardness will destroy 1 lb. of soap in 700 gal. of water, so that from an economical point of view alone it can be readily seen how serious it is to be using a water of questionable quality. But the use of very hard water is very detrimental in another—and perhaps equally important—way, and that is, that the calcium and magnesium salts will combine with the detergents to form very dangerous and insoluble lime soaps, which will adhere tenaciously to the wool fibre through every process, and result in not only impeding the successful working of the material, but retarding the influence of dyestuffs at some later stage of its manufacture.

Chemical Tests for Impurities in Water.—The presence of lime soap in water can easily be detected by adding a few drops of ammonium oxalate solution to a little of the water. If lime soap is present a white precipitate will form which has the appearance of powdered chalk. The presence of sulphates, bicarbonates, and chlorides of the calcareous and magnesium impurities can be detected by very simple means. If, by adding to the sample of water taken, a small quantity of hydrochloric acid and barium chloride, a white precipitate is formed, it can be taken for granted that sulphates are present. Should there be no perceptible change, another test should be made with a new sample of water.

If a white curdy substance is formed by the addition of nitric acid and silver nitrate, the presence of chlorides is denoted.   The presence of bicarbonates is detected if a white precipitate is formed by the addition of a clear solution of lime water.   Organic impurities are detected by the change in colour produced in a solution of permanganate of potash when it is added to water which contains them. This process consists of adding sufficient permanganate of potash to impart a pink colour.   Add to this solution a small quantity of sulphuric acid, and boil.   If organic impurities are present, the solution will be discoloured.

Testing Water for Hardness.—A very simple but efficient method of testing water for total hardness is to secure from a chemist a standard soap solution, which consists of soap dissolved in alcohol, and measure off into a stoppered flask of 250 c.c. capacity 70 c.c. of the water to be tested.   Place the soap solution into a burette to enable it to be measured off in cubic centimetres, 1 c.c. at a time. After the addition of each cubic centimetre of soap solution, shake up the water vigorously.   Continue in this manner until a lather is formed that will remain visible for about five minutes.   When sufficient soap solution has been added to produce the desired effect, read from the burette the number of cubic centimetres taken.   The number indicated minus one represents the degrees of total hardness.

Water Softening.—For the softening of water it is usual in the case of " permanent hardness " to employ carbonate of soda, and for " temporary hard " water lime water will precipitate the carbonates.   The latter method for " temporary hard " water is much less expensive and much more convenient than boiling.   There exists at the present time, however, such efficient water softening plants that it is undoubtedly advisable to have one working in conjunction with any plant where wool scouring is carried on to any great extent.

Soap.—Providing a suitable water has been secured, the next consideration is the class of soap and scouring agent necessary for securing the best results both in appearance and handle of the wool to be scoured.   The soap used is of exceptional importance, as scouring must not only be done efficiently, but must also be done as economically as is practicably possible.   It must not be taken for granted that because a wool is coarse in fibre that liberties can be taken which are not possible with wools that are much finer in quality.   To take such a view is to make a very grave mistake, as it is not only imperative to consider the nature of the wool being dealt with, but also

the fact that a waste of scouring materials will materially affect the value of the yarn that is subsequently to be produced.

Broadly speaking, there are two classes of soap which are spoken of as " soft " and " hard " respectively. The former one, known as potash soap, is really potash in combination with suitable oils and fats, and is much more soluble in water than " hard " or soda soap. The readiness with which they become soluble in water, in spite of the fact that they are liable to contain free alkali to a greater extent than soda soaps, makes them much more popular for wool-scouring purposes. A compensating feature of potash soaps is the presence of glycerine, which modifies the effect of the free alkali and has a very mellowing effect upon the wool. Another important feature in the employment of soft soap as against hard soap is the fact that lower temperatures are necessary in the use of the former than is altogether possible in the use of the latter.

It must be pointed out that in soaps of either type free caustic alkali may be present in excess, and every care should be exercised in the selection of either, as the presence of free caustic with the application of heat may not only tend to make the wool yellow in appearance, but impart a harsh handle which very much depreciates the quality of the yarns and fabrics to be subsequently produced. The presence of free caustic in a scouring liquor may be easily detected with a piece of red litmus paper. Should the red litmus paper be turned blue, the presence of free caustic is certain, and neutralisation can only be procured by the addition of such reagents as salammoniac or boric acid.

Alkalis.—Soaps of all kinds are very liable to adulteration, and such adulterants as resin, French chalk, and fuller's earth are the most common, and especially so in the case of soda soaps.

Undoubtedly the best soap for scouring purposes is a neutral one, or one containing no unsaponifiable fat or uncombined alkali, and to this may always be added the requisite alkali of suitable strength and quality. Of the alkalis most commonly used the carbonates of ammonia, potash, and soda are the most popular. Ammonia, though the most costly, is without doubt the mildest detergent possible, as it not only causes ready emulsification but imparts to the wool a soft and natural handle, which is a great factor in the subsequent working up of the material. There is absolutely no danger in its use, as its volatile nature causes all residual traces to leave the wool fibre long before it is turned out in the form of yarns or fabrics.

The two carbonates of soda and potash are alkalis very commonly

used, but for preference the latter is the least harmful, as its com·
position is more in keeping with the nature of the wool yolk or natural
wool fat of the wool fibre with which it readily forms an emulsion.
The common terms applied to the carbonates of soda and potash are
" soda ash " and " pearl ash " respectively. The latter is the most
expensive of the two, and should always be used for the finer grades of
wool. When the wool to be scoured is coarse and strong fibred there
is no great harm done by using the cheaper and equally effective
" soda ash." In the scouring of slipe wools or wools containing
lime in excessive quantities soda ash is exceptionally suitable, and
on no account should soap be used, or otherwise the danger of forming
very insoluble lime soap cannot possibly be avoided.

Temperature.—Before treating upon scouring processes proper,
it should be mentioned that the temperature of a scouring bath should
vary according to the nature and condition of the wool being dealt
with and the quality of soap and alkali being used. It is very advisable
to keep the temperature of a scour as low as is practicable with the
efficient cleansing of the wool. Heat in combination with the deter·
gents used in scouring may be considered as a very detrimental
factor if wrongly or negligently applied. Even though the scouring
materials may be all that is desirable, excessive heat may cause such
a physical reaction to take place that the wool is rendered yellow in
appearance, and may be tendered or reduced in strength.

In applying soaps and alkalis to the bowls it is advisable to have
such a series as will enable the scourer to alter the strengths of scour
as well as the temperatures according to the condition of the wool as
it passes from one stage of the scouring process to another. By
this arrangement a much better control can be kept over the scouring
process than is the case where only one bowl is used. In up·to·date
wool-scouring plants every facility is provided for coping with large
quantities of wool through a series of scouring bowls in a continuous
manner, besides having equipment for running off or renewing the
scouring liquor in each bowl.

Where steeping or desuinting takes place before actual scouring,
the wool is passed through a bowl of tepid water at about 45° C.
(113° F.), and allowed to steep until no further quantity of yolk is
dissolved. If a second tank can be provided it is advisable to utilise
same for a second steeping to ensure a thorough removal of the wool
grease. When the water has become thoroughly saturated with yolk
it is ready for being evaporated to dryness, calcined, etc., and the
potash salts can then be recovered. It is only in cases where large

quantities of greasy fine wools are dealt with that are rich in potash salts that steeping is worth while, as the average manufacturer does not scour sufficient wool to enable him to economically employ a special steeping process, and invariably he will arrange for the first bowl in the ordinary scouring process to act as a steeping tank.
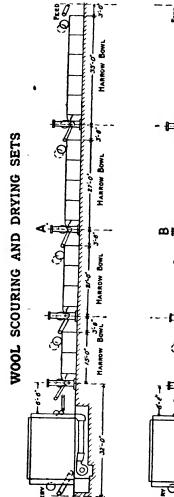
Scouring Machines.—The most popular types of scouring machines are known as the " Harrow " and the " Rake " machines respectively. The former is a machine that is very well adapted for dealing with short fine wools on account of the minimum amount of agitation to which the wool is subjected whilst it is in the scour. This feature is of special importance in fine wool scouring, as too much agitation causes wools of this character to felt or mat together, so that when they are being treated in the subsequent carding and combing operations the fibres are liable to become broken or damaged by the rough usage necessary in opening them out.
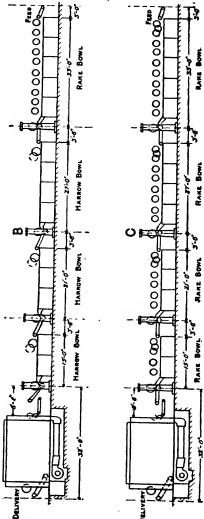
The " Harrow " type of machine consists principally of a frame-work of forks which are so arranged as to work in a cycle of movements to propel the wool through the scour in a very gentle manner. The " Rake " type of machine is made up of six to ten individual rakes which have a more or less individual action. The same purpose is served in this machine as in the " Harrow," but the action is a much more violent one, and in consequence is only suitable for the coarser types of wools which are much less liable to felt. These machines are also made with a self-cleaning attachment, by which the dirt which settles to the bottom of the bowls is automatically removed. This increases the production of the machines, and conduces to more uniform scouring.

In the three diagrams A, B, C (see next page), three complete wool-scouring plants are illustrated, and these are respectively suitable for fine, medium, and coarse wools. It will be noticed that in each case four scouring bowls are used, although in practice, and especially for coarse wools, only three bowls are used in many cases. But working upon the most up-to-date lines, there is no doubt that the best results, both economical and otherwise, are obtained by a four-bowl plant, no matter what type of wool it is intended to scour.

The scouring and drying plant shown at A is one of the best arrangements possible for dealing with fine merino wools, and will scour and dry to perfect cleanliness 3000 to 4000 lbs. weight per hour of fine greasy merino wool with a yield of 50 per cent.

The set of machines shown at B is very similar to that shown at A, with the exception that the first machine in the series is a swing

WOOL SCOURING AND DRYING SETS

" Rake " machine- and the remaining three " Harrows." This machine is well adapted for fine crossbred wools, and it is an advantage with these wools to have a swing rake opening bowl for the first machine and a reduced agitation as the wool becomes clean.

At C is shown a complete set of rake machines, which is a very efficient plant for the coarser varieties of wool, and each plant shown is capable of dealing with large weights of wool.   The quantity of material dealt with will vary according to the lengths and widths of machines adopted.

The capacity of a machine or set of machines is determined by the manufacturer's own requirements, and should be in accordance with the amount of work it is intended to deal with.   In this respect it is not advisable to employ the largest machines possible if the require-ments are not such as will keep the plant fully employed.   It is far better to have a smaller machine with a lower output and to keep it constantly employed, as a greater saving will accrue in the more economical use of steam and scouring detergent than will otherwise be the case.   It is inadvisable that a restricted output should be made by a reduction in the number of scouring bowls composing the plant, as a series of four bowls is an ideal arrangement for the best physical treatment of the wool fibre.

The greatest service obtained by having a four-bowl set of machines is the possibility of having a graduated temperature of scour in each bowl besides a graduated strength of scouring liquor.   The wool being subjected to four distinct rinsings in scours of varying tempera-tures from higher to lower, as well as a total of four squeezings in the press rollers when leaving the machines, renders the wool supple and lofty to handle, and especially so if care has been taken with the composition of the scour and the temperature at which it has been treated.

Each scouring bowl is fitted with a side settling tank, so that as the wools pass from one bowl to another the dirty water and soluble grease, etc., squeezed out by the press rollers, does not flow back into the scouring bowl but direct into the side settling tanks, from which, if so desired, the grease may be recovered.

In the majority of cases the wool scourer will employ both the strongest scour and the highest temperature in the first bowl.   This method is quite correct, as the wool, at this stage being possessed of all its natural grease, is best preserved against the action of the scour, both as regards the strength of the detergents and the heat to which it is subjected.   To give the reader some idea as to the composition of the scour in each individual bowl, the following tables have been

compiled from actual processes, and are in keeping with the plants shown in the diagrams at A, B, and C.

In the diagram shown at A a four-bowl scouring plant is used of " Harrow " machines, and these may be utilised for scouring merino wools of fine quality with the scours prepared as follows :—

	First Bowl.	Second Bowl.	Third Bowl.	Fourth Bowl.
Length of bowl -	33 ft.	27 ft.	21 ft.	15 ft.
Capacity - -	1980 gals.	1650 gals.	1165 gals.	938 gals.
Temperature - -	120° F.	115° F.	110° F.	100° F.
Potash soap - -	140 lbs.	78 lbs.	45 lbs.	12 lbs.
Potassium alkali carbonate	42 lbs.	6 lbs.	Nil	Nil
Immersion - -	3 mins.	3 mins.	2½ mins.	2 mins.

From the above it will be seen that the strongest scouring liquor is used in the first bowl, and great care should be exercised to see that the scour is kept up to the requisite strength according to the quantity of wool dealt with.

In scouring fine crossbred wools with a plant as shown at B, the following scours will be found to be quite suitable :—

	First Bowl.	Second Bowl.	Third Bowl.	Fourth Bowl.
Length of bowl -	33 ft.	27 ft.	21 ft.	15 ft.
Capacity - -	1980 gals.	1650 gals.	1165 gals.	938 gals.
Temperature - -	125° F.	120° F.	115° F.	110° F.
Potash soap - -	178 lbs.	78 lbs.	40 lbs.	13 lbs.
Alkali - potassium carbonate	42 lbs.	10½ lbs.	Nil	Nil
Immersion - -	3 mins.	2½ mins.	2 mins.	1½ mins.

The above scours are quite suitable for fine crossbred wools varying from 48's to 56's quality, and yielding from 60 to 70 per cent.

In scouring coarse wools of such types as Lincoln and Leicester fleece wools, the following compositions of scour will be quite adequate :—

	First Bowl.	Second Bowl.	Third Bowl.	Fourth Bowl.
Length of bowl -	33 ft.	27 ft.	21 ft.	15 ft.
Capacity - -	1980 gals.	1650 gals.	1165 gals.	938 gals.
Temperature - -	130° F.	120° F.	115° F.	110° F.
Potash soap - -	192 lbs.	112 lbs.	24 lbs.	13 lbs.
Alkali (soda bonate)	42 lbs.	10½ lbs.	Nil	Nil
Immersion - -	3 mins.	2½ mins.	2 mins.	1½ mins.

The agitation of the wool in each case must be such as to leave the wool perfectly lofty without in any way causing any felting, and any tendency to felt must be immediately remedied by causing a slower movement of the " Harrows " or " Rakes," and increasing the period of the immersion.

Wool Drying is a companion process to wool scouring. Its purpose is to remove the greater part of the moisture absorbed in the process of scouring, and in doing this great care should be exercised to prevent the wool from being reduced to absolute dryness. Too much stress cannot be laid upon the fact that it is of equal importance to leave the requisite amount of moisture in wool as it is to take the requisite amount from it after scouring. To leave too much moisture in after scouring involves a danger of mildewing the wool fibre, and no person engaged in the trade of wool manufacture is ignorant of the disastrous results caused by mildew fungi. At the same time it is very important that the wool should retain sufficient moisture to fully maintain its natural suppleness, and thus enable it to be dealt with in subsequent operations possessed of all its hygroscopic affinity. In all cases very great care should be taken that at least 12 to 14 per cent. of moisture is left in the wool after it leaves the drying machine, and if this is done there is very little likelihood of any detrimental results.

The drying of wool should take place at a temperature varying from 100° to 112° F., and if this cannot be accomplished it is quite obvious that the machine used is inadequate for the purpose.

A fixed thermometer should always be available for the scourer both in the wash bowls and in the drying machine. By this means the various temperatures can be taken periodically, and any necessary alterations can be made from time to time according to the state of the thermometer.

WOOL OILING

All wools, excepting those which are very light in grease, are scoured before being blended. The washing operation removes practically all the grease present in the raw wool, consequently it is necessary to apply a quantity of a suitable oil to lubricate the fibres before submitting the material to the opening processes which follow. This is the principal object of oiling wool, and by the use of a rich, fatty oil the fibre breakage and waste in carding is greatly reduced, whilst an even distribution of the twist in drafting and spinning also results. A secondary use of oil is to prevent the generation of static electricity by the friction between the wool and wire points in carding, whilst the oil used should also be readily removed in scouring.

Properties of Oils.—There are two main classes of oils—saponifiable and unsaponifiable. The former combine with alkalis to form soap, and include vegetable and animal oils and fats, such as olive, coconut, tallow, and whale oils, as well as certain oleines. Unsaponifiable oils do not form soap with alkalis, but may be removed as an emulsion and include all classes of mineral oils. The two main ingredients of saponifiable oils are glycerine and fatty acids, both of which vary in quantity, whilst the latter likewise varies considerably in composition, and largely determines the character of the oil or fat. Although one particular fatty acid may predominate in an oil, smaller proportions of others are always present. When these oils are used in their natural condition they are said to consist of neutral saponifiable matter, and some of them are very suitable for wool oiling. Saponifiable oils are commonly treated to separate the glycerine, which is used for other purposes, leaving free fatty acids. The latter, although liable to attack metal surfaces and leather, is also in use for wool oiling. A proportion of free fatty acid is beneficial in starting the scouring operation which has to follow, but once this is done other oils, if suitably selected, can be removed by saponification or emulsification. Olive oil, which contains only 2 to 15 per cent. of free fatty acid, is difficult to start scouring, but is a good wool lubricant, whilst distilled oleines have the reverse characteristics and are chiefly used for soap-making. The ideal wool oil should therefore contain a proportion both of free and neutral fatty acids, the former to start the scouring and the latter to serve the principal object of lubricating the material.

In addition to the chemical composition of oils, the physical properties must also be considered in selecting a wool oil. The most important of these are now considered,

Body.—When an oil adheres firmly to wool it is said to have good body. This is practically the converse of fluidity, and if too much body is present it does not spread sufficiently freely to give good results. If too little body is possessed by the oil it may run off the wool and collect at the bottom of the pile, or sheet when these are allowed to stand for some time.

Oxidisation.—Most oils absorb a proportion of oxygen from the atmosphere, and according to the rate at which this occurs may be classified as drying, semi-drying, and non-drying oils. The first group includes such oils as linseed and poppy-seed, which absorb oxygen rapidly and may become gummy or dry in six to nine days. Semi-drying oils absorb oxygen more slowly and may in time become viscid and thick, but not dry. The last group includes olive, nut, and lard oils, which retain their oily nature.

Firing Point.—As oxygen is absorbed it reacts with the oil and generates heat, which in time may reach a sufficiently high temperature to cause the material to burst into flame. This is known as spontaneous combustion and is the cause of many mill fires. Mineral oils do not readily absorb oxygen, and if blended with fatty oils also prevent the latter from doing so. The tendency of any oil to fire varies with its composition, the area it covers, and the temperature of the room. The presence of a proportion of free water also promotes spontaneous combustion, possibly by maintaining the heat generated. It has also been observed that direct sunlight hastens oxidation, whilst in the case of oiled wool tight sheeting prevents the ready dispersion of the heat generated and may lead to firing.

Flash Point.—On account of the varying tendencies of different oils to ignite spontaneously, insurance companies vary their premiums accordingly, but they generally base their rates on what is termed the flash point, which is usually 50° to 80° F. lower than the firing point. The term refers to the lowest temperature at which vapours which will ignite in presence of a light are given off from the oil, whilst the firing point refers to the lowest temperature at which spontaneous combustion will occur. The flash point is of greater importance with reference to the liability of any conflagration spreading—oils with the lowest flash points being the most dangerous in this respect. Oleic acid and most oleines have flash points between 320° and 350° F., those below 330° F. being dangerously low. Only low-grade mineral oils are as low as this; good grades having flash points of 370° to 410° F. Good olive, neatsfoot, lard, and cotton-seed oils, fairly free from free fatty acids, have flash points of 470° to 500° F. and firing points of 550° to 600° F. and can be safely used on wool. Insurance companies generally impose a minimum flash point of

340° F. for any oils used, but oils with flash points below **350° F.** should be avoided for the purpose of oiling wool.

Evaporation.—The lighter constituents of any oil may evaporate, causing the residue to become rancid and gummy. Although evaporation frequently occurs with lubricating oils, it is seldom a source of trouble in the case of wool oils. These evaporate very slowly, especially when little mineral and much fatty matter are present.

Presence of Mineral Oils.—Too great a proportion of mineral oil may result in scouring difficulties, but a reasonable proportion reduces oxidation, prevents spontaneous combustion, reduces the price, and does not interfere with the scouring operation.

Free Acidity.—Free acids, especially mineral acids such as sulphuric, which is frequently present in recovered oils, attack metals such as tanks and card wire as well as the arms of workers employed in blending and carding. The presence of free acids may be detected by adding a few drops of caustic soda to a solution of phenolphthalein till tinged red, when a little of the oil to be tested is added and the mixture well shaken. If acid is present the reddish colour will disappear. To distinguish mineral acid from free fatty acid, methyl orange is used as an indicator instead of phenolphthalein, the former remaining unchanged in the presence of free fatty acids, but being turned pink when mineral acids are present.

So many factors influence the oiling of wool that any one oil cannot give the best results with all materials. In deciding upon a suitable oil it is thus necessary to consider the type of material used. Wools vary greatly in lustre, length, elasticity, fineness, and strength, and these factors influence the quality and quantity of oil to be used. Short, coarse, and dry wools, as well as shoddy, require a rich, fatty oil containing much neutral fatty matter. Fine wools do not require such heavy lubrication, but it is desirable that oil of good quality should be used.

The condition in which the material reaches the blending room is also important. Clean, dry wools require fatty oils, whilst oils used for greasy and badly-scoured wools should possess a higher percentage of free fatty acids. If oils containing much neutral fats are applied to these wools the teeth on the carding machine may clog up, whilst more care is essential in obtaining clean scoured pieces. Oils with a high, free fatty acid content should not be used on skin wools, especially those removed by the lime process, as the fatty acid reacts with the lime, forming calcium soaps. These are sticky, insoluble, difficult to remove, and adhere to the card wires, necessitating frequent cleaning. Similar results may occur

when wools are scoured in water containing metals, such as calcium and magnesium salts, in solution.   The residual acid frequently present in carbonised wool makes the use of an oil with much neutral matter highly beneficial, whilst dyed wools require a similar oil to give satisfactory lubrication.   This is due to all the grease being removed before dyeing and the high temperatures and chemicals used in the operation as well as the presence of the actual dyestuff on the fibre. The price per cwt. is generally given more attention than it merits; the yield of yarn per 100 lb. of wool and other factors being of much greater importance, although commonly overlooked.   The method of oiling in use likewise limits the type of oil which can be employed, and to obtain the best results this may require to be modified when new oils are introduced.

Three methods of application are in common use, namely, oil applied " dry," oil and water applied mixed, and in emulsion form. The first is expensive if the full proportion is used and unsatisfactory if reduced in quantity, as it does not spread readily.   It may, however, be practised with good results on damp wool.   In the second method the oil and water do not mix intimately, and readily separate either before or after application to the wool.   The free water may also injure the carding machines and lead to mildew in the yarns.   The last method gives the best results, as the oil and water are intimately combined and spread uniformly over each fibre.   This results in better lubrication and the card wires are not liable to rust, as the water does not occur in a free state.   It is, however, important that the emulsion be permanent and that the constituents be pure, or faults may occur in the yarn-making or scouring.   If unstable the same faults occur as in the use of a water and oil mixture.

Application of Oil.—The oldest method consists of throwing the oil on to the wool with a small hand bowl and beating the layers to spread the oil.   This is unsatisfactory, as the oil is distributed very badly, some portions of the material being saturated whilst others have little or no oil.   A slight improvement is obtained by spreading the oil by means of a can with a perforated, T-shaped spout.   In recent years hand and mechanical sprayers have been introduced with good results, as they distribute the oil in a fine spray permitting of much more even lubrication.   Automatic oilers are now frequently applied to the teaser, which oil the wool as it travels along with the feed lattice.   The quantity of oil can be regulated and the action of the machine helps to distribute it evenly.

In commission spinning, 1 lb. of oil to 5 lb. of wool is commonly used, but this is excessive, as the oil prevents the proper working of the rubbers and tapes.   Ten or even 8 per cent. of oil should suffice

with average material if good in quality and applied in a proper manner. Other factors must, of course, be considered in determining the actual amount to be applied. Dyed wool, being drier and harsher than white, requires more oil, whilst dark colours should receive more than tints. Shoddies, wastes, and overdried wools also require more than the normal amount, whilst the excessive evaporation and loss due to high-carding speeds likewise entails the application of extra oil. When emulsions are used a larger quantity of this should be applied; 12 to 25 per cent. emulsion representing 6 to 12½ per cent. of actual oil being illustrative of common practice. On the Continent where dry spinning is practised very little oil is used—an emulsion of 1 part lard oil and 3 parts of water being commonly employed.

OILS USED FOR WOOL BLENDING

Olive Oil was the first to be used and gave excellent results; but, on account of its high price, it is now retained only by a few firms chiefly engaged in worsted-top making. The oil is obtained from the fruit of the olive tree, which is placed in mortars and pressed, the best quality oil being used for edible purposes. A second quality is obtained by boiling the residue and pressing again, and is used for lubricating, soap-making, and wool oiling. By treating the residual cake with carbon bisulphide a third grade is obtained, but this has a dark colour and objectionable odour. The best qualities have yellowish colour, whilst lower grades possess a dark-greenish, brown tint. Olive oil is almost wholly saponifiable, but contains only 2 to 15 per cent. free fatty acid, which makes the scouring slow and costly. Top makers, recognising the danger to the material and machines from free acidity, generally impose a maximum limit of 5 per cent. when making purchases. Due to its high price olive oil is frequently adulterated with coconut, cotton-seed, and mineral oils, whilst substitutes, with nut and rape oils as bases, are also sold.

Oleic Acid is a by-product in the manufacture of stearic and palmitic acids from tallow and palm oils for the manufacture of candles. It is obtained in various ways, varies in colour from pale straw to reddish-brown, and is sold as oleic acid, oliene, and brown cloth oil, etc. These are satisfactory wool oils from the scouring point of view, but due to the high percentage of free fatty acid do not lubricate well, give lower blend yields, and attack metals with which they come into contact.

Recovered Oils.—By treating the grease recovered from wool-scouring liquors, a number of wool lubricants, variously called wool·

oils and oleines, are obtained. The grease is placed in cast-iron stills and distilled, yielding two or three qualities of oleine. These vary in composition according to the type of wool grease employed and are liable to contain particles of rust from the presses. Oleines are frequently marketed as containing 70, 80, or 90 per cent. saponifiable matter, and if insufficient in amount may result in defective cloth scouring.

Blended Oils are increasing in importance, as in these it is possible to obtain excellent lubricating properties without sacrificing an easy scour. A small percentage of mineral oil may be beneficial in reducing the risk of firing as well as assisting uniform spreading of the oil over the material. It is important, however, that the amount be not excessive and that only high-grade oils are used in the blending.

Emulsified Oils are also increasing in popularity, as by their use better carding and spinning with a smaller quantity of oil are obtained. The water content assists in spreading the oil, gives cleaner carding, and prevents the generation of static electricity. Better yarns and blend yields are generally obtained, whilst the emulsion simplifies the subsequent scouring. The use of ready-made emulsions is not, however, always profitable, as the water present represents extra carriage cost, whilst gum, flour, and turkey-red oil which cause stickiness may be added to maintain the emulsion. Since the oil is spread over a greater surface—a very desirable feature as regards lubrication—it is oxidised more rapidly, so that the original oil should have a higher firing point than normal.

Oiling Faults.—The presence of mineral acids or too much free fatty acid blisters the workers' arms, rusts cans and tanks, and deteriorates the card clothing, rubbers, and tapes. Excessive flyings and loss in the carding operation may be due to the use of an oil with poor lubricating properties or to the application of an insufficient quantity. Frequent breakage and uneven yarns in spinning may be due to the use of an oil with too little neutral fatty matters, too thick an oil or separation of the constituents especially in cold weather. Defective cloth scouring may result from the blending oil having too low a percentage of free fatty acid or the presence of too much mineral oil. The trouble may be more often traced to faults apart from the oil, such as the use of greasy wool or unsuitable scouring methods. Stains, which are a frequent source of trouble, may also be traced to the blending oil, although drops of machinery lubricants are more commonly the cause. Wool oil stains are generally caused by excessive oxidation or the presence of too much free fatty acid, which acts on iron and copper tanks, pipes, and machine parts.

NOTES ON WOOLLEN AND WORSTED MACHINERY

Woollen Machinery.—WILLOW.—Floor space, 11 ft. × 9 ft. Pulleys, 18 in. × 6 in. Speed, 400 revs. per min. Power, 4 I.H.P. Production, 1000 lbs. per hour.

FEARNOUGHT.—Floor spaces, 12 ft. × 9 ft. Pulleys, 20 in. × 6 in. Speed, 160 revs. per min. Power, 3 I.H.P. Production, 1000 to 1500 lbs. per hour.

Carding Machinery.—SCRIBBLER.—Floor space, 25 ft. × 7 ft. Pulley, 28 in. × 5 in. Speed, 95 revs. per min. Power, 1½ I.H.P.

INTERMEDIATE.—Floor space, 15 ft. × 7 ft. Pulley, 26 in. × 5 in. Speed, 100 revs. per min. Power, 1 I.H.P.

FINISHING CARD.—Floor space, 18 ft. × 7 ft. Pulley, 26 in. × 5 in. Speed, 100 revs. per min. Power, 1½ I.H.P.

MULE (Draws of 66, 72, 78, and 84 in.).—Floor space : Depth, 72 in. ; draw, 12 ft. Length of mule equals number of spindles × gauge + 5 ft. Speed : Countershaft, 180 revs. per min. Pulleys (headstock), 17 in. dia.

Worsted Machinery.—WOOL WASHER.—Floor space, 110 ft. × 7 ft. Pulleys, 29 in. × 6 in. Speed, 15 revs. per min. Power, 8 I.H.P.

WOOL DRYING MACHINERY (M'NAUGHT's).—Floor space, 17 ft. × 5 ft. Pulleys, cone. Production, 350 to 1000 lbs. per hour.

WORSTED CARD.—Floor space, 32 ft. × 11 ft. Pulley, 32 in. × 6 in. Speed, 110 to 120 revs. Power, 3 I.H.P. The arrangement of this machine varies according to the class of material to be treated. For long wools and mohair one licker-in is used ; for cross-breds a two licker-in machine ; and for merino, Botany-bred fine wools, a four licker-in machine is usually employed.

The table on p. 229 gives the classes of card clothing generally used on the worsted carding machine for the counts indicated.

CAN PREPARING BOX.—Floor space, 8 ft. × 5 ft. Pulley, 12 in. × 3 in. Speed, 220 revs. per min. Power, 1 I.H.P.

BACK-WASHING MACHINE.—Floor space, 16 ft. × 5 ft. Pulleys, 18 in. Speed, 150 revs. per min. Power, 4 I.H.P.

COMB (NOBLE's).—Floor space, 10 ft. × 7 ft. 6 in. Pulley, 9 in. × 3 in. Speed of circle, 4 revs. per min. Power, ¾ to 1 I.H.P.

FINISHER BOX.—Floor space, 10 ft. × 5 ft. Pulley, 9 in. × 2¼ in. Speed, 300 revs. per min. Power, ¾ I.H.P.

CAN GILL.—Floor space, 10 ft. × 5 ft. Pulley, 12 in. × 3 in. Speed of fallers, 200 per min. Power, ½ I.H.P.

Clothing for the Worsted Card

Name of Roller.	Dia. in Inches.	64's Botany.			50's Cross-bred.		
		Wire.	Count.	Crown.	Wire.	Count.	Crown.
						Garnett.	
1st licker-in -	30	26	30	6	...	...	...
2nd ,, -	26	28	90	9	24	60	6
3rd ,, -	26	30	100	10	26	80	8
4th ,, -	26	32	115	10	30	100	10
1st divider -	20	25	70	6	24	60	6
2nd ,, -	14	29	90	10	26	80	8
3rd ,, -	14	31	110	10	29	90	9
4th ,, -	14	32	120	10	31	110	10
1st swift - -	50	34	130	12	31	110	10
1st workers -	12	34	135	12	32	115	10
1st strippers -	5	31	110	10	27	80	8
1st fancy - -	16	31	70	8	29	60	7
1st doffer - -	40	35	140	12	32	115	10
Dick or clearer -	6	32	120	10	...	...	...
2nd swift - -	50	35	150	13·5	33	125	12
Angle-stripper -	6	31	120	10	30	110	10
2nd workers -	12	35	150	13·5	34	130	12
2nd strippers -	5	32	115	10	30	90	9
2nd fancy - -	16	33	90	8	31	70	7
2nd doffer - -	40	36	155	14	34	130	12

Reducer.—Floor space, 15 ft. × 6 ft.   Pulleys, 12 in. × 3 in.   Speed of spindles, 900 to 950 revs. per min.   Power, 1 I.H.P.

Rover.—Floor space, 30 spindles, 18 ft. × 3 ft.   Pulleys, 12 in. × 3 in.   Speed of spindles, 900 to 1000 revs. per min.   Power, 1 I.H.P.

Flyer Spinning Frame.—Floor space : Width, 5 ft.   Pulley, 16 in. × 3 in.   Speed of spindles, 2000 revs. per min.   Power, 2½ I.H.P.

Cap Spinning Frame.—Floor space : Width, 4 ft.   Pulley, 16 in. × 3 in.   Speed of spindles, 7000 revs. per min.   Power, 5 I.H.P.

Looms.—*Heavy Woollen Loom* (90 in. reed space).—Floor space, 12 ft. × 5 ft. 6 in.   Speed, 80 picks per min.

Cross Rod Loom.—Floor space (42 in. reed space).   7 ft. 6 in. × 4 ft.   Speed, 200 picks per min.

In regard to the power required for driving woollen looms we give below the results of some interesting experiments.

The test of a loom was made with the motor fastened to the wall by

brackets and indicating 5 H.P. when running at 1250 revs. per min. with 0·88 kw. per horse-power. The shafting was driven by belting. The power consumed was indicated as follows :—

					H.P.
(a) The motor running empty	-	-	-	-	0·74
(b) Shafting, but without belts on the looms	-	-	-	0·52
(c) The loom belts	-	-	-	-	0·18
(d) 8-harness 4-box loom	-	-	-	-	0·46
(e) 14-harness 3-box loom	-	-	-	-	0·42
(f) 8-harness 5-box loom	-	-	-	-	0·42
(g) 8-harness 4-box loom	-	-	-	-	0·44
Total	-	-	-	-	4·3

The loom was run 78 picks per min. weaving a 6/4 kersey. Readings were taken every half-minute, and the average of these was calculated.

Northrop Woollen Loom.—Made in sizes from 60 in. to 102 in. reed space (rising by 5 in.). Standard loom (85 in. reed space, with dobby). Floor space, 12 ft. 10 in. × 5 ft. 9 in. Speed, 105 picks per min. Power, 1 to 1¼ H.P.

NOTES ON WOOLLEN CARDING

Woollen carding is the most negative operation in the textile trade, and the most important one as well. The selection of a suitable machine is invariably a problem to the majority of manufacturers.

There is probably no process in which the same or similar results are secured by so many variable means as in woollen carding. Carding engineers themselves universally differ as to how the process should be carried out, hence there is no wonder at the unsettled opinions of the trade as to what best suits its purpose.

The cosmopolitan nature of the raw materials dealt with in this industry is undoubtedly responsible for this state of affairs, and it is wise to take a broad-minded view of the conditions that exist. A large production is a great asset in woollen carding, and it is probably due to endeavours to secure this object, that there are so many variations in the designing of the machine. Much controversy has arisen upon the advantages and disadvantages of the several types of condensers, and whether it is most advisable to employ two swifts and a breast cylinder in the scribbler, or three swifts and a breast. In the writer's opinion these differently composed machines each have their place in the industry. The fact that one machine possesses more swifts than another, does not necessarily mean that it is capable of a larger output.

For the treatment of loose open material such as the majority of skin

and slipe wools better results are obtained with three swifts than with four. This is especially the case with loose wasty materials which are apt to deposit large quantities of short fibrous material at every doffer under any conditions of speeding and setting. In point of fact, the only standpoint on which a larger number of swifts favour an increased output, is when the blend consists of a goodly proportion of ripped worsteds, which have a better opportunity of being opened out on an increased number of cylinders than they have where the number of cylinders is small.

In blends where the principal constituent is cotton, in either the raw state or in the form of lap waste, it has been the writer's experience that the best results are obtained on the smaller number of swift parts, as over-working cotton is not to be commended, as it is very liable to produce neppy and weak yarns under such conditions. Similar results are obtained when attempts are made to card such like materials on coarse cards. Four-swifted scribblers are very useful for wools that are more or less matted in the staple, and especially so in the short fine trade.

A better and more systematic graduation is possible in the card clothing, where the greater number of swifts obtain, but for some classes of material this cannot be considered a very great advantage. An increased number of threads on a condenser does not necessarily mean an increased output, as a condenser cannot condense more than the machine which precedes it can adequately deal with. It is a mistake to think that a tape condenser will yield a greater output than a double ring doffer condenser, as this is by no means the case. The principal advantage of a tape machine over a double ring doffer machine is the equitable distribution of the fibres in the composition of the threads.

In a similar manner the single ring doffer has an advantage over the double ring machine, but it has the corresponding disadvantage of a decreased output. The larger number of threads that can be appointed on a tape machine, facilitates a more compact distribution of the fibres which build up the thread than is practicable upon a double ring doffer machine. But this advantage can only be appreciated where the threads are carded small. It is of no great consequence in dealing with thick counts.

The great disadvantage of a double ring doffer condenser is the unequal distribution of the material in the formation of the threads on the top and bottom rings respectively. This is certainly overcome by the tape system of condensing. If manufacturers would content themselves with this great advantage and not endeavour to get a greater output than is possible with a double ring doffer condenser, the tape machine would be much more popular than it is to-day.

MACHINES WITH 3 SWIFTS AND BREAST-PART IN SCRIBBLER AND 2 SWIFTS IN CARDER

Scribbler Parts

Name of Part.	Fine Work—56's and Upwards.			Medium Work—40's to 56's.			Coarse Work—Below 40 s Quality.		
	Counts of Card.	Crown of Card	Birmingham Gauge Size of Wire.	Counts of Card.	Crown of Card	Birmingham Gauge Size of Wire.	Counts of Card.	Crown of Card	Birmingham Gauge Size of Wire.
	needle	point		needle	point		needle	point	
Feed rollers	,,	,,	14's	,,	,,	14's	,,	,,	12's
Licker-in	60's	6	14's	40's	4	14's	30's	4	12's
Angle stripper	70's	7	24's	60's	6	20's	50's	5	19's
Breast cylinder	75's	7	26's	65's	6	24's	50's	5	21's
4 ,, workers	60's	6	27's	40's	4	25's	30's	4	21's
4 ,, strippers	double	twill	24's	double	twill	20's	double	twill	19's
,, fancy	73's	7	23's	65's	6	21's	50's	5	18's
,, doffer	60's	6	27's	40's	4	25's	30's	4	21's
Angle stripper	90's	9	24's	80's	8	20's	65's	6	19's
1st swift	95's	9	29's	85's	8	28's	65's	6	25's
4 1st workers	70's	6	30's	45's	4	28's	40's	4	25's
4 ,, strippers	double	twill	26's	double	twill	21's	double	twill	20's
,, fancy	100's	9	26's	85's	8	25's	65's	6	22's
,, doffer	80's	8	31's	60's	6	28's	40's	4	25's
Angle stripper	110's	10	28's	100's	9	24's	80's	8	20's
2nd swift	113's	10	32's	105's	9	31's	85's	8	28's
4 2nd workers	90's	9	32's	80's	8	31's	60's	6	28's
4 ,, strippers	double	twill	29's	double	twill	28's	double	twill	24's
,, fancy	115's	10	29's	105's	9	28's	85's	8	25's
,, doffer	90's	9	32's	80's	8	31's	60's	6	28's
Angle stripper	130's	11	29's	120's	11	28's	100's	9	24's
3rd swift	135's	11	34's	125's	11	32's	100's	9	31's
4 3rd workers	100's	9	35's	80's	8	33's	60's	6	31's
4 ,, strippers	double	twill	31's	double	twill	28's	double	twill	24's
,, fancy	135's	11	31's	125's	11	29's	100's	10	28's
Doffer	110's	9	35's	90's	9	33's	80's	8	32's
Dick roller			33's			30's			28's

MACHINES WITH 3 SWIFTS AND BREAST-PART IN SCRIBBLER AND 2 SWIFTS IN CARDER—continued

Carder Parts

Name of Part.	Fine Work—56's and Upwards.			Medium Work—40's to 56's.			Coarse Work—Below 40's Quality.		
	Counts of Card.	Crown of Crad.	Birmingham Gauge. Size of Wire.	Counts of Card.	Crown of Card.	Birmingham Gauge. Size of Wire.	Counts of Card.	Crown of Card.	Birmingham Gauge. Size of Wire.
Feed rollers	Garnett	clothing or	16's needle pt.	Garnett	clothing or	16's needle pt.	needle	point	14's
Licker-in	Garnett or	60's/6 cr.	24's	,,	60's/6 cr.	24's	50's	6	23's
Tummer	80's	8	28's	80's	8	28's	70's	6	26's
Angle workers	120's	11	33's	120's	11	31's	100's	9	31's
1st swift	130's	11	34's	120's	11	32's	100's	9	31's
4 1st workers	135's	11	35's	125's	11	33's	105's	10	32's
4 „ strippers	100's	9	31's	80's	8	28's	60's	6	24's
„ fancy	double	twill	30's	double	twill	29's	double	twill	28's
„ doffer	135's	11	35's	125's	11	33's	105's	10	32's
Angle stripper	100's	9	31's	90's	9	29's	80's	8	28's
2nd swift	135's	11	35's	125's	11	33's	115's	10½	32's
4 2nd workers	135's	12	35's	130's	11	34's	120's	11	33's
4 „ strippers	100's	9	31's	90's	9	29's	80's	8	28's
„ fancy	double	twill	31's	double	twill	30's	double	twill	29's
Single ring doffer	125's	As allowed by width of ring	34's	115's	...	33's	100's	...	31's
Doublering doffers	125's	11	34's	115's	...	33's	100's	...	31's
Tape doffer	125's	11	34's	115's	10½	33's	100's	10	31's
Taking-off stripper	110's	10	33's	100's	9	31's	80's	8	28's

MACHINES WITH 2 SWIFTS AND BREAST-PART IN SCRIBBLER AND 2 SWIFTS IN CARDER

Scribbler Parts

Name of Part.	Fine Work—56's and Upwards.			Medium Work—40's to 56's.			Coarse Work—Below 40's Quality.		
	Counts of Card.	Crown of Card.	Birmingham Gauge Size of Wire.	Counts of Card.	Crown of Card.	Birmingham Gauge Size of Wire.	Counts of Card.	Crown of Card.	Birmingham Gauge Size of Wire.
Feed rollers	needle	point	16's	needle	point	14's	needle	point	12's
Licker-in	,,	,,	16's	,,	,,	14's	,,	,,	12's
Angle stripper	50's	4	25's	40's	4	24's	30's	4	23's
Breast cylinder	70's	7	27's	60's	6	26's	50's	5	24's
4 ,, workers	75's	7	27's	65's	6	27's	55's	5	25's
4 ,, strippers	60's	6	26's	50's	4	24's	40's	4	24's
,, fancy	double	twill	24's	double	twill	23's	double	twill	21's
,, doffer	75's	7	27's	65's	6	27's	55's	5	25's
Angle stripper	60's	6	26's	50's	4	24's	40's	4	24's
1st swift	100's	9	29's	90's	9	29's	70's	7	27's
4 1st workers	110's	9	29's	100's	9	29's	73's	7	27's
4 ,, strippers	90's	9	28's	80's	8	27's	60's	6	26's
,, fancy	double	twill	27's	double	twill	26's	double	twill	24's
,, doffers	110's	9	29's	100's	9	29's	75's	7	27's
Angle stripper	90's	9	28's	80's	8	27's	60's	6	26's
2nd swift	130's	11	34's	120's	11	33's	100's	9	29's
4 2nd workers	135's	11	35's	125's	11	33's	110's	9	30's
4 ,, strippers	100's	9	29's	90's	9	28's	80's	8	27's
,, fancy	double	twill	30's	double	twill	29's	double	twill	27's
,, doffer	135's	11	35's	125's	11	33's	110's	9	30's
Dick roller	100's	9	29's	100's	9	30's	80's	8	27's

MACHINES WITH 2 SWIFTS AND BREAST-PART IN SCRIBBLER AND 2 SWIFTS IN CARDER—*continued*

Carder Parts

Name of Part.	Fine Work—56's and Upwards.			Medium Work—40's to 56's.			Coarse Work—Below 40's Quality.		
	Counts of Card.	Crown of Card.	Birmingham Gauge. Size of Wire.	Counts of Card.	Crown of Card.	Birmingham Gauge. Size of Wire.	Counts of Card.	Crown of Card.	Birmingham Gauge. Size of Wire.
Feed rollers	Garnett clothing			needle	point	16's	needle	point	14's
Licker-in	,,	,,		,,	,,	16's	,,	,,	14's
Tummer	90's	9	29's	80's	8	28's	60's	6	26's
Angle worker	120's	10	32's	115's	10	30's	80's	8	28's
1st swift	130's	11	34's	120's	11	32's	100's	10	30's
4 1st workers	135's	11	35's	125's	11	33's	115's	10	31's
4 ,, strippers	100's	9	31's	90's	9	29's	80's	8	27's
Fancy	double	twill	30's	double	twill	29's	double	twill	27's
Doffer	135's	11	35's	125's	11	33's	115's	10	31's
Angle stripper	110's	10	32's	90's	9	29's	80's	8	27's
2nd swift	135's	11	35's	130's	11	34's	115's	10½	32's
4 2nd workers	135's	12	35's	135's	11	35's	120's	11	33's
4 ,, strippers	110's	10	32's	100's	9	30's	80's	8	27's
Fancy	double	twill	31's	double	twill	30's	double	twill	29's
Single ring doffer	120's	as allowed by width of ring	34's	120's	...	33's	110's	...	31's
Double ,, ,,	120's		34's	120's	...	33's	110's	...	31's
Tape doffer	125's	11	34's	120's	10½	34's	110's	10	31's
Taking-off stripper	110's	10	33's	110's	10	33's	100's	9	29's

NOTES ON CLOTHING FOR WOOL CARDING

The question of card clothing as it obtains in the woollen trade is such a controversial subject, and occasions so many varied opinions, that it is unwise to endeavour to establish any hard and fast rules. But these notes and the tables that accompany them are at least suggested by practical experience.

Carding machines are in good or bad condition according to the arrangement and condition of the cards with which they are mounted. It is important that a proper graduation of densities shall obtain from the start to the finish of the machine in accordance with the quality of the materials to be dealt with. The conditioned doffers and workers are often the outcome of badly mated stripper cards. Any roller or cylinder that is working in conjunction with another one should be mounted with wire that will work harmoniously with its fellow. The "fancy" is the most important roller in the machine, and may be the carding engineer's best friend or greatest enemy. "Fancies," with the wires set in plain order in the "crown," though widely used, are not ideal. If too strongly wired and set with open crown they furrow the swift and render it very rough and irregular. Smooth surfaced cards are always to the advantage of good work, and their development should be encouraged in all branches of woollen textiles. Fancies with wire set in twill or double twill order develop smooth surfaced swifts much better than plain or ribbed settings, even when strongly wired or open set in the crown.

A simple and very efficient method of arranging "fancies" in a set of cards is to have them all set in double twill or zigzag twill order, with a size of wire agreeing with the cylinder wire in which they are working. On this principle, the same number of wires per square inch obtains in each fancy. Three different styles of setting the wires in card clothing are illustrated on p. 42.

Plain setting is undoubtedly the superior arrangement for swift cards.

Ribbed setting is the most popular arrangement for fillet cards on account of the unbroken edge of the wires, which is necessary in this type of card. It is well to note that the "crown" of the card is represented by the number of heads or crowns across one inch of the card, whilst the "count" is determined by the number of wire points down five inches of the card. (Note, this is different to the system of counting prevalent in the cotton trade.)

Twill set cards have been more largely adopted for "fancies" than other parts of the machine. Recently, however, they have been successfully applied to doffers and workers, and for the working up of thready material the arrangement is quite a logical one.

Cards should not be harshly ground, as the life of a card is consider·ably reduced by so doing. It is much easier to soften the wires by hard grinding and the generation of intense heat under this process, than it is to retain the hard tempered points so ideal in well-conditioned cards.

Tape doffers should not be nailed with cards that are too full in the wire ; to keep them fairly open is to ensure a more receptive surface of the doffer, than is the case if the wires are too compact in their distribution.

Card foundations that hold the wires too rigid should be avoided for swifts, as the fancies have great difficulty in clearing them under such conditions.

In the arrangement of cards in the foregoing tables slight modifications will be found necessary in the working up of extremely coarse materials. For the general run of the woollen trade they will be found capable of producing very satisfactory results.

NOTES ON PRODUCTION IN WOOLLEN CARDING MACHINES

The production of a woollen carding machine depends more upon the arrangement, condition, and setting of the cards than upon the amount of material that is fed into the machine. The limit of production is reached when the cards have as much material in them as they can adequately cope with. To overcrowd the cards with material often militates against production, as the spinning conditions of condensed yarns is a potent factor in the regulation of the same. To run a machine too long in order to save fettling or cleaning, invariably leads to a reduction of output, and is certainly very false economy.

The nature and quality of blended materials help or hinder output considerably. A manufacturer acts wisely if he pays due regard to this fact in the composition of his blends. Blends containing excessive amounts of dirt and foreign matter are invariably expensive ones. They not only retard output by the stoppage of machines for cleaning, but they materially affect the condition and life of the cards. Carding machines should be kept thoroughly, but not excessively lubricated. Lack of lubrication results in hard driving and the attendant breakages of many belts. A larger number of threads on a condenser does not necessarily mean a greater output (see Notes on Woollen Carding). An increased number of cylinders in a carding machine may reduce, rather than increase output (see Notes on Woollen Carding). Old worn-out belts with many joints should be rigorously avoided. The time lost in frequent stoppages for belt repairs is a much heavier expense than the cost of a new belt would be.

ESTIMATING THE PRODUCTION OF WOOLLEN CARDING MACHINES

The following tables will be found very useful for making a quick calculation of the amount of work turned out of carding machines of the most general type. As will be noticed from a perusal of the same, they are made up of a series of gauge points or convenient numbers which can be utilized for the purpose stated according to the type of machine to be dealt with.

GAUGE POINTS FOR CALCULATING THE PRODUCTION OF TAPE CONDENSERS WITH 8-INCH SURFACE DRUMS

Number of Good Threads.	Gauge Point.	Number of Good Threads.	Gauge Point.	Number of Good Threads.	Gauge Point.
40	6·50	76	12·43	120	19·6
44	7·20	78	12·76	128	20·9
48	7·85	80	13·00	136	22·5
50	8·15	84	13·74	144	23·5
52	8·50	88	14·40	150	24·5
56	9·25	96	15·70	156	25·5
60	9·80	100	16·30	162	26·5
64	10·60	104	17·00	168	27·48
66	10·80	108	17·65	174	28·4
72	11·70	112	18·50	180	29·4
75	12·25	116	19·00	240	39·2

RULE.— $\dfrac{\text{Gauge point} \times \text{revs. of surface drums}}{\text{skeins}} = \text{lbs. per hour.}$

From the table of gauge points select the number which suits the type of condenser dealt with and multiply this number by the number of revolutions per minute of the surface drums. Divide the product by the Yorkshire skein count of the condensed thread and the result will be the number of lbs. per hour the machine is producing.

EXAMPLE.—The surface drums of a machine with 120 threads are running at 20 revs. per minute, and condensing 10 skeins.

$$\frac{19·6 \times 20}{10} = 39·2 \text{ lbs. per hour produced.}$$

If the machine had 9-inch surface drums then the product would be $\frac{1}{8}$th greater.

GAUGE POINTS FOR PRODUCTION ON DOUBLE RING DOFFER CONDENSERS WITH 9-INCH SURFACE DRUMS

Number of Good Threads.	Gauge Point.	Number of Good Threads.	Gauge Point.	Number of Good Threads.	Gauge Point.
40	7·4	60	11·4	96	17·7
44	8·1	64	11·8	100	18·4
48	9·0	72	13·2	104	19·0
50	9·2	76	14·0	112	20·6
52	9·5	80	14·7	120	22·8
56	10·3	88	16·2		

In calculating the production of a double ring doffer condenser, take the average revolutions of the two sets of drums.

Thus, if the top surface drums run at 30 revs. and the bottom surface drums run at 28 revs., the average $30 \times 28 \div 2 = 29$ revs. must be taken and dealt with as before, viz. :—

$$\frac{\text{Gauge point} \times \text{revs. of surface drums}}{\text{skeins}} = \text{lbs. per hour.}$$

For 8-inch surface drums deduct ⅛th.

GAUGE POINTS FOR PRODUCTION ON SINGLE RING DOFFER CONDENSERS WITH 9-INCH SURFACE DRUMS

Number of Good Threads.	Gauge Point.	Number of Good Threads.	Gauge Point.
50	9·2	60	11·4
52	9·5	70	12·9
56	10·3	75	13·8

ANOTHER METHOD OF ESTIMATING PRODUCTION IN WOOLLEN CARDING, SPINNING, WEAVING

The maximum theoretical production in woollen carding is dependent on the following factors :—

(1) The size of the surface drum.
(2) The revs. per min. of the surface drum.
(3) The number of good threads produced.
(4) Yards per lb. of carded slivers.

In formulating a rule to estimate maximum production, it will be necessary to fix a period, and 10 hours is suggested.

Then the following rule is obtained on a basis of Yorkshire skein counts :—

$$\frac{\substack{\text{Circum. of} \\ \text{surface drum}} \times \substack{\text{revs. per min. of} \\ \text{surface drum}} \times \substack{\text{60 mins. per} \\ \text{hour}} \times \substack{\text{Number of good} \\ \text{threads}} \times 10\,\text{hours}}{36 \text{ inches per yard} \times \text{skein counts} \times 256 \text{ yards in 1 lb. of 1's}} = \substack{\text{lbs. in} \\ \text{10 hrs.}}$$

As 9-inch surface drums in machines taking off 50 good threads are common, a simple formula may be obtained, taking these factors into consideration :—

$$\frac{(9 \times 3\tfrac{1}{7}) \times \text{r.p.m.} \times 60 \times 50 \times 10}{36 \times \text{skein counts} \times 256} = \text{lbs. in 10 hours.}$$

$$\frac{\text{Revs. per min. of surface drum} \times 92}{\text{Yorkshire skein counts}} = \text{lbs. in 10 hours.}$$

For Galashiels yarn counts 118 may be substituted, and in the case of West of England counts 73·5 should be employed.

The annexed table of maximum production will be found useful for comparative purposes.

It will be obvious that the maximum production as indicated in the table cannot be obtained in practice, but the actual production compared with the maximum theoretical production is a useful basis for comparing the relative efficiency.

Other than the variations in machinery, viz.,

(a) The size of the surface drums.
(b) The number of good threads.

The chief factors which affect production are—

1. The type and quality of material, which affect both the amount of waste made and the time running;
2. The skill with which the machine is set for its work, and tended afterwards;
3. The size of the lots to be worked;
4. The exigencies of trade.

Observations of the average production in practice, under ordinary working conditions over a long period, from single doffer machines taking off 50 good threads was found to be approximately as follows :—

$$\frac{\text{Revolutions per minute of surface drum} \times 80}{\text{Yorkshire skein counts of silver}} = \text{lbs. in 10 hours.}$$

In other words, the average efficiency is about 87 per cent.

MAXIMUM PRODUCTION OF WOOLLEN CARDS

Body figures = Lbs. per 10 Running Hours. Column head revs. per min.: upper row = 6-In. Surface Drum, 100 Good Threads; lower row = 9-In. Surface Drum, 50 Good Threads.

West.	Gala.	Skein.	7½ / 10	8¼ / 11	9 / 12	9¾ / 13	10½ / 14	11¼ / 15	12 / 16	12¾ / 17	13½ / 18	14¼ / 19	15 / 20	15¾ / 21	16½ / 22	17¼ / 23	18 / 24	18¾ / 25
3·2	5·12	4	230	253	276	299	321	345	368	391	418	437	460	483	507	529	552	575
4	6·4	5	189	202	221	239	257	276	294	313	331	349	368	386	405	423	442	460
4·8	7·68	6	153	169	184	199	215	230	245	261	276	291	307	322	337	353	368	383
5·6	8·96	7	131·5	144·5	157·5	171	184	197	210	223	237	250	263	276	289	302	315	329
6·4	10·25	8	115	126·5	137	149½	161	172·5	184	195·5	207	219	230	242	253	263	276	288
7·2	11·54	9	102	112·2	122·5	133	143	153·5	163·5	173·5	184	194	204·5	215	225	235	245	255
8	12·8	10	92	101	110·5	119½	128	138	147	156·5	165·5	175	184	193	203	212	221	230
8·8	14·1	11	83·6	92	100·5	109	117	125·5	134	142	150·5	159	167·5	176	184	192·5	201	209
9·6	15·36	12	76·6	84·4	92	99·6	107·5	115	122·5	130·5	137	146	153·5	161	169	176·5	184	194
10·4	16·64	13	70·7	77·8	85	92	99·1	106	113	120·5	127·5	134·5	141·5	148·5	155·5	162·5	170	177
11·2	17·9	14	65·7	72·3	78·9	85·5	92	98·5	105	111·4	118·3	124·6	131·5	137	144·5	151	157·5	164·5
12	19·2	15	61·4	67·5	73·5	79·7	85·8	92	98·1	104·3	110·4	116·6	122·8	129	135	141	147·3	153·4
12·8	20·5	16	59·5	63·2	69	74·7	80·5	86·2	92	97·7	103·5	109·3	115	120·8	126·5	132·2	138	143·8
13·6	21·65	17	54·1	59·5	65·0	70·4	75·8	81·2	86·9	92	97·4	102·8	108·2	113·6	119	124·5	130	135·2
14·4	23·2	18	51·1	56·2	61·3	66·5	71·6	76·7	81·8	86·9	92	97·1	102·2	107·3	112·3	117·5	122·5	127·7
15·2	24·3	19	48·4	53·2	58·1	62·9	67·8	72·7	77·5	82·3	87·1	92	96·8	101·7	106·5	111·4	116·2	121
16	25·6	20	46	50·6	55·2	59·8	64·4	69	73·6	78·2	82·8	87·4	92	96·6	101·1	105·7	110·3	115
16·8	26·9	21	43·8	48·2	52·6	57	61·3	65·7	70·1	73·5	78·8	83·2	87·7	92	96·2	99·7	105	109·5
17·6	28·15	22	41·8	46	50·2	54·3	58·6	62·8	67·9	71·2	75·3	79·4	83·7	87·8	92	96·2	100·3	104·6
18·4	29·42	23	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100
19·2	30·7	24	38·3	42·2	46	49·8	53·7	57·5	61·3	65·2	69	73·8	76·7	80·5	84·3	88·1	92	95·8
20	32	25	36·8	40·5	44·2	47·8	51·5	55·2	58·9	62·5	66·8	69·9	73·6	77·3	81	84·7	88·3	92

Revs. per Min.   —   Lbs. per 10 Running Hours.

ESTIMATING PRODUCTION IN WOOLLEN SPINNING

The maximum theoretical production in woollen spinning is dependent on the following factors :—

    1. Inches of yarn for winding per draw.
    2. The number of spindles in the mule.
    3. The number of draws per hour.
    4. The counts of yarn.

In formulating the rule for estimating the maximum production, it will be advisable to take the period of 10 hours, as in carding. For Yorkshire skein yarns, the rule would then work out as follows :—

$$\frac{\text{Inches for winding} \times \text{spindles} \times \text{draws per hour} \times 10 \text{ hours}}{36 \text{ inches per yard} \times \text{yarn counts} \times \text{yards in 1 lb. of 1's yarn}} = \frac{\text{lbs. per}}{10 \text{ hours.}}$$

For a mule with 300 spindles, the rule will be modified thus :—

$$\frac{\text{Inches for winding} \times 300 \times \text{draws per hour} \times 10}{36 \times \text{yarn counts} \times 256} = \text{lbs. in 10 hours.}$$

Inches for winding is a variable factor, even in mules with the same length of "draw," as the length of yarn to be wound on the spindle is dependent on the amount of "jacking up" of the mule owing to shrinkage of the yarn in twisting.

If the length for winding is taken as 72 in., then the above rule becomes :—

$$\frac{72 \times 300 \times \text{draws per hour} \times 10}{36 \times \text{yarn counts} \times 256} = \text{lbs. in 10 hours.}$$

$$\frac{23 \cdot 4 \times \text{draws per hour}}{\text{yarn counts}} = \text{lbs. in 10 hours.}$$

Obviously this will not be reached, as there are no allowances made for filling, doffing, various other stoppings, and waste.

Yet the above data is useful as a check of efficiency. It has been found that an average production in practice over a long period from a 600-spindle mule, with 72 inches draw, is approximately as follows for good and medium class work.

    (I.) $\dfrac{6000}{(1 \cdot 1 \times \text{skeins} + 10)} = \text{lbs. in 10 hours.}$

From some published particulars of production in the Colne Valley, the following rules have been devised for mules with a draw of 7 feet :—

    (II.) $\dfrac{6000}{(1 \cdot 05 \times \text{skeins} + 5 \cdot 5)} = \text{lbs. in 10 hours for a 600-spindle mule.}$

The above is estimated for weft yarns; on warp yarns the production is about 7½ per cent. less.

The production of a mule does not vary as the number of spindles. With an increase in spindles, the production per spindle is reduced. In the Colne Valley it has been found that

700-spindle mules produce 15 per cent. more than 600 spindles.
800   ,,   ,,   29   ,,   ,,
900   ,,   ,,   40   ,,   ,,

The following table of production in woollen spinning has been calculated on the Rules I. and II. given above, for a period of 10 hours. By substituting 28,800 in place of 6000 in both cases, the production for a 48-hour week is obtained.   Or, the weight in pounds in the table may be multiplied by 4·8 to obtain the weekly production per 48 hours.

PRODUCTION OF WOOLLEN SPINNING MULES

(Lbs. in 10 *hours)*

Yorkshire Skeins.	Good and Medium Qualities (By Rule I.).	Medium and Low Qualities (Calculated by Rule II.).							
		Warp.				Weft.			
	Spindles.	Spindles.				Spindles.			
	600	600	700	800	900	600	700	800	900
6	361	471	542	607	660	509	585	656	713
7	339	433	498	549	606	467	537	604	636
8	319	400	460	517	560	432	496	557	604
9	301	373	429	481	522	402	462	518	564
10	285	347	399	448	486	375	432	484	526
12	259	307	353	395	430	332	382	426	465
14	236	275	316	355	385	297	342	384	416
16	217	249	286	321	349	269	309	347	376
18	201	227	261	293	319	245	282	316	344
20	187	209	241	270	293	226	260	292	316
22	175	194	223	250	271	210	241	270	294
24	165	181	208	233	253	195	225	252	274
26	155	169	194	218	237	183	210	235	256
28	147	159	183	205	223	172	198	222	240
30	139	150	173	194	210	162	186	209	227
32	133	142	163	183	199	153	176	198	215
34	127	134	155	174	189	145	167	188	204
36	121	128	147	165	179	138	159	179	194
38	116	122	141	158	171	132	152	170	185
40	111	117	135	151	164	126	145	163	177

THE PROPERTIES OF THE WOOL FIBRE

By J. B. Speakman, M.Sc., F.I.C.
(Leeds University)

Mode of Formation.—The wool fibre grows from within a tube-like depression in the skin of the sheep, known as the follicle. The cells formed and segregated at its base escape upwards through the tube and are changed and consolidated during growth into the hardened keratin structure known as wool and hair. Associated with the follicle are the sebaceous glands : these open into the tube near its mouth and serve to coat the fibre with wool fat, giving it some form of protection against weathering and other influences up to the time of shearing. In addition, the sweat glands of the skin exude sweat (suint), and wool in fleece-form is thus contaminated with both wool fat and suint, commonly grouped together under the term "yolk." These impurities and the dirt accumulated by the fleece during growth result in the yield of clean wool from greasy wool being only of the order of 50 per cent. by weight.

Composition of Raw Wool.—It is important to have some knowledge of the composition of greasy wool, not only from the point of view of knowing the yield of clean wool to be expected, but also because the suint content of greasy wool has recently attained importance on account of the successful development of suint scouring processes. The American Bureau of Chemistry has analysed a large number of samples of greasy wool [1] from many different sources, and their results are summarised in Tables I. and II. below. In Table I. the results have been arranged to indicate the relationship between wool fat and suint content and wool quality, while in Table II. their relationship to the locality in which the wool was grown is indicated.

TABLE I

Wool Quality.	No. of Samples.	Moisture.	Wool Fat.	Suint.
		Per Cent.	Per Cent.	Per Cent.
Fines (70's) · ·	93	5·6	17·4	14·0
1/2 Blood (60's) ·	48	5·5	12·7	15·2
Medium (58's) ·	29	5·0	10·5	14·7
3/8 Blood (56's) ·	44	6·3	9·8	16·8
1/4 Blood (48's) ·	38	7·0	8·6	15·4

Two important conclusions emerge from the preceding data. In the first place, it will be seen that the percentage of wool fat present in greasy wool increases with wool quality. This is an observation whose truth has long been suspected by the manufacturer, but no proof of its validity has previously been given. Secondly, the suint content of greasy wool is quite independent of wool quality.

TABLE II

Locality.	No. of Samples.	Wool Fat.	Potash (K_2O) from Suint.
		Per Cent.	Per Cent.
United States - - -	213	12·74	3·98
South America - - -	33	10·36	3·42
Cape - - - - -	20	16·14	3·90
Australia and New Zealand	22	15·50	3·19

The values given in Table II. for the potash content of greasy wool indicate that its suint content is almost independent of the locality in which the wool was grown. Wool-fat content appears to be highest in the case of Cape wools and least with South American wools.

The Cell Structure.—The wool fibre is not a homogeneous structure, but is built up from two main types of cell: an outer layer of overlapping scales constituting the cuticle, which encloses a core (cortex) of long spindle-shaped cells. The scales are far more resistant to chemical attack than the interior of the fibre, for which they form a kind of protective plating.

In addition to these two types of cell, certain wools, especially those of relatively low quality, contain a third type of cell. This is hollow and rounded, and is to be found along the main axis of the fibre. Such cells constitute what is known as the medulla, which may run continuously from end to end of the fibre or may be arranged as isolated medullary islands in a solid cortex. The hollow character of the medulla is responsible for its dark appearance when viewed by transmitted light under the microscope (see Fig. 1, kemp, and Fig. 2, Leicester wool), and for the dead-white appearance of medullated fibres when viewed by reflected light in the ordinary way.

In certain exceptional cases the medulla may occupy the whole interior of the fibre, which then has a sufficiently characteristic dead-white appearance to be capable of special designation as kemp.[2] A microphotograph of a typical kemp fibre, viewed by transmitted

light, is shown in Fig. 1. Kempy fibres are usually much coarser than the accompanying wool fibres, and are definitely objectionable in a fleece, because, although they are capable of absorbing the same percentage by weight of dyestuffs as non-medullated fibres, they appear to be almost undyed to the eye on account of their hollow character. No exact definition of kemp can be given because several
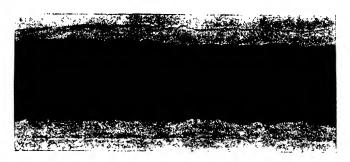
FIG. 1.—KEMP.
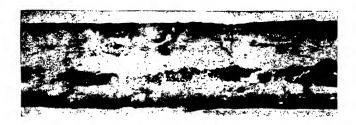
FIG. 2.—LEICESTER.

different types have been recognised, and no sharp line of demarcation has been drawn between the ordinary medullated wool fibre and kemp. It is, however, clear that the appearance of kemp in a fleece is the first stage of a reversion to the coat of the primitive sheep, which consisted of an outer coat of hair and an inner one of wool.

The outer scales of the wool fibre are worthy of detailed discussion. Their shape and arrangement vary from one type of wool to another, as shown in Fig. 2. Where the scales are large, or where they lie
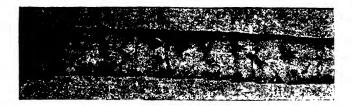
Fig. 2.—Southdown.
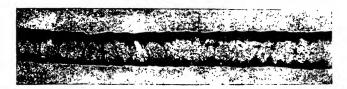
Fig. 2.—Merino.
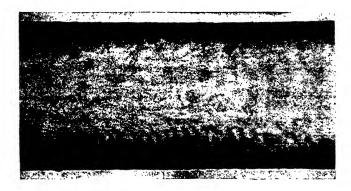
Fig. 2.—Human Hair.

closely to the body of the fibre, they present a uniform surface for the reflection of light, and give the fibres a high lustre, as in the case of Leicester wool, mohair, and human hair. The main interest of the scales, however, lies in the fact that they are directly responsible for the milling process to which wool fabrics are subjected. They give rise to the well-known difference between the frictional resistance to motion of a fibre moving first in the direction of the root-end and, second, in the direction of the tip. This difference in friction imparts unidirectional freedom of motion to the fibres in the cloth undergoing the milling process, and shrinkage is induced in the manner described by Shorter.[3] In spite of its obvious importance, no measurements of this difference in the frictional resistance to motion in the two directions specified appear to have been made until recently. The data quoted in Table III. are taken from unpublished work by the writer and Miss E. Stott, who made their measurements with a type of violin bow constructed from wool fibres, sliding over a cloth having a trail pile finish. In all cases, the difference in friction is expressed as a percentage of the friction observed when the fibres were moving in the direction of the root-end.

TABLE III

Wool.		Mean Fibre Diameter.	Percentage Difference in Friction.
		Cms.	
Australian Merino (80's)	-	0·0018	60·4
Australian Merino (64's)	-	0·0023	44·0
Southdown -	- - -	0·0033	28·3
Romney Marsh	- - -	0·0034	27·5
Corriedale -	- - -	0·0024	26·3
Exmoor - -	- - -	0·0041	23·5
Oxford Down -	- - -	0·0042	21·3
Wensleydale -	- - -	0·0037	16·3
Leicester -	- - -	0·0038	13·5
Mohair - -	- - -	0·0032	5·0

In the case of extreme types like Australian merino wool, English wools and mohair, there is an obvious direct correlation between scaliness, as measured by the difference in friction and the rate of shrinkage of fabrics in a milling machine. Where only small differences in scaliness exist between wools, direct correlation between

scaliness and shrinkage can hardly be expected because of the other factors which play a part in the process.

DIMENSIONAL CHARACTERISTICS

(a) *Shape of Cross-section.*—A microphotograph of the cross-sections of New Zealand Romney wool fibres is shown in Fig. 3.
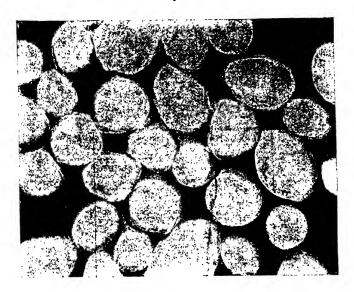
FIG. 3.—NEW ZEALAND ROMNEY FIBRES (CROSS-SECTION).

It serves to illustrate the well-known fact that the shape of the cross-section of wool fibres is by no means always circular. In conjunction with fineness of fibre, the shape of the cross-section is supposed to determine the behaviour of the wool during spinning. By analysing samples of approximately the same average fineness and distribution of fineness, but whose spinning powers were known to differ, it has been found that the presence of a high percentage of circular or nearly circular fibres materially assists the spinning of the wool.[4]

(*b*) *Fineness*.—Wools are normally classified by the wool sorter according to a scale of qualities which is determined mainly by the sense of touch.   Within any one quality, fibres of very different diameter are to be found, and the variation in diameter of any one fibre along its length is usually very considerable.   Nevertheless, it has been found that the mean fibre diameter of a wool is closely related to its quality number as determined by the sense of touch. A number of attempts have been made to define this relationship, and although the connection between the two quantities can scarcely be expected to be precise in view of the non-circular section of the fibre and of the unknown character of the factors determining the sorter's quality, the relationship is sufficiently close to indicate that fineness is the main factor involved in the assessment of quality. The most recent of these many attempts to relate fibre diameter and wool quality is due to Duerden,[5] whose figures are quoted in Table IV.

TABLE IV

Quality Number.	Mean Fibre Diameter.
	Cms.
150	0·00142
120	0·00149
100	0·00158
90	0·00166
80	0·00177
70	0·00184
66	0·00197
64	0·00205
60	0·00217
58	0·00243
56	0·00270

(*c*) *Length*.—The length to which the wool fibre grows during a normal year varies very considerably from one breed of sheep to another.   Even within the one quality of a particular wool, the variation in length is often very considerable, as shown in Fig. 4, for a 56's Down top.   Merino wool fibres vary in length from about 2 to 12 cms., English Southdown wool being very similar in this respect.   In extreme cases, as, for example, Leicester wool, the length of the wool fibre may reach 40 cms. (15·7 in.), the variation in

length being correspondingly great. With wool in the form of top, the frequency distribution of fibres of various lengths is ascertained by means of the Schlumberger machine.
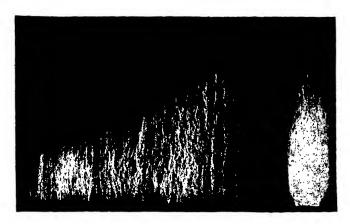
FIG. 4.—ANALYSIS OF DOWN TOP.

(d) *Crimpiness*.—In its normal unstretched condition, the wool fibre usually has a wavy form. This is seen to the best advantage

FIG. 5.—CRIMP.

in the case of merino wool, where the wave-length is small, and a photograph of a typical staple of 64's Cape merino wool is reproduced in Fig. 5. The waviness or crimpiness of wool, such as merino wool,

is a very valuable property, a characteristic loftiness and sponginess of handle being thereby produced in the fabric. The origin of crimpiness is still uncertain, but the modern view seems to be that the normal form taken by the undeformed wool staple is that of a flat spiral, a formation which can be seen in the coat of the newborn merino lamb. As the fleece increases in density with age, lateral compression of such spirals must occur, and the result is the creation of a uniplanar wave in the fibres. Very early in the study of the wool fibre, Bowman recorded the existence of a connection between the number of waves in unit length of a fibre and its diameter. More recently, Duerden [6] made a parallel study with Cape merino wools, and recorded a similar increase in the number of waves per inch, with decrease in fibre diameter. Barker and Norris [7] perfected the relationship by relating the number of crimps per inch to the cross-sectional area of the fibre instead of to its diameter. They found that the crimpiness of different wools could be expressed by the equation
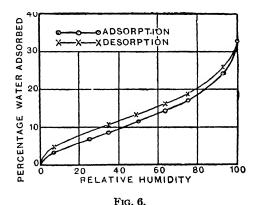
$$k = n\mathrm{A} \sqrt{\frac{b}{a}},$$

where n is the number of crimps per inch, A is the area of cross-section, and b and a are the axes of the elliptical cross-section. k is a constant which usually has the value 9×10^{-6}, but for South African wools the value is more nearly 8×10^{-6}.

In regard to the origin of crimp, the most valuable observation yet recorded is due to a Mr Lefroy [8] of Walebing, West Australia. He observed that the staple of a merino wool grew at an irregular rate throughout the twelve months during which it was under observation, the increases in length every four months being 1·16 in., 0·81 in., and 1·31 in. Each of these three regions, however, showed ten crimps, suggesting that the formation of crimp is a function of time and not of the length of fibre grown. The extension of this observation will be awaited with interest.

Physical Properties.—(*a*) *Hygroscopicity.*—Wool has a pronounced affinity for water, and it is bought and sold on the assumption that it contains definite amounts of water fixed by the so-called standards of regain. The amount of water combined with wool is determined by the relative humidity and temperature of the atmosphere to which it is exposed and by the direction in which any particular humidity was reached. This latter fact has only recently been discovered,[9] and its importance is indicated by the following figures :—

if perfectly dry merino wool is exposed to an atmosphere at **63·3** per cent. relative humidity and 25° C., it combines with **13·97** per cent. by weight of water, whereas, if the same wool is wetted out and then dried down until it is in equilibrium with the same atmosphere as before, it is found to be combined with a much greater amount of water, **16·12** per cent. This difference of about 2 per cent. in the amount of water adsorbed has a profound influence on the elastic properties of wool, as will be shown later, and the preceding observations serve to explain why it is always a mistake to over-dry wool at any stage of its manufacture. The adsorption of water by a variety of wools in commercial forms has been studied in detail by Shorter and Hall,[10] and although they made no allowance for the phenomenon described above, their results are of great practical

FIG. 6.

value. The effect of temperature on the adsorption of water by wool was studied by Schloesing,[11] who found that at any one humidity the amount of water adsorbed decreases with rise of temperature. At constant temperature, the amount of water adsorbed by wool increases with increase in relative humidity. The form of the relation between these two quantities under both adsorption and desorption conditions is illustrated for Southdown wool in Fig. 6. **Data for** the amount of water adsorbed [9] by different wools at 25° C. **are given in Table V.**

Table V

Relative Humidity.	Percentage Increase in Weight of :—			
	Geelong, 80's Merino.	Southdown.	Leicester.	Mohair.
Per Cent.				
7·0	3·40	3·37	3·40	3·41
25·0	6·96	6·90	6·96	6·93
34·2	8·41	8·62	8·54	8·64
49·8	11·22	11·48	11·44	11·51
63·3	13·97	14·19	14·46	14·41
75·0	16·69	17·03	17·43	17·33
92·5	23·81	24·17	24·59	24·24
100·0	33·3	32·9	32·9	31·8

DESORPTION

92·5	24·70	25·70	25·98	25·82
75·0	18·69	18·79	19·02	18·91
63·3	16·12	16·16	16·28	16·26
48·7	13·36	13·38	13·39	13·46
34·2	10·57	10·55	10·58	10·68
7·0	4·77	4·73	4·79	4·87

(b) *General Elastic Properties*.[12]—Although stretched wool fibres return very slowly to their original length in atmospheres only partially saturated with water vapour, they nevertheless return rapidly and completely to their original length in water, even after being stretched as far as 70 per cent. of their original length. When wool fibres are stretched in water at high temperatures, their rate of recovery in cold water is reduced until, when the temperature of stretching exceeds 90° C., the fibre fails to contract to any significant extent in cold water. Up to this critical temperature of stretching, however, the fibre returns to its original length on being immersed in water at the same temperature as that in which stretching occurred. Wool fibres which have been steamed in the stretched condition fail to return exactly to their original length on being resteamed in the absence of tension, although partial contraction is still possible. These properties all find extended use in wool-finishing processes.[13]

(c) *Strength*.—The strength of the wool fibre is dependent on the amount of water with which it is combined. This is well illustrated by the following table,[9] in which is given the breaking load of English Cotswold wool fibres at various humidities at 72° F. :—

TABLE VI

Relative Humidity.	Breaking Load.
Per Cent.	G./Cm².
0·0	$22 \cdot 1 \times 10^5$
8·3	21·6
34·2	19·4
49·8	16·8
65·0	16·1
75·0	15·4
100·0	14·9

The fall in breaking load with rise of humidity is accompanied by an increase in the extension at break.

(d) *Rigidity*.[14]—The rigidity of the wool fibre is the property which determines its resistance to the insertion of twist, and is therefore of great interest in connection with spinning processes. The rigidity depends to a marked extent on the amount of water combined with the wool, the exact connection being given by the following expression for humidities between 23 and 87 per cent. at 25° C. :—

$$\text{Relative rigidity} = 1 \cdot 255 - 0 \cdot 047 A,$$

where A is the amount of water adsorbed by the wool, and relative rigidity is the ratio of the rigidity of the wool at any humidity to that at absolute dryness. Actually, the rigidity of dry wool fibres is about fifteen times greater than that of fibres saturated with water. It is important to note that the strength of wool fibres is much less dependent than the rigidity on the amount of water combined with the wool.

Chemical Properties.—Wool belongs to the class of chemical compounds known as the proteins, of which it is one of the most resistant to chemical and bacterial attack. The most destructive reagents for wool are the sulphides of sodium and calcium, used in unhairing skins, and the caustic alkalis. Wool is built up chiefly from the five elements—carbon, hydrogen, oxygen, nitrogen, and sulphur. Their relative proportions are slightly variable, and the

following empirical analysis, due to Hummel, must not be taken as valid for all wools :—

Element.							Percentage by Weight.
Carbon	-	-	-	-	-	-	49·25
Hydrogen	-	-	-	-	-	-	6·57
Oxygen	-	-	-	-	-	-	23·66
Nitrogen	-	-	-	-	-	-	15·86
Sulphur	-	-	-	-	-	-	3·66

The nitrogen content of a large number of wools has been studied by Barritt,[15] but the degree of variation was by no means great. The extreme values were 17·07 per cent. in the case of Monte Video wool and 15·85 per cent. for black alpaca. The sulphur content of wool has likewise been the subject of detailed investigation by Barritt, King, and Rimington. It has been shown that the percentage of sulphur in dry wool is distinctly variable,[16] being as high as 4·00 per cent. in the case of Cape merino wool and as low as 3·24 per cent. with kempy Blackface wool. The presence of medulla in a fibre was found to imply a reduction in the percentage of sulphur present, an observation which may be found to have great significance in regard to the origin of medulla. In addition, it was found that the tip of a staple usually contained a higher percentage of sulphur than the root.[17] Finally, Rimington[18] has shown that the whole of the sulphur present in wool can be accounted for as cystine.

LITERATURE

1. VEITCH and BENEDICT, *Trans. Amer. Inst. Chem. Engineers*, 1924, **16**, Pt. 2, 259.
2. *J. Text. Inst.*, 1926, **17**, T 264.
3. SHORTER, *J. Soc. Dyers and Colourists*, 1923, p. 270.
4. WINSON, *J. Text. Inst.*, 1920, **20**, T 219.
5. DUERDEN, *J. Text. Inst.*, 1929, **20**, T 93.
6. DUERDEN, *J. Text. Inst., Loc., cit.*, p. T 95.
7. BARKER AND NORRIS, *J Text. Inst.*, 1930, **21**, T 1.
8. LEFROY. quoted by Barker and Norris, *loc. cit.*, p. T 4.
9. SPEAKMAN, *J. Soc Chem. Ind.*, 1930, **49**, T 209.
10. SHORTER and HALL, *J. Text. Inst.*, 1924, **15**, T 305.
11. SCHLOESING, ' Report to the Société d'Encouragement pour l'Industrie Nationale," Paris, 1893.
12. SHORTER, *J. Text. Inst.*, 1924, **15**, T 207.
    SPEAKMAN *J. Text. Inst.*, 1927 **18**, T 431 ; *Proc. Roy. Soc.*, 1928, **130** B, 377 ; *Trans. Far. Soc.*, 1929, **25**, 160.
13. SHORTER, *J. Soc. Dyers and Colourists* 1923, p. 270.
14. SPEAKMAN, *Trans. Far. Soc.*, 1920, **25**, 2.
15. BARRITT *J. Soc. Chem. Ind.*, 1928, **47**, T 69.
16. BARRITT and KING, *J Text. Inst.*, 1926, **17**, T 386.
17. BARRITT and KING, *J. Text. Inst.*, 1929, **20**, T 151.
18. RIMINGTON, *Biochem. J.*, 1929, **23**, 726.

WEAVES FOR STANDARD CLOTHS IN THE WORSTED, WOOLLEN AND UNION TRADES

Owing to the great diversity of fabrics produced in the above sections of trade, it will be necessary to give a little explanation of the various factors which govern the use, in any particular case, of the weaves tabulated below.   In addition to the specific nature of the con struction of the weaves, it is essential that the cloth constructor must be familiar with :—1. The various raw materials most suitable for producing the type of fabrics required. 2. The structure of the yarns to be employed.   3. The build of the fabrics, and the effects obtained by judicious colour schemes.   4. The influences of finishing operations. 5. How the cost of the product is affected by the foregoing particulars. 6. How certain effects can be produced in fabrics in two alternative ways, *e.g.*, a repp or poplin, obtained either by the use of a repp weave, and woven with warp and weft yarns equal in thickness, or by using the plain weave and weaving with a fine yarn for warp and a coarse or thick yarn for weft.
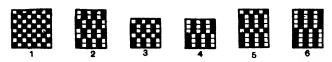
It is advisable to examine every weave in its particular application and its structural form, as by altering the relative stresses and strains, either by variation in count of warp and weft, or by variation and application of the processes in the finishing of the fabric, an entirely different appearance in the finished product can be obtained.

Many of the weaves given can be used in entirely different types of fabrics, and give results that are satisfactory in each case, *e.g.*, the 2/2 twill used (*a*) in a worsted Botany serge ; (*b*) for a Scotch tweed ; or (*c*) in a gabardine cloth, having a fine worsted Botany warp, and a cotton weft, the last fabric having a twill at a much higher angle than 45°, owing to the great excess of warp threads compared with the picks of weft.   On the examination of the threads and picks from a fabric of this type, it will be found that the threads of warps are wavy, *i.e.*, possess comparatively large curves, whilst the picks of weft are prac- tically straight and without curves.   Observations of this kind, and careful mental analysis of the weaves to be applied, will assist greatly to obtain the most satisfactory results by their use.

Cloths that deserve to be classed as standard ones are those where- in the raw material is the most suitable, spun into yarn on the system which gives the type of yarn required, with a setting compatible with the weave and yarn counts, in addition to meeting the needs and assist- ing in the processes of finishing, in all its similar operations.   Thus all weaves must be considered in the light of, and in conjunction with, the knowledge of preceding and succeeding operations and processes to those required in the actual manufacturing stage.

Plain Weave and its Modifications.—Weave No. 1 * is the plain or tabby weave used in all classes of trade.

Weaves, 2, 3, 4, 5, and 6 are warp ribs, or poplin weaves, or modifications of the plain weave made by lengthening the warp floats. The
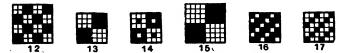
warp appears on the face of the fabric, whilst the weft is almost entirely hidden. This is due to the warp being compelled to do all the bending by the two or more picks of weft being in one shed, and lying therein perfectly straight.

Weaves 7, 8, 9, 10, and 11 are the weft cords, or modifications of the plain weave made by lengthening the weft floats. The conditions are the reverse to those already explained for warp ribs.

Weaves 12, 13, 14, and 15 are Hopsack, Celtic, or mat weaves, which are really modifications of the plain weave. Weave 14 is a firmer weave than weave 13, owing to the second and fifth threads and picks being perfectly plain in their interlacing.
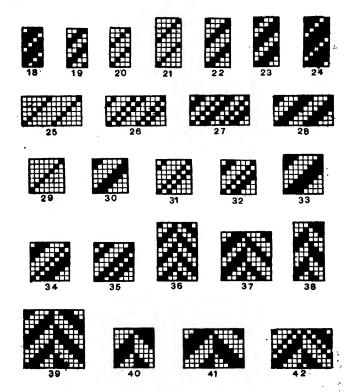
Ordinary Twills.—The application of these twills and types of interlacing are numerous, e.g., weaves 16 and 17 are used to obtain different angles of twills. The former, a warp-faced twill, is used in

certain kinds of gabardine and costume cloths to give a high angle; whilst the latter is used in the production of the well-known cashmere fabric, composed of cotton warp, and a fine Botany weft, with the picks much in excess of the threads. The angle of the twill in the fabric is a very low one. They are termed prunelle twills.

* In all the weaves, Nos. 1 to 171, filled-in squares represent warp ends raised over the weft.

Weaves 18 and 20 show the warp and swansdown or crow twills.

Weave 19 shows the Cassimere, Shalloon, or common 2/2 twill.

Weaves 21, 22, 23, and 24 show 5-end twills varying in length of floats.
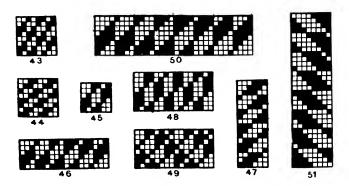
Weaves 25, 26, 27, and 28 are 6-end twills

Weaves 29, 30, 31, and 32 are 7-end twills.

Weave 33 is the common 4/4 twill.

Weaves 34 and 35 are 8-end double line twills, sometimes named 8-end diagonals.
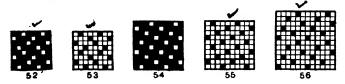
Weaves 36 to 42 are herring-bone, or feathered weaves, as they are occasionally termed.

Broken Twills.—These weaves, which are very useful, are obtained by grouping floats and making them cut (*i.e.*, warp floats of one group meet weft floats of the next group). The number of threads or picks in each group is determined by the character and size of effect required. Weaves 43 to 51 are typical examples.

Sateens.—Weaves 52 and 53 are the 4-end warp and weft sateens, or broken crow twill, or swansdown weave. In certain types of union goods (woollen wefts), weave 53 is preferred to weave 20, because of the breaking up of the twill, and the production of an irregular surface.

Weave 54 is the 5-end warp sateen, used in the manufacture of the best grades of doeskin cloths. It gives a fine twill at a high angle, and is also the base on which covert weaves are constructed.
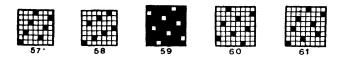
Weave 55 is the 5-end weft sateen, employed in the production of cotton warp and woollen weft goods, also in Italian linings.

Weave 56 is the 6-end sateen. It is a useful base for distributing figures or spots, and as a weave sometimes replaces weave 54 when any appearance or semblance of a twill is objectionable.

Weaves 57 and 58 are 7-end sateens.
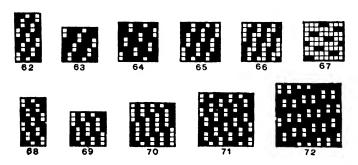
Weaves 59 and 60 are 8-end warp and weft sateens. Weave 59 serves as a base for constructing many other weaves upon, and is also used as a weave by itself in certain types of fine worsted cloths.

Weave 61 shows an irregular 8-end sateen, most useful for figure and spot distribution.

57·   58   59   60   61

Sateen Derivatives.—These are weaves constructed upon the sateen bases, and the floats of warp and weft are divided or broken up, to either obtain a weave of a different character, or to produce the same character on the face of the fabric, but giving a firmer or tighter woven structure.

Weaves 62 and 63 are 5-end and 7-end weaves similar in character, and both used for somewhat similar purposes, such as venetians, coverts, and whipcords, the difference obtained depending upon the

62   63   64   65   66   67

68   69   70   71   72

variation of yarns, both in quality, angle, and direction of twist, and also peculiarities of setting in relation to threads and picks per inch.

Weave 64 is the 8-end warp buckskin—a fine woollen fabric heavily milled in the finishing processes.

Weaves 65 and 66 are 8-end derivatives giving high-angled twills.

Weave 67 is the 8-end weft buckskin weave.

Weaves 68 to 72 are corkscrew weaves on 5, 7, 9, 11, and 13 threads and picks respectively. The three former ones are mostly used in
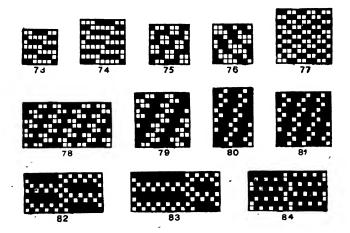
cloths made from fine worsted warps and woven with angola weft (*i.e.*, wool and cotton mixture), whilst the two latter are applied in the fine qualities of worsted in both warp and weft.   Weave 72 is the standard corkscrew weave for the finer qualities.   It has a warp ribbed surface, the ribs being at a low angle.

Weaves 73 and 74 are weft corkscrew weaves, and in this case the angle of the weave is usually a high one.

Weave 75 is a twilled hopsack, Celtic, or mat weave, and is known as the " Barathea."

Weave 76 is the " Mayo " or " Campbell " twill.

Weave 77 is a " Barathea " weave used in the dress trade, woven

73   74   75   76   77

78   79   80   81

82   83   84

with fine cotton warp and fine Botany weft, having about 64 threads of 2/80's cotton, and 140/210 picks of 70's worsted.

Weaves 78 and 79 are typical whipcord weaves, the latter being used in the production of officers' khaki.
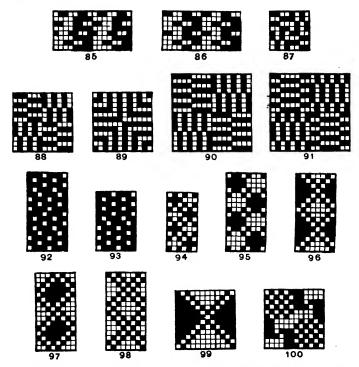
Weaves 80 and 81 are whipcords used more in the dress trade than in the coating trade.

Weaves 82, 83, and 84 are Bedford cord weaves.   These give a firm cord running in the direction of the warp, having a plain weave on the surface of the ridges, and at the back long weft floats.   It will be observed that at intervals two threads are weaving tightly and cutting ; these form the dent in the cloth, and should be cotton, whilst the shrinkage in width, assisted by the long floats of weft at the back, make the ridges

in the cloth. These weaves are useful for fabrics suitable for both ladies' and gentlemen's wear.

Weaves 85 and 86 are reversible weft corded weaves.

Weaves 87 to 91 are basket weaves, producing interlacing effects after the style of wicker work.
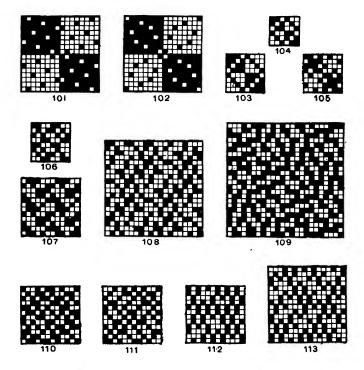
Weaves 92 and 93 are soliel weaves applied chiefly in the dress trade, giving a smooth warp face—obtaining lustre—and approximately a plain weave at the back, supplying the necessary firmness.

Weaves 94 and 95 are mock-gauze weaves. The characteristic of these weaves is that perforations are produced. They are used on dress goods.

Weaves 96 to 99 are honeycomb weaves. The name implies the nature of the effect in the woven fabrics.

Weave 100 is an example of the "Brighton" weave, giving a surface somewhat similar to a honeycomb, but plain weave appearance at the back almost all over.

Weaves (Various).—Weaves 101 to 105 are of the dice type, and the smaller ones are useful in the manufacture of dress goods.

101

102

104

103

105

106

107

108

109

110

111

112

113
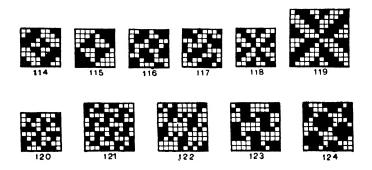
Weaves 106 to 111 are crêpe weaves giving an irregular surface on the fabric when woven. The first four are built up irregularly, and due regard paid to suitable length of float, but the last two are obtained by superimposing one sateen weave upon another within a space of threads and picks equal to the L.C.M. of the threads and picks of the component weaves.

Weaves 112 and 113 are crêpoline weaves for dress fabrics.

Weaves 114 to 117 are granite weaves. These are useful in the manufacture of fabrics for both ladies' and gentlemen's wear, especially in worsted cloth.
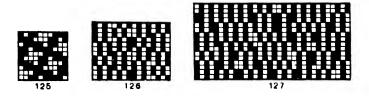
Weaves 118 and 119 are suitable for small cut checks.

Weaves 120 and 121 are pinhead weaves. Both give excellent results when woven with colours, the former warped and wefted 2 and 2, and the latter 1 and 1.

114   115   116   117   118   119

120   121   122   123   124
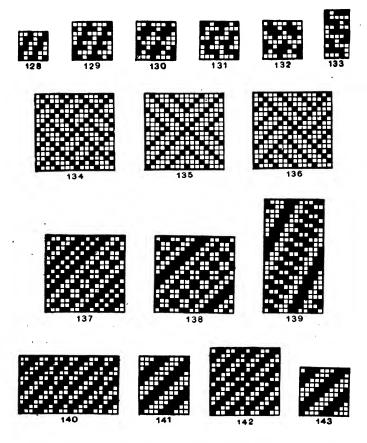
Weaves 122 to 125 are sponge weaves, and are based on the five-end sateen base enlarged. They are useful for cream serges for autumn wear, as well as for lighter weight fabrics.

Weaves 126 and 127 are armure weaves which are strictly for dress goods.

125   126   127

Weaves for Union Cloths.—Weaves 128 to 133 are typical ones for the production of union cloths, wherein cotton warps are interwoven with woollen wefts. The variety of fabrics in which they are applied is wide, and includes costume cloths, overcoatings, blanket cloths, and plain or fancy dressing gown cloths.

Weaves 134, 135, and 136 are typical weaves for union lustre fabrics, made with cotton warp and wefts of a lustrous character, *e.g.*, Lincoln, Leicester, wool yarns, or mohair.

128   129   130   131   132   133

134   135   136

137   138   139

140   141   142   143

Diagonals.—Weaves 137 and 138 are compound twills. Weave 139 is a combination twill, pick and pick alternately of 2/2 and 3/3 twill.
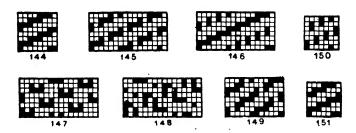
Cut Stripes and Checks.—Weaves 140 and 141 show cut stripe weaves for single cloths. Weaves 142 and 143 show cut check weaves for single cloths.

Backed, Imitation Backed, and Multi-Ply Weaves. Warp Backed Weaves

Weave 144 is a 2/2 twill face with 1/3 twill warp back.

Weave 145 is a 2/2 twill face with 8-end sateen warp back.
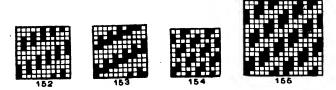
Weave 146 is a 2/2 twill face with 1/7 twill warp back. This is liable to produce unequal twills on the face, and its use is inadvisable.

144

145

146

150

147

148

149

151

Weave 147 is a twilled hopsack face and 8-end sateen warp back.

Weave 148 is a Mayo or Campbell twill face weave and 8-end sateen warp back. Proportions of face and back warp for weaves 144 to 148 are 1 : 1.
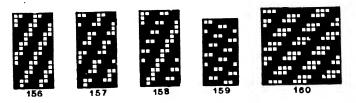
Weave 149 is a 2/2 twill face and an imperfect sateen back. Proportions of face and back warp 2 : 1.

152

153

154

155

Weaves 150 and 151 are pseudo weaves giving 2/2 twill face with sateen warp back in former, and 1/2 twill warp back in the latter. Threads and picks are in the ratio of 2 : 1.

Weaves 152 and 153 are similar to weaves 150 and 151, but have 3/3 twill on the face.

Weaves 154 and 155 are pseudo weaves, 154 being a 2/2 twill face and sateen back, while 155 has a 3/3 twill face with a sateen back. The proportions of warp and weft are 3 : 2.

156   157   158   159   160
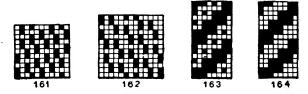
Weft Backed Weaves

Weave 156 is similar to 144, except that it is backed with weft instead of warp.

Weave 157 is similar to 145, except that it is backed with weft instead of warp.

Weave 158 is similar to 146, except that it is backed with weft instead of warp.

161   162   163   164

Weft Pseudo Weaves

Weave 159 is as 150, but weft face instead of warp.

Weave 160 is as 155, but weft face instead of warp.

Weave 161 is a warped pseudo backed twill.

Weave 152 is a warp pseudo backed weave producing hopsack face.

Double Cloth Weaves Used for Heavier Weights of Goods and Special Types of Woollen and Worsted Fabrics
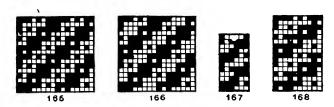
Weave 163 is the double 2/2 twill, with the backing warp bound to the face picks in twill order.

Weave 164 is like 163, but bound with both face and back warps to their opposite wefts.
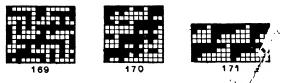
Weaves 165 and 166 are similar to weaves 163 and 164, but are on 16 threads and picks, and bound in sateen instead of twill order.

Weave 167 is a 2/2 twill face and plain back, and bound in plain order. It is a useful weave for firms doing check-back fabrics on looms having limited figuring or heald shaft capacity. Face and back both ways 2 and 1.

Weave 168 is the same as weaves 163 and 164, but bound by two special threads in one repeat to both face and back cloths. The third and eighth threads are acting as binder threads.

165   166   167   168
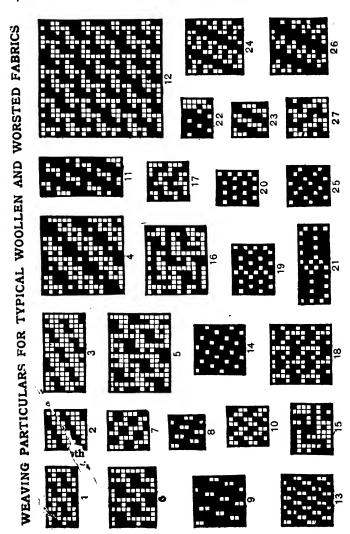
Weave 169 is a 2/2 twill face and back, bound as 168, but proportions of face warp and weft, and back warp and weft are 2 and 1. These two weaves are extremely useful when producing fabrics, having contrasting colours on both sides, that are needed to be milled in the finishing. In such cases the ordinary method of binding is very inadequate, to prevent the fibres on the one side of the fabric bursting through on to the opposite side, especially when woollen yarns are being used in their production.

169   170   171

Weave 170 is a treble weave 3/2 twill throughout, the face and back warp threads bind the top and bottom cloths to the middle one, in twill form.

Weave 171 is a quadruple weave, being plain weave throughout, and bound together similar to weave 170. Both these weaves are employed in the manufacture in special kinds of woollen fabrics, used as roller or press cloths.

23

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Botany Worsted Trouserings

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave. (See p. 257.)
2/48's worsted	64's	72	In. 33	2/48's worsted	64's	72	Clear	6¼	2/2
,, ,,	,,	120	34	,, ,,	,,	60	,,	8	1
,, ,,	,,	120	,,	,, ,,	,,	60	,,	8	2
,, ,,	,,	132	,,	,, ,,	,,	66	,,	8¾	3
,, ,,	,,	128	33	,, ,,	,,	124	,,	11¼	4
2/36's	,,	64	34	2/36's	,,	61	,,	7¼	2/2
,, ,,	,,	104	,,	,, ,,	,,	52	,,	9¼	1
,, ,,	,,	104	,,	,, ,,	,,	52	,,	9¼	2
,, ,,	,,	114	,,	,, ,,	,,	57	,,	10	3
2/28's	,,	112	33	2/28's	,,	106	,,	8	4
,, ,,	,,	56	,,	,, ,,	,,	54	,,	9¼	2/2
2/24's	,,	64	,,	,, ,,	,,	64	,,	9¾	3/3
,, ,,	,,	52	,,	,, ,,	,,	50	,,	9¾	2/2
,, ,,	,,	60	,,	,, ,,	,,	59	,,	10¼	3/3
2/48's worsted, 1 { 12 yds. 1 { 13 ,,	,,	128	,,	2/48's worsted, 2 13 skeins, 1	,,	84	,,	12½	5
,, ,, 1 { 12 ,, 1 { 13 ,,	,,	120	,, 35	2/48's worsted, 2 13 skeins, 1 2/48's worsted	,,	78	,,	11¾	6
2/36's	,,	84	,,	2/36's ,,	,,	34	,,	7¾	17
2/28's	,,	72	,,	2/28's ,,	,,	73	,,	8¾	,,
		64			,,	64	,,	10	,,

Botany Worsted Coatings

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave. (See p. 257.)
2/48's worsted	64's	68	70	2/48's worsted	64's	69	Clear	12/13	2/2
2/36's	,,	60	,,	2/36's ,,	,,	59	,,	14/15	,,
2/28's	,,	52	,,	2/28's ,,	,,	51	,,	16/17	,,

N.B.—Skeins = yds. pe. dram.

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Botany Worsted Coatings—continued

Warp	Quality	Ends per Inch	Width in Reed	Weft	Quality	Picks per Inch	Finish	Ounces per Yard Finished	Weave
2/24's worsted	64's	50	In. 70	2/24's worsted	64's	50	Clear	18/19	2/2
2/18's	"	42	"	2/18's	"	43	"	20/21	"
2/14's	"	36	" 74	2/14's	"	36	Semi-milled	22/23	"
2/48's	"	78	"	2/48's	"	80	"	15/16	3/3
2/36's	"	68	"	2/36's	"	70	"	18	"
2/28's	"	80	"	2/28's	"	62	"	20/21	"
2/24's	"	56	"	2/24's	"	56	"	22	"
2/18's	"	48	"	2/18's	"	49	"	25	4
2/70's	70's	144	"	2/70's	70's	136	"	19/20	4
2/60's	"	128	"	2/60's	"	132	"	21	4
2/48's	"	116	"	2/48's	"	117	"	23/4	4
2/40's	"	108	"	2/40's	"	104	"	25/6	4

Worsted Suitings

Warp	Quality	Ends per Inch	Width in Reed	Weft	Quality	Picks per Inch	Finish	Ounces per Yard Finished	Weave
2/48's worsted	64's	68	68	2/48's worsted	64's	68	Clear	12	2/2
2/36's	"	60	"	2/36's	"	60	"	14	"
2/28's	"	56	"	2/28's	"	53	"	16/17	"
2/24's	"	50	"	2/24's	"	48	"	17/17½	"
2/18's	"	42	"	2/18's	"	42	"	19/20	3/3
2/28's	"	80	"	2/28's	"	62	"	18/19	"
2/24's	"	56	"	2/24's	"	56	"	20	

Crossbred Suitings

Warp	Quality	Ends per Inch	Width in Reed	Weft	Quality	Picks per Inch	Finish	Ounces per Yard Finished	Weave
2/40's worsted	56's	60	66	2/40's worsted	64's	58	Semi-milled	12	2/2
2/30's	"	52	"	2/30's	"	50	"	14	"
2/24's	"	46	"	2/24's	"	46	"	16	"

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Crossbred Suitings—*continued*

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
2/18's worsted	56's	40	In. 66	2/18's worsted	64's	38	Semi-milled	18	2/2
2/15's ,,	,,	36	,,	2/15's ,,	,,	37	,,	20	,,
2/40's ,,	,,	56	,,	2/30's ,,	,,	54	,,	13	,,
2/80s ,,	,,	48	,,	2/24's ,,	,,	48	,,	15	,,
2/24's ,,	,,	42	,,	2/18's ,,	,,	43	,,	17	,,
2/18's ,,	,,	38	,,	2/15's ,,	,,	38	,,	19	,,

Dress Suitings

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
2/70's worsted	80's	96	72	2/70's worsted	80's	96	Semi-milled	12/13	3/3
2/64's ,,	,,	90	72	2/64's ,,	,,	92	,,	14	7
2/64's ,,	,,	126	69	1/36's ,,	64's	94	Clear	14½	8
2/52's ,,	,,	91	73	2/52's ,,	,,	86	,,	15¼	8
2/40's ,,	70's	60	78	1/22's ,,	70's	78	Semi-milled	16	7
2/36's ,,	,,	56	76	1/32's ,,	,,	60	,,	16/17	2/2
2/70's ,,	80's	165	67½	1/32's ,,	64's	100	Clear	17/18	9
2/48's ,,	70's	68	72	1/24's ,,	70's	68	Semi-milled	13/14	2/2
2/52's ,,	,,	78	71½	40 skeins (yds. per dram)	,,	64	,,	,,	,,

Low Vicunas

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
18 skeins, cross-band twist	Waste	36	72	18 skeins, open-band tw.	Waste	36	Milled	17	⅓
14 ,, ,,	,,	30	72	14 ,, ,,	,,	30	,,	18	10
12 ,, ,,	,,	30	70¾	12 ,, ,,	,,	30	,,	20	10

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Good Vicunas

Warp	Quality	Ends per Inch	Width in Reed	Weft	Quality	Picks per Inch	Finish	Ounces per Yard Finished	Weave
2/36's worsted	64's	50	In. 80	37 skeins (yds. per dram)	64's	60	Milled	15/16	2/2
32 skeins	"	64	74	32 "		48	"	16	"
2/48's worsted	"	64	86	37 "	70's	60	"	17	11
" " "	"	72	82	46 "	"	105	"	18	
" " "	"	68	85	45 "	64's	115	"	22	12
2/48's worsted, 2 (12 yds.) 1 (13 ")	"	96	72	1/20's worsted, 2 / 20 skeins, 1	60's	96	Semi-milled	22/3	

Saxony Suitings

Warp	Quality	Ends per Inch	Width in Reed	Weft	Quality	Picks per Inch	Finish	Ounces per Yard Finished	Weave
33 skeins (yds. per dram)	64's	52	72	33 skeins (yds. per dram)	64's	52	Slight cover	14	2/2
25 "	"	44	"	25 "	"	44	"	16	"
20 "	"	40	"	20 "	"	40	"	18	"
16 "	"	36	"	16 "	"	36	"	20	"
13 "	"	32	"	13 "	"	32	"	22	"
33 "	"	50	"	25 "	"	46	"	15	"
25 "	"	44	"	20 "	"	40	"	17	"
20 "	"	40	"	16 "	"	37	"	19	"
16 "	"	36	"	13 "	"	33	"	21¼	"

Saxony Woollen Coatings

Warp	Quality	Ends per Inch	Width in Reed	Weft	Quality	Picks per Inch	Finish	Ounces per Yard Finished	Weave
25 skeins (yds. per dram)	64's	44	76	25 skeins (yds. per dram)	64's	44	Semi-milled	17	2/2
20 "	"	40	"	20 "	"	40	"	19	"
16 "	"	36	"	16 "	"	36	"	21	"
13 "	"	32	"	13 "	"	32	"	23¼	"

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Saxony Woollen Coatings—continued

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
25 skeins (yds. per dram)	64's	44	In. 76	20 skeins (yds. per dram)	64's	40	Semi-milled	18	2/2
20 " "	"	40	76	16 " "	"	37	"	20	"
16 " "	"	36	76	13 " "	"	33	"	22½	"
2/40's cotton	"	34	70	7 skeins, open-band tw.	Waste	30	"	19	1/2
23 skeins/30's cotton	Waste	38	68	23 skeins/30's cotton		38	"	16/16½	2/2
18 " "	"	40	72	24 skeins Angola	Waste and Cotton	50	"	21	"

Cheviot Suitings

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
20 skeins (yds. per dram)	Cheviot	40	69	20 skeins (yds. per dram)	Cheviot	40	Semi-milled	16	2/2
17 " "	"	36	"	17 "	"	35	"	18	"
13 "	"	30	"	13 "	"	30	"	20	"
11 "	"	28	"	11 "	"	28	"	17	"
20 "	"	36	"	17 "	"	37	"	19	"
17 "	"	32	"	13 "	"	33	"	21	"
13 "	"	30	"	11 "	"	28	"	16	"
13 "	"	16	"	10 "	"	19	"	21	1/1
10 "	"	24	67	10 "	"	23	"	17	2/2
10 "	"	20	67	10 "	"	20	"	18/19	10
10 "	"	20	68	16 "	"	30	"	17/18	2/2
2/22's skeins	"	28	69	22 "	"	38	"	15	1/1
2/30's "	"	38	66	10 "	"	22	"		
16 "	"	20	70						

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Flannel Suitings

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
33 skeins (yds. per dram)	64's	45	In. 74	33 skeins (yds. per dram)	64's	45	Semi-milled	12/13	2/1
25 ,,	,,	40	,,	25 ,,	,,	41	,,	14/15	,,
20 ,,	,,	36	,,	20 ,,	,,	35	,,	16/17	2/2
33 ,,	,,	48	,,	33 ,,	,,	50	,,	14	,,
25 ,,	,,	44	,,	25 ,,	,,	43	,,	16	,,
20 ,,	,,	40	,,	20 ,,	,,	37	,,	18	,,
33 ,,	,,	44	,,	25 ,,	,,	43	,,	13/14	2/1
25 ,,	,,	36	,,	20 ,,	,,	37	,,	16/17	2/2
33 ,,	,,	48	,,	25 ,,	,,	47	,,	14/15	,,
25 ,,	,,	40	,,	30 ,,	,,	40	,,	16/17	,,
2/32's ,,	Waste and Cotton	52	71	30 ,,	,,	51	,,	13	,,
17 skeins Angola	Waste and Cotton	48	66	1/24's cotton	,,	54	Milled	14	,,

Coverts, etc.

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard. Finished.	Weave.
45/60 skeins (yds. per dram)	70's	60	72	35 skeins (yds. per dram)	64's	64	Raised	19/20	13
45 skeins/70's worsted	,,	70	70	35 ,,	,,	56	,,	17/18	,,
33 skeins	64's	70	72	33 ,,	,,	54	Clear		,,
2/44's worsted	,,	105	65	2/44's worsted	Waste and Cotton	60	,,	16	14
28 skeins/48's worsted	60's	55	69	22 skeins Angola	Waste and Cotton	40	Raised	20	,,
28 skeins/40's cotton	,,	55	69	20 ,,		38	,,		,,
2/48's worsted	,,	65	67	12 ,,		37	Clear	18/19	2/2
2/52's ,,	70's	120	63	2/70's cotton	,,	61	,,	12¼	,,
2/60's ,,	,,	168	63	,,	,,	56	,,	13/14	,,

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Coverts, etc.—continued

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard Finished.	Weave.
			In.						
2/48's worsted	64's	88	68	1 24's worsted	64's	50	Clear	12¼	3/1
,, ,,	60's	91	62	2/40's cotton	,,	62	,,	12	23
,, ,,	,,	72	66	20 skeins Angola	Waste and Cotton	42	Semi-milled	15	2/1
35 skeins (yds. per dram)	,,	45	72	35 ,,	60's	45	Clear	11/12	,,
2/32's worsted	64's	90	66	2/32's worsted	64's	50	,,	17	24
2/48's ,,	,,	102	72	2/48's ,,	,,	100	,,	19	26
Overcoatings									
7½ skeins (yds. per dram)	Cheviot	18	66	6½ skeins (yds. per dram)	Cheviot	16	Fleece	19/20	2/2
2/18 ,,	,,	24	88	2/18 ,,	,,	24	Semi-milled	22/3	,,
14 ,,	,,	46	71	14 ,,	,,	38	Fleece	25	4
8 ,,	,,	24	69	8 ,,	,,	24	,,	25/6	2/2
Reversible Cloths									
14 skeins (yds. per dram), 4 / 2/40's cotton, 1	..	11/5	70	14 skeins (yds. per dram)	..	42	Velvet	27/8	15
16 skeins Cheviot, 2 / 2/48's worsted, 4 / 2/40's cotton, 1	..	98	66	16 skeins Cheviot, 1 / 2/48's worsted, 2	..	80	Semi-milled	24/5	16
20 skeins Saxony, 2 / 2/48's worsted, 4 / 2/4's cotton, 1	..	,,	68	20 skeins Saxony, 1 / 2/48's worsted, 2	..	,,	,,	22/3	,,
2/36's worsted, 4 / 20 skeins Saxony, 2 / 2/40's cotton, 1	..	,,	,,	2/36's worsted, 2 / 20 skeins Saxony, 1	..	,,	,,	26/7	,,

WEAVING PARTICULARS FOR TYPICAL WOOLLEN AND WORSTED FABRICS

Melton Cloth

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard Finished.	Weave.
16 skeins, cross-band twist -	..	46	In. 80	20 skeins, open-band twist	..	54	Milled	33	17
34 ,, ,,		46	80	30 ,, ,,		64	,,	30	25

Beaver Cloth

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard Finished.	Weave.
32 sks., cross-band tw.,2 {100 / 1 {118}	..	42	100	{32 skeins, open-band tw.,2 / 115 ,, ,, 1}	..	75	Dressed	30	18

Saxony Overcoatings

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard Finished.	Weave.
8 skeins (yds. per dram) -	Saxony	24	76	8 skeins (yds. per dram)		23	Milled	24	2/2
14 ,, -	,,	42	74	12 ,,		34	,,	26	4
10 ,, -	,,	27	78	10 ,,		26	,,	25	2/2
9 ,, -	,,	32	74	9 ,,		27	,,	28	3/3

Naps

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard Finished.	Weave.
8 skeins (yds. per dram) -	,,	28	68	8 skeins (yds. per dram)		28	Napped	28	10
2/28's cotton -	,,	30	74	6 ,,		50	,,	37	27

Cords

Warp.	Quality.	Ends per Inch.	Width in Reed.	Weft.	Quality.	Picks per Inch.	Finish.	Ounces per Yard Finished.	Weave.
26 skeins woollen, 4 - / 2/28's worsted, 1 -		57/8	78	26 skeins woollen		50	..	30	19
22 skeins woollen, 6 - / 2/30's cotton, 1 -		66/7	76	22 ,, ,,		52	..	24	20
22 skeins woollen, 6 - / 2/24's cotton, 11 -		72	78	22 ,,		62	..	23¾	21
2/36's skeins woollen -		52	74	9 ,,		36	..	32	22

RAYON

It is usual to classify the present artificial silks under the four headings : Viscose, Nitro-cellulose, Cuprammonium, and Acetate. It should be understood, however, that there are other types of lesser importance not included under any of the above headings. In addition there are wide variations in the methods of producing the above types and in the properties possessed by different brands of the yarns produced.

Viscose.—At present viscose is manufactured on the largest scale covering at least 80 per cent. of the world production. Bleached sulphite wood pulp is the usual basis of manufacture, but cotton linters are also used. The material is steeped in a 17 or 18 per cent. caustic soda solution, pressed, kneaded, or shredded into " crumbs," and matured. The next process is that of churning in which the crumbs are treated with carbon bisulphide. Cellulose xanthate is formed, which is mixed with a 3 to 4 per cent. yellow solution of caustic soda to produce viscose. The viscose is allowed to ripen for four or five days, during which it is filtered. Any air in the viscose is abstracted by vacuum, and the material is then ready for spinning. In the spinning machine the viscose is ejected by pumps through the spinnerets or jets into a spinning bath of various composition, but usually containing sulphuric acid, sodium sulphate, and glucose. The bath coagulates the filaments which are wound in this country usually in a centrifugal spinning pot which inserts twist and builds up a cake. On the Continent the threads are often wound untwisted on to bobbins. In the first case the cakes are reeled into hanks, in which form they are successively washed, stretched, and stoved, desulphurised by treatment with 1 per cent. sodium sulphide, washed, bleached (if required), scoured, washed, dried and conditioned, and sorted into grades. Viscose artificial silks are like cotton, chemically pure cellulose (modified and regenerated) having a greater attraction for moisture and dyestuffs.

In the past viscose silk has not been noted for the fineness of its filaments, but in the last two years yarns with as many as 75 filaments in 150 denier have been standard commercial products. " Lilienfeld " yarns now emerging from the experimental stage contain an even larger number of filaments. Viscose artificial silk can be made with any degree of lustre as required, and considerable progress has been made in increasing the wet and dry strengths.

Nitro-cellulose, Chardonnet, or Collodion.—Nitro-cellulose silk has not been produced in this country, perhaps owing to the price

or difficulties of using some of the raw materials. Abroad the pro-
duction is decreasing. It is capable of spinning to very fine counts,
a commercial size being as fine as 35 denier, but other types have
recently developed in this respect. In the manufacture purified
cotton waste or linters is nitrated by a mixture of nitric and sulphuric
acids to form pyroxylin, which is also used as guncotton. The
nitrated cellulose is washed, bleached and washed (if required),
pulped, dried, and dissolved in a mixture of alcohol and ether to
give collodion. This is filtered, deaerated, and spun. Coagulation
is effected by evaporation of the alcohol and ether in dry spinning,
or in a water or salt bath in wet spinning. Bobbin spinning is usual,
and the spools are taken to the twisting machines. The threads are
then reeled into hanks, denitrated by mixed solutions of calcium,
sodium, or ammonium hydrosulphites, etc., washed, soured, bleached,
soured, washed, soaped, and dried.

Cuprammonium.—The cellulose used is usually purified cotton
waste or linters. This is dissolved in copper-ammonia (Schweitzer's
reagent) or copper-hydroxide ammonia solution, prepared in various
ways. The solution is filtered and freed from air, and is spun into a
strong sulphuric acid or caustic soda bath. To remove the copper
the yarn is afterwards treated with acid. Bobbin spinning is usual,
and the thread is often or usually stretched in its passage from jet
to bobbin through the coagulating bath moving in a counter-direction
and of increasing strength.

The production of cuprammonium yarn is growing. The out-
standing characteristic of present cuprammonium yarns is that they
are usually of fine filament, even finer than 1 denier. The chemical
method and stretch spinning may lend themselves to this purpose.
The fine filaments result in certain desirable qualities of lustre,
cover, and soft handle. The elongation up to breaking-point of
cuprammonium silks is usually less than viscose or acetate silks,
and they have less real elasticity. The stretch is little greater when
wet than when dry.

Cellulose Acetate.—Unlike the other types of artificial silk
mentioned, acetate silk is a compound of cellulose, namely, cellulose
acetate or acetyl cellulose. Purified cotton waste or linters is heated
with a mixture of acetic acid and acetic anhydride and a catalytic
agent, usually sulphuric acid or zinc chloride. A cellulose acetate
is formed which is soluble in chloroform. This is mixed and heated
with a further quantity of acetic acid and water, precipitated by water,
washed, and dried, when it is a cellulose acetate soluble in acetone.
The solution in acetone is filtered, freed from air, and spun in wet
spinning into baths of oils, other hydrocarbons, or solutions of salts,

in some cases by stretch spinning methods. In dry spinning the thread is coagulated by the evaporation of the acetone. In wet spinning the threads are usually collected on bobbins, washed and dried, twisted, reeled, etc. In dry spinning the threads may be twisted at the spinning frame by cap spinning (similar to worsted frames) or centrifugal spinning.

Cellulose acetate has a lower specific gravity than other artificial silks. The acetate silks are also warmer than other silks, though they are not as warm as pure real silk, and are harsher according to the thickness of the filaments. The elasticity of cellulose acetate silks is usually much greater than that of the pure cellulose forms, and they also possess greater insulating power, but less capacity for taking up moisture. Those formed from secondary products are susceptible to damage by heat or hot water. The affinity for dyes is entirely different, and special ranges of dyestuffs are used.

Hollow Filament Artificial Silk.—The principal kind in use is " Celta." These are of viscose, but the yarn is spun with air or gas imprisoned within the walls of the filament. The viscose prior to spinning is emulsified with air or a certain amount of sodium carbonate or other chemicals. When fully inflated the tubes are rigid, and they are partially deflated in some cases by steeping in air-free water to give hollow filaments in ribbon form. The object of the hollow filaments is to give greater covering power and warmth, and lighter garments.

Twist or Turns per Inch.—General qualities of artificial silk of all types of manufacture contain from 2 to 2¼ turns per inch.

Filaments.—The filaments are the fine, hair-like strands that comprise the complete thread; the more filaments such threads contain the greater will be the covering power, the softer the handle, and the more delicate the lustre. The common size of filament is 4 to 6 denier, but yarns are produced with filaments as fine as 1 denier and finer on a commercial basis. The principal makers now supply the popular deniers in three or more different grades of filament. The use of finer filament yarns is growing, and is likely to increase still further.

Hanks.—Artificial silk is reeled, not in a fixed standard length as is the case with most yarns, but is reeled so that the number of hanks per pound or per kilo is the same. This method varies with the maker, but in the case of English yarn, hanks are usually made up in bundles of 10 lb. weight with approximately 100 hanks to the bundle.

Grading.—All artificial silks are spun as first quality, but in the course of manufacturing some suffer in treatment more than others. The hanks are subsequently examined and sorted; those which are
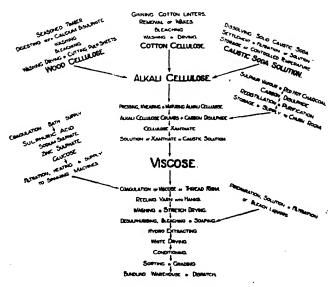
perfect are described as first quality; those with only a few broken filaments, other points such as lustre being equal, are classified as second quality, and so on. It does not follow that the first quality of one maker is equal to that of another; the manufacturers each set their own standard of quality.

Counts.—The method of counting artificial silk yarns usually adopted is the metric denier. The basis of this method is the weight in half-decigrams of 450 metres of yarn. For convenience it is usual to take the weight in grams of 9000 metres. (See p. 132.)

THE MANUFACTURE OF VISCOSE RAYON

Raw Materials.—The raw materials from which viscose rayon is produced comprise : Cellulose in the form of wood pulp or cotton linters; caustic soda; carbon disulphide; water.

Wood Pulp.—The source of the greater proportion of the cellulose, which forms the essential raw material for viscose rayon, is wood

FLOW SHEET OF VISCOSE PROCESSES.

pulp. Supplies of this material are available in ample quantity, as the manufacture of wood pulp for paper, as well as for rayon, is a highly organised industry. Wood pulp intended for viscose rayon should conform to the following requirements :—

1. A high degree of uniformity in the pulp, both as regards regularity throughout any one batch, and also between different batches, in order that the final yarn produced may possess identical physical properties, and especially even dye affinity, over extended periods.

2. The ash content must be as low as possible and must not exceed 0·3 per cent.

3. The sheets of pulp must be of a size suitable for the cellulose presses in which they are to be steeped in caustic soda.

4. Uniform moisture content over any one batch and over different batches.

5. The swelling factor of the pulp, when immersed in caustic soda solution, must be uniform throughout individual batches and also from batch to batch.

6. Continuous supplies should be available, free from interruption, in order that the charges of pulp in the rayon mill may be free from variation rendered necessary by intermittent supplies.

The manufacture of wood pulp from evenly grown timber of twenty to thirty years' growth comprises the following processes :—

1. Seasoning the logs.

2. Cutting the logs to suitable lengths, the removal of bark and thorough cleansing.

3. Chopping and subsequently chipping the wood.

4. Feeding the chips to digesters, where the wood is boiled by steam under a pressure of 80 to 90 lbs. per sq. in. in contact with calcium bisulphite.

5. Thorough screening and washing of the pulp after this leaves the digesters.

6. Bleaching.

7. Final washing of the pulp.

8. Feeding the pulp on to travelling wire mesh conveyer, the removal of water by suction, and the final drying of the pulp by heated rollers.

9. Cutting the pulp sheets to requisite size of about 24 × 36 in., and the final baling of the pulp ready for dispatch.

Cotton Linters.—An alternative raw material for viscose rayon consists of cotton in the form of cotton linters sheets. These linters consist of the short fibres adhering to the seed after the first ginning operation. They are removed by a second ginning, which is often given in the seed oil mills. The fibre so obtained is thoroughly cleaned and then boiled for about three hours in dilute caustic soda

of about 5 per cent. strength. After washing free from alkali, the linters are bleached and finally washed, dried, and made up into sheets similar to those of wood pulp.

The cost of cotton linters is about three times that of wood pulp, the comparative costs being 2d. per lb. for wood and 6d. per lb. for cotton pulp. This fact materially restricts the use of cotton, especially as the cellulose of a well-prepared wood pulp is not degraded sufficiently to seriously affect the final yarn made by the viscose process. Cotton pulp is restricted to special requirements, therefore, and to a relatively small proportion of the total cellulose charge for viscose rayon. For acetate and cuprammonium rayon it is, however, very much more extensively used, as these processes require minimum degradation of the cellulose.

The aim of the viscose process is to bring cellulose into the form of a solution from which cellulose of similar composition to the original raw material may be reprecipitated. It is, however, reformed as a continuous thread which can be utilised for textile purposes. The essential object of the viscose process of rayon production is, there-fore, the conversion of a physical form of cellulose, and not an alteration in chemical composition.

Formation of Alkali Cellulose.—The first stage in the reduction of cellulose to a solution consists in the formation of a compound of caustic soda and cellulose known as alkali cellulose. This is achieved by immersing the wood pulp sheets, after these have been conditioned, in caustic soda solution at a strength of about 17·5 per cent. in the tank of a horizontal cellulose press.

Pressing.—The pulp remains immersed for about two hours, after which a portion of the solution is pressed out by means of the ram, and this, together with the liquor used for immersion, is run off, and after strengthening is re-used. After running off the caustic soda, the head of the hydraulic press is sent forward a further stage with the object of expressing a further quantity of caustic soda, but allowing a definite weight equivalent to double the original weight of the pulp to remain in the pulp.

Kneading.—The pulp sheets containing this caustic soda, part of which is in combination, are then disintegrated in powerful kneading machines, which are designed to give a tearing action, so that the pulp fibres may be separated rather than crushed. The machine generally used utilises powerful beater arms, which exert the tearing action against a serrated drag plate at the bottom of the kneader trough. The kneader is jacketed for the circulation of water or brine, in order that the temperature of the charge may be controlled, a rise usually taking place from 18° to 27° C. After two hours the

charge has been reduced to the form commonly known as " crumbs," which adequately describes their appearance.

Maturing.—In this form they are charged into steel maturing tins which hold about 30 kilos of alkali cellulose. The maturing tins are then held under exact temperature control for between two and three days in the maturing room. During this period the reaction between soda and cellulose, which results in the formation of alkali cellulose, continues. The extent to which the process of maturing is carried controls the viscosity of the viscose solution finally produced, and consequently the maturing conditions are varied with this object.

Churning.—The next operation consists in treating the alkali cellulose crumbs with carbon disulphide, with the formation of a compound, cellulose xanthate. The reaction is carried out in churns, the bodies of which are built of steel free from all internal projections and completely gas-tight. The churn bodies are provided with gearing, so that they may be slowly revolved at a speed of one revolution in about two minutes. After charging the crumbs and closing the churn door, carbon disulphide in liquid form is introduced from a measuring vessel into a spray pipe running axially the length of the churn. The liquid is gasified, and combines with the alkali cellulose, forming cellulose xanthate.

The progress of the reaction, which takes about two and a half hours, is accompanied by a reduction in bulk of the crumbs, the evolution of heat, and a change in colour of the charge from white, through yellow, to orange. The latter change in colour gives some indication of the stage of the charge, but is seldom used for control in works practice, a time factor based upon experience being generally employed. The churns must be most carefully controlled as regards temperature, which may be accomplished by local control of each churn by means of a water jacket. Alternatively the churns may be wood lagged, and the temperature of the room exactly controlled. Adequate ventilation for the removal of churn gases is essential to the health of the operatives.

Solution of Xanthate to Form Viscose.—The contents of the churn is discharged by gravity into a viscose dissolver, where the xanthate is dissolved in dilute caustic soda solution. The dissolvers are equipped with powerful stirrers, which depend for their efficiency upon the creation of liquid friction. After solution, which is complete in about two and a half hours, the batches of viscose may be mixed in blenders of similar design but larger capacity than the viscose dissolvers. After blending from three to six batches these are passed forward to the ripening room.

Ripening and Filtration of Viscose.—The ripening of viscose

24

is similar to the maturing of alkali cellulose, in that it depends upon holding the viscose for a period of about four days under exact temperature control in order to allow chemical action to continue. During this period the viscose is filtered to remove all solid impurities, and undissolved or semi-dissolved xanthate. Recent developments have used centrifuging instead of, or in conjunction with, filtration for this purpose. At the end of the ripening period the viscose is held under vacuum for eighteen hours in order to remove all air.

Spinning the Viscose.—After ripening, the viscose is fed to the spinning-room under a compressed air pressure of about 50 lbs. per sq. in., and distributed to the spinning machines. The viscose is carried forward by measuring pumps, one of which is provided for at each spindle. By these pumps, which may be of the gear or multi-plunger type, the viscose is forced through a filter known as a candle filter. After passing through this final filter the viscose reaches the spinning jet, which may be of platinum or porcelain, and which is provided with a number of small apertures of about 0·1 mm. in diameter. This jet is immersed in a coagulation bath of sulphuric acid and metallic salts in solution, which reacts with the viscose regenerating cellulose. A separate filament is formed for each of the holes in the jet. The number of these varies over a wide range and in accordance with the denier of the yarn. Between twenty-four and thirty-six holes per jet is, however, typical for 150 denier yarn. The thread which is formed at the jet is drawn through the coagulation bath and carried through the air in order to allow a further period for coagulation.

The thread must now be collected by one of two general methods : (a) bobbin spinning, (b) centrifugal spinning. The first depends upon the collection of the thread direct upon a bobbin. In this case no twist is imparted to the thread, which must then be given by a separate operation at a later stage. The centrifugal is most generally employed in this country, and depends upon the collection of the thread in a revolving spinning pot round the inside of which the yarn is wound.

After leaving the bath the thread passes over a glass roller known as a godet roller, and is then fed through a glass funnel into the spinning pot. The godet roller is driven at a peripheral speed, which delivers the yarn at 50 metres per minute, while the spinning pot revolves at about 6,000 revs. per min. In this way a twist of about two and a half turns per inch is imparted to the yarn, which is sufficient for most commercial purposes. A separate twisting operation is therefore obviated.

Spinning Pot Drive.—The drive to the spinning pots is almost

invariably by means of individual electric spindles, which are usually run at a speed of 6,000 revs. per min. as stated. Recently considerable attention has been directed to the production of higher speed spindles, and to the natural corollary of higher productions of yarn and larger spinning pots.

It is possible to run electric spindles at considerably higher speeds up to 10,000 revs. per min. The power curve rises steeply at these speeds, however, and a further limiting of factor lies in the manufacture of spinning pots of sufficient strength to resist the bursting stresses. At the present time the practical limit of speed may be taken at 8,000 revs. per min.

Supply of Coagulation Acid.—As the formation of a thread depends no less upon the acid than the viscose, the supply of this at correct strength, and temperature, is of great importance. The acid is fed by gravity from tanks at a higher level than the spinning-room. After leaving the spinning machines the acid is returned to the acid house by gravity. Here it is strengthened up, filtered, and pumped up to the feed tanks for temperature control and recirculation.

Reeling.—The whole of the processes up to and including spinning must be carried on for twenty-four hours per day and often for seven days a week. The reeling of the spun yarn into hanks, which is the next process, is only suited to girl labour, and can therefore only be continued for sixteen hours per day. The reeling room must therefore be so balanced as to deal with twenty-four hours' spinning in sixteen hours. The yarn produced during the night-shift is stored in damping chambers under warm, moisture - saturated conditions. Special reeling machines are employed which wind two hanks on each shift, the usual length of hank being 3,000 metres for 150 denier, with proportionate lengths for other deniers.

Washing.—The operation following reeling is the washing of the yarn free from the acid and acid salts remaining from the coagulation bath. The process depends upon traversing the yarn under water sprays. During the transit through the machine the skein rods carrying the yarn are slowly rotated in order to ensure even treatment.

Stretch Drying.—After washing the yarn is charged on to stretcher frames, where the yarn is held between two rods, one being placed in the top and one in the bottom of the hanks. The stretcher frames are then charged into chamber drying machines, in which the yarn is dried by an upward current of warm air. During drying the yarn naturally contracts; this tendency, being prevented by the stretcher rods, exerts considerable tension on the yarn. The tension so exerted is continued during drying, and materially assists in bringing out the full lustre of the yarn,

Combined Washing to Bleaching. — In some instances the yarn produced does not require the fullest lustre, and this may even be undesirable. Where this and other conditions permit, drying the yarn after washing is sometimes omitted entirely, and the yarn is passed direct from washing to bleaching. An obvious simplification then becomes possible by combining washing in the bleaching machine. A first zone is then added to the bleaching machine, where the yarn is washed before being passed to the normal zones of desulphiding and bleaching. This procedure considerably simplifies the plant required, and also reduces handling of the yarn and operation costs. The stress of present-day economic pressure is therefore causing considerable attention to be devoted to this divergence from normal processing.

Bleaching.—The yarn after spinning not only contains acid and acid salts but also sulphur precipitated on and in the thread. This sulphur must now be removed by solution, after which the yarn must be washed free from the sodium sulphide used for this purpose. The yarn must then be bleached, soured, and washed in order to remove any colouring matter. Finally, the yarn is usually soaped. These processes, together with a first wash, if stretch drying is omitted, are given on a single machine in which the yarn traverses through the appropriate zones in sequence without any intermediate handling.

. The natural lustre and colour of the yarn becomes apparent on the bleaching machine for the first time.

Cake Bleaching.—Considerable attention has been given recently to the treatment of yarn in the cake form in which it is spun. Patents have been taken out in this country, America, and Germany for this purpose, with the object of washing, desulphurising, bleaching, washing, and soaping without reeling the yarn into hanks. The yarn is spun in the usual manner by the centrifugal process, usually into spinning pots of special design, and in these pots the yarn is transferred to a distinct machine, where the pots are revolved while the various bleaching liquors are introduced in sequence. The importance of successful solution of the problem of processing in cake form is apparent, as further simplification of plant and process becomes possible.

Hydro-extraction.—Leaving the bleaching machine, the yarn is fully saturated with soap or water, which must be removed before the yarn is ready for sorting and packing. The greater part of the weight of liquor is removed by centrifuging the yarn in hydro-extractors. Before introduction into the cage of the extractors the yarn is wrapped in coarse linen cloths holding about 10 lb. of yarn. In this protective

wrapping the yarn is centrifuged for about five minutes under a pressure of about 500 to 600 gravities, which results in bringing down the weight of liquor from eight times the dry weight of yarn to an equal weight.

White Drying and Conditioning.—The yarn is now dried in drying rooms, where it is hung loosely on poles and slowly dried by the circulation of warm air. Drying machines are also used for the white drying of the yarn, in which case drying, cooling, and con· ditioning zones are employed. The conditioning of yarn at this stage is of primary importance, and as control is easier in rooms than in drying machines, the former are to be preferred for high-quality production.

Sorting, Grading, and Bundling.—After thorough conditioning to a moisture regain of 10 per cent., the yarn must be graded into the various market qualities under which it is sold. These are usually A, B, C, X, and Inferior. The grading does not depend upon the physical properties or strengths of the yarn, which should be constant throughout the product of any one factory. The various grades into which the yarn is sorted depends upon the freedom from defects in the yarn, arising from such causes as broken filaments or threads, viscose threads, bad colour, spotted yarn, and similar irregularities. All these defects are visible, and the yarn is sorted by visual examina· tion by skilled girl sorters, the uniformity of whose standards is ensured by systematic resorting. After being graded the hanks are " doled " or twisted together, and are then bundled by power presses into packages of 10 lb. weight of yarn. Finally, the bundles are passed to the warehouse for packing and dispatch from the factory.

THE INSTALLATION OF A VISCOSE RAYON FACTORY

Selection of Site.—The considerations which decide the suita· bility of a site for a viscose factory include the following :—

(*a*) *Labour.*—Two policies with regard to the supply of suitable male and female labour are possible, depending upon the attraction of trained operatives from existing factories, or upon the training of unskilled workers with a minimum nucleus staff of trained executives. The decision of the policy in this respect has a definite influence upon site selection, the first alternative having a limiting effect.

(*b*) *Water Supply.*—Water must be available in sufficient quantity for the considerable requirements of this industry, which total about 100 gals. per lb. of yarn produced. The water must also be of suit· able quality, free from impurities likely to be harmful to the yarn,
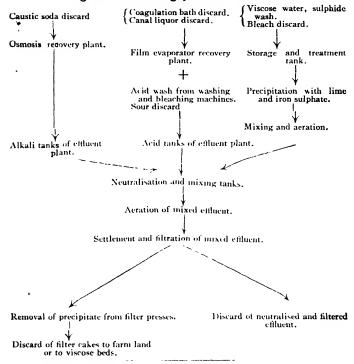
such as iron salts or peaty colouring matter, etc. The water must also be free from bacteria capable of multiplying in contact with cellulose. It must be soft, or else must be capable of being softened easily, preferably by means of a zeolite base exchange softening plant. Finally, the water must be cheap, as the quantity used may mean an appreciable cost per lb. of yarn.

In most cases it is desirable that the water supply should be drawn from natural sources, the rights to which form a part of the site facilities available.

(c) *Effluent and Waste*.—The disposal of effluent is of serious importance in deciding upon a site for a factory, as this may entail technical difficulties in operation and cost of upkeep. In all cases some effluent treatment is necessary, the elaboration of plant depending upon whether the final effluent is passed to (1) the sea or tidal waters ; (2) industrialised rivers where fish life is not existent ; or (3) fish bearing rivers, or the sewage works of local authorities. Generally speaking, selection should be confined to the first two conditions. In addition to liquid effluent, provision must be made for the disposal of waste viscose. Direct disposal into a disused coal mine or quarry provides the easiest solution of this problem. Failing this, viscose beds must be built with walls of clinker or boiler ash between which the viscose is allowed to coagulate.

(d) *Locality*.—In addition to liquid effluent the ventilation of a viscose factory entails the removal of fumes which must eventually be thrown into the atmosphere. This is usually accomplished through a fume stack, the height of which is decided by the lie of the surrounding country and the character of the neighbourhood. It is not usually desirable to erect a viscose factory in a closely populated district, especially if this is residential. There are, however, developments in the removal of hydrogen sulphide from liberated fumes.

(e) *Accessibility to Raw Materials and Markets*.—Considerable quantities of raw materials, some of which, such as sulphuric acid and carbon disulphide, present difficulties in handling, are used in process. Accessibility to the producing centres of raw materials is therefore desirable. As regards accessibility to markets, the transit cost on rayon does not in any case form a serious cost on the yarn. Low transport cost for the final product is not therefore as important as for raw materials. Accessibility to markets is chiefly of importance for technical reasons.

Buildings.—The production of viscose rayon is a highly specialised industry involving features of both chemical and textile manufacture. It is further desirable that the most advantage should be taken of gravity in facilitating the flow of process. It is unusual, therefore, for

Diagram Illustrating Effluent Treatment

Caustic soda discard

{ Coagulation bath discard.
{ Canal liquor discard.

{ Viscose water, sulphide
{   wash.
{ Bleach discard.

↓

Osmosis recovery plant.

Film evaporator recovery plant.

+

Storage and treatment tank.

↓

Acid wash from washing and bleaching machines.
Sour discard

Precipitation with lime and iron sulphate.

↓

Mixing and aeration.

↓

Alkali tanks of effluent plant.

Acid tanks of effluent plant.

Neutralisation and mixing tanks.

↓

Aeration of mixed effluent.

↓

Settlement and filtration of mixed effluent.

Removal of precipitate from filter presses.

Discard of neutralised and **filtered** effluent.

↓

Discard of filter cakes to farm land or to viscose beds.

Disposal of waste *viscose* in beds where coagulation and solidification is obtained.

existing buildings to be adaptable to the needs of this industry with-out sacrificing to a greater or lesser extent the efficiency of process. With the exception of certain of the finishing departments, where the processes are purely textile, the requirements of buildings include lofty rooms, and often special strengths of floors as well as the con-struction of these from materials resistant to acid or alkali, and with ample falls and gutters for the removal of swill and wash waters.

Preparation Section.—The preparation section, comprising the processes up to the production of viscose, may most suitably be built

with two storeys and a basement, giving three floors in all. Special bitumen - covered floors are desirable in the whole of this section, except for the pulp store, pulp conditioning room, and the maturing room, in all of which wood-block floors are suitable. Adequate strength and height is necessary for these rooms, and, as stated, special provision for removal of swill water is important. The ripening and maturing rooms are usually built underground in order to facilitate temperature control, and they must be carefully insulated on all walls and ceilings for the same reason. The spinning room is constructed with a Warren girder, north light roof of ample height to accommodate spinning machines and ventilation plant. Special floor construction with acid-resisting surface is necessary. Reeling rooms, sorting and grading, white drying, conditioning, and warehousing accommoda- tion may be similar to general textile practice. Washing, bleaching, stretch drying, and acid house all require special treatment, especially with respect to floors.

Ventilation, Humidity, and Temperature Control.—The problem of atmospheric control requires more careful and complete treatment than in any other textile manufacture. It is no exaggera- tion to state that for satisfactory results the atmosphere must be manufactured. The following are the main requirements to be met by the ventilation plant, which operates upon the principle of the introduction of conditioned air :—

Pulp conditioning room ·		Exact automatic relative humidity control.
Ripening room	- -	Exact automatic temperature control.
Maturing room	· ·	,. .. ,, ,,
Spinning room	- -	Relative humidity and temperature control, and adequate ventilation for fume removal.
Reeling room ·	- -	Exact automatic relative humidity control.
Sorting and grading room		,, ,, ,, ,,
Final drying or con- ditioning room	- -	.. ,, ,, ,,
Yarn store	- - -	.. ,, ,, ,,

The remaining buildings requirements include storage of carbon disulphide at least 60 ft. from the nearest buildings. Canteens for both male and female operatives are essential, and first-aid facilities must be provided. In addition, the usual auxiliary services of steam- raising plant, electric transformers and frequency converters, mechanics' and joiners' shop must be accommodated.

THE USE OF RAYON YARNS

The paramount importance of uniformity in the manufacture of rayon yarns generally, and of viscose yarns in particular, has received increasing attention in the producing factories during the last few years.

The necessity of careful conditioning of the yarn in the stages subsequent to white drying especially has been appreciated, with the result that the product leaves the factory after the most careful regulation of moisture regain. This care has been rendered necessary owing to the nature of the yarn, which is very susceptible to variations in humidity caused by the relative humidity of the atmosphere. In winding and subsequent processes it is important that similar care should be exercised.

Rayon yarns are more susceptible to variations in stretch, caused by alterations of humidity content, than either wool or cotton, and consequently greater uniformity of relative humidity in the atmosphere of the workrooms must be maintained.

It is becoming evident that a special technique, based upon the character of the rayon yarns, is requisite if the satisfactory results which are possible are to be achieved.

This is of greater importance, as defects caused by variations of stretch in turn resulting from inadequate humidity control, are often only seen at later stages, and often during dyeing. These processes are, in consequence, credited with faults which in reality have been caused at earlier stages.

Considerable improvements have recently been made in both the dry and wet strengths of rayon yarns, which have assisted in improving the results from these yarns. It should be pointed out, however, that the elastic limit of the yarn is of far greater importance in winding and weaving than either the dry or wet strength.

The elastic limit of the yarn is the maximum tension which the yarn will support without permanent elongation or stretch or alteration of lustre. All tensions during winding and processing must be well within the elastic limit of the yarn, otherwise bright picks, uneven dyeing, and other faults will result.

In addition to this, the performance of the yarn is directly affected by its humidity, and it is desirable therefore that the relative humidity during winding and weaving should be similar to that of the manufacturing factories. Only in this way, with similar conditions throughout the processes of manufacture of both yarn and cloth, can optimum results be obtained.

Winding.—The yarn is received in bundle form, and should be opened out in a room of suitable humidity condition, as described above. Complete drying of the hanks is favoured by some users, but over-dried yarn is brittle. In straightening the hanks prior to putting them on the swifts no shaking or pulling is permissible. The winder should first turn the hanks right side out, and put them on the swift in the same position as they were made up on the reel—that is, outside on the reel should be outside on the swift. Each hank should be spread out evenly as wide as the swift will allow, and all the swift bands should be equidistant from the swift-axis. Care should also be taken that the swifts are all weighted to the same tension : if one bobbin is wound tighter than the bulk, it is liable to show up in the woven piece as a bright end (or picks in the case of weft). It is necessary for the winder to be constantly on the alert to avoid this ; but still there must be sufficient tension on to make a hard bobbin, as slack bobbins soon get entangled, and owing to the smooth nature of the yarn slip very easily.

When a thread breaks during winding, a length of yarn on both the bobbin and swift sides is very liable to be stretched, so when piecing a broken thread it is best to take out the portion which is likely to be strained. Speaking generally, a yard from each side would have to be taken off to remedy the place. Weavers' knots should be tied, as clumsy knots and long ends left on invariably cause trouble to the weaver. The bobbin should be started gently, as a sudden jerk involves a risk of making a strained place. It is essential that all rubbing of the threads on stationary rails, thread guides, etc., be reduced to the minimum. Particular care should also be taken that any parts with which the yarn makes rubbing contact in passing from the swift to the bobbin are perfectly smooth, so as to reduce the risk of filaments being broken. The speed of winding may vary somewhat with the strength of the yarn, but in general should be regulated to obtain the maximum production possible with the minimum number of yarn breakages and the minimum risk of stretching the yarn. Warpers' bobbins should be small and light and of uniform weight.

Winding Weft.—In winding artificial silk into the form of pirns or cops for use as weft, it is equally necessary to keep the yarn perfectly dry and to exercise every care against straining the yarn. The winding can be done direct from the hank to the pirn, but generally it is preferable to do this in two operations, namely, to wind from the hanks on to bobbins and then from these bobbins to pirns or paper tubes. The double winding is a little more costly to carry out,

but it has compensating advantages. The natural springiness and the slippery nature of artificial silk yarn makes it particularly liable to slip or slough off in coils under the repeated shocks administered to the shuttle by the picker. This makes it necessary to h ive the tension during winding as near uniform as is mechanically possible. Owing to variations in the rotation of the swift, winding from hanks does not give the precise uniform tension required, and better results are obtained by winding from bobbins to pirns or cops. The best results are obtained with artificial silk weft when it is wound on to specially prepared tubes about $4\frac{1}{2}$ in. in length and $\frac{3}{8}$ in. in diameter, made from unpolished paper free from roughness, and with indented rings at intervals to restrict the yarn from slipping off. The winding should be very firm, and, if possible, knotless. If knots have to be made, they should be run to the outside of the slope. When knots occur at the base, or part of the way down the slope, they are a source of continual trouble, as the loosely twisted fibres of the yarn catch on the knot as the thread is drawn away, and either cause the thread to break or cause tight picks in the cloth. These tight picks show very distinctly in cloths woven with all artificial silk weft, and appear to be of a different count and lustre to the remaining portion, giving a frayed and uneven character to the cloth. Winders should therefore be instructed to grade the bobbins and pirns into knotless and other grades according to the number of knots which each contains. Those containing knots can then be used in inferior goods. When knots do occur in the yarn, the best thing the weaver can do when the weft breaks upon it, is to unravel the thread until the knot is drawn off.

The winding of artificial silk weft is preferably carried out on a machine specially designed for the purpose, of which there are several available. The spooling should never be attempted on any machine where the yarn makes harmful rubbing contact with metal, such as the pirn rotating in a cup, or the like.

Warping.—This is usually carried out on the horizontal circular warping mill on which the warp is built up in sections. The machine is usually also a beaming machine, the full warp being run from the mill or drum on to the weaver's beam. The beams may be without flanges, suitable papers being run in as the beam is built. Flanged beams are, however, being used to an increasing extent. These machines are much to be preferred to the upright circular warping mill owing to the saving of a process. After making a warp on the circular ball machine, it must be pulled from the mill and dressed on to a beam for sizing. This entails a large amount of work in sleying,

winding on the beam, etc., and generally does damage to the threads, as at this process the filaments are still free, and in the case of " dumb " yarn are void of turns which would keep them together; therefore, the fewer the operations, the better will be the yarn on reaching the weaving stage. To meet the requirements of sizing it is an advantage to have only a moderate number of ends per inch, as, if the ends are closer set, there is not sufficient room for them to open out after passing through the size-box, with the result that ends are broken and carried forward attached to another thread. The width of beams will be in accordance with the required width of the weaver's beam ; but it is safe to allow 4 in. or 5 in. extra, which will be reduced to the width of the weaver's beam in sizing. Any additional width beyond this causes friction between the reed and the yarn in sizing, which in all cases should be avoided. The bobbins in the creel should be changed only at the end of a " run." By adopting this rule a saving in material will be effected, not to mention a reduction of imperfect cloth, as the knots both in sizing and in weaving have a tendency to hold in the reed and healds, and if they do not actually break the thread, there is a risk of stretching. It is to be remembered that strained ends show up in the woven pieces much brighter, and cause a stripy appearance.

In all cases warps made from artificial silk, when they are to be woven alongside cotton or other warps in the same piece, should be kept on a separate beam. Mixing them, even if they are the same weave or have similar intersections, will lead to disaster. It is only by being able to alter the tension on the artificial silk that good cloth is produced. For instance, the weaver will stop the loom for a meal-time ; but, on restarting, it will be noticed that, owing to the strain of standing in a stretched position, the artificial silk has gradually released itself by stretching, and that the ends are hanging slack in the shed, whilst the cotton or other fibre has remained tight. It will therefore be necessary to adjust the tension again before starting, and unless the yarn is on a separate beam this will be impossible. This peculiarity will be noticed in all the processes when the artificial silk is allowed to stand, but it has no detrimental effect except in weaving. It arises through the artificial silk absorbing the moisture from the atmosphere at a much greater rate than the other fibres; and the more moisture there is present, the quicker and greater will the slackness be shown. Too much importance cannot be attached to working wherever possible with the atmosphere free from moisture.

Sizing of Rayon.—The earliest methods practised followed closely those applied to cotton yarn; rayon in hank form was saturated in thin starch paste or in a solution of soluble starch gelatine or other substance. This method is attended by certain difficulties. Unless great care is used, the threads tend to adhere together, and attempts to prevent this by shaking out or brushing out the skein after immersion result in damage to the filaments. Further, in the process of drying threads there is a risk of the size draining to the low end of the hank. Apart from these defects, the liability of the sized rayon, especially in the case of the regenerated celluloses, to absorb moisture and to extend as a consequence of this absorption, results in variation of tension on the beam. Ball warp sizing is impracticable. The slasher sizing machine, almost universally used for the preparation of beams for grey cotton weaving, is usually too heavy for rayon. Samuel Walker & Sons Ltd. devised a beam-to-beam sizing machine in which the warp threads passed over a roller fed with size by a second roller running in a trough. The warp in the open width was then passed in close proximity to the polished surfaces of heated cells, and wound in the dry state on to a further beam. This machine gives good results, but has a comparatively low production.

The second beam-to-beam sizing machine resembles more closely the slasher sizing machine referred to, in that the sized threads are dried over heated cylinders. The Johnson sizing machine (Textile Accessories Ltd.) is on this principle, and is claimed to have high running speed, and consequently relatively high production. In the beam-to-beam sizing machines inter-connected indicators running on the surface of the beams may indicate the stretch of the yarn.

Livesey & Crowther Ltd. have introduced a bobbin-to-bobbin sizing machine which has some advantages over the beam machine mentioned in that breakage of a single thread need not cause a stoppage in the rest of the material, and stocks of bobbins of various colours and kinds of sized yarn can be kept, and from these warps may be made up as required. The warp thus made goes straight to the loom.

More recently it has been found that sizes with a basis of linseed oil confer remarkably good weaving properties on rayon yarns. The Bayeux process, developed in France and introduced about a year ago to this country, has made great headway, and it is said that the Schetty and Gamma processes in use in Germany are also very successful. In these cases the method of treating in the hank is reverted to. The rayon is saturated in a suitable solution of the size, hydro-extracted, and dried at the appropriate temperature. Certain difficulties have been experienced in the removal of the size after weaving, but it would seem that these are being overcome.

Weaving.—Artificial silk is not difficult to weave if reasonable precautions are taken in the arrangement of the loom and in the use of the right accessories. In the case of weft, it is usual for the weft to be supplied ready wound on a strong paper tube or pirn. These tubes are carefully constructed, and it is usual for manufacturers to use shuttles with a round tongue which completely fills the inside of the tube. At the base of the tongue is provided a knife-edge screw on which the pirn is twisted. Such a tongue securely holds the pirn and prevents it moving about inside the shuttle. It has the added advantage that a pirn can be easily placed in the shuttle by the weaver holding the tip of the pirn without touching the yarn. The inside of the shuttle should be lined with two strips of fur, which gently brush the yarn coming from the pirn, giving it a light drag. The eye of the shuttle should be made of pot, and should be inserted in such a way that it is pointing downwards and slightly backwards. In this eye should be placed a tuft of worsted to still further regulate the drag on the yarn. All shuttles should be carefully examined to ensure that there are no rough places likely to catch the yarn as it is running from the pirn. Shuttle boxes should be carefully examined for any roughness, and it is advisable to line the front of the shuttle box with a strip of swansdown or other soft material. This minimises the possibility of the weft being cut, bruised, or damaged by shuttle marking. Care should be taken in setting the loom so that the pick is as soft as possible, and the checking should be regulated so that the shuttle is not subjected to any shock. Care should also be taken that a minimum of drag is placed on the weft, and that all shuttles used in the loom have the same amount of drag.

Artificial silk is now of such good quality, and warps are so well prepared, that it is very easy to weave fabrics with an artificial silk warp, provided the following precautions are taken. The warp beam itself should be absolutely regular in diameter and the trunnions accurately centred. The flanges also should be well made with smooth surfaces, and be absolutely rigid. The ruffles should be smooth and fitted so that they are concentric with the warp beam itself. A variation in the position of the ruffle or of the trunnion will create inequality in the tensioning of the warp, and great care should be taken to avoid this. Weighting may be performed in the ordinary way, but for warp beams it is better to balance the tension on the warp by passing a rope round the ruffle and suspending a weight on either end of the rope, the inside weight being lighter than the outside weight. In this system of weighting, the tension on the warp is the difference between the two weights, and the warp swings forward and backward with the shed. The healds used for weaving artificial

silk warps should be made from smooth wire, and the eyes should be as small as possible to give the least friction and shock in shedding. Before use, all healds should be carefully examined to ensure that there are no rough projections likely to cut or damage the yarn. The reed should be of the " flexible " type. Such a reed is made of rather better and finer wire than the ordinary weaving reed, and creates much less friction in weaving. The shuttle race should be covered with swansdown or other soft woven material. This gives a soft basis for the warp to rest on and reduces friction between the shuttle and the warp. If artificial silk is used in association with cotton to form warp effects, the artificial silk should always be on a separate beam. As artificial silk has a different take-up in weaving from cotton and shrinks in finishing, due allowance must be made in measuring the respective warps, and the lengths of the pieces or " cuts " should be accurately indicated by marks on the warps, so that the weaver uses the correct amount of artificial silk in proportion to cotton. Generally, in weaving artificial silk stripes, care should be taken that the artificial silk is relatively slack. This can always be checked by taking tension off the warp, when the artificial silk should tend to cockle and look slack on the surface of the fabric. Artificial silk stripes which are woven tightly never have a satisfactory appearance and are likely to be burst in any subsequent finishing process. Care should be taken in the choice and fitting of temples to avoid the catching and pulling of the artificial silk. Such temples are now available for use with artificial silk fabrics. The covering of sand-rollers should also be carefully examined, as any unnecessary roughness may damage the fabric or injure its appearance. For the finer artificial silk fabrics, it is advisable to cover this roller with rubber filleting.

When artificial silk warp is introduced in the form of stripes, either ordinary or crammed, a specially dented reed must be employed whenever the ground portion requires fifty or more wires per inch. The usual method is to omit every alternate wire in the striped portion. The wires must be well boiled in to make them firm, or a wavy, reedy appearance is produced which is far from satisfactory. This denting reduces the friction of the reed upon the yarn, and allows the knots and other irregularities to come through without breakage. It is also a good plan to strain the dents alongside the stripes towards the ground, as this gives more space for the artificial silk threads. The reed can afterwards be repaired. In taking up a broken thread, great care must be taken to have the thread about the same tension as the remainder; if too tight or too slack, the result is very noticeable.

The friction of the shuttle upon the artificial silk yarn should be avoided as far as possible by weaving the figure with the warp on

the face of the cloth, and by lifting the figuring warp a little higher and depressing it a little lower than the ground warp. But on no account should it be allowed to press on the going part, nor be subjected to overshedding. The shedding should also be timed to avoid a large amount of friction on the warp by the beating-up of the weft on a crossed shed. When the loom has to stand some considerable time it is well to relieve the tension from the artificial silk beam. A good weaver will do this every night, as it is quickly done and is equally easy to adjust the following morning. By attention to this detail there will be no difficulty with slack ends, and perfect cloth will be assured. The weaving shed should be kept free from moisture. Blowing live steam into the atmosphere, or humidifying in any way, is very detrimental to the good working of artificial silk.

In the manufacture of ordinary fabrics to be piece-dyed, good qualities of artificial silk may be woven in single-shuttle looms, but where super-excellence of production is required it is generally advisable to use two shuttles, checking 2-and-2. Care must be taken in weaving dyed weft, and when this is done, it is always advisable, as in the case of silk and worsted, to use two shuttles. The fine nature of the artificial silk fibre and the chemical and mechanical processes through which it passes before it reaches the weaver, create a varying affinity for dyestuffs, and this variation is greatly emphasized by the lustre of the material in the finished product. Variations in the denier of artificial silk yarn also effect the appearance of a fabric. These variations are more pronounced in some makes than in others, and where a first-class fabric is required great care should be taken in the choice of the yarn to be used, only the better makes being satisfactory for this purpose. In the case of warps, such inequalities are not likely to display their presence to any noticeable extent.

In the manufacture of fabrics in which artificial silk of fine filaments is used as weft, care should be taken in their weaving to allow for a much greater shrinkage in width than is normally given in a fabric made from cotton or ordinary filament yarns. It may be said that the finer the filaments the greater should be the amount of shrinkage in the finished width. This is especially the case where a crêpe warp is used, and the shrinkage allowed in such cases should be not less than 10 per cent. from the grey to the finished width. This shrinkage may be as much as 20 per cent. where extra fullness of handle is demanded. If sufficient shrinkage is not allowed, the fabric will have a very poor appearance and is liable to damage, due to the presence of bars of strained yarn.

COTTON BLEACHING

In the evolution of cotton bleaching from ancient times the introduction of chlorine compounds for bleaching cotton and linen towards the close of the eighteenth century; of caustic alkali and resin soaps for high-pressure boiling about the middle of the nineteenth century; and in more recent times the introduction of liquid chlorine and the successful commercial exploitation of the solvent process of scouring by M. Fort, are the chief events, together with improved design and increased efficiency of boiling vessels and other apparatus, in order to keep pace with the ever-increasing demands for greater production.

General Planning.—It is desirable that the boiling and bleaching should be carried on in a well-lighted one-story building, provided with an efficient ventilating system. In some cases it is customary to have means whereby access of direct sunlight to the department may be prevented. The requirements of a works in which the continuous system of cloth bleaching is carried on include the provision of pits in which the cloth can be packed after souring, chemicking, or the final washing operation. The pits are built of brick or concrete. If the former, a good interior layer of concrete is necessary, though perhaps the best plan is to line the interior surfaces with glazed tiles set in a special cement. The tops of the pits should project a short distance above the floor level. If several pits are built near together, an overhead automatic piling apparatus attached to a runway is often used in both British and American practice. The various machines and apparatus are placed in such positions that the goods to be subsequently bleached pass through as short a space as is practicable from one machine or piece of apparatus to the next one placed in order of the sequence of operations.

It is the usual practice to assemble the battery of kiers—two at least are needed for economical working—along one side of a blank wall, in the upper portions of which are suitable openings for the entry of the cloth from the singeing machines. The kier supports generally rest on a concrete floor placed several feet below the level of the main floor. Various methods of conserving the heat radiated from the outer surfaces of the kiers during boiling operations will occur to the engineer. One method is to build a brick wall on the main floor in such a position that one side of it is in alignment with the vertical cutting leading to the kier basement floor. It should be of sufficient height to act as a support for a working

25

platform, which thus secures the complete enclosure of three-fourths of the area of the kier shells. Steps lead up to the platform, and doors provide access to the lower portions of the kiers.

The auxiliary machinery and apparatus for souring, chemicking, etc., are placed in front of the kiers, leaving sufficient passage room wherever necessary. The floor may be formed of concrete with a specially prepared bitumen or rock asphalt surface. Perhaps the most serviceable type of floor is one made of 2 in. vitrified paving bricks set in concrete with the joints well grouted. A gradual slope toward the centre is desirable, so that water and other liquids may quickly drain away to a central channel, which can be formed of half-round glazed earthenware piping. The latter is laid in bitumen and built into the concrete, suitable gratings being fixed flush with the level of the floor.

On the other side of the wall to that against which the kiers are assembled is the singeing place and grey store room, and near to these is the general store for chemicals, etc. A fair size annexe to the main building is usually provided for the purpose of preparing solutions of bleaching powder or sodium hypochlorite. In this case, suitable pipes carry the filtered solutions to the requisite vats or machines. The pipes commonly employed for the conveyance of acids and hypochlorites are usually made of hard lead, whilst pumps for similar liquids are also made of lead, although bronze is commonly employed, and monel metal has been suggested.

Kiers or Boiling Pots.—These are used for boiling cotton in all its forms with alkaline solutions, at low or high pressure. The operation is termed lye-boiling, and one usually speaks of a lye-boil, lime-boil, etc., according to the particular alkali used. Kiers are cylindrical metal vessels, generally designed to stand in vertical positions. They may be of cast iron or fashioned from boiler plate. The former—usually open at the top—are still in use for boiling goods at atmospheric pressure or thereabouts; they are not so prone as ordinary kiers made of iron or steel to cause stains, and are very serviceable for delicate and expensive types of fancy cotton goods. The bottom of the kier is usually convex in shape, as is also the top in vessels of the enclosed type or those with full-sized lids. In the open type of kier the lower end of a pipe passes through an opening in the centre of a perforated grid, or false bottom, which is fixed at the lowest extremity of the parallel sides and fits into or over the steam supply pipe. When in action, an intermittent stream of liquor is forced up the pipe by the action of the steam, and is deflected and

spread over the top of the goods in the kier by means of a spreader attached to the top of the open end of the pipe. This type of vessel is called a " puffer pipe," kier, or pot.

Instead of a puffer pipe, an outside heater for the liquor and a pump for its circulation are to be found in some works.

The Injector Kier.—Here the puffer pipe is dispensed with, the liquor being circulated by means of a special type of steam injector, which is coupled to the lower end of an external pipe communicating with the top and bottom of the kier. An improved modern variety of this kind of boiling vessel is known as the Jefferson-Walker kier, in which the circulation is effected by what is termed an "inspirator," and is automatically regulated by means of a positively-timed vomiting control, so as to proceed in cycles— each of 60 seconds duration, immediately followed by a rest of 30 seconds.

The Multitubular Heater Kier.—This type of vessel has found great favour amongst bleachers in this country and abroad. Its main points of difference in comparison with the foregoing types are the provision of (a) a separate cylinder, or multitubular heater, for heating the liquor; (b) a powerful centrifugal pump which lifts the liquor from beneath the false bottom of the kier and forces it through the tubes of the heater (high-pressure steam being contained in the surrounding cavities) to the top of the kier; (c) since the heating of the liquor is effected by indirect steam, it follows that the original volume of liquor remains constant throughout the whole of the boiling operation, and the risk of stains caused by oil or other impurities in the steam is avoided.

A simple modification of the Walsh type of kier is obtained by arranging a steam coil beneath the false bottom of the kier, the exit end of the coil being connected to a trap. But this method of heating does not appear to give satisfactory results. Those kiers in which the heating of the liquor is effected out of contact with live steam are eminently adapted for boiling cotton and linen goods with caustic soda under pressure. In all high-pressure kiers one or more man-holes are provided, whilst suitable pipes and connections serve for (a) introducing the scouring liquors and water, and (b) running off the waste liquors.

The Mather-Koechlin Kier.—This is a well-known type. It is best suited for fairly large works, since the output with its aid when used to its fullest capacity is of a high order. A horizontal cylindrical body is designed to receive two waggons, each of which is provided with a false bottom, and a connection which automatically couples

with a main channel leading to a powerful centrifugal pump. The cloth is packed into the waggons, which are subsequently run into the kier, the door closed, scouring liquor introduced, and boiling and circulating carried on for several hours. A special method of treating the cloth is recommended when using this kier.

Open Width Kiers.—Several kinds of these kiers have been in use for many years. Some of them are specially suitable for the lye-boiling, souring, and chemicking of heavy drills, and other varieties of cloth which show a tendency to curl at the selvages, or for corded fabrics, satins, or other cloths which tend to become distorted or creased when bleached in the rope form.

Impurities in Cotton ; Selection of Bleaching Process.— The actual mode of procedure in any system of bleaching is mainly governed by the kind of material to be bleached and the nature of the impurities which may or may not have to be completely removed. With the exception of the artificial silks and mineral " fibres," practically all commercial textile fibres are obtained directly as the result of the life processes of living organisms, and since the latter need fats, proteins, sugars, etc., for their sustenance, it follows that such substances will be invariably found in the raw and spun fibres. Moreover, it is possible that complex polymerisation of many of the initial simple substances takes place during the growth of the fibres, with the result that their ultimate removal from the manufactured articles is rendered more difficult. Other impurities which are accidentally introduced into raw cotton during its progress towards the cotton bale are parts of seeds and pods, husks, etc. Impurities of this kind, which appear in the spun yarn or woven cloth, are termed motes, shives, etc. They are distinctly woody in character and contain resinous bodies which are difficult to bleach. Perhaps the best method of attack is by the use of caustic soda under pressure. The best kinds of yarn and fabrics, *e.g.*, those made from combed Sea Island and Egyptian cotton, are remarkably free from these impurities. Finally, the bleacher has to consider the properties of such impurities as are included under the term " sizing materials " ; also mineral oil in the form of stains, and dirt of various kinds acquired by the fibres in the course of manufacture. The following scheme summarises the foregoing notes, and indicates the behaviour of the substances enumerated towards certain chemicals which are known to exercise little detrimental action on the valuable fibre substance under prescribed conditions.

On referring to the table, it will be evident that one or more methods of removing the impurities generally present in manufactured

Substances	Behaviour in Presence of						
	Boiling Water.	Alkalis at High Temperatures.	Soap Solution and Caustic Soda.	Various Selective Organic Solvents.	Malt Extract.	Oxidising Agents.	Dilute Cold Mineral Acids.
So-called pectic matter	Swells and dissolves to a moderate extent.	Dissolves readily.	Dissolves readily.	..	..	Bleached.	..
Natural waxy matter	Melts.	Considerable amount removed from cloth.	Emulsifies to a large extent.	Dissolves.	..	Bleached.	..
Vegetable and animal oils and fats	..	Undergo hydrolysis, forming soluble soaps.	Undergo hydrolysis, forming soluble soaps.	Dissolves	..	..	..
Starchy matter	Slight action.	Thickens and is gradually reduced to soluble derivatives.	Result as in No. 2 column.	..	Gradually converted into soluble derivatives.	..	Converted into soluble derivatives.
Mineral oil (stains)	..	..	Emulsifies to a certain extent.	Dissolves	..	..	..
Paraffin wax	..	..	Very little action.	Dissolves	..	..	..
Residual colouring matters of cotton	..	..	..	..	..	Bleached.	..

cotton goods are available to the bleacher, *e.g.*, the bulk of the foreign matter may be removed either by boiling the goods with alkali, or far more completely by treating them first with a volatile solvent, followed by dilute alkali; again, it is conceivable that a combined process involving the essential features of both is capable of being developed.   The choice between available processes is almost entirely dependent on comparative cost, taking into consideration the differences in the results.   An expensive fabric of flax, for example, might yield an infinitely better article when treated by a solvent process than it does by the ordinary method. Again, Fort has pointed out that the solvent process is the only satisfactory one available for the complete elimination of paraffin wax from either cotton or linen.   Generally speaking, the best known processes of cotton bleaching consist of two main operations, viz., boiling in alkali to remove the greater proportion of the impurities, and chemicking to decolorise the residual natural colouring matters. Each main operation is invariably preceded or followed by one or more preliminary or auxiliary operations respectively, whilst the type of plant is usually dependent on the condition of the cotton.

Cotton is bleached in the raw state, either as waste from the ginning plant, or from spinning and allied operations; in the form of sliver; in yarn form, both hanks and warps, or as cops, cheeses, and on the weaver's beam ; woven fabrics of all kinds and knitted circular fabrics in piece form ; whilst the bleaching of manufactured detached articles, such as embroideries, lace goods, handkerchiefs, cotton hosiery of various kinds, etc., is an indication of the important sectional branches of the industry.

Bleaching of Raw and Waste Cotton.—Comparatively poor qualities of raw cotton are sometimes bleached before spinning into medium quality yarns for use as filling threads in the manufacture of multicoloured goods.   In such cases, the material may be placed in a pack machine, *i.e.*, a closed vessel provided with a pump for circulating the liquor, wet out well with hot water containing a little sulphonated castor oil, cooled, and bleached by circulating a cold " neutral " solution of sodium hypochlorite, about 3° to 5° Tw., for a short time.   It is then rinsed well, soured with hydrochloric acid, 1° to 2° Tw., rinsed again, treated with $\frac{1}{2}$ per cent. solution of sodium thiosulphate for a few minutes, and finally soaped.   In this way the wax and natural oily matter are but slightly affected, and the material spins well.   It is practically impossible to remove or decolorise the motes, shives, etc., by this process, but the material is suitable for

the particular purpose mentioned. As a rule, however, it is better to scour first with caustic soda, in which case a final steeping operation in soap solution should complete the process, *e.g.*, the bleached fibre is placed in a warm solution of soap containing from ½ to 1 lb. of soft soap per gallon.   It is then squeezed, allowed to stand for several hours, and dried.

Sliver Bleaching.—If the cotton to be bleached is in the form of sliver, the most successful mode of procedure is to use a pack machine similar to one of the types used in the dyeing of worsted slubbing, preferably made of wood or phosphor-bronze, and in which the liquors used are circulated in the usual manner, so as to prevent any movement of the material.

The sliver should be packed uniformly into the machine so as to avoid channels. The apparatus is then closed and water circulated while raising the temperature to boiling point. Then there is gradually added a well-diluted solution of sulphonated castor oil corresponding to about ¼ per cent. of oil on the weight of the sliver. The liquor is circulated for ten minutes, and one-fourth is then removed. The machine is filled up again with water containing 1 to 1½ per cent. caustic soda. The liquor is then boiled and circulated for two to three hours or longer, according to the size of the machine.. The material is then well washed, first with hot water, then with cold. The material is then treated with sodium hypochlorite solution, 2° to 3° Tw., which is circulated for one hour, then washed, soured with hydrochloric acid, 1° to 2° Tw., washed thoroughly, and finished as in previous example. In places where pack machines are not available, the lye-boiling of loose cotton other than slubbing takes place in an ordinary kier. Kier boiling invariably ensures the production of a better bleach, but at the same time the material is less suitable for spinning. After washing in the kier, the material is thrown out by hand, and treated in a wooden cistern with sodium hypochlorite solution, 1° to 2° Tw., this operation being followed by the usual practice.

The bleaching solution and acid are kept in cement or stone tanks built in the ground ; they are circulated by means of a pump communicating with the chamber beneath the false bottom of the cistern to the top of the latter. Such tanks are commonly built of wood, or sometimes of cement, made water and acid proof by means of a siliceous internal coating.

Cotton wadding is usually made from gin waste, or from the waste obtained from spinning mills. It is necessary to bleach it to a permanent white, and in order to achieve this result, care has to

be taken to remove all impurities before the actual bleaching operation.

Absorbent or Surgical Cotton.—In the manufacture of absorbent cotton for medical purposes, similar statements to those just made apply, except that a pure white is not absolutely necessary. This type of bleached cotton should be one of the most highly purified forms in commerce. The best grades are made from the waste from combed Egyptian cotton, though, as this is limited in amount, it is not unusual to mix poor quality " fly " waste with good quality " combers." If the finished material is medicated it is often tinted pink to distinguish it from other qualities, Rhodamine 6G being commonly used for the purpose.

METHOD OF WORKING.—The bales of waste are opened and the material passed through an opening willowing machine, which removes much dust and dirt, and loosens the material so as to prevent compact lumps from going forward. This operation is not always essential, but as the machine also serves to blend the different qualities of waste—cotton from different bales being fed into the willow at the same time—its use is now regarded as an essential feature of the process. The mixed cotton is placed in the kier, and trampled by men into position, whilst periodically warm water is sprinkled on it so as to ensure that the whole is packed in a firm and uniform manner. Since this is a very dusty operation, it is essential that proper respirators should be supplied to the operatives. When the kier has been filled to the requisite point, the manhole is closed, warm water introduced, and the cotton allowed to steep for a time. The water is then discharged, and a lye, consisting of about 1 per cent. caustic soda, 1 per cent. sodium carbonate, and sometimes a little soap run in, circulation and heating of the liquor being effected by means of a pump and multitubular heater respectively. Action continues at about 30 lbs. pressure for six to ten hours, according to the nature of the waste. The liquor is discharged when boiling is finished, and the cotton rinsed well in the kier and allowed to drain. Afterwards it is thrown out by hand on to the kier stage or platform from which it is removed to a large wooden cistern, provided with a false bottom perforated with fairly large holes ; or the bottom of the tank may be grooved. In any case, the outlets need to be covered with cloth, so as to prevent the cotton from being carried away in the drains. Here, the material is washed again, then bleaching powder solution of about 2° Tw. is circulated from a storage tank beneath the cistern for two or more hours ; it is then allowed to drain, and is next washed and soused with dilute sulphuric acid, 1° to 2° Tw., for some time (circulation), then steeped for about two hours, and washed until it is free from acid. The bleached cotton then

passes forward to a machine of the harrow type, in which it is constantly moved forward by the " harrows," and treated with a dilute solution of soaps and blue, etc. At the exit end of the machine it is well squeezed; it is then hydro-extracted and passed to the top of a drying machine in which it is carried forward on lattice work until it leaves the machine at the bottom, a current of hot air meeting it during its passage. The dry bleached cotton is next made into " laps " on a scutching machine, from which the laps pass to the carding engines, which transform the laps into a thin fleece of cotton. Several thicknesses of these fleeces constitute the " cotton wool " of commerce, which is interleaved with paper, cut to the required dimensions, and packed.

Apart from the purposes to which bleached loose cotton is put as mentioned above, the demand for it is now enormous, and is ever increasing owing to the requirements of the cellulose-ester and artificial silk industries.

YARN BLEACHING

Cops and Cheeses.—In the bleaching of yarn in this form the operations of reeling and winding back on to bobbins for use as white yarns in weaving would be avoided. Yarn wound on spools and also cheeses are more easily bleached than cops. Occasional packages of the latter are bleached by placing them in hempen bags and boiling in a kier with dilute caustic soda. They are then washed well in the kier, removed to wooden cisterns, and subjected to the action of sodium hypochlorite, which is circulated by the usual means. Washing, souring, washing and soaping complete the process. For a large production in continental practice it is customary to use a kier somewhat similar in design to the Mather-Koechlin kier. The cops and cheeses are placed in two trucks shaped to fit the horizontally placed kier. Each truck is jacketed round the sides and bottom, and open at the top, the inner walls being perforated. The liquor is circulated by means of a pump, and evenly distributed by a sieve on to the cops, through which it percolates sideways and downwards to the space beneath the false bottom and bottom of the truck, from which it is again drawn by the pump. A steam injector is used for heating purposes, and also assists in the circulation of the liquor. The caustic soda process is invariably employed, the cops being washed, chemicked, and soured in cisterns.

When tightly spun fine yarns are to be bleached, it is an advantage to employ a so-called vacuum kier. The outer shell is of wrought iron with an inner lining of lead. A second shell of wood, with perforated wooden bottom, is used as a container for the cops.

Immediately beneath the kier are special cement, wood, or glazed brick tanks containing the liquors to be used. A pump removes air from the kier and, on opening the necessary valve, the particular liquor required passes up a pipe to the top of the kier, and is evenly distributed over the material, through which it percolates rapidly, to be drawn off at the bottom, the cycle of operations being repeated with the different liquids throughout the process.

Yarn in Hank Form.—Small lots of yarn are merely boiled out in a solution of caustic soda contained in a wooden tank. The hanks are placed on sticks, the ends of which rest on the sides of the tank, and either turned by hand or by means of broaching sticks. Caustic soda, 2° Tw., may be used for boiling, or sodium carbonate solution of about 5° Tw., if the yarn has subsequently to be dyed. The length of time of boiling depends on the nature of the yarn and the ultimate purpose to which it is to be put. If many motes, shives, etc., are present, boiling for two to three hours may be necessary, whereas a good quality yarn may be clean enough for the next operation after an hour's boiling. Larger parcels of yarn in hank form may be bleached as follows :—The hanks are linked by hand, and the chain thus formed is drawn by means of winches to a kier in which it is evenly packed. An ordinary central puffer pipe kier is commonly used in some works, the boiling being conducted either with 3 to 5 per cent. sodium carbonate or caustic soda, 2° Tw., for about four to five hours. The liquor is removed, hot water introduced to wash the yarn, and then cold water. Chemicking takes place in a cistern with bleaching powder solution, 1½° Tw., for two hours, and is followed by the usual operations in sequence. Finally, the yarn is well washed and passed over a winch into a dumping machine, which consists merely of a tank with guide rollers, and squeezing rollers at the exit. The tank contains soap solution and a blue colouring matter; after impregnation, the yarn is squeezed and placed in waggons. Too much blue in the soap liquor must be carefully avoided. Indeed, it is better to pass the hanks through the machine two or three times, using a more dilute solution of blue, than to allow it to absorb too much blue in one passage. The above method is suitable for medium quantities of sewing cotton and also for weft yarn.

Yarn intended for dyeing in pale shades is boiled in pressure kiers with about 3 per cent. sodium carbonate and ¼ to ½ per cent. caustic soda. In other respects it is treated as in the above example up to the soaping stage.

Bleaching Cotton Warps.—These are bleached with various objects in view, e.g., when required for dyeing, for white warp threads in multicoloured fabrics, or for weft if the yarn is subsequently wound

on to pirns. This system of working is favoured in many parts of the world, both for bleaching and dyeing of yarn. The results are invariably better than those obtained on cops or cheeses. Warps vary enormously in the number of ends and length, and consequently weight, so that the method of bleaching is largely determined by these factors. When the warps are of good quality and of insufficient weight to fill a kier, it is the usual practice, especially if they are intended for dyeing, to pass them through boiling sodium carbonate solution of from 5° to 10° Tw., contained in tanks provided with guide rollers at the top and bottom, each tank being separated from its neighbour by a pair of squeezing rollers. The warps must not be in the linked form. After scouring they are washed in two similar tanks, thus requiring altogether a five-box machine.

On leaving the last water tank, the warps pass over a winch, and are plaited down by mechanical means into the chemicking cistern which contains sodium hypochlorite, 1½° to 2° Tw. The plaiting or piling apparatus is attached to a runway extending over a series of tanks, so that when a sufficient number of warps has been placed in one cistern, the adjacent cistern is filled and so on. Steeping is prolonged till the desired effect has been obtained. The liquor is then run off into a pit to prevent entanglement of the warps when drawn out of the cistern. The warps are next passed through a multiple tank similar to the scouring machine described above. This may consist of as many as ten tanks or boxes with the necessary guiding and squeezing rollers. In the first few boxes the warps are thoroughly washed, then soured in another, again well washed, soaped, and tinted, if necessary, and dried.

For the best quality warps, which may be in the linked form, it is advisable to fasten them end to end and boil them in a kier of the multitubular heater type, with 1 per cent. caustic soda, or 3 per cent. sodium carbonate, and ¼ per cent. caustic soda, for four to six hours at 25 to 30 lbs. pressure. They are then washed in the kier and run over a winch into a cistern containing sufficient acid to neutralise the alkali remaining in the fibres. Care should be taken to see that the reaction of the liquor in the cistern is faintly alkaline after the warp has been introduced. The liquor is then discharged, and sodium hypochlorite, 1½° to 2° Tw., circulated in the usual way for an hour or more. Washing, souring, washing, followed by tinting and soaping in the dumping machine, complete the process, though a treatment with ½ per cent. sodium thiosulphate immediately after the final wash is an excellent practice. The upper roller of the dumping machine is best wrapped to a thickness of several inches with hempen rope, and it rests merely by its own weight on the

lower one. Several ply yarns, those tightly twisted, and Egyptian yarns in general, need a somewhat more drastic series of operations, in order to get the best possible permanent results. Many modifications of the foregoing methods are also practised.

Warps on the Beam.—The main advantage of this system is that the threads remain practically undisturbed throughout the whole of the bleaching process. Special back-beams, made of copper tubing, are used by the spinners for beaming the warps. The copper beam is perforated round its periphery. The beamed warp, which may be 18 or 20 in. in diameter, is placed horizontally in a wooden tank, and one end of the copper beam is coupled to a powerful pump placed on the outside of the tank. Hard lead piping communicating with the pump enables the particular liquor in use during any part of the process to be carried to the pump, which then forces it through the warp threads by way of the perforations and back to the pump by means of an outlet in the tank. Circulation is first conducted with boiling caustic soda solution, 2° Tw. This is subsequently removed and hot water circulated; finally, the process is completed by circulation of sodium hypochlorite, $1\frac{1}{2}$° to 2° Tw., followed by washing, souring, and washing again. This process is also subject to considerable modification according to the type of plant and nature of the yarn.

COTTON CLOTH BLEACHING

The bleaching of woven and knitted cotton goods is a more difficult process than is yarn bleaching, inasmuch as various sizing materials, besides additional oil and dirt contracted during weaving, have to be removed. Knitted fabrics are frequently contaminated with a considerable amount of oil acquired from the knitting machines. As regards the bleaching of knitted goods, up-to-date bleachers should not have any difficulties in coping with the work.

Cloth bleaching is carried on with one or more of several objects in view : (1) to supply pure white cloth for sale in the domestic markets of the world, *i.e.*, the " market bleach "; (2) a second object in bleaching is to produce a white ground for a subsequent process of calico-printing, *i.e.*, the printer's bleach; (3) the third object is to " prepare " the grey cloth of the weaver for the dyer, *i.e.*, the dyer's bleach. At the present time the differences are of little import.

Just as in the methods previously discussed under yarn bleaching, cloth requires to be (*a*) boiled in a suitable alkaline solution, (*b*) acted on by means of an oxidising agent, and (*c*) treated with a chemical, *e.g.*, hydrochloric or sulphuric acid, capable of removing the last traces of substances left in the cloth from the preceding operations as well as their decomposition products. Lastly, a thorough washing

in water is essential. The following two typical processes will be considered :—(*A*) 1. Boil with milk of lime. 2. Wash to remove surplus "lime." 3. Sour with hydrochloric acid. 4. Wash. 5. Boil with soda ash and resin soap. 6. Wash. 7. Chemick. 8. Wash. 9. Sour with dilute sulphuric acid. 10. Wash thoroughly. (*B*) 1. Boil with dilute caustic soda. 2. Wash. 3. Chemick. 4. Wash. 5. Sour. 6. Wash.

The first process, or one closely identical with it, has been used for a great number of years, especially for cloth intended to be used in calico-printing. Instead of the soda resin boil, sodium carbonate or caustic soda alone can be used. As regards the efficiency of lime in comparison with other alkalis in boiling either cotton or linen goods, opinion in the twentieth century still differs to a remarkable extent, but the incessant demands for increased production, both in this country and America, have had the effect of causing the question to be more or less neglected by the questions of economy of time, labour, chemicals, and wear and tear of machinery. It is probably correct to say that at least 60 per cent. of the cotton goods bleached at the present time are not subjected to a lime-boiling operation. Certain expensive goods, such as damasks, etc., may yield better results if lime-boiled, whilst the same remark applies to the better qualities of printed calicoes. In other respects, however, the use of caustic soda as the scouring agent bids fair to become pre-eminent in all parts of the world. No doubt the development of its application for the purpose under discussion is largely due to the paramount necessity for the utilisation of the waste caustic soda liquors obtained in the mercerising process, and to the introduction of kiers specially designed to minimise the development of working conditions of a kind which induce tendering of the cloth.

Lime Bleach.—A fuller example of a " lime bleaching " process is as follows :—1. Singe. 2. Pass the cloth in rope form through milk of lime (5 to 6 per cent. slaked lime, calculated on the weight of the cloth) into the kier, and add sufficient water to cover the cloth. 3. Boil at 25 to 30 lbs. pressure for six to seven hours. 4. Wash in the kier and then in the machine to remove adhering " lime." 5. Sour in the machine with hydrochloric acid, 2° Tw., and allow the cloth to lie for two hours. 6. Wash. 7. Boil with 3 per cent. sodium carbonate, $\frac{1}{2}$ per cent. caustic soda, and $\frac{1}{2}$ to 1 per cent. resin for six hours at 30 lbs. pressure. 8. Wash with hot water in the kier. 9. Wash through two machines. 10. Chemick in the machine, using bleaching powder solution, $\frac{1}{2}$° Tw., and allow to lie overnight. 11. Sour through one machine with hydrochloric acid, 1° Tw., and allow to lie for a short time. 12. Wash through two machines. 13. Pass through the squeezing machine. 14. Scutch and dry.

The " caustic soda bleach " is carried out as follows :—A kier
of the vertical or horizontal type may be used, although the former
is generally preferred.   The various lots of cloth required to make
up about 2 tons of cloth are marked with the requisite particulars
at the ends of each piece, or " lump," for subsequent identification.
These particulars are entered into the kier book.   A marking or
stamping paste containing finely-divided carbon is desirable, since
very few coloured bodies are capable of withstanding the powerful
hydrolytic action of caustic soda at high temperatures, especially in
the presence of the natural impurities extracted from the cotton fibre.
It is here suggested that American gas carbon of the finely-divided
sort might serve as an efficient basis for a really satisfactory ink.

Singeing.—The pieces are sewn end to end and passed to the
singeing machine for the purpose of removing surface fibres, etc.,
which would interfere with the subsequent production of certain
finished effects.   Singeing machines are of two kinds.   In one type
a red-hot plate is in contact with the face of the cloth as the latter is
drawn forward, and in the other a non-luminous flame produced by
the combustion of a mixture of coal-gas and air is used to obtain
the singeing effect.   The former is still much in favour, and when
provided with an arrangement for causing the cloth to execute a
traversing motion concentric with the plate, and heated by the com-
bustion of atomised hydrocarbon oil, constitutes a highly efficient
singeing unit.   The rate of passage of the cloth depends on its quality
and moisture content ;   it may vary from 60 to 200 yards per minute.

Gas singeing is specially adapted for light and figured goods,
corduroys, etc., though it can be used for almost any class of goods.
The air for the burners is slightly compressed by means of a rotary
blower, and before reaching them is well mixed with the gas.   A
4-burner machine for singeing twice on each side is considered to be
more economical than the 2-burner type.

The cloth, after singeing, is immediately drawn through a box
containing steam or water, to extinguish sparks ;   a friction device
may be used for the same object.   At this stage the cloth is caused
to assume the rope form by passing it through a " pot-eye," *i.e.*,
an iron ring lined internally with porcelain, placed in a suitable
position.   It is then drawn forward to a machine consisting of a
box in which is a guide roller, and above it a pair of squeezing
rollers.   The box contains caustic soda solution, 2° Tw., through
which the cloth passes, entering at one end of the machine and
passing between the rollers in a spiral fashion, the strands being
separated by means of wooden pegs attached to a rail at the back
of the machine until it reaches the other end, whence it is carried

forward direct to a " 2-ton " kier, of the multitubular heater-type previously described, and arranged in uniform layers by boys who guide the cloth with sticks, and stamp it in position from time to time.

Two strands of cloth may be impregnated at the same time, each strand being diverted at the middle of the machine to an overhead winch, and thence to the kier. The rate of travel of each strand is often as high as 200 yards per minute, and the kier can be filled with an average kind of cloth in an hour or thereabouts. Sufficient caustic soda solution to make a total percentage of about 1 per cent. of 98 per cent. sodium hydroxide on the weight of the cloth is introduced, care being taken to see that the latter is well covered with the liquor. The goods are kept in position, *i.e.*, they are prevented from being " tossed " by means of wooden beams, iron bars, or chains fixed firmly across the top, sheeting being interposed between them and the supports. There is much less danger of uneven circulation, " tossing," and channelling if proper care is taken in packing the cloth in the first instance. Circulation of the liquor is then started, and the air valve is left open until all air has been completely displaced by steam. As the pressure rises, this valve is gradually closed, and boiling and circulating continued at about 30 lbs. pressure for five to six hours. The liquor is then removed, fresh hot water being introduced into the kier at the same time. Cold water washing follows in the kier, and the strands of cloth are washed again through one or two " rope " washing machines to remove the last traces of alkali. Knecht has shown that four hours' boiling with caustic soda, 2° Tw., removes 28 per cent.. and with addition of resin soap, 73 per cent. of the total wax.

Chemicking is conducted differently in the various works. One method is to pass the cloth through a " rope " machine somewhat similar to a washing machine. The box of the machine contains a solution of bleaching powder, $\frac{1}{4}$° to $\frac{3}{4}$° Tw., which is continually replenished from a suitable storage tank during the passage of the cloth. From this machine the cloth passes through pot-eyes and over winches to the " plaiting-down " or " piling " pits, and is arranged in a uniform manner by boys. After standing for a few hours—or even overnight, provided no portions are allowed to become partially dry—the cloth is either washed slightly through one machine, and soured in a similar machine with dilute sulphuric acid, 1° to 2° Tw., or is passed through the latter directly without washing. Hydrochloric acid is often used in place of sulphuric acid, especially if the goods are intended for dyeing. A thorough washing now takes place ; the goods are passed through a dilute solution of sodium thiosulphate, and washed again. They then pass to a squeez-

ing machine, in which they are rinsed, and squeezed by two heavy bowls under considerable pressure, so that a large percentage of the water is removed very quickly. Opening out is effected by means of a scutcher, and the goods are finally dried. Fig. 1 is a plan of a works designed for an output of 50 tons per week. Circular knitted fabric is boiled under similar conditions to those described, but subsequent operations of washing, chemicking, souring, etc., are either done in " slack " roller machines, or in cisterns with circulation of liquors.

Souring is commonly carried out after rinsing in the kier, i.e., after the caustic soda boil, owing to the difficulty of readily removing the alkali by washing. A wash through one machine follows, and the cloth is then chemicked, or with many thick goods or those made from tightly-twisted yarn, a second boil with $\frac{1}{2}$° Tw. caustic soda may take place.
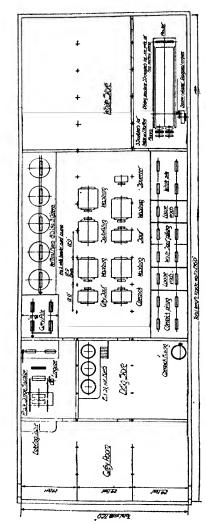
FIG. 1.—BLEACHING AND DRYING PLANT FOR COTTON PIECE GOODS.

Instead of using the machine method of chemicking, which many authorities consider has a tendency to cause uneven results, the cloth is sometimes plaited down automatically into large cisterns into which bleaching powder solution of about 1° to 2° Tw₆ is introduced. Steeping continues for about two hours, and the cloth is then washed through one machine, soured, washed, and finished in the manner outlined above. A commoner method is to place the cloth in a cistern as described, but instead of the liquor remaining stationary, it is caused to circulate by means of a pump.

Suitable dimensions for a cistern to hold about 2 tons of cloth are 8 ft. × 7 ft. × 6 ft. The chemick liquors used in the steeping and circulating processes are generally a little stronger than are those which find favour in machine chemicking of the kind discussed above, though even here stronger liquors must be employed if the cloth is thoroughly washed before souring.

GENERAL NOTES ON BLEACHING PROCESSES

The degree of efficiency with which a lye-boil has been conducted is a matter which is exceedingly difficult to standardise, owing to the widely varying nature of the goods placed in the kier from day to day. The more efficient the operation, the more readily is the residual colouring matter removed by chemicking. Goods containing a large percentage of woody matter, *e.g.*, motes, etc., need to be boiled with caustic soda for a longer period than is necessary for cleaner goods. Furthermore, it may be advisable to employ a more concentrated bleach-liquor for complete and permanent decolorisation of the residue arising from the impurities. It is sometimes considered that a better system of boiling is one in which the operation is carried out in two stages, using, say, 1 per cent. caustic soda for one to two hours, then discharging the liquor and boiling again with a further 1 per cent. caustic soda for a definite period. This practice may result in a reduction in the total time of the boiling operation, but whether or not such a possible reduction will compensate for the increased cost involved in raising the temperature of the second volume of lye to the required point can only be determined by accurate records and calculations. In this connection brief reference may be made to a system of boiling designed in conjunction with a continuous piling apparatus, to enable the cloth to be in a state of motion from the time it leaves the singeing machine till it is dried. The idea is not new. Briefly, the cloth in rope or open width form is drawn continuously through a series of three kiers. A solution of caustic soda is delivered into the third kier of the series from which a flow of

liquor passes to the second and then to the first kier. The liquor is
circulated back and forth across the cloth as it is piled in the boiling
liquor, the lower layer, *i.e.*, the strand at the bottom of the kier, being
withdrawn as fresh cloth enters at the top. The cloth is squeezed
after leaving each kier, and after washing thoroughly, is ready for
chemicking, which is done by one of the quick impregnation processes.
It is then drawn to the top of the bleach-house and allowed to drop
continuously into a piling apparatus of the type shown in Fig. 2,
in which it forms a pile resting on the bottom or the
rollers at the bottom. As the weight of the pile in-
creases the cloth moves slowly downwards, the front
end of the pile being subsequently turned upwards
in the short delivery end, from which the cloth is
removed continuously, and either piled in another
similar apparatus or drawn to the washing or souring
machine, according to requirements. Light-weight
fabrics need to be piled in an apparatus of small
sectional area as compared with the type required
for heavy goods. This arrangement prevents en-
tanglement, and each apparatus can be built to
hold from 5000 to 10,000 yards of cloth. A series
of four pilers enables the cloth to be removed con-
tinually from one of them, and introduced into the
next, and so on, with the result
that sufficient time elapses from
the moment the cloth enters No. 1
piler from the chemicking mach-
ine, until its exit from No. 4 to
complete the chemicking operation.
The pilers may also be used after
souring the cloth.

FIG. 2.—GANTT PILER.

A combined piling and saturating apparatus recently introduced can
be fitted to any type of vertical cylindrical kier.   As the cloth is
automatically piled in the kier it is saturated with scouring liquor
issuing from perforations in a hollow ring. The apparatus ensures
even piling and uniform saturation, and is said to be a great aid in
producing well-finished goods.

The solutions of caustic soda used in boiling are prepared in cast-
iron tanks situated above the level of the kier tops, and can then be
introduced by gravity into the kiers, either by way of a valve near
the bottom, or at the top   "Feeding" the liquor from the bottom
is said to minimise the danger of "air pockets" being left in the mass
of cloth. If the liquor is prepared on the ground level, it is carried
to the kiers by means of a pipe communicating with the pump.

Sodium bisulphite is often recommended as an addition to the lye when caustic soda is employed, with the object of diminishing the ever-present risk of the formation of oxidised cellulose. In view of the efficiency of modern kiers, and the fact that the alkali extract of raw cotton goods acts as a powerful reducing agent, there does not appear to be any necessity for such an addition. Other substances specially adapted to act as penetrative agents, detergents, or grease solvents, quite apart from ordinary soaps, have long been advocated as useful adjuncts in the scouring liquor. Many of these have undoubtedly considerable merit, but in some cases the odour produced in actual practice is an objectionable feature. Generally, one finds that substances like tetrachlorethane and allied compounds in admixture with suitable soaps of the castor oil type constitute the basis of many of the products under review.

Another interesting product which is likely to exert a considerable influence in the scouring of textiles in the future is tetrahydro-naphthalene, and the proprietary mixtures produced from it.

Preparation of Bleaching Liquors.—The cheapest kind of bleaching agent for the treatment of vegetable fibres is a solution of bleaching powder, which is made by grinding the powder in water at about 70° to 80° F. for some time, and allowing the excess of suspended matter to settle. One pound of the fresh substance per one gallon of water gives a solution which indicates about 12° Tw., and if this stock solution is diluted with water until it is of about the average " bleaching strength," say 1° Tw., it will contain approximately 3 grms. of available chlorine per litre, or 210 grains per gallon. Owing to the readiness with which the free calcium hydroxide—always present in freshly-made solutions of bleaching powder—is converted into calcium carbonate during bleaching operations, there is always a tendency for such solutions to become too " active," especially when steeping methods of chemicking are in use. In machine chemicking, this property is of less importance. On the other hand, the goods passing to the chemick from the washing machine immediately following the lye-boil should be either neutral or contain only a slight amount of alkali, since the introduction of any form of the latter into a hypochlorite solution retards its decomposition under the conditions which usually obtain, and this results in a slower bleaching action.

Sodium hypochlorite is nowadays very largely used in place of the calcium salt in many branches of the bleaching industry. It is generally made by double decomposition between sodium carbonate, or a mixture of the latter and sodium sulphate, and bleaching powder solution. The commercial product is more stable than are solutions

of bleaching powder, inasmuch as its free alkali content is not easily converted into an inert salt. Sodium hypochlorite can be " activated " by the addition of sodium bicarbonate, or by the various means available to the chemist for the removal of free alkali.

Hypochlorite solutions made by the electrolysis of brine do not appear to be used to any great extent in large scale bleaching operations. Taking into consideration the initial capital outlay for plant, cost of salt, working costs, and wear and tear of the electro-lysers, it will be evident that such a plant will need to be very efficient indeed to compete successfully with the older processes of making hypochlorites.

Liquid Chlorine in Bleaching.—The consumption of liquid chlorine in Canada and the U.S.A. has increased very rapidly during the last few years, and there is a great possibility of the expansion continuing. The manufacture, handling, and transport of the latter are costly and objectionable operations, whilst the by-product is a nuisance. On the other hand, liquid chlorine is now easily manufactured; it is less bulky, and the preparation from it of sodium or calcium hypochlorite solutions of high " available chlorine " concentration is merely a matter which requires the exercise of reasonable care, coupled with the selection of suitable plant. In works already accustomed to the daily preparation of bleaching powder solution, it is a good plan to allow chlorine gas to pass into the liquor whilst the bleaching powder is being mixed, whereby a solution may be obtained containing an additional 20 to 40 per cent. of available chlorine. Furthermore, there is only about one-fourth of the amount of sludge ordinarily obtained.

The Solvent Process.—The successful application of the process on a commercial scale to linen and cotton goods is due to M. Fort, who was responsible for the establishment of a solvent plant working as a regular feature, about the year 1919, at the Perth works of Messrs Lumsden & Mackenzie. The writer understands that the plant is still in operation for the extraction of oil, fat, and wax from linen and cotton damasks and sheetings. It is claimed that the goods treated by the process yield a better " white " and finished effect than is the case with similar material bleached by the ordinary method, whilst they keep better in stock. The main conditions governing the successful working of a solvent process of any kind are dependent on the particular solvent or mixture of solvents used, design of plant, and actual working temperature. The solvent process is the only one which completely removes paraffin wax from fabrics contaminated with this substance.

THE FINISHING OF COTTON GOODS

By S. R. Trotman, M.A., F.I.C.

The finishing of cotton goods is primarily a physical and in many cases purely a mechanical process. The chemicals used as assistants are generally employed on account of their physical rather than their chemical properties, and the particular effect which they produce is only developed under suitable physical treatment. The final effect of a " finish " is determined largely by the nature of these physical operations involved in its production, but, nevertheless, a good knowledge of the chemical properties of the materials used is essential for successful work. Formerly, finishing was conducted by " rule-of-thumb " or empyrical methods, which are only successful so long as conditions remain normal. Small and unknown variation in the conditions or in the properties of the chemicals used may cause the breakdown of an empyrical process, although the variation may be allowed for if scientific methods of control are employed. The scientific control of finishing is very difficult, owing to the number of factors involved. the complexity of the materials used, and the impossibility of a quantitative expression of the results of experiments. Moreover, the problems to be solved are principally those of colloidal chemistry, which require special knowledge for their solution. Valuable work in this field of research is being carried out by the Cotton Research Association.

The " Finishes " applied to cotton goods may be classified as (1) pure finishes ; (2) assisted finishes ; (3) stiffened finishes ; (4) special finishes.

For the production of pure finishes no chemicals are employed, the effect being dependent upon mechanical processes only. In the case of piece-goods, these mechanical operations may have for their object the production of smoothness, brightness, closing up of the surface, or of a thready appearance. These effects are obtained principally by beetling, calendering, or stentering. Assisted finishes are those in which a small proportion of a stiffening or binding agent is used in order to increase the effect of the mechanical processes employed, and to give a greater body to the goods, without making the addition too evident. The term " stiffened " is applied to finishes in which the proportion of stiffening or binding material is large and in which weighting agents are also employed. Whilst in assisted finishes the cloth must be apparent, in stiffened finishes, on the other hand, the chemicals used may almost disguise the cloth, unless the

mixture is applied to the back of the fabric only. A woven appearance is, however, imparted to heavily filled goods by means of a process termed " chasing." " Special finishes " are employed, as the term denotes, for the production of some particular property or effect. These include such things as the simulation of wool or linen, water-proofing, fire-proofing, and rot-proofing.

Assistants in finishing may be classified as follows :—

1. Stiffening and binding materials: Starch, dextrin, gelatin, glue, casein, and gums.

2. Filling agents: Gypsum, kaolin, calcium carbonate, French chalk, Epsom salt.

3. Softening agents, such as soap, oil, fat or wax, or glycerin.

4. Deliquescents: Zinc chloride, magnesium chloride, calcium chloride, glycerin.

5. Bluing materials: Smalt, ultramarine, or coal-tar dyes.

6. Antiseptics: Boric acid, borax, copper salts, phenol, formalde-hyde, zinc chloride.

7. Waterproofing agents: Insoluble soaps, oxidised or oxidisable oils, gelatin tannate, formaldehyde-gelatin, waxes, rubber, or cellulose esters.

8. Fireproofing agents: Metallic oxides, tungstates, phosphates, borates, and silicates.

This classification is neither exhaustive nor invariable, and is based only upon the more important properties of the bodies named. Assistants used for one purpose may simultaneously act in a second capacity. Thus, filling agents may also affect the superficial appear-ance of the cloth and even act as stiffening agents. Deliquescents and such antiseptics as zinc chloride have also weighting properties, and act as softeners. Binding agents may produce hard or brittle finishes or those as soft and pliable as the cloth itself, according to their nature and method of application.

Finishing Operations.—After the goods have been bleached and washed, they are opened out and subjected to mechanical pro-cesses, the object of which is to recover width and correct strains or distortions produced during bleaching. They are then partly dried. All processes subsequent to this are termed " finishing." The amount of drying depends upon the type of finish employed. For pure finishes a greater degree of dehydration is required than for assisted or stiffened finishes. It is important, however, to note that the effect produced by a mechanical finishing process is affected by both temperature of the cloth and its " condition " or moisture content. The condition is controlled either by drying the goods until they contain the desired percentage of moisture, or by drying

them completely and introducing the moisture by means of a damping or dewing machine. After drying, the treatment depends upon the finish required. For pure finishes, the mechanical processes alone are sufficient; in the case of assisted or stiffened finishes, the finishing mixture is applied to the cloth first by means of a mangle, after which it is again dried to the required condition and subjected to the necessary mechanical treatments.

The Mechanical Processes of Finishing.—The principal operations are stentering, pressing, beetling, and calendering, which may be used alone or in combination with one another. It is not intended to describe machines in the present article, but only to deal with the effects which they produce.

Stentering is employed chiefly for the lighter kinds of cotton goods, such as nets or loosely woven materials containing patterns which must remain undistorted. It is used also when it is necessary to dry in the absence of pressure. The chief effects produced by the stenter are: (1) Bringing goods to a definite width; (2) straightening of weft threads and establishment of a pattern; (3) drying the goods by hot air whilst in this stretched state; (4) production of a desired " handle " by the application of heat, either with or without the aid of special motions of the fabric. A stenter consists essentially of two extended horizontal frames, provided with means of supporting and stretching the cloth. The distance between the frames is adjustable, and the fabric is gripped close to the selvages. Tension may thus be applied to the ends of the weft threads, causing them to become stretched and straightened, whilst in the damp condition, with the minimum amount of mechanical strain. The goods are then dried by hot air, thus fixing the dressing whilst the cloth is stretched. The " handle " is controlled by regulation of the temperature and rate of drying, and also by imparting a " swissing " motion to the cloth, which prevents the starch from setting at the junctions of the threads. Stenters may be either stationary or progressive, the former are used for such things as nets, the latter for cloth.

Pressing.—This is used chiefly for garments or hosiery which cannot well be treated by a continuous process. It is employed, also, for finally improving the appearance of piece-goods. Garments are placed on boards which stretch them to the desired shape and size, and are then placed in the press, the temperature and pressure of which is capable of being accurately regulated.

Beetling is a very important mechanical process consisting of subjecting the cloth to a rapid succession of blows applied independently across its surface by a series of hammers. Each hammer has a smooth, round end, and delivers about 72 blows a

minute; but, owing to a progressive and lateral movement of the cloth, each blow strikes the surface at a different point. The rounded end of the hammer limits its contact to a small area within which the inner threads are subjected to a vertical pressure, and the outer threads to an oblique pressure causing their lateral deflection. The combined effect of these two pressures produces a rolling motion which tends to round the threads, whilst the vertical pressure tends to flatten them. The final result of beetling is thus a combination of these two effects. The chief objects of beetling are : (1) Closing up . the threads of the cloth and eliminating the spaces between adjacent threads; (2) producing a bright, hard, or a relatively dull, thick, and clothy finish; (3) increasing the width of the cloth; (4) producing a surface effect or watermark. Beetling is, of course, merely a development of a very old hand-operated process. A traveller in Korea relates that the principal occupation of the women seemed to consist of beating the washed cotton robes worn by the men with a pair of small hammers one in each hand. There are both flat and roller types of beetles, although the latter are used chiefly. The results of beetling are affected by many conditions, such as the percentage of moisture, the temperature, the duration of treatment, and the purity of the cloth.

According to Fort (*Journ. Soc. Dyers and Col.*, 1921, 162), the effect of beetling appears to depend upon the absence of oil, fat, or wax. He found that the presence of so little as 0·1 per cent. of fatty matter, *i.e.*, residual cotton wax, was sufficient to render the process futile in many cases. When, however, the fat was removed by means of an organic solvent, no trouble was experienced. This indicates that good beetling is governed by thorough lye-boiling. The same author (*J.S.C.I.*, 1918, 121A) investigated also certain cases of the mechanical disintegration of cotton fabrics which may occur during beetling, owing to the hammers falling continuously upon the same section of cloth. This is accompanied by loss of moisture, a rise of temperature, and the formation of a deposit which can be powdered readily. This powder has the chemical properties of cellulose, and contains neither hydro-cellulose nor oxy-cellulose. Cross and Bevan found it to consist largely of β-cellulose, which is characterised by being soluble in alkalis.

Calendering.—This process consists of subjecting the prepared and dried cloth to pressure between rollers or bowls. The effect produced depends upon many factors, such as the pressure between the bowls, the temperature, the nature of the surface of the bowl, and the properties of the cloth under treatment. The last-named include condition or humidity, thickness, elasticity, and the nature

of the dressing agents present. The effects produced by calendering include glazing and brightening, flattening, closing, thready or cloth-like appearance, embossing, and similar effects. The number of bowls may vary from three to twelve, and are made of metal. The metal bowl may be covered with layers of paper or cotton, being then termed " soft." The metal used in the construction of the bowl may be brass, cast iron, chilled iron or steel, the varying hardness of these producing different effects. The result obtained in calendering is determined largely by the nature of the bowls and the number of nips; a predominance of metal nips tending to produce a hard, bright, closed-up, and flat surface. Soft bowls alternate, generally, with metal bowls, since if only the latter were used the pressure would be too great for cotton goods.

The following arrangement of bowls, starting from the top (where C = cotton, P = paper, M = metal), will indicate the dependance of effect upon the combination used: (1) For soft dull finishes, CCPCMCM; (2) for hard bright finishes, CCMCMPM. " Chasing," " swissing," and " jacking " are among the special effects obtained by calendering. Swissing represents the normal process, in which the cloth is run straight through the nips in series, in order to smooth and brighten the surface, close up the threads, and produce either a hard or mellow finish. Chasing produces a thready appearance, with closed-up threads and firmness. In jacking an attempt is made to imitate beetling. The cloth passes through the nips of three bowls (cotton, paper, cotton), and is then wound tightly on a batch roller between the rolling surfaces of the upper cotton and the top paper bowls, as well as being in contact with the cloth in the batch. The cloth in the batch, being under the same pressure, becomes closed up and highly glazed.

The changes which take place in cotton when beetled or calendered have been investigated by Hübner and Malvin (*Journ. Soc. Dyers and Col.*, 1924, 5), who measured the tensile and ripping strains of fabrics before and after treatment. During prolonged hot calendering, the ripping strain increased, the increase being greater in the weft than in the warp. After 40 nips there was a uniform reduction in tensile strain, both in weft and warp. Cold calendering does not produce any reduction. Beetling up to a period of fifty hours increased the ripping strain, but caused a gradual though small reduction of the tensile strain.

Combined Finishing Processes.—In practice the final properties of a finish are due in most cases to a combination of several of the single processes described above, and the result depends upon the order in which they have been employed. An important factor is

the nature of the goods to be treated, different effects being produced by the same finish on goods of different qualities. Thus, in the case of a pure finish. to which it is desired to impart the appearance of a finely woven fabric resembling linen, the effect may be obtained by beetling alone in the case of high-grade goods, whilst an inferior material may, if closed up to the same extent, develop a hard, flat surface. It is obvious that something must be done to make the inferior cloth resemble that of the superior quality. This might be effected by allowing the shrinkage of the lower quality to remain, if the specified finished width will allow of it, and treating the fabric with a little thin starch to give greater fullness to the threads. The important point is that finishes must be varied with the goods and cannot be standardised permanently. It is the same in dyeing. No dyeing formula gives exactly the same colour with different lots of goods; shading generally has to be resorted to.

Auxiliary Processes.—Some subsidiary processes which are made use of to modify the final effect of a finish cannot be classified readily. They include damping, stretching, breaking-down, wetting-out, and facing-up.

Damping rectifies harshness, smooths and brightens the surface of the cloth, and takes out " water marks," due to chasing or beetling. It also increases weight by addition of moisture. Breaking-down denotes the reduction of the harshness of a finish, and may be accomplished by stretching the cloth or by drawing it over a hard edge. Wetting-out consists of passing the cloth through a two-bowl water mangle, the lower bowl of which dips in water, or a light dressing of a softening material. Facing-up implies the application, in a similar manner, of a supplementary dressing or filling to either face of the cloth.

Pure, Assisted, and Stiffened Finishes.—The simplest pure finish is that required for goods which have to be dyed or printed. These are simply opened out and washed in a mangle, during which operations width is recovered and distortions are corrected. They are then dried and delivered. Calico and similar goods would be beetled or calendered, the latter being the less expensive process. It is often necessary, however, to use a little starch to bring out the full effects of the mechanical treatments, and thus there is no definite line of demarcation between pure and assisted finishes. The latter only become typical when sufficient of the assistant is employed to give additional body to the fabric. For stiffened and filled finishes both an adhesive or binding agent and a weighting material must be present, and, generally, other assistants become necessary, such as softening, bluing, antiseptic, and conditioning agents. The basis

of most of these finishing mixtures is starch, the most important being potato, wheat, and maize starches. Potato starch (or farina) gives a highly viscous paste, which has great thickening power and is used for " thick " finishes. Maize gives rather a thinner paste, but holds more filling material than " farina " and imparts a firm handle to goods. It is a good binding agent and takes a high gloss. Wheat starch gives a comparatively thin paste, which has greater penetrating powers than that made from either farina or maize starch. Hence it is taken up by the goods, giving them a thick handle but leaving the surface smooth and bright. Its binding properties are very good. Cassava starch is used sometimes instead of maize starch. Tapioca starch is used to a certain extent. It gives a comparatively thin paste, which penetrates the goods well, and, when dried, forms a transparent soft film. Sago starch gives a very thin paste with marked binding properties and good penetration. It is used chiefly for the sizing of yarns.

Soluble starch, thin starch, and dextrin are employed also. Soluble starch, since it forms clear solutions with comparatively low viscosities, penetrates goods very readily, and, when dried, gives a continuous film, whereas in the case of a highly viscous paste, like that of farina, the dried film is discontinuous. Hence, soluble starch gives a fuller handle than that produced by ordinary starch, but it has no binding power. It is suitable, therefore, for the production of a full handle without the use of filling agents. Dextrin has similar properties, but gives a softer finish than soluble starch. Thin starch is a mixture of soluble starch, dextrin, and unchanged starch, and its properties vary with the proportions of these bodies present. By using mixtures of the different starches and dextrin, the properties of the ingredients may be combined. Mixtures containing the desired proportions of starch, soluble starch, and dextrin can be made by treating starch under suitable conditions with enzymes such as diastase and rapidase. The latter is particularly suitable for this purpose, since it produces very little dextrose. Glue and gelatin are used to a certain extent for such things as nets or veilings, in which a certain amount of stiffening is required without any appreciable filling. Gum arabic may be used for the same purpose. The other vegetable gums, such as tragacanth, have no adhesive properties, and cannot be used as binding agents unless combined with starch. Gum tragasol is an exception, possessing considerable binding properties. The preparation of a suitable finishing mixture is a matter which requires both knowledge and experience. For example, if a soft filled finish is required, the binding agent used may tend to make the fabric too stiff. To correct this a softening agent is intro-

duced. A certain amount of mellowness or softness may be assured by the use of a deliquescent agent, which assists further in preventing the goods from becoming harsh owing to loss of moisture. A complex dressing containing starch or other organic matter will be attacked by micro-organism if kept under suitable conditions. To prevent this an antiseptic is included in the dressing, whilst the colour is improved by the addition of a little blue such as smalt or ultramarine. In order to obtain good results care must be taken in the selection of materials, unconsidered impurities often affecting the result deleteriously. One example may be given. Thin starches often contain acid. Ultramarine is decomposed by acid with the production of a brown colour. If it be used in a finishing mixture which is acid, not only will the colour not be improved, but, on the contrary, will be spoiled.

Preparation of the Finishing Mixture.—Water is placed in a tub containing a steam-pipe ending in a spreader at the bottom of the vessel. The starch is weighed out and made into a cream with cold water. The water in the tub is heated, the starch cream introduced gradually with constant stirring, then the other constituents of the finish, the heaviest being added last. The mixture is now heated, with continual stirring, till the starch is completely gelatinised and the insoluble ingredients distributed homogeneously throughout the mixture, after which the contents of the tub are brought to the boiling point, diluted if necessary with hot water, and allowed to cool. If the consistency of the mixture is too great, the steaming is continued till the requisite degree of thinness is produced.

Application of the Finishing Mixture.—The finishing mixture is placed in the box of a starch mangle, and is applied to the goods either cold or warm. The goods are run through the nip and the lower bowl, which dips into the mixture, gathers it up and applies it to the cloth. In the case of thick mixings the box of the mangle is provided with a mechanical agitator. The exact kind of starch mangle used depends upon the type of finish required. Simple stiffening mangles are used for straightforward work. For heavy fillings a friction mangle is employed, and a back-filling mangle when only one face of the cloth has to be dressed. For goods requiring the starch to be pasted on to one side only a back-starching mangle is more suitable.

Special Finishes.—A great deal of work has been published of late on the production of special finishes on cotton or other goods. Owing to the high price of wool there is a considerable demand for cotton which has the appearance, handle, and some of the physical properties of wool. Wool or linen-like effects are obtained by treating cotton with mineral acids, of sufficient concentration to cause swelling

and shrinkage, and then washing rapidly with water. The cotton
may be mercerised before or after treatment. Other swelling agents,
such as zinc chloride and calcium thiocyanate, may be substituted
for the acid. When cotton is treated with nitric acid of about 82° Tw.
strength it becomes mercerised, but if the concentration be 84° Tw.
a wool-like effect is obtained. The treatment must be of very short
duration, not more than 30 secs., the temperature below 15° C.,
and the washing must be rapid and complete. The action may be
modified by the addition of sodium nitrate or ammonium nitrate.
Sulphuric acid is used by the Heberlein Company (B.P. 12559,
1914). The material is first mercerised, then treated with sulphuric
acid of sp. gr. 1·515 to 1·546 and washed. Phosphoric acid (sp. gr.
1·60 to 1·65) is said also to produce similar effects, and a solution of
zinc chloride at about 60° C. The use of strong mineral acids is
very inconvenient, and the washing difficult to carry out. Moreover,
special apparatus is necessary for use with concentrated acids, and
for these reasons the process has never found much favour.

A linen-like finish is obtainable also in a similar manner.   For
example, the Calico Printers' Association (E.P. 213353, 1923)
treat the cloth with sulphuric acid of 106° to 113° Tw. for from 4 to
8 secs., either before or after mercerisation. None of the methods
depending upon the use of strong acids are really satisfactory;
but more promising results are obtainable by the process of Lilienfeld,
and others in which cellulose xanthate is used. In Lilienfeld's pro-
cess (E.P. 274860) it is claimed that the treated material not only
has the full handle and appearance of wool, but also its resiliency and
flexibility, creases and wrinkles being capable of being removed
by smoothing or brushing. The fabric is treated with gaseous or
liquid carbon disulphide, and then with sodium hydroxide solution
of not less than 12 per cent. strength. During treatment the fabric
must be free to shrink both longitudinally and laterally. The
insoluble xanthate is washed with water and then treated with an
aqueous solution of nitrous acid until no more gas is evolved. It is
then bleached, if necessary, with sulphurous acid, washed and dried.
The nitrous acid acts as a mild oxidising agent, which converts
the xanthate into a stable compound. It should be noted that
an identical process has been patented by Harrison. A very simple
method of obtaining wool-like effects (E.P. 284686) on unbleached
cotton consists of wetting it and then treating with sodium hydroxide
solution of 50° Tw. strength for five minutes at 40° C.

Although not a true finish, the immunisation of cotton against
direct dyestuffs is of sufficient interest to be mentioned. This consists
of converting it, superficially, into a comparatively stable cellulose

ester. The process was patented by the Textilwerk Horn A. G. (B.P. 195619). The scoured and bleached material is dried and treated with a warm alcoholic solution of sodium hydroxide for an hour. It is then hydro-extracted and immersed in a solution of paratoluene-sulphochloride in an indifferent solvent, such as toluene, for about an hour at a temperature of 85° C. to 95° C., after which it is hydro-extracted, soaped at 60° C., washed and dried. The product formed consists of a sulpho-ester of cellulose containing the grouping—$OSO_2C_6H \cdot CH_3$.

Waterproof or showerproof finishes are required sometimes on light goods. These may be produced in several ways, but the following are simple and satisfactory : (1) A solution of acetate-sulphate of aluminium is prepared by dissolving 6·65 parts of aluminium sulphate and 9·5 parts of lead acetate separately in water and mixing the solutions. After the precipitated lead sulphate has settled the clear liquid is drawn off and diluted with water to about 15° Tw. The goods are worked in a dilute soap solution (0·5 per cent.) hydro-extracted, and passed into the aluminium acetate-sulphate for about half an hour. They are then hydro-extracted and dried. The only drawback to this process is that there is a possibility of sulphuric acid being developed on drying the goods. When aluminium formate is substituted for the acetate sulphate this cannot happen. (2) The cotton is first impregnated with a solution of soap containing some emulsified stearin or Japan wax. It is then hydro-extracted and placed in a solution of either aluminium formate or aluminium sulphate. When formate is used the goods are dried without washing but with aluminium sulphate they are first washed in water to remove excess of the reagent. Better results are obtained if the goods are dried after treatment with the soap solution.

Nets are sometimes made fireproof. The chemicals used for this purpose have been mentioned above. If only a temporary effect be required, the compound chosen may be mixed with the dressing. As a rule, however, it is better to precipitate the reagent on the fabric by double reaction. Thus, the goods may be passed through solutions of magnesium sulphate and sodium phosphate. Perkin's process for flannelette may be mentioned. The fabric is impregnated with a solution of sodium stannate, squeezed and dried. It is then placed in a solution of ammonium sulphate which causes the production of ammonium stannate and sodium sulphate—

$$Na_2SnO_3 + (NH_4)2SO_4 = (NH_4)2SnO_3 + Na_2SO_4.$$

Upon steaming the ammonium stannate is decomposed, leaving tin oxide firmly fixed in the fabric.

CALICO PRINTING

Dyeing consists in the application of dyestuffs to loose fibres, yarns, cloth, etc., with the object of equally colouring every part. The calico printer, however, aims at producing a localised dyeing of a woven fabric according to a pattern. To achieve this object, he employs the same dyestuffs that the dyer uses, but applies them by means of engraved blocks or cylinders, and dissolved or suspended in an aqueous medium suitably thickened by means of starches, dextrins, or gums. The dyer, except in the case of aged aniline black, completes the fixation of his colours in the dyebath; the printer subjects the printed cloth in most cases to the action of live steam, which may be superheated, either with or without pressure.

There are three different methods of producing a printed design.

I. Direct printing.
II. Discharge printing.
III. Resist printing.

Thickenings.—The commonly employed thickenings for printing are made up as follows :—

Albumen.—To 500 grms. of water at 35° C. add with constant stirring 500 grms. of albumen. Allow to stand for twenty-four hours, stirring occasionally till dissolved. This thickening soon goes putrid, unless preserved by the addition of 10 grms. carbolic acid crystals.

Starch Thickening.—Wheat starch, 220 grms.; water, 750 grms.; olive oil, 30 grms. The starch is stirred up with the cold water in a jacketed pan, and slowly brought to the boil with continued stirring. When the mixture begins to thicken, add the olive oil. Boil for twenty minutes.

Gum Tragacanth, 60/1000.—Tragacanth powder, 60 grms.; water, 940 grms. Mix the gum with 475 grms. of warm water, and allow to soak for twenty-four hours. Heat up and add gradually another 475 grms. of water. Boil and stir till a smooth paste results. Add 10 grms. carbolic acid.

Gum Tragasol or Gatto, 5 *per cent.*—Tragasol powder, 50 grms.; water, 950 grms. Add the powder gradually to the water, which is kept constantly stirred. When no further increase in thickness takes place, boil for one hour. Add 10 grms. carbolic acid.

Gum Arabic, 1/1.—Gum arabic, 500 grms.; water, 500 grms,

Mix the gum with warm water, and stir occasionally till dissolved. Finally boil till clear. A sample of gum which will not give a clear solution in water, but merely swells up, is unfit for printing.

Starch Tragacanth.—Wheat starch, 120 grms.; water, 780 grms.; tragacanth, 60/1000, 100 grms. The tragacanth paste is placed in a pan fitted with a good stirrer, and the water added a little at a time, waiting before each addition until the previous addition has been completely absorbed. When quite homogeneous, the starch is added, stirred till smooth, and then brought to the boil.

Colloresin DK.—Colloresin DK., 40 grms.; water, 940 grms.; ammonium sulphocyanide, 20 grms. The water and sulphocyanide are brought to the boil and added to the dry colloresin lumps. The mixture is stirred till the lumps have broken up, after which cold water is passed through the jacket of the pan. When the mixture has cooled to 80° C., solution will take place. No preservative is required.

Gum Dextrin Thickening.—White dextrin, 250 grms.; water, 250 grms.; gum arabic, 1/1, 500 grms. Stir the dextrin into the cold water, boil for five minutes, add the gum solution, and stir till homogeneous.

Starch British Gum Thickening.—British gum, 250 grms.; wheat starch, 80 grms.; water, 670 grms. The starch and gum are placed in the pan, the water mixed in gradually, and when quite smooth, brought to the boil, after which cooling water is turned on, and stirring continued till cold.

Alkaline Starch British Gum Thickening.—Wheat starch, 30 grms.; British gum, 150 grms.; caustic soda, 76 Tw., 350 grms.; water, 470 grms. The starch and British gum are stirred up with the cold water till smooth, the caustic soda is then added, and the mixture warmed to 70° C. for twenty minutes, being finally stirred till cold.

Direct Printing.—*Pigment Printing.*—Of all methods of direct printing, this is the simplest. Fixation depends on the fact that albumen, when heated to 70° C., is coagulated and becomes insoluble. The pigment, in paste or powder form, is mixed with albumen thickening. The printed cloth is dried as usual, and for complete fixation passed over steam-heated drying tins. Or it may be given a rapid passage through a steamer. Such prints are fast to rubbing and to cold water. But as the thickening is left on the cloth, the design is hard to the touch. The brightest of colours may be obtained in pigment form, but the fastness to light is very variable.

Direct Colours.—The method of fixation of the direct colours is not radically different from that employed in the dyehouse. The dyestuff

is printed on to the cloth dissolved in a suitable thickening, to which is also added a certain amount of sodium phosphate and glycerine. After printing, the cloth is dried, and steamed for one hour in wet steam. After steaming, the goods are washed in cold water, to which a little malt extract or rapidase may be added to assist in the removal of the thickening. Prints obtained in this way are of the same degree of fastness as the corresponding dyeings, and may be subjected to the same after-treatments as these for the purpose of increasing the fastness to light or washing.

Print Colour

Direct dye - - -	50 grms.	
Water - - -	- 400 ,.	
Sodium phosphate	- 20 ,.	
Glycerine - -	- 100 ,.	
Traganth, 60/1000	- 430 ,.	(or starch tragacanth).

Basic Colours.—Tannic acid and a salt of antimony are employed for the fixation of basic dyes in printing as they are in dyeing, but the method of application of the mordant takes a different course. The tannic acid is dissolved together with the dyestuff in the thickening. In order to prevent the dyestuff from combining immediately with the tannic acid to form an insoluble colour lake, a suitable solvent is added as well; those usually employed being acetic, formic or tartaric acid, glycerine, acetin, anilin oil, etc. After printing and drying, the goods are steamed, whereupon the volatile solvent is dissipated, and the dyestuff combines with the tannic acid. Fixation is completed by passing the steamed goods through a warm bath containing from 5 to 10 grms. of tartar emetic per litre. Finally wash in water, and soap hot.

Print Colour

Basic dye - - -	- 10 grms.	
Acetic acid, 40 per cent. -	- 150 ,.	
Water - - - -	- 160 ,.	
Starch tragacanth - -	- 600 ,.	
Tartaric acid, 10 per cent. -	- 20 ,.	
Tannic acid, 1/1 - - -	- 60 ,,	

The dyestuff is boiled up with the water, acetic acid, and tartaric acid. The solution is added to the thickening, boiled and stirred

till smooth and then cooled. The tannic acid solution must be made separately, and only added to the thickened dyestuff when the latter is quite cold.

Print colours made in this way do not keep very well, as the dyestuff gradually combines with the tannic acid. A similar combination takes place on the surface of the cloth if the printed goods are kept for any length of time before steaming. These difficulties may be avoided by printing a thickened tannic acid on to the cloth, which is then fixed in a salt of antimony in the usual way. On treating the printed cloth with a solution of basic dye, colour is taken up by the mordanted pattern. The tint that is absorbed by the unmordanted ground is removed on soaping. A suitable tannin print paste may contain—

Tannic acid	·	·	·	·	50	grms.
Water	·	·	·	·	450	,,
British gum	·	·	·	·	500	,,

The cloth may also be mordanted by padding in a 5 per cent. tannic acid solution, drying, and fixing with tartar emetic. The mordanted cloth is then printed with a colour containing—

Basic dye	·	·	·	·	10	grms.
Acetic acid, 40 per cent.	·	·	·	100	,,
Water	·	·	·	·	290	,,
Starch tragacanth	·	·	·	600	,,

After a slight steaming, the goods are washed in water and soaped hot.

Sulphur Colours.—For dyeing with sulphur colours, the dyestuff is dissolved in a solution of sodium sulphide, but this substance cannot be used for printing, owing to its deleterious effect on the copper print rollers. This action can be avoided by dissolving the dyestuff by the aid of sodium bisulphite and hydrosulphite. The printed goods are dried, steamed in a Mather and Platt ager at 102° to 104° C., washed, soaped, and dried.

Print Colour

Sulphur colour	·	·	·	·	30	grms.
Sodium bisulphite, 70° Tw.	·	·	40	,,
Water	·	·	·	·	110	,,
Caustic soda, 76° Tw.	·	·	·	250	,,
Hydrosulphite powder	·	·	·	10	,,
British gum, 1/1	·	·	·	560	,,

The dyestuff and bisulphite are mixed with the water at 65° to 70° C., the caustic soda is added, and the temperature maintained at 70° until complete solution sets in.   The hydrosulphite is dissolved in the British gum, which is then stirred into the dyestuff solution.

Vat Colours.—The vat dyes have to be reduced to their soluble leuco compounds before they can be fixed in printing as they are in dyeing. But owing to the easy oxidisability of the leuco compounds, they cannot be applied to the cloth ready formed in the print paste.   The print paste contains the unreduced colour, together with a reducing agent which only becomes active when exposed to air-free steam inside the Mather and Platt ager.   On leaving the ager, the leuco compound which was formed there is at once oxidised by the oxygen of the air, and the development of the full shade is completed, as in the case of the dyeing with the vat dyes, by means of a boiling soap bath.   The temperature of the steamer should be 102° to 104° C., and the speed of the cloth is regulated so as to give a passage lasting from five to six minutes.   The reducing agent almost universally employed to-day is the formaldehyde hydrosulphite compound sold as Rongalite, Formosul, or Britulite.

Print Colour

Vat dye paste	-	-	-	-	100	grms.
Glycerine	-	-	-	-	50	,,
Rongalite	-	-	-	-	80	,,
Alkaline starch British gum				-	770	,,

The vat dyes in powder form are not as easily got into solution as are the pastes, so that a preliminary reduction is necessary in the course of preparing the print colour.

Vat dye powder	-	-	-	-	10	grms.
Glycerine	-	-	-	-	50	,,
Alcohol	-	-	-	-	20	,,
Water	-	-	-	-	110	,,
Caustic soda, 90° Tw.	-	-	-	30	,,
Gum dextrin	-	-	-	-	570	,,
Hydrosulphite powder		-	-	20	,,
Rongalite	-	-	-	-	50	,,
Caustic soda, 90° Tw.	-	-	-	150	,,

The dye powder is first moistened with the alcohol, the glycerine and water added, followed by the caustic soda and thickening. The mixture is warmed to 60° C., and the hydrosulphite added. When reduction is complete, as shown by the change in colour, the mixture is cooled down to below 30° C., the second lot of caustic soda is added, and last of all the rongalite. If finely powdered, this will soon dissolve. If preferred, it may be added in the form of a solution, using 60 grms. of water for this, and only 50 grms. of water in the first stage of the mixing operation.

Indigo may also be printed by the caustic and hydrosulphite method, but the older glucose caustic method is still largely employed. The cloth is first padded in a 20 per cent. solution of glucose, and dried at 50° C. It is then printed with the following mixture :-

Indigo, 20 per cent. - - 100	grms.
Water - - - - - 180	,,
British gum - - - - 170	,,
Caustic soda, 90° Tw. - - 550	,,

The British gum is mixed with the water to a smooth cream, the indigo added, followed by the caustic liquor. Print, dry, steam for one minute in an air-free ager with moist steam. On issuing from the ager the pattern should show a yellow-brown colour. A bright yellow colour indicates over-ageing, with consequent loss in depth of colour. To complete oxidation, the goods are run straight into a cold bath containing 0·1 per cent. of sodium bichromate, well washed, and soaped hot.

Goods printed with a paste containing rongalite or the starch glucose mixture, rapidly become unfit for use, so that it is imperative to steam them as soon as possible after printing. According to a recently patented process of I.G. Dyes, this difficulty may be obviated by the use of colloresin DK, a water-soluble derivative of cellulose. The vat dye paste is mixed in the unreduced form with a suitable colloresin thickening. After drying, the prints may be kept indefinitely without fear of deterioration. For fixing, the goods are padded with an alkaline solution of rongalite and immediately dried at a moderate temperature and steamed. The colloresin becomes insoluble in the presence of an alkali, so that the dyestuff is firmly held during the padding process, without any fear of marking off.

Print Colour

Vat dye paste	-	-	-	-	250	grms.
Solution salt B	-	-	-	-	20	,,
Water	-	-	-	-	80	,,
Starch thickening	-	-	-	350	,,
Glycerine	-	-	-	-	50	,,
Colloresin solution	-	-	-	250	,,

The starch thickening contains—

Wheat starch	-	-	-	100	grms.
Water	-	-	-	-	880	,,
Ammonium sulphocyanide	-	-	20	,,

Rongalite developing bath—

Rongalite	-	-	-	-	140	grms.
Soda ash	-	-	-	-	65	,,
Water	-	-	-	-	630	,,
Glycerine	-	-	-	-	100	,,
Glauber's salt	-	-	-	65	,,

In order to avoid the extra process involved in padding the printed goods with rongalite, drying and steaming, they may be taken through a bath containing—

Water	-	-	-	-	800	grms.
Common salt	-	-	-	200	,,
Prestabit oil	-	-	-	2	,,
Acetone	-	-	-	-	20	,,
Caustic soda, 76° Tw.	-	-	-	90	,,

Just before use, 30 to 40 grms. of hydrosulphite powder are added. From this the goods pass straight into a steam chest for 30 seconds at 110° to 115° C. from which they run into a bath slightly acidulated with acetic acid, then oxidised with $\frac{1}{2}$ grm. perborate per litre, washed and soaped. Small amounts of vat dyes may be added to the padding liquor, should it be desired to produce a tinted ground. The machine is shown in Fig. 1 on page 338.

The Indigosols.—The leuco compounds of the vat dyes, as formed by the reduction of the dyestuff by means of alkaline hydrosulphite, are very unstable in the presence of air. It is possible, however, to add a stabilising chemical group, the resulting compounds being quite unaffected by atmospheric oxidation; under the influence of more energetic oxidising agents, the insoluble vat dye pigment is reformed, with the same degree of fastness as that of the vat dyes produced in the usual manner. There are three different methods

by which these indigosols or Soledon colours may be applied in printing.

(a) Chlorate method —

Indigosol orange, 4R - - -	60 grms.
Glycerine - - - - -	50 ,,
Solution salt B - - - -	30 ,,
Water - - - - -	250 ,,
Starch tragacanth - - -	450 ,,
Ammonium sulphocyanide - -	30 ,,
Sodium chlorate - - - -	20 ,,
Ammonium vanadate, 1/1000 -	100 ,,
Ammonia, 25 per cent. - -	10 ,,
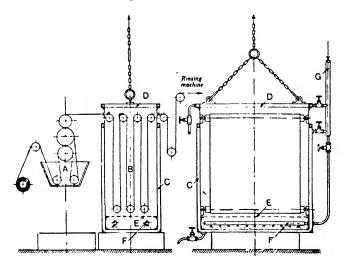
FIG. 1

A. Three-roller padding machine.
B. Steaming chest.
C. Iron container with steam jacket.
D. Cover for steam heating.
E. Perforated bottom.
F. Perforated pipe for working steam.
G. Steam conduit pipe.

Print, dry, steam five minutes at 95° C., and finish in a boiling soap. The printed goods may be kept for several days before steaming, should this be convenient.

(*b*) Nitrite method. The goods are printed with a colour containing—

Indigosol red, IIR · · ·	90 grms.
Glycerine · · · · ·	50 ,,
Water · · · · ·	300 ,,
Starch tragacanth · · ·	500 ,,
Sodium nitrite · · · ·	50 ,,
Ammonia · · · · ·	10 ,,

dried, and passed into a bath containing 20 grms. sulphuric acid per litre at 65° C., washed and soaped. Some colours require a slight steaming before going into the acid bath, and in no case is it deleterious.

(*c*) After-oxidation method.

The indigosol is applied by means of a paste containing—

Indigosol green, IB · · ·	80 grms.
Glycerine · · · · ·	50 ,,
Water · · · · ·	370 ,,
Starch tragacanth · · ·	500 ,,

Dry, steam five minutes, and oxidise in

	Grms.	
Ferric chloride · ·	30	
(or sodium nitrite) ·	30	for forty-five secs.
Sulphuric acid, 168° Tw.	20	at 40° C.
Sodium chloride · ·	20	
Water · · · ·	1000	

The Mordant Colours.—These colours have no affinity for the cellulose fibre, but have to be fixed with the help of a metallic oxide, applied either at the same time, or before the dyestuff. The mordant most commonly employed is chromium oxide, but aluminium and iron are also used.

The print colour may contain—

Alizarin blue, SR · · ·	70 grms.
Water · · · · ·	360 ,,
Starch tragacanth · · ·	500 ,,
Chromium acetate, 32° Tw · ·	70 ,,

Steam for one hour with not too dry steam, wash, and soap. During the steaming the chromium acetate gradually loses its acetic acid, and the chromium oxide as liberated combines with the dye to form the insoluble colour lake. Alizarin or turkey red requires a somewhat special treatment. The goods are first padded in a solution containing 70 grms. turkey red oil and 2·5 grms. ammonia 25 per cent. per litre, and dried at 50° C. They must be printed as soon as they are dry, otherwise a yellow discoloration may develop. The print paste for red contains—

Alizarin, 20 per cent.	-	-	-	-	150	grms.
Starch tragacanth	-	-	-	-	580	,,
Aluminium sulphocyanide, 32° Tw.	-	-	90	,,
Calcium acetate, 15° Tw.	-	-	-	-	96	,,
Oxalate of tin, 25° Tw.	-	-	-	-	84	,,

Dry, steam for one and a half hours, and fix in a bath containing 10 grms. chalk per litre at 60° C. Finally soap for half-hour in a bath containing—

Olive oil soap	-	-	-	-	3	grms.
Sodium stannate	-	-	-	-	0·15	,,
Water	-	-	-	-	-	1000	,

The goods may alternatively be printed with the mordant, steamed and dyed up subsequently. The mordant print colour is composed of—

Wheat starch	-	-	-	-	80	grms.
British gum	-	-	-	-	50	,,
Water	-	-	-	-	40	,,
Aluminium acetate, 32° Tw.	-	-	800	,,
Castor oil	-	-	-	-	30	,,

Steam and chalk as before. Great care must be taken to remove all the thickening before entering the dyebath. To ensure this, the chalk bath may be followed by a passage through diastafor or rapidase. To give a better shade, the goods may be padded in olein before printing. The dyeing is carried out by entering the goods into a bath of cold water containing the necessary amount of alizarin paste in suspension, and the temperature is gradually raised to 60° C. Rinse, steam, and soap at 60° with 2 grms. soap and 0·2 grm. sodium stannate per litre.

The Naphthol Colours (*Azoics*).—As in dyeing, the azoics are formed by the union of a naphthol or naphthoic acid (Naphthol, AS) with a diazotised " Fast Colour Base." The goods may be padded with the naphthol, dried, and printed with the thickened diazo base, or printed with the naphthol and the colour developed by padding in a solution of the diazo body. There are also marketed a certain number of " Rapid Fast Colours," which are a stabilised mixture of the naphthol and diazo body. The colour is developed by an acid treatment after printing and steaming.

(1) *Naphthol Prepare Method.*—The cloth is padded with a solution of the desired naphthol, and dried at not too high a temperature. The depth of the resulting print will depend on the concentration of the naphthol used in the padding liquor. The usual method of dissolving the naphthol is to stir it with the requisite amounts of caustic soda liquor and turkey red oil, and then to add hot water, after which the solution is diluted to the desired extent. It will be found that a more rapid solution of the naphthol results by stirring the powder with methylated spirit and water before the addition of the caustic. The following are the quantities required :—

Naphthol.	AS.	AS. BO.	AS. RL.	AS. SW.	AS. BG.	AS. TR.	AS. G.	AS. D.	AS. OL.	AS. E.
Weight	16 grms.	16	16	16	16	16	16	16	16	16
Alcohol	16 ,,	24	16	20	16	16	16	16	16	16
Caustic, 76° Tw.	6·2 c.cs.	8·5	6·2	5·2	5·2	6·2	9·5	6·2	5·2	6·2
Cold water	24	24	32	16	32	32	32	24	16	24

When solution has taken place, the naphthol is added to the required volume of water, to which has already been added 32 grms. of turkey red oil, and the following quantities of 76° Tw. caustic soda :—

Naphthol.	AS.	AS. BO.	AS. RL.	AS. SW.	AS. BG.	AS. TR.	AS. G.	AS. D.	AS. OL.	AS. E.
	13·5	19	33	33	33	20	30 Glauber's salt, 8 oz. per gal.	13·5	14·5	14·5

The fast colour salt is used at about four times the concentration of the naphthol pad. Thus if the naphthol pad contains 4 grms. per litre, the print paste would be made to contain—

Fast colour salt	-	-	-	16 grms.
Cold water -	-	-	-	34 ,,
Tragacanth, 6/1000	-	-	-	50 ,,

(The Fast Colour Salts are stabilised diazo preparations of the Fast Colour Bases.)

After printing, the goods are given a short air passage to give time for complete coupling to take place, then washed well, first in cold water, followed by hot water, and finally a soaping with 5 grms. soap per litre at the boil.

(2) *Printing on the Naphthol.*—The naphthol solution is prepared as above, and stirred into starch tragacanth thickening containing the requisite amount of caustic soda and turkey red oil. After printing, the goods are dried and passed into the solution of the Fast Colour salt, washed well, and soaped at the boil.

(3) *Rapid Fast Colours.*—The print paste contains—

Potassium chromate	-	-	-	50 grms.
Water -	-	-	-	300 ,,
Starch tragacanth	-	-	-	500 ,,

Just before use add Rapid Fast Colour, 150 grms.
Print, dry, and steam for five minutes. Develop in -

Acetic acid, 40 per cent.	-	-	35 grms.
Glauber's salt	-	-	-	75 ,,
Water to	-	-	-	1000 ,,

Wash, soap at the boil.

Aniline Black.—As in the dyeing of aniline black, a variety of catalysts may be employed, but for printing the most convenient is sodium carbonyl ferrocyanide, as it will stand drying up better than the more active catalysts, vanadium, iron or copper, without any danger of premature development of the black.

The print paste contains—

Aniline hydrochloride	-	-	-	-	95	grms.
Aniline oil	-	-	-	-	10	..
Sodium chlorate, 1/1	-	-	-	50	..
Water	-	-	-	-	-	245	..
Sodium carbonyl ferrocyanide, 1/1	-	-	100	,,
Tragacanth, 6/1000 -		-	-	500	,,

Print, dry carefully, and steam for two and a half minutes. Wash off, and soap at the boil. A bluer shade will be produced by a passage through a 1 per cent. solution of sodium bichromate before soaping.

Discharge Printing.—The cloth to be discharged is first dyed a uniform shade all over and then a design printed on which will discharge the dyed colour. Another dyestuff, which will withstand the action of the discharging reagent, may be added to the print colour, thus producing a coloured in place of a white discharge.

Discharges on Direct Colours.—White discharge—

British gum, 1/1	550 grms.
Rongalite, 1/1	400 ,,
Soda ash	10 ,,
Water	40 ,,

Print, dry, steam three to five minutes in air-free ager, and wash off in cold water.

Coloured Discharge.—As none of the direct colours are very fast, it is not economical to use expensive vat colours for the coloured ingredient. Basic dyes, however, are quite suitable. Use—

Basic dyestuff	40 grms.
Glycerine	140 ,,
Water	140 ,,
Acetin	60 ,,
Starch tragacanth	350 ,,
Tannin alcohol, 1/1	120 ,,
Rongalite powdered	150 ,,

Print, dry, steam five minutes, and complete the fixation of the basic colour by a passage through 5 grms. tartar emetic in 1000 warm water. Rinse.

Discharges on Basic Colours.—The cloth is padded with tannin and tartar emetic, dried, and printed with an alkaline paste which destroys the tannin and antimony mordant. The discharge paste contains—

British gum, 1/1	60 grms.
Glycerine	2 ,,
Caustic soda, 76° Tw.	38 ,,

Print on the mordanted cloth, dry thoroughly, steam with dry steam, and pass into 0·5 per cent. solution of sulphuric acid. Wash free from acid, and dye in the ordinary way with the desired basic dye.

To clear the whites, soap well after dyeing. Coloured discharges may be produced by the addition of a sulphur or vat colour and rongalite to the alkaline discharge paste. A suitable mixture is—

Vat dye paste	-	-	-	-	-	100	grms.
British gum, 1/1	-	-	-	-	370	,,
Caustic soda, 76° Tw.	-	-	-	250	,,
Rongalite -	-	-	-	-	-	100	,,
Kaolin, 1/1	-	-	-	-	-	150	,,
Sodium bisulphite	-	-	-	30	..

A half discharge can be obtained by printing on to the mordanted cloth a discharge of a mild alkaline character, which only partially destroys the mordant—

British gum	-	-	-	-	-	300 grms.
Sodium carbonate	-	-	-	-	50	,,
Water	-	-	-	-	-	650	..

After-treatment is the same as for the white caustic discharge.

Discharge Prints on Indigo.—Whilst the majority of the anthra-quinone vat colours are not very amenable to discharge processes, indigo may be discharged either white or coloured, by oxidising or reducing agents. Oxidation discharge—

(*a*) Wheat starch	-	-	-	-	-	100	grms.
Water	-	-	-	-	-	360	,,
Sodium chlorate, 1/1 -	-	-	-	540	,,
(*b*) British gum, 1/1	-	-	-	-	300	,,
Tartaric acid	-	-	-	-	-	500	,,
Citric acid, 1/1 -	-	-	-	-	200	,,

For use take 70 parts *a*, 20 parts *b*, and 5 parts potassium ferro-cyanide. Print on indigo dyed cloth, dry, steam five minutes at 100° C., and wash off in 0·5 per cent. caustic soda solution, followed by boiling soap. By using material which has been first dyed with indigo and afterwards with a naphthol, the indigo will be discharged leaving the naphthol colour for the design.

Chromate Discharge.—The indigo dyed cloth is printed with—

Starch tragacanth	-	-	-	-	70	grms.
Potassium chromate	-	-	-	-	15	,,
Olein oil	-	-	-	-	-	5	,,
Water	-	-	-	-	-	25	,,

Dry, steam two minutes at 100° C., pass into a solution containing 5 per cent. sulphuric acid and 5 per cent. oxalic acid at 60°. Wash till free from acid, and soap well.   By replacing the water with a proportion of a rapid fast colour, a coloured discharge is produced.

Reduction Discharge.—Reduction discharges with indigo are produced by adding to a suitably thickened rongalite paste leucotrope W, the function of which is to combine with the reduced indigo to give a stable leuco derivative which is soluble in alkali, but does not suffer reoxidation when exposed to the air.   A small amount of anthraquinone is also added, to act as a catalyst during the steaming.

Gum arabic, 1/1 - - - -	600 grms.
Zinc oxide paste, 1/1 - - -	200 ,,
Anthraquinone, 30 per cent. - -	40 ..
Leucotrope W - - - - -	80 ,.
Rongalite - - - - - -	80 ,,

The printed goods are dried and steamed as quickly as possible in an air-free ager at 105° C. for three minutes, and washed for twenty seconds in a solution containing 2 c.c. caustic soda of 76° Tw. per litre at the boil, after which they are rinsed in cold water and well soaped.

For the discharging of vat colours, a higher proportion of the active ingredients is required, and it is also better to pad the dyed cloth before printing with a 1·5 per cent. solution of leucotrope W.   The print paste contains—

British gum, 1/1 - - - -	300 grms.
Rongalite, 1/1 - - - - -	300 ,,
Leucotrope W - - - - -	150 ,,
Glycerine - - - - - -	50 ,,
Caustic, 90° Tw. - - - -	200 ,,

Steam three minutes, rinse in warm water, and soap at the boil for half an hour.

Discharges on Mordant Colours.—This style of printing is mainly of importance in connection with turkey red.   Reduction methods have practically displaced the older methods of oxidation discharges, with which there is always a grave danger of tendering through production of oxycellulose.   White discharge—

Gum arabic, 1/1 - - - -	100 grms.
Brown dextrin - - - - -	130 ,,
Rongalite - - - - - -	150 ,,
Caustic soda, 90° Tw, - - -	600 ,,

Warm to 50° C., and stir till dissolved; cool and add **20 grms.** bisulphite liquor. Print, dry, steam at 102°, wash and soap at **60°.** For coloured discharges, the following modification of the above may be employed—

Vat dye paste - - - - -	15 grms.
Wheat starch - - - - -	80 ,,
Water - - - - - -	200 ,,
China clay, 1/1 - - - - -	150 ,,
Rongalite - - - - -	250 ,,
Caustic soda, 76° Tw. - - -	170 ,.

Discharges on Naphthol Colours.—These are not susceptible to oxidation, but with the exception of those derived from Naphthol, AS.BR and AS.G are easily discharged by reduction.
White discharge—

Starch tragacanth - - -	500 grms.
Rongalite - - - - -	400 ,,
Anthraquinone paste, 30 per cent. -	50 ,,
Water - - - - -	50 ,,

Coloured Discharge with Basic Dyes—

Basic dye - - - - -	10 grms.
Acetin - - - -	50 ,,
Water - - - - -	100 ,,
Gum arabic, 1/1 - - -	220 ,,

Boil till dissolved, cool, and add—

Rongalite - - - - -	250 grms.
Aniline oil - - - -	100 ,,
Tannin alcohol, 1/1 - - -	270 ,,

Print, dry, steam, and fix the basic colour in tartar emetic.
Coloured Discharge with Vat Dyes—

Vat dye paste - - - -	100 grms.
Starch tragacanth - - -	400 ,,
Anthraquinone, 30 per cent - -	50 ,,
Glycerine - - - -	50 ,,
Rongalite - - - - -	250 ,,
Potassium carbonate - - -	150 ,,

Resist Printing.—The goods are printed with a design which, **on** subsequently dyeing or padding, completely resists absorption or

development of the dyestuff on the printed design. The process is mainly of importance in connection with vat colours and aniline black, as this cannot be discharged.

Resist for Vat Colours—

Wheat starch	100 grms.
Water	280 ,,
Gum arabic, 1/1	100 ,,
Copper sulphate	140 ,,
Lead nitrate	100 ,,
Lead sulphate paste, 60 per cent.	220 ,,
Lead acetate	60 ,,

Print, dry well, and dye in open width or on the padding mangle. After dyeing, wash well in hot water, and finally soap. Should the discharge pattern not be a clear white, it may be necessary to remove the remaining traces of coloured metallic compounds by treating with chemic followed by warm dilute hydrochloric acid.

Coloured vat dye resist—

Vat dye paste	100 grms.
Hydrosulphite	130 ,,
Glucose, 1/1	260 ,,
Ferrous sulphate	80 ,,
Stannous chloride	50 ,,
Gum arabic, 1/1	380 ,,

Print, dry, and pass into a 5 per cent. solution of caustic soda at 80° C., wash off and soap at the boil.

Resists with Aniline Black.—The cloth is padded with the mixture given on page 348, dried, and printed with—

Potassium sulphite, 90° Tw.	300 grms.
Zinc oxide, 1/1	100 ,,
Sodium acetate	100 ,,
British gum, 1/1	500 ,,

Steam for three minutes in the rapid ager to develop the black wash off, and soap at the boil.

Coloured Resist with Vat Colours—

Vat dye paste	100 grms.
Rongalite	80 ,,
Alkaline starch, British gum	300 ,,
Gum dextrin	400 ,,
Glucose, 1/1	120 ,,

Print, dry carefully, steam two minutes at 98° to 100° C., and finish off in a solution of 5 grms. sodium bichromate per litre at 60°. Wash and soap at the boil.

Coloured Resists with Naphthol Colours.—The cloth is padded with the aniline black liquor, dried carefully, and printed with—

Naphthol AS	-	-	-	-	-	40 grms.
Alcohol	-	-	-	-	-	40 ,,
Caustic soda, 76° Tw.		-	-	-	16 ,,
Water	-	-	-	-	-	60 ,,

When dissolved, stir into—

Starch tragacanth	-	-	-	-	500 grms.
Water	-	-	-	-	-	40 ,,
Olein oil	-	-	-	-	-	40 ,,
Zinc oxide, 1/1	-	-	-	-	150 .
Caustic, 90° Tw.	-	-	-	-	120 ,,

After printing, dry again carefully, steam for three minutes to develop the black, and develop the naphthol in a solution containing from 80 to 100 parts per 1000 of the appropriate fast colour salt. Give a short airing, rinse thoroughly, and soap at the boil.

Coloured Resists with Indigosols.—The print colour contains—

Indigosol dyestuff	-	-	-	-	50 grms.
Glycerine	-	-	-	-	-	50 ,,
Water	-	-	-	-	335 ,,
Starch tragacanth	-	-	-	450 ,,
Ammonium oxalate	-	-	-	40 ,,
Ammonia, 25 per cent.	-	-	10 ,,
Potassium sulphite, 90° Tw.	-	-	40 ,,
Sodium acetate	-	-	-	-	25 ,,

Print, dry, steam in the rapid ager for five minutes, and develop as before. In place of a fast colour salt, a fast colour base may be diazotised as follows :—

Fast scarlet TR base	-	-	-	20 grms.
Water	-	-	-	-	400 ,,
Hydrochloric acid, 32° Tw.	-	-	20 ,,
Sodium nitrite, 20 per cent.	-	-	48 ,,

After twenty minutes, add—

Sodium acetate, 30 per cent.	-	-	55 grms.
Acetic acid, 40 per cent.	-	-	20 ,,
Water to make	-	-	-	-	1000 ,,

Conversion Style.—Pad the cloth in a solution containing 40 grms. naphthol AS, D per litre, dry and develop in scarlet GG salt, 50 grms. per litre. Wash, dry, and pad in—

Indigosol, O	35 grms.
Water	800 ,,
Tragacanth, 65/1000	50 ,,
Ammonium sulphocyanide	7·5 ,,
Sodium chlorate	6 ,,
Ammonium vanadate, 1 1000	25 ,,
Water to make	1000 ,,

Print on White Discharge Resist—

British gum, 1/1	400 grms.
Rongalite, 2/1	260 ,,
Zinc oxide, 1/1	100 ,,
Potassium carbonate	100 ,,
Leucotrope W	50 ,,
Anthraquinone, 30 per cent.	40 ,,
Water	50 ,,

Red Resist—

British gum, 1/1	500 grms.
Sodium acetate	30 ,,
Sodium thiosulphate	200 ,,
Water	270 ,,

Dry carefully, steam five minutes in the rapid ager, dry, and print on the following blue resist :—

British gum, 1/1	500 grms.
Rongalite, 1/1	200 ,,
Potassium carbonate	100 ,,
Anthraquinone, 30 per cent.	50 ,,
Water	150 ,,

Dry carefully, steam three minutes in the air-free ager, pass into a dilute solution of sodium bichromate to reoxidise the indigo, wash well, and finish off in boiling soap.

THE APPLICATION OF DYESTUFFS TO COTTON AND RAYON MATERIALS

Machinery Used in Dyeing.—(*a*) Cotton wool is dyed on the pack system in machines of the Obermeyer type. The material is tightly packed in a perforated metal basket, round a central perforated cylinder. The dye-liquor is forced by means of a centrifugal pump into the central cylinder. It passes through the cotton into an outer tank, in which is located a coil of steam-pipes for heating. It is drawn from the outer tank by the pump, and returned to the central cylinder.

(*b*) Cops and cheeses, wound on perforated paper tubes, are fixed on to perforated metal skewers, the bases of which communicate with the interior of a hollow metal cylinder. The cylinder is immersed in a suitable tank, and the dye-liquor circulated through the material by means of a centrifugal pump. After dyeing and washing, surplus moisture is removed by connecting the cylinder to an evacuated receiver.

(*c*) Yarn in the hank is dyed suspended on sticks in a " dyebeck," a wooden box carrying a perforated steam-pipe along the bottom. It may be lined with monel metal or copper. The beck is of such a width as to carry conveniently sticks holding two hanks side by side, and of such a length as to accommodate from 10 to 100 lbs. of yarn. Apparatus for dyeing hanks mechanically may be divided into two classes. Either the liquor is moved through the hanks, as in the Hussong and Lonclose Engineering Company's machines, or the hanks are moved through the liquor. Representatives of this type are the Clauder Weldon and the more recent Gerber machines.

(*d*) Warps are dyed most commonly on a warp dyeing machine. This consists of a number of boxes fitted with rollers top and bottom, and squeeze rollers between each two boxes. The first box may contain boiling caustic soda for scouring the yarn, followed by one or two wash boxes supplied with cold water. The dyeing boxes proper are fed continuously with a solution of dyestuff of such a strength as to maintain the concentration of the dyestuff in the box. In order to obtain level dyeings, it is necessary to pass the warps several times backwards and forwards through the machine. Warps may also be dyed on the beam, a hollow, perforated cylinder through which the dye-liquor is forced, similarly to the method employed in dyeing cops or cheeses.

(*e*) Cotton piece goods are usually dyed in the open width on a " jigger " or " jig." The body of the jig is a conical box with parallel ends, the width of the cloth to be dyed. It carries two loose

rollers near the narrow bottom, and two more near the top. Above the box are mounted larger power-driven rollers, so placed that either one or the other is driven at will, or both may run " free." The cloth (100 lbs. or less) is wound on to one roller, and the loose end, threaded outside the four small rollers, fastened to the other roller. The box is charged with the requisite amount of dye-liquor, and the cloth wound back and forth from one large roller to the other until dyeing is complete. The cloth is removed by being wound up on a ": batch roller," a light wooden roller with iron axes resting on iron arms sloping up in such a manner that the " batch " rests on the jig roller, and the cloth is wound up on to the batch roller by frictional contact with the driven jig roller. When large quantities of cloth are required to be dyed to the same pale or medium shade, the operation is performed on a padding mangle. The cloth is drawn under rollers in a small box, through one nip of a 3-bowl mangle, down through the liquor again, and finally through the second nip, to be plaited down behind the machine. Dyestuff solution of a suitable strength is supplied continuously to the mangle box.

(*f*) Cotton and rayon mixture cloths and pure rayon cloths are too fragile to withstand the rough usage and tension of a jig. They must be dyed, either open or in the rope form, sewn into an endless band on a winch machine. The winch is a large open bobbin driven slowly above a dye-box with smooth sloping sides. The bulk of the material is thus always lying in the liquor, free from tension. The steam-pipe for treating the liquor is placed behind a perforated partition at one end of the dye-box. After dyeing, surplus moisture is removed either by drawing the fabric over a suction box or by hydro-extracting.

Classification of Dyestuffs

I. **Direct Dyes** are soluble in water. The material is treated with the aqueous solution of the dyestuff at or near the boil. Pale shades require no addition to the dye-bath, but in the case of medium and dark shades from 10 to 20 per cent. of common salt or Glauber's salt is added. To facilitate the production of level shades small additions of soap, sodium carbonate, or sodium phosphate may be added.

The fastness of many direct dyes is improved by an after-treatment with metallic salts, formaldehyde, or diazotisation and development.

(*a*) After-treatment with metallic salts. After dyeing the material is heated to 60° C. in a fresh bath containing 1 to 3 per cent. of copper

sulphate and 3 per cent. of acetic acid (40 per cent.). This gives increased fastness to light. The shade is frequently dulled.

(*b*) The material is treated in a fresh bath with 1 to 3 per cent. of sodium bichromate and 3 per cent. of acetic acid to give increased fastness to washing.

(*c*) The copper sulphate and sodium bichromate are applied together to give increased fastness both to light and washing.

(*d*) Chromium fluoride and acetic acid applied as above also gives increased fastness to washing.

(*e*) After-treatment with formaldehyde. Certain blues and blacks gain considerably in fastness to washing by working the dyed cotton in 3 per cent. formaldehyde (or the weight of the cotton) at 70° C. for half an hour.

(*f*) Diazotising and developing. Dyestuffs containing an, amino group, as auxochrome, are first dyed in the ordinary manner for direct dyes, washed, and worked for fifteen minutes in 2 per cent. sodium nitrite and 4 per cent. hydrochloric acid as cold as possible, washed, and entered at once into a cold developing bath containing an amine or phenol with a sufficiency of alkali to bring the " developer " into solution. The chiefly used developers are : Alpha and beta-naphthol, meta - phenylene and tolulene diamine, amino-naphthol, resorcin, amino - diphenylamine, and certain naphthol sulphonic acids. Primaline (with beta-naphthol) and chlorazol black BH with phenylene diamine are two of the most important developed colours.

(*g*) A variant of this process is that known as *Coupling*. The cotton is dyed as usual and then worked in a cold solution of a diazotised amine, para-nitranilin being the " coupler " most usually employed. A stable form of diazotised para-nitranilin can be bought under the name of nitrazol, azophor red, or nitrosamine red.

In general, the direct dyes are capable of giving fairly bright and full shades on cotton, none of which are at all fast to hot water, and still less so to a washing with soap. Some few are fast to light and chlorine.

II. **Basic Dyes**.—Cotton has very little affinity for basic dyes ; consequently they can only be applied to cotton which has been previously impregnated with a metallic mordant. The cotton is entered into a bath at 80° C. containing from 1 to 5 per cent. of tannic acid and worked till cold. It is then evenly wrung out or squeezed and entered without washing into a fixing bath containing from 1 to 2·5 per cent. of tartar emetic, or antimony fluoride, or oxalate. It is then washed and entered into a bath containing 5 per cent. of acetic acid, to which a solution of the basic dye is added gradually,

to ensure level shades. Finally the temperature is slowly raised to 80° C. (only to 60° C. in the case of Auramine), or until the dye-liquor is completely exhausted.

The basic dyes yield some of the brightest colours known, but in general are very fugitive to light, though fairly fast to washing.

Brighter, though more fugitive, shades can be obtained by padding the material in a solution of turkey red oil, drying, and fixing in aluminium acetate.

Direct dyes act as weak mordants for basic colours. The direct dyed material is entered into a cold acetic acid bath, to which is gradually added the solution of basic dye. This " topping " process is only employed where a little extra brightness is desired. The results are not at all fast.

III. **Sulphur Colours**.—-These dyes are marketed as dark coloured powders, insoluble in water. To get them into solution they are boiled with equal weights of soda ash and sodium sulphide and a little water. The solution thus obtained is added to the dye-bath through a sieve, and the material dyed at the boil with the addition of from 30 to 100 per cent. of common salt. Copper-lined vessels or copper pipes must be avoided. As the dye-liquor oxidises very readily, with consequent deposition of insoluble colouring matter, it is better to dye hanks on bent iron rods, so that they hang entirely below the surface of the liquor.

The fastness to light of many of the sulphur colours is considerably improved by an after-treatment with sodium bichromate and acetic acid. This after-treatment also avoids to a considerable extent the danger of subsequent tendering, a fault which is liable to develop only after the dyed goods have lain for some months in store. The tendering is due to the slow formation of sulphuric acid. A final treatment in a bath of sodium acetate or sodium carbonate is said to be a preventive, but has not proved to be universally successful. The shades given by sulphur colours are none of them very bright, but all are extremely fast to washing, and usually to light as well. They are not fast to bleaching (hypochlorites).

The sulphide dyes are distinguished commercially by such names as Sulphur, Sulphurol, Thiogene, Thionol, Thioxine, Cross-dye, Immedial, Katigen, Kryogen, Pyrogen, Pyrol, Rexol, Eclipse, Vidal, and Auronal.

IV. **Vat Dyes**.—The vat dyes are sold commercially either as insoluble powders or in the paste form, containing usually about 10 per cent. of colouring matter in a very finely divided form. Until recently indigo was the only vat dye known, but there are now many derivatives of indigo available, verging in shade from scarlet to

violet and deep blue. Like indigo itself they are brought into solution by reduction with caustic soda and sodium hydrosulphite. Dyeing takes place at the ordinary temperature. When complete, the goods are squeezed evenly and exposed to the air, whereby the residual hydrosulphite is destroyed and the leuco compound of the dyestuff oxidised back to the original insoluble pigment. The operation is completed by a treatment with boiling soap.

The vat dyes derived from anthraquinone are applied in a similar manner, except that they require a higher proportion of caustic soda, and are usually dyed at an elevated temperature, up to 80° C. Similar precautions have to be taken, as in the case of sulphur colours, to prevent undue access of air with consequent unlevel or bronzy dyeings. The anthraquinone vat colours are as a rule considerably faster than the indigoid colours, both to light, washing, and chlorine. Some of the vat dyes may now be obtained as soluble stabilised leuco compounds, which are applied just like direct colours, and fixed by a subsequent mild oxidation with ferric chloride or acidified sodium nitrite. The indigo derivatives are known as Indigosols, those from anthraquinone as Soledon colours.

V. **Azoic Colours.**—These are insoluble azo dyes formed on the fibre by impregnation with a phenol, followed by treatment with a suitable diazotised amine. Practically the only phenolic body employed is beta-naphthol and certain naphthol carboxylic acids and their derivatives. The forerunner of this process was "Para Red." Cotton is padded in an alkalin resolution of beta-naphthol (2·5 grams) per litre, together with the necessary amount of caustic soda and about three times its weight of turkey red oil. The goods are dried as rapidly as possible in absence of light (which causes brown stains), cooled, and passed into a solution of diazotised para-nitraniline, made faintly alkaline by the addition of sodium acetate. The formation of the red colour is instantaneous. A final hot soaping is required to remove loosely combined colouring matter. Much superior both in fastness and in brightness of shade are the dyeings made with naphthol AS (beta-oxynaphthoic acid) and its derivatives, which are characterised by two more letters in their designation. These " naphthols " are all to a certain extent substantive to cotton, so that it is not necessary to fix them by drying, as in the case of beta-naphthol itself. A great number of " developers " are also available with which they may be coupled, which are known as fast colour bases. Fast colour salts are the corresponding ready-made diazo-compounds.

VI. **Oxidation Colours.**—The only important member of this series is aniline black. " Dyed black," which is applicable only

to cotton yarn, is produced by entering the hanks into a cold bath containing 3 per cent. of aniline, with sufficient hydrochloric and sulphuric acid to bring it into solution, and 6 per cent. of sodium bichromate. The yarn is turned constantly whilst the mixture is brought slowly to the boil, and the bronzy black thus produced, steamed and finally soaped. Yarn dyed in this way is not tendered, but inevitably rubs somewhat. Piece goods are dyed with an '' Aged Black.'' The cotton is padded with a cold solution containing about 15 per cent. of aniline, partly free, partly as hydrochloride, sodium chlorate, and an oxygen carrier such as copper sulphate, ferric sulphate, sodium ferrocyanide (prussiate black) or ammonium vanadates. The goods are dried and passed slowly through a closed chamber at about 65° C., when a greenish black is rapidly developed. The full shade is developed by a subsequent treatment in a cold bath of 3 per cent. sodium bichromate, which at the same time renders the black ungreenable. There is a risk of tendering by this process.

The shade may be modified by the addition of small amounts of other amines to the aniline. Artho-toluidine gives a browner tone, paraphenylene diamine a deeper bluish black (and also more rapid ageing), ortho-amido-phenol or para-amino-diphenylamine a greenish tone. The tone of the pure aniline black can also be modified by small additions of acid or alkali to the chrome bath. Acetic acid gives a greener shade, whilst sodium carbonate or a little free aniline gives a redder tone.

VII. **Metallic Dyes.**—Iron buff is produced by precipitating hydrated ferric oxide in the fibre. The cotton is padded in a solution of ferric chloride or sulphate and passed into a boiling bath of sodium carbonate or hydroxide. More level shades are obtained by first bottoming the cotton with tannic acid. The iron black is treated with an oxidising agent, which destroys the tannin and leaves the iron oxide intact. Admixture of a chromium salt with the iron salt, and fixation in sodium silicate, gives the shade of mineral khaki. Iron buff is very fast to light and washing, but is rapidly removed by weak acids. On treatment with acidified sodium ferrocyanide it is converted into prussian blue. This colour is fast to light and acids, but not to alkalies.

Chrome yellow is produced on cotton by padding with lead acetate, drying, and passing into a solution of sodium bichromate. It is converted into chrome orange by boiling with lime water. These two colours, although extremely fast, are no longer much used on account of the danger of lead poisoning both to the dyers and wearers of the material.

Rayon.—Regenerated cellulose (viscose and cuprammonium) is

dyed similarly to cotton. On account of the greater affinity for dyestuffs in general, more difficulty is experienced in obtaining level shades. Unequal degrees of affinity are exhibited by different brands of silk, and even in batches of the same quality. This defect is avoided to some extent by careful grading of qualities on the part of the rayon manufacturers. British Dyestuffs Corporation have also contributed to the solution of the problem of unlevel dyeing rayons by marketing a range of direct dyes under the name of the Icyl colours, which have the valuable property of dyeing level shades on rayons of normally diverse character. C. M. Whittaker, of Messrs Courtaulds, has recently published some very valuable work on this subject. He has found that direct cotton dyes can be classified by their power of dyeing viscose at different temperatures. Those dyestuffs which dye a full shade from a cold bath are those which tend to accentuate unlevelness in the yarn. Dyestuffs which dye viscose most readily at a high temperature only are characterised by their level dyeing qualities.

The Dyeing of Cellulose Acetate Silks.—This material is absolutely unaffected by the great majority of direct cotton dyestuffs. Sulphur and vat dyes cannot be used, as the alkaline native of the dye-bath rapidly saponifies the acetyl group, with consequent regeneration of cellulose. The deacetylated fibre can be dyed in this condition, but parallel with the attack on the acetyl group goes a proportional destruction of lustre. Cellulose acetate can be dyed from an acetic acid solution with basic colours, but the shades obtained, though bright and full, are very sensitive both to light and washing. Professor Arthur Green was the first to work out a class of dyestuffs giving fast shades on cellulose acetate. Insoluble strongly coloured bodies were converted into soluble omega-sulphonic acids, which in the dye-bath slowly revert to the insoluble form. The particles of insoluble pigment are liberated in a fine, colloidal state of division, in which form they are capable of being absorbed by the acetate fibre and firmly fixed. This class of colour, the Ionamines, has now, however, been superseded by colloidal dispersions of insoluble pigments in sulphonated oil. The only Ionamine still in use is that for producing a black, by diazotising and developing after dyeing in the normal manner. The insoluble colloidal colour dispersions made by the Celanese Company under the name of the S.R.A. colours were amongst the earliest introduced. They are applied from a soap bath, the temperature of which should not exceed 75° C. All the more important dyestuff firms now market similar products, sold under the names of Duranol, Celatene, Setacyl, Cibacete, etc.

IDENTIFICATION OF TEXTILE FIBRES

By J. M. PRESTON

Although an enormous volume of work has been published upon this subject, it can be divided up into relatively few categories: the chemical, the physical, the morphological or microscopical appearance, the ultramicroscopical, and those depending on polarised light and ultra violet light. It is not proposed, however, to say more than a few words about any but the first two of these, as the others either require special apparatus or technique. Taking the above list in the reverse order: ultra violet light has been proposed for the identification of rayons and vegetable fibres, but is unreliable; however, it is very useful for showing the presence of foreign matter. The ultramicroscope has been used with some success to distinguish amongst the natural and artificial silks, yet its technique is too difficult for general application. Whilst polarised light in conjunction with the microscope has proved both useful and reliable in investigating textile fibres, yet it supplements rather than replaces observations on the morphology or form of the fibre, of which last the cross section is especially important. Lastly, physical and chemical tests are comparatively simple to execute, and in many cases are capable of identifying the fibres quite accurately, in others, however, such as distinguishing between viscose and cuprammonium rayons, testing for mercerisation and identifying the constituents of a mixed yarn, these tests should be used in conjunction with the microscope.

(*a*) **Burning Test.**—This is simply carried out by igniting a small portion of the fibres, allowing them to burn for a few moments and then blowing them out. The charred stump should be smelled, and the odour (if any) noted, as this gives a valuable method of distinguishing the animal fibres. It should also be observed whether or not there is any ash or residue (*vide* note 8).

(*b*) **Staple Test.**—This test is made by untwisting the fibres in a yarn, when it will be seen whether they are staple fibres or continuous filaments (*vide* note 7).

(*c*) **Twist Test (Nodder).**—This test must be carried out on the individual fibres of the yarn and not on the yarn itself. It depends on the direction of the spirals in the fibre, which are arranged like a spiral spring; in some fibres they are left-handed, and in others right-handed. When a fibre is wetted the fibre spirals uncoil slightly and coil up again on drying, and the direction of the twisting that takes place depends on the direction of the spiral in the fibre.

TABLE OF PHYSICAL AND CHEMICAL TESTS

		Burn Test (A).	Staple Test (B).	Twist Test (C).	Elongation Test (D).	Herzberg Solution (E).	Acetic Acid (F).	Sodium Plumbite (G).	Diphenyl-amine (H).	Special Tests.
Vegetable	Cotton	No smell / No ash	Staple	...	Short	Claret-Brown	...	...	...	...
	Linen		,,	Clock	,,	...	...	...	...	...
	Hemp		,,	Anticlock	,,	...	...	...	...	(1)
	Jute		,,	,,	,,	Yellow	...	...	...	...
	Ramie		,,	Clock	,,	Claret	...	...	...	...
Rayon	Cuprammonium	Characteristic smell / Black residue	Continuous (7)	...	Long	Purple-Blue	...	...	...	(2), (3)
	Nitro		,,	...	,,	...	...	...	Blue	...
	Viscose		,, (7)	...	,,	...	...	...	...	(4), (3)
	Sulphur viscose		,,	...	...	...	...	Brown	...	...
	Lillienfeldt viscose		,,	...	Short	Yellow	...	...	...	...
	Acetate		,,	...	Long	,,	Dissolve (9)	...	...	...
Animal	Wool		Staple	...	...	...	...	Brown	...	...
	Silk (8)		Continuous	...	...	...	...	...	Brown	...
	Tussah silk		,,	...	...	...	...	...	Brown	...
Modified	Mercerised cotton	No smell / No ash	Staple	...	Short	Dark Purple	...	...	...	(5)
	Oxycellulose		...	...	,,	...	...	...	...	(6)

Thus the test is carried out by taking the fibre and holding the free end towards the observer; the direction of rotation of this end as the fibre dries is found to be either clock or anti-clockwise, depending on the fibre in question.

(*d*) **Elongation Test.**—If the behaviour of fibres on breaking them is observed, it will be found that some stretch or elongate to a considerable extent (20-30 per cent.) before breaking, whilst others break with scarcely any elongation at all.

(*e*) **Herzberg Solution.**—The fibres are treated with the solution and the colour is noted. The solution is made as follows:—

(*a*) 20 grms. zinc chloride are dissolved in 10 c.c. water.

(*b*) 2·1 grms. potassium iodide $\Big\}$ are dissolved in 5 c.c. water.
0·1 grm. iodine

Mix the two solutions, leave to settle, filter, and add a fragment of iodine. Store away from the light.

(*f*) **Glacial Acetic Acid** is found to dissolve acetate rayon in the cold, but no other fibre.

(*g*) **Sodium Plumbite.**—This reagent can be used to demonstrate the presence of sulphur in a fibre by placing them in contact and warming gently. The solution is made as follows:—

To a 10 per cent. solution of lead acetate add 20 per cent. caustic soda solution till the precipitate which forms just dissolves on heating.

(*h*) **Diphenylamine.**—This substance is capable of giving an intense blue colour with nitro groups, and its use in the present instance depends on its ability to detect traces of nitro groups in nitro rayon that have not been entirely removed during denitration. The reagent is dissolved in concentrated sulphuric acid to a 1 per cent. solution. It is used cold.

Special Tests.

(1) **Phloroglucinol.**—When the fibres are moistened first with a 10 per cent. solution of phloroglucinol in alcohol and then with concentrated hydrochloric acid, lignified fibres give a deep crimson colour.

(2) **Copper Xanthate Reaction (Wagner).**—In this, use is made of the intense yellow colour of copper xanthate, the reaction being sufficiently sensitive to detect the minute traces of copper which are left in cuprammonium rayon. The procedure is to ash 3·5 grms. of the rayon in a platinum crucible; this is then dissolved in hydrochloric acid and boiled. Ammonia is added in slight excess to precipitate the hydroxides of iron and aluminium which are filtered off. The filtrate is concentrated to 5 c.c., and a drop of a 5 per cent. solution of potassium xanthate is added.

(3) Differential Dyeing Test.—This test utilises the different dyeing properties of viscose and cuprammonium rayons; the two fibres are dyed simultaneously in a dye bath containing a red and a blue dye, the blue is preferentially absorbed by the cuprammonium, and the red by the viscose. The method is as follows :—

15 c.c. pelican ink No. 4001 (Gunther Wagner).
20 c.c. ½ per cent. solution of eosin extra (I. G. Farb).
65 c.c. water.

The rayons under examination are worked in this bath for 5 minutes at room temperature. They are then thoroughly washed and dried.

(4) Hydrogen Sulphide Test (Bureau of Standards).—This test depends on the presence of traces of sulphur compounds in viscose rayon, therefore sulphur compounds from dyestuffs (if any) must be washed out as well as possible before making the test. These sulphur compounds are decomposed by prolonged boiling with acids into hydrogen sulphide, and this latter is detected by passing the evolved gases through lead acetate paper, which is blackened by it. The test is carried out on 5 grms. of the rayon, which is placed in a special " diaphragm " flask (this is designed so that it can be perfectly covered by a lead acetate paper, and prevents any gases escaping without first passing through the paper). The mouth of the flask is covered with a filter paper, previously soaked in 10 per cent. lead acetate solution, and made air-tight with rubber bands. The rayon had been covered with 100 c.c. of water, and the flask was then heated for 4 hours on a gently boiling water bath, then another 100 c.c. water plus 3 c.c. glacial acetic acid were added, and again heated for 4 hours; at the end of this period 100 c.c. water, 3 c.c. glacial acetic acid, and 3 c.c. concentrated sulphuric acid were poured over the rayon and heated on the water bath as before. A black or brown coloration of the filter paper indicates viscose.

(5) Mercerisation Test (Mendell).—This test uses the increased affinity of mercerised cotton for direct dyestuffs. Mercerised and unmercerised materials are treated by diluting 320 c.c. of 1,600 sp. gr. sulphuric acid with 260 c.c. of 40 per cent formaldehyde. The samples are treated in this solution for 2 minutes at room temperature, washed, and neutralised with hot dilute sodium carbonate and then dyed with Chlorazol sky blue G. W. The mercerised material shows a much darker colour under these conditions.

(6) Oxycellulose Test (Rhodes).—This test depends on the ability of oxycellulose to reduce mercuric potassium iodide solution to metallic mercury, which shows up as a dark stain on the yarn or

fabric. The reagent can be used on rayons as well as vegetable fibres. The solution is made up by dissolving:—

$$\left.\begin{array}{l} \text{100 grms. mercuric iodide} \\ \text{80 grms. potassium iodide} \end{array}\right\}$$

in   500 c.c. water, and to this is added
    5000 c.c. 3N caustic soda.

Allow to stand over night and filter through glass wool.

After removing starch or other foreign matter, test samples are boiled for 1 minute in the solution, then rinsed in warm 1 per cent. potassium iodide solution, and finally washed in water. Over-bleached or tendered material shows up darker than normal.

(7) **Note on Staple Test.**—In the case of cuprammonium and viscose rayons, although these are usually in the form of continuous filaments, they may also be met with cut up into short lengths and spun in the form of staple fibre.

(8) **Note on Burning Test.**—In the case of weighted silk, the fibres will only burn with difficulty, and will leave behind a mineral skeleton which does not shrivel up as does the pure material.

(9) **Note on Modified Acetate.**—In order to obtain solid effects when dyeing mixed fabrics and for printed goods, acetate rayons are partially hydrolysed. When in this state they only partially dissolve in acetic acid. The Burning Test, however, will still be found to work if conducted very carefully—the fibre must be heated without actually igniting it.

JUTE

By T. WOODHOUSE and A. BRAND

Consumption of Jute.—The present annual consumption of jute approximates to 9⅜ million bales of 400 lbs. each, or, say, 1⅜ million tons.

For purposes of comparison, 3·57 bales per acre are taken to constitute a 100 per cent. crop. During the past eleven seasons the crop has varied from 66·7 per cent. in 1920-21 to 95·2 per cent. in 1918-19. The highest, lowest, and average figures are given in the following table.

Jute Consumption

Season.	Acres Sown.	Number of Bales.	Weight in Tons.	Bales per Acre.	Percentage Crop.
Highest -	2,500,382	8,501,258	1,518,082	3·40	95·2
Average -	2,493,291	7,478,192	1,335,391	2·98	83·5
Lowest -	2,502,273	5,962,192	1,064,677	2·38	66·7

Classification of Jute Fibres.—It is possible to classify the many different qualities into nine groups, five of primary importance, and four of a secondary character. The first five are Serajgunge, Naraingunge, Uttarya, Daisee, and Dowrah ; the other four are Bimlipatam, Chittagong, Dacca, and Tossa. Particular samples may differ greatly from the characteristic descriptions which follow, but this is due to the large area cultivated, together with climatic conditions and differences in methods of cultivation and subsequent operations. In general, the fibres agree with the characteristics embodied in the table on the next page.

Chittagong is similar in all general characteristics to Naraingunje. Dacca is also similar to Naraingunje, but is usually more cleanly prepared and almost entirely free from objectionable root ends. Tossa is similar to the best Daisee, but is cleaner and stronger ; the best grades have good lustre and excellent spinning qualities, and are suitable for fine yarns.

There are several important phases between the time of cultivation and the time that the fibre, baled or in loose state, reaches the spinning mills. Space will not permit of the description of any of these phases.

Classification of Jute Fibres

Type of Jute.	Description of Fibre.	Colour of Fibre.	Kind and Quality of Yarn, &c., Suitable for	Area in which Fibre is Grown.	Chief Market.
1. Serajgunge	Moderately strong, soft, easily bleached, tends to produce nappy or hairy yarn, fine gloss particularly in Deswal quality, which is under average length.	White to bluish- or reddish-grey; occasionally black-coloured or dark reddish-coloured root ends.	First-class wefts; 30 per cent. of production is hessian quality.	Tracts of land watered by New Brahmaputra or Jamuna River.	Serajgunge.
2. Naraingunge	Good strength, crisp and free-running inte fibre; rooty and mossy upon occasion.	Mainly creamy-white, but reddish at fibre ends; often red roots.	First-class warps and wefts; 30 per cent. of production is hessian quality.	Lands watered by Old Brahmaputra River, liable to floods.	Naraingunge and Chandpur.
3. Uttarya	Similar to (1) and (2) in its general characteristics.	Inferior to (1) and (2); often retted and washed in ditch water.	About 30 per cent. is hessian quality.	High lands watered by tributaries of the Brahmaputra River.	Domar, Forbeshgunje, Huldibari, Kasba and Kissingunje.
4. Daisee	Moderately strong; soft and silky; obtained from *Corchorus Olitorius*.	Light red to slate blue and dark grey.	Used in mixtures where colour is not important.	Highlands near Calcutta watered by the rivers Bhagirathi, Damoodar and Roopnerain.	Baidyabati and Belgatchia.
5. Dowrah	Medium strength; coarse, hard, short, and brittle, rooty and barky.	Dark reddish, brown and nearly black.	Common heavy sacking, and other similar wefts; also used for ropes.	Low-lying lands periodically flooded by River Ganges.	Angari, Berbamgunje, and Madaripur.
6. Bimlipatam	Fair strength; coarse, hard and short; lacking in spinning quality; really a kind of hemp obtained from the *Hibiscus Cannabinus*.	Light grey to dark grey.	Mainly in heavy weft mixtures.	Many parts of India.	

Batch-Setting.—Batch-setting refers to the arrangement, quality, and number of bales required in a batch.   Practically any number of bales up to twenty or many more may be used, and the variety is **great.**

Typical batches may be as under :—

1. A 10-bale batch for 8 lbs. per spyndle fine warp—
    2 bales Standard First Grade Serajgunge.
    2   ,,   First Grade Naraingunge.
    2   ,,   Second Grade Naraingunge.
    2   ,,   First Grade Daisee.
    2   ,,   Hard jute with roots cut at blades before batching.
2. A 10-bale batch for 8 lbs. per spyndle medium warp—
    4 bales First Grade Serajgunge.
    3   ,,   Superior Grade Naraingunge.
    3   ,,   Hard Jute.
3. A 9-bale batch for 8 and 9 lbs. common weft—
    3 bales First Grade Daisee.
    3   ,,   Second Grade Serajgunge.
    2   ,,   Third Grade Serajgunge.
    1 bale Cuttings, or, alternatively, 400 lbs. waste.
4. A 10-bale batch for 48 lbs. per spyndle sacking weft—
    3 bales Naraingunge, with roots.
    3   ,,   Rejections.
    3   ,,   Cuttings.
    1 bale (400 lbs.) spinners' soft waste.

Bale Opening.—The operation of loosening the fibre by subjecting the hard heads of jute to suitable processes, sometimes done by hand, but more usually by specially designed machines.   The desired number of bales in the batch is placed near the feed of such a machine, the ropes are cut, and the heads of jute fed into the machine where they are treated and ultimately delivered in a comparatively loose state. As the treated heads emerge, each is passed to a striker-up or batcher who divides it into pieces or stricks of 2 to 3 lbs. weight, ready for the softening machine.

There are at least three distinct types of bale openers, each of which is capable of dealing with about twenty bales per hour, or approximately one thousand bales per week.   Some machines have deep-fluted rollers, others have rings of projecting spherical knobs, and some vary the speed of the rollers.   25 to 30 cwt. pressure is imparted to the material, while representative data may be : Floor space, 15 ft. 8 in. × 6 ft. 4 in. ;   pulleys, 20 in. diameter × 4½ in. wide ;   pulley speed, 140 r.p.m. ;   approximately 3 H.P. ;   weight about 90 cwts.

Softening.—This embodies division of the heads of jute, its lubrication, and treatment between a considerable number of fluted rollers, say sixty-three pairs, or even more, each roller being about 5 in. diameter.   The small stricks of 2 to 3 lbs. each are delivered from this machine in an extremely soft and pliable condition. and during their passage dust and dirt are removed, while the stricks are lubricated with oil and water at suitable places.   A safety device is invariably attached to each machine to minimise accidents.   The softened and lubricated fibre is stacked and allowed to condition for twenty-four to forty-eight hours.   Special machines are utilised for the treatment of root ends and cuttings.

Animal or fish oils, vegetable oils, and mineral oils are used along with water—sometimes made as emulsions—while " clensel " and other compounds are also used.   About 1 to $1\frac{1}{2}$ gals. of oil and 6 to 8 gals. of water are used for each bale.   When these liquids are applied independently, it is a common practice to apply the oil about the middle of the machine (the 32nd pair in a 63-pair machine), and the water is introduced a few pairs nearer the feed.

Batching mixtures vary greatly, and the following are given as bases :—

1. For a 10-bale batch ; ordinary warps and wefts—
   Whale oil -   -   -   -   4 gals.
   Mineral oil -   -   -   -   12 ,,
   Soft soap   -   -   -   -   4 lbs.
   Water   -   -   -   -   70 to 80 gals., depending upon atmospheric conditions.

2. For a 12-bale batch ; medium or fine yarns—
   Whale oil   -   -   -   -   5 gals.
   Seal oil   -   -   -   -   4 ,,
   Mineral oil   -   -   -   8 ,,
   Water   -   -   -   -   70 to 80 gals.
   Soft soap   -   -   -   -   5 lbs.

3. For a 14-bale batch ; common or low grade yarn—
   Whale oil (Nos. 3 or 4)   -   4 gals.
   Fish oil   -   -   -   -   8 ,,
   Mineral oil -   -   -   8 ,,
   Water   -   -   -   :   60 to 70 gals., heated to increase the poor absorbent properties of the fish oil.

Softening machines are usually arranged abreast of each other and parallel to the length of the batching or softening house.   The pulley speed is approximately 140 r.p.m.   The horse-power varies

from 8 H.P. for 31 pairs of rollers to 18 H.P. for 71 pairs, while the floor space is about 9 ft. in width by 23 to 42 ft. in length. In nearly every case a dust extraction plant is fitted, for there is usually a considerable amount of dust escaping particularly near the feed and a little further forward.

The ropes which bind the bales are cut up into about 1-ft. lengths, knots and splices removed, and the lengths and all available material treated in some type of waste cleaner or teazer. The treated ropes should be well batched, and conditioned for a few days before the carding operation. The root ends are also treated in " The Spence Root-Comber " made by Messrs James F. Low & Co. Ltd., Monifieth, Forfarshire.*

Carding.—Two types of carding machines—breaker card and finisher card—are in general use, but occasionally an intermediate card is employed. All have the object of parallelising the fibres and splitting them lengthwise into more filaments.

BREAKER CARDS.—These are usually 2-pair, half-circular, down-strikers, shell-feed machines. All the rollers are 6 ft. wide and 5 ft. 11 in. between the flanges. The cylinders are usually 4 ft. diameter, but several modern machines have 5-ft. diameter cylinders ; the advantage of the latter is in the greater number of pins in effective working position opposite each roller. Cast-iron cylinders and steel tube rollers are tending to displace the more common wood-lagged variety. Cylinder speeds vary from 180 to 200 r.p.m. with 4-ft. cylinders to from 145 to 165 r.p.m. with 5-ft. cylinders. In both cases two strippers and two workers are used.

INTERMEDIATE CARDS.—These are similar to the breaker cards, but have either 3 or 4 pairs of strippers and workers, usually 3 pairs ; a few are 4-pair full circular machines, some of which are fitted with back deliveries in place of the more usual side deliveries.

FINISHER CARDS.—These are either 3 or 4-pair half circular machines, or 4 to 6-pair full circular machines. Three-pair half circular machines are often used in Calcutta mills, while 4-pair full circular machines are more common in home mills. The 5 and 6-pair machines are used in several mills ; in one or two instances they are fitted with drawing heads.

The following are particulars of a finisher card recently introduced and said to give excellent results with poor class raw material :—

CYLINDER.—12 pins per sq. in. ; pins project $\frac{7}{8}$ in. ; 17 B.W.G. ; 5 ft. diameter ; 165 revs. per min. ; ring lubrication ; flangeless ; cast-iron arbor cruciform section in centre, with steel journals.

---

* See "Jute and Jute Spinning," by T. Woodhouse and P. Kilgour, Emmott & Co. Ltd., Manchester, 15s., for full details of the mechanism of this and other machines.

FEEDER.—9 pins per sq. in. ; 14 B.W.G. ; set No. 10 to cylinder ; 5 in. diameter ; plain roller on top ; pinned roller below.

FEED STRIPPER.—9 pins per sq. in. ; 15 B.W.G. ; set No. 16 to cylinder and to feeder ; 7 in. diameter.

1ST STRIPPER.—10 pins per sq. in. ; 15 B.W.G. ; set No. 16 to cylinder ; 11 in. diameter ; pins project $\frac{1}{16}$ in. ; stripper speed can be altered by changing pinion in train of gear from cylinder ; range of speed 120 to 240 r.p.m.

2ND STRIPPER.—12 pins per sq. in. ; 16 B.W.G. ; set No. 17 to cylinder ; 11 in. diameter ; pins project $\frac{5}{64}$ in.

3RD STRIPPER.—14 pins per sq. in. ; 16 B.W.G. ; set No. 18 to cylinder ; 11 in. diameter ; pins project $\frac{5}{64}$ in.

4TH STRIPPER.—16 pins per sq. in. ; 17 B.W.G. ; set No. 18 to cylinder ; 11 in. diameter ; pins project $\frac{5}{64}$ in.

1ST WORKER.—10 pins per sq. in. ; 15 B.W.G. ; set No. 10 to cylinder and No. 14 to 1st Stripper ; 9 in. diameter ; pins project $\frac{7}{16}$ in. ; speed can be altered from 12 to 24 r.p.m.

2ND WORKER.—12 pins per sq. in. ; 16 B.W.G. ; set No. 12 to cylinder and No. 15 to 2nd Stripper ; 9 in. diameter ; pins project $\frac{7}{16}$ in.

3RD WORKER.—14 pins per sq. in. ; 16 B.W.G. ; set No. 14 to cylinder and No. 16 to 3rd Stripper ; 9 in. diameter ; pins project $\frac{7}{16}$ in.

4TH WORKER.—16 pins per sq. in. ; 17 B.W.G. ; set No. 16 to cylinder and No. 17 to 4th Stripper ; 9 in. diameter ; pins project $\frac{7}{16}$ in.

DOFFER.— 24 pins per sq. in. ; 18 B.W.G. ; set No. 19 to cylinder ; 18 in. diameter.

BOXING.— Usual boxing above feed rollers and on upper portion of cylinder ; boxing below replaced by 5 tin cylinders.

ROLLER BEARINGS.—Supplied with lubricant by oil pipes to hole in cover from two oil boxes at each side of card.

DRAWING ROLLER RUBBER.—Revolving type set 1¼ in. from doffer pins.

CONDUCTOR.—Single sliver delivery ; polished mild steel sliver plate.

Proportions of Breaker Cards to Finisher Cards.—Usually 1 breaker to 2 finishers in the older mills, and 2 breakers to 3 finishers in the more modern mills, in systems making hessian warps and wefts, and sacking warps. In sacking weft systems it is preferable to use 1 breaker to 1 finisher, as the lighter load on the breaker gives better results in carding.

Balling and Dollop Systems.—With the dollop system, weighed

quantities of material—termed dollops—are fed into the breaker card while the pointer of a " clock " driven by the feed roller makes one revolution. Half-dollops are weighed when two feeders are employed at each card. The dollop may vary from 20 lbs. when making fine hessian warps to 40 or 50 lbs. when making heavy rove for wefts.

The balling or lap system is used in a few mills, chiefly in those where the sizes of the rooms or flats prevent the breaker cards from being in the same department as the finisher cards. Laps or balls containing 4 to 6 slivers each, 100 yds. long, are produced from breaker card slivers on the balling machines. These are weighed and made up into sets of two or three, each set weighing a predetermined amount. A set of balls is then put up at the feed cloths of the finisher cards.

The dollop system is practised wherever possible as it is considered to give better results. It has the obvious advantage of omitting a process and of establishing at an early stage a definite relation between length and weight.

An automatic balling machine, M'Intyre's patent, made by Messrs Fairbairn's, Leeds, has been placed on the market recently. It operates as an auxiliary to the breaker card, being driven therefrom, and produces 100-yd. rolls of sliver. The mechanism is completely automatic, and the sliver rolls are delivered into individual compartments of special barrows, which facilitate their removal to the finisher cards where uniformity in feed is secured.

Drawing Frames.—The processes of doubling, drawing, and parallelising the fibres are performed in these machines of which there are several types, *e.g.*, rotary, circular or fan, spiral or screw-gill, chain, push-bar, open link chain or link-gill, ring push-bar, and Gamble's push-bar. Detailed drawings, etc., of most of these types can be seen in " Jute and Jute Spinning," T. Woodhouse and P. Kilgour.

The driving shaft runs parallel to the fallers, as a rule, but occasionally these machines are driven by quarter-twist belts. In a Calcutta 500-loom mill, with two lines of frames, the shaft would be approximately in the centre of the two lines, and driven by means of open belts to each line. The shaft is carried on column brackets almost invariably; it runs at 180 to 200 r.p.m., and varies from 5½ in. diameter at the source of power to 2¾ or 2½ in. at the far end. This assumes that the roving frames are driven from the same shaft as is commonly the case.

The length of a 2-head drawing frame practically decides the pitch of the columns across the mill, and the number of drawing frames often determines the overall width of the mill. As made by various makers,

the overall length of the machine is 9 ft. 9½ in. to 10 ft. 4 in., and the pitch of the columns is fixed at 11 ft. The length of the bays varies, according to circumstances, from 30 to 35 ft. The first drawing frames are usually in the same bay as the finisher cards with a 6-ft. pass between, while the second drawing frames are in the same bay as the roving frames with a 4 or 5-ft. pass between.

Pressing Roller Weighting.—No definite practice appears to be followed by machine makers in fixing the pressure per inch width on the pressing rollers. The pressures appear to vary from 28 lbs. in a 10-in. reach spiral frame to 30 lbs. in a 12¾-in. reach spiral frame, and 35 to 40 lbs. in push-bar frames.

Sliver Cans.—The cans used are the same as at the breaker and finisher cards; thirty to forty cans are required for each frame. Rectangular cans are used in some mills, but oval ones are more common; these are 36 in. high × 13¼ in. × 10 in.

Block Spaces.—The following formulæ will give a close approximation to the actual block spaces of a drawing frame, given the reach, number of heads, number of gills per head, and width of gill :—

Let

R = reach in inches.
N = number of heads.
G = number of gills per head.
W = width of gill.

Then   Overall length = 2 ft. 2¾ in. + N {1 ft. 6 in. + (G × W)}, and
Overall breadth = 3 ft. 5¾ in. + R.

Covering of Leather Pressing Rollers.—Leather-on-flat pressing rollers are largely used, although some firms—chiefly for ease in replacements—use the leather-on-edge variety. It is false economy to use inferior leather or to hurry the operation of placing the covers on the rollers, for badly covered rollers are a continual source of trouble and expense. Best English leather (oak-tanned hides) should be used for the work, and all other materials used for fixing the leather should be of high quality.

Specification of Push-Bar First Drawing Frame.—Two heads per machine, 4 bosses per head; 1 or 2 deliveries per head; 15 in. reach; 2⅛ in. diameter of drawing roller; 2 in. diameter of retaining roller; drawing roller irregularly fluted; leather-on-flat pressing roller, 10 in. diameter; ⅞ in. pitch of fallers; 6½ in. width of conductor; 18 pins per row; 14 B.W.G.; 2 rows; 2⅞ pins per inch; 16 in. diameter of driving pulleys; 4 to 7 draft range; dead type rubbers; stripping rollers in front of drawing roller.

Specification of Spiral Second Drawing Frame.—Arranged to work in series with the above push-bar machine. Three heads per machine; 6 bosses per head; 1, 2, or 3 deliveries per head; 12 in. reach; drawing roller irregularly fluted; leather-on-flat pressing

rollers, 8 in. diameter : 1¾ in. diameter of screw ; $\frac{1}{16}$ in. pitch of fallers ; 3½ in. width of conductor ; 4 in. width over pins ; 1¼ in. total length of pins ; 20 pins per row ; 15 B.W.G. ; 2 rows ; 5 pins per inch ; 20 in. diameter of driving pulleys ; 5 to 10 draft range ; dead type rubbers ; stripping rollers in front of drawing roller.

Roving Frame.—To all intents and purposes the roving frame is a form of drawing frame to which mechanism is added to twist the delivered sliver, and simultaneously to coil it evenly, regularly, and without strain on to a rove bobbin. The twist in the rove strengthens the fine sliver and serves as a restraining medium to the drafting action of the spinning frame. The designation of roving frames has, in general, a reference to the size of rove bobbin used. Thus, there are, *inter alia*, 10 in. × 5 in., 9 in. × 4½ in., 8 in. × 4 in. In each case the larger number refers to the traverse or length of bobbin within the flanges, and the smaller number refers to the diameter of the flanges. The faller mechanism is usually of the spiral type, although push-bar types are also employed, especially for heavy rove, or for rove-spun yarns. The mechanisms are identical with those of the corresponding types in drawing frames, but the reaches are shorter, the various details, such as screws, slides, fallers, etc., are smaller, while the gills are also smaller and more finely set.

Arrangement of Roving Frames.—In both home and Indian mills it is usual to arrange the roving frames in pairs with the spindles facing, and with all the driving pulleys at one end. The drive is then taken from a shaft running across the mill, and at right angles to the length of the frames. The belt may be quarter-twist, or universal guide pulleys may be used ; the latter method is preferable and very often adopted. Ample floor space must be provided for the storage of full and empty bobbins.

Production and Speeds.—Actual production depends upon : (1) The quality of the material ; (2) the spindle speed ; (3) the twist on the rove ; (4) the organisation of the department. The speed of a spiral roving frame is limited by the faller speed which seldom exceeds 220 bar drops per minute in a 10 in. × 5 in. frame. The faller speed depends on the draft ; the smaller the draft, the higher the bar speed. Provided the faller speed can be satisfactorily adjusted, the next limiting factor is the flyer speed. Centrifugal force at high speeds has a detrimental action on the life of the flyer, and for this reason the flyer and spindle speed is often about 600 r.p.m., while the approximate limiting speeds are :—

> 800 r.p.m. for a 10 in. × 5 in. machine.
> 1000 r.p.m. for a 9 in. × 4½ in.   „
> 1200 r.p.m. for an 8 in. × 4 in.   „

On material for hessian warps and wefts, the production is about 3 cwts. per hour. This weight increases to about 4 cwts. per hour in the heavy sacking weft systems, and may reach 5 cwts. per hour when making very heavy rove such as bagging wefts. The normal capacity of a 9 in. × 4½ in. frame is about 2½ to 2¾ cwts. per hour, and that of an 8 in. × 4 in. machine, 2 to 2¼ cwts. per hour.

Specification of a 10-in. × 5-in. Roving Frame.—To be used in the same system as the aforementioned drawing frames, 8 heads per machine; 8 bosses per head; 64 spindles per machine; ⅝ in. diameter of spindle; 11 in. reach; 2¼ in. diameter of drawing roller; 2 in. diameter of retaining roller; drawing roller irregularly fluted; leather-on-flat pressing rollers, 7 in. diameter; 10 in. length of traverse; 5 in. diameter of bobbin flange; 1⅝ in. diameter of bobbin shank; 3⅞ in. pitch of bobbin-driver pins; 1½ in. diameter of screw; ⅛ in. pitch of fallers; 1 in. width of conductor; 2½ in. width over pins; 1 in. total length of pins; 13 pins per row; 5 to 10 draft range; ¼ to 1¼ turns per inch twist range; dead type rubbers.

Double-Threaded Spiral Roving Frame.—Particulars of 10 in. × 5¼ in. frame as made by Messrs Combe, Barbour, Ltd., Belfast.

PRODUCTION.—520 lbs. per hour on 84 lbs. per spyndle spinning rove with spindles running at 690 r.p.m.

REACH, ETC.—9⅜ in. reach; 2¼ in. drawing roller; 1¾ in. diameter retaining roller; bobbin, 10 in. traverse × 5¼ in. diameter.

SCREWS, SLIDES, ETC.—Double-threaded screws; upper scıew, 1⅝ in. outside diameter, ⅞ in. body diameter; ¾ in. pitch, ⅞ in. lead; lower screw, 1⅞ in. outside diameter; ⅞ in. body diameter; ¾ in. pitch; faller section, ⅟₄ in. thick and ⅝ in. deep; faller end, 1¼ in. deep; slide sections both rectangular, no reception cam; upper slide 1⅛ in. by ¾ in.; lower slide, 1⅛ in. by ⅝ in.

CONSTRUCTION.—Steel plates to support front ends of screws; screws run in separate brackets bolted to machined faces on web of stand.

Spinning.—The operation of spinning is performed in throstle or flyer spinning frames, in which the spindles are driven at the required speed by tapes or lists running on tin cylinders and on the whorls of the spindles. The spindles in a few frames are of the ball-bearing type and driven by friction discs. Rabbeth type spindles are also being tried. Other innovations at present on trial are rove-stop motions, gear-driven spindles, and ball-bearings in the tin cylinders. Extra long frames, up to 120 spindles, 4 in. pitch, are being favoured in some Calcutta mills.

CONSTRUCTION.—Spinning frames are usually double-sided, each side driven by its own belt; they may be single-sided if placed next

to walls or main passes. The pitches used vary according to the yarn counts being spun. The function of breasting the rove is usually performed by plate up to $4\frac{1}{2}$ in. pitch ; coarser pitches by rod or half plate.

DRIVING PULLEYS.—Mounted directly on the driving cylinder, which is 9 or 10 in. diameter, made in lengths not exceeding 9 or 10 ft., united by screw or clutch couplings.

DRAWING ROLLER.—Driven from the cylinder pinion through the twist gear ; the retaining roller is driven from the drawing roller through the draft or grist gear at the pass end. The heart cam which actuates the lifter receives its motion from the retaining roller.

SPINDLE DRIVE.—Nearly all frames are now equipped with some form of jockey cylinder, either above or below the listing, usually the latter in old frames. The saving in power effected by the use of the jockey cylinder, which is generally 6 in. diameter, is from 25 to 33 per cent.

BREAST PLATES.—In modern machines the breast plates are arranged for combined adjustment, *i.e.*, all the plates are secured to a long rod which can be turned through the required angle by a worm and worm wheel, or by some form of quadrant angle.

TRAVERSE GEAR.—Now invariably fitted to the drawing roller to give it an extremely slow lateral movement of about $\frac{1}{2}$ in., in order to equalise the wear. The same mechanism is used to traverse the rove across the retaining roller bosses for the same purpose. Ball-bearing washers are used in most modern frames to take the side thrust on the drawing roller at the journal where the traverse motion is located, and to take up the thrust of the driving cylinders.

Saving Due to Jockey Cylinders.—1. In a certain mill, with 5618 spinning spindles, the engine which drives the spinning rooms also drives a small preparing flat. Before the application of jockey cylinders, the engine indicated 685 to 700 H.P. After the installation of jockey cylinders, the I.H.P. was reduced to from 450 to 480. The mean decrease in I.H.P. is thus about 36 per cent., and additional savings were made by using 3 in. belts instead of 4 in. belts, and $1\frac{1}{4}$ in. listing in place of $1\frac{1}{2}$ in. 2. In a small mill of 2112 spinning spindles, the savings are stated to be equal to 1 ton of coal in eleven hours.

Arrangement of Machines.—In home mills the spinning frames are arranged in two rows parallel to the main walls with a central pass of not less than 6 ft. ; each frame is placed at right angles to the wall, between two windows, and with the driving pulleys next to the wall.

In Indian mills they are usually arranged in two or three long rows across the full width of the mill, with the length of the frame parallel to the length of the mill.

In both cases the drive is by leather or woven belting from a shaft at right angles to the frame length and over guide pulleys. In turbine-driven mills, this shaft is coupled direct to the prime mover.

Distribution of Columns.—The columns supporting the roof in Indian mills are pitched at 11 ft. centres across the breadth or width of the mill, and from 36 to 45 ft. centres along the length of the mill. The width dimension is practically constant, but the length dimension depends upon the number of spindles of given pitch in the length of the frame—usually 72 to 120 of 4 in. pitch—and on the arrangement of the roving and winding machinery. These machines are preferably, and should naturally be, in close proximity to, and sometimes driven from, the same shafts as the spinning frames.

In home mills there are often two columns in the width of the flat or room, in which case the driving cylinders of the frame have to be pitched at about 22½ in. centres in order to allow room for the columns inside the frames ; the more usual distance is 18½ in. The shaft lies immediately above the central pass and drives to both sides of the room.

Shafting, Etc.—The shafting is heavy as the power required is high and liable to fluctuations through atmospheric changes. In a 500 loom Indian mill the first length is often 6 in. diameter, and occasionally 6½ in., or even 7 in. ; it is reduced step by step as the power is taken off to about 3 or 2¾ in. diameter at the end farthest from the source of power. The bearings are often of the single brass variety lubricated by oil rings or chains, and 2½ to 3 diameters long. The speed varies from 180 to 220 r.p.m., and may reach 300 to 485 when turbine or electrically driven. The driving drums are often of the double convex type, varying, according to shaft speed, from 20 to 40 in. diameter. The usual width is 5 in. for a 4-in. belt, while the guide pulleys are generally 18 in. diameter × 5 in. wide, and occasionally 24 in. diameter × 5 in. wide. With high speed shafting, 3-in. belts may be used, even for long frames, and the drums and pulleys may be correspondingly less in width.

Constructional Details of Typical 4-in. × 4-in. Spinning Frame :—

REACH.—10 in.

PULLEYS.—17 in. diameter × 3½ in. wide × 1⅛ in. bore.

GABLES.—5 ft. 8 in. wide ; 1¼ in. section ; 3 ft. 5 in. floor to top of bend rail ; 9 gables in all ; 4½ in. over driving end gable to 1st bend ; 7 in. over pass end gable to 1st bend.

DRAWING ROLLERS.—4¼ in. diameter; 1⅟₆ in. broad; **automatic traverse motion**; scratch flutes; 2 couplings per side; **128 plain balls**; 40 bossed balls; 2 support brackets.

RETAINING ROLLERS.—2¼ in. diameter; 1½ in. wide; 45 flutes; round top and bottom.

GEAR WHEELS.—See the following table.

Jute Spinning Frame Gear Wheels

Name of Wheel.	Number of Teeth.	Pitch Number.	Width.	Bore.	Key.	Number Required.
			In.	In.	In.	
Cylinder pinion -	27	6	1¾	1¾	⅜	2
Stud wheel and socket	134	6	1¾	1⅞	None	2
Twist wheel - -	90	6	1⅞	1½	⁵⁄₁₆	2
Drawing roller wheel	120	8	2	1½	1⅛	2
Stud wheel - -	70	8	2	1½	1⅛	2
Retaining roller wheel	80	8	1½	1¼	1⅛	2
Change pinions -	25 to 50	8	1½	1⅛	1⅞	2 sets
Heart wheel - -	128	10	1¼	2¼	⅜	2
Heart pinion -	11	10	...	Screwed	...	2

HEART SHAFT SET.—Two pairs end brackets; 20 bosses, 3¾ in. diameter; 8 quadrants, 5 in.; 8 weights, 16 lbs.; 4 couplings.

CONNECTING ROD.—Forked head, 17 in. long; 2 couplings; 4 nuts.

BENDS.—One right hand and 1 left hand for driving end; 1 right hand and 1 left hand for pass end; 20 middle; 24 lower covers and brasses 3 and 2⅟₆ × 1⅞ in.

UPPER GRATES.—Twenty for 8 spindles; 2 for 6 spindles (86 spindles per side, 172 spindles per double-sided frame).

LOWER GRATES.—Twenty for 8 spindles; 2 for 6 spindles.

BREAST PLATES.—20 for 8 spindles; 2 for 6 spindles; 24 rod brackets; 24 adjusting screws; 24 washers; 2 end setting brackets.

THREAD PLATES.—Cut from right-hand side; 2 right-hand and 2 left-hand end sections; 16 mid sections; all for 8 spindles each; 2 mid sections for 6 spindles.

HAKE.—Right hand, 1 length per side, 11 points per length ; left hand, 1 length per side, 11 points per length ; middle, 1 length per side with 10 points, and 1 length per side with 11 points.

RAILS.—Spindle rails, 3 lengths per side ; top rails, 4 lengths per side.

NECKS.—2¾ in. long ; screws, 1 in. long, with square head at back.

STEPS.—Cast-iron caps ; screws, 1¼ in. long, with square head at front.

SPINDLE RAIL BRACKETS.—Cast on gable.

CYLINDER BRACKETS AND COVERS.—Driving end journals, 4¼ in long × 1¾ in. diameter ; pass end journals, 3½ in. long × 1½ in. diameter ; both types have solid oil covers with hinged cap ; middle journals, 3½ in. long × 1¼ in. diameter, with solid oil cover.

CYLINDER.—10 in. diameter ; 6 clutch couplings.

CYLINDER BRACKET STRAPS.—Bridge rails cast in.

BOBBIN BOARDS.—Five lengths per side ; coarse fronts ; temper-band holes, ¾ in. to left of spindle centre-line.

TEMPER WEIGHTS.—20 oz. each.

Power Tests on Spinning Frames.—In certain power tests, a Houldsworth differential wheel, with a 2-ft. lever attached, was used as a dynamometer. The wheel with lever tends to revolve at half the speed of the driving pulley, hence

if   P = the pull in lbs. in driving belt,
             L = the length of lever in feet,
             R = the radius of the pulley in feet,
             D = the diameter of the pulley in feet,
and   W = the weight in lbs. on the lever,

then, $$P = \frac{WL}{2R} = \frac{WL}{D}.$$

The belt speed in the three frames tested was **1558·3 ft. per min.**

whence $$H.P. = \frac{1558·3 \times WL}{33000 \times D} = \frac{0·0472WL}{D}.$$

Production from Spinning Frames.—The following Table is an analysis of the daily production of a large Calcutta jute mill. In most cases the records embrace a period of five days of thirteen hours each in mid-summer.

PRODUCTION OF JUTE SPINNING FRAMES

Size of Frame Pitch × Traverse.	Date in July.	Count of Yarn Lbs. per Spindle.	Grade of Yarn.	Total Number of Spindles Employed.	Total Yarn Produced per 13 Hour Day.		Average Production per Spindle per Hour.	
					Spindles.	Lbs.	Spindles.	Lbs.
Inches. 4 × 4	24	Lbs. 8	Hessian Warp	558	336·0	2688·0	0·0463	0·3704
,,	25	8	,,	558	403·2	3225·6	0·0556	0·4448
,,	26	8	,,	558	403·2	3225·6	0·0556	0·4448
,,	27	8	,,	558	436·8	3494·4	0·0615	0·4920
,,	28	8	,,	558	403·2	3225·6	0·0556	0·4448
Totals and averages for week -				-	1982·4	15859·2	0·0549	0·4392
Inches. 4 × 4	24	Lbs. 9	Sacking Warp	3438	2831·0	25479·0	0·0634	0·5706
,,	25	9	,,	3438	2522·4	22701·6	0·0565	0·5085
,,	26	9	,,	3438	2816·0	25344·0	0·0630	0·5670
,,	27	9	,,	3438	3146·4	28317·6	0·0704	0·6336
,,	28	9	,,	3438	3072·0	27648·0	0·0688	0·6192
Totals and averages for week -				-	14387·8	129490·2	0·0644	0·5796
Inches. 4 × 4	24	Lbs. 10	Hessian Weft	240	208·8	2088·0	0·0669	0·6690
,,	25	10	,,	240	205·2	2052·0	0·0657	0·6570
,,	26	10	,,	240	211·4	2114·0	0·0676	0·6760
,,	27	10	,,	240	205·2	2052·0	0·0657	0·6570
,,	28	10	,,	240	194·4	1944·0	0·0623	0·6230
Totals and averages for week -				-	1025·0	10250·0	0·0656	0·656
Inches. 5 × 5	24	Lbs. 16	Dyed Yarn	62	32·0	512·0	0·0428	0·6848
,,	25	16	,,	62	34·0	544·0	0·0454	0·7264
,,	26	16	,,	62	38·5	616·0	0·0514	0·8224
,,	27	16	,,	62	42·5	680·0	0·0568	0·9088
,,	28	16	,,	62	40·0	640·0	0·0534	0·8544
Totals and averages for week -				-	187·0	2992·0	0·0500	0·8000
Inches. 5 × 5	24	Lbs. 28	Sacking Weft	124	96·5	2702·0	0·0598	1·6744
,,	25	28	,,	124	137·0	3836·0	0·0850	2·3800
,,	26	28	,,	124	198·7	5563·6	0·1232	3·4496
,,	27	28	,,	248	250·7	7019·6	0·0778	2·1784
,,	28	28	,,	248	204·2	5717·6	0·0634	1·7752
Totals and averages for week -				-	887·1	24838·8	0·081	2·2904

PRODUCTION OF JUTE SPINNING FRAMES—*contd.*

Size of Frame Pitch × Traverse.	Date in July.	Count of Yarn Lbs. per Spindle	Grade of Yarn.	Total Number of Spindles Employed.	Total Yarn Produced per 13 Hour Day.		Average Production per Spindle per Hour.	
					Spindles.	Lbs.	Spindles.	Lbs.
Inches. 5 × 5	24	Lbs. 33	Sacking Weft	1488	1109·3	36606·9	0·0574	1·8942
,,	25	33	,,	1240	967·0	31911·0	0·0600	1·9800
,,	26	33	,,	1240	959·6	31666·8	0·0595	·9635
,,	27	33	,,	1116	787·8	25997·8	0·0543	1·7919
,,	28	33	,,	1116	816·2	26934·6	0·0562	1·8546
Totals and averages for week - - -					4639·9	153117·1	0·0575	1·8975
Inches. 5 × 5	24	Lbs. 36	Sacking Weft	372	331·5	11934·0	0·0685	2·4660
,,	25	36	,	620	453·0	16308·0	0·0562	1·9032
,,	26	36	,,	620	420·0	15120·0	0·0521	1·8756
,,	27	36	,,	620	568·5	20466·0	0·0705	2·5380
,,	28	36	,,	620	570·0	20520·0	0·0706	2·5416
Totals and averages for week - - -					2343·0	84348·0	0·0636	2·2896
Inches. 5 × 6	24	Lbs. 36	Sacking Weft	572	451·5	16254·0	0·0617	2·2212
,,	25	36	,,	572	441·0	15876·0	0·0593	2·1348
,,	26	36	,,	572	447·0	16092·0	0·0601	2·1636
,,	27	36	,,	118	148·5	5346·0	0·0968	3·4848
Totals and averages for week - - -					1488·0	53568·0	0·0695	2·5020
Inches. 5 × 6	27	Lbs. 40	Sacking Weft	338	235·2	9408·0	0·0551	2·2040
,,	28	40	,,	456	320·6	12824·0	0·0541	2·1640
Totals and averages for week - - -					555·8	22232·0	0·0546	2·1840
Inches. 5 × 6	27	Lbs. 65	Sacking Weft	116	36·2	2353·0	0·0240	1·5600
,,	28	65	,,	116	71·5	4647·5	0·0474	3·0810
Totals and averages for week - - -					107·7	7000·5	0·0357	2·3205

Winding Machinery.—The bulk of warp yarn is delivered on rolls, spools, or cheeses. the common dimensions of which are 9 to 10 in. long by 8 to 9 in. diameter   The driving rollers are 4 to 4½ in. diameter, and rotate at 480 to 425 r.p.m.   Many machines have 80 spindles, two upper rows of 20 each and two lower rows of 20 each.

Neglecting slip, the non-stop speed of the yarn is 167½ yards per min. Each roll winder spindle winding 8 lbs. per spyndle warp will keep 8 spinning spindles in work.   These spools are used almost exclusively in the banks of dressing machines.   A comparatively small quantity of yarn—mostly coloured and bleached—is wound on flanged bobbins for the carpet trade.

Weft Winding. —Pirns are used only in a few factories.   The common form for weft is in cop.   These are made 1½ in., 1⅝ in., and 1¾ in. diameter, by 8 in., 9 in., 10 in., and 12 in. long.   In the bagging trade, these dimensions are exceeded, and cops are made from 18 in. to 24 in. long, and 2½ in. to 3 in. diameter.   The waste in copping amounts to 2½ to 4 per cent. of the yarn used, and exceeds that made with pirns.

Cop winding machines are built 4½ in. to 6 in. pitch to wind from 4 in. × 4 in., and 5 in. × 6 in. spinning bobbins   The pitch is from 7¼ in. to 8 in. in machines intended for making cops from hanks. The main shafts of cop winding machines run at 315 to 436 r.p.m., while the pindle speed varies from about 750 to 950 r.p.m.   The following table shows the average production of one operative obtained on different counts of yarn.

JUTE WEFT WINDING PRODUCTION

Count of Yarn in Lbs. per Spyndle.	Number of 25-lb. Boxes Wound per Hour (for Internal Use).	Number of 50-lb. Bags Wound per Hour (for External Use).	Number of Spyndles Wound per Hour.
6½	1·2 to 1·4	0·6 to 0·7	4·62 to 5·38
7½	1·4 to 1·6	0·7 to 0·8	4·67 to 5·34
8	1·6 to 1·8	0·8 to 0·9	5·00 to 5·62
9	1 8 to 2·0	0·9 to 1 0	5·00 to 5·56
10	2·0 to 2·2	1·0 to 1·1	5·00 to 5·50
11	2·2 to 2·4	1·1 to 1·2	5·00 to 5·46
12	2·4 to 2·6	1·2 to 1 3	5·00 to 5·42
13	2·6 to 2·8	1·3 to 1·4	5·00 to 5·38
14	2·6 to 2·8	1·3 to 1·4	4·64 to 5·00
15	2·8 to 3·0	1·4 to 1·5	4·67 to 5·00
16	2·8 to 3·0	1·4 to 1·5	4·37 to 4·69
17	3·0 to 3·2	1·5 to 1·6	4·42 to 4·71
18	3·0 to 3·2	1·5 to 1·6	4·17 to 4·44
19	3·2 to 3·4	1·6 to 1·7	4·21 to 4·47
20	3·4 to 3·6	1·7 to 1·8	4·25 to 4·50

WARPING AND BEAMING

Warps are made in various ways :—

1. In chains on warping mills from spinning bobbins.
2. In chains on warping mills from spools.
3 In chains on linking machines from spools.
4. In dry beaming machines from spools in a bank.
5. In dressing machines from spools in banks.

In the first three methods, a dry beaming machine is necessary to complete the warp on the weaver's beam.

The methods of starch mixing, dressing, drawing-in and reeding, tying-on, etc., are very similar to those practised in other industries.

Finished Widths of Hessians and Number of Threads Required for Different Porters

Finished Width in Inches	8 Porter.	9 Porter.	10 Porter.	11 Porter.	12 Porter.	Finished Width in Inches	8 Porter.	9 Porter.	10 Porter.	11 Porter.	12 Porter.
28	264	296	328	360	394	57	524	592	658	722	790
29	272	306	340	372	406	58	536	602	670	736	804
30	280	316	352	396	420	59	544	612	682	750	818
31	290	326	364	398	434	60	552	622	692	762	830
32	298	336	374	410	448	61	562	632	704	774	844
33	306	346	384	424	462	62	570	642	714	786	858
34	316	356	396	436	476	63	580	652	726	800	872
35	326	366	408	448	488	64	590	662	738	812	886
36	334	376	420	460	500	65	598	672	750	824	900
37	344	386	432	474	516	66	606	682	762	836	912
38	354	396	442	486	530	67	616	692	774	848	926
39	362	406	454	500	544	68	624	704	786	860	940
40	370	416	466	512	558	69	634	714	796	872	954
41	380	426	476	524	572	70	644	724	806	886	968
42	388	436	486	538	586	71	652	734	818	898	980
43	398	446	498	550	600	72	660	744	828	910	994
44	406	456	508	562	612	73	670	754	840	922	1008
45	414	466	520	574	626	74	678	764	850	936	1020
46	424	478	532	588	640	75	686	774	860	948	1034
47	434	488	544	600	654	76	696	784	872	960	1048
48	442	500	556	612	668	77	706	794	884	972	1062
49	452	510	566	624	680	78	714	804	896	986	1074
50	460	520	578	636	694	79	724	812	906	998	1088
51	470	530	590	648	708	80	732	822	916	1010	1100
52	480	540	602	660	722	81	740	832	928	1022	1114
53	488	550	612	674	734	82	750	842	938	1034	1126
54	498	562	624	686	748	83	758	854	950	1046	1140
55	508	572	636	698	762	84	766	864	960	1058	1154
56	516	582	646	710	776	85	774	878	972	1070	1168

Shotting Constants and Change Pinions

Maker of Loom.	Ratchet.	Stud Wheel.	Stud Pinion.	Roller Wheel.	Roller Circum. Inches.	Shotting Constant
G. Hattersley & Sons Ltd.	40	90	50	90	14·11	453·3
Lee, Croll, & Co. -	40	90	45	90	14·50	496·6
C. Parker & Sons -	40	80	40	80	16·50	387·9
Robertson, Orchar Ltd.	100	..	..	100	17·27	579·0
Urquhart, Lindsay, Ltd.	44	70	27	82	17·27	541·6

Table X. shows the shots per inch given by particular shotting pinions when used with the above uptake motions. The pinions given are suitable only when the ratchet is moved *one* tooth per pick. If the pinion given is too large to be accommodated in the loom, the ratchet should be altered to move *n* teeth at a time, and a suitable pinion will then be obtained by dividing the pinion given in the table by *n*.

TABLE X.—Take-Up Change Pinions for Jute Looms

Teeth in Pinion.	Hattersley. 453·3.	Lee, Croll. 496·6.	Parker. 387·9.	R. and O. 579·0.	U.L. 541·6.	Teeth in Pinion.	Hattersley. 453·3.	Lee, Croll. 496·6.	Parker. 387·9.	R. and O. 579·0.	U.L. 541·6.
13	34·82	38·19	29·85	45·51	41·65	43	10·53	11·54	9·02	13·46	12·59
14	32·33	35·46	27·71	41·35	38·70	44	10·29	11·28	8·82	13·15	12·30
15	30·20	33·10	25·86	38·59	36·07	45	10·06	11·04	8·62	12·87	12·03
16	28·31	31·03	24·25	36·19	33·82	46	9·85	10·79	8·43	12·58	11·78
17	26·63	29·20	22·82	34·05	31·84	47	9·64	10·56	8·25	12·31	11·51
18	25·15	27·58	21·55	32·17	30·07	48	9·44	10·35	8·08	12·07	11·27
19	23·84	26·13	20·42	30·47	28·50	49	9·24	10·14	7·92	11·81	11·04
20	22·67	24·82	19·40	28·95	27·08	50	9·07	9·93	7·76	11·57	10·83
21	21·58	23·64	18·48	27·58	25·80	51	8·99	9·73	7·61	11·34	10·61
22	20·60	22·57	17·64	26·31	24·60	52	8·72	9·55	7·46	11·12	10·41
23	19·68	21·59	16·87	25·17	23·55	53	8·55	9·37	7·32	10·91	10·22
24	18·86	20·68	16·16	24·14	22·57	54	8·39	9·19	7·19	10·72	10·03
25	18·11	19·86	15·52	23·18	21·65	55	8·24	9·03	7·05	10·52	9·85
26	17·42	19·09	14·92	22·26	20·82	56	8·09	8·87	6·93	10·34	9·67
27	16·78	18·39	14·36	21·43	20·06	57	7·95	8·71	6·81	10·15	9·50
28	16·18	17·73	13·86	20·65	19·33	58	7·81	8·56	6·69	9·99	9·34
29	15·62	17·12	13·38	19·96	18·68	59	7·68	8·41	6·57	9·81	9·19
30	15·11	16·55	12·93	19·30	18·04	60	7·55	8·27	6·47	9·65	9·03
31	14·61	16·02	12·51	18·68	17·48	61	7·43	8·14	6·36	9·49	8·89
32	14·15	15·52	12·13	18·10	16·91	62	7·31	8·01	6·26	9·34	8·74
33	13·72	15·04	11·75	17·53	16·40	63	7·19	7·88	6·16	9·20	8·60
34	13·32	14·60	11·41	17·02	15·92	64	7·09	7·76	6·06	9·04	8·46
35	12·94	14·19	11·09	16·53	15·48	65	6·97	7·64	5·97	8·91	8·34
36	12·58	13·79	10·77	16·08	15·03	66	6·87	7·52	5·88	8·78	8·21
37	12·24	13·42	10·48	15·66	14·63	67	6·76	7·41	5·79	8·64	8·09
38	11·91	13·06	10·21	15·23	14·26	68	6·67	7·30	5·71	8·52	7·97
39	11·61	12·73	9·95	14·84	13·89	69	6·57	7·20	5·62	8·39	7·85
40	11·31	12·41	9·70	14·48	13·53	70	6·48	7·09	5·54	8·27	7·74
41	11·04	12·11	9·46	14·12	13·20	71	6·39	6·99	5·46	8·15	7·63
42	10·78	11·82	9·24	13·79	12·90	72	6·30	6·90	5·39	8·04	7·52

JUTE COUNTS AND EQUIVALENTS

Jute Count. Lbs. per Spyndle.	Linen Count. Leas per Lb.	Continental Count. Grams per 100 Metres.	Continental Count. Metres per Kilo.	Jute Count. Lbs. per Spyndle.	Linen Count. Leas per Lb.	Continental Count. Grams per 100 Metres.	Continental Count. Metres per Kilo.
6	8·00	20·67	4837	41	1·17	141·2	709
6·5	7·38	22·40	4465	42	1·14	144·8	691
7	6·86	24·10	4150	43	1·12	148·1	675
7·5	6·40	25·82	3878	44	1·09	151·6	660
8	6·00	27·56	3635	45	1·07	155·0	645
8·5	5·65	29·30	3420	46	1·04	158·5	631
9	5·34	31·00	3230	47	1·02	162·0	618
9·5	5·05	32·75	3055	48	1·00	165·4	605
10	4·80	34·45	2902	50	0·96	172·1	580
10·5	4·57	36·20	2763	52	0·92	180·0	555
11	4·36	37·90	2640	54	0·89	185·0	540
11·5	4·17	39·63	2522	55	0·87	189·6	529
12	4·00	41·30	2420	56	0·86	192·0	520
12·5	3·84	43·10	2322	58	0·83	200·0	500
13	3·69	44·80	2232	60	0·80	206·5	484
13·5	3·56	46·55	2150	62	0·78	214·0	468
14	3·43	48·20	2075	64	0·75	220·4	453
15	3·20	51·60	1936	65	0·74	224·0	447
16	3·00	55·10	1815	66	0·73	228·0	440
17	2·82	58·60	1709	68	0·71	234·1	427
18	2·67	62·00	1612	70	0·69	241·2	415
19	2·52	65·50	1528	72	0·67	248·0	403
20	2·40	68·90	1451	74	0·65	255·0	392
21	2·28	72·40	1382	75	0·64	258·1	387
22	2·18	75·90	1320	80	0·60	275·0	363
23	2·08	79·20	1263	84	0·57	289·5	346
24	2·00	82·60	1210	90	0·54	310·0	323
25	1·92	86·10	1161	96	0·50	330·5	300
26	1·84	90·00	1111	100	0·48	344·5	290
27	1·78	93·00	1077	120	0·40	413·0	240
28	1·71	96·50	1038	140	0·34	482·0	207
29	1·65	100·0	1000	150	0·32	516·0	194
30	1·60	103·2	967	160	0·30	551·0	180
31	1·55	106·9	937	180	0·27	620·0	160
32	1·50	110·2	907	200	0·24	700·0	143
33	1·45	113·7	880	250	0·19	861·0	116
34	1·41	117·0	855	300	0·16	1032	96·7
35	1·37	120·6	830	350	0·14	1206	83·0
36	1·33	124·0	807	400	0·12	1378	72·6
37	1·30	127·4	785	500	0·10	1721	58·0
38	1·26	130·9	765	600	0·08	2065	48·4
39	1·23	134·3	745	700	0·07	2412	41·5
40	1·20	138·0	725	800	0·06	2758	36·3

Loss in Weight Due to Dyeing.—Jute yarns may lose from 4 to 10 per cent. of their original weight during the dyeing process. The percentage loss depends upon the shade required and the mode of dyeing. The loss may be even greater than that mentioned when the yarns have to be bleached before they are dyed.

30

PARTICULARS OF TYPICAL JUTE FABRICS

Name of Fabric.	Single or Double Warp.	Weave.	Yarn Counts in Lbs. per Spyndle.		Setts.		Intended for Use of
			Warp.	Weft.	Porter.	Shots per In.	
Bagging	Double	Plain	6-10	20-40	5-10	6-10	Coarse bags.
Brattice cloth	"	3-leaf	8	16-24	7-8	9-12	Wind screens, etc.
" " Brusselette	Single	Plain	8	12-16	7-8	9-12	" " "
Brusselette	"	Plain	10-12 and 2/7	10-12	7³-12³	6-8	Carpets of various kinds.
Brussels carpets	Special structure	Jacquard figured	2/7-2/8	12-14	6-8¼ pile threads per in.	6-8 wires	Carpets and rugs.
Brussels cut-carpets	"	"	...	...	6¼-12¼	...	"
Buckram	Single	Plain	7-9	8-12	6¼-12¼	3-6	Stiffeners, etc.
Cable matting	"	2/2 Twill	2/2/9	36	14-18	6-10	Matting.
Checked hessian	"	Plain	8	8-9	10	12-13	Mattress covers.
Cotton bagging	"	"	8-12	200-400	4-7	2-5	Baling cotton.
Dutch carpeting (heavy)	"	"	2/8	30-40	13¼-20	10-12	Stair carpeting.
" " (low)	"	"	2/8	36-50	7-10	6-8	"
" " (medium)	"	"	2/8	32-45	11-14	8-10	"
Fancy lobby carpeting	Double	4-8 leaf weaves	2/6¼-2/7	20-24	20¼-28²	10-12	Lobby carpeting.
Fine hessian	Single	Plain	6-7	6-7	14-18	16-20	Biscuit bags, etc.

PARTICULARS OF TYPICAL JUTE FABRICS—*continued.*

Fabric	Warp	Weave					Uses
Fine pocketing	Double	Plain	10	15-18	9-11	12	Pockets.
Hat cloth	Single	Fancy weaves	2/3½-2/4	6-7	18^2-24^2	20-28	Millinery.
Heavy matting	,,	Twill and other 4-leaf weaves	3/16	36	14^2-18^2	8-12	Matting.
Hessians (ordinary)	,,	Plain	7-10	7-10	9-12	11-14	Bags, etc.
Hop pocketing	Double	4-leaf twill	12-14	30-36	9^1·11^4	8-12	Hop pockets.
Jute rug backing	Single	Plain	3/8-3/10	6/10-6/12	8-10	7-9	Rug backings.
Jute scrim	,,	,,	7-9	7-9	5-7	6-8	Onion bags, etc.
Lobby carpeting	Double	,,	2/6½-2/7½	20-24	22^2-28^2	10-16	Lobby carpeting.
Medium matting	Single	4-leaf twills and fancy weaves	2/16, 3/11, and 2/14	20-36	8^3-12^3	6-10	Matting.
Medium twill carpeting	.	4 to 8 leaves	2/8	20-30	9^3-12^3	8-12	Carpeting.
Mending bagging	,,	Plain	8-12	350-500	3-5	1½-4	Mending cotton bagging.
Padding D.W.	Double	,,	9	10	14	14	Padding.
Sacking	,,	3-leaf twill	7-10	20-36	6-14	6-12	Sacks.
Scotch carpets	Singl.	Double plain	8-10	12-48	30-40 threads per in.	20-30	Carpets.
Tarpauling	Double	Plain	7-8	6-20	14-18	10-16	Hayrick covers, etc.
Twist bagging	Single	,,	3/8-6/11	3/8-6/11	3½-10	4½-12	Bags, etc.
Venetian carpeting	,,	,,	2/5	40-60	24^2-30^2	8-11	Stair carpets, etc.
Vine netting			7-9	7-9	3^1-5^1	3½-6	Fruit carpets, etc.
Wilton carpets	Single and double	Jacquard figured	2/7-2/8	12-14	7-9 pile threads per in.	6-8 wires	Cut pile carpeting.
Wool packs	Double	2/1 twill	8-9	30-48	8-10	8-10	Wool packs.

Loom Production Table.—The following table gives the approximate production in yards per loom per hour from looms running at the speeds indicated on cloths with various numbers of picks per inch. The production factors or loom efficiencies are assumed at 85. 80, and 75 per cent., varying according to the number of picks per inch.

JUTE LOOM PRODUCTION IN YARDS PER HOUR

	Picks per Inch.	Speed of Loom in Picks per Minute.								
		80	85	90	95	100	105	110	115	120
85 per cent. efficiency.	5	22·68	24·10	25·50	26·90	28·35	29·75	31·18	32·58	34·00
	5½	20·61	21·90	23·18	24·47	25·76	27·01	28·34	29·60	30·90
	6	18·90	20·08	21·24	22·41	23·60	24·80	25·98	27·14	28·32
	6½	17·45	18·55	19·62	20·70	21·80	22·88	23·07	25·05	26·15
	7	16·20	17·21	18·23	19·21	20·24	21·24	22·25	23·28	24·28
	7½	15·12	16·07	17·00	17·94	18·89	19·82	20·75	21·72	22·67
	8	14·18	15·06	15·94	16·81	17·71	18·59	19·47	20·36	21·24
	8½	13·34	14·18	15·00	15·83	16·67	17·50	18·33	19·17	20·00
	9	12·60	13·39	14·17	14·95	15·73	16·54	17·30	18·10	18·89
	9½	11·94	12·68	13·43	14·17	14·90	15·67	16·39	17·14	17·89
	10	11·33	12·04	12·75	13·45	14·17	14·88	15·58	16·29	17·00
80 per cent. efficiency.	11	9·69	10·20	10·91	11·51	12·11	12·71	13·32	13·94	14·54
	12	8·89	9·45	10·00	10·56	11·10	11·67	12·22	12·78	13·33
	13	8·20	8·72	9·24	9·75	10·26	10·78	11·27	11·79	12·30
	14	7·62	8·10	8·57	9·05	9·53	10·00	10·48	10·95	11·42
	15	7·11	7·56	8·00	8·45	8·90	9·34	9·78	10·22	10·67
	16	6·67	7·09	7·50	7·92	8·33	8·75	9·17	9·58	10·00
	17	6·28	6·67	7·06	7·46	7·84	8·24	8·63	9·02	9·42
	18	5·92	6·30	6·67	7·04	7·41	7·79	8·15	8·53	8·89
	19	5·61	5·97	6·32	6·67	7·02	7·37	7·72	8·07	8·43
	20	5·33	5·67	6·00	6·33	6·67	7·00	7·34	7·67	8·00
75 per cent. efficiency.	21	4·76	5·06	5·36	5·65	5·95	6·25	6·65	6·85	7·14
	22	4·54	4·83	5·12	5·40	5·69	5·97	6·25	6·53	6·82
	23	4·35	4·62	4·89	5·16	5·44	5·71	5·98	6·25	6·52
	24	4·17	4·43	4·69	4·95	5·21	5·47	5·73	5·98	6·25
	25	4·00	4·25	4·50	4·75	5·00	5·25	5·50	5·75	6·00
	26	3·85	4·09	4·33	4·57	4·81	5·05	5·29	5·53	5·77
	27	3·70	3·94	4·17	4·40	4·63	4·86	5·10	5·32	5·55
	28	3·57	3·80	4·02	4·24	4·47	4·69	4·91	5·14	5·36
	29	3·45	3·67	3·88	4·10	4·31	4·53	4·74	4·95	5·17
	30	3·33	3·54	3·76	3·96	4·17	4·38	4·58	4·79	5·00
	32	3·13	3·32	3·52	3·72	3·91	4·10	4·30	4·49	4·69
	34	2·94	3·13	3·31	3·49	3·68	3·86	4·05	4·23	4·41
	36	2·78	2·95	3·13	3·30	3·47	3·65	3·82	3·99	4·17
	38	2·63	2·80	2·96	3·13	3·29	3·46	3·62	3·78	3·95
	40	2·50	2·66	2·82	2·97	3·13	3·28	3·44	3·59	3·75

JUTE LOOM PRODUCTION IN YARDS PER HOUR

	Picks per Inch.	Speed of Loom in Picks per Minute.								
		125	130	135	140	145	150	155	160	165
85 per cent. efficiency.	5	35·42	36·83	38·24	39·64	41·10	42·50	43·90	45·35	46·75
	5·5	32·20	33·52	34·78	36·03	37·34	38·67	39·92	41·20	42·50
	6	29·52	30·72	31·88	33·04	34·24	35·42	36·58	37·80	38·98
	6·5	27·24	28·38	29·41	30·52	31·60	32·72	33·78	34·89	36·00
	7	25·30	26·33	27·32	28·35	29·33	30·40	31·36	32·40	33·40
	7·5	23·62	24·58	25·50	26·45	27·39	28·35	29·25	30·24	31·18
	8	22·12	23·05	23·90	24·73	25 67	26·58	27·42	28 33	29·20
	8·5	20·83	21·68	22·50	23·33	24·17	25·00	25·81	26·67	27·50
	9	19·68	20·49	21·25	22·04	22·81	23·60	24·39	25·20	25·96
	9·5	18·64	19·40	20·13	20·88	21·61	22·35	23·10	23·86	24·60
	10	17·71	18·42	19·13	19·83	20·54	21·25	21·96	22·67	23·38
80 per cent. efficiency.	11	15·15	15·76	16·37	16·97	17·57	18·18	18·78	19·38	20·00
	12	13·88	14·45	15·00	15·55	16·10	16·77	17·22	17·77	18·33
	13	12·82	13·34	13·84	14·36	14·87	15·38	15·90	16·40	16·91
	14	11·90	12·38	12·86	13·33	13·81	14·28	14·76	15·23	15·70
	15	11·11	11·56	12·00	12·44	12·88	13·33	13·78	14·21	14·67
	16	10·42	10·83	11·25	11·66	12·08	12·50	12·91	13·33	13·74
	17	9·81	10·20	10·59	10·98	11·37	11·77	12·16	12·55	12·98
	18	9·26	9·64	10·00	10·37	10·73	11·11	11·48	11·84	12·22
	19	8·78	9·13	9·48	9·83	10·17	10·52	10·87	11·22	11·58
	20	8·34	8·68	9·00	9·33	9·67	10·00	10·33	10·67	11·00
75 per cent. efficiency.	21	7·45	7·74	8·04	8·34	8·63	8·93	9·23	9·53	9·83
	22	7·10	7·39	7·67	7·95	8·24	8·52	8·81	9·10	9·38
	23	6·80	7·07	7·34	7·61	7·88	8·15	8·43	8·70	8·97
	24	6·51	6·78	7·04	7·30	7·55	7·81	8·08	8·34	8·60
	25	6·25	6·50	6·75	7·00	7·25	7·50	7·75	8·00	8·25
	26	6·01	6·25	6·50	6·73	6·97	7·21	7·45	7·70	7·94
	27	5·79	6·02	6·25	6·49	6·71	6·94	7·18	7·41	7·64
	28	5·58	5·80	6·02	6·25	6·48	6·70	6·92	7·14	7·37
	29	5·39	5·60	5·82	6·04	6·25	6·47	6·69	6·90	7·12
	30	5·21	5·42	5·62	5·83	6·05	6·25	6·46	6·67	6·88
	32	4·88	5·08	5·27	5·47	5·67	5·86	6·06	6·25	6·45
	34	4·60	4·78	4·97	5·15	5·33	5·52	5·70	5·88	6·07
	36	4·34	4·51	4·69	4·86	5·04	5·21	5·38	5·56	5·73
	38	4·12	4·28	4·44	4·60	4·77	4·94	5·10	5·27	5·43
	40	3·91	4·07	4·22	4·37	4·53	4·69	4·85	5·00	5·16

Machinery Equipment of 400-Loom Calcutta Jute Mill

4 Jute softeners ; 63 pairs rollers, spring loaded, for warp.
2 Jute softeners ; 63 pairs rollers, dead-weight loaded, for weft.
1 Waste cleaner.
2 Teaser cards.
8 Breaker cards ; for warp.
4 Breaker cards ; for weft.
13 Finisher cards ; for warp.

5 Finisher cards ; for weft.

13 First drawing frames ; leather-on-edge pressing rollers, for warp.

5 First drawing frames ; hard-to-hard pressing rollers, for weft.

13 second drawing frames ; leather-on-edge pressing rollers, for warp.

5 second drawing frames ; hard-to-hard pressing rollers, for weft.

13 Roving frames ; 64 spindles each, for warp

5 Roving frames ; 64 spindles each, for weft.

45 Spinning frames ; 4-in. traverse, double-sided, 72 spindles per side.

8 Spinning frames ; 6-in. traverse, double-sided, 58 spindles per side.

8 Roll or spool winders ; double-banked, double-sided, 12-in. pitch, 84 spindles each.

9 Cop winders ; 4½-in pitch, 60 spindles per side, to make cops up to 10 in. long and 2 in. diameter.

1 Roll winder ; double-sided, 12-in. pitch, 14 spindles in all, to wind from 90-in. hanks.

1 Power reel ; 24 spindles per side, double-sided, 6-in. pitch, 90-in. hank reel.

5 Beaming machines ; 52½ in. wide, for hessian looms.

4 Beaming machines ; 37½ in. wide, for sacking looms.

250 Looms, plain ; 52½-in. reed-space, for hessians.

150 Looms, 3-leaf twill ; 37½-in. reed-space, for sackings.

2 Calenders, heavy ; 5-bowled, 96 in. wide, 27 in. diameter, paper bowls, for hessian.

2 Calenders, medium ; 5-bowled, 64 in. wide, 24-in. diameter, paper bowls, for sacking.

1 Spray damping machine ; 96 in. wide, for hessians.

1 Spray damping machine ; 64 in. wide, for sackings.

1 Cloth measuring machine ; 96 in. wide, for hessians.

1 Cloth measuring machine ; 64 in. wide, for sackings.

1 sack cutting machine.

2 Lapping machines ; for 60 in. wide cloth, to make laps from 36 in. to 90 in.

16 Sacking sewing machines.

8 Hessian sewing machines.

2 Hydraulic presses.

1 Set of 8-barrel pumps for hydraulic presses.

In the above list, the machines indicated " for warp " are for hessian warp and hessian weft, and sacking warp, while those marked " for weft " are for sacking weft only.

FLAX FIBRE, ITS PREPARATION AND SPINNING

The flax fibre of commerce is obtained from a plant, the botanical name of which is *Linum Usitatissimum*. This plant grows and thrives under a diversity of climatic and soil conditions, but it is especially suitable for cultivation in the temperate regions, in which the best fibre flax is grown.

The seed is sown about the middle or end of April at the rate of about two bushels per statute acre. In eight to ten days the young plants begin to appear, and in about sixteen weeks from the time of sowing they are ready for pulling; this process is usually carried out by hand. After pulling, the straw is rippled to remove the seed bolls, it is then tied into " beets," or sheaves, when it is ready for retting.

The water-retting process consists in steeping the flax straw in water in order to loosen the layer of fibres which is situated between the cortex or bark and the hard woody centre called the boon. The length of the retting process varies, amongst other things, with the temperature of the water ; but it is usually complete in from six to ten days. The straw is then removed from the dams and spread out to dry, this operation being termed grassing. Four to six days suffice for grassing, after which the straw is tied up again and the beets stooked for two or three weeks to season ; they are then stacked until it is found convenient to start scutching.

Dew retting is practised in some parts of the continent, more particularly in Russia. The straw, after being pulled, is spread out in a thin layer on the grass and subjected to the influence of sun, wind, rain, and dew, until it is found that the fibre will part easily from the core. The length of time taken in dew retting varies according to the weather conditions. Neither the yield nor quality of the fibre obtained by this method compares favourably with that obtained by water retting.

In scutching the straw is first crushed or broken by being passed between several pairs of fluted metal rollers, after which operation it is beaten in order to remove the broken fragments of woody tissue and cortex from the fibre.

From an acre of flax yielding, say, 80 cwt. of green straw, and allowing 55 per cent. for loss in weight during drying, there is obtained 36 cwt. of straw. Deducting 20 per cent., or 7·2 cwt. for deseeding, leaves 28·8 cwt. The retting process reduces the weight by about 25 per cent., leaving 21·6 cwt. of retted straw. The final process of breaking and scutching removes about 80 per cent. of the

retted material, so that from an acre of flax yielding 80 cwt. of green straw an average yield of about 4·3 cwt. of fibre may be obtained.

Flax growing for fibre is confined principally to European countries, Russia being by far the largest producer, Belgium, France, Holland, Ireland, and Italy also contribute to the world supply. A small percentage is contributed by Egypt, Canada, and the United States.

The linen industry of the United Kingdom is centred round Belfast and Dundee. The Irish section is the larger of the two, and is concerned more with the fine end of the industry, the production of various household goods such as damasks, sheetings, etc., the manufacture of lawns and cambrics for wearing apparel, and the production of handkerchief linens. An important section of the Irish linen industry is the manufacture of thread. The Scotch section is concerned mainly with the coarse end of the industry, such as the manufacture of canvas, tickings, etc., and the production of heavy linen yarns for carpet manufacture.

Flax.—Belgian flax, or Courtrai flax, as it is more generally called, is the best handled flax fibre on the market. Greater care is taken in the selection of the straw, its storage, and the subsequent retting and scutching operations, with the result that the fibre is more uniform, being stronger and cleaner and the scutched flax better graded than any other class of flax on the market. Courtrai flax may be divided into three main classes: (1) River retted; (2) tank retted; (3) dew retted. The river-retted flax is for the most part steeped in the lower reaches of the river Lys, the waters of which seem to contain some property which render them specially suitable for this operation. Under this heading are grouped the best qualities of Courtrai flax. Tank-retted flax is to all outward appearance similar to river-retted fibre, but the tank-steeped product does not yield as well when dressed nor work so well over the preparing or spinning machinery as does the river-retted material. The quality of the latter also is superior to the former.

Dew-retted material comprises the lowest qualities of Courtrai flax, the straw instead of being steeped under water is spread out on grass, where it is acted upon by the sun, rain, and dews, which gradually loosen the fibre on the stem. This class of material is only suitable for the manufacture of medium warp and weft yarns up to 40's or 45's lea. Patent steeped or tank steeped flax can be used over a very much wider range of leas according to quality, while the finest qualities of river-retted fibre are capable of being spun into yarn of 300 leas to the pound.

Irish flax, owing to the indifferent treatment which it receives during growth and extraction of the fibre, is variable in quality and,

at best, is only equal to the medium grades of Courtrai flax. The colour varies considerably according to the districts in which it has been grown and retted. Flax retted in standing water—as in dams—is iron grey to light grey in colour, while that retted in running water is silvery white in colour. The fibre as a whole is fairly strong and is suitable for spinning into warp yarns up to 90's lea ; the finer qualities may be spun as fine as 140's lea for wefts.

Dutch flaxes are divided into two classes according to colour. Blue Dutch flax is obtained from straw which has been retted in standing water—the colour being attributed largely to the peaty nature of the soil and the brackish condition of the water. The fibre is clean, big-boned, and strong. It is best suited to the spinning of warp numbers up to 50's lea. White Dutch flax is obtained from straw which has been retted in the river Scheldt, the fibre in this case is smaller and cleaner in nature and is capable of spinning up to 70's lea warp.

Flemish flaxes are similar to Dutch fibre in many ways. They are usually big-boned and warpy in nature and are suitable for the manufacture of warp yarns up to 40's lea. The colour varies between light and dark blue according to the district in which it is grown and retted.

French flax is somewhat similar to the medium and lower grades of Courtrai flax. It is usually either river steeped or dew retted. A large percentage of the flax grown in France is bought up by the owners of retting concerns on the Lys, who steep it in the river, the fibre so obtained being equal in quality with that grown in Belgium.

Russia is the greatest flax-producing country in the world. During the thirty years prior to the outbreak of war in 1914 the area under this crop increased rapidly. Following the Revolution the flax growing industry, like many others, was brought to a standstill, and it is only during the last four or five years that she has again entered into competition with other countries. The Baltic States of Latvia, Lithuania, Livonia, and Esthonia, are now the main centres of the industry, the chief ports of export being Riga, Pernau, Reval, Archangel, and Petrograd or Leningrad. During the winter the Gulf of Riga is closed by ice, and at this period flax is shipped mainly from Reval.

Russian flax is classified under two main headings :—

1. Motchenetz, or water-retted fibre.
2. Slanetz, or dew-retted fibre.

Water-retted fibre includes the best grades of Russian flax, and dew-retted material the lower grades.

Flax from the various districts is sorted and exported under certain marks. For Riga water-retted fibre the marks are G, R, ZK, SPK, PK, and K, the fibre being quoted at so much per ton for a certain mark—usually R or G—with an " ecart " of £5 to £7 between each of the others. Water-retted flax from the Hoffs district is exported under the marks XRX, XHDX, SPHD, FPHD, PHD, HD. The marks for Pernau flax are G, R, GD, D, OD, and LOD. Dew-retted flaxes are usually graded I., II., III., IV., V., etc., No. I. being the best quality.

The better grades of Russian water-retted flax are suitable for the manufacture of medium quality warp yarns up to 40's lea, and they may be spun out to 70's or 80's lea weft. The lower marks are not suitable for leas above 25 for warp and 40 for weft. Dew-retted fibre may be used in the manufacture of yarns up to 40's lea according to the class of material used and the quality of the yarn required.

The flax markets open about the beginning of October in Ireland and the Western European countries. Buyers from the different mills and commission houses visit the various market towns and trade with the farmers for their fibre. In the Courtrai district most of the fibre is bought at the large scutching centres in connection with the various retteries.

Courtrai and French flax is generally quoted at so much per kilogramme, or per 100 kilogrammes. It is made up into bales of 2 cwt. each for shipment. Dutch flax is sold at stuivers per stone of 6 lb. 3 oz., there being 36 stones to the 2 cwt. bale. Russian flax is quoted at pounds sterling per ton for a certain mark with an " ecart " of from £4 to £7 between each grade. Riga flax is usually exported in mats, but many qualities are made up into trusses or " bobbins," without any covering. Irish flax is quoted at shillings per stone in most districts, except Strabane and Omagh, where it is frequently quoted at shillings per cwt.

Roughing.—This is the first process to which the fibre is subjected in the course of preparation into yarn. The rougher unties a stone of flax and takes up one of the " stricks " of which it is made up. This he splits up into pieces weighing six or eight to the pound, taking care to ensure that all the pieces are uniform in size; this operation is termed piecing out. Having obtained a sufficient number of these pieces to keep him engaged in roughing for some time, he takes a piece and, holding it by the top end first, combs out the root by passing it repeatedly through the pins of a coarse hackle which is screwed to a bench. This done he breaks off the straggling ends on a touch pin and, turning the piece in his hand, repeats the operation on the top end. As each piece is finished he lays it

on the bench, turning it in his hand at the same time so that a half lap or twist remains in it, this serves to keep each piece separate and prevents tossing of the fibre in subsequent operations. Having built up a bunch of about 40 lb. he ties it up and lays it aside ready for the hackling process.

Rougher's Tools.—The hackle consists of a beech block about 15 in. long by 5 in. broad by 1·5 in. thick, this is studded with steel pins 6 or 7 in. long and tapering from the base of the pin, the diameter at the base being about 6 B.W.G. The touch pin is a square or triangular steel pin ¼ to ⅜ in. thick and set in a metal or wooden block which is fixed to the bench on the left side of the hackle.

Hackling.—This process has for its object the parallelising of the fibres, splitting up the larger bundles and removing short, broken fibre, lumps of tow, fragments of straw, and other extraneous matter.

The hackling machine proper consists of two or more massive gables, between each of which is mounted a pair of endless sheets. Each of these sheets rotates around a top roller and a bottom pulley shaft, motion being imparted to the latter which carries a number of studded pulleys along its length. The studs engage with brass eye-letted holes in the sheet leathers, imparting a positive drive to the sheet. A channel extends the full length of the machine and is free to move up and down in the gables; a reciprocating motion is imparted to it by the head wheel through the medium of an adjustable stud, link, and chain, or by an eccentric compounded with the head wheel.

Two machines are essential to complete the cleaning and splitting of the fibre, one for the root end of the piece and the other for the top end. They are arranged parallel to each other and are connected front and rear by cross channels. The pieces of roughed flax are screwed up in steel holders, the ends projecting at each side. The screwing and unscrewing of the holders is done by an automatic wrench. The full holders are transferred to the machine channel which, as it rises, carries them over the sheets. In its downward motion that portion of the flax hanging down from the holder is drawn through the nip of the hackle sheets, the pins of the hackles penetrating it through from either side and splitting up the large fibre bundles, at the same time removing all short matted fibre, neps, pieces of cortex, and any other foreign matter contained in the fibre.

The holders are passed slowly along the machine from one end to the other, the pins per inch of the hackles becoming finer so that the fibre is acted upon gradually. At the fine end the holder is transferred to the cross channel at the back, where the top plate is

unscrewed, the unhackled portion between the plates drawn through, the plates being again screwed together and the holders transferred to the channel of the second machine, on which the unhackled ends of the pieces are treated in a similar manner to that already stated.

The pieces of hackled flax are removed from the holder, while it is travelling along the front cross channel, by the machine attendant, who builds them up into a " tipple " by placing each piece cross-wise over the other in the tipple box.

Number of Hackles.—The number of hackles or rounds of tools to each machine varies according to the nature of the material in work. Beginning with coarse hackles in the first round the pins per inch are increased by stages in each succeeding round in order that the fibre may be acted upon gradually. The modern tendency is in the direction of longer machines, which permit of a gentler gradation and which give a better yield and cut than can be obtained on short machines with fewer rounds of tools.

GRADATION OF HACKLING MACHINE TOOLS

No. of Tools.	Superfine Courtrai Long Line and Cut Line.		Strong and Clean Warp Flax.		Medium Quality Weft Flax.		Inferior Quality Water-Retted Warp Flax.		Inferior Quality Water-Retted and Dew Retted-Weft Flax.	
	Pins per Inch.	Wire Gauge	Pins per Inch.	Wire Gauge	Pins per Inch.	Wire Gauge	Pins per Inch.	Wire Gauge	Pins per Inch.	Wire Gauge
1	¾	12	½	13	½	13	½	13	½	13
2	½	13	1	14	1	14	1	14	1	14
3	¾	13	2	15	1·5	14	2	15	2	15
4	1	14	3	16	2	15	3	16	3	16
5	1·5	14	4	16	3	16	4	16	4	16
6	2	15	6	17	4	16	6	17	5	17
7	2·5	15	8	18	5	17	8	18	6	17
8	3	16	10	19	6	17	11	19	8	18
9	4	16	12	20	8	18	14	20	10	19
10	5	17	15	21	10	19	18	22	12	20
11	6	17	18	22	12	20	22	23	15	21
12	8	18	22	23	15	21	26	24	18	22
13	10	19	26	24	18	22	30	25	22	23
14	12	20	30	25	22	23	..	..	26	24
15	15	21	35	26	26	24	..	..	30	25
16	18	22	40	27	30	25	..	..	..	..
17	22	23	..	..	35	26	..	..	..	..
18	26	24	..	..	40	27	..	..	..	..
19	31	25	..	..	..	..	..	..	..	..
20	36	26	..	..	..	..	..	..	..	..
21	42	27	..	..	..	..	..	..	..	..
22	50	29	..	..	..	..	..	..	..	..

Intersection.—The setting of the sheets is a most important factor, for the cut or amount of splitting which the fibre bundles receive, and the yield of hackled flax depend to a very large extent on the amount of intersection given to the pins when setting the sheet rollers. This varies with the nature of the material in work. Soft, wefty flax of a dirty nature, such as the lower grades of Irish, Russian, and most dew-retted flaxes, require an open setting so that the maximum yield may be obtained. Strong warp fibre, on the other hand, requires a close setting in order that the piece may be thoroughly penetrated by the pin points and a good cut obtained. With superfine grades of Courtrai flax, and " middles " or cut line, the piece must be thoroughly penetrated so that all the tow and nep may be removed, at the same time care must be taken to ensure that the highest possible yield is obtained. The following are suitable intersections for the three classes of material just mentioned :—

	Bearing at Coarse End.	Middle Bearing.	Bearing at Fine End.
Soft wefty flax of a dirty nature	$\frac{1}{8}$ in. open	$\frac{1}{32}$ in. open	Point to point.
Strong warp flax - -	$\frac{1}{32}$ in. open	Point to point	$\frac{1}{8}$ in. closed.
Superfine Courtrai flax and cut line	$\frac{1}{32}$ in. open	Point to point	$\frac{1}{32}$ in. closed.

Grouping.—This consists in dividing the hackles which compose a round of the sheet into a number of groups, the number varying with the pins per inch in the hackle. In every group the pins of each hackle are so arranged that they strike into the fibre at a different point to the previous one ; by this arrangement a maximum amount of cutting is obtained with the tools in work. The method of obtaining the position of the first pin in each tool of the group is as follows. A number of hackle stocks, exceeding by one the number of hackles in the group, are placed on a flat surface to ensure that the ends are kept level. The first and last hackle stock of the row should have a pin inserted at a point as near to the end of the stock as possible, consistent with strength. A distance is marked off on the last stock in from the pin and equal to the pitch of pins in the round, then a line is traced from the pin in the first stock to the point, already obtained, on the last stock ; along this line the first pin of each hackle in the group must be placed, the other pins being spaced

at the required distance from the first one. The number of hackles in the group must be a factor of the number of bars in the sheet, and it will be obvious that the coarser the pitch the greater the number of hackles it is possible to have in the group. No advantage is obtained by grouping hackles which are pitched finer than eight per inch. In the following table a system of grouping is given for tools up to eight pins per inch :—

Pins per inch · -	$\frac{1}{2}$	$\frac{3}{4}$	1	2	4	6	8
Tools in group ·	15	10	10	5	3	2	2

Speed.—The amount of work which the material receives depends on the speed of the sheets and the number of lifts per minute of the channels. The latter are usually run at from 6 to 9 lifts per minute and the sheets at from 8 to 15 revs. per minute according to the nature of the material in work, strong warp flax requiring a faster sheet than is necessary than fibre of a wefty nature is being hackled. No hard and fast rules can be laid down, for the requirements of fibre in the same class vary very considerably. Careful examination of each parcel of flax is necessary as it comes on to the hackling machine, so that the speeds may be arranged to give a maximum yield consistent with a thorough splitting up of the fibre bundles and the removal of all tow, nep, and dirt.

Removal of Tow.—On most of the modern machines the tow is removed from the hackle pins by a circular brush situated below the bottom sheet roller. This brush deposits it on a doffer clothed with knee bent wire filleting, which in its turn is cleaned by a stripper knife, the tow falling before the latter into boxes placed to receive it.

The floor space occupied by a pair of eighteen tool machines of the brush and doffer type, complete with automatic screwing attachment and machine boy's bench, is 25 by 15 ft.

Sorting.—The hackled flax is placed in skips as the tipples or bunches are lifted from the machine. The poorer qualities are taken directly to the preparing rooms. Only the better grades of fibre justify the extra expenses entailed in sorting. This process consists in a further hackling of the fibre—this time by hand—breaking off the ends of each piece on a touch pin, after which a lap is put on one end, the pieces being graded according to quality and built up into bunches on the sorter's bench,

Sorter's Tools.—As in roughing the tools are affixed to the bench directly in front of the sorter. A "ten" or "eighteen" constructed on the same principle as the rougher's hackle, but with smaller and more closely set pins. A "switch" on the same principle as the "ten," but with the pins much shorter and set more closely together. The touch pin is similar to that used by roughers. The last, a tool called the "nep extractor," consists of a single row of pins set very closely together. Over this tool the ends of the pieces are drawn to remove any neps or "flag" that may be left after it has been worked over the "ten" and "switch."

Numbering the Sorts.—Two methods of numbering the different grades or sorts of flax are practised. One system, which is confined to the coarse end of the trade, is based on the method of indicating the count or weight of the yarn in pounds per spangle of 14,400 yds.; the sorts being called 1, 2, 3, 4, 5, 6, etc., when they are considered capable of being spun into yarn of 1, 2, 3, 4, 5, or 6 lb. per spangle. The other system which is in vogue in the wet flax spinning trade consists in numbering the sort according to the lea of warp yarn to which it is thought capable of being spun. In this way the sorts range from 15's lea to 150's lea, rising usually by five.

Storing Dressed Flax.—The dressed and graded flax is built up into bunches, each weighing about 20 lb., these are tied up firmly and ticketed with their mark and sort, being afterwards sent to the line store until required for preparing into yarn.

Dressed line calculations: The average yield of dressed line per cwt.

$$= \frac{\text{Total pounds of dressed line} \times 112}{\text{Total pounds of flax in lot}}.$$

Average Sort.—The average sort may be obtained by multiplying each sort by the total number of pounds of dressed line in that sort, adding the totals together and dividing by the total yield of dressed line (breakings not included). The quotient will give the average sort.

Cost of Dressed Line.—To find the cost of dressed line per pound, to the price per cwt. of flax, is added the cost of roughing, hackling, and dressing per cwt. The total value of the tow is then ascertained and also the value of the breakings; these are added together and deducted from the total cost of flax and dressing. The yield of dressed line in pounds per cwt. divided into the result, reduced to pence, gives the cost of dressed line in pence per pound.

Lot Constant Number.—Having obtained the average sort and the cost per pound, the cost of any sort in the lot may be calculated by simple proportion. A constant number for the lot is obtained by dividing the average sort into the average cost of dressed line per pound. This constant should be calculated out to four figures in decimals to ensure accuracy. The value of any sort per pound is found by multiplying the sort by the lot constant number.

Spreading.—The first process to which the dressed flax line is subjected in the course of preparation for spinning consists in the formation of a continuous ribbon or sliver from the pieces of dressed line. This is effected on the spreadboard.

Two types of spreadboard are in use: the large board on which each piece is spread as a whole, and the small board on which it is split up into six or eight portions for spreading. Advantages of spreading on the large board are, greater production and a reduction in the cost of spreading, one board can keep from five to nine systems supplied. Disadvantage is the production of a heavy sliver requiring extra " drafting " to reduce it to the required weight. The small board is still used to some extent in the preparation of superior warp yarns.

At the back of the spreadboard a table is fixed, over which four, six, or eight endless leather sheets travel, these are arranged parallel to each other and they move in the direction of the feed rollers at the back of the board. Pieces of dressed flax are laid on each of these leathers, by which they are conveyed forward to the feed rollers, other pieces being laid on so that each piece overlaps its predecessor on the sheet, thus ensuring a continuous supply to the feeds.

The fallers are thin metal bars, the ends of which are steel tipped to enable them the better to resist wear. These engage in the threads of square threaded spiral screws and rest on slides affixed to the framework. The gills are riveted on the upper surface of these bars.

The Gills.—These consist of brass stocks bored to receive a double row of pins. The function of the gills is to hold the fibre in its passage from the feed rollers to the boss roller, and to prevent it from being gulped through the nip of the boss roller as it is being drafted. The pins, by penetrating the fibre, assist in the breakdown of the large fibre bundles during drafting.

As the fibre passes through the nip of the feed rollers, the fallers rise from the bottom slide to the top slide and into gear with the top spiral screws, the pins of the gills penetrating the fibre. The motion of the spiral screws is such that the fallers are carried forward to the boss roller, bearing with them the fibre in the gills. Here they are lowered one by one from the top slide and out of gear with

the top screws, the pins being drawn clear of the fibre, which is caught up in the nip of the boss and wooden pressing rollers.

Lead of Fallers.—The fallers have a slight lead in speed—about 3 per cent.—on the feed roller, so as to ensure thorough penetration by the pins of the gills as they rise into gear with the top screw.

Formula for calculating the lead of faller

$$= \frac{\text{Speed of screw} \times \text{pitch of thread per inch}}{\text{Speed of feed roller} \times \text{circumference}}.$$

The pressing rollers work in grooves which are fixed to the framework. In the large board each roller is mounted on a separate axle or arbor, pressure being transmitted from the compound leverage system through the medium of hangers suspended from each end of the arbor. In the small board the pressing rollers are mounted in pairs, pressure being transmitted through the medium of a single screw and gib, the latter resting on the arbor between the rollers. The arbors in the large board are usually fitted with ball bearings so as to reduce the amount of power absorbed by friction between the hangers and the arbor ends.

After drafting, the slivers are drawn through slots on the doubling plate, being united together and passed over the delivery roller to a can in front.

On the small board the sliver must be measured as it passes over the delivery roller in order that the weight per unit length may be regulated at the set frame. In the case of the large board this is not necessary, the sliver being measured as it leaves the doubler.

Doubler.—This frame is constructed on the same principle as the spreadboard. Back rails and guide pulleys take the place of table and feed leathers of the board, and over these the slivers are drawn to the feed rollers, through them to the gills which convey the material to the boss roller, here the ends are drafted out, being united into one sliver on the doubling plate and this passed over the delivery roller to a can in front.

The length is measured off by a worm and wheel reduction gear driven from the delivery roller and operating a bell when some prearranged amount—usually 1000 yds. for flax line—has been delivered into the can. The weight per unit length of the sliver to be delivered from the doubler may be regulated by altering the draft, which is the ratio between the surface speed of the feed rollers and that of the boss roller, or by increasing or reducing the number of ends put up at the back of the frame.

The regulating of the weights at the doubler or spreadboard is rendered necessary in order that a definite weight of material may

31

SPREADBOARDS AND DOUBLERS

	Large Boards.		Small Boards.		Doublers	
	Coarse.	Fine.	Coarse.	Fine.	Coarse.	Fine.
No. of heads					4	4
Slivers per head					6	6
Deliveries per head					1	1
Leathers per board	-	4	8	8		
Deliveries per board	2	2	1	1		
Length of reach	36 in.	28 in.	28 in.	24 in.	26 in.	20 in.
Diameter, front rollers	5	4	3½	2½	2½	2¼
Diameter, back rollers	4	3	3	2½	2½	2
Pitch of screw	¾	½	⅜	⅜	½	⅜
Breadth of gill	8	12	16	22	14	18
Pins per inch	8	13	20	23	19	21
No. of wire	15					
Length of pin	2 in.	1¾ in.	1½ in.	1 in.	1⅞ in.	1 in.
Conductor	6¼ ,,	5¼ ,,	2 ,,	1½ ,,		1¼ ,,
Range of drafts	15 to 30	15 to 30	15 to 30	15 to 30	10 to 25	10 to 25
Length of bell, yards	500 and 1000	500 and 1000	500 and 1000	500 and 1000	500 and 1000	500 and 1000
Range of set weights	lb. 200 to 400	lb. 80 to 200	lb. 80 to 120	lb. 60 to 100	lb. 200 to 400	lb. 80 to 200

be put up at the back of each head of the first drawing frame. The combined weight of the cans is termed the set. A definite length, usually 1000 yds. for line and 500 for tow, is measured off into each can. The weight of the set for line yarns may be obtained by means of the following formula :—

$$\frac{\text{No. of yds. per can} \times \text{drafts (1st, 2nd, 3rd, 4th drawings and roving)}}{\text{Yds. per oz. rove} \times 16 \times \text{doublings (2nd, 3rd, 4th drawings and roving)}}.$$

(See particulars of spreadboards and doublers, p. 398.)

Drawing and Doubling.—Having obtained sliver of a pre-arranged weight per unit length, it is now necessary to reduce it to a degree of fineness consistent with the lea of yarn to which it is to be spun. This is accomplished by passing it over a series of drawing frames similar in structure to the doubler, drafting the sliver out on each frame and at the same time doubling a number of ends together to ensure regularity. On each succeeding drawing frame the details become finer to suit the smaller body of material being dealt with and the shorter staple of the fibre.

In the preparation of line material the slivers are passed over from three to five drawing frames according to the degree of fineness desired and the quality of the material in work. As any increase in the number of drawings necessarily increases the cost, five drawing systems are only used in the preparation of good quality yarns.

Roving.—The final drawing is effected on a frame termed a roving frame. It differs somewhat from the preceding frames. On this frame the doubling plate and delivery roller give place to a positively controlled flyer and bobbin mechanism on which the drawn ends receive a small amount of twist and are wound on to wooden bobbins. No doubling takes place on the roving frame.

The amount of pressure to be applied to the wooden pressing rollers varies with the nature of the material and width of roller, being greater for strong warp flax than for fibre of a wefty nature. It is calculated at from 80 to 100 lb. per inch width of roller face.

With constant running the wooden pressing rollers become coated with substance of a waxy nature which is picked up from the fibre, this adheres so firmly that the stationary friction rubbers in contact with the face of the rollers fail to remove it. If allowed to accumulate it causes the drafted sliver to lick up, this producing an excessive amount of waste. In order to remove this substance the face of each roller must be washed regularly, and for this purpose a mixture composed of equal parts of paraffin and sperm oil, or of two parts of the former to one of the latter, will be found suitable.

The extent to which licking-up occurs varies with the class of fibre in work, the quality of wood in the rollers, and the degree of humidity in the air. Dew retted and patent steeped flax will be found to give most trouble in this respect. Wood with a soft open grain is unsuitable for the manufacture of pressing rollers, as it seems to hold the dirt; close-grained firm timber is most suitable for preparing bosses, and for this reason boxwood, sycamore, mahogany, satinwood, and maple give best results.

Speed of Faller.—The speed at which the fallers may be driven determines to a large extent the speed of the frame. The proper regulation of this point is of the utmost importance to efficiency in preparing and the life of the machinery. The speed of the fallers is equal to the speed of the feed rollers, plus a small percentage for "lead." About 200 drops per minute may be taken as an average for coarse line systems and 120 drops per minute for fine line systems.

$$\text{Speed of faller (drops per minute)} = \frac{\text{Speed of spiral screw}}{\text{Pitch}}.$$

$$\text{The speed of the spiral screw} = \frac{\text{Speed of back shaft} \times \text{back shaft bevel}}{\text{Bevel on screw}}.$$

The drafts on the various frames comprising a system should not exceed 12 for the finer and better grades of line yarns, or 15 for the heavier numbers. The shorter the drafts the more regular will be the resulting sliver. Where it is possible to keep the supply of sliver up, the drafts should be arranged so that they are highest on the first and second drawing frames and lowest on the last drawing and roving frame. It is obvious that the number of doublings must not exceed the draft, otherwise the resulting sliver will be heavier than that put up at the back of the frame, which would be contrary to the aim in view, *i.e.*, a reduction in weight of the sliver on each succeeding drawing. The usual doublings are :—

Large spreadboard	=2	1st drawing	=8
Small ,,	=8	2nd ,,	=8
Doubler	=6	3rd ,,	=8
		4th ,,	=4
		Roving	=1

The draft is obtained by dividing the surface speed of the boss roller by that of the feed roller or from the following gearing formula :—

Back roller wheel	×	stud wheel	×	draft change pinion	×	crown wheel	×	diameter of boss roller
Stud pinion	×	back shaft pinion	×	boss roller wheel	×	crown pinion	×	diameter of back roller

The spindles on the roving frame are positively driven, their speed being constant, as also is that of the boss roller. It is obvious that if the rate of delivery of the drafted sliver does not vary the speed of the bobbins must change as they are filled, on account of the increase in the diameter of the bobbin barrel as each layer of rove is wound on.

The winding on of the rove results from the difference in speed of the spindles and bobbins, and may be effected by having the spindle rotating faster than the bobbin or *vice versa*. In the flax spinning industry it is usual to have the spindle " lead " the bobbin. When this is the case the difference between the speeds of the spindles and the bobbins is greatest when the latter are empty and is gradually reduced as they fill up. The rate of change is not constant but of a differential nature, and is obtained by driving the bobbin shaft through the medium of an epicyclic train of gearing, called the differential motion. The resulting motion V of the bobbins is a combination of two distinct velocities, a constant v_1 and a variable v_2, being such that

$$V = v_1 \pm 2v_2.$$

Tow Preparing.—Flax tow comprises the broken and matted fibre which is removed from the flax during roughing, hackling, and dressing. An inferior quality of tow also is produced during the scutching process.

Classes of Tow.—Scutching tow consists of coarse fibre of poor quality and very lumpy. It contains a large amount of straw and other foreign matter.

Pluckings.—This is composed of loose fibre which has been pulled from the bunches of scutched flax after they are tied up. It is much superior to scutching tow, being long of staple and free from shive.

Roughing Tow is coarse and lumpy and contains a considerable amount of straw and shive, especially in the lower grades. It should contain only a small percentage of long fibre.

Machine Tow is divided into two grades, root-end tow and top-end tow. These grades are subdivided into 1, 2, 3, 4 root, or top running from coarse to fine according to the pitch of pin in the tools by which it is removed. Root-end tow is more open and the fibre coarser than top-end tow, the latter is soft and contains a large amount of

nep. The fibre becomes correspondingly cleaner towards the fine end of the machine, No. 4, the finest being comparatively free from nep or dirt, but short in staple.

Sorter's Tow.—This is produced during the final dressing process. It is comparatively clean and free from any foreign substance. Sorter's tow is superior in quality to any of the other grades.

Tow Mixing.—Most tow yarns are prepared from mixes of different grades of tow. Even where one grade only is being used it is advisable to prepare a mix in order that the fibre may be well blended and the colour level. Mixing is effected in the tow store by spreading a thin layer of each grade, one on the other, in the mixing bins. Owing to the matted and dirty condition of the fibre, tow material requires to undergo a special cleaning process prior to preparation for spinning; this is effected on the carding and combing machines.

The Breaker Card.—This is a coarse card, the function of which is to open up coarse, lumpy material, such as scutching tow; it is also used to break up inferior quality flax for work over tow machinery. It consists of a large metal cylinder covered with wooden staves or clothing in which are set steel pins. Round this cylinder at intervals and parallel to its axis are arranged a number of other rollers of various diameters and similarly clothed, these are the feed rollers, workers, strippers, and doffers.

The material is laid on an inclined feed sheet which carries it forward to the feed roller, this roller delivers it to the cylinder on which it is carried round to the first worker, the pins of which are hooked against those of the cylinder so that the fibre is retained by them, the pins of the cylinder tearing through it and opening up any lumps.

The fibre is removed from the worker by the stripper. This roller revolves at a much higher speed than the worker, and as the pins on it are hooked in with those of the worker the fibre is stripped off the latter, no breakdown occurring at this point.

The stripper carries the material back to the cylinder at a point behind the first worker, so that it is passed repeatedly over the first worker and stripper until broken small enough to escape the pins of the worker when it passes on to the second worker. This worker is set closer to the cylinder than the first worker and the fibre is passed repeatedly round the second worker and stripper until it is broken small enough to pass through when it is carried up to the doffing roller.

The doffing roller is pinned similarly to, and rotates in the same direction as the workers. It is set more closely to the cylinder than

the last worker, so that the fibre is caught up on the pins and carried round to the drawing-off rollers, which strip it off in a fleece or braird, this passes down a V-shaped conductor to a bag or some other receptacle.

In the following table particulars are given for a breaker card suitable for working coarse tows, etc :—

	Dimensions.	No. of Wire. B.W.G.	Projection of Pin.	Length of Stave.	Width of Stave.	Rows in Width	Pins per Row	Rake of Pin.
	Ft. Diam.		In.	In.	In.			
Cylinder - -	4 × 6	12	$\frac{1}{2}$	24	3	6	55	75°
	In. Diam.							
Feed roller -	12	10	$\frac{1}{2}$	24	$2\frac{3}{4}$	6	63	65°
1st worker -	10	12	$\frac{3}{4}$	24	$2\frac{1}{4}\{\frac{1}{4}$	5	63	45°
1st stripper -	12	12	$\frac{5}{8}$	24	$2\frac{1}{2}$	6	75	35°
2nd worker -	10	13	$\frac{3}{4}$	24	$2\frac{1}{4}\{\frac{1}{4}$	5	72	45°
2nd stripper -	12	13	$\frac{5}{8}$	24	$2\frac{3}{4}$	6	84	35°
Doffer - -	16	13	$\frac{1}{2}$	24	$2\frac{1}{4}$	6	72	35°

Suitable settings for the details are as follows :—

Shell to cylinder	$\frac{1}{4}$ in.	
Feed rollers to shell	$= \frac{3}{8}$ in.	
Feed rollers to cylinder	$= \frac{1}{4}$ in.	
1st worker to cylinder	10 B.W.G.	
1st stripper to worker	14	,,
1st stripper to cylinder	$= 12$	,,
2nd worker to cylinder	11	,,
2nd stripper to worker	14	,,
2nd stripper to cylinder	$= 13$	,,
Doffer to cylinder	12	,,
Drawing-off roller to doffer	$= 14$	,,

Finisher Card.—The finer and cleaner grades of material, such as roughing, machine, and sorting tows, do not require preliminary treatment on the breaker, the finisher card being sufficient to open and clean the fibre. On the finisher card, the working principle of which is similar to that of the breaker, the fibre is usually delivered to the feed sheet by an automatic feed mechanism, by which the weight per unit area of sheet may be regulated. It is fed to the cylinder by a pair of porcupine rollers covered with brass staves in which are mounted several rows of pins, these are hooked against the cylinder and prevent the fibre from being gulped through.

The finisher card is fitted with from four to eight pair of workers and strippers according to the size of the cylinder and the fineness of the card. The function of these is exactly the same on this card as on the breaker. The workers strip the fibre from the cylinder and are themselves stripped by the strippers, these in their turn are stripped by the cylinder. Between the cylinder and the workers the fibre is opened up, and on the strippers nep, straw, and any other foreign

PARTICULARS OF FINISHER CARDS
Suitable for Various Classes of Work

	Coarse	Medium.	Fine.
Cylinder.			
Diameter and length -	4 x 6 ft.	4×6 ft.	4 6 ft.
Pins per inch - - -	5	5½	6
No. of wire - - -	18	19	19
Feeds.			
Diameter over metal -	3 in.	2½ in.	2 in.
No. of wire - -	15	16	17
Pins per inch - -	4	5	6
Feeds to cylinder - -	14	14	14
Feeds to each other -	16	17	18
Feed Stripper.			
Diameter over metal -	6 in.	7 in.	8 in.
No. of wire - - -	14	15	16
Pins per inch - - -	4	5	6
Feed stripper to cylinder	16	17	18
Feed stripper to feed -	14	15	16
Strippers.			
Diameter over metal -	7 in.	6 in.	6 in.
*No. of wire - - -	15 to 19	16 to 20	17 to 21
Pins per inch - - -	3½ ,, 5	4 ,, 5¾	5 ,, 6¼
*Strippers to cylinder -	15 ,, 19	16 ,, 20	17 ,, 21
Workers.			
Diameter over metal -	6 in.	5 in.	5 in.
*No. of wire - - -	14 to 19	15 to 20	16 to 21
Pins per inch - - -	4 ,, 5	5 ,, 6	6 ,, 7
*Workers to cylinder -	14 ,, 19	15 ,, 20	16 ,, 21
Doffers.			
No. of wire - - -	Top 18 / Bottom 19	Top 19 / Bottom 20	Top 20 / Bottom 21
Pins per inch - - -	Top 5 / Bottom 5½	Top 6 / Bottom 6½	Top 7 / Bottom 7½
Top doffer to cylinder -	18	19	20
,, ,, knife -	19	20	21
Bottom doffer to cylinder	19	20	21
,, ,, knife -	19	20	21

Strippers.

No. of Stripper.	No. of Wire and Strippers to Cylinder.		
	Coarse.	Medium.	Fine.
1	15	16	17
2	16	17	18
3	17	18	19
4	18	19	20
5	18	19	20
6	19	20	21
7	19	20	21

Workers.

No. of Worker.	No. of Wire and Workers to Cylinder.		
	Coarse.	Medium.	Fine.
1	14	15	16
2	15	16	17
3	16	17	18
4	17	18	19
5	18	19	20
6	18	19	20
7	19	20	21

* Details in the extreme right-hand column.

matter is thrown off by centrifugal force owing to the high speed at which they are driven.

As the fibre is removed from the doffers it is drawn through bell-mouth conductors and between rollers, where it is compressed into firm slivers. These are united together and delivered into a can or, if a rotary head is attached to the card, they are drafted out and doubled on this prior to passing into the can.

Angle of Pins.—The efficiency of the card depends largely on the keenness of the clothing, that is, the angle occupied by the pins with the surface of the stave. Suitable settings for both breaker and finisher cards are: Cylinder, 75°; feed rollers, 65°; workers, 45°; strippers, 35°; doffers, 35°.

Speed of Card Details.—This is an important point in carding, for if the speed is too low a dirty sliver will result, and if too high an excessive amount of good fibre will be thrown off as waste. It will vary with the quality of the material in work. A range of surface speeds for the various details are here given, they are: Cylinder=2500 to 3000 ft. per minute. Strippers=450 to 650 ft. per minute. Workers=5 to 15 ft. per minute.

The requirements of different classes of material may be summarised as follows :—

For tows of a wefty and dirty nature, such as are obtained from some grades of Irish, Russian, patent steeped, and dew-retted fibre: Fast workers, fast strippers, and a medium cylinder.

Strong warp tows of a dirty nature, under which heading may be included most Irish, Dutch, and the better grades of Russian fibre: Slow workers, medium strippers, and a fast cylinder.

For fine, clean tows, open and free from dirt, such as fine root-end machine tow and sorting tow: Fast workers, slow strippers, and a medium cylinder.

Clean warp tows require slow workers, slow strippers, and a fast cylinder.

Combing.—Tow which is to be combed requires to be passed over a doubler first in order to regulate the weight of material to be put up at the back of the comb and to assist in parallelising the fibre bundles. Two different makes of flax-tow comb in general use are the Schlumberger and Delette. The principle of construction of both machines is similar, although they differ in detail and each machine can claim certain advantages over the other.

Slivers to the number of eight or fifteen are arranged in cans at the back. The ends are drawn in through feed rollers and on to a grid which is intersected by the pins of the feed comb. The latter consists of a number of single rows of pins a certain distance apart

and mounted on a metal base. The feed carriage is capable of movement in an upward and downward, and backward and forward direction, in order to feed the slivers forward to the comb segment. The feed comb assists in holding the material firmly and so preventing it from being gulped through during combing operations.

The circular comb consists of a number of rows of pins, graded from coarse to fine, which are mounted on a metal segment and the latter attached to a revolving shaft, as in the Schlumberger, or to a reciprocating shaft, as in the Delette. The pins of the circular comb penetrate the fringe of fibre which projects beyond the feed comb, removing all nep and dirt and parallelising the fibre bundles. This done the fixed comb, which consists of a single row of pins, descends and penetrates the fringe of combed fibre; a pair of drawing rollers rise, seize the combed end of the fringe and draw the fibres away, so that the tail ends are cleaned in passing through the fixed comb. The combed fibre is deposited on a leather sheet, so that each succeeding layer overlaps its predecessor, forming a continuous fleece which is drawn through a bell-mouth conductor and compressed into a sliver by passing between a pair of metal rollers in front; this sliver is delivered into a can.

The number of combs in the circular segment and the grading of the pins of these together with those of the fixed comb, considerably influence the appearance of the combed sliver and the percentage of noil or waste produced. The number of rows and the grading of the pins in the feed comb also affect the yield.

In the following table a range of pins suitable for different classes of material is given for each comb :---

Class of Material.	Range of Pins per Inch.		
	Feed Comb.	Circular Comb.	Fixed Comb.
Coarse - - - -	10 to 20	5 to 40	40
Medium - - -	10 ,, 20	7½ ,, 45	45
Fine - - - -	10 ,. 20	10 ,, 50	50

Subsequent to combing, the weight of the sliver again requires to be regulated. This is effected on the first drawing frame of the preparing system. The length per can for tow sets is usually taken at 500 yds. The cans constituting a set are put up at the back of the second drawing frame.

FLAX-LINE PREPARING SYSTEMS

		100 to 200 Yards per Ounce.				
	Doubler.	1st Draw-ing.	2nd Draw-ing.	3rd Draw-ing.	4th Draw-ing.	Roving.
Heads per frame - - -	1	2	3	4	5	10
Slivers per head - " -	6	8	8	8	8	8
Deliveries per head - -	1	1	1	1	2	8
Length of reach - -	26 in.	24 in.	22 in.	20 in.	18 in.	16 in.
Diameter, front rollers -	2¼ „	2 „	1¾ „	1½ „	1½ „	1½ „
Diameter, back rollers -	2 „	1¾ „	1¾ „	1¼ „	1¼ „	1¼ „
Pitch of screw - -	₇⁄₁₆ „	¾ „	¾ „	½ „	¼ „	¼ „
Breadth of gill - -	2¼ „	2¼ „	2¼ „	1¾ „	1½ „	1 „
Pins per inch (two rows) -	14	22	24	26	28	32
No. of wire - - -	19	23	24	25	25	26
Length of pin - - -	1½ in.	1¾ in.	1¾ in.	¾ in.	1¼ in.	¾ in.
Conductor - - -	1¼ „	1¾ „	1½ „	1₁⁄₁₆ „	¾ „	¾ „
Number of roving spindles -	..	..	..	..	..	80
Size of rove bobbin - -	..	..	..	..	..	8×4 in.

		250 to 400 Yards per Ounce.				
	Doubler.	1st Draw.	2nd Draw.	3rd Draw.	4th Draw.	Roving.
Heads per frame - - -	1	2	2	2	3	9
Slivers per head - -	6	8	8	8	12	10
Deliveries per head - -	1	1	1	1	3	10
Length of reach - -	26 in.	22 in.	20 in.	18 in.	18 in.	16 in.
Diameter, front rollers -	2¼ „	2 „	1¾ „	1¾ „	1¾ „	1¾ „
Diameter, back rollers -	2 „	2 „	1¾ „	1¾ „	1¼ „	1½ „
Pitch of screw - -	¾ „	¾ „	₄⁄₁₆ „	₇⁄₁₆ „	₅⁄₁₆ „	¼ „
Breadth of gill - -	2¼ „	1¾ „	1½ „	1⅜ „	1¼ „	¼ „
Pins per inch (two rows) -	18	22	26	30	34	38
No. of wire - - -	21	23	25	26	26	27
Length of pin - - -	1¼ in.	¾ in.	¾ in.	1¼ in.	⅝ in.	½ in.
Conductor - - -	1¼ „	1₁⁄₁₆ „	1¾ „	⅞ „	1₁⁄₁₆ „	¼ „
Number of roving spindles -	..	..	..	..	..	90
Size of rove bobbin - -	..	..	..	..	..	6×3 in.

		450 to 550 Yards per Ounce.				
	Doubler.	1st Draw.	2nd Draw.	3rd Draw.	4th Draw.	Roving.
Heads per frame - - -	1	2	2	3	5	10
Slivers per head - -	6	8	8	8	8	10
Deliveries per head - -	1	1	1	1	2	10
Length of reach - -	22 in.	20 in.	20 in.	18 in.	16 in.	14 in.
Diameter, front rollers -	2¼ „	1¼ „	1½ „	1¾ „	1½ „	1¾ „
Diameter, back rollers -	2 „	1½ „	1¼ „	1½ „	1½ „	1¼ „
Pitch of screw - -	¾ „	₃⁄₁₆ „	1₁⁄₁₆ „	₉⁄₁₆ „	¼ „	₅⁄₁₆ „
Breadth of gill - -	2¼ „	1½ „	1¾ „	1¼ „	1 „	1₁⁄₁₆ „
Pins per inch (two rows) -	18	26	32	36	40	45
No. of wire - - -	21	25	26	27	28	29
Length of pin - - -	1 in.	¾ in.	¾ in.	⅝ in.	₇⁄₁₆ in.	¼ in.
Conductor - - -	1¼ „	¾ „	¾ „	⅝ „	1₁⁄₁₆ „	¾ „
Number of roving spindles -	..	..	..	..	..	100
Size of rove bobbin - -	..	..	..	..	..	5×3 in.

TOW PREPARING SYSTEMS

For Preparing Rove

	40 to 80 Yards per Ounce.				80 to 120 Yards per Ounce.				130 to 160 Yards per Ounce.			
	1st Draw-ing.	2nd Draw-ing.	3rd Draw-ing.	Roving.	1st Draw-ing.	2nd Draw-ing.	3rd Draw-ing.	Roving.	1st Draw-ing.	2nd Draw-ing.	3rd Draw-ing.	Roving.
No. of heads	3	3	4	7	2	3	4	8	3	4	5	9
Slivers per head	8	8	8	10	8	8	8	10	8	8	8	10
Deliveries per head	1	1	2	10	1	2	2	10	1	2	2	10
Length of reach	14 in.	12½ in.	11 in.	10 in.	12½ in.	11 in.	10 in.	9 in.	11 in.	10 in.	9 in.	8 in.
Diameter, front rollers	1¾	1¾	1¾	1½	1¾	1¾	1½	1½	1¾	1½	1½	1½
Diameter, back rollers	1½	1½	1½	1¼	1½	1½	1¼	1¼	1½	1½	1¼	1¼
Pitch of screws	2¼	2¼	2¼	1½	2¼	2¼	1½	1½	2¼	2	1¾	1¾
Breadth of gill	10	12	14	16	14	17	20	22	18	21	24	25
Pins per inch	18	18	19	20	19	20	22	25	20	22	24	30
No. of wire	1¼ in.	1 in.	¾ in.	¼ in.	1¼ in.	1 in.	¾ in.	¼ in.	1 in.	¾ in.	1 in.	¼ in.
Length of pin	1¾	1½	1¼	70	1½	1¼	1¼	80	1½	1¼	1	90
Conductor	...	...	...	1¾ in.	...	...	...	¾ in.	...	...	...	1¼ in.
Number of spindles	...	...	...	8¼×4	...	...	...	8×4	...	...	...	8×3¾
Diameter of spindles	500 yds.	...	...	...	500 yds.	...	...	...	500 yds.	...	...	...
Dimensions of bobbin												
Length of bell												

The formula for finding the weight of set for tow systems is :—

$$\frac{\text{Number of yards per can} \times \text{drafts (2nd, 3rd drawings and roving)}}{\text{Yards per ounce rove} \times 16 \times \text{doublings on 3rd drawing}}.$$

Tow material being used in the manufacture of an inferior grade of yarn the cost of preparing must be reduced to a minimum ; for this reason in tow-preparing systems the number of frames do not exceed three drawings and a roving frame, and for inferior grades of material two drawings and a roving frame. Owing to the short staple of tow fibre the drafts over the system are necessarily lower than for line. In tow preparing the standard may be taken as 9 ; for this reason also the reach, or distance between the nip of the back rollers and that of the boss and wooden pressing rollers also is shorter, as will be seen on comparing the tables of particulars for line and tow preparing systems.

<div align="center">(See two previous pages.)</div>

Spinning.—Two methods are in existence for converting prepared flax fibre into yarn. The dry spinning process in which the material is passed over a frame, the construction of which is similar to that of the roving frame. This process is only practised in the coarse end of the trade.

The wet spinning process is most extensively practised and is employed in the manufacture of all the better and finer grades of yarn, such as are utilised in the production of various classes of linen for household use or wearing apparel. In this process the rove bobbins are set in creels above the frame, the rove, being guided over rove rails, is drawn down and through a trough filled with hot water. This has the effect of softening the pectin which binds the individual fibres together and puts the rove in a fit condition for further drafting.

Drafting is effected by passing the softened rove through two pairs of fluted rollers, the ratio of the speeds of which can be arranged so as to reduce the rove to any desired fineness. On delivery from the drawing rollers the ends pass down through the thread-plate eyes and are wound on to bobbins, twist being inserted by means of positively driven spindles and flyers.

Temperature of Water.—The spinning frame trough is heated by a steam pipe, the ends of which are open so that the steam may pass into the water. Regulation of the water temperature is an important point. The amount of heat required varies with the nature of the material in work. Soft wefty flax requires a low temperature—a better yarn and higher production being obtained when this is observed. Strong warp flax, on the other hand, requires

a high temperature if a level yarn free from faults is to be obtained. Temperatures varying from 160° to 180° F. for warp yarns, and 120° to 140° F. for wefts will usually be found sufficient.

The drawing rollers are fluted, those of the top or feed roller being coarser than those of the bottom or drawing roller, in order to deal effectively with the larger body of fibre in the nip. The shape of flute and number per inch varies with the pitch of frame. On coarse frames which deal with heavy roves, rollers with large flutes are necessary in order that the fibre may be properly retained during drafting. As the pitch of frame becomes finer, so also does the average weight of rove spun on it, so that smaller and finer pitched flutes are required. When the depth of flute is increased the number per inch must be reduced, otherwise a sharp-pointed flute will be obtained; this is undesirable, as it becomes worn very quickly and necessitates frequent refluting.

On each roller rides a number of pressing rollers. These are mounted in pairs on arbors and held in position against the face of the feed and drawing rollers by means of a saddle and stand. Pressure is applied to the saddle and through it to the rollers by means of a spring wire connected with a weighted lever and screwed against the saddle back.

The spindles are supported on two horizontal rails extending from gable to gable on each side of the frame. The dimensions of the spindle blade are closely connected with the distance between these two rails. When these are set well apart the spindle will be better balanced on its bearings and less likely to be top heavy. This setting, however, necessitates the use of a heavy spindle and a consequently larger bobbin barrel with a reduced capacity for holding yarn.

Smooth running of the spindle depends largely on the position occupied by the whorl in relation to the tin driving cylinder. In order to eliminate any tendency on the part of the spindles to jump, it is usual to set the groove of the whorl slightly above the level of the cylinder shaft centre where the spindles are being driven from the under side of the cylinder, and below the level of the cylinder shaft centre when the drive is off the top of the cylinder.

Flyers.—The flyers represent in form an inverted U. They are bored out in the centre and threaded so as to allow them to be screwed on to the spindle top. The tips of the legs are hollowed out to admit the end of the brass eye which is soldered in. Only wire of the best quality, hard and with a smooth surface, should be used in the construction of flyer eyes. Inferior wire generally cracks when being turned to form the eye, and in this condition will do an infinite

amount of damage to the yarn if not detected, producing a chafed or frayed thread which is most unsightly. The wire should be a proper fit for the leg socket, and after the eye is turned it should be given a " set " so as to prevent the yarn bearing on the flyer. The life of the eye depends on the quality of the wire used and the class of yarn being spun, strong tight twisted warp yarns being more severe than slack twisted wefts. The eyes should be renewed on warp frames at least once a week.

Lines of a Spinning Frame.—The path followed by the rove in its passage from the trough, through the feed and drawing rollers and down through the thread plate and flyer eyes, constitutes the lines of the frame.

Projection.—The distance between the outside face of the brass drawing roller and a vertical line drawn through the centre of the spindle is termed the projection of the frame. This depends on the width of flyer and the class of work for which the frame is intended; frames for spinning weft yarns have a smaller projection than those for warps in order that the strain on the end may be reduced.

Angle of Beam.—The roller beam in which the feed and drawing rollers are mounted is set at an angle of from 15° to 18° with the vertical according to the pitch of frame. In the following table approximate settings and distances are given :—

Pitch of Frame.	Angle of Beam.	Projection.	Thread Plate Bearing.	Distance from Flyer Eye to Nip of Drawing Rollers.	Distance from Spindle Screw to Thread Plate.
In.		In.	In.	In.	In.
3	18°	$\frac{7}{8}$	$\frac{3}{16}$	10$\frac{3}{4}$	2$\frac{5}{8}$
2$\frac{3}{4}$	18°	1$\frac{3}{16}$	$\frac{1}{4}$	10$\frac{5}{8}$	2$\frac{1}{4}$
2$\frac{1}{2}$	18°	$\frac{3}{4}$	$\frac{1}{8}$	9$\frac{3}{4}$	2$\frac{3}{8}$
2$\frac{1}{4}$	17°	1$\frac{1}{16}$	$\frac{1}{16}$	9	2
2	17°	$\frac{9}{16}$	$\frac{1}{16}$	8$\frac{1}{8}$	1$\frac{3}{4}$
1$\frac{3}{4}$	16°	$\frac{1}{2}$	$\frac{1}{32}$	7$\frac{1}{2}$	1$\frac{1}{2}$
1$\frac{1}{2}$	15°	$\frac{2}{3}$	$\frac{1}{16}$	7$\frac{1}{8}$	1$\frac{1}{4}$

The yarn is wound on to the bobbin by the flyer as it rotates. The normal condition of the bobbin is at rest, the pressure of the drag band preventing it from rotating. When winding on the yarn the pull exerted by the flyer through the thread causes the bobbin to rotate at such a speed that the twisted thread is wound on by reason of the lag of the bobbin behind the spindle.

The speed of the bobbin at any time during the doff is equal to—

$$\text{R.P.M. spindle} - \frac{\text{Length of yarn spun per minute}}{\pi(\text{D plus 2 Nd.})}.$$

Where D= diameter of bobbin barrel.
$d=$ effective diameter of thread.
$n=$ number of layers of thread on the barrel.

Draft.—The draft is the ratio between the speed of the feed and drawing rollers. It depends on the weight of rove from which the yarn is to be spun. As in preparing, it is desirable to keep it as low as possible in order that the resulting yarn may be uniform. In spinning two factors arise which tend to alter the lea of the spun yarn : they are (1) loss of weight which occurs owing to the removal of soluble matter from the rove during its passage through the hot-water trough ; (2) contraction due to twist inserted into the drafted rove ; this tends to increase the weight of the yarn.

The factors 1 and 2 working in opposite directions neutralise each other to some extent. Taking the effect of these factors into consideration the formula for obtaining the draft is—

$$\frac{19 \times \text{yarn lea}}{\text{Yards per ounce rove}}.$$

For yarn leas under 25 and over 100 the constant 20 should be used in the above formula instead of 19.

Reach.—This is the distance between the nip of the feed rollers and that of the drawing rollers. It varies in general with the lea of the yarn, being greater for coarse numbers than for fine counts. The quality of the material in work must also be taken into consideration, strong warp flax requires a longer reach than is necessary for soft weft grades.

Twist.—The twist to be inserted varies according to the quality of the material and the use to which the yarn is to be applied. The following formula is used to obtain the number of turns per inch for any lea of yarn :—

$$\text{Turns per inch} = \text{T.F.} \times \sqrt{\text{C}},$$

where C is the lea of the yarn and T.F. a twist factor which varies according to the class of yarn being spun.

For weft yarns T.F. $=1 \cdot 5$ to $1 \cdot 8$.
For warp yarns T.F. $=1 \cdot 8$ to $2 \cdot 0$.
For thread yarns T.F.$=1 \cdot 9$ to $2 \cdot 3$.

In the following table the turns per inch are given, using various twist factors for the range of leas to which flax is usually spun :—

TURNS PER INCH: FLAX SPINNING

Using Various Twist Factors

Leas.	Twist Factors.									
	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·1	2·2	2·3
8	3·96	4·24	4·53	4·81	5·1	5·38	5·66	5·95	6·23	6·51
10	4·42	4·74	5·06	5·37	5·69	6·05	6·32	6·64	6·95	7·27
12	4·84	5·19	5·54	5·88	6·23	6·57	6·92	7·26	7·61	7·96
14	5·24	5·61	5·98	6·36	6·73	7·1	7·48	7·85	8·23	8·6
16	5·6	6·0	6·4	6·8	7·2	7·6	8·0	8·4	8·8	9·2
18	5·94	6·36	6·78	7·2	7·62	8·06	8·47	8·9	9·32	9·75
20	6·26	6·7	7·15	7·6	8·04	8·49	8·93	9·38	9·84	10·3
22	6·56	7·02	7·5	7·96	8·43	8·98	9·37	9·82	10·3	10·78
25	7·0	7·5	8·0	8·5	9·0	9·5	10·0	10·5	11·0	11·5
28	7·41	7·95	8·47	9·0	9·54	10·08	10·6	11·13	11·65	12·2
30	7·67	8·21	8·77	9·3	9·85	10·4	10·96	11·5	12·03	12·6
32	7·92	8·49	9·06	9·62	10·19	10·75	11·32	11·88	12·43	13·0
35	8·3	8·80	9·49	10·08	10·68	11·26	11·85	12·45	13·04	13·64
40	8·87	9·5	10·14	10·76	11·4	12·04	12·68	13·3	13·94	14·58
45	9·4	10·09	10·74	11·4	12·1	12·75	13·43	14·1	14·77	15·45
50	9·9	10·61	11·33	12·02	12·75	13·45	14·15	14·85	15·56	16·28
55	10·4	11·14	11·9	12·62	13·38	14·1	14·84	15·6	16·33	17·1
60	10·86	11·63	12·4	13·17	13·95	14·73	15·5	16·26	17·02	17·8
65	11·3	12·1	12·9	13·71	14·52	15·33	16·14	16·94	17·74	18·55
70	11·72	12·53	13·4	14·2	15·05	15·87	16·75	17·55	18·4	19·24
75	12·12	13·0	13·85	14·7	15·56	16·45	17·3	18·2	19·05	19·9
80	12·5	13·4	14·3	15·2	16·0	16·98	17·88	18·77	19·66	20·55
85	12·9	13·85	14·75	15·7	16·6	17·5	18·45	19·4	20·3	21·2
90	13·3	14·25	15·2	16·15	17·1	18·0	19·0	19·95	20·85	21·8
95	13·65	14·6	15·6	16·55	17·52	18·5	19·5	20·45	21·42	22·4
100	14·0	15·0	16·0	17·0	18·0	19·0	20·0	21·0	22·0	23·0
110	14·7	15·74	16·8	17·84	18·9	19·95	21·0	22·05	23·1	24·15
120	15·33	16·43	17·52	18·6	19·7	20·8	21·9	23·0	24·1	25·2
130	15·96	17·12	18·25	19·4	20·52	21·7	22·8	23·95	25·1	26·25
140	16·64	17·82	19·0	20·2	21·4	22·55	23·75	24·95	26·1	27·3
150	17·14	18·36	19·6	20·8	22·05	23·3	24·5	25·7	26·9	28·15
160	17·7	18·98	20·25	21·5	22·8	24·05	25·3	26·55	27·85	29·1
170	18·26	19·57	20·9	22·15	23·5	24·8	26·1	27·4	28·7	30·0
180	18·8	20·15	21·5	22·85	24·2	25·5	26·85	28·2	29·55	30·9
190	19·3	20·7	22·06	23·45	24·8	26·2	27·55	28·95	30·3	31·7
200	19·8	21·25	22·65	24·06	25·43	26·9	28·3	29·7	31·12	32·55
210	20·3	21·75	23·2	24·65	26·1	27·55	29·0	30·43	31·9	33·33
220	20·75	22·26	23·73	25·2	26·7	28·2	29·7	31·15	32·65	34·12
230	21·25	22·75	24·28	25·8	27·3	28·8	30·35	31·86	33·4	34·9
240	21·7	23·25	24·8	26·45	27·88	29·45	31·0	32·55	34·1	35·65
250	22·15	23·75	25·3	26·9	28·5	30·1	31·66	33·25	34·8	36·4
260	22·6	24·2	25·8	27·45	29·05	30·65	32·3	33·9	35·5	37·1
270	23·03	24·68	26·3	27·95	29·6	31·25	32·9	34·55	36·2	37·8
280	23·45	25·12	26·8	28·47	30·15	31·8	33·5	35·15	36·85	38·5
290	23·84	25·54	27·25	28·95	30·65	32·36	34·06	35·76	37·47	39·17
300	24·25	25·98	27·71	29·44	31·18	32·91	34·64	36·37	38·1	39·84

Turn Off.—In calculating the production, allowance must be made for twist contraction, time lost in doffing, washing down the frame, executing repairs, etc. The actual formula for finding the cuts per spindle per day of ten hours is—

$$\frac{\frac{\text{R.P.M.}}{\text{line}}\times\frac{\text{drum}}{\text{diam.}}\times\frac{\text{cylinder}}{\text{pinion}}\times\frac{\text{twist}}{\text{pinion}}\times\frac{\text{ex-}}{\substack{\text{treme}\\\text{diam.}\\\text{of}\\\text{draw-}\\\text{ing}\\\text{roller}}}\times 3\cdot4\times\left\{\substack{\text{twist}\\\text{100-cont.}\\\text{time}\\\text{lost, etc.}}\right\}\times 600=\text{min. per day}}{\text{Pulley diameter}\times\text{crown wheel}\times\text{delivery roller wheel}\times 36\times 300\times 100}\ .$$

The power required to drive a wet spinning frame varies in general with the pitch and the speed at which it is running. Other points must be taken into consideration, such as the efficiency of the frame, size of pulley, width of belt, etc. The following figures may be taken as an average for each pitch:—

$1\frac{1}{2}$ in. pitch=0·5 H.P. per 100 spindles.
$1\frac{3}{4}$ in. ,, =0·85 ,, ,, ,, ,,
2 in. ,, =1·3 ,, ,, ,, ,,
$2\frac{1}{4}$ in. ,, =2·1 ,, ., ,, ,,
$2\frac{1}{2}$ in. ,, =3·0 ,, ,, ,, ,,

Reeling.—All wet spun yarns which are wound on to bobbins must be reeled in order that they may be measured and dried. Fine weft yarns from 100's lea upwards are frequently spun on paper tubes, being dried on these and sold by weight.

The reel is usually made double with pins for 30 bobbins on each side. The swift on which the yarn is wound is collapsible in order to facilitate the removal of the reeled yarn. The circumference is 90 in. for long reeled yarns and 54 in. short reel. The swift is driven by a small friction pulley and plate, the latter set on the axle. It may be started or stopped at will by pressing a foot lever.

A worm, set on one end of the swift axle, engages a bell wheel which operates a bell, causing it to ring each time the swift makes 120 revolutions. By means of this the worker is enabled to insert her lease band as each "cut" or lea is wound off. When twelve cuts have been reeled off against each end the reel is stopped, the ends cut and knotted up with each lease band, and the "hanks," as they are now termed, removed from the reel.

YARN TABLES

Long Reeled Yarns.—

1 circumference of reel=90 in. =2½	yds. =1 thread.	
120 threads	=300	,, =1 lea or cut.
12 cuts=1440 threads	=3600	,, =1 hank.
16 2/3rd hanks=24,000 threads=60,000	,, =1 bundle (Irish or	
		English).

Short Reeled Yarns.—

1 circumference of reel=54 in.=1½	yds. =1 thread.	
100 threads	=150	,, =1 cut.
12 cuts=1200 threads	=1800	,, =1 hank.

Dry Spun Yarns.—

1 circumference of reel=90 in.=2½	yds.=1 thread.	
120 threads	=300	,, =1 lea or cut.
2 cuts	=600	,, =1 heer.
6 heers	=3600	,, =1 hank.
4 hanks	=14,400	,, =1 spyndle or
		spangle.

The count of yarn is indicated in pounds per spyndle.

Drying.—Reeled yarn is either loft dried or machine dried. In the former case the hanks are hung on poles, being properly spread out so that the air can penetrate them thoroughly. The poles are arranged in racks or stands over a nest of steam pipes which maintain the temperature of the loft between 120° and 130° F. during the drying process. In machine drying the yarn is passed over a series of steam-heated cylinders, the hanks being spread out and linked together by means of brass cleeks, thus forming a continuous chain from the filling end to the stripping end.

Machine-dried yarn has a smooth skin imparted to it, and on the whole looks better than yarn which has been loft dried. The latter method, however, is to be preferred for drying all fine sorts and superior qualities, as there is less likelihood of the yarn being scorched. Loft-dried yarn also behaves better during the weaving process than the machine-dried product.

Conditioning.—Subsequent to drying the yarn must be conditioned before bundling. Moisture will be absorbed best by hanging it on poles in a cooling shed which permits free access of outside air. Bone dry yarn will absorb from 8 to 10 per cent. moisture under atmospheric conditions.

Bundling.—For convenience flax yarns are generally made up into bunches for marketing. The number of bundles per bunch varies with the lea of the yarn as follows:—

Up to 12 lea incl. = 1½ bundles per bunch.
14 to 16   ,,   = 2   ,, ,, ,,
18 to 32   ,,   = 3   ,, ,, ,,
35 to 65   ,,   = 6   ,, ,, ,,
70 and upwards = 12   ,, ,, ,,

Breaking Strength of Flax Yarns.—Many factors affect the breaking strength of yarn and, as few, if any, of these are taken into consideration when the tests are carried out, the results can only be approximate. As to the number of breaks necessary, repeated tests have shown that at least sixty should be taken to obtain a fair average. The length of test piece, turns per inch, percentage of moisture in the yarn, and the degree of humidity in the atmosphere, all have a considerable effect on the breaking strength.

The accompanying table of breaking strengths for three different classes of flax-line yarn represents the summarised results of tests taken over a considerable period of time.

BREAKING STRENGTH OF FLAX-LINE YARNS IN OUNCES

Lea.	Prime Warp.	Medium Warp.	Weft.	Lea.	Prime Warp.	Medium Warp.	Weft.
20	86·0	65·2	51·5	70	21·6	15·8	13·3
25	67·6	51·4	40·8	75	19·9	14·5	12·2
30	55·8	42·1	33·7	80	18·4	13·3	11·4
35	47·3	35·5	28·6	85	17·1	12·3	10·6
40	40·9	30·6	24·7	90	15·9	11·4	9·9
45	35·9	26·8	21·8	95	14·9	10·6	9·3
50	31·9	23·7	19·4	100	13·9	9·8	8·7
55	28·6	21·2	17·4	110	12·3	8·6	7·7
60	25·9	19·0	15·8	120	10·9	7·5	7·0
65	23·6	17·3	14·5				

KNITTED FABRICS

Fabric Structure.—The basic structure of knitted fabrics is the plain stitch, which in its simplest form is created from a single thread which runs crosswise in the texture. It is formed into loops, one row being drawn through the next until the whole texture is one dependent whole, which explains its advantages and some of its disadvantages as a clothing texture. The interlooped nature of the fabric imparts considerable elasticity, because when the texture is stretched at one point the loops seek to restore the equilibrium so that the garment in the case of underwear is kept in close contact with the body without hampering the movements as a woven fabric would do. This elasticity is greatest in the direction of the width, but the strength in the direction of the length exceeds that of the width, so that what is gained in elasticity is lost in strength. The plain stitch worked in its ordinary form is susceptible to laddering, which is a great disadvantage in stockings and knitted garments generally, for if the thread becomes broken it runs down as long as any strain is applied.

The knitted fabric on the face appears as a series of V-shaped loops, whilst on the back or wrong side the stitches show a series of closely interlocking semicircles which are not so sightly as the face aspect. This difference in appearance between the face and back gives rise to two of the commonest variations of the knitted stitch, namely, the rib stitch and the purl or pearl stitch. The rib stitch occurs in an upright direction in the cloth, and consists of vertical rows of face stitches alternating with rows of stitches which are worked wrong side up. The wrong side fabric stitches take a lower level than the face stitches, and a groove is formed which causes the fabric to contract considerably in width. This property renders the rib texture very suitable for the rib tops or rib bottoms placed at the extremities of legs, arms, etc. Several inches of the rib stitch are added in order to make the fabric grip the limbs at those points, thus keeping the garment in correct position on the wearer. This stitch is also used as the foundation of branches of trade such as the ribbed hose and half-hose, the rib-vest trade, and others where the rib stitch in its various forms gives a fabric of greatly augmented weight and body, and imparts to the article a more fancy appearance than is obtainable from the plain stitch. The rib stitch in its various ramifications, particularly with skilful colour schemes, has been the foundation of the success of many types of fabrics which have been in great demand for outerwear.

The pearl stitch is made by having wrong side fabric stitches alternating with face fabric stitches in pattern form, but in this case

the back stitches occur in a cross direction in place of being in vertical array. When brought up in this way the back stitches, in place of sinking into a kind of groove, are raised higher on the surface of the fabric, and stand above the ordinary fabric level with considerable distinctness. Such patterns are most effective when arranged as designs, because it takes but a simple arrangement of the back loops to produce a fancy pattern effect. To give the best results such cloths are confined to the stouter gauges of machines, those ranging between 3 and 7 stitches per inch being the most common. Patterns worked in vertical form and arranged in cable and basket styles take their place from time to time in the cycle of fashion, and their permanent use lies in juvenile and infants' wear. The coarse sett of loops lends itself to rapid production on the hand-knitting pins where minor alterations of stitch are quickly effected. Flat knitting machines are specially built for this class of pearl stitch trade, and when the Jacquard attachment is employed these back stitches can be planted in any form in the texture to give all kinds of figured designs.

The variations in loop formation next in importance are the tuck stitches, which, as the name indicates, are produced by tucking certain portions of the yarn in the fabric without allowing them to intersect in the usual way. The general run of this floating stitch is for two courses, but in slack fabrics three or four tucked courses produce effects which resemble lace patterns. Of these tuck stitches there are two varieties, one in which the stitches which are tucked are discharged in the same loop as another stitch. When formed in bunches of 3 to 5 courses on this principle there is a distortion amongst the loops of the fabric which makes the surface variable. In this type the colours employed are more or less mixed together, and it is remedied by causing the unknitted stitches not required for the colour pattern to float on the back.

The effect of these tuck stitches is to increase the weight of the cloth, render it much more firm and compact if such qualities are desired, and they also give to the knitted fabric a greatly increased range of patterns in colour.

Lace Stitch.—The lace or open stitch in the knitted fabric is extremely effective, and is produced by removing certain loops from their rightful needles and transferring them either on the right or left to neighbouring needles. This is done after the ordinary course of loops has been completed, and as a result openings occur in the work which, when arranged according to a pattern, give a very elegant appearance to the cloth. These designs are rendered more elegant when the lacing course in the machine makes two selections after a course of plain knitting, transferring its first selection of

stitches to the needles immediately on the right, whilst the second selection moves its stitches one needle space towards the left. The production of these lace-like fabrics requires the addition of special Jacquard tackle to the machine, and it is not surprising to know that various devices are adopted to produce imitations of this open-work effect. One style frequently adopted on circular machines is to bunch stitches together in the same loops on the tuck principle already referred to, and the other is to remove certain needles from the machine or render them inoperative so that open places occur in the fabric. Openwork stripes, for example, can be produced by omitting needles from any machine, because on these needles no stitches are formed, and the yarns lie loosely in the fabric, producing open spaces at these points. By the extension of this principle of structure, cellular fabrics can be obtained in which the characteristic open appearance is a feature of their success. Owing to the heat-retaining properties of the air in the spaces, there is greater warmth in such garments than would be inferred from their very light weight. These stitches proper are made on a circular machine termed the eyelet machine, which forms the open stitches with rapidity, and produces an extremely airy fabric at small cost.

The hosiery manufacturer has a considerable variety of equipment, the nature of which depends on the branch of the industry which he conducts. For the cut-up hosiery trade, which supplies by far the largest proportion of knitted goods for general wear, the first essentials are suitable machines for making plain and plated knitted web for ordinary requirements of cutting out. In this branch circular machines are used which divide themselves into two classes, one type using the latch needle and the other the spring or bearded needle. Latch needle machines are employed for the general run of trade in cut-up goods where the fabric requirements are not minutely exact. For the superior class trade where a higher price is asked, the web is generally produced on one or other of the spring or bearded needle machines, of which there are several distinct varieties.

Latch Needle Machines.—It is interesting to classify circular latch needle machines according as the needles revolve with the cylinder in which they work, or are fixed in a stationary cylinder. The moving needle cylinder machines are loosely classified as American, whilst those with the stationary cylinder are known as English latch needle circular frames. This distinction can also be noted in hose-producing machines where American-built machines usually have their needles and needle cylinders swinging round, with the thread guides and cams stationary, and it is clear that for high production of fabric this principle of building circular frames

is being largely followed in machine building. Both types are built with a large number of feeds, the number for general purposes being 16 to 24, which means that this number of courses is worked at each revolution of the machine. There can be little doubt that this type of machine ranks as the highest fabric productive mechanism in the textile industry, because a set of machines, from 5 to 8 being operated by one individual, produces from 3000 to 4000 yards of average gauge fabric per working week. The machines are built in various diameters according to the width of fabric required. Ordinary body width machines are 19 to 22 in. in diameter, but machines for producing cloth fabrics to finish 56 in. wide, vary from 32 to 36 in. in diameter. In the latter widths they have been built up to 80 feeds, that is, at each turn this number of courses are worked, and these are used for very rapid production of jersey cloth fabric and "meat" bags, the latter being the gauzy textures employed for wrapping round the carcasses of animals in the frozen meat trade. Other large feed frames are employed for producing fabric intended for use in nightdresses, as this gives a large width that is afterwards used in circular form. Such fabrics are nearly always brushed in order to hide the spirality of the texture, which is the result of the excessive number of feeds. For better grade underwear, the manufacturer finds it advantageous to employ a larger number of machines with a smaller number of feeds in each, the usual range being from 16 to 24.

Latch needle circular machines have a wide range of fabric structures possible on any particular gauge; for the gauze textures already referred to a thin cotton counts 30's would be employed on a sett of 10 needles per inch, whilst for a normal fabric the counts would be nearer 8's cotton on this gauge. For stiff fabrics 6's could be employed without injury to the machine parts. These different counts represent a wide range of textures suitable for diverse purposes, and with various routines of finishing the range of cloths is remarkable. Some of these machines are further provided with interchangeable cylinders, so that for winter season's goods, the machine may be working a gauge of 8 needles per inch, whilst for the lighter weight summer trade the cylinder may be replaced by another which produces fabrics with 16 needles per inch in much finer counts of yarn. This is a useful advantage to all firms who desire to restrict their capital outlay to the minimum.

Loop Wheel Circular Frames.—These machines are largely employed for the production of fabric of high grade quality in close sett gauges for the finer textures, for which there has been an increasing demand during the past decade. The machine is of English origin

arid employs bearded needles fixed vertically round the cylinder, so that the work passes upwards through the winding-up rollers. As the designation leads one to suppose, the loops are sunk over the needles by the loop wheel which is bladed, and a continuation of this principle of bladed wheels right through the feed enables the processes of dividing, landing, and knocking over the loop to be performed by their respective wheels.   The machine's most interesting adaptation is for the well-known fleecy-backed goods made with a fine gauge face and a thicker and heavier backing yarn to give augmented weight, handle, and firmness.   These fabrics are afterwards subjected to vigorous brushing on the raising machine which renders them very soft, absorbent, and full in handle.

These machines give fabrics at a high rate of production per worker, the quota being often as many as twelve machines tended by one individual, with the assistance of one juvenile, who attends to the yarn supplies.   Such fabrics do not have the thick backing yarn actually intersecting on the needles at each stitch, but a binding thread affords the connection between the face and the backing threads.

French Circular Frame.—This type of machine, also known as the German circular, is adapted for the production of fabrics having great perfection of mesh and is used for the best grade of cut garments.   The needles are fixed radially in a circle with the beards facing upwards, so that the work descends through the winding-up rollers.   The system of loop formation is, in comparison with other machine types, extremely complicated, and the production considerably less than the latch needle machines referred to.   One outstanding advantage of this machine is the facility with which stripes, small check patterns, bird's eye effects, and diamonds can be produced, owing to the system of cutting the presser wheels to tuck stitches.   This affords a means of considerably increasing the thickness of the fabric over the plain stitch, as these tucked loops are made to slip to the back or intersect with another loop.   In this way a greater weight of yarn can be inserted into the gauge.   Worked with good felting wool and suitably finished, the patterned products of this machine have recently been adapted for purposes of ladies' and gent.'s outer clothing, being made into garments which in style and appearance can scarcely be distinguished from the more densely woven fabrics.

Full-Fashioned Trade.—The full-fashioned trade deals with garments made with their respective portions fully fashioned to the precise shape of the wearer, and by this system exact interpretation can be given to any abnormality of physique.   The cut-up or circular trade is conducted on the highest principles of specialisation, giving

enormous production of moderately priced materials, but the full-fashioned trade concerns itself with the higher grades of yarns, and gives articles with perfect selvages which will form elastic and comfortable seams in underwear.   The chief drawback to the cut-up trade is the waste incurred, because in carving out the garments sections have to be cast aside as useless.   In the full-fashioned branch the garment parts are shaped exactly with only a slight frame waste incurred, so that in this respect it is more economical.   The full-fashioned system of manufacture calls for a larger initial outlay in respect of knitting machinery, and the principle of working the garments is more laborious and exacting, so that less production is secured.   The two branches are close competitors, and the deciding factor in many lines is the cost of raw materials.   If yarns rise above a certain price the loss due to waste neutralises to a large extent the lesser cost of production of the cut goods, so that when the cost of yarn is on the up-grade, it tends to swing the balance in favour of the full-fashioned branch where waste is less.   Any style of article can be produced on the full-fashioned system.   Full-fashioned stockings in cashmere and silk are important pillars of the trade, whilst the staple branches of ladies' and gent.'s underwear form a large bulk of the business.

Gauge in Knitting.—Machines are built to a particular spacing of needles or gauge, and the fabrics are approximately of this gauge, being from 10 to 20 per cent. closer, depending on the contraction, according to the material, type of machine, and tension of yarn.   There is a growing tendency to give the gauge in needles per inch, which in flat and circular feeder machines may be measured as tricks per inch.   In the case of straight bar bearded needle machines, the gauge may mean the number of leads in 3 in., which with normal two-needle leads is the number of needles in $1\frac{1}{2}$ in., with split gauge for coarse machines the number in 3 in., and with three-needle leads for fine machines the number of needles in 1 in.   In seamless hosiery the total number of needles and the diameter may be given, or the number of cylinder tricks per inch of diameter.   French circular machines may have a gauge for coarse machines of half the number of needles in 3 zoll or French inches, that is $\frac{1}{34}$ metre, and for fine machines one-third the needles in 3 zoll.   The German circular frame may be gauged as gross or fein: 20 fein has 15 needles per inch, 26 fein has 20 needles per inch, 30 fein has 23 needles per inch, and 36 fein has 28 needles per inch.   In latch needle warp-knitting machines the gauge may be the number of needles in two Saxon inches, the Saxon inch being about 0·93 in.

KNITTED COATS AND COSTUMES

This branch of the industry has assumed considerable dimensions, and the progress made bids fair to swing the course of demand heavily in favour of the knitted fabric. This vogue started with the discovery that the elasticity of the looped texture, particularly in the width, made it peculiarly suitable for sports wear. With continued experience great advance was made in the system of manufacturing these garments into suitable styles, and they are now supplying an increased part of the textile requirements of the public. The knitted garment is well adapted for wear during leisure hours and on occasions of sport. Starting with knitted coats and upper garments, a demand has developed for complete knitted dresses. Manufacturers have enlisted the skilled assistance of those accustomed to produce outer garments in woven cloth, so that the knitted productions follow closely on the approved lines of fashion, and each season sees a wide range of garment designs which make an unfailing appeal to the wearer. These knitted articles lend themselves to rapid making-up on a large scale in a few standard sizes, for the inherent elasticity of the knitted stitch enables the article to stretch to fit an ample figure, whilst it conveniently contracts to fit a more slender individual equally well. The general run of these goods are made in woollen materials, but a large and important trade has sprung up in artificial silk knitted textures where the inherent lustre of the artificial silk combines with the characteristic appearance of the knitted stitch to yield fabrics of great beauty. To meet this demand there has been a considerable increase in fineness of gauge on which those fabrics are worked, so that the mesh is delicate and the texture perfect.

The Flat Knitting Machine — The developments in the knitting industry just referred to have given a wide distribution to the flat knitting machine, as it is universally called. This machine is constructed with two needle beds placed almost at right angles to each other, and which are cut with tricks or grooves in which the latch needles operate. The gauge of the machine is that of the number of such tricks or grooves which cover an inch, so that a 5-needle machine has 5 needles per inch in one bed. It does not give a big range of gauges, and whilst the coarsest in use runs about 3 needles per inch, the gauge seldom goes finer than 13 needles per inch. The machine can be worked either by hand or power, but as the garments produced on it have generally to be made full fashioned to shape, the majority of such machines are operated by hand, as by this means waste is kept to the minimum. On a set of power-driven

machines of this class where fancy stitches are the rule, a section pressed off is frequently laid aside as waste, as the defect is generally so serious that it cannot be repaired in a reasonable time, so that the piece has to be worked afresh. The loss in time and material due to this cause is so great that it has been found an advantage in many branches of the trade to work these machines by hand, except for articles more or less standard in form, which admit of making long lengths of fabric with minor alteration in shape.

The fact of its being worked by hand is, of course, a disadvantage in establishing this industry securely in recognised centres of knitting where operators are accustomed to fast-moving automatic machinery which creates a disinclination for the more tedious hand work. The machine has a number of very decided advantages which render it ideal for many purposes. It has an unlimited scope of production both for pattern of stitch and form of garment, as any kind of style can be produced on it fully fashioned to shape. These changes in stitch and colour scheme can be very quickly effected, and can appear on one and the same garment. For example, in making a full-length dress, the rib stitch can be introduced at the waist portion to give contraction, whilst the stitch can be altered to one which goes more to width at another part of the garment where greater girth is needed.

Hose and Half-Hose.—A considerable section of this trade is done on the seamless principle, with parts made circular on machines with the needles arranged round the circumference of a cylinder, and where the only seaming operation consists in joining about 2 in. of fabric across the toe. The present-day stocking machine gives a production of five dozen pairs of stockings per working day, and an operator can tend four to six machines, according to type. The chief developments during the past few years have been along the lines of making the machine more and more self-contained in its operations, so that double handling shall not be necessary. The most important improvements have been in the direction of the automatically turned welt. In making plain stockings the top is produced with a double turn over, so as to keep the article in position on the limb and give a more finished appearance with added strength. In some machines this turn over has to be done and a separate welt made on a second machine which involves double handling of the article as well as additional plant. By the automatic welt attachment this can be done on the machine itself, and the article made with the turn over complete. Another improvement lies in, the introduction of courses of loops taking alternate stitches at given points in the stocking which will prevent that laddering which is a great trouble in this article. These anti-laddering courses are gener-

ally introduced near the knee, and the broken stitches run to this but will not proceed farther. Other additions have been made to the machine for producing other refinements in the article, but these are not finding the fullest favour on account of the increased mechanism which has to be added, and which calls for greater skill in the mechanic. More machine parts are liable to go wrong, and increased expenditure is demanded for more skilled mechanics or a larger number of them.

A large and important class of hose and half-hose are made with plain leg and foot, with the addition of a rib top, and in recent machines a successful attempt has been made to produce the rib top and the plain leg and foot on one and the same mechanism. Prior to this the universal practice was to make the rib tops on special rib machines in long lengths, which were afterwards separated. The rib tops were then run on to the hose machines individually from a transfer ring by hand to have the leg and foot knitted on. By the autoswift machine, which has now been successfully tested over a period of years, it becomes possible to make the rib top, leg, and foot in one piece by drawing needles into an upper cylinder from which they work rib stitch ; for the production of the plain leg and foot these needles have to be returned to the lower cylinder, where they produce plain knitting.

A very persistent demand is experienced in fancy design hose, due, possibly, to a rather obscure cause. When skirts and trousers were worn long there was little opportunity to display fancy footwear, but happily for this branch of the business the vogue for shorter garments appears likely to remain more or less permanent, so that the display of fancy embroidered patterns and other forms of orna·mentation becomes opportune. Men's socks are embellished in this way on what is known as the vertical striping hose machine, where extra coloured threads are worked into the article along with the ground yarn to form a range of designs which expands with every advance made in the mechanism for controlling the fancy threads. Not only straight clocking effects, but diamonds and floral effects are now made possible on the circular hose machine.

There has also been a great increase in the bulk of ribbed hosiery placed on the market, and the ribbed hose machine, with its most recent developments, has rendered possible a very wide range of broad and narrow ribbed textures. These have become increasingly popular as variants on plain stitch hose, and particularly for sports use have experienced an ever-expanding demand. Although the modern circular knitting machine can produce those articles at a high rate of production, a limited section of the hose trade is done on machines

such as the hand Griswold stocking knitter, which is primarily a domestic machine. Other types of stockings are made on the flat knitting machine, where the best facilities exist for attaching the fancy coloured top favoured in certain departments of sports wear, particularly for use on the moors during the shooting season. Golf and tennis players have their special tastes in regard to footwear of special features, which can be obtained on the slower working machines referred to.

The circular machines used for making hose and half-hose are gauged by the number of needles in the upright cylinder, and are made in various diameters from a small size, such as 3 in. for juvenile socks to 4¼ in. diameter for outsized hosiery. The range of gauge extends from 64 needles in the circumference to 240 needles or so in the normal diameter of 3¾ in. A considerable proportion of plain goods are produced in the region of 120 needle gauge, whilst the 220 needle gauge is a standard sett for the fine gauge silk or cashmere hosiery trade. Articles made on the hand circular knitter generally range between 84 and 144 needles in the cylinder.

Gloves.—Knitted gloves form a standard article of demand in the knitting industry, and these are largely made on the flat knitting machine, which has the capacity for making circular work in any width adapted for the production of seamless hands and fingers. This industry is highly specialised and worked on the team system, for although all parts of a glove can be made complete on one and the same machine, to secure the fullest production various machine widths are employed.   The trade divides the glove into three sections— the cuff or gauntlet, the hand, and the fingers—for each of which a certain type of machine is used.   For cuffs and gauntlets the usual stitch is ribbed plain or cardigan, and as these cannot be made on the flat knitting machine in circular form, they are produced flat and at double width, which is afterwards folded over its centre line for the addition of the hand portion.   The hand is worked on a machine having about 8 in. of needles, with the cams specially adapted for making circular fabric. Similarly the next machine, termed the fingerer, is adapted for circular fabric, but the main difference between this and the hand machine is that it is only a few inches in needle width to make the narrow ribbons required for fingers. The cuff machine, about 30 in. across, is the widest of the series, as it has to allow of gauntlets being produced when these are in fashion, and cardigan cams are the chief essential. When the machines are built in a width suitable for each part of the glove in the way mentioned, the fastest output is assured, as the worker only causes the carriage to traverse the needles at the width required;

also narrow width machines are more lightly constructed, so as to allow of swift operation. It is found that the traverse motions of an expert glove hand exceed what would be feasible by power, with the additional advantage that the hand worker at once feels any obstruction on the needles, and can stop instantly to remedy this before further damage is done to the fabric.

Scarves.—Knitted scarves are largely used by the public, and these are quickly made on plain stitch circular knitting machines of the correct width. The usual system is to work them on this machine in tubular form, this circle being afterwards pressed double to make the scarf. For the staple article the ground is plain with a colour scheme near the extremities. The woollen scarf is generally brushed on the teasles or card clothing to bring up the surface fibre, for which the longer stapled crossbred types are best adapted. This trade is also done by producing pieces on the flat knitting machine in plain or rib stitch, whilst lustrous goat fibres, such as alpaca, mohair, and cashmere, are also largely employed for these articles. Artificial silk and mercerised cotton also figure in small neat scarves for certain seasons, whilst there has also been an extensive demand for scarves produced on the warp loom, which has a ready capacity for giving vertical stripes along with the characteristic shogged effects, which add charm to the colour scheme.

Smallware.—The knitt d fabric is being increasingly employed for special purposes, one of the most important being that of binding and millinery perquisites. For tapes, small diameter circular machines are constructed, having only about a score of needles in the circumference, and the tubes produced from machines of this class can be used for insulating purposes and for covering wires, pipes, and tubing. If the machine be fitted with two or more thread guides, so that several colours can be introduced, a wide range of millinery trimmings can be produced in any kind of material, and these are being increasingly employed. Such fabrics made with a tuck stitch as vertical effect give neat results, and are very effectively applied for binding under garments round the neck and down the fronts. When these narrow fabrics are worked in the rib stitch with a tight tension they can be used for binding ladies' coats round the edges to make them firm, and impart stability to the garment in wear.

The knitted stitch forms the basic texture for many types of elastic bandages, and the use of different forms of the knitted stitch gives a range of articles, such as body belts, knee caps, and bandages. The knitted stitch has several important variants, of which the contraction on the needles can be definitely ascertained. The rib stitch

tends to contract abnormally when it leaves the needles, but if this is made half cardigan stitch with the loops knocked over in pairs on one side, then this increased weight of yarn fills out the fabric and makes it come off the needles at a greater width than the plain rib. Further, if this double structure of loops be followed on both sides of the fabric a still greater width is obtained, and the fabric may actually show wider than its needle width when out of the machine. In garment manufacture great use can be made of this principle of form to give articles and garments which will suit certain parts of the body of varying widths without the loss of time and increased costs connected with making them fully shaped and fashioned. In making body garments, for example, the wider half cardigan stitch may be used for the abdominal portion, with the plain rib stitch employed for the few inches of fabric at the foot of the garment. Similarly in sleeves the fuller cardigan stitches can be used for the body of the sleeve, with the plain rib at the bottom to draw inwards and give the correct shape, simply by an alteration of the cams from plain to cardigan, which can be effected automatically by means of a chain with links inserted to regulate the intervals.

Probably the most important example of the use of this principle of knitting is that of the knitted ribbed vest trade, which has in recent times assumed considerable proportions. These are for ladies' wear, and the shape is made narrow to fit the waist, and wider at the bust portion. This can be done in the manner mentioned by having the narrower waist portion in plain 1-and-1 rib, and altering it to the cardigan variety for the wider bust portion. Exactly the same principle is adopted for making body belts. The upper and lower extremities of the belt are constructed in the narrower 1-and-1 rib stitch to grip the body and keep the belt in position, whilst the centre part, which has to fit the abdomen and go round the spine, is worked in the fuller, warmer, and wider cardigan stitch. For these articles rib machines of ordinary body width of 19 in. diameter are used, and the same principle can be employed for knee-caps where the width of the machine is considerably less. Above and below the knee the plain 1-and-1 rib stitch occurs, whilst over the knee itself is placed the fuller cardigan stitch.

Ties.—Knitted ties are largely made on circular knitting machines of small diameter, where the chief patterning agent is the tuck stitch combined with several thread carriers which can be fitted with different colours. In the latest types of necktie machine, a pattern wheel is provided with pieces which are inserted at given points so that the corresponding needles are lifted up higher to reach for a different colour to that which is normally passing into the fabric.

By the further use of tucking cams, whereby the needles so selected do not knit except at alternate courses, a series of very effective colour schemes are producible. A chain can also be affixed to the circular necktie machine to introduce colours as required and to produce any width of stripe. In certain districts very high-class neckties are knitted in pure silk on the Cotton's patent frames, where the forms of fancy attachments can be utilised to the fullest extent for colour schemes and variations of stitch.

The development of the knitting industry in several of its most important branches has been due to the invention of suitable means of sewing and joining the garment pieces together. One aspect of seaming concerns those seams which are intended to unite two perfect edges such as are presented in the full-fashioned trade where the edge stitches are intact and can be joined without biting into the edge. The other division of seaming is connected with the trade in cut-up goods where the edge is raw owing to the way in which the knife has severed the stitches. Such cut stitches have no support for the seaming threads, and a larger grip is required for them to take hold. There is also the function of attaching pieces of fabric as is done in trimming and strengthening the fabric. The most suitable means of seaming and joining are determined by whether the article is required to be worn next to the skin, in which case an elastic seam will be essential, or whether, as in the case of knitted goods for outer wear, strength is the main desideratum. In attaching bands of cotton to provide firmness and rigidity to retain the article in position, a stitch is required which shall be unyielding and firm like the cloth it is attaching.

Seaming and Sewing Knitted Goods

Chain Stitch.—This is one of the first stitches to be used for seaming and sewing, and is produced from a single thread which is linked on itself in a series of chains. The bulk of the stitch appears on the back of the fabric where the thread is double; on the face the stitch only shows as a series of single pieces. The double aspect of the stitch, as seen on the wrong side, however, has a useful place in embroidery, for this side becomes the face of the stitch, and patterns are arranged in great variety on this basis with excellent effect. In regard to seaming, the chief disadvantage of this chain stitch is that when the thread breaks it unravels when the least strain is placed upon it, and so it cannot be used for joining the important parts of a garment. To-day its chief function is for ornamentation and embroidery, as is done in the Cornelly machine where the wrong side

33

of the stitch appears on the face of the cloth. It is also employed in the trimming of trousers and pants where ornamental rows of stitching are added to the band as a feature of the style. It is also adapted for felling seams for cut goods in conjunction with the overlock stitch, the latter by itself tending to stand up at right angles to the fabric. This projecting seam is often run through the chain stitch machine, which has the effect of laying it flatter. The stitch is also found in present-day seaming machines in various modifications, such as the double chain; it is also used in seaming full-fashioned underwear to a considerable extent on account of its great elasticity.

Lock Stitch.—The lock stitch sewing machine is largely used in trimming hosiery garments, and, as compared with the chain stitch, is very firm and rigid in its structure. Pieces seamed together with the lock stitch cannot be unravelled easily, as the stitch can only be opened by pulling out the stitches individually, as they will not "run." In this stitch two threads are employed, one coming from the needle above the fabric, while the second thread is located in the shuttle underneath the fabric. The process of sewing consists in laying the upper needle thread underneath the lower shuttle thread, so that they lock in the centre of the fabric. There is practically no elasticity in the lock stitch, which renders it quite unsuitable for seaming knitted goods where the seams must yield with the natural elasticity of the garment. If used for such purposes, as is sometimes the case in districts where the industry is poorly developed, the strain descends largely on the two seaming threads during wear, and these soon break. The lock stitch is best adapted for attaching the rigid parts of a garment such as bands and fronts, which are designed to keep it in shape and form. The stitch is very suitable as the foundation of button-holes and eyelets, where absolute firmness and durability are prime essentials. The chain stitch machine being the simplest in construction and using one thread only, can produce up to 4000 stitches per minute. The lock stitch speed usually runs about 3500 stitches per minute for factory work.

Overlock.—The overlock plays a very important part in seaming knitted goods, and is largely adopted for joining the constituent parts of all kinds of garments. The two-thread overlock stitch, as the name implies, is built up of two strands, whilst the term overlock has reference to the system in which these two threads lock over the edge of their seam. It is usually employed, not for attaching bands to a flat piece of fabric like the chain stitch and lock stitch, but for joining two cut edges of knitted fabric together which are laid one on top of another. The upper thread is composed of ordinary sewing cotton, which is pushed through the fabric by means

of the needle; whilst the second thread, made of a material similar to the ground, travels round the edge of the seam to interlock with the cotton thread from the needle. The second thread passes through what is termed the looper, which intersects with the needle thread below the fabric and, travelling round the edge, intersects with the needle thread above the fabric as well, so that the two threads lock on the edge. This gives a seam of considerable elasticity suitable for many types of underwear. It opens out or gapes under strain, which makes it unsuitable for joining outer garments, as this exposes the white cotton yarn and detracts from the finish. Even when dyed the cotton fades more quickly than the wool, and for this reason it is usual to employ a three-thread modification of the overlock seam for outer garments. The principle of looping is the same, but the seam is constructed from three threads, one of which only is cotton, while the others are composed of the ground material. This gives a firmer seam which withstands considerable wear and tear before yielding. The overlock seam is often used for ornamentation, the two-thread variety being worked on the wrong side of the fabric in a fancy colour which, when stretched, gives a solid stripe on the face of the hose or half-hose. The three-thread overlock is also capable of treatment in colours, and alteration in the relative tensions of the coloured threads gives rise to an interesting series of neat edgings, which are very useful for many kinds of outer and under garments.

Flatlock.—The principle of seaming by the flatlock system provides a distinct departure from the methods previously adopted, and has had a far-reaching influence on the development of the trade in garments cut from the roll. In the overlock seam there are two threads of seaming plus two thicknesses of fabric bunched together in a seam which stands at right angles to the cloth, and this for general purposes of underwear is an objection on account of its bulk. In the flatlock seam the two pieces to be joined are first trimmed and made to abut on each other, lying edge to edge. The flatlock system creates what is virtually a new line of fabric at the points where the two cloths touch, so that the join is perfectly flat, and, moreover, is extremely strong and durable. In the seam there are nine threads; four threads are of cotton and pass through the needles of the machine, there being four needles which pierce the cloth at every stitch. Underneath the fabric are other four threads operated by loopers which intersect with the needle threads during the formation of the seam. Further, over all there is what is known as the coverer thread, which dips to and fro over the surface of the seam, removes the rawness, and gives it a more finished appearance. A close

examination of the admirable system of structure of this stitch shows that where the two fabrics touch each other, which is the weakest point of the seam, there is a double crossing of the seaming threads to reinforce the join. By the introduction of fancy colours into the loopers the flatlock seam has been made the basis of a large number of fancy effects which can be rapidly worked on to a knitted costume or skirt on the machine, a system of ornamentation which has proved in considerable demand. It is effective and easily added at the points required, giving an otherwise plain garment an inexpensive touch of colour and style.

Embroidery.—The principle of embroidery is applied to knitted fabrics in various ways to produce special colour effects. The simplest scheme is that referred to in the description of the overlock and flatlock stitches where the extra coloured yarn is run on to the surface of the goods by means of those machines. A large trade is done in fancy hose where the circular machines have a series of embroidery fingers arranged round their circumference. The fingers have the fancy yarns run through eyes in their lower ends, and are made to lay their threads over the needles of the machine at specified points according to the pattern, with the result that the fancy yarns show on the face over and above the ground of the fabric. The inventors have recently improved this method of figuring on the embroidery principle by extending the range of patterns which it is possible to make without unduly complicating the selective mechanism and the machine parts. On the Cotton's patent frame there is a very complete system of producing patterns on this pfinciple in flat fabrics, a point bar being introduced with embroidery fingers for every second needle of the machine if required. The threads passing through these can be made to work individually in the machine to produce any form of plain or floral effect. This attachment also gets over the difficulty of the knitting machine in introducing vertical stripes in the fabric, and such patterns are largely adopted for the men's shirting trade. This method of producing figuring and vertical striping involves the use of yarns which are added to the plain ground, but an increasing number of vertical stripes and patterns are now being made on circular frames by the use of low and high butt needles where the patterns can be produced without reduction in the output once the needle lay-out has been arranged. When fancy threads are introduced on the embroidery principle there is a considerable reduction in the normal productive capacity of the machine owing to the time required to lay the fancy yarns over the needles in the intervals between plain knitting.

OILING OF YARN FOR KNITTING

Many knitting faults can be traced to irregular tensioning, caused by humidity of the air, which varies from day to day and from morning to night. The " wet strength " of most rayon filaments is lower than the " dry strength," and where moisture has access the filament yields and stretches under tension. If the humidity in the air varies, the stretching powers of the filament vary, hence irregular knitting. Irregular humidity causes " barriness," " bright spots," " cockling," etc., and variation in the amount of fabric produced from a given weight of rayon. There should be some control of the temperature and humidity in the warehouse and factory.

If the filament is protected from moisture by suitable oil the following results are obtained : protection from moisture ; improved handle and pliability ; correct looping at the needles ; ideal tension and stress ; broken filaments are laid and held ; lower qualities can be knitted equally well with better qualities.

The protection of the filament must be regular and complete, otherwise humidity will have access at some points and irregular fabric will result. It cannot be too strongly emphasised that the time to give oil protection from humidity is immediately the hanks are opened up. Hanks should be protected till ready for use, and opened only immediately before oiling.

Natural oils, from expensive olive oil down to mineral oil, have been tried, but there does not seem to be any one naturally occurring oil which in itself has all the desired qualities. By selecting, treating, and blending various raw materials, it is possible to obtain exactly the qualities needed for any particular type of work, without the staining and stickiness risks of olive, rape, mineral oils, etc., and at a minimum cost. Oils affect wool, silk, artificial silk, and cotton in different ways, so that where these fibres are mixed in the same fabric, special treatment may be needed, and the requirements of each fabric must be considered separately.

As regards the quantities of oils used, 10 per cent. on the weight of the yarn is normal, but in some cases as much as 30 per cent. of oil is used, and it is stated that sufficiently good results are obtained to cover the extra cost of the oil. On the other hand, amounts as low as 6 per cent. have been found satisfactory for certain classes of work.

Whilst the old method of opening the bundles and pouring in oil at each end is fairly satisfactory, better results are obtained by the following methods :—

Box and Spray.—The 10-lb. bundles of yarn are opened right out

and the hanks laid out in single layers in a suitable box lined with tin or grease-proof paper, fitted with a tight lid. The oil can be applied by means of hand-spray or watering-can, and after one layer of yarn has been oiled, further layers can be placed on the top and the process repeated. The box when full should be left for about twelve hours (or overnight) to allow diffusion of oil.

Soaking.—Some firms soak the hanks and then " hydro-extract " them; this uses rather more oil, and the hanks should be put into a cheese cloth to prevent entangling and bursting whilst being " whizzed."

Oiling on the Winding Machine.—The " roller and trough " method has proved satisfactory, but it is preferable to oil before winding, rather than on the machine, as this allows more time for maturing or conditioning.

Bobbin Immersion.—If the bobbins are immersed in the oil satisfactory results are not always obtained, because, being tightly wound, the filament on the bobbin acts as a sort of filter, and although after a period the oil might penetrate right to the heart, there may be a risk of irregular distribution.

Oiling on the Knitting Machine.—The " bottle-and-wick " method has proved satisfactory for some purposes. The wicks should be of open texture, so as to allow free siphoning and prevent filtration. There are also other devices on the market which are quite good.

Pure silk presents problems different from those of rayon. It is difficult to lay down any hard-and-fast rule as to the handling of pure silk in the gum, because factories have their own method, and the material has to be suited to the process. One point which indirectly affects the oiling of pure silk is that whilst in some cases the de-gumming and dyeing are satisfactorily carried out in one bath, they ought to be separate operations if freedom from trouble is to be ensured. Olive oil is sometimes used in the form of a cream which can be supplied in any desired strength, or the natural oil can be bought and made into a cream in the factory. There is, however, no need to pay the price for olive, neat's-foot, lard oils, etc., as oils specially prepared for silk processing are available at a lower price, and free from the defects of some of the natural oils.

Tests have shown that whilst it may be necessary to lubricate the highest quality of worsted yarns when used under the most favourable condition, it is economical to lubricate average yarn with a correct lubricant, but unwise, dangerous, and costly to lubricate average yarn with a poor lubricant. The lower the quality of the yarn the more necessary it is to give proper lubrication. Olive, lard, neat's-foot,

and rape oils, etc.. have in the past been used to make a " boiled-up " lather, but it has been proved by research for the woollen industries that practically all these natural oils have some disadvantages of solidification, staining, stickiness, etc. Oils are available blended from refined raw materials, for the particular process of lathering. Where the old-fashioned boiled-up soap and oil lather is preferred, a heavy type lather can still be obtained without using olive or neat's-foot, etc., oils, thus reducing the risk of stickiness and staining. It is unwise to leave any sort of emulsion exposed in the trough indefinitely, as it collects dirt and fibre, etc., which clog the rollers and spoil the " lather."

The Scouring of Hosiery.—Much depends on the type of filament and on the nature and quantity of the oil. Some oils, whilst satis-factory in winding and knitting, would be difficult to scour. It is essential that the dyers should be informed of any changes in the quantity of oil supplied, so that the scour may be adjusted.

There are rayon filaments which in themselves, and in the processes through which they pass, cause greater difficulties in scouring than others, and for this purpose a solvent is available for hosiery scouring. The advantage of a solvent is that a quick and easy scour without purging is obtained at a low temperature. Excess oil or oil stains are removed without risk of getting a harsh handle, and very often there is a slight economy of soap. On woollen hosiery the use of solvent with a reduction of soap and alkali tends to reduce risk of mildew.

Many stains occurring on fabrics are due not to oil but to metal from the bearings, which comes out with the oil splashes on to the fabric.

White Stainless Mineral Oil Lubricant.—The hosiery industries have had considerable difficulty with stains on their fabrics produced by the lubricating oils used on knitting machines. The knitted fabric is often stored in bins or boxes before dyeing and finishing. This storage period may cover six or more months, during which time oil stains develop through oxidation of the oil. These stains are very difficult to remove in subsequent finishing processes.

In the hope of obtaining a white stainless lubricating oil, a study was undertaken by the U.S.A. Bureau of Standards; tests have yielded a tentative specification. the requirements of which were fulfilled by three oils out of many submitted.

TEXTILE STEAM-RAISING PLANTS

A single Lancashire boiler burns on an average up to 30 tons of coal per week of, say, 50 hours for 50 weeks in-the year. This with coal at 25s. per ton will give a coal bill of £1875 per annum. An increase of 5 per cent. alone in the efficiency of such a boiler will mean a saving of £95. 15s a year, which is no small figure with a number of boilers in a range. Consequently we find to-day all steam users are searching for means of increasing the thermal efficiency of their plant. There are two sorts of efficiency with which we are concerned, thermal or heat efficiency. and commercial or money efficiency. It is quite possible to obtain high thermal efficiency by a constant supply of good water of a pure non-sedimentary character; by high-pressure water-tube boilers, with superheaters, economisers, air heaters. or supermisers, and chain grate stokers, and with ample reserve in the way of stand-by boilers to put on load if one of these highly sensitive units gives out at an inopportune time. If you can afford to pay a highly skilled combustion engineer to look after your plant, then you can get high thermal efficiency, probably up to 85 to 90 per cent., which would be considered excellent. But all these things are expensive.

For textile mills the Lancashire boiler is the most usual and is suitable for several reasons. Some of the claims of the Lancashire boiler are large steam and water space, simplicity of design and management, low upkeep or maintenance and working costs, and unfailing reliability. For pressures, however, beyond 250 lb. we must depend upon the water-tube boiler.

Nevertheless there are many Lancashire boiler plants that are giving not more than 65 to 70 per cent. efficiency, that is, a quarter of the coal bill is lost money.

Every steam-generating plant should have some means whereby the efficiency of the boiler and furnace may be checked daily. This applies even to the smallest plant. The requirements for such a test are: (1) The total weight of coal used; (2) the total weight of water fed to and evaporated by the boiler; (3) the average temperature of the feed water; (4) the average steam pressure in the boiler. From the figures obtained under these heads can be ascertained the quantity of water evaporated per lb. of coal, and from this the efficiency of the boiler.

A set of hypothetical readings on a boiler might be: Duration of test, eight hours; total weight of coal fired, 4000 lb.; weight of

water evaporated, 28,000 lb.; average temperature of feed water, 180° F.; average steam pressure, 100 lb. per sq. in.; calorific value of coal used, 12,500 B.Th.U. per lb.

The first figure required is the amount of water evaporated per lb. of coal burned. This is obviously 28,000÷4000=7 lb.

The next step is to find from "Steam Tables" the heat in B.Th.U. (British thermal units) to evaporate 1 lb. feed water at 180° F. into steam at 100 lb. per sq. in. (gauge) pressure, which is a temperature of 338° F. This is sensible heat, 1 lb.×(338°−180° F.) B.Th.U. +latent heat of vaporisation, 885 B.Th.U. The total is 158+885= 1043 B.Th.U. per lb. of water or steam. This assumes that the steam is dry, and that superheat is not used.

The steam would be normally about 97 per cent. dry. If superheat is used, add to the above 1043 B.Th.U. the figure of specific heat of steam, say 0·5×degrees of superheat. The heat for the 7 lb. of water or steam requiring 1043 B.Th.U. per lb. is 7301 B.Th.U. The efficiency of the boiler is therefore 7301÷12,500 B.Th.U. (per lb. of coal), which is 58 per cent.

The capacity of the boiler can for comparison be converted to the equivalent evaporation from and at 212° F., which requires 970 B.Th.U. per lb. of water or steam. The equivalent of the 7 lb. of steam above would be then 7 lb.×1040÷970=7·5 lb. from and at 212° F. The fuel cost with coal at 20s. per ton would be

$$\frac{20s. \times 1000 \text{ lb.}}{7 \cdot 5 \text{ lb.} \times 2240 \text{ lb.}} = 1s. \ 3d.$$

for evaporating 1000 lb. of water from and at 212° F., or 12s. 6d. per 1000 gals. The calorific value of different coals varies and may be higher than the above assumed figure.

The data are very valuable, and the daily log of such should be taken in every boiler-house. It is of considerable value as a check on the boiler-room operation. The result of the example test I have given you is a very poor one, but typical of many plants. There is no reason why any boiler plants should ever fall below 70 per cent., and with economisers and intelligent firing 70 to 75 per cent. There are three errors into which boiler-room operators fall, viz., the admission of excess air, the maintenance of dirty heating surfaces, and the loss of combustible matter by allowing partly burnt coal to fall through the grates, but of these three the greatest is the first, and this brings me to consider the importance of CO_2 readings, which ought to be taken in every boiler-house.

As is well known, the general principle of the CO_2 recorder is to

analyse the percentage of CO_2 in the flues gases, that is, the air after passing through the furnaces.

The percentage of CO_2 in the gases tells us whether and how much air is being used in excess of the quantity which is theoretically required. If no excess air is used, then all the oxygen present in it would combine with the carbon in the coal and produce approximately 21 per cent. CO_2. This is impossible, as in practice it is always necessary to use an excess of air. If twice the quantity of air necessary for complete combustion were used then the CO_2 percentage would be 10·5 per cent., if four times 5·25 per cent., and so on.

The pyrometer is a thermometer for measuring high temperatures. It usually consists of a tube with a metal rod inside. This metal rod expands when heated, and the amount it lengthens is recorded on a dial calibrated to record the temperature. These instruments are placed in the flues of the boiler, and they record the heat at the various parts. A good temperature for a hand-fired furnace is 2300° F., and for machine firing 2500° F. At the downtake of a Lancashire boiler 1000° F. is the average, and at the back end of the side flue about 600° F. If economisers are fitted then the gases leaving the economisers should not be more than 400° F.

Good natural draught requires a high temperature of the flue gases, and within limits the greater the difference in temperature between the outside air and the chimney gases the greater would be the draught. To get the most perfect natural draught we have to keep a mean chimney temperature of about 550° F. to 600° F., but it is by no means economical to pass the gases away at this temperature, although it means a more intense draught if we do so. Draught is controllable, and care should be taken in using it. If the furnace temperature is 2000° F. and the flue gases at the chimney 550°, then there is 550 ÷ 2000, or 25 per cent. loss of heat at the chimney. If you could increase the furnace temperature to 2200° F., and reduce the temperature at the chimney to 380° F., the loss is only 17 per cent.

A boiler should be of sufficient capacity to meet without undue forcing the heaviest demands made upon it. An overloaded boiler is always working against economy and efficiency.

Flues and seatings are often arranged in a very objectionable manner. The foundation should be well drained and the seatings kept dry. The flues should be of ample area, and easily accessible for cleaning for draught and for inspection. In many cases the seatings are so broad that it is impossible without considerable trouble to ascertain the condition of the plates in contact with them. As a

result corrosion is liable to go on unperceived until the defect becomes so serious that it can be no longer hidden. There is no need for the blocks to be 4 in. or 5 in. on the bearing surface to the boiler-plate, a width of 2 in. or even 1 in., if the seating blocks are properly built in, is quite ample. Contracted flues not only interfere with inspection, but impede the draught and reduce boiler efficiency.

It is essential, in order to get the highest efficiency from the boiler, that the brickwork should be kept in good condition. Combined losses due to both air leakage and short circuiting of the gases often lead to 15 per cent. loss of fuel from defective boiler setting alone, and as a method of making airtight the front and back walls where in contact with the boiler, the use of asbestos rope packing is commendable, and also the specially designed appliances for this work which are now made, and which are giving good results in keeping the front and back ends of the brickwork tight and in order.

Another important fact, and one which should receive careful attention, is the removal of soot from the shell-plates and brick flues every time the boiler comes off for the periodical cleaning.

One has to realise that in a steam-generating plant it is not possible efficiently to extract the heat from the flue gases solely by the boiler. The temperature of the steam and water in a moderately high-pressure boiler is about 350° F., and this is a reasonably efficient temperature at which the flue gases should pass up the chimney. A boiler would have to have an enormous heating surface to drop the flue gas temperature to this point, and such a design is impracticable, so that an economiser is installed. The feed water to the boiler is passed through the pipes, and the comparatively hot gases passing from the boiler plays on the outer surface of these pipes. An increase in the temperature of the water is obtained at the expense of heat that would otherwise pass up the chimney. It can, however, be a costly piece of apparatus in the way of upkeep unless certain conditions are observed when working it. First the metal of the pipes can, with unsuitable feed water, rapidly corrode away.

The best way of keeping the defect in check is to test the water for free oxygen. If it is found to prevail, the effects of the oxygen can be neutralised by the addition of cutch or tannin extract to the feed water, or, better still, the oxygen can be extracted by a de-aerating plant.

Another bad feature of the economiser is the susceptibility of the vertical pipe to become wasted externally on the lower parts. The best way to preserve the life of these is to keep the temperature of the inlet water from 110° to 120° F.

NOTES ON ROPE DRIVING

Rope gearing is now very extensively employed for driving in mills and factories, and it is also applied to drive many kinds of machines formerly driven by wheel gearing or belts. The ropes are nearly all made from cotton (hemp being but little used), and vary in diameter from ½ to 2 in. With the modern tendency to employ higher-speed machinery the range of rope diameters covers slightly smaller diameters. Ropes of more than 2 in. diameter are never used nowadays.

In the application of rope driving, the average speed of ropes is from 4000 to 5000 ft. per minute, when transmitting power from large rope fly-wheels; the speed of the intermediate ropes varies from 2500 to 6000 ft. per minute, but sometimes even higher speeds are employed. The pulleys are usually of cast iron, with their rims grooved. The sides of the groove are inclined to each other at from 25° to 45°, depending upon the conditions. The rope should be of a sufficient diameter to rest on the sides of the groove, and not on the bottom, and should be fitted exactly to the best working part of the groove of the pulley. The frictional resistance to slipping is very great, without wedging, and the weight of the rope will assist it to leave the groove, which will occur without loss of power if the groove surfaces are polished. The joints are made by splicing, the length of splice not being less than about thirty times the circumference of the rope.

MINIMUM ADVISABLE PULLEY DIAMETERS IN INCHES

Rope Velocity in Feet per Minute.	ROPE DIAMETERS, IN INCHES.										
	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2
1000	10	12·5	15	18	20	23	27	30	35	39	43
1500	11·5	14	16·5	19·5	22	25	29	33	38	41	46
2000	12·5	15	18	21	24	28	31	35	41	44	49
2500	14	16·5	19·5	23	26	30	34	39	43	48	53
3000	15	18	21	25	28·5	33	37	41	46	51	57
3500	16·75	19·5	23	27	31	35	40	44	49	55	60
4000	18·75	21	25	29	33	38	43	47	53	59	65
4500	20	23	27	31	36	41	46	51	57	63	70
5000	—	25	29	33·5	38·5	44	49	55	60	67	74
5500	—	27	31	36	41	47	52	58	65	72	79
6000	—	30	33	38	44	50	56	62	69	76	84
6500	—	—	36	41	47	54	59	67	74	82	90
7000	—	—	39	43	50	57	63	71	79	88	97

The old formula that the pulleys should be at least thirty times the rope diameter has now proved to be too conservative. The ratio, in any case, is not constant, but depends upon velocity as well as upon other factors. The table on p. 440 gives modern standards of design for round cotton ropes.
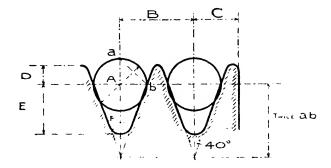
There are limits to centre distance apart from convenience. Many drives with cotton ropes are now installed with pulleys almost touching, whilst the use of adequate supporting pulleys enables drives to run to any length. The position of the slack side on a drive is of little importance, the difference in power capacity between a drive with slack side on top and one with slack side below being only about 5 per cent.

Square plaited ropes, now made in Manila hemp, are claimed to transmit somewhat more power than round cotton ropes, to have no slip, and to be much cheaper than cotton ropes. It is stated that the minimum size of pulley is two-thirds that permissible with round ropes.

Grooves for Rope Transmission.—One form of groove for rope-power transmission is the straight-sided flangeless groove, as shown below, on which the following table is based :—

Diameter.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Rope A -	¼	⅜	¾	1⅜	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1⅞	2
Pitch B -			1½	1½	1½	1½	1½	1½	1½	2½	2½	2½	2¼
„ C -			1½						1¼	1½	1⅜	1½	1⅜
„ D -													
„ E -													
„ F -													

A flanged 45° groove is also favoured.

HORSE-POWERS FOR COTTON DRIVING ROPES

Rope Diameter Velocity in Feet per Minute.	½ In.	⅝ In.	¾ In.	⅞ In.	1 In.	1⅛ In.	1¼ In.	1⅜ In.	1½ In.	1⅝ In.	1¾ In.	1⅞ In.	2 In.
1000	1·0	1·6	2·3	3·2	4·2	5·3	6·6	8·0	9·5	11·2	13·0	14·9	17·0
1100	1·2	1·8	2·6	3·6	4·7	5·9	7·4	8·9	10·6	12·5	14·5	16·7	19·0
1200	1·3	2·0	2·9	4·0	5·2	6·5	8·1	9·8	11·7	13·8	16·0	18·5	20·9
1300	1·4	2·2	3·2	4·4	5·7	7·1	8·8	10·7	12·8	15·1	17·5	20·2	22·8
1400	1·5	2·4	3·5	4·8	6·2	7·7	9·5	11·6	13·9	16·3	18·9	21·9	24·7
1500	1·6	2·6	3·8	5·2	6·7	8·3	10·2	12·5	15·0	17·5	20·3	23·5	26·5
1600	1·7	2·8	4·1	5·5	7·1	8·9	10·9	13·4	16·0	18·7	21·7	25·0	28·3
1700	1·8	3·0	4·4	5·8	7·5	9·5	11·6	14·2	17·0	19·9	23·1	26·5	30·1
1800	1·9	3·2	4·6	6·1	7·9	10·1	12·3	15·0	18·0	21·0	24·4	28·0	31·8
1900	2·0	3·4	4·8	6·4	8·3	10·7	13·0	15·8	18·9	22·1	25·7	29·5	33·5
2000	2·1	3·6	5·0	6·7	8·7	11·2	13·7	16·6	19·8	23·2	27·0	31·0	35·2
2100	2·2	3·8	5·2	7·0	9·1	11·7	14·4	17·3	20·7	24·3	28·2	32·5	36·8
2200	2·3	3·9	5·4	7·3	9·5	12·2	15·1	18·0	21·6	25·4	29·4	33·9	38·4
2300	2·4	4·0	5·6	7·6	9·9	12·7	15·7	18·7	22·5	26·5	30·6	35·3	39·9
2400	2·5	4·1	5·8	7·9	10·3	13·2	16·3	19·4	23·3	27·3	31·8	36·6	41·4
2500	2·6	4·2	6·0	8·2	10·7	13·7	16·9	20·1	24·1	28·5	32·9	37·9	42·9
2600	2·7	4·3	6·2	8·5	11·1	14·1	17·4	20·8	24·9	29·4	34·0	39·1	44·4
2700	2·8	4·4	6·4	8·8	11·4	14·5	17·9	21·5	25·7	30·3	35·1	40·3	45·8
2800	2·9	4·5	6·6	9·1	11·7	14·9	18·4	22·2	26·5	31·1	36·1	41·4	47·1
2900	3·0	4·6	6·8	9·4	12·0	15·3	18·9	22·8	27·2	31·9	37·1	42·5	48·4
3000	3·1	4·7	7·0	9·6	12·3	15·7	19·3	23·4	27·9	32·7	38·0	43·6	49·6
3100	—	4·8	7·2	9·8	12·6	16·0	19·7	23·9	28·5	33·4	38·9	44·6	50·7

3200	51·8	45·6	39·7	34·1	29·1	24·4	20·1	16·3	12·9	10·0	7·3	4·9	—
3300	52·8	46·5	40·5	34·7	29·7	24·9	20·5	16·6	13·2	10·2	7·4	5·0	—
3400	53·8	47·4	41·2	35·3	30·3	25·3	20·9	16·9	13·4	10·4	7·5	5·1	—
3500	54·7	48·3	41·9	35·9	30·8	25·7	21·3	17·2	13·6	10·6	7·6	5·2	—
3600	55·6	49·1	42·6	36·5	31·3	26·1	21·7	17·5	13·8	10·8	7·7	—	—
3700	56·4	49·9	43·2	37·1	31·8	26·5	22·0	17·8	14·0	11·0	7·8	—	—
3800	57·2	50·7	43·8	37·7	32·2	26·9	22·3	18·1	14·2	11·1	7·9	—	—
3900	58·0	51·4	44·4	38·3	32·6	27·3	22·6	18·3	14·4	11·2	8·0	—	—
4000	58·8	52·1	45·0	38·8	33·0	27·7	22·9	18·5	14·6	11·3	8·1	—	—
4100	59·6	52·7	45·5	39·3	33·4	28·1	23·2	18·7	14·8	11·4	—	—	—
4200	60·3	53·3	46·0	39·8	33·8	28·4	23·5	18·9	15·0	11·5	—	—	—
4300	61·0	53·9	46·5	40·2	34·2	28·7	23·8	19·1	15·2	11·6	—	—	—
4400	61·7	54·4	47·0	40·6	34·6	29·0	24·1	19·3	15·4	11·7	—	—	—
4500	62·3	54·9	47·5	41·0	35·0	29·3	24·4	19·5	15·6	11·8	—	—	—
4600	62·9	55·4	48·0	41·4	35·4	29·6	24·7	19·7	15·8	11·9	—	—	—
4700	63·5	55·9	48·5	41·8	35·8	29·9	24·9	19·9	16·0	12·0	—	—	—
4800	64·1	56·4	49·0	42·2	36·1	30·2	25·1	20·1	16·2	12·1	—	—	—
4900	64·7	56·9	49·5	42·6	36·4	30·5	25·3	20·3	16·3	12·2	—	—	—
5000	65·3	57·4	50·0	43·0	36·7	30·8	25·5	20·5	16·4	12·3	—	—	—
5100	65·9	57·9	50·4	43·4	37·0	31·1	25·7	20·7	16·5	—	—	—	—
5200	66·4	58·4	50·8	43·8	37·3	31·4	25·9	20·9	16·6	—	—	—	—
5300	66·9	58·9	51·2	44·2	37·6	31·7	26·1	21·1	16·7	—	—	—	—
5400	67·4	59·4	51·6	44·6	37·9	32·0	26·3	21·3	16·8	—	—	—	—
5500	67·9	59·9	52·0	45·0	38·2	32·3	26·5	21·5	16·9	—	—	—	—
5600	68·4	60·3	52·4	45·3	38·5	32·5	26·7	21·7	—	—	—	—	—
5700	68·9	60·7	52·8	45·6	38·8	32·7	26·9	21·9	—	—	—	—	—
5800	69·4	61·1	53·2	45·9	39·1	32·9	27·1	22·1	—	—	—	—	—
5900	69·9	61·5	53·6	46·2	39·4	33·1	27·3	22·2	—	—	—	—	—
6000	70·4	61·9	54·0	46·5	39·6	33·3	27·5	22·3	—	—	—	—	—

For special drives such as short centres, high inclinations, etc., grooves of 25° and 30° are usually employed.

Friction.—The coefficient of friction of a rope working on a cast-iron pulley is 0·28; when working in a groove of 45° it is increased about three times, or from 0·28 to 0·84 for ungreased pulleys. If the pulleys are greased, the coefficient is reduced to about one-half.

Durability.—The life of a rope depends on its make, the condition of the groove, the tension, and other points, so that no hard-and-fast rule can be laid down. In one case, a rope which had been running for 116½ hours per week for eighteen years was found to be in an excellent condition, whilst interstranded round cotton ropes have been known to last for more than fifty years on the card-room drive of a cotton mill. The size of the pulleys has an important bearing on the durability of driving ropes.

The Strength of Rope varies considerably and, except that it is an indication of the quality of material used, is of little or no importance, as the working stresses seldom exceed one-twenty-fifth of the ultimate strength. In one made of rope, 4·78 in. in circumference, which failed under an ultimate stress of 13,260 lb., the extension under a load of 1775 lb. was only 2·8 per cent. The effective working tension must, however, be only a very small percentage of the ultimate strength to secure the best results as regards efficiency and durability. From the best modern practice, the writer has found that the effective stress per rope, including centrifugal tension, is about $s = 160d^2$ lb., in which d is the nominal diameter of the rope in inches. This corresponds to a stress of about 200 lb. per square inch of section.

The Power Transmitted by cotton driving ropes depends principally upon five things :—

(1) Size of rope (d); (2) speed (V); (3) coefficient of friction (μ); (4) groove angle (a); (5) tension (T).

Power transmissible is approximately directly proportional to d^2, to V, to μ, to tan a, and to $T_1 - T_2$, where T_1 is tight side tension, T_2 slack side tension. $T_1 + T_2$ is taken as being equal to $2 \cdot (T_0 + T_c)$, where T_0 is the initial tension and T_c is the centrifugal tension. Then

$$T_c = \frac{WV^2}{32},$$

W being the weight per foot of rope.

The list of powers, pp. 442, 443, assumes a groove angle of not more than 45°, a lubricated cotton rope, and an initial tension equal to one-thirtieth of the ultimate strength of the rope.

CHAIN DRIVING

General.—Extensive use is now made of chains for transmitting power. They occupy little space and overcome the difficulties of cramped and awkward positions, while they give efficient service at centre distances too short for belts and too long for gearing. The chains most commonly used are the roller type used for medium and

Roller Chain.

Inverted Tooth Chain (Noiseless).

low speeds, and the inverted tooth or "noiseless" type used for high speeds. Chain driving is positive, as tension is not required to make chains grip their sprockets, as is the case with belts and pulleys, and therefore friction due to it is eliminated. The efficiency of chain drives is very high, and in a well-designed drive is given as about 98 per cent. The efficiency is constant, and remains high during the useful life of the chain and wheels.

The following statement prepared by the Association of British Driving Chain Manufacturers shows the approximate limits that usually obtain in the economical application of chain gearing. Where circumstances do not permit its application within these limits, the chain manufacturer should be consulted.

	Roller Type.	Inverted Tooth Type.
Gear Ratio (maximum) - - -	7 : 1	6 : 1

Chain Speed (feet per minute).—Normal maximum, assuming the number of teeth is 19 for roller type and 21 for inverted tooth type :—

	Feet per Minute.	Feet per Minute.
Up to $\frac{1}{2}$ in. pitch - - -	1000	1500
$\frac{3}{4}$ in. and $\frac{3}{4}$,, - - -	900	1400
1 ,, 1$\frac{1}{4}$,, - - -	800	1350
1$\frac{1}{2}$,, 1$\frac{3}{4}$,, - - -	700	1300
2 ,, 2$\frac{1}{2}$,, - - -	600	1250
3 in. pitch - - - - -	500	1200

Number of Teeth in Wheels—

Minimum -	-	-	-	-	17	19
Maximum -	-	-	-	-	120	120*

* This applies only to inverted tooth chains with a profile based on a 60° link face angle.

34

In cases where the chain speed is substantially less than that shown above, for any given pitch, the number of teeth in the pinion may be reduced.

Centre Distance Between Shafts.—The maximum centre distance is governed by the amount of inclination, nature of load, size of wheels, etc. The following are limiting values for ordinary conditions and steady loads, but are subject to considerable variation in individual circumstances :—

(a) *Desirable Maximum Centre Distance.*—(Expressed in pitches of chain.)

Pitch of Chain.				Roller Chain.	Inverted Tooth Chain.
¾ in. to ¾ in.	·	·	·	100	70
1 in. to 1¾ in.	·	·	·	85	60
2 in. upwards	·	·	·	70	50

With inclined drives with the wheel higher than the pinion, and with an inclination up to 60°, the horizontal component of the actual centre distance should not exceed the foregoing values. In the case of vertical drives, and those with an inclination approaching the vertical, the chain manufacturers should be consulted.

(b) *Desirable Minimum.*—The centre distance should be such that the arc of contact between the chain and any wheel is not less than 120°, and with at least seven teeth in engagement.

(c) *Adjustment.*—It is advisable to provide suitable means for the adjustment of the centre distance, and the normal minimum amount of this adjustment should be 1½ times the pitch of the chain. In some cases adjustment can only be obtained by the use of a jockey wheel, which must engage with the slack side of the chain and have machine-cut teeth.

(d) *Chain Length.*—It is desirable that the number of pitches in the chain should not be a multiple of the number of the teeth in either the pinion or the wheel.

Disposition of Drives and Direction of Rotation.—Drives may be arranged to run horizontally, inclined, or vertical.

In the case of an inclined drive with the pinion on top, the maximum angle of inclination should approximate 45° from the horizontal.

In cases where the inclination of the drive exceeds 45°, the large

wheel should preferably be on top. The direction of rotation should be such that the tight or driving side of the chain is on top.

Clearance.—The minimum radius of clearance (in inches) for that portion of the chain which is in contact with the wheels should be—

$$\frac{\text{Pitch diameter} + 3 \text{ (pitch)}}{2}.$$

The clearance for sag should be greatest at a point somewhere midway along the free portions of the chain, and this clearance should be allowed for both above and below each free portion of chain.

The minimum amount of clearance is—

$$\frac{\text{Centre distance between wheels (in inches)}}{12} + \frac{1}{4} \text{ in.}$$

The total amount of side clearance for any chain drive is—

$$\frac{\text{Centres of wheels (in inches)}}{30} + \frac{1}{2} = \text{Width of chain (in inches)}.$$

This total amount of clearance should, in general, be equally divided on both sides of the chain.

Lubrication.—Lubrication of the working joints is essential for chain gearing. The most efficient form of lubrication is to enclose the drive in a case and pump a constant stream of oil on to the inside faces of the chain from a filter sump. An alternative arrangement is to run the chain through oil. For speeds up to 1000 ft. per min. a drip-feed lubricator may be used, fixed so that the oil drips regularly on to the inner face of the chain. A light or medium machine oil should be used, and one drip pipe provided for every 3 in. of chain width.

For slow running chains up to 500 ft. per min. satisfactory lubrication can be obtained by removing the chain periodically, and, after thoroughly cleansing with paraffin, immersing it in a bath of warm mineral oil or grease for such a time as to allow the lubricant to penetrate to the rivets. Chain gearing should not be unduly exposed to damp or dirt.

Erection.—Chain wheels must be rigidly mounted on shafts which are parallel and truly horizontal, and the teeth of the wheels must be in correct alignment. Where possible, wheels should be placed close to bearings, and must run true on their shafts. Care should be taken that the chain connection is properly secured. Before starting up the drive the chain should be adjusted to the correct degree of tension, and lubricated.

Maintenance.—Periodic examination is advisable to ascertain :— (1) If correct alignment of the wheels has been maintained ; (2) if undue wear is taking place ; (3) if adjustment of chain tension is needed ; (4) if the chain requires cleaning ; (5) if lubrication is being effectively carried out. Improved service usually results when chains are removed from time to time for cleaning. They should be washed with paraffin and, after draining, thoroughly lubricated before being used again. When fitting new chains it should always be ascertained that undue wear has not taken place on the teeth of the wheels.

Wheels.—It is of the utmost importance that chain wheels should have their teeth accurately machined with cutters of correct form. Pinions should preferably have an odd number of teeth to equalise wear on the chain.

Pitch Diameters.—The following table gives correct pitch diameters for all types of chain having a pitch of 1 in. The pitch diameters for wheels to suit other pitches of chain are directly proportional to the pitch of the chain.

PITCH DIAMETERS FOR CHAINS 1 IN. PITCH

Number of Teeth.	Pitch Diameter.	Number of Teeth.	Pitch Diameter.	Number of Teeth.	Pitch Diameter.	Number of Teeth.	Pitch Diameter.	Number of Teeth.	Pitch Diameter.
9	2·924	28	8·931	47	14·972	66	21·016	85	27·063
10	3·236	29	9·249	48	15·290	67	21·335	86	27·381
11	3·549	30	9·567	49	15·608	68	21·653	87	27·699
12	3·864	31	9·885	50	15·926	69	21·971	88	28·017
13	4·179	32	10·202	51	16·244	70	22·289	89	28·335
14	4·494	33	10·520	52	16·562	71	22·607	90	28·654
15	4·810	34	10·838	53	16·880	72	22·926	91	28·972
16	5·126	35	11·156	54	17·198	73	23·244	92	29·290
17	5·442	36	11·474	55	17·517	74	23·562	93	29·608
18	5·759	37	11·792	56	17·835	75	23·880	94	29·927
19	6·076	38	12·110	57	18·153	76	24·198	95	30·245
20	6·392	39	12·428	58	18·471	77	24·517	96	30·563
21	6·710	40	12·746	59	18·789	78	24·835	97	30·881
22	7·027	41	13·063	60	19·107	79	25·153	98	31·200
23	7·344	42	13·381	61	19·425	80	25·471	99	31·518
24	7·661	43	13·700	62	19·744	81	25·790	100	31·836
25	7·979	44	14·018	63	20·062	82	26·108	...	...
26	8·296	45	14·336	64	20·380	83	26·426	...	...
27	8·614	46	14·654	65	20·698	84	26·744	...	...

SHAFTING

Speed of Shafting.—For textile mills the usual speed of shafting is from 300 to 400 revs. per minute ; for machine shops 120 to 300 revs. per minute, and for wood-working plant, 250 to 350 revs. per minute.

Horse-Power of Shafting.—The tables on page 450 give the horse-power of turned shafting of mild steel. For cold-rolled steel shafting the power transmitted may be increased by 10 per cent. The first table is for main driving shafts carrying heavy gears or pulleys. The second table is for line shafts with pulleys as usually arranged. The third table is for shafts transmitting power only, *i.e.*, for shafts without pulleys. It is assumed that the shafting is supported somewhat as follows :—

Shaft Bearings—Distances Between Centres

Diam. of Shaft.	Table I.		Table II.		Table III.		Diam. of Shaft.	Table I.		Table II.		Table III.	
In.	Ft.	In.	Ft.	In.	Ft.	In.	In.	Ft.	In.	Ft.	In.	Ft.	In.
1½	6	3	6	6	7	3	3¼	10	3	11	0	12	0
1¾	7	0	7	3	8	0	3½	11	0	11	6	12	6
2	7	6	7	9	8	9	3¾	11	6	12	0	13	3
2¼	8	3	8	6	9	6	4	12	0	12	6	13	9
2½	8	9	9	3	10	3	4½	13	0	13	9	15	0
2¾	9	3	9	9	10	9	5	14	0	14	9	16	0
3	10	0	10	6	11	6	6	16	0	16	6	18	0

Weight of Steel Shafting

Diameter.	Weight per Foot.	Diameter.	Weight per Foot.	Diameter.	Weight per Foot.
In.	Lbs.	In.	Lbs.	In.	Lbs.
1½	6·00	3¼	28·0	5	66·5
1¾	8·15	3½	32·6	6	95·8
2	10·60	3¾	37·5	7	130·0
2¼	13·50	4	42·5	8	170·0
3	24·00	4½	48·0	9	215·0

HORSE-POWER OF SHAFTING

I. Main Shafting Carrying Heavy Gears or Pulleys

Diam. of Shaft in Inches.	NUMBER OF REVOLUTIONS PER MINUTE.										
	60	80	100	125	150	175	200	225	250	275	300
1¾	2·6	3·4	4·3	5 4	6·4	7·5	8 6	9·7	10·7	11·8	12·9
2	3·8	5·1	6 4	8	9·6	11·2	12·8	14·4	16	17·6	19·2
2¼	5·4	7·3	8·1	10	12	14	16	18	20	22	24
2½	7·5	10	12 5	15	18	22	25	28	31	34	37
2¾	10	13	16	20	24	28	32	36	40	44	48
3	13	17	20	25	30	35	40	45	50	55	60
3¼	16	22	27	34	40	47	54	61	67	74	81
3½	20	27	34	42	51	59	68	76	85	93	102
3¾	25	33	42	52	63	73	84	94	105	115	126
4	30	41	51	64	76	89	102	115	127	140	153
4½	43	58	72	90	108	126	144	162	180	198	216
5	60	80	100	125	150	175	200	225	250	275	300
5½	80	106	133	166	199	233	266	299	333	366	400

II. Line Shafting Carrying Pulleys

Diam. of Shaft in Inches.	NUMBER OF REVOLUTIONS PER MINUTE.										
	100	125	150	175	200	225	250	275	300	325	350
1¾	6	7·4	8·9	10·4	11 9	13·4	14·9	16·4	17·9	19 4	20 9
1⅞	7·3	9·1	10·9	12·7	14·5	16·3	18 2	20	21·8	23 6	25·4
2	8 9	11·1	13 3	15·5	17·7	20	22 2	24·4	26·6	28·8	31
2¼	10·6	13 2	15·9	18·5	21·2	23·8	26 5	29·1	31·8	34·4	37
2⅜	12 6	15 8	19	22	25	28	31	35	38	41	44
2½	15	18	22	26	29	33	37	41	44	48	52
2¾	17	21	26	30	34	39	43	47	52	56	60
2⅞	23	29	34	40	46	52	58	64	69	75	81
3	30	37	45	52	60	67	75	82	90	97	105
3¼	38	47	57	66	76	85	95	104	114	123	133
3½	47	59	71	83	95	107	119	131	143	155	167
3¾	58	73	88	102	117	132	146	162	176	190	205
4	71	89	107	125	142	160	178	196	213	231	249

III. Shafting Simply Transmitting Power

Diam. of Shaft in Inches.	NUMBER OF REVOLUTIONS PER MINUTE.										
	100	125	150	175	200	233	267	300	333	367	400
1½	6 7	8·4	10·1	11·8	13 5	15·7	17·9	20·3	22·5	24·8	27
1⅝	8·6	10·7	12·8	15	17·1	20	22·8	25·8	28·6	31·5	34·3
1¾	10·7	13·4	16	18·7	21·5	25	28	32	36	39	43
1⅞	13·2	16·5	19·7	23	26·4	31	35	39	44	48	52
2	16	20	24	28	32	37	42	48	53	58	64
2¼	19	24	29	33	38	44	51	57	63	70	76
2½	22	28	34	39	45	52	60	68	75	83	90
2¾	27	33	40	47	53	62	70	79	88	96	105
2⅞	31	39	47	54	62	73	83	93	104	114	125
2¾	41	52	62	73	83	97	111	125	139	153	167
3	54	67	81	94	108	126	144	162	180	198	216
3¼	68	86	103	120	137	160	182	205	228	250	273
3½	85	107	128	150	171	200	228	257	285	313	342

SPEEDS OF PULLEYS AND GEAR WHEELS

As the circumference of a pulley is directly proportional to its diameter, the latter can be used in all questions of speeds of pulleys and gear wheels. In belt pulley calculations the thickness of the belt should be added to the pulley diameter if close results are required. In the case of rope pulleys, the diameter should be measured to the centre of the rope, and in spur gear the *pitch diameter*, and not the outside diameter, must be taken.

The rules relating to the diameters and speeds of pulleys are given conveniently in the following statement, in which R.P.M. indicates revolutions per minute.

Given.	Required.	Rule.
Diameter of driving pulley, Diameter of driven pulley, R.P.M. of driving pulley.	R.P.M. of driven pulley.	Multiply diameter of driving pulley by its R.P.M., and divide by diameter of driven pulley.
Diameter of driving pulley, R.P.M. of driving pulley, R.P.M. of driven pulley.	Diameter of driven pulley.	Multiply diameter of driving pulley by its R.P.M., and divide by R.P.M. of driven pulley.
Diameter of driving pulley, Diameter of driven pulley, R.P.M. of driven pulley.	R.P.M. of driving pulley.	Multiply diameter of driven pulley by its R.P.M., and divide by diameter of driving pulley.
Diameter of driven pulley, R.P.M. of driven pulley, R.P.M. of driving pulley.	Diameter of driving pulley.	Multiply diameter of driven pulley by its R.P.M., and divide by R.P.M. of driving pulley.

As a check on such calculations, it should be noted that the diameter of a driving pulley multiplied by its revolutions per minute, is equal to the diameter of the driven pulley multiplied by *its* revolutions per minute.

For a compound drive such as a train of gears or a compound belt drive multiply the diameters of all the driving wheels together, and the diameters of the driven wheels together. Dividing the first product by the second, and multiplying by the revolutions per minute of the first driving pulley, will give the revolutions per minute of the last driven pulley.

NOTES ON BELTING

A belt transmits its motion solely through frictional contact with the surface of the pulley. The lower side of the belt should be made the driving side when possible, as the arc of contact is thereby increased by the sagging of the slack side. Increase of power will be obtained by increasing the size of pulleys, the same ratio being retained. Wide belts are less effective per unit of sectional area than narrow belts, and long belts are more effective than short ones. The proportion between the diameters of two pulleys working together should not exceed 6 to 1. Convexity of pulleys to receive belt $= \frac{1}{8}$ to $\frac{1}{4}$ in. in the width up to 12 in. wide; for larger sizes, $\frac{1}{8}$ to $\frac{1}{4}$ in. per foot of width. The convexity of driving and driven pulleys should be alike in amount. The width of pulley should equal $1\cdot2$ time width of belt.

Speed of Belts.—Belts have been employed running over 5800 ft. per minute. Nothing, however, is gained by running belts much over 4000 ft. per minute. About 3500 ft. per minute for main belts agrees with good practice. With link or chain belts 3000 to 3500 ft. per minute should not be greatly exceeded. At higher speeds the effect of centrifugal tension reduces the power transmitted.

Coefficient of Friction.—Various values are given for the coefficient friction of leather belting running in contact with iron pulleys. Much depends upon the suppleness of the belt, as when in a pliable condition it lies in more intimate contact with the pulley face. Under ordinary conditions the value of the coefficient of friction may be taken between $0\cdot25$ and $0\cdot35$.

Effective or Working Tension.—The ultimate strength of good leather belting is about 4000 lbs. per square inch, but the maximum tension to which it should be subjected should not exceed 400 lbs. per square inch when the joints are cemented and sewn, or 300 lbs. per square inch if laced joints are employed. With ordinary single belting $\frac{7}{32}$ in. thick this would give maximum stresses of about 88 lbs. and 65 lbs. per inch of width respectively, and assuming a ratio of tensions of 3 we obtain 58 lbs. and 45 lbs. as the effective tension per inch of width for the two methods of jointing.

Arc of Contact.—When the arc of contact is small the load on the belt should be reduced. The table of horse-power of leather belts given herewith assumes an arc of contact of not less than 180°. For smaller arcs of contact the power transmitted will be less and the tabular values should be multiplied by a factor, as given in the following table :—

Arc of Contact -	157·5°	150°	135°	120°	112·5°	90°
Multipliers for H.P.	0·85	0·80	0·71	0·62	0·58	0·45

To find the arc of contact with the smaller pulley :—Multiply the difference of the pulley diameters in inches by 4·75, divide by the distance apart of the shaft centres in feet, and subtract the result from 180°.

Power of Leather Belts.—The effective working tension, *i.e.*, the difference between the tight and slack sides of the running belt is usually from 70 to 150 lb. per inch. of width. Double belts transmit 1½ times as much as single belts. The thickness of the belt and the slip may be allowed in calculating the belt speed.

Belt Lacing.—To lace a belt, the ends should be cut perfectly true with the aid of a square, and the holes punched exactly opposite each other in the two ends. For belts 1 to 2¼ in. wide, ¼-in. lacing; 2¼ to 4¼ in. wide, ₅⁄₁₆-in. lacing; 5 to 12 in. wide, ⅜-in. lacing are suitable. In punching a belt for the lacing, it is desirable to use an oval punch, the longer diameter of the punch being parallel with the belt, so as to cut off as little of the leather as possible. There should be in each end of the belt two rows of holes staggered, and these holes should be as small as possible.

Care of Belts.—Belts and pulleys should be kept clean and free from accumulations of dust and grease, and particularly lubricating oils, some of which permanently injure the leather. They should be well protected against water and moisture. Resin should not be used to prevent belts from slipping. If a belt slips, the pulley and belt should be cleaned, and the belt treated with a dressing composed of two parts of tallow and one part of fish oil, rendered and allowed to cool before using. If the belt still slips it is overloaded, and the suggested remedies are a leather-covered pulley, a wider belt, or larger pulleys.

Woven Belting.—Although leather belting is still very largely employed, it has, more especially during recent years, been very largely displaced by woven beltings, which are strong and very pliable—two of the most important features in any flexible transmitter of power—while they have the further advantage of not being affected by changes of temperature, water, steam, fumes of chemicals, etc.

TOOTHED GEARING

Machine-cut gears, with their very much smoother action, are rapidly supplanting cast gears, mainly because of the increased loads they will transmit, the greater speeds at which they run, and the greater efficiency which is obtained. With modern methods of manufacture even large size cut gears are now commercially possible.

Pitch.—Two systems of denoting the pitch of a toothed gear are in use. These are (1) the **Circular Pitch,** which is the distance from the centre of one tooth to the centre of the next tooth measured along the pitch diameter line (along the curve), and (2) the **Diametral Pitch,** which indicates the number of teeth in a wheel per inch of its pitch diameter. That is, a gear with, say, 6 teeth for each inch of its pitch diameter is **6** diametral pitch, or as generally abbreviated, "6 pitch."

Circular Pitches and Their Equivalent Diametral Pitches

Circular Pitch.	Diametral Pitch.	Circular Pitch.	Diametral Pitch.	Circular Pitch.	Diametral Pitch.
In.		In.		In.	
2	1·5708	1	3·1416	⅓	9·4248
1⅞	1·6755	1 5/16	3·3510	5/16	10·0531
1¾	1·7952	⅞	3·5904	¼	12·5664
1⅝	1·9333	1 3/16	3·8666	2/9	14·1372
1½	2·0944	¾	4·1888	⅕	15·7080
1 7/16	2·1855	1 1/16	4·5696	3/16	16·7552
1⅜	2·2848	¾	4·7124	⅙	18·8496
1 5/16	2·3936	⅝	5·0265	⅐	21·9911
1¼	2·5133	9/16	5·5851	⅛	25·1327
1 3/16	2·6456	½	6·2832	⅑	28·2743
1⅛	2·7925	7/16	7·1808	1/10	31·4159
1 1/16	2·9568	⅜	8·3776	1/16	50·2655

Forms of Gear Teeth.—There are in common use two systems of gear tooth shapes, viz., the *cycloidal* and the *involute.* The cycloidal form of tooth was up to recently most generally used, but owing to difficulties in its accurate production on a commercial basis it has fallen into comparative disuse, except perhaps in the case of very large gears, for which it is still employed somewhat extensively. This shape of tooth is formed by separate curves above and below the pitch line, being known for this reason as the double curve tooth. The curve above the pitch line is traced by a point in a circle rolling on the

outside of the pitch circle, whilst the curve below the pitch line is traced by a point in a circle rolling on the inside of the pitch circle. The diameter of the rolling circle is equal to the radius of a 12-tooth gear of the pitch required, the same diameter rolling circle being used for all gears of the same pitch. The teeth of the rack in this system have double curves which are traced by a point in the rolling circle alternately on each side of the pitch line.

Diametral Pitches and Their Equivalent Circular Pitches

Diametral Pitch.	Circular Pitch.	Diametral Pitch.	Circular Pitch.	Diametral Pitch.	Circular Pitch.
	In.		In.		In.
¾	4·1888	8	0·3927	26	0·1208
1	3·1416	9	0·3491	28	0·1122
1¼	2·5133	10	0·3142	30	0·1047
1½	2·0944	11	0·2856	32	0·0982
1¾	1·7952	12	0·2618	34	0·0924
2	1·5708	13	0·2417	36	0·0873
2¼	1·3963	14	0·2244	38	0·0827
2½	1·2566	15	0·2094	40	0·0785
2¾	1·1424	16	0·1963	42	0·0748
3	1·0472	17	0·1848	44	0·0714
3½	0·8976	18	0·1745	46	0·0683
4	0·7854	19	0·1653	48	0·0654
5	0·6283	20	0·1571	50	0·0628
6	0·5236	22	0·1428	56	0·0561
7	0·4488	24	0·1309	60	0·0524

The chief claim for the involute tooth form is that gears may be separated a little from their correct centre distance without interfering with the angular velocity. Another advantage is that the rack and worm in the involute system has straight sides to the teeth, which can be easily produced accurately, and, since the introduction of the gear generating machine, this simple form of rack and worm tooth is used as a basis from which to generate the teeth in all gears, on the principle that all gears which will work into the same rack will work together.

Spur Gears represent the type of gear most commonly used, their function being to transmit motion from one shaft to another parallel with it, at the same or at different speeds. They are easy and cheap to produce accurately, and there is now very little excuse for the employment of gears with cast teeth. The use of gears having machine-

cut teeth has made considerably higher speeds possible, surface speeds of 3000 ft. per minute being now frequently met with in common practice. The main factors in proportioning spur gears are the width of face and the pitch, which to a very large extent determine the strength of the gear. The width of tooth is often made three times the pitch. The effect of widening the face directly increases the strength of the gear, and is often resorted to rather than increasing the pitch, because of the quieter running obtained with finer pitches.

Strength of Gear Teeth.—The "Lewis" formula is now generally accepted, and has proved to be satisfactory. In the following table the horse-powers have been worked out and tabulated for various numbers of teeth and various speeds of cast-iron gears, 1 diametral pitch, 1 in. face, 15° involute by the "Lewis" formula. To use the table, divide the value given in the table (opposite the teeth required and under speed required) by the diametral pitch of the gear, obtaining the horse-power for that pitch. For any other width of face, multiply by the face.

If the gear is of other material than cast iron, multiply by 2·5 for cast steel ; 3 for forged steel ; and 1·4 for good bronze.

If the gears are 20° involute or radial flank teeth, multiply by the constants given at the right-hand side of the table.

Example.—Required the horse-power that can be safely transmitted by a cast-iron spur gear having 15 teeth, 10 pitch, 1½ in. face, at 400 ft. per minute.

From the table opposite, 15 teeth and under 400 ft., read 15·02.

$$\text{H.P. of gear} = \frac{15 \cdot 02 \times \text{face}}{\text{pitch}} = \frac{15 \cdot 02 \times 1 \cdot 5}{10} = 2 \cdot 25 \text{ H.P.}$$

Example.—Required the horse-power that can be safely transmitted by a cast-iron spur gear having 30 teeth, ½ in. pitch, 1¼ in. face, running at 1500 ft. (Equivalent D.P. = 6·2832.)

From the table opposite, 30 teeth and under 1500 ft., read 30·35.

$$\text{H.P. of gear} = \frac{30 \cdot 35 \times \text{face}}{\text{equivalent D.P.}} = \frac{30 \cdot 35 \times 1 \cdot 25}{6 \cdot 2832} = 6 \text{ H.P.}$$

Example.—Required the horse-power that can be safely transmitted by a cast-iron spur gear having 20° involute tooth, 50 teeth, 5 pitch, 2 in. face, running at 500 ft. per minute.

From the table opposite, 50 teeth and under 500 ft., read 24·34.

$$\text{H.P. of gear} = \frac{24 \cdot 34 \times \text{face and constant for 20 involute opposite 50 teeth}}{\text{pitch}}$$

$$\text{H.P. of gear} = \frac{24 \cdot 34 \times 2 \times 1 \cdot 16}{5} = 11 \cdot 3 \text{ H.P.}$$

NOTES ON HUMIDIFICATION

Regarded strictly from the practical point of view, artificial humidifi-
cation consists in the provision of means by which unfavourable
atmospheric conditions can be modified, in order that better results
may be obtained in the manufacturing processes.   Under average or
normal conditions all textile fibres are capable of holding a fairly large
percentage of water in a state of mechanical suspension, that is, the
water can be driven off by the simple expedient of drying the material
at about 220° F.; but immediately the material is restored to a normal
atmosphere it will absorb or "regain" (see table of regains below) an
amount of moisture approximately equal to that which it originally
contained.   The moisture content, then, both of the material and the
surrounding atmosphere is a very important factor, and it is not over-
stating the case to say that the smoothness and evenness of a thread
are very much dependent upon the moisture content and that of the
surrounding atmosphere at the time of spinning.   It is proved beyond
doubt that a deficiency of moisture, either during spinning or weaving,
has an appreciable adverse effect on both the strength and elasticity of
the yarn, and this is the reason why the best informed investigators in
this subject contend that all spinning and weaving establishments
should be equipped with means of modifying natural atmospheric
conditions, for the purpose of providing ideal conditions for the working
of the fibre and yarn.

Inseparably linked with the question of humidity is that of tempera-
ture, for in order to maintain fibre in the requisite pliable condition
to render it amenable to the carding, combing, drawing, spinning, and
weaving processes, it is necessary to maintain a fairly high temperature.
This varies with different fibres and with different textile processes,
but in no case should it be so high as to interfere with the comfort of
the operatives.   The following tables are given by one authority as
approximately proper atmospheric conditions :—

Worsted

	Humidity. Per cent.	Temperature. Deg. F.
Preparation, fine combed wools	83	72
Preparation, medium wools	75	75
Preparation, common wools	65	75
Wool-drawing rooms	65	75
"Bradford" spinning	55	72
French or mule spinning	80	80
Weaving	60	75

Cotton

	Humidity. Per cent.	Temperature Deg. F.
Cards - - - - - - -	55	72
Combers - - - - - - -	60	72
Drawing, slubbing, intermediate, and roving frames - - - - - - -	65	75
Mule spinning for counts up to 60's - -	56	75
Mule spinning for 60's to 150's - - -	53	77
Mule spinning for 150's and upwards -	50	80
Ring spinning up to 10's - - - -	60	75
Ring spinning from 10's to 40's - - -	55	78
Weaving light goods where little size is required - - - - - -	60	72
Weaving heavily-sized goods - - -	85	80

Flax and Jute

	Humidity. Per cent.	Temperature. Deg. F.
Cards - - - - -	60	65
Preparation - - - -	85	70
Spinning - - - - -	70	72
Weaving - - - - - -	85 upwards	75

Another authority recommends the temperatures shown in the following table for average cotton mills :—

Cotton

	Humidity. Per Cent.	Dry Bulb Temp. Deg. F.
Bale storage, opening, scutching, mixing room, and lap storage - - -	62	70 to 75
Carding, combing, and drawing - -	62	74 to 80
Slubbing, intermediate, and roving -	62	74 to 80
Mule and ring spinning, coarse - -	53	80
Mule spinning, medium - - - -	52	86
Mule spinning, fine - - - -	50	90
Winding, warping, beaming, bundling, coarse - - - - - -	63	68
Winding, warping, beaming, bundling, medium - - - - - -	66	74
Winding, warping, beaming, bundling, fine - - - - - - -	68	80
Yarn conditioning cellars - - -	88	66 to 76
Warehouse storage - - - -	88	60 to 65
Waste spinning (condenser) - • •	70	70 to 76

COTTON CLOTH FACTORIES ACT, 1911

Maximum Limits of Humidity of the Atmosphere at Given Temperatures

Dry Bulb Readings.	Wet Bulb Readings.	Grains of Moisture Per Cubic Foot of Air.	Percentage of Humidity Saturation =100.	Dry Bulb Readings.	Wet Bulb Readings.	Grains of Moisture Per Cubic Foot of Air.	Percentage of Humidity Saturation =100.
Deg. F.	Deg. F.			Deg. F.	Deg. F.		
35	33	1·9	80	68	66	6·6	88
36	34	2·0	82	69	67	6·9	88
37	35	2·1	83	70	68	7·1	88
38	36	2·2	83	71	68·5	7·1	85·5
39	37	2·3	84	72	69	7·1	84
40	38	2·4	84	73	70	7·4	84
41	39	2·5	84	74	70·5	7·4	81·5
42	40	2·6	85	75	71·5	7·65	81·5
43	41	2·7	84	76	72	7·7	79
44	42	2·8	84	77	73	8·0	79
45	43	2·9	85	78	73·5	8·0	77
46	44	3·1	86	79	74·5	8·25	77·5
47	45	3·2	86	80	75·5	8·55	77·5
48	46	3·3	86	81	76	8·6	76
49	47	3·4	86	82	76·5	8·65	74
50	48	3·5	86	83	77·5	8·85	74
51	49	3·6	86	84	78	8·9	72
52	50	3·8	86	85	79	9·2	72
53	51	3·9	86	86	80	9·5	72
54	52	4·1	86	87	80·5	9·55	71
55	53	4·2	87	88	81·5	9·9	71
56	54	4·4	87	89	82·5	10·25	71
57	55	4·5	87	90	83	10·3	69
58	56	4·7	87	91	83·5	10·35	68
59	57	4·9	88	92	84·5	10·7	68
60	58	5·1	88	93	85·5	11·0	68
61	59	5·2	88	94	86	11·1	66
62	60	5·4	88	95	87	11·5	66
63	61	5·6	88	96	88	11·8	66
64	62	5·8	88	97	88·5	11·9	65·5
65	63	6·0	88	98	89	12·0	64
66	64	6·2	88	99	90	12·3	64
67	65	6·4	88	100	91	12·7	64

Generally the working of the fibre through the various processes has a tendency to abstract some proportion of the natural percentage

of moisture, and the function of humidifying apparatus is to supply additional moisture through the atmosphere, so as to ensure both the proper "conditioning" of the fibre, and to counteract the baneful effects of static electricity that would otherwise accompany attempts to work the fibre in too dry a condition or at high temperatures. In some mills there is a tendency to keep the temperature too high and the air too humid for the comfort of the operative, although in most cases it is found that inefficient ventilation is the real cause of the discomfort. However, as a measure of protection against the possibly harmful effects of a too humid atmosphere, the Cotton Cloth Factories Act fixes the maximum permissible humidity for a given range of temperatures as shown in the foregoing table.

It is further provided that there shall be no artificial humidification in any *humid shed* (a) at any time when the wet bulb reading of the hygrometer exceeds 75° F.; or (b) at any time when the wet bulb reading of the hygrometer is higher than that specified in the following schedule, in relation to the dry bulb reading of the hygrometer at that time ; or, as regards a dry bulb reading intermediate between any two dry bulb readings indicated consecutively in the schedule, when the dry bulb reading does not exceed the wet bulb reading to the extent indicated in relation to the lower of those two dry bulb readings ; or (c) at any time, after the first half-hour of employment in any day, when the dry bulb reading of the hygrometer is below 50° F. ; or (d) at any time, within the first half-hour of employment on any day, when the wet bulb reading of the hygrometer is less than 2° F. below the dry bulb reading.

HUMIDITY SCHEDULE

Dry Bulb Readings.	Wet Bulb Readings.	Dry Bulb Readings.	Wet Bulb Readings.	Dry Bulb Readings.	Wet Bulb Readings.
Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.
50	48	60	58	70	68
51	49	61	59	71	68·5
52	50	62	60	72	69
53	51	63	61	73	70
54	52	64	62	74	70·5
55	53	65	63	75	71·5
56	54	66	64	76	72
57	55	67	65	77	73
58	56	68	66	78	73·5
59	57	69	67	79	74·5
				80	75

The efficient operation of humidifying systems in order to conform to the foregoing regulations, and above all to provide as near as is practicable ideal working conditions for the fibre, cannot well be accomplished without the most careful use of the hygrometer. This instrument consists of two thermometers, as nearly as possible identical, the one marked Dry and the other Wet. The thermometers should have very small bulbs, so as to be as delicate and sensitive as possible; and their graduations are preferably scored on their own stems. The bulb of the Wet thermometer is covered with thin muslin, and round the neck of the bulb and over the muslin is twisted loosely or tied in a loose knot a conducting thread of lamp wick; this passes to an adjacent vessel of water placed at such a distance as to allow a length of conducting thread of about 3 in. The reservoir of water should be placed on one side of, and a little below the level of the wet bulb, so that evaporation from the water may not affect the reading of the dry bulb by its too close vicinity. The use of a glass reservoir situated between the two thermometers is objectionable, as the water becomes heated above or cooled below the surrounding temperature, and so vitiates the readings of both the thermometers.

STANDARD REGAINS

The following is a list of the "standard regains" along with the equivalent direct losses—

	Regain.	Loss from Normal Condition.
	Per Cent.	Per Cent.
Cotton -	8½	7·83
Worsted yarns -	18¼	15·43
Worsted tops in oil -	19	15·96
Worsted tops dry -	18¼	15·43
Woollen yarns -	17	14·53
Wool scoured -	16	13·79
Wool noils -	14	12·28
Worsted and woollen cloths -	16	13·79
Shoddy -	13	11·5
Silk -	11	9·91
Flax and hemp -	12	10·71
Jute -	13¾	12·09

THERMOMETER SCALES

Comparative Values in Fahrenheit and Centigrade Scales

(Deg. F. − 32) × 5 ÷ 9 = Deg. C.   (Deg. C. × 9 ÷ 5) + 32 = Deg. F.

F.	C.	F.	C.	F.	C.	F.	C.	F.	C.
0	−17·78	50	10·00	100	37·78	150	65·56	200	93·34
1	−17·23	51	10·56	101	38·34	151	66·11	201	93·90
2	−16·67	52	11·11	102	38·90	152	66·67	202	94·45
3	−16·11	53	11·67	103	39·45	153	67·23	203	95·00
4	−15·56	54	12·23	104	40·00	154	67·78	204	95·56
5	−15·00	55	12·78	105	40·56	155	68·34	205	96·11
6	−14·45	56	13·34	106	41·11	156	68·90	206	96·27
7	−13·90	57	13·90	107	41·57	157	69·45	207	97·23
8	−13·34	58	14·45	108	42·23	158	70·00	208	97·78
9	−12·78	59	15·00	109	42·78	159	70·56	209	98·34
10	−12·23	60	15·56	110	43·34	160	71·11	210	98·90
11	−11·67	61	16·11	111	43·90	161	71·67	211	99·45
12	−11·11	62	16·67	112	44·45	162	72·23	212	100·00
13	−10·56	63	17·23	113	45·00	163	72·78	213	100·56
14	−10·00	64	17·78	114	45·56	164	73·34	214	101·11
15	−9·45	65	18·34	115	46·11	165	73·90	215	101·67
16	−8·89	66	18·89	116	46·67	166	74·45	216	102·23
17	−8·34	67	19·45	117	47·23	167	75·00	217	102·78
18	−7·78	68	20·00	118	47·78	168	75·66	218	103·34
19	−7·23	69	20·56	119	48·34	169	76·11	219	103·90
20	−6·67	70	21·11	120	48·90	170	76·67	220	104·45
21	−6·11	71	21·67	121	49·45	171	77·23	225	107·23
22	−5·56	72	22·23	122	50·00	172	77·78	230	110·00
23	−5·00	73	22·78	123	50·56	173	78·34	235	112·78
24	−4·45	74	23·34	124	51·11	174	78·90	240	115·56
25	−3·90	75	23·90	125	51·67	175	79·45	245	118·34
26	−3·34	76	24·45	126	52·23	176	80·00	250	121·11
27	−2·78	77	25·00	127	52·78	177	80·56	255	123·90
28	−2·23	78	25·56	128	53·34	178	81·11	260	126·67
29	−1·67	79	26·12	129	53·90	179	81·67	265	129·45
30	−1·11	80	26·67	130	54·45	180	82·23	270	132·23
31	−0·56	81	27·23	131	55·00	181	82·78	275	135·00
32	0·00	82	27·78	132	55·56	182	83·34	280	137·78
33	0·56	83	28·34	133	55·11	183	83·90	285	140·56
34	1·11	84	28·89	134	56·67	184	84·45	290	143·34
35	1·67	85	29·45	135	57·23	185	85·00	295	146·11
36	2·23	86	30·00	136	57·78	186	85·56	300	148·90
37	2·78	87	30·55	137	58·34	187	86·11	310	154·45
38	3·34	88	31·11	138	58·90	188	86·67	320	160·00
39	3·90	89	31·67	139	59·45	189	87·23	330	165·56
40	4·45	90	32·22	140	60·00	190	87·78	340	171·11
41	5·00	91	32·78	141	60·56	191	88·34	350	176·67
42	5·56	92	33·33	142	61·11	192	88·90	360	182·23
43	6·11	93	33·89	143	61·67	193	89·45	370	187·78
44	6·67	94	34·45	144	62·23	194	90·00	380	193·34
45	7·23	95	35·00	145	62·78	195	90·56	390	198·90
46	7·78	96	35·56	146	63·34	196	91·11	400	204·45
47	8·34	97	36·11	147	63·90	197	91·67	450	232·23
48	8·89	98	36·67	148	64·45	198	92·23	500	260·00
49	9·45	99	37·23	149	65·00	199	92·78	550	287·75

SPECIFIC GRAVITY, DEGREES TWADDELL, AND DEGREES BAUMÉ

(At 15° C.)

Twaddell.	Baumé.	Specific Gravity.	Twaddell.	Baumé.	Specific Gravity.	Twaddell.	Baumé.	Specific Gravity.
0	0	1·000	36	22·0	1·180	72	38·2	1·360
1	0·7	1·005	37	22·5	1·185	73	38·6	1·365
2	1·4	1·010	38	23·0	1·190	74	39·0	1·370
3	2·1	1·015	39	23·5	1·195	75	39·4	1·375
4	2·7	1·020	40	24·0	1·200	76	39·8	1·380
5	3·4	1·025	41	24·5	1·205	77	40·1	1·385
6	4·1	1·030	42	25·0	1·210	78	40·5	1·390
7	4·7	1·035	43	25·5	1·215	79	40·8	1·395
8	5·4	1·040	44	26·0	1·220	80	41·2	1·400
9	6·0	1·045	45	26·4	1·225	81	41·6	1·405
10	6·7	1·050	46	26·9	1·230	82	42·0	1·410
11	7·4	1·055	47	27·4	1·235	83	42·3	1·415
12	8·0	1·060	48	27·9	1·240	84	42·7	1·420
13	8·7	1·065	49	28·4	1·245	85	43·1	1·425
14	9·4	1·070	50	28·8	1·250	86	43·4	1·430
15	10·0	1·075	51	29·3	1·255	87	43·8	1·435
16	10·6	1·080	52	29·7	1·260	88	44·1	1·440
17	11·2	1·085	53	30·2	1·265	89	44·4	1·445
18	11·9	1·090	54	30·6	1·270	90	44·8	1·450
19	12·4	1·095	55	31·1	1·275	91	45·1	1·455
20	13·0	1·100	56	31·5	1·280	92	45·4	1·460
21	13·6	1·105	57	32·0	1·285	93	45·8	1·465
22	14·2	1·110	58	32·4	1·290	94	46·1	1·470
23	14·9	1·115	59	32·8	1·295	95	46·4	1·475
24	15·4	1·120	60	33·3	1·300	96	46·8	1·480
25	16·0	1·125	61	33·7	1·305	97	47·1	1·485
26	16·5	1·130	62	34·2	1·310	98	47·4	1·490
27	17·1	1·135	63	34·6	1·315	99	47·8	1·495
28	17·7	1·140	64	35·0	1·320	100	48·1	1·500
29	18·3	1·145	65	35·4	1·325	110	51·2	1·550
30	18·8	1·150	66	35·8	1·330	120	54·1	1·600
31	19·3	1·155	67	36·2	1·335	130	56·9	1·650
32	19·8	1·160	68	36·6	1·340	140	59·5	1·700
33	20·3	1·165	69	37·0	1·345	150	61·8	1·750
34	20·9	1·170	70	37·4	1·350	160	64·2	1·800
35	21·4	1·175	71	37·8	1·355	170	66·3	1·850

ELECTRICAL DRIVING IN THE TEXTILE INDUSTRIES

The problem of the future in textile industries is to increase produc-
tion and reduce costs. It is impossible to foresee just how severe the
economic struggle may become, but it certainly will be severe, and the
victors will be those who avail themselves of every aid to efficiency and
economy. No radical improvement is to be anticipated in textile
machinery, so that, apart from better commercial organization, the only
way in which the mill owner can reduce costs is to lower his power
expenses. Out of the few pence per pound difference in price between
raw and manufactured cotton, there has to be covered the whole cost
of manufacture and the manufacturer's profit. Power costs form only
a fraction of the total, but the reduction which can generally be effected
in them, by electrical instead of mechanical driving, represents a large
saving per annum.

The equipment of a textile mill involves unusually high investment
per employé, so that any saving in time and increase in production
means a relatively large reduction in overhead costs and a correspond-
ing increase in the margin of profit. The experience of an ever-
increasing number of mills shows that electric driving and electric
lighting result in saving of time ; increase and improvement in product ;
and all-round betterment in conditions of working. These benefits
relate to employer and employed alike. Individual circumstances are
of great importance where the power supply and driving of textile
factories is concerned, but it is certainly safe to say that no mill can
afford to overlook the possibilities of more or less extensive "electri-
fication" of its plant. Rising cost of fuel, more efficient electricity
stations, dearer labour, and the importance of increasing production—
these and other factors all combine to make the advantages of elec-
trification greater than ever before.

At a conservative estimate there are now hundreds of thousands of
electric motors (totalling 2,000,000 H. P. or so) in use in textile factories.
The total horse-power is increasing rapidly, and the total number of
motors yet more rapidly. In the early days of electric driving, large
motors (up to 200 H.P. or so) were used, and had sufficient powerful
units been available, it is quite likely that a single electric motor would
have been used in place of the steam engine. It was soon realized,
however, that the chief advantages of electric driving could be realized
only by subdividing the power and eliminating mechanical drive as
completely as possible. With the use of motors to drive smaller groups
of machines or individual machines, the average horse-power of the

motors decreased rapidly. The mean horse-power of motors in textile service is now only one-fourth or one-fifth of what it was ten years ago. In a number of modern textile factories the average power of the motors is as low as $1\frac{1}{4}$ H.P., and the average for all electrically-driven mills is probably between 3 and 5 H.P., compared with 15 H.P. four or five years ago, and 50 H.P. or so in 1905. This point is emphasized at an early stage in these notes, because subdivision of drive is one of the chief factors in electrification.

Defects and Misconceptions in Mechanical-Driven Mills.— Friction losses in such a transmission system as that of a mechanically-driven cotton mill amount to between 25 and 50 per cent. under full-load conditions. This loss is often under-estimated, because the friction as determined from the light-load indicator card is considerably less than the full-load friction. Analyses of power distribution in mechanical mills are generally misleading for a similar reason. Running one department at a time and taking the corresponding indicator card on the engine merely gives the average total power requirements for that department, and takes no account of the variations in friction with different loads on the transmission system.

The principal reasons why the cost of steam driving is frequently under-estimated are as follows :—(1) Certain indirect (but substantial) costs are left out of consideration. (2) The maximum indicator card of the engine is used in working out power costs—the mean power is much lower than the maximum. (3) The fuel charged to heating is too great, naturally leaving less than the true amount to be charged against power production.

One of the most common arguments in favour of mechanical driving in textile mills is that a large amount of steam is required, and this being so, that a central station cannot offer power cheaply enough to compete. Apart from the fact that this argument does not affect the relative merits of mechanical and electrical driving in a mill using only private plant, the actual fuel requirements for " manufacturing steam " (as distinct from "power steam") are less than commonly supposed, and can be supplied by a special boiler in an electrically-driven mill, whilst still showing an overall economy. It is often estimated, for instance, that steam for slashing represents 20 per cent. to 25 per cent. of the total fuel consumption, whereas 7 per cent. to 15 per cent. is nearer the truth. If no steam be required for slashing or dyeing, a small vertical boiler easily supplies the steam required for heating.

Advantages of Electric Driving.—The fact that electric motors are now used so extensively for driving textile machinery is practical evidence that electric driving offers substantial advantages. In the

case of the scattered machinery used more or less intermittently for dyeing, bleaching, and finishing, there is no possibility of denying that electricity offers the most convenient and efficient means of transmitting energy and driving the machinery. In spinning mills and weaving sheds the net advantage of electric driving may not be so obvious, but it can be demonstrated if all factors be taken into account, and though the percentage gain may be small, the annual total which it represents is far from negligible.

The advantages claimed below are all more or less applicable to the three cases of (1) converting a mechanical mill to electric drive; (2) extending a mechanical mill by electrically-driven equipment; (3) equipping a new mill. In the case of the new mill, electric driving makes possible lighter and cheaper buildings; and in all cases electric driving facilitates the arrangement and extensions of plant, decreases maintenance and repair costs, yields steadier speed and increased production of better quality, and contributes to overall efficiency by other means to be described.

Convenience in transmission of power is a fundamental advantage of electric driving, which carries with it many other advantages of similar importance. Due to the virtual elimination of shafts and belting where individual driving by electric motors is employed, buildings may be made lighter, and the overall capital cost of new mills is lower with electric driving than with mechanical driving. Capital economy, as between mechanical and electrical driving and as between one arrangement and another of electric motors is, however, of secondary importance. The primary factor is efficiency of production. A very small improvement in running efficiency soon pays for any reasonable capital expenditure in the textile industry, owing to the enormous turnover and the relative importance of even the smallest addition to the normal margin of profit on unit output.

Where electric driving is employed, the mill and engine house may be set in whatever position is most convenient for erection and for the performance of manufacturing processes. If electrical energy be purchased from a central station, the power house may, of course, be miles away from the mill, and it is no longer any concern of the mill owner. Whether purchased energy or private generating plant be employed, millwrighting may be practically eliminated by electric driving. The number and cost of gear, belt, and rope drives is greatly reduced, even if machines be driven in small groups by motors of from 10 to 50 H.P., and mechanical transmission is almost entirely eliminated if each machine be provided with its own electric motor. In place of heavy, cumbersome, and inflexible shafting, gears, pulleys, and belts,

we have light electric cables which transmit energy with much higher efficiency, and can be run anywhere without obstruction and with infinite flexibility. Machines can be laid out exactly as required, un-fettered by any consideration as to how power is to be brought to them ; and extensions can be made at any time and in any direction with equal ease and efficiency. The total incumbrance offered by electric motors is less than that of the shafts and belting of mechanical driving, and whereas the motors can be placed absolutely " out of the way," overhead shafting introduces a constant menace from oil, whilst pulleys and belting obstruct light, involve physical danger to workers, and continuously stir up dust and fly. The whole space which would be occupied by engine room, boiler house, and coal store, can be saved by using electricity purchased from a central station.

Constant Speed and Mechanical Efficiency. — The electric motor is the most flexible and reliable driving agent available. Its characteristics can be arranged to meet any requirements, and the machine is reliable both from the point of view of maintenance and of service rendered. Steady speed, or speed varying in any desired manner, can be obtained at will. The simple and accurate control which can be exercised over the speed of an electric motor is seen to advantage in the making ready and operation of calico printing machinery, to quote only a single example. On the other hand, the constancy of speed which can be maintained in driving, spinning, and weaving machinery is an advantage which it is worth while to consider in detail.

Where there is a maximum speed prescribed by the strength of the material worked upon, and where the speed is variable, it is clear that the average speed must be lower than the maximum, *which could, how-ever, be maintained by a constant speed drive.* These facts are directly applicable to electrical as against mechanical driving in textile mills. Due to the steadier speed which can be maintained with small groups of electrically-driven machines compared with mechanically-driven mills, and the steadier speed which can be maintained by individual electric drive compared with group driving, it is possible to run at a higher average speed and with a tension nearer the breaking strength of the yarn. According to the individual circumstances of existing mills, and the alternative schemes proposed for new mills, it is generally safe to reckon upon 5 to 10 per cent. higher output per hour, due solely to the uniformity of speed in electric driving.

In mechanically-driven mills it is common experience that machine speeds are steadier, and may therefore be higher near the engine than at outlying parts of the transmission, where the output is consequently reduced. Well established records show that although the engine

speed in a mechanically-driven mill may vary not more than 2 or 8 per cent., the speed of individual countershafts in the mill may vary 10 to 20 per cent., due to the cumulative effect of backlash in gearing, torsional whipping in shafts, and slipping and flapping of belts. Constancy of speed in the driving agent, be it steam engine or electric motor, is not sufficient in itself. Efficient subdivision of the drive is an essential factor in obtaining steady speed at the driven machinery. A small group of machines can be driven more steadily than a whole roomful driven from a single lineshaft, but the varying angle of twist of long lineshafts and belt slip, which is variable with load and atmospheric changes, must be eliminated by individual driving if the speed constancy of the driven machine is to equal that of the electric motor. Speed variations of 10 per cent. are practically inevitable in a mechanically-driven installation, but speed constant within 1 per cent. is easily obtainable with individual electric drive. From these figures it follows at once that roughly 10 per cent. higher output is obtainable with electric driving. At the same time maintenance and depreciation are reduced, and the quality of the manufactured product is improved. The case for electric driving does not rest on the latter claim, but it is obvious that greater uniformity of tension on the yarn and fewer breakages result in a higher quality of product. The gain from this cause has been estimated at 2 or 3 per cent. higher market value.

Electric driving of machinery in small groups or individually eliminates mainly or entirely the friction losses in mechanical transmission systems. Losses in the transmission cables serving the motors are negligible so far as the mill owner is concerned. The efficiency of the electric motor itself ranges from 83 per cent. in the case of ½ H.P. machine to 93 per cent. in the case of large group-driving motors. The overall efficiency from supply mains to driven machinery should be 80 to 82 per cent. if individual drive be used throughout, and 85 to 87 per cent. if the drive be by large groups. It should be remembered, however, that there are advantages compensating for the lower efficiency of the smaller machines, in particular the unit control and greater speed constancy of driven machines. With a well subdivided electric drive the risk of serious breakdown is obviously much lower than with mechanical driving.

Maintenance of Efficiency.—In order that efficiency may be maintained it is essential that inefficiency be detected promptly. This can be done easily where electric driving is employed, for by connecting electrical measuring instruments in circuit, indications or, if desired, continuous permanent records, can be obtained of the power consumption of any motor or group of motors, under any conditions of operation, and this

without disturbing normal operation in the least. Granted such an accurate and detailed insight into the actual power consumption of individual machines, it is a simple matter to operate the whole plant at its highest efficiency and to maintain this efficiency continuously. Accurate costing is enormously facilitated, and sources of inefficiency are located with the utmost ease. If one cares to do so, it is quite a simple matter to arrange for an automatic alarm to be given when the power consumption of any motor exceeds a predetermined limit.

It is easy enough to determine the rate of output from any textile machine, but only where electric driving is employed is it at all easy to determine the output, *i.e.*, the amount and cost of energy consumed. It is easy to determine the indicated horse-power of a steam engine driving a mill, and thus the total power consumption of the whole installation, but it is very difficult to ascertain where that energy is ultimately consumed, indeed it is virtually impossible to analyse the power distribution of a mechanically-driven mill under actual conditions of operation. With electric drive, on the other hand, one can determine readily the losses in individual lineshafts and the energy consumption of individual machines. The cost of electric driving is easily demonstrated, but that of the mechanical drive is difficult to determine and often much under-estimated. The fact that little reliable information is available or obtainable in mechanically-driven plant often makes it difficult to convince the mill owner that electric driving is more economical. Fortunately it is possible, by considering all factors, to explain from first principles an economic superiority which is daily becoming more powerfully substantiated by practical experience.

Irregularities are detected easily in an electrically-driven mill, and power costs determined with an accuracy impossible where any other drive is employed. By connecting portable or permanent measuring instruments in the circuit of a motor, absolutely reliable information is obtainable on such points as the best running speed, best spindle oil, advantage of ball bearings, correct tightness of spindle banding, loss in belt or gear drive, and in fact the effect on power consumption of any variation in working condition. When it is considered that the substitution of a more suitable spindle oil may alone effect as much as 10 per cent. reduction in the power required to drive a ring frame, it will be realized that even if electric driving offered no other advantages, it would be worth employing for the sake of the control which it gives over operating efficiency.

Another important advantage secured by subdivided electric driving is the reduction or elimination of idle running and waste power. Individual machines or sections of the mill can be run overtime, where

electric driving is employed, without that inefficiency which is involved by running a mechanical transmission system for the sake of a few machines. Electric driving makes possible departmental overtime without increased cost per pound of production, whereas in a mechanical mill overtime involves a considerable increase in power costs per pound. The superiority of electric driving in this respect is particularly evident in woollen mills, where the power employed is small compared with that used in jute and cotton mills, and where a large percentage of machinery is often idle. In such mills it is necessary to run night shifts at some seasons and short hours at other seasons. Electric driving permits part load or part time to be run as efficiently as the whole plant or 24-hour working. In order that full benefit be derived from this flexibility of electric driving, energy should be purchased from a central station, since there is inevitably inefficiency in power production (but not in transmission) in a private generating station when operating at only a fraction of full load.

Central Station Service or Private Generating Plant?—The two main arguments in favour of central station service for textile mills are that the costs of private generation of power are almost invariably under-estimated ; and that power generation is the whole-time business of the central station, whereas it is only a " side line " if carried out by the mill owner. Were space available it would be easy to show by actual data that a central station—which develops energy on a whole-sale basis to meet the varied but collected demands of an industrial community, and which devotes its whole resources to the economical generation of electrical energy—is in a more favourable position than any private generating plant, and it will generally be found that a large central station can sell energy at a profit, at a lower price than that at which a mill can generate it (provided that allowance be made for all the costs of private plant). When estimating the cost of private generating plant, allowance must be made for all the labour involved, from handling coal to delivering electrical energy to the distributing mains and keeping the books relating to the power house. Allowance must be made also for interest and depreciation on the whole equipment involved by power generation ; and for a share in rent, rates, taxes, oil, waste, and other supplies. Finally, it is often contended that it is only fair to debit private generating plant with the profit which might have been made by devoting the staff, space, and investment concerned to textile manufacture instead of to power production.

By taking energy supply from a central station, the mill owner has available for productive work space which would otherwise be occupied

by power plant. The cost of power house, coal stores, and power plant is eliminated, and besides being relieved of the investment required by private generating plant, the mill owner is also relieved of the responsibility and risks thereof. There is greater security of supply in a large central station with reserve plant and an elaborate distributing network than there can be in a private installation, and the central station (which supplies a great number of varied demands) is able to work with larger power units and a more uniform load. It is probable that quite half of the electrically-driven textile factories in service to-day take their energy supply from central stations, and in the case of any mill for which electrification is proposed, one should ascertain very carefully the *complete* cost of energy obtained from private plant. Should this cost be lower than the rates offered by a central station in the district, one has still to consider carefully whether it is not worth while to incur the additional expenditure for the sake of the various advantages enumerated above.

Choice of Motors.—This is a matter which should be left to a specialist. The factory owner cannot be expected to have, and need not have, that intimate knowledge and experience of electrical matters which is needed to obtain the best results from any electrical installation. Competent expert advice must be obtained if the most suitable plant is to be installed in the best manner possible, but once the equipment is set to work its operation and maintenance are simpler and less costly than in the case of the mechanical drive.

The type of motor most commonly used in spinning mills and weaving sheds is the squirrel cage induction motor operating on three-phase alternating current supply. This is the simplest and most robust of all types of electric motors. It yields very steady speed, and is easily arranged for absolutely reliable operation in hot and humid atmospheres laden with dust and fly. Without going into details which would involve too much explanation of technical terms,* it may be stated definitely that there are now available electric motors and control gear fulfilling completely every possible requirement. This assertion is sweeping, but it can be justified to the hilt.

Group v. Individual Driving.—By group driving is meant the use of one electric motor to drive a number of machines through lineshaft and belting, whereas individual driving means the provision of a motor for each driven machine. In the early days of electricity in textile

---

* Readers wishing to study the main principles of generating plant and the purchase of electrical energy, electric motors, and motor selection and applications, from the standpoint of the mechanical engineer, may be referred to "Electrical Engineering Practice," by J. W. Meares.

mills the tendency was to use a few large motors to take charge of sections of existing mills. In those days small motors were relatively costly and inefficient, and it was far easier to subdivide existing mechanical transmissions for electrical group driving than it would have been to install individual motors throughout. Even to-day existing conditions and lay-out of plant have considerable influence on the arrangement of electric drive when converting an existing mill, but the tendency is now undoubtedly towards the use of individual drive for all machines.

As will have been gathered from earlier paragraphs on speed constancy and friction losses, there are strong reasons for preferring individual drive. Carrying group driving to its extreme by merely substituting for the steam engine of a mechanical mill an electric motor of equal power would give little or no reduction in friction losses, and no increase in production due to steadier speed. On the other hand, as smaller groups are used and individual driving is ultimately reached, there is greater reduction in friction and greater increase in production owing to the steadier speed of driven machinery. These facts are well shown by the following data due to J. E. Mellett :—

Electric Drive by—	Friction Loss Eliminated.	Increased Production.
	Per Cent.	Per Cent.
Large groups - - - -	3 to 10	2 to 8
Large and small groups - -	10 to 20	4 to 10
Individual and small groups -	20 to 30	8 to 15
Individual only - - -	30 to 40	10 to 20

Motors of higher horse-power are more efficient and relatively less costly than smaller machines, hence individual driving, or driving in small groups (say two or four machines per motor), means more expenditure on motors, but, on the other hand, there is obtained maximum flexibility, maximum production, and a saving in shafts, hangers, pulleys, belts, and maintenance. The higher efficiency and lower cost of large group motors compared with small individual motors is soon compensated for by belt and shaft losses in group drives.

Elimination of belting by individual drive obviates that constant attention to belt tightness, cleaning, and pulley alignment without which a belt drive soon becomes irregular, and the speed below normal. Backlash and variations due to belt slipping and flapping cannot be eliminated from mechanical drives, whether the latter be comprehensive

or only used in group drives. Individual motors give smoother driving and higher mean speed than group driving, especially where there are heavy reciprocating parts or irregular loads. The use of group motors for driving mules may smooth out peak loads, but, on the other hand, the peak loads may synchronize with ill effects on all the machines in the group. The elimination of belts by individual driving leaves more light and air in the workroom, reduces the stirring up of dust, etc., and contributes to all-round cleanliness, which is specially valuable where silk and other fine fabrics are concerned. Any machine which has to be shut down for long periods should certainly be driven individually. The quick starting and high starting torque obtainable by motor drive are advantageous compared with belt shifting, but it should be clearly understood that any desired smoothness and gradation of starting can be obtained by judicious choice of motor and control gear.

Group driving saves on the first cost of the motors, but the larger the group the nearer we approach the disadvantages of mechanical drive, and the more we sacrifice the unit control possible with electric motors on each machine. Small groups of machines working uniformly, and under virtually identical conditions, may be driven advantageously by a single motor for each group, and group drive is quite suitable for bale breakers, blowing machinery, scutchers, carding engines, and combers, since uniform speed and clear head room are not so important where preparing machinery is concerned. Group driving should not, however, be applied to large groups of machines, or to long lineshafts. Individual drive may now be considered standard for the speed and spinning frames and looms. Individual motors need only be run when the machine they drive is in production ; quieter and healthier surroundings are obtained, good lighting is facilitated, and the structure of new factories may be appreciably lighter if the weight of shafting and the pull of belts have not to be considered.

Power Requirements.—The total horse-power of motors installed in all departments of an electrically-driven cotton mill is estimated to work out at about 27 spindles per horse-power on the average. This, it must be remembered, is based on the total horse-power of motors installed. A higher value of spindles per horse-power will generally be obtained by dividing the number of spindles in a steam mill by the indicated horse-power of the engine ; a fair comparison with this figure may be obtained by dividing the number of spindles in an electrically-driven mill by the average horse-power consumed (as indicated by a meter in the main supply circuit). The average horse-power consumed is, of course, materially lower than the motor horse-power installed.

In a recent analysis of modern practice in electric driving for textile

industries, Mellett gives the following distribution for the power requirements of a cotton mill :—Pickers, 6 per cent. ; carding, 16 per cent. ; spinning and spooling, 50 per cent. ; weaving, warping, and slashing, 23 per cent. ; miscellaneous machinery, 5 per cent. Considering various departments in turn, *opening* machines may be driven individually or in groups as preferred, motors of from 5 to 15 H.P. being usual ; *pickers* may be driven individually by 5 to 10 H.P. motors, belt coupled to the beater shaft, or group drive may be employed if preferred ; in the *carding* department small groups of machines are usual with motors of from 20 to 50 H.P. for each group. Drawing frames, slubbers, and fly frames may be driven individually by chain-coupled motors. Roving frames may be driven conveniently in groups of 2 or 4 by motors mounted on the ceiling above the frames, and needing only one belt per frame.

Spinning is often responsible for from 50 to 60 per cent. of the total power consumption in cotton mills, the actual power requirements varying with the count spun, whether weft or warp, with the atmospheric conditions, and with the spindle speeds, cleanliness of machines, and tightness of cotton banding. When working always on one count, a very efficient arrangement is to drive each frame individually by a high speed motor direct coupled to the tin-roller shaft, the latter being speeded up accordingly. Wool spinning frames, and frames operated on varying counts, may be belt driven from motors of 5 to 10 H.P. suspended from the ceiling. Group driving may be used if preferred, two or four frames being driven by a motor of 10 to 30 H.P. suspended from the ceiling, or larger groups being driven by more powerful motors attached to ceiling, wall, or floor. The inherent advantages of individual driving compared with large groups should be borne in mind.

In *weaving*, speed uniformity is highly important, and can best be obtained by driving looms individually, each by its own motor of from $\frac{1}{2}$ to 2 H.P. according to circumstances. Individual drive was first employed on silk, worsted, and woollen looms, and its advantages are undoubtedly a maximum in these cases, but it is now widely recognized that individual driving is a commercial proposition for cotton looms as well. If it is not considered that the flexibility of individual drive and its steadier speed are worth the additional investment involved, group driving can of course be employed ; but the larger the group, the nearer one approaches to the speed irregularities of mechanical driving. Ten per cent. greater production and appreciably improved quality has been demonstrated in individually-driven compared with group-driven looms. *Spoolers and warpers* may be driven individually or in large or small groups.

Individual motors may be incorporated in *finishing machines*, but when changing over from mechanical to electrical drive, these machines may be driven in groups by motors of 10 to 25 H.P. The machine shop may be group-driven by a motor of 5 to 10 H.P., and the humidifier pump by a 5 to 15 H.P. motor. *Slashing* and *sizing* requirements are generally met by one group motor (say 10 to 30 H.P. for 3 to 7 slashers). In *conditioning yarn*, electrical energy may be used to drive the pumps for lighting and for heating. During the winter months it is generally more economical to employ steam heat, but from spring to autumn economical and efficient service may be obtained from electric heaters which, in conjunction with a thermostat, automatically maintain constant temperature.

In a new mill laid out for electric driving, electrically-driven centrifugal *fire pumps* would be installed as a matter of course, but where an existing mechanically-driven mill is converted to electric driving, the steam-driven pumps may be retained if steam is needed for slashing or dyeing. On the other hand, if steam is required only for heating it is advisable to install electrically-driven pumps and to provide steam for heating from a small vertical boiler.

In conclusion, the whole case for electric driving is summarized by the statement that, for equal or lower cost, it yields a greater production, of higher quality, from practically all textile machinery.

ELECTRIC LIGHTING IN TEXTILE MILLS

Good Lighting Essential.—The advantages of good lighting in any work place admit of no argument, but their number and importance are greater than generally realized. Good lighting " pays," whether it serves an all-night shift or is used only during evening hours and on dull days. A few minutes delay occasioned to a worker by inadequate lighting will cost more than providing good illumination. There are special reasons why good lighting should be provided in textile mills. Good sight is essential, but it can be neither used nor retained if the worker is provided with inadequate illumination. Without good lighting it is impossible to detect imperfections with certainty, and impossible to find and join broken threads without delay. Good lighting makes for cheerful workrooms, healthy and contented workers, easy and effective supervision, and all-round briskness and efficiency. Bad lighting, dirt, inferior work, and inefficiency go together. There is no reason why night-shift output should be lower than or inferior to day output, indeed the converse has been the case in some mills where the artificial lighting is particularly good. For

a similar reason, the inferiority of winter-made goods is or should be a thing of the past.

It is estimated by experts that 25 per cent. of industrial accidents are attributable directly or indirectly to poor lighting, and there is incontrovertible evidence to show that industrial accidents are most frequent during the darkest months of the year, and more frequent during the evening than during the morning and afternoon. Recent official statistics for the textile industry show a higher accident rate per hour by artificial light than by daylight, the former being higher by 76 per cent. in the case of accidents due to falling, and by 46 per cent. in the case of accidents due to all other causes. Good lighting has undoubtedly direct influence on the safety of workpeople ; on their willingness and ability to work at maximum output ; and on the quality of product. Production is increased at least 10 per cent. by efficient lighting, and fewer mistakes are made in reading orders, selecting materials, and tending machines.

What Constitutes Good Lighting.—An excellent idea of what is requisite to good lighting is obtainable from the official statement as to the usual *causes of unsatisfactory lighting.* According to Blue Book, Cd. 8000,* these are : (1) Too few or too weak lights. (2) Antiquated methods of lighting. (3) Inadequate supply (*i.e.,* insufficient engine or dynamo power where private plant is used). (4) Neglect of upkeep. (5) Inside obstruction. (6) Shadows and improper placing of lights· throwing of objectionable shadows by part of the machine itself is especially to be guarded against.

Illumination Required.—The unit of illumination is the *foot-candle,* which is the illumination provided on a surface by a standard candle at a distance of 1 foot. For any given candle-power of lamp the illumination varies inversely with the *square* of the distance. Thus a lamp of 16 candle-power (c.p.) produces the same illumination at a distance of 4 ft., as the standard candle does at a distance of 1 ft. Similarly a 64-c.p. lamp is required to produce an illumination of 1 ft.-candle at a distance of 8 ft., and so on. Determining the effective candle-power of a lamp and the illumination required for a certain purpose is a matter for the specialist in illumination—indeed it pays to employ an illuminating engineer to lay out any lighting installation. The brightness of the surface depends not only upon the foot-candles of incident illumination, but also upon the nature of the surface. That is, with equal illumination, white paper will be much brighter than cast iron.

It is impractical and frequently misleading to attempt to estimate foot-candle values simply by viewing an illuminated surface. The

simplest instrument for measuring these values is a foot-candle meter with which foot-candles can, with a little practice, be read accurately enough for ordinary purposes.

The Departmental Committee already mentioned recommends the following values for *minimum* illumination at floor level :—Open places where people are employed, danger points of roads and approaches, 0·05 ft.-candle ; all parts of factories over which people pass, 0·1 ft.-candle ; working area of factories generally, 0·25 ft.-candle.   It must be understood that these illuminations are suggested only as *minima.* The actual illumination desirable for carrying out work is considerably higher according to circumstances.   The saving clause in the official recommendations is that the illumination must everywhere be "adequate."   The values of illumination given in the following table may be taken as typical of good modern practice.

Desirable Illumination in Foot-Candles

	Foot-Candles.
Storage spaces, yards and roadways - -	¼ to ½
Passages and stairways - - - -	½ ,, 2
Receiving, preparing, packing, and shipping departments - - - - -	2 ,, 3
Offices - - - - - -	3 ,, 4
Inspecting - - - - - -	5 ,, 10 or over
Spinning, twisting, warping machines, etc. -	2 ,, 5
Weaving—cotton - - - - -	3 ,, 5
,, wool or silk - - - -	4 ,, 8
Dyeing—cotton - - - - - -	3 ,, 5
,, wool - - - - -	2 ,, 4
Very fine work or dark materials - -	10 ,, 15

As regards the power required to yield the desired illumination, it may be taken that where tungsten-filament glow lamps are used to provide illumination over a considerable area, from 250 to 400 watts must be allowed per 1000 sq. ft. of working surface per foot-candle of illumination required. *
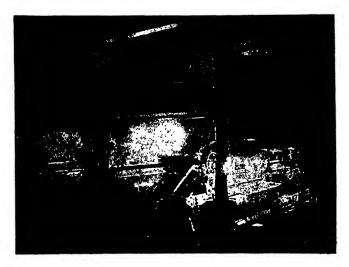
When very intense illumination is required (as for fine work on dark materials), the general illumination of anything from 2 to 5 ft.-candles must be supplemented by "local" lamps in suitable reflectors.

Suggestions for Good Lighting.—The fundamental requirements for good lighting are : (1) Adequacy (see preceding paragraphs).   (2)

* *Example.*—To provide an illumination of 3 ft.-candles over a working surface 100 ft. by 50 ft. would require the expenditure of from (3 × 250 × 100 × 50 ÷ 1000) to (3 × 400 × 100 × 50 ÷ 1000) watts, *i.e.*, from 3750 to 6000 watts.   If electricity costs 1d. per unit, *i.e.*, 1d. per 1000 watts per 1 hour, the cost of current for lighting would be from 3¾d. to 6d. per hr. in this case,

Reasonable constancy and uniformity of illumination over the working area. (3) Lamps so placed and (or) shaded that the source is not directly in view when the operator is working or looking horizontally across the room. (4) Lamps so located as not to cast extraneous shadows on the work.

Quite 90 per cent. of the textile firms in this country are lit by electricity, many generating their own supply by means of a dynamo driven from one of the main steam engines, and hence the cost of the

POOR LOOM-LIGHTING IN A WOOLLEN SHED. Note Shadows.

power to them is almost negligible. They have, however, in most cases a considerable objection to increasing their lighting load owing to the fact that their generators are already fully loaded, and any extensive improvement in lighting would necessitate the installation of a new dynamo, probably accompanied by additions to the supply cables in order to cope with the increased load. In many instances a power allocation of as low as 1 watt to 6 sq. ft. of floor area has been encountered, which makes it very evident that a considerable increase in the power available for lighting will be necessary in order to bring illumination up to a satisfactory value.

It should be noted that the B.E.S.A. standard dispersive reflector is a suitable unit for the great majority of textile mill lighting, and where no other type of unit is specified it is to be inferred that this will be applicable. In the case of 60 and 100 watt units, the pearl or opal type of lamp, which is as yet little used in the industry, seems to be the most suitable from all points of view. For larger units, opal or bowl-frosted lamps provide the most suitable light from the point of view of diffusion and freedom from glare.

WELL-LIGHTED WEAVING SHED.

Cotton Opening and Scutching.—A daylight blue lamp is, however, employed in this department by one or two firms, and these do make the grading possible after dark. A system of general lighting is applicable in the majority of cases, but this should be arranged so that no lighting units are located directly over the machines, so that there is no possibility of anything falling into them.

As scutchers are not more than 5 ft. in height, even narrow gangways between machines will receive adequate illumination from units about 10 ft. from the floor.

Wool Picking and Washing.—Raw wool is judged by texture,

impurities, and colour, and sorting is usually carried on during daylight. There is, however, every reason for supposing that with an intensity of 10 ft.-candles of colour-corrected light on the inspection benches, sorting could be reliably carried out once the operatives had become accustomed to the differences between the artificial daylight and the genuine article. The bale-storage space need not be illuminated to the same intensity as the benches—3 to 5 ft.-candles will ensure that the brightness contrast in the room is not excessive, while providing ample illumination for visual needs.

Wool washing is in hot solutions, and a considerable amount of water vapour is evolved, so that light units should be of a totally enclosed vapour-proof type. Those incorporating a reflector are preferable, as ceiling and walls are seldom light enough to give useful reflection of light emitted above the horizontal. It is desirable to have daylight-blue lamps over the delivery ends where the dried wool passes to the suction trunks which convey it to the cardroom. An illumination of 5 ft.-candles is desirable, as any impurities which have escaped the washings must here be detected.

Flax Dressing.—In hand dressing no fine work is entailed, but sufficient illumination must be provided for the operatives to see how complete is the dressing of their fibres. Four foot-candles is adequate over the benches, and units should be arranged to ensure that no operative is working in his own shadow.

In machine dressing by hackling machines, about 5 ft.-candles should be provided at the feeding end, where poor illumination or heavy shadows might easily be responsible for an accident to the boys who tend the mechanism which grips the bunches of fibres.

Cardroom Lighting.—Difficulties in the form of the very low ceiling and small space available have been overcome by the use of angle reflectors. Five to eight foot-candles illumination is produced on the vertical plane from 60-watt pearl lamps.

Normally, carding engines are arranged in two or more rows. The delivery end is the most important one from a lighting point of view. Any inequalities and irregularities in the sliver must be observed. Five foot-candle intensity over the delivery ends should be provided for normal cases, but some 8 ft.-candles are necessary for equal visibility with the dark material sometimes encountered in the wool industries. Roving frames may be anything up to 7 ft. in height, so that, except where an exceptionally high ceiling is available, a line of units above each " gate " between machines is required.

The region where good illumination is required lies between 2 ft. and 4 ft. from the floor level, and is partly in a horizontal and partly a

vertical plane, so that, assuming an available mounting height of 11 ft., the maximum spacing for reasonable uniformity of illumination will be about 12 ft., which would mean placing four units over an average length of gate, giving an average illumination of 6 ft.-candles.

Spinning.—The lighting of ring or cap spinning frames is a similar problem, except that in many instances the frames are not more than 4 to 5 ft. high, in which case, where a mounting height of 10 ft. or over is available, an alternate gate spacing will give quite satisfactory lighting. This, in fact, practically amounts to a general lighting system.

Warping.—Adequate lighting for beam-warping machines calls for a row of units over the line of beams, each unit being located between two beam ends, and a further line of units, each situated on the " V " of the creel. Eight foot-candle intensity is desirable on the beams.

Drawing-in.—A general illumination of 6 ft.-candles, supplemented by a 60-watt local unit in an angle reflector close to the work, gives good results in practice. The local unit can be moved by sliding the rod from which it is suspended. The intensity on the work is about 70 ft.-candles.

Weaving.—Installations with no local units have been introduced with good results, but some weavers cannot work satisfactorily without some local lighting as well. In cotton-weaving sheds a grouped system with one unit in the middle of four looms is satisfactory, and thus an economy can sometimes be effected by using one 200-watt lamp instead of four 60-watt lamps, one to each loom. In wider looms one unit for each pair is found satisfactory. For jacquard damask and similar looms, local units 2 or 3 ft. above the work must be employed. On smaller jacquards there may be one unit at each end of a pair of loom fronts, sometimes without it for plainer work. A minimum intensity of 8 ft.-candles is desirable for all jacquards, as the multiplicity of warp controls renders setting-up or broken-warp mending a fine and tedious business, even under the best illumination. In some cases the dark materials render it necessary to provide a unit at each corner of the majority of the looms. The mounting height is 11 ft., and an intensity of 8 ft.-candles horizontal and 5 to 6 ft.-candles vertical is obtained from 100-watt units on approximately 9-ft. centres.

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	14	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25.	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4185	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	14
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	3	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	3	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	4	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	2	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
·47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
·49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6
·50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
·77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
·78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
·79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
·80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
·81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
·82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
·83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
·84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
·85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	11	13	15
·86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
·87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
·88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
·89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
·90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
·91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
·92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	11	13	15	17
·93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
·94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
·95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
·96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	9	11	13	15	17	19
·97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
·98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
·99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

BRITISH WEIGHTS AND MEASURES

LENGTH

Inches.	Feet.	Yards.	Fathoms.	Furlongs.	Miles.
1	0·0833	0·0277	0·0139	0·000126	0·000016
12	1	0·3333	0·1667	0·001515	0·000189
36	3	1	0·5000	0·004545	0·000568
72	6	2		0·009091	0·001136
7920	660	220	110	1	0·125000

SURFACE

Inches.	Feet.	Yards.	Poles.	Roods.	Acre.
1	0·0069444	0·0007716	0·0000255	0·00000064	0·00000016
144	1	0·1111111	0·0036731	0·0000918	0·000023
1296	9	1	0·0330579	0·0008264	0·0002066
39204	272¼	30¼	1	0·025	0·00625
1568160	10890	1210	40	1	0·25
6272640	43560	4840	160	4	1

SURFACE (SURVEYORS)

Links.	Poles.	Chains.	Roods.	Acre.	Sq. Metres.
1	0·0016	0·0001	0·00004	0·00001	0·04046
625	1	0·0625	0·025	0·00025	25·292
10000	16	1	0·4	0·1	404·6782
25000	40	2·5	1	0·25	1011·696
100000	160	10	4	1	4046·782

CAPACITY

Cubic Inches.	Cubic Feet.	Cubic Yards.
1	0·0005788	0·00000214
1728	1	0·0370370
46656	27	1

WEIGHT (TROY)

Grains.	Dwt.	Ounces.	Lbs.
1	0·0416667	0·0020833	0·0001737
24	1	0·05	0·0041666
480	20	1	0·0833333
5760	240	12	1

WEIGHT (AVOIRDUPOIS)

Drams.	Ounces.	Lbs.	Quarters.	Cwt.	Ton.
1	0·0625	0·0039063	0·0001395	0·0000349	0·00000174
16	1	0·0625	0·0022321	0·000558	0·00002790
256	16	1	0·0357143	0·0089285	0·00044643
7168	448	28	1	0·25	0·0125
28672	1792	112	4	1	0·5
573440	35840	2240	80	20	1

EQUIVALENTS OF IMPERIAL AND METRIC WEIGHTS AND MEASURES

Imperial	Metric

LINEAR MEASURE

Imperial	Metric
1 Inch = 25·400 Millimetres.	1 Millimetre (mm.)
1 Foot = 0·30480 Metre.	$(\frac{1}{1000}$ m.) = 0·03937 In.
1 Yard = **0·914399 Metre.**	1 Centimetre($\frac{1}{100}$ m.) = 0·3937 ,,
1 Fathom = 1·8288 Metres.	1 Decimetre ($\frac{1}{10}$ m.) = 3·937 ,,
1 Pole = 5·0292 ,,	1 Metre (m.) = { 39·370113 In.
1 Chain = 20·1168 ,,	3·280843 Ft.
1 Furlong = 201·168 ,,	1·0936143 Yds.
1 Mile = 1·6093 Kilometres.	1 Dekametre (10 m.) = 10·936 Yds.
	1 Kilometre(1000m.) = 0·62137 Mile.

SQUARE MEASURE

Imperial	Metric
1 Sq. Inch = 6·4516 Sq. Centimetres.	1 Square Centimetre = 0·15500 Sq. In.
1 Sq. Foot = 9·2903 Sq. Decimetres.	1 Sq. Decimetre = 15·500 ,,
1 Sq. Yard = 0·836126 Sq. Metre.	1 Sq. Metre = { 10·7639 Sq. Ft.
1 Rood = 10·117 Ares.	1·1960 Sq. Yds.
1 Acre = 0·40468 Hectare.	1 Are = 119·60 ,,
1 Sq. Mile = 259·000 Hectares.	1 Hectare = 2·4711 Acres.

CUBIC MEASUREMENT

Imperial	Metric
1 Cubic Inch = 16·387 Cub. Centimetres.	1 Cubic Centimetre = 0·0610 Cub. In.
1 Cub. Foot = 0·028317 Cubic Metre.	1 Cubic Decimetre } = 61·024 ,,
1 Cub. Yard = 0·764553 ,, ,,	(c.d.) }
	1 Cubic Metre = { 35·3148 Cub. Ft.
	1·307954 ,, Yds.

MEASURE OF CAPACITY

Imperial	Metric
1 Pint = 0·568 Litre.	1 Centilitre($\frac{1}{100}$ litre) = 0·0710 Gill.
1 Quart = 1·136 Litres.	1 Decilitre ($\frac{1}{10}$,,) = 0·176 Pint.
1 Gallon = **4·5459631 Litres.**	1 Litre = **1·76980 Pints.**

WEIGHT

AVOIRDUPOIS.		AVOIRDUPOIS.
1 Grain = 0·0648 Gram.	1 Milligram ($\frac{1}{1000}$ g.) =	0·015 Grain.
1 Dram = 1·772 Grams.	1 Centigram ($\frac{1}{100}$ g.) =	0·154 ,,
1 Oz. = 28·350 ,,	1 Gram (1 g.) =	15·432 Grains.
1 Lb. (7000 Grains) = 0·45359243 Kilogram.	**1 Kilogram** } = {	2·2046223 Lbs. or 15432·3564 Grains.
	(1000 g.) }	
1 Hundred-weight = { 50·80 Kilogram. 0·5080 Quintal.	1 Quintal (100 kg.) =	1·968 Cwt.
1 Ton = { 1·0160 Tonnes, or 1016 Kilograms.	1 Tonne (1000 ,,) =	0·9842 Ton.
1 Gr. (Troy) = 0·0648 Gram.	1 Gram (1 g.) =	{ 0·03215 Oz. Troy.
1 Troy Oz. = 31·1035 Grams.		15·432 Grains.

BRITISH WEIGHTS AND METRIC EQUIVALENTS

Lbs.	Kilos.	Lbs.	Kilos.	Cwt.	Kilos.
1	0·4536	57	25·8548	1	50·802
2	0·9072	58	26·3084	2	101·605
3	1·3608	59	26·7620	3	152·407
4	1·8144	60	27·2156	4	203·210
5	2·2680	61	27·6692	5	254·012
6	2·7216	62	28·1228	6	304·814
7	3·1751	63	28·5763	7	355·617
8	3·6287	64	29·0299	8	406·419
9	4·0823	65	29·4835	9	457·221
10	4·5359	66	29·9371	10	508·023
11	4·9895	67	30·3907	11	558·826
12	5·4431	68	30·8443	12	609·629
13	5·8967	69	31·2979	13	660·431
14	6·3503	70	31·7515	14	711·233
15	6·8039	71	32·2051	15	762·036
16	7·2575	72	32·6587	16	812·838
17	7·7111	73	33·1123	17	863·640
18	8·1647	74	33·5659	18	914·443
19	8·6183	75	34·0195	19	965·245
20	9·0719	76	34·4731	20	1016·048
21	9·5254	77	34·9266	21	1066·85
22	9·9790	78	35·3802	22	1117·65
23	10·4326	79	35·8338	23	1168·45
24	10·8862	80	36·2874	24	1219·26
25	11·3398	81	36·7410	25	1270·06
26	11·7934	82	37·1946	26	1320·86
27	12·2470	83	37·6482	27	1371·66
28	12·7006	84	38·1018	28	1422·47
29	13·1542	85	38·5554	29	1473·27
30	13·6078	86	39·0090	30	1524·07
31	14·0614	87	39·4626	31	1574·87
32	14·5150	88	39·9162	32	1625·68
33	14·9686	89	40·3698	33	1676·48
34	15·4222	90	40·8234	34	1727·28
35	15·8757	91	41·2769	35	1778·08
36	16·3293	92	41·7305	36	1828·89
37	16·7829	93	42·1841	37	1879·69
38	17·2365	94	42·6377	38	1930·49
39	17·6901	95	43·0913	39	1981·29
40	18·1437	96	43·5449	40	2032·09
41	18·5973	97	43·9985	41	2082·90
42	19·0509	98	44·4521	42	2133·70
43	19·5045	99	44·9057	43	2184·50
44	19·9581	100	45·3593	44	2235·30
45	20·4117	101	45·8129	45	2286·11
46	20·8653	102	46·2665	46	2336·91
47	20·3189	103	46·7201	47	2387·71
48	21·7725	104	47·1737	48	2438·51
49	22·2260	105	47·6272	49	2489·32
50	22·6796	106	48·0808	50	2540·12
51	23·1332	107	48·5344	51	2590·92
52	23·5868	108	48·9880	52	2641·72
53	24·0404	109	49·4416	53	2692·53
54	24·4940	110	49·8932	54	2743·33
55	24·9476	111	50·3488	55	2794·13
56	25·4012	112	50·8024	56	2844·98

METRIC WEIGHTS AND BRITISH EQUIVALENTS

Kilos.	Lbs.	Kilos.	Lbs.	Kilos.	Cwt.
1	2·2046	51	112·436	10	0·19684
2	4·4092	52	114·640	20	0·39368
3	6·6139	53	116·845	30	0·59052
4	8·8185	54	119·050	40	0·78736
5	11·0231	55	121·254	50	0·98420
6	13·2277	56	123·459	60	1·18105
7	15·4323	57	125·663	70	1·37789
8	17·6370	58	127·868	80	1·57473
9	19·8416	59	130·073	90	1·77157
10	22·0462	60	132·277	100	1·96841
11	24·2508	61	134·482	110	2·16525
12	26·4554	62	136·686	120	2·36209
13	28·6601	63	138·891	130	2·55894
14	30·8647	64	141·096	140	2·75578
15	33·0693	65	143·300	150	2·95262
16	35·2739	66	145·505	160	3·14946
17	37·4785	67	147·710	170	3·34630
18	39·6832	68	149·914	180	3·54314
19	41·8878	69	152·119	190	3·73998
20	44·0924	70	154·323	200	3·93682
21	46·297	71	156·258	210	4·13366
22	48·502	72	158·733	220	4·33051
23	50·706	73	160·937	230	4·52735
24	52·911	74	163·142	240	4·72419
25	55·116	75	165·347	250	4·92103
26	57·320	76	167·551	260	5·11787
27	59·525	77	169·756	270	5·31471
28	61·729	78	171·960	280	5·51155
29	63·934	79	174·165	290	5·70839
30	66·138	80	176·370	300	5·90523
31	68·343	81	178·574	310	6·10208
32	70·548	82	180·779	320	6·29892
33	72·758	83	182·984	330	6·49576
34	74·957	84	185·188	340	6·69260
35	77·162	85	187·393	350	6·88944
36	79·366	86	189·597	360	7·08628
37	81·571	87	191·802	370	7·28312
38	83·776	88	194·007	380	7·47996
39	85·980	89	196·211	390	7·67681
40	88·184	90	198·416	400	7·87364
41	90·389	91	200·620	410	8·07049
42	92·594	92	202·825	420	8·26733
43	94·799	93	205·030	430	8·46417
44	97·003	94	207·234	440	8·66101
45	99·208	95	209·439	450	8·85785
46	101·413	96	211·644	460	9·05469
47	103·617	97	213·848	470	9·25154
48	105·822	98	216·053	480	9·44838
49	108·026	99	218·258	490	9·64522
50	110·231	100	220·462	500	9·84206

CONVERSION TABLE

MILLIMETRES TO INCHES

Mm.	Inches.	Mm.	Inches.	Mm.	Inches.	Mm.	Inches.
1	0	55	2⅛	109	4¼	163	6⅜
2	0	56	2	110	4	164	6
3	0	57	2	111	4⅜	165	6½
4	0	58	2	112	4	166	6½
5	0	59	2	113	4	167	6
6	0	60	2	114	4	168	6
7	0	61	2	115	4½	169	6⅝
8	0	62	2	116	4	170	6
9	0	63	2	117	4	171	6
10	0	64	2½	118	4	172	6
11	0	65	2	119	4	173	6
12	0	66	2	120	4	174	6
13	0	67	2	121	4	175	6
14	0	68	2	122	4	176	6
15	0	69	2	123	4	177	6
16	0	70	2	124	4	178	7
17	0	71	2	125	4	179	7
18	0	72	2	126	4	180	7
19	0	73	2	127	5	181	7
20	0	74	2	128	5	182	7
21	0	75	2	129	5	183	7
22	0	76	2	130	5	184	7
23	0	77	3	131	5	185	7
24	0	78	3	132	5	186	7
25	0	79	3	133	5	187	7
26	1	80	3	134	5	188	7
27	1	81	3	135	5	189	7
28	1	82	3	136	5	190	7
29	1	83	3	137	5	191	7
30	1	84	3	138	5	192	7
31	1	85	3	139	5	193	7
32	1	86	3	140	5	194	7
33	1	87	3	141	5	195	7
34	1	88	3	142	5	196	7
35	1	89	3	143	5	197	7
36	1	90	3	144	5	198	7
37	1	91	3	145	5	199	7
38	1	92	3	146	5	200	7
39	1	93	3	147	5	300	11
40	1	94	3	148	5	400	15
41	1	95	3	149	5	500	19
42	1	96	3	150	5	600	23
43	1	97	3	151	5	700	2 ft. 3
44	1	98	3	152	5	800	2 „ 7
45	1	99	3	153	6	900	2 „ 11
46	1	100	3	154	6	1000	3 „ 3
47	1	101	3	155	6	2000	6 „ 6
48	1	102	4	156	6	3000	9 „ 10
49	1	103	4	157	6	4000	13 „ 1
50	1	104	4	158	6	5000	16 „ 4
51	2	105	4	159	6	6000	19 „ 8
52	2	106	4	160	6	7000	22 „ 11
53	2	107	4	161	6	8000	26 „ 2
54	2	108	4	162	6	9000	29 „ 6

f, full; b, bare.

CONVERSION TABLES

INCHES TO MILLIMETRES

Inches.	0	1	2	3	4	5	6	7	8	9	10	11
0		25·40	50·79	76·19	101·6	127·0	152·4	177·8	203·2	228·6	254·0	279·4
1/16	1·587	26·99	52·38	77·78	103·2	128·6	154·0	179·4	204·8	230·2	255·6	281·0
1/8	3·175	28·57	53·97	79·37	104·8	130·2	155·6	181·0	206·4	231·8	257·2	282·6
3/16	4·762	30·16	55·55	80·95	106·4	131·8	157·2	182·6	208·0	233·4	258·8	284·2
1/4	6·347	31·75	57·14	82·54	107·9	133·4	158·8	184·2	209·6	235·0	260·4	285·8
5/16	7·937	33·34	58·77	84·17	109·5	134·9	160·3	185·7	211·1	236·5	261·9	287·3
3/8	9·524	34·92	60·31	85·71	111·1	136·5	161·9	187·3	212·7	238·1	263·5	288·9
7/16	11·112	36·51	61·90	87·30	112·7	138·1	163·5	188·9	214·3	239·7	265·1	290·5
1/2	12·700	38·10	63·49	88·89	114·3	139·7	165·1	190·5	215·9	241·3	266·7	292·1
9/16	14·287	39·69	65·08	90·48	115·9	141·3	166·7	192·1	217·5	242·9	268·3	293·7
5/8	15·874	41·27	66·66	92·06	117·5	142·9	168·3	193·7	219·1	244·5	269·9	295·3
11/16	17·462	42·86	68·25	93·65	119·1	144·5	169·9	195·3	220·7	246·1	271·5	296·9
3/4	19·049	44·45	69·84	95·24	120·7	146·1	171·5	196·9	222·3	247·7	273·1	298·4
13/16	20·637	46·04	71·43	96·83	122·2	147·6	173·0	198·4	223·8	249·2	274·6	300·0
7/8	22·224	47·62	73·01	98·41	123·8	149·2	174·6	200·0	225·4	250·8	276·2	301·6
15/16	23·812	49·21	74·60	100·0	125·4	150·8	176·2	201·6	227·0	252·4	277·8	303·2

FEET TO METRES

Feet.	0	10	20	30	40	50	60	70	80	90
0		3·0479	6·0959	9·1438	12·1918	15·2397	18·2877	21·3356	24·3836	27·4315
1	0·3048	3·3527	6·4007	9·4486	12·4966	15·5445	18·5925	21·6404	24·6884	27·7363
2	0·6096	3·6575	6·7055	9·7531	12·8014	15·8493	18·8973	21·9452	24·9031	28·0411
3	0·9144	3·9623	7·0103	10·0582	13·1062	16·1541	19·2021	22·2500	25·2979	28·3459
4	1·2192	4·2671	7·3151	10·3630	13·4110	16·4589	19·5068	22·5548	25·6027	28·6507
5	1·5240	4·5719	7·6199	10·6678	13·7158	16·7637	19·8116	22·8596	25·9075	28·9555
6	1·8288	4·8767	7·9247	10·9726	14·0205	17·0685	20·1164	23·1644	26·2123	29·2603
7	2·1336	5·1815	8·2295	11·2774	14·3253	17·3733	20·4213	23·4692	26·5171	29·5651
8	2·4384	5·4863	8·5342	11·5822	14·6301	17·6781	20·7260	23·7740	26·8219	29·8699
9	2·7432	5·7911	8·8390	11·8870	14·9349	17·9829	21·0308	24·0788	27·1267	30·1747

METRICAL AND BRITISH CONVERSION TABLES

METRICAL TO BRITISH.		
Litres to Fluid Ounces.	Litres to Pints.	Litres to Gallons.
1 = 35·215468	1 = 1·7607734	1 = 0·22009668
2 = 70·430936	2 = 3·5215468	2 = 0·44019336
3 = 105·646404	3 = 5·2823202	3 = 0·66029004
4 = 140·861872	4 = 7·0430936	4 = 0·88038672
5 = 176·077340	5 = 8·8038670	5 = 1·10048340
6 = 211·292808	6 = 10·5646404	6 = 1·32058008
7 = 246·508276	7 = 12·3254138	7 = 1·54067676
8 = 281·723744	8 = 14·0861872	8 = 1·76077344
9 = 316·939212	9 = 15·8469606	9 = 1·98087012

BRITISH TO METRICAL.		
Fluid Ounces to Cubic Centimetres.	Pints to Litres.	Gallons to Litres.
1 = 28·396612	1 = 0·567932	1 = 4·543458
2 = 56·793224	2 = 1·135864	2 = 9·086916
3 = 85·189856	3 = 1·703796	3 = 13·630374
4 = 113·586448	4 = 2·271728	4 = 18·173832
5 = 141·983060	5 = 2·839660	5 = 22·717290
6 = 170·379672	6 = 3·407592	6 = 27·270748
7 = 198·776284	7 = 3·975524	7 = 31·804206
8 = 227·172896	8 = 4·543456	8 = 36·347664
9 = 255·569608	9 = 5·111388	9 = 40·891122

METRICAL TO BRITISH.		
Grammes to Grains.	Kilogrammes to Ounces.	Kilogrammes to Pounds.
1 = 15·4323488	1 = 35·27394	1 = 2·20462
2 = 30·8646976	2 = 70·54788	2 = 4·40924
3 = 46·2970464	3 = 105·82182	3 = 6·61386
4 = 61·7293952	4 = 141·09576	4 = 8·81848
5 = 77·1617440	5 = 176·36970	5 = 11·02310
6 = 92·5940928	6 = 211·64364	6 = 13·22772
7 = 108·0264416	7 = 246·91758	7 = 15·43234
8 = 123·4587904	8 = 282·19152	8 = 17·63696
9 = 138·8911392	9 = 317·46546	9 = 19·84158

Metrical and British Conversion Tables—*continued*

BRITISH TO METRICAL

Grains to Grammes.	Ounces to Grammes.	Pounds to Kilogrammes.
1 = 0·0647989	1 = 28·34954	1 = 0·45359265
2 = 0·1295978	2 = 56·69908	2 = 0 90718530
3 = 0·1943967	3 = 85·04862	3 = 1·36077795
4 = 0·2591956	4 = 113·39816	4 = 1·81437060
5 = 0·3239945	5 = 141·74770	5 = 2·26796325
6 = 0·3887934	6 = 170·09724	6 = 2·72155590
7 = 0·4535923	7 = 198·44678	7 = 3·17514855
8 = 0·5183912	8 = 226·79632	8 = 3·62874120
9 = 0·5831901	9 = 255·14586	9 = 4·08233385

METRICAL TO BRITISH

Square Centimetres to Square Inches.	Square Metres to Square Feet.	Square Metres to Square Yards.
1 = 0·1550059	1 = 10·7642993	1 = 1·1960333
2 = 0·3100118	2 = 21·5285987	2 = 2·3920665
3 = 0·4650177	3 = 32·2928980	3 = 3·5880998
4 = 0·6200236	4 = 43·0571974	4 = 4·7841330
5 = 0·7750296	5 = 53 8214967	5 = 5 9801663
6 = 0·9300355	6 = 64·5857960	6 = 7 1761995
7 = 1·0850414	7 = 75·3500954	7 = 8 3722328
8 = 1·2400473	8 = 86·1143947	8 = 9·5682631
9 = 1·3950532	9 = 96·8786941	9 = 10·7642993

BRITISH TO METRICAL

Square Inches to Square Centimetres.	Square Feet to Square Metres.	Square Yards to Square Metres.
1 = 6·451367	1 = 0·0928997	1 = 0·8360972
2 = 12·902734	2 = 0·1857994	2 = 1·6721943
3 = 19·354101	3 = 0·2786990	3 = 2·5082915
4 = 25·805468	4 = 0·3715987	4 = 3 3443887
5 = 32·256835	5 = 0·4644984	5 = 4·1804858
6 = 38·708202	6 = 0·5573981	6 = 5·0165829
7 = 45·159569	7 = 0·6502977	7 = 5 8526801
8 = 51·610936	8 = 0·7431974	8 = 6·6887773
9 = 58·062303	9 = 0·8360971	9 = 7·5248744

MENSURATION OF SURFACES AND SOLIDS

The circumference of a circle=diameter × $\frac{22}{7}$ (or 3·1416) ; **area of** circle=square of the diameter × 0·7854.

Area of sector of circle=length of arc × $\frac{1}{2}$ radius.

Area of segment of circle=area of sector less area of triangle.

The area of a square, rhombus or rhomboid=base × height.

The area of a triangle=$\frac{1}{2}$ base × perpendicular height.

Area of equilateral triangle=square of side × 0·433.

Area of trapezium=$\frac{1}{2}$ sum of two parallel sides × height.

Area of any right-lined figure of four or more unequal sides is **found** by dividing it into triangles, finding area of each and adding together.

For any regular polygon, inscribe a circle ; then $\frac{1}{2}$ **radius of that** circle × length of one side × number of sides=area.

The area of a parabola=base × height × $\frac{2}{3}$.

The area of an ellipse=long axis × short axis × 0·7854.

Surface and cubic content of prism or cylinder—1st (area of **two** ends)+(length × perimeter)=surface ; 2nd, area of base × height= content.

For a cone or pyramid—1st, $\frac{1}{2}$ (slant height × perimeter of **base**)+ area of base surface=surface ; 2nd, $\frac{1}{3}$ (area of base × perpendicular height)=content.

For a cube or parallelepipedon—1st, sum of areas of all the sides= surface ; 2nd, length × breadth × depth=content.

For a sphere—1st, square of diameter × 3·1416=surface ; 2nd, cube of diameter × 0·5236=content.

Volume of hexagonal prism=square of side × 2·598 × height.

Volume of ring (circular section)=mean diameter of ring × 2·47 × square of diameter of section.

Side of square of area equal circle=diameter × 0·8862.

Diameter of circle equal in area to square=side × 1·1284.

Side of square inscribed in circle=diameter of circle × 0·707.

Diameter of circle circumscribing square=side of square × 1·414.

CONVERSION FACTORS

1 pound (Troy) - - -	=1·2153 pound (Avoirdupois).
1 pound (Avoirdupois) -	=0·8228 pound (Troy).
1 ton - - - -	=0·000447 pound (Avoirdupois).
1 square foot - - -	=0·00694 square inch.
1 cubic foot - - -	=0·000579 cubic inch.
1 pound per square inch -	=0·0703 kilos per square centimetre.
1 kilo per square centimetre	=14·223 pounds per square inch.
1 pound per cubic inch -	=27·679 grammes per cubic centimetre.

Conversion Factors—*continued*

1 kilo per cubic centimetre	$=36\cdot127$ pounds per cubic inch.
1 pound per cubic foot -	$=16\cdot018$ kilos per cubic metre.
1 kilo per cubic metre -	$=0\cdot0624$ pound per cubic foot.
1 grain per gallon - -	$=0\cdot01426$ gramme per litre.
1 gramme per litre - -	$=70\cdot12$ grains per gallon.
1 gramme per cubic centimetre	$=10\cdot022$ pounds per gallon.
1 pound per gallon - -	$=0\cdot09983$ kilo per litre.
1 kilo per litre - - -	$=10\cdot438$ pounds per gallon.
1 grain per inch -	$=0\cdot0255$ gramme per centimetre.
,, ,, - -	$=0\cdot00514$ pound per yard.
1 gramme per centimetre -	$=39\cdot198$ grains per inch.
,, ,, -	$=0\cdot2016$ pound per yard.
1 dwt. per yard - - -	$=1\cdot7$ grammes per metre.
1 gramme per metre - -	$=0\cdot5878$ dwt. per yard.
1 pound per inch -	$=178\cdot579$ grammes per centimetre.
1 gramme per centimetre -	$=0\cdot005599$ pound per inch.
1 pound per foot - -	$=583\cdot33$ grains per inch.
,, ,, -	$=14\cdot8816$ grammes per centimetre.
1 grain per inch - -	$=0\cdot001714$ pound per foot.
1 pound per yard - -	$=194\cdot444$ grains per inch.
,, ,, - -	$=4\cdot96054$ grammes per centimetre.
1 kilo per metre - -	$=391\cdot983$ grains per inch.
,, ,, - -	$=2\cdot016$ pounds per yard.
1 oz. per square yard - -	$=33\cdot905$ grammes per square metre.
1 grain per square metre -	$=0\cdot02949$ oz. per square yard.
1 penny per foot - -	$=1\cdot70$ francs per metre.
,, ,, - -	$=0\cdot28$ mark per metre.
,, ,, - -	$=2\cdot03$ cents per foot.
1 cent per metre - -	$=0\cdot4508$ penny per yard.
1 penny per yard - -	$=2\cdot218$ cents per metre.
1 franc per metre - -	$=1\cdot767$ pence per yard.
,, ,, - -	$=1\cdot63$ marks per metre.
,, ,, - -	$=1\cdot19$ cents per foot.
1 mark per metre - -	$=3\cdot57$ pence per foot.
,, ,, - -	$=6\cdot07$ francs per metre.
,, ,, - -	$=7\cdot26$ cents per foot.
1 penny per square yard -	$=2\cdot428$ cents per square metre.
1 cent per square metre -	$=0\cdot4118$ penny per square yard.
1 penny per ounce - -	$=18\cdot26$ francs per kilo.
,, ,, - -	$=3\cdot00$ marks per kilo.

Conversion Factors—*continued*

1 shilling per pound	- = 13·7 francs per kilo.
,, ,,	- = 2·25 marks per kilo.
,. ,,	- = 1·52 cents per ounce.
1 franc per kilo	- = 0·073 shilling per pound.
,, ,,	- = 0·163 mark per kilo.
,. ,,	- = 1·76 cents per pound.
1 mark per kilo	- = 0·444 shilling per pound.
,, ,,	- = 6·20 francs per kilo.
,, ,,	- = 0·675 cent per ounce.
1 shilling per ton	- = 6·21 francs per metric ton.
,, ,,	- = 1·005 marks per metric ton.
,, ,,	- = 0·243 dollar per ton.
1 franc per metric ton	- = 0·162 shilling per ton.
,, ,,	- = 0·163 mark per metric ton.
,, ,,	- = 0·04 dollar per ton.
1 mark per metric ton	- = 0·994 shilling per ton.
,, ,,	- = 6·20 francs per metric ton.
,, ,,	- = 0·242 dollar per ton.
1 penny per gallon	- = 1·687 cents per U.S. gallon.
,, ,,	- = 0·114 franc per litre.
1 shilling per gallon	- = 0·2025 dollar per U.S. gallon.
,, ,,	- = 1·37 francs per litre.

DECIMAL EQUIVALENTS OF FRACTIONS

Fractions.	Decimals.	Fractions.	Decimals.	Fractions.	Decimals.	Fractions.	Decimals.
1-64	·015625	17-64	·265625	33-64	·515625	49-64	·765625
1-32	·03125	9-32	·28125	17-32	·53125	25-32	·78125
3-64	·046875	19-64	·296875	35-64	·546875	51-64	·796875
1-16	·0625	5-16	·3125	9-16	·5625	13-16	·8125
5-64	·078125	21-64	·328125	37-64	·578125	53-64	·828125
3-32	·09375	11-32	·34375	19-32	·59375	27-32	·84375
7-64	·109375	23-64	·359375	39-64	·609375	55-64	·859375
1-8	·125	3-8	·375	5-8	·625	7-8	·875
9-64	·140625	25-64	·390625	41-64	·640625	57-64	·890625
5-32	·15625	13-32	·40625	21-32	·65625	29-32	·90625
11-64	·171875	27-64	·421875	43-64	·671875	59-64	·921875
3-16	·1875	7-16	·4375	11-16	·6875	15-16	·9375
13-64	·203125	29-64	·453125	45-64	·702125	61-64	·953125
7-32	·21875	15-32	·46875	23-32	·71875	31-32	·96875
15-64	·234375	31-64	·484375	47-64	·734375	63-64	·984375
1-4	·25	1-2	·5	3-4	·75	1	1·0

RECENT TEXTILE INVENTIONS

On different occasions we have been requested by readers to compile a list of the most notable inventions of each year. Such a task is hedged with many difficulties. Patents vary greatly. Some are simple and some are extraordinarily complicated. Very many are abandoned, and many undergo extended practical trials before they are introduced to the public. Nearly all which attain a practical measure of success, or a promise of same, come before our notice, and we have therefore compiled a list of current textile inventions from the pages of the *Textile Manufacturer*. The list has been divided into five sections—spinning; winding, warping, and reeling; weaving; dyeing, drying, and finishing; and miscellaneous—and entries are given in the order of date. The list extends from November 1929 up to October 1930. At the end of each reference we give the page number and date of the issue of the *Textile Manufacturer* in which a full description appears, and if further information is required in respect of any machine or appliance, it can be obtained on request from the maker.

SPINNING PROCESSES AND APPLIANCES

Cotton Opening Machinery Control.—PLATT BROTHERS & CO. LTD., OLDHAM.—The trend of development in cotton opening, cleaning, and blending machinery is towards greater effectiveness in opening and cleaning, with more gentle treatment—as by less beating --and greater regularity. Developments in these particulars are leading to the possibility in some cases of single ranges of machines making laps to go direct to the card. More cotton of " outside growths " is being used, and even apart from this high density bales come forward more frequently. As regards regularity, a timing motion has been applied to the full range, which is considered in three groups which are automatically started and stopped in sequence. The arrangement avoids the irregularity previously caused by excess material accumulating on the cages of the lap forming part during and after stoppage for doffing. An example of a full sequence of machines for laps to go direct to the card is : creeper lattice, hopper bale opener, patent hopper opener, hopper feeder, patent lattice feeder with Shirley cage, Crighton opener, grid dust

trunk, patent condenser, hopper feeder with patent reserve feed box, patent double cylinder opener with lap forming part. Production is **350 to 400** lbs. per hour. (*T.M., July* 1930, *p.* 251.)

" **One-Process** " **Cotton Opening and Cleaning.**—LORD BROTHERS & CO. (incorporated in Brooks & Doxey Ltd., Manchester). —The " one-process " system of cotton opening and cleaning machinery reduces labour cost by avoiding the necessity for operative, attention at any point by the introduction of automatic control, in the present case either by the customary swing-board motions, or by an improved type of electro-magnetic system. A main feature of a range proposed for one-process lapping is that a single initial combination, *e.g.*, bale opener, hopper feeder, patent opener and cleaner, double Crighton opener, delivers by Vibro-pneumatic dust trunks automatically to two hoppers feeding two single-beater scutchers. (*T.M., Oct.* 1930, *p.* 365.)

A New Model Bale Opener.—TWEEDALES & SMALLEYS (1920) LTD., CASTLETON.—A new improved model, the No. 3 bale opener, has a lower inclination of lattice, bigger cotton chamber, higher delivery end, and an evener lattice is fitted as standard instead of an evener roller, together with other alterations in constructional details and dimensions. (*T.M., Oct.* 1930, *p.* 366.)

Spiked Cylinder Hopper Bale Opener.—HOWARD & BULLOUGH LTD., ACCRINGTON.—A new No. 8 hopper bale opener designed for dealing with very hard matted bales has two spiked all-metal barrels instead of the usual inclined spiked lattice. The lower 12-in. diameter roller has a surface speed of about 110 ft. per min. and delivers to a 27-in. diameter roller of surface speed 81 ft. per min. (*T.M., Oct.* 1930, *p.* 371.)

The Shirley High-Speed Dust Cage.—PLATT BROTHERS & CO. LTD., and HOWARD & BULLOUGH LTD.—For extracting dust from cotton, giving healthier atmospheric conditions in the card-room and a cleaner and brighter yarn, a perforated cage having a speed of about 100 r.p.m. is combined with opening and scutching machines. A light film of cotton is deposited on the cage by suction, and drawn off with a fresh supply of clean air. (*T.M., July* 1930, *p.* 251.)

Shedding and Opening Machine.—P. & C. GARNETT LTD., CLECKHEATON.—A machine for shredding and opening wastes, bagging, clippings, etc., comprises feed rollers, licker-in covered with pinned lags and fitted with clearer roller, under licker-in and under worker, all covered with strong Garnett wire. The cylinder

is clothed with cast-steel Garnett wire with five workers, undergrate, and plain roller under the cylinder. The doffer has staple teeth or Garnett wire. Taking-off is by strong comb or small diameter rollers. (*T.M·*, *Jan.* 1930, *p.* 19.)

Hopper Feed to Self-Acting Willow.—BROOKS & DOXEY (1920) LTD., WEST GORTON, MANCHESTER.—The attachment of a hopper feeder to a self-acting willow avoids the necessity for hand feeding of willows and allows a more even feed. At the delivery, part of the hopper material accumulates in a reserve box, surplus being returned. The delivery roller is operated intermittently from the willow. (*T.M.*, *Jan.* 1930, *p.* 17.)

Ramsdell Automatic Doffing of Laps on Cotton Openers and Scutchers.—Mechanism for automatically doffing the laps on cotton openers and scutchers, without stopping the machine, has been designed by the H. & B. American Machine Co. The arrangement reduces the labour required, and leads to better regularity, higher production, and less strain on the machines. (*T.M.*, *Aug.* 1930, *p.* 292.)

Improved Mixed Carding Engine.—DOBSON & BARLOW LTD., BOLTON. —A carding engine, which has two pairs of rollers and strippers and 75 revolving flats, is used on low-grade cottons, mixtures, and wastes. The rollers and strippers have metallic card clothing so that grinding and stripping of these rollers is unnecessary. (*T.M.*, *Sept.* 1930, *p.* 329.)

Wool Opening, Cleaning. and Blending.—THE TEXTILE CONVEYOR CO. LTD., BRADFORD.—A machine for opening, cleaning, and mixing wool and other fibres has a constant feed and delivery, instead of the usual intermittent and irregular motion. (*T.M.*, *Dec.* 1929, *p.* 432.)

Motor Chain Drive of Flat Cards.—HOWARD & BULLOUGH LTD., ACCRINGTON.—Alterations of drive are necessary in flat cards for the periodical stripping and grinding, and require special consideration in fitting the card with individual motor drive. In this arrangement the motor can be reversed in direction of rotation, and is coupled by a centrifugal clutch to a chain drive, and there is a clutch on the cylinder shaft. The arrangement gives convenient control of speeds, directions, and starting-up, and a narrower machine. (*T.M.*, *Nov.* 1929, *p.* 392.)

Card Cylinder Undercasings.—PLATT BROTHERS & CO. LTD., OLDHAM.—A new arrangement of card cylinder undercasing joint

connects the two segments by a combined overlap and knuckle joint. Both sides are also supported by adjusting brackets. A perfect hinge without gap or possibility of getting out of order is thus obtained. (*T.M.*, *May* 1930, *p.* 175.)

Shirley Cotton Flat Card.—PLATT BROTHERS & CO. LTD., OLDHAM.—A card which has been exhaustively tested to indicate that similar results are obtained has only 48 flats instead of 106. The taker-in is placed well above the horizontal line of the main cylinder, and diameters of cylinder and doffer are only 40 and 20 in. The whole machine is smaller and more compact. (*T.M.*, *Feb.* 1930, *p.* 60.)

Anti-ballooning on Flyer Frames.—DOBSON & BARLOW LTD., BOLTON.—On cotton flyer frames the roving is carried round, and thus vibrated as the hole in the side of the flyer rotates. By fitting a pin horizontally and centrally through the flyer top the roving is guided always on the central axis and uneven stretching is avoided. (*T.M.*, *July* 1930, *p.* 256.)

" Primus " Worsted Drawing Machinery.—PRINCE, SMITH, & SON LTD., KEIGHLEY.—A redesigned range of drawing boxes, finishers, reducers, and rovers incorporates many detail improvements as regards frames, safety guards, drive, and change gear. The carrier rollers are driven by sprocket wheels from sliding chains. Grease-gun lubrication is adopted for low front rollers. Drawing boxes have a safety spindle top bracket. Front rollers on finishers, reducers, and rovers are drawn together by adaptable spring pressure, and upper half or full bearings may be provided above the flyers. (*T.M.*, *May* 1930, *p.* 173.)

Improvements on Worsted Spinning and Drawing Frames.—HALL & STELLS LTD., KEIGHLEY.—The " Eclipse " spindle is fitted with self-lubricating footstep bearing, intermediate ball-bearing, and top patent ball-bearing steadier. These save power and lubricating attention and increase speeds. A simple " Constant " oiler mechanically lubricates low front rollers. Additional diagonal fluting on rollers allows less weighting, and results in more even draught, particularly with cross-bred and long wools. (*T.M.*, *June* 1930, *p.* 211.)

Intersecting Gill Boxes.—HALL & STELLS LTD., KEIGHLEY.—Intersecting gill boxes are of special interest in the use of tops including shorter fibres, in which at present there is much experimenting. The intersecting gill boxes are now being made on the Bradford

type of frame. Special cleaners are fitted, and the whole of the upper portion of the heads can be lifted on strong hinges.

A Special Cap Spinning Frame.—HALL & STELLS LTD., KEIGHLEY.—A special cap spinning frame is suitable for dry-combed, fine, short wools about 30's to 80's worsted to compete with mule-spun yarns. The roller stand is at an angle of $47\frac{1}{2}°$, and has five rows of fluted bottom rollers. The spindles are tape driven. (*T.M.*, *May* 1930, *p.* 170.)

Hartman Combined Drafting Ring Frame.—In addition to the elimination of one or more flyer frame process by using high drafting, it has also been recently suggested that two or even one process of drawing is sufficient. A further alternative has been proposed in using drawing frame sliver directly in a special ring frame having two sets of drawing rollers combined, the second with Casa-blancas high draft. A draft up to 200 is thereby obtained. The drawing frame sliver is condensed between " rubbing " leathers, and formed into cross-wound packages for the ring frame creel. (*T.M.*, *Feb.* 1930, *p.* 64.)

Mule Roller-Delivery Motion.—ASA LEES & CO. LTD., OLDHAM. —The click wheel used to give a small delivery, whilst twisting at the head is modified so that when running free for normal work the six pawls used are kept clear by their own centrifugal force. The arrangement gives better accuracy and less wear, and the arrangement can be more easily removed. (*T.M.*, *Mar.* 1930, *p.* 101.)

Riley Ring Spinning Frame.—A ring frame spinning a mule-wound type of cop on a bare spindle uses a " bar " traveller hinged with a stop so that it can lie against the ring but can only approach the centre at a certain distance. (*T.M.*, *July* 1930, *p.* 253.)

High-Speed Rayon Spinning Spindles.—DOBSON & BARLOW LTD., BOLTON.—Higher spindle speeds of rayon spinning-pots may allow corresponding higher production, particularly with cuprammonium and acetate and higher twisted viscose yarns. A new design of spindle and motor renders practicable speeds of 8000 to 10,000 r.p.m. (*T.M.*, *Jan.* 1930, *p.* 23.)

Processing Viscose after Spinning.—A tendency in rayon manufacture is to wash, desulphurise, bleach, soak, dye, and dry in package form, and without reeling the cakes or bobbins of spun yarn into skeins. (*T.M.*, *April* and *July* 1930, *p.* 259.)

WINDING, WARPING, REELING, ETC.

" J. S. " High-speed Cone Drum Winder.—JOSEPH STUBBS LTD., ANCOATS, MANCHESTER.—The " J. S." high-speed cone winder builds a cone of increasing taper with saucer-shaped convex base and concave nose, with " open " wind without figuring. The traverse is individual, and each drum is fitted with a stop motion. The speed is up to about 600 yds. per min. (*T.M., Mar.* 1930, *p.* 97.)

Schlafhorst Rayon Winding Machine.—H. OSTHEIDE, LITTLE NEVILLE STREET, LEEDS.—The W.K. frame uses a double-spring spindle which is not taken out of the machine. The T-pattern splicer bobbin winder varies the speed according to the winding on diameter of the bobbin and the drive is positive. (*T.M., April* 1930, *p.* 134.)

High-Speed Winding and Warping.—THOMAS HOLT LTD., ROCHDALE.—One method of high-speed winding and warping uses the M. or M.2 Foster increasing-taper cone winder with a suitable beaming creel single or magazine. An alternative system uses bottle bobbins, and in the beaming frame the central bank of the creel may be withdrawn and another with a new set substituted, or a V-shaped magazine creel may be used. The tension is taken off the beam whilst running, being used only in stopping and starting. (*T.M., Jan.* 1930, *p.* 20.)

Conical Drum Winder for Jute, etc.—R. BROADBENT & SON LTD., STALYBRIDGE.—A conical drum winder is designed for large packages 12 in. long, and carrying 18 to 20 lbs. of jute or similar yarn.

I. T. Cone Drum Winder.—R. BROADBENT & SON LTD., STALY-BRIDGE.—A cone drum winder winds cones with increasing taper, a patent spool carriage altering the inclination as the package builds up with greater incline under the influence of the eccentricity of the cam.

Rayon Winding and Warping.—UNIVERSAL WINDING CO., SAVILLE STREET, OXFORD ROAD, MANCHESTER.—There is stated to be a growing practice of winding direct from hank to cones and pirns on No. 50 and No. 90 " Leesona " machines. Cones are also being used as an endless rayon warping supply

in a magazine creel as in cotton beaming. (*T.M.*, *Feb*. 1930, *p*. 57.)

Rail Weavers' Knotter.—MELLOR, BROMLEY, & CO. LTD., LEICESTER.—The Boyce weavers' knotter has been adapted to a carriage fitted with ball bearings to run on a rail attached to a winding frame. (*T.M.*, *May* 1930, *p*. 174.)

Improved Bobbins.—WILSON & CO. (BARNSLEY) LTD., BARNSLEY. —A new type of shield for bobbin tips and bases has a locking arrangement in which the internal edge is embedded in the wood and combined with external corrugations. (*T.M.*, *Dec*. 1929, *p*. 430.)

" L " Drive No. 5 Winding Machine.—UNIVERSAL WINDING CO., MANCHESTER.—A slow-start mechanism, particularly useful in winding rayon direct from hanks, comprises a belt which is brought into driving contact with any of the spindle pulleys by an auxiliary pulley operated in conjunction with the starting handle. (*T.M.*, *Oct*. 1930, *p*. 367.)

Mechanical Yarn Inspection.—UNIVERSAL WINDING CO., MANCHESTER.—The " Leesona " gate slub catcher consists of right and left hand blades pivoted between the projecting ears of a slub catch holder. It can be adjusted. This and other mechanical inspection improves the quality and allows increased production at later processes. (*T.M.*, *Aug*. 1930, *p*. 289.)

A Selvedge Bobbin Warping Machine.—HARRISON PATENT MACHINE CO. LTD., MANCHESTER.—Better control of selvedges is obtained when the yarn is separately wound, and a convenient simple machine for winding two selvedge bobbins has been designed. (*T.M.*, *Aug*. 1930, *p*. 291.)

Hank Measuring Stop Motion for Rayon Reel.—DOBSON & BARLOW LTD., BOLTON.—A hank-length measuring motion eliminates the necessity of changing wheels. The reel is stopped when a spring plunger enters a slot in the rim of a compound disc. By altering the position of the discs, slots in each coincide at places which represent different lengths. (*T.M.*, *Sept*. 1930, *p*. 33.)

Rayon Sizing Temperature Control.—TEXTILE ACCESSORIES LTD., 22 PARSONAGE, MANCHESTER.—The " Johnson " rayon warp sizer may be fitted with automatic temperature control. The squeezing rollers are now designed with a high-pressure control which is adjustable by one handwheel. (*T.M.*, *Sept*. 1930, *p*. 333.)

WEAVING MACHINERY AND APPLIANCES

Platt-Toyoda Automatic Loom.—PLATT BROTHERS & CO. LTD., OLDHAM.—Automatic looms are growing in favour in the Lancashire industry. The Platt-Toyoda is a shuttle-changing automatic, loose-reed loom in which there is no stop for weft replenishment, and which runs at a high speed. (*T.M., Jan.* 1930, *p.* 18.)

Valentin Automatic Weft Replenishing Attachment.—C. VALENTIN, STUTTGART.—A weft replenishing motion for attachment to new or existing fast or loose reed ordinary looms has a curved battery, electric feeler, or electric weft-fork control. (*T.M., Feb.* 1930, *p.* 67.)

Silk or Rayon Looms.—ROBERT HALL & SONS, BURY.—A new model silk or rayon loom has separate beam stand, adjustable breast roller, modified side-lever underpick, extra shuttle-checking swells, controlled two-box motion, and special finish of all contacting parts, etc. (*T.M., July* 1930, *p.* 254.)

Electric Heald Warp Stop Motion.—E. TH. WAGNER, CHEMNITZ.—An electric heald warp stop motion requires no additional control of the yarn. When a warp end breaks, electrical contact is made with the top bar of the shaft, and the circuit is completed when the shaft has reached a certain position, thus stopping the loom. (*T.M., Feb.* 1930, *p.* 67.)

A Double-lift Selvedge Jacquard.—J. T. HARDAKER LTD., BRADFORD.—A double-lift jacquard controls 16 mails at each selvedge. An endless band of paper is used for pattern purposes. (*T.M., April* 1930, *p.* 135.)

Shuttle for Large Cops.—The most important present controversy in weaving concerns systems of more looms per weaver. One factor required is less labour for the weaver in weft replenishment, and to obtain this the use of large cops is desirable, but without introducing other limitations. A new shuttle is designed to be of the same external size, but to hold a cop having almost double the length of weft. (*T.M., Mar.* 1930, *p.* 102.)

Technical Developments in Cotton Weaving.—SCHÄRER-NUSSBAUMER & CO., ZÜRICH.—To allow a weaver to attend more looms, weft may be rewound and the pirns may have also a reserve bunch wound at the commencement and the looms be fitted with

weft feelers. Machines have been designed for this purpose. (*T.M.*, *Oct*. 1930, *p*. 371.)

A Constant-Tension Warp Let-off.—JOHN T. MURRAY, 4 WATER STREET, MANCHESTER.—In a warp let-off arrangement the beam is fitted with a chain wheel and endless chain on which is suspended a chain wheel and pulley provided with a band brake. The brake is eased when the arrangement is drawn up against a stop, and the device then slips down the chain. (*T.M.*, *July* and *August* 1930, *pp*. 225 and 291.)

Improved Two-Shuttle Box Loom.—HENRY LIVESEY LTD., BLACKBURN.—A two-shuttle box motion is operated by a sector wheel of the interrupted gear type, which drives an eccentric controlling the box motion. The sector wheel and pinion may be put out of gear by a handwheel or by operation from the dobby. (*T.M.*, *Sept*. 1930, *p*. 332.)

The Adolff Bobbin Stripper.—A. HILL & CO. LTD., 17A LLOYD STREET, MANCHESTER.—In a bobbin stripper machine for automatic-loom bobbins the stripping jaws are controlled by guide templates corresponding to the bobbin profile, and can remove even small traces of yarn without damage to the bobbin. (*T.M.*, *Sept*. 1930, 335.)

A Weft-Feeler Motion.—BRITISH NORTHROP CO. LTD.—A simple mechanical feeler of the " Midget " type is controlled by a spring which allows a forward movement when the feeler is in contact with the bobbin, whilst this movement brings the pull of the spring behind the fulcrum so that a side-slip movement is also caused in the absence of yarn and the indication given for weft replenishment or for stopping the loom. (*T.M.*, *Sept*. 1930, *p*. 335.)

The Gripper Loom for Axminster Carpets.—DAVID CRABTREE & SON LTD., BRADFORD.—In the gripper loom for Royal Axminster and similar carpet, the selection of eight to sixteen colours is made by a jacquard, and the gripper takes the selected yarn, which is cut and inserted into the carpet. The method allows smaller scale production and compares favourably in other respects with other systems of carpet manufacture.

The structure is economical and is very near to the simplicity of the oriental hand-knotted carpet.

Wide seamless carpets may be woven. (*T.M.*, *Nov*. 1930, *p*. 406.)

38

DYEING, FINISHING, DRYING MACHINERY

Saree Printing Machines.—MATHER & PLATT LTD., MAN-CHESTER.—A saree or cross border printing machine allows any length of saree to be printed up to 16 yds. or more in intervals of ¼ yd. The machine is a six-nip machine, allowing jumping of heading and filling rollers. (*T.M., June* 1930, *p.* 212.)

The Simcoe Static Eliminator.—TEXTILE ACCESSORIES LTD., 22 PARSONAGE, MANCHESTER.—An apparatus for removing static electricity from yarns and fabrics, particularly of rayon, consists of wire points charged by high tension alternating current. (*T.M., April* 1930, *p.* 133.)

Warp-Knitted and Rayon Fabric Stentering Machine.—C. G. HANBOLD A.G., CHEMNITZ.—A machine for stretching warp-knitted or rayon fabrics allows a considerable reduction of labour, as these fabrics are usually treated on hand-stretching frames. (*T.M., Feb.* 1930, *p.* 58.)

The Ripple Washing Machine.—MATHER & PLATT LTD., MANCHESTER.—The " Ripple " washing machine for delicate fabrics such as crêpes, marocains, voiles, rayon goods, etc., consists of an endless phosphor-bronze wire gauze apron on which the fabric falls in ripples, and is washed by spray pipes on the countercurrent principle.

Fabric Guider Improvements.—G. DURRANT & SON, BURY STREET, STOCKPORT.—Fabric selvedge roller heads are controlled for width position by attachment to an endless chain instead of by mounting on a right and left hand screw as before. The operative wheel is more conveniently placed, and the arrangement more suitable for non-stop high-speed work. The position of either head can be easily set. (*T.M., Oct.* 1930, *p.* 368.)

Automatic Selvedge Printing.—DANIEL FOXWELL & SONS, CHEADLE, MANCHESTER.—A selvedge printing machine prints clear and neat designs or names at intervals of every yard, metre, or fractions. The rollers, printing dies, and inking rollers are all mechanically driven at the cloth speed. (*T.M., p.* 197, *June* 1929.)

POWER AND MISCELLANEOUS

Reducing Pressure Turbines.—METROPOLITAN VICKERS ELECTRICAL CO. LTD.—Many reducing-pressure turbine plants have been installed for economical production of power and electricity

in textile mills where process steam is used. (*T.M.*, *Sept.* 1929 and *Sept.* 1930.)

A Carpet Mill Power and Steam Plant.—BELLISS & MORCOM LTD., BIRMINGHAM.—A pass-out turbine in which a steady pressure is maintained in each pass-out branch results in many cases in considerable economy. (*T.M.*, *May* 1930, *p.* 180.)

Turbine Smoke-Preventing Baffle Bridge.—TURBINE FURNACE CO. LTD.—It is stated that it is impossible for dust to lodge in a new hollow perforated baffle bridge for smoke preventing in Lancashire boilers. (*T.M.*, *Feb.* 1930, *p.* 396.)

A Super Lancashire Boiler.—DANIEL ADAMSON & CO. LTD., DUKINFIELD.—A more compact and efficient type of modified Lancashire boiler has nests of tubes through which the flue gases return to the front from the downtake chamber, and go thence through tubes of an air preheater at the side. (*T.M.*, *Aug.* 1930, *p.* 298.)

The Removal of Dust and Fog in Textile Mills.—TEXTILE ILLUMINATING & ENGINEERING CO. LTD.—Fabric filter and diffuser tubes are used with fans to give an internal air circulation in cotton card-rooms, and the like to free the dust from air and fluff. The tubes may also be used as air and fog filters in air conditioning plants. (*T.M.*, *Oct.* 1930, *p.* 372.)

Lighting of Textile Mills.—Many inefficient lighting systems in textile mills are being replaced, principally by well-placed B.E.S.A. standard dispersive reflectors with pearl, opal, or bowl frosted lamps to give a suitable intensity of illumination throughout. (*T.M.*, *May* 1930, *p.* 178.)

Short Centre Endless V-Rope Machine Drives.—CROFTS (ENGINEERS) LTD., BRADFORD.—Endless V-rope drives made of cord fabric embedded in rubber avoid difficulties of short centre drives and give a silent drive, allowing ready change of machine speed. (*T.M.*, *Mar.* 1930, *p.* 102.)

DIARY

AND

MEMORANDA

FOR

1931

January 1931

1st JANUARY, Thursday—Bank Holiday in Scotland

2nd Friday

3rd Saturday

4th Sunday

January 1931

5th Monday

6th Tuesday

7th Wednesday

8th Thursday

9th Friday

10th Saturday

11th Sunday

January 1931

12th Monday

13th Tuesday

14th Wednesday

15th Thursday

16th Friday

17th Saturday

18th Sunday

January 1931

19th Monday

20th Tuesday

21st Wednesday

22nd Thursday

23rd Friday

24th Saturday

25th Sunday

26th Monday

27th Tuesday

28th Wednesday

29th Thursday

30th Friday

31st Saturday

1st FEBRUARY Sunday

February 1931

2nd Monday

3rd Tuesday

4th Wednesday

5th Thursday

6th Friday

7th Saturday

8th Sunday

February 1931

9th Monday

10th Tuesday

11th Wednesday

12th Thursday

13th Friday

14th Saturday

15th Sunday

February 1931

16th Monday

17th Tuesday

18th Wednesday

19th Thursday

20th Friday

21st Saturday

22nd Sunday

февруари—March 1931

23rd Monday

24th Tuesday

25th Wednesday

26th Thursday

27th Friday

28th Saturday

1st MARCH Sunday

March 1931

2nd Monday

3rd Tuesday

4th Wednesday

5th Thursday

6th Friday

7th Saturday

8th Sunday

March 1931

9th Monday

10th Tuesday

11th Wednesday

12th Thursday

13th Friday

14th Saturday

15th Sunday

16th Monday

17th Tuesday

18th Wednesday

19th Thursday

20th Friday

21st Saturday

22nd Sunday

March 1931

23rd Monday

24th Tuesday

25th Wednesday

26th Thursday

27th Friday

28th Saturday

29th Sunday

30th Monday

31st Tuesday

1st APRIL Wednesday

2nd Thursday

3rd Friday—BANK HOLIDAY IN SCOTLAND

4th Saturday

5th Sunday

April 1931

6th Monday—BANK HOLIDAY

7th Tuesday

8th Wednesday

9th Thursday

10th Friday

11th Saturday

12th Sunday

April 1931

13th Monday

14th Tuesday

15th Wednesday

16th Thursday

17th Friday

18th Saturday

19th Sunday

April 1931

20th Monday

21st Tuesday

22nd Wednesday

23rd Thursday

24th Friday

25th Saturday

26th Sunday

April—May 1931

27th Monday

28th Tuesday

29th Wednesday

30th Thursday

1st MAY Friday

2nd Saturday

3rd Sunday

May 1931

4th Monday—BANK HOLIDAY IN SCOTLAND

5th Tuesday

6th Wednesday

7th Thursday

8th Friday

9th Saturday

10th Sunday

May 1931

11th Monday

12th Tuesday

13th Wednesday

14th Thursday

15th Friday

16th Saturday

17th Sunday

18th Monday

19th Tuesday

20th Wednesday

21st Thursday

22nd Friday

23rd Saturday

24th Sunday

May 1931

25th Monday – BANK HOLIDAY

26th Tuesday

27th Wednesday

28th Thursday

29th Friday

30th Saturday

31st Sunday

June 1931

1st JUNE Monday

2nd Tuesday

3rd Wednesday

4th Thursday

5th Friday

6th Saturday

7th Sunday

June 1931

8th Monday

9th Tuesday

10th Wednesday

11th Thursday

12th Friday

13th Saturday

14th Sunday

June 1931

15th Monday

16th Tuesday

17th Wednesday

18th Thursday

19th Friday

20th Saturday

21st Sunday

June 1931

22nd Monday

23rd Tuesday

24th Wednesday

25th Thursday

26th Friday

27th Saturday

28th Sunday

June—July 1931

29th Monday

30th Tuesday

1st JULY Wednesday

2nd Thursday

3rd Friday

4th Saturday

5th Sunday

July 1931

6th Monday

7th Tuesday

8th Wednesday

9th Thursday

10th Friday

11th Saturday

12th Sunday

July 1931

13th Monday

14th Tuesday

15th Wednesday

16th Thursday

17th Friday

18th Saturday

19th Sunday

July 1931

20th Monday

21st Tuesday

22nd Wednesday

23rd Thursday

24th Friday

25th Saturday

26th Sunday

27th Monday

28th Tuesday

29th Wednesday

30th Thursday

31st Friday

1st AUGUST Saturday

2nd Sunday

August 1931

3rd Monday—BANK HOLIDAY

4th Tuesday

5th Wednesday

6th Thursday

7th Friday

8th Saturday

9th Sunday

August 1931

10th Monday

11th Tuesday

12th Wednesday

13th Thursday

14th Friday

15th Saturday

16th Sunday

August 1931

17th Monday

18th Tuesday

19th Wednesday

20th Thursday

21st Friday

22nd Saturday

23rd Sunday

August 1931

24th Monday

25th Tuesday

26th Wednesday

27th Thursday

28th Friday

29th Saturday

30th Sunday

31st Monday

1st SEPTEMBER Tuesday

2nd Wednesday

3rd Thursday

4th Friday

5th Saturday

6th Sunday

September 1931

7th Monday

8th Tuesday

9th Wednesday

10th Thursday

11th Friday

12th Saturday

13th Sunday

September 1931

14th Monday

15th Tuesday

16th Wednesday

17th Thursday

18th Friday

19th Saturday

September 1931

21st Monday

22nd Tuesday

23rd Wednesday

24th Thursday

25th Friday

26th Saturday

27th Sunday

28th Monday

29th Tuesday

30th Wednesday

1st OCTOBER Thursday

2nd Friday

3rd Saturday

4th Sunday

October 1931

5th Monday

6th Tuesday

7th Wednesday

8th Thursday

9th Friday

10th Saturday

11th Sunday

October 1931

12th Monday

13th Tuesday

14th Wednesday

15th Thursday

16th Friday

17th Saturday

18th Sunday

October 1931

19th Monday

20th Tuesday

21st Wednesday

22nd Thursday

23rd Friday

24th Saturday

25th Sunday

October—November 1931

26th Monday

27th Tuesday

28th Wednesday

29th Thursday

30th Friday

31st Saturday

1st NOVEMBER Sunday

November 1931

2nd Monday

3rd Tuesday

4th Wednesday

5th Thursday

6th Friday

7th Saturday

8th Sunday

November 1931

9th Monday

10th Tuesday

11th Wednesday

12th Thursday

13th Friday

14th Saturday

15th Sunday

November 1931

16th Monday

17th Tuesday

18th Wednesday

19th Thursday

20th Friday

21st Saturday

22nd Sunday

23rd Monday

24th Tuesday

25th Wednesday

26th Thursday

27th Friday

28th Saturday

29th Sunday

30th Monday

1st DECEMBER Tuesday

2nd Wednesday

3rd Thursday

4th Friday

5th Saturday

6th Sunday

December 1931

7th Monday

8th Tuesday

9th Wednesday

10th Thursday

11th Friday

12th Saturday

13th Sunday

14th Monday

15th Tuesday

16th Wednesday

17th Thursday

18th Friday

19th Saturday

20th Sunday

December 1931

2■■Monday

22nd Tuesday

23rd Wednesday

24th Thursday

25th Friday—CHRISTMAS DAY

26th Saturday—BANK HOLIDAY

■■■unday

December 1931

28th Monday

29th Tuesday

30th Wednesday

31st Thursday

Memoranda

DATE OF ISSUE

This book must be returned within 3/7 days of its issue. A fine of ONE ANNA per will be charged if the book is overdue.

For Reference

NOT TO BE TAKEN FROM THIS ROOM.