DYEING AND CLEANING.

DYEING AND CLEANING:

A PRACTICAL HANDBOOK.

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FIFTH EDITION, ENTIRELY RE-WRITTEN

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PREFACE TO FIFTH EDITION.

MR. FARRELL'S work quickly established itself as the standard work on the subject, indispensable to those engaged in the Cleaning and Dyeing Industry, and four large editions were sold.

While thoroughly revising the whole book and bringing it up to date, I have thought it advisable to preserve the original "lay-out," which has proved so acceptable.

Many developments have taken place in all branches of the industry since the publication of the last edition, and these have been treated in their appropriate sections.

In Dry Cleaning, closed-circuit or continuous flow systems of cleaning and clarification are displacing batch methods. In Dyeing, machinery and processes are changing, so that the lighter and more delicate fabrics, including those made from rayon and cellulose acetate, can be handled better. In Finishing, the increased use of improved vacuum steam pressing machines for wearing apparel, is a noticeable feature. These and other matters will be found to be dealt with in detail in the text.

While tabular lists of Dyestuffs are given in the Dyeing section, unnecessary duplication of names has been largely avoided by making use of the numbers given in the "Colour Index" published by the Society of Dyers and Colourists.

F. W. W.

April 1929.

PREFACE.

In this book I have endeavoured to justify the sub-title " A Practical Handbook " ; I have, however, paid more attention to the general principles which govern the methods employed than to minute working details. The latter are superfluous to the practical man, and of little value to the beginner.

In the chapter devoted to Dyeing it has been found impracticable to mention more than a tithe of the colouring matters which are now available ; therefore only one or two series of dyestuffs have been given as prototypes.

I have avoided as far as possible detailed descriptions of substances or methods which are fully described in more general text-books on dyeing ; to those requiring further particulars the following brief bibliography may be useful :—

Plant, etc.
Davis, *A Handbook of Chemical Engineering.*

Technology of the Fibres.
Hannan, *A Dictionary of the Textile Fibres.*
Matthews, *The Textile Fibres.*

Petroleum.
Cooper-Key, Major A., *Storage of Petroleum.*
Thomson and Redwood, *Handbook on Petroleum* (Griffin).

Dyestuffs and Dyeing.
Cain and Thorpe, *The Synthetic Dyestuffs* (Griffin).
Dreaper, *Chemistry and Physics of Dyeing.*
Knecht, Rawson, and Loewenthal, *A Manual of Dyeing* (Griffin).
Rawson, Gardner, and Laycock, *A Dictionary of Dyestuffs* (Griffin).
Society of Dyers and Colourists, *Colour Index,* Edited by F. M. Rowe, D.Sc.

Dyeing and Cleaning.
Chaplet, A., *Dictionnaire de Détachage Textile* (L'Edition Textile, Paris).
Gouillon, *Manuel du Teinturier-Dégraisseur.*
Heywood & Co., Ltd., *Garment Dyeing and Cleaning.*

I wish to express my indebtedness to the following gentlemen for information or suggestions :—Sir Robert Pullar, M. Jolly (President of the Paris Syndicate of Dyers), J. Ollis, Esq. (Public Control Dept., L.C.C.), and F. E. Robertson, Esq. ; and I beg to thank Messrs C. W. May and F. E. Robertson for their help in the revision of the proofs.

<div style="text-align:right">F. J. F.</div>

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ABBREVIATIONS.

J.S.C.I.	Journal of the Society of Chemical Industry.
J.S.D.C.	Journal of the Society of Dyers and Colourists.
B.D.C.	Imperial Chemical Industries, Ltd.
C.A.C.	Clayton Aniline Co., Ltd., Manchester.
I.G.	I. G. Dyestuffs, Frankfort.
L.B.H.	L. B. Holliday & Co., Ltd., Huddersfield.
Gy.	J. R. Geigy, S.A., Basle.
S.	Sandoz Chemical Co., Ltd.

DYEING AND CLEANING.

TECHNOLOGY OF THE TEXTILE FIBRES.

THE fabrics submitted to the dyer and cleaner are manufactured from a considerable number of different types of fibres, and some knowledge of their chemical and physical properties is essential. The particulars which are given are condensed as much as possible, and those desiring further information are referred to the text-books devoted to this subject.

The textile fibres are usually divided, according to their origin, into vegetable fibres and animal fibres; to these might be added artificial fibres, but as all the artificial fibres in commerce are of vegetable origin, they will be considered under that classification. An exception is artificial silk manufactured from gelatine.[1] The vegetable fibres employed on the large scale are cotton, linen, China grass (*ramie*), jute, and hemp. Of these cotton is the most important, linen taking the second place. The animal fibres include wool, hair, and the different kinds of silk. Any or all of these fibres may be employed in the construction of a fabric; *e.g. satin* is made with a silk warp and a cotton weft. In some cases the individual threads may be composed of more than one kind of fibre; *e.g. Viyella* fabrics are woven from warp and weft threads containing wool and cotton spun together. The animal and vegetable fibres behave very differently towards acids, alkalies, and the other reagents employed in the processes of scouring, bleaching, and dyeing, and it may be taken as a general rule that the animal fibres are better able to withstand the action of acids, and the vegetable fibres to withstand alkalies.

1. VEGETABLE FIBRES.

Cotton.

The employment of cotton in the making of fabrics dates back to 450 B.C., and probably much earlier. Allusions to cotton

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[1] *Vanduara silk* does not appear to find extensive employment at the present time.

clothing are to be found in Herodotus (445 B.C.) ; a century later the Hindoos are referred to as wearing a fabric made from " *a stuff which grew upon trees*," and Pliny speaks of the Egyptians wearing cotton.   Raw cotton as it comes into the market consists of the hairy filaments which surround the seeds of various species of the cotton-plant (*Gossypium*), which belongs to the natural order of the *Malvaceæ* or mallow-worts.   The filaments attached to the seeds are enclosed in a capsule which, when ripe, bursts and exposes a ball of snowy-white down.   The cotton is collected as soon as possible after ripening, and after separation from the seeds by *ginning* it comes into the market.   There are several species of the cotton-plant, but the following four include those cultivated for commercial purposes :—

(1) *Gossypium Barbadense.*—This is the most valuable, producing the long-stapled Sea Island cotton.   The *Gossypium hirsutum*, from which the bulk of the United States cotton is raised, is supposed to be a variety of this species.   The true Sea Island bears a yellow flower, while that of the *hirsutum* is white or pale primrose.

(2) *Gossypium Peruvianum.*—This is indigenous to South America, flourishing in Peru, Brazil, and the adjoining countries. It has a yellow flower.

(3) *Gossypium herbaceum.*—This is a short, shrubby plant, bearing a yellow flower.   It is a native of Asia and furnishes the Madras, Surat, short-stapled Egyptian, and other short-stapled cottons.

(4) *Gossypium arboreum.*—This is a tree-like plant bearing a reddish flower, and is found in India and China.   It has a long and silky fibre, and yields nearly all the long-stapled varieties of Egyptian, Indian, and Chinese cottons.

Bowman defines the typical cotton fibre as a long, tubular, compound vegetable cell, from 1200 to 1500 times as long as it is broad.   Viewed under a microscope (fig. 1) it appears as a twisted ribbon, the spiral shape being due to the drying up of the sap originally contained in the ripe fibre.   The length of the fibre and its diameter vary considerably according to the origin, the following figures being given by Evan Leigh :—

Description of Cotton.	Length of Staple in inches.		Diameter of Fibre in inches.	
	Min.	Max.	Min.	Max.
New Orleans . .	0·88	1·16	0·000580	0·000970
Sea Island (long-stapled)	1·41	1·80	0·000460	0·000820
Brazilian . . .	1·03	1·31	0·000620	0·000960
Egyptian . . .	1·30	1·32	0·000590	0·000720
Indian . . .	0·77	1·02	0·000659	0·001040

As the fibre matures, the cell-wall becomes thicker and the fibre whiter, while the central cavity gradually enlarges; finally, the sap in the cavity is withdrawn, passing back to the seed, the twisting already referred to resulting. This twisting is one of the most valuable features of the cotton fibre, as it adapts it for spinning purposes and accounts for the elastic character of cotton as compared with linen fabrics.

Immature or *dead* fibres are almost transparent, have no central cavity, are flat and non-twisted, and are found in cloth in the form of knots or *neps*; in alizarin (Turkey Red), indigo, and other vat-dyed calico they show up as white specks.

Chemical Composition and Properties of Cotton.—Cotton, when freed from five or six natural impurities, consists almost entirely of *cellulose*, a substance found throughout the vegetable kingdom, forming (sometimes in a modified form) the ligneous or woody fibres of plants. Ultimate analysis shows that cellulose consists of carbon, hydrogen, and oxygen, its simplest formula being $C_6H_{10}O_5$. Cellulose in the pure condition is a white, translucent substance, with a density of nearly 1·5, and it is absolutely insoluble in water,

FIG. 1.—Cotton Fibres.

ether, alcohol, benzol, etc. When heated to 90°–100° C. it loses water and is slowly destroyed, several days' exposure at that temperature being necessary to bring about complete destruction of the fibre. If the heating to 100° C. is not prolonged, the cotton regains on exposure to air the water it has lost. Fort,[1] using a temperature-controlled flat-iron, has observed that the temperature for scorching of cotton is around 250° C. This has since been confirmed by Knecht.

Mercer was the first to observe that an ammoniacal solution of copper hydrate (*Schweitzer's reagent*) causes the fibre to swell up and slowly dissolve; it appears to pass into solution in the form of *oxy-cellulose*. From this solution a blue, hydrated com-
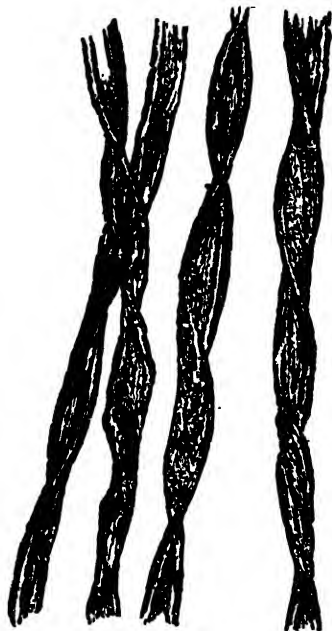
[1] *J.S.D.C.*, 1910, p. 185.

pound of copper oxide and cellulose may be precipitated by the addition of sugar, gum, common salt, etc.   Cotton fabrics immersed in the solution and dried are rendered waterproof (*Willesden canvas*, etc.).

Action of Acids.—Mineral acids have a more or less powerful action on cotton, depending upon the concentration of the acid, its temperature, and the duration of the action.

Sulphuric Acid.—Cold concentrated sulphuric acid rapidly destroys cotton ; a brief immersion causes the fibre to swell up, contract in length, become transparent, and to have an increased affinity for dyestuffs.   It is, however, difficult to avoid the destruction of the fibre.   With acid of a lower specific gravity the action is more under control.   *Vegetable parchment* is prepared by dipping unsized paper in cold sulphuric acid of 140° Tw. for a few seconds and rinsing in a plentiful supply of water.   With acid of 115° Tw. cotton becomes contracted (to a less extent than with concentrated sulphuric acid), is stiffened, and rendered more opaque ; it is also said then to have an increased affinity for basic dyestuffs ; treatment with acid of this density has been patented for the production of a fabric for *bookbinding cloth*.

By the continued action of strong sulphuric acid, cotton is converted into *dextrine* ; by dilution with water and boiling, this is further changed into *glucose* or *grape sugar*.

Nitric Acid.—Cotton is entirely decomposed by hot, strong nitric acid, the products of decomposition including *oxalic acid*. Cold nitric acid, or a mixture of strong sulphuric and nitric acids, does not alter the external appearance of cotton, but converts it into a series of *nitro-celluloses*, the degree of nitration depending upon the strength of the mixture of acids and the duration of their action.   The most highly nitrated product, represented in its simplest formula as $C_6H_7(NO_2)_3O_5$, is known as gun-cotton or *insoluble pyroxylin*.   A less nitrated product is known as *soluble pyroxylin* ; it is soluble in a mixture of ether and alcohol and in other solvents (toluene and wood spirit, acetone, etc.), its solution in ether and alcohol being known as *collodion*.   The lower nitrated celluloses are employed in the manufacture of *artificial silk* (*q.v.*).

Hydrochloric acid, when concentrated, disintegrates cotton. *Hydrofluoric acid*, if applied at a temperature below 60° C., has little or no tendering action and is useful as a safe medium for removing iron-mould.

Dilute mineral acids have little or no action on cotton in the cold ; if cotton is dried out of a dilute mineral acid solution the

acid becomes concentrated in the fibre, which becomes *tendered*. Tendering has been found to take place if the cotton contains more than 0·01 per cent. acid. Hence all cotton goods should be well washed after treatment with mineral acids. In calico-printing processes, in which mineral acids may be formed during steaming or drying, it is usual to employ a certain quantity of sodium acetate in the printing paste; this combines with the mineral acid, forming the sodium salt and liberating acetic acid, which has no destructive action on the fibre. This property can be made use of in *spotting* or stain-removing when mineral acids must be used.

Organic Acids.—Those in general use are acetic, citric, formic, lactic, oxalic, and tartaric acids. In solution they have no action on the fibre; when the fibre is dried direct from a solution of oxalic acid, tendering (with a 2 per cent. solution) or dis-integration (with a 10 per cent. solution) takes place. Acetic and formic acids under ordinary working conditions appear to have no action upon cotton.

The effect of dilute acids, mineral and organic, at 60° C. and 100° C. has been studied by Coward, Wood, and Barrett.[1] Bleached cotton was immersed in various acids of twice normal and normal strength respectively, and for periods of 1 minute, 15 minutes, and 60 minutes. The cotton was afterwards thoroughly rinsed and dried, and its strength tested by machine. The following table shows the results :—

TENDERING IN ACID AT 100° C.

Strength of Acid	Twice Normal Acid.			Normal Acid.		
Period of Immersion in Minutes	1	15	60	1	15	60
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrochloric acid	100	100	100	100	100	100
Sulphuric acid	22	100	100	34	100	100
Hydrofluoric acid	11	100	100	7	28	51
Acetic acid	0	15	15	4	9	18
Monochloracetic acid	3	35	100	17	23	39
Hydrochloric acid + salt	100	100	100	100	100	100

[1] *J. Text. Inst.*, 1923, p. 520.

TENDERING IN ACID AT 60° C.

Strength of Acid . .	Twice Normal Acid.			Normal Acid.		
Period of Immersion in Minutes . . .	1	15	60	1	15	60
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrochloric acid . .	16	45	100	7	25	52
Sulphuric acid . . .	9	16	66	14	18	25
Hydrofluoric acid . .	0	0	0	0	0	0
Acetic acid . . .	..	2	0	..	0	7
Monochloracetic acid .	0	7	12	..	..	0
Hydrochloric acid + salt .	5	61	100	0	13	50

It will be seen from these results that there is a marked difference between the tendering action at the higher and lower temperatures, this being very much less at the lower temperature. An interesting point is the action of hydrofluoric acid on cotton. At 60° C. no tendering occurs with this acid when used in the strengths indicated, and even at 100° C. the tendering action is small compared with that of hydrochloric acid for short periods. As *hydrofluoric acid* is an excellent solvent for iron oxide it is much safer as a *spotting agent* for removing iron-mould than hydrochloric acid. It should be stored in lead tubes or gutta-percha bottles on account of its solvent action on silica.

Action of Alkalies.—Mild alkalies, such as alkaline carbonates, soap, borax, sodium phosphate, etc., have no action upon cotton. Ammonia has no action at the ordinary temperature. Dilute caustic alkalies, in the absence of air, do not affect the fibre; in the presence of air even heated lime-water may produce tendering. John Mercer in 1844 discovered that concentrated solutions of caustic soda and caustic potash had a remarkable action upon cotton, causing the fibres to become contracted in length, thickened, and more transparent. No practical use of this process was made until about 1894, when it was employed in the production of *crepon* or *crimped effects*. These effects are obtained by printing the calico with a *gum* "*resist*" and immersion in caustic soda, or by printing direct on the fabric with thickened caustic soda. In either case the portion of the fabric acted upon by the caustic soda is contracted,

the uncontracted portion being thrown up into folds, producing the crepon effect.

Two years later it was found that if cotton was contracted with caustic soda and then stretched to its original length whilst in a gelatinous condition, or if treated with caustic soda under tension, the subsequent washing also taking place under tension, it became highly lustrous; the process was named *mercerisation*, in honour of the first observer of the action of caustic alkalies on cotton.

The action of caustic soda solutions on cotton has been exhaustively investigated by Hubner and Pope.[1] These investigators found that even dilute solutions of caustic soda (1° Tw.) produce some shrinkage and at the same time an increased affinity of the fibre for substantive dyestuffs. They found that the affinity of the fibre for substantive dyestuffs and the degree of contraction increased with the density of the caustic solution up to a certain point (not quite the same in each case), after which a diminution in each property occurred with increased density of the caustic solution. They gave the following table of contraction for hanks of 200 yards length in caustic soda of various densities :—

Strength of Caustic Soda Solution.	Length of Hank after Treatment.	Strength of Caustic Soda Solution.	Length of Hank after Treatment.
0 ° Tw.	198·0 yards.	22 ° Tw.	171·3 yards.
1　,,	196·4　,,	24　,,	163·1　,,
2　,,	195·7　,,	26　,,	160·3　,,
3　,,	195·6　,,	28　,,	160·0　,,
4　,,	195·5　,,	30　,,	158·2　,,
5　,,	195·2　,,	35　,,	150·2　,,
6　,,	194·2　,,	40　,,	143·7　,,
7　,,	193·7　,,	45　,,	141·0　,,
8　,,	194·2　,,	50　,,	142·2　,,
9　,,	194·0　,,	55　,,	142·7　,,
10　,,	194·2　,,	60　,,	145·3　,,
12　,,	194·5　,,	65　,,	149·2　,,
14　,,	192·7　,,	70　,,	150·3　,,
16　,,	190·4　,,	75　,,	152·8　,,
18　,,	188·7　,,	80　,,	154·2　,,
20　,,	186·8　,,		

Concentrated caustic potash has a similar action to caustic soda.

[1] *J.S.C.I.*, 1904.

Action of Reducing and Oxidising Agents.—Reducing agents, *e.g.* sodium hydrosulphite, have little or no action on cellulose, but oxidising agents, *e.g.* chromic acid, potassium permanganate, persulphates, chlorine, bleaching powder, etc., convert it into *oxy-cellulose*, accompanied by tendering of the fibre. In consequence of this tendering action oxidising agents employed in bleaching cotton must be used with care, as prolonged action or use in excess may entirely rot the fibre.

Action of Light on Cotton.—This has been investigated by various observers, who have found that exposed cotton always loses strength, which is accompanied by *yellowing* or *browning* and formation of *oxy-cellulose.*

Action of Metallic Salts and other Substances.—The cotton fibre has little or no affinity for normal metallic salts such as alum, copperas, copper sulphate, etc. ; it is capable, however, of decomposing their basic solutions and loosely fixing the metallic hydroxides.   It has a direct affinity for *tannins* which are largely employed as *mordants* for basic dyestuffs.

Immunised Cotton.[1]—A material known as *immunised cotton* has been introduced by Sandoz of Basle.   This is prepared by treating swollen cotton with *para-toluene sulpho-chloride*.   The resulting cotton has a greatly reduced affinity for direct cotton colours (it is similar to *cellulose acetate* in this respect) and can be used for marking goods intended for dyeing.   As the immunised cotton does not absorb substantive dyes, the marking ink stands out clearly upon it after the dyeing process.

Linen.

Linen, which is the product of the flax plant *Linum usitatissimum,* is, next to cotton, the most important of the vegetable fibres.

The flax plant is cultivated in nearly all parts of Europe ; it is a herbaceous plant, growing to a height of 3 to 4 feet, and bearing a blue flower.   After becoming mature and in full seed, it is cut down and dried.   The stalks are then *rippled,* or *combed,* to remove the seeds, which are employed in the preparation of linseed oil and oilcake.   The stalks at this stage contain only 20 to 27 per cent. of fibre, the remainder being wood, pith, and rind.   The separation of these from the fibre is a tedious process involving several operations.   The first of these is *retting,* a fermentative process.   It may be carried out in several ways ; viz., by steeping in stagnant or running water, by dew, by ex-

posure to steam or hot water, or by treatment with mineral acids. After retting, the fibre is washed in water and dried ready for the mechanical operations which remove the woody portions of the stem; these are known as *breaking* and *scutching*, and are followed by *combing* or *heckling*. The combed flax is technically known as *flax-line*.

Properties.—Like cotton, linen consists essentially of *cellulose*. The ultimate fibres average from $\frac{3}{4}$ inch to $1\frac{1}{4}$ inches in length, and are about $\frac{1}{2000}$ inch in diameter. In the flax-line a large number of these *fibrillæ* are united together to form a *fibre-bundle* or filament, which may be of considerable length, 2 to 3 feet. Under the microscope the individual fibres are seen in the form of long cylindrical cells terminating conically at each end. The fibre is encrusted with impurities, *pectic matters*, amounting to 15 to 30 per cent.; these render the operation of bleaching longer and more complicated than in the case of cotton. When freed from these impurities linen is more lustrous and tenacious than cotton, but less elastic. It differs from cotton in being a better conductor of heat; on this account linen fabrics always feel colder than cotton fabrics.

Towards most chemical reagents linen behaves like cotton. It also behaves in the same way as cotton towards dyes, but is more difficult to dye than the latter; this is probably due to the presence of pectic matters and to the difference in physical structure.

Hemp.

This fibre is obtained from the hemp plant, *Cannabis sativa*, which is cultivated in most temperate climates. The treatment of the hemp stalks involves the same processes as those described for linen. The fibre is usually employed in the manufacture of ropes, sacking, and canvas, and is rarely bleached or dyed. It is particularly suitable for the purposes named, as it is very tenacious and does not easily rot when immersed in water. The fibre is almost cylindrical and has a large central cavity; it differs from linen and jute fibres in the frequent branching of the apices of the fibre stems into two forks.

Jute.

The fibre of jute is obtained from various species of *Corchorus*, the most common being the *Corchorus capsularis*, which is largely cultivated in India, Turkey, and Asia Minor. It is separated

from the woody portions of the stem by operations similar to those employed for linen and hemp.

Properties.—The fibres are polygonal in shape, and have a larger central cavity than linen. They vary in length from 0·03 to 0·17 of an inch, and have a diameter of 0·0004 to 0·0013 inch. The jute fibre is more readily acted upon by acids and alkalies than cotton and linen, being decomposed into insoluble cellulose and soluble tannin compounds. Cross and Bevan have suggested the name *bastose* for the fibre principle of jute, and the name *corchorobastose* for the compound of that substance and cellulose.

Jute, on treatment with sulphuric acid and iodine, or zinc chloride and iodine, is coloured brown; treated with chlorine and then with sodium sulphite it is coloured crimson. (Tannin-mordanted cotton gives the same reaction.) Jute readily absorbs chlorine and bromine, becoming chemically changed; this renders it impossible to use the ordinary process of bleaching by means of hypochlorites.

Basic dyestuffs dye jute by virtue of the tannin matters which it contains, in the same way as tannin-mordanted cotton. It has some affinity for many acid dyestuffs from a sulphuric acid or alum bath. It can also be dyed with neutral dyeing acid colours. Jute is largely employed in the manufacture of carpets, matting, etc.

China Grass.

This fibre is also known as *ramie* and *rhea*; it is obtained from plants of the order *Urticaceæ*, or nettles, viz. *Boehmeria nivea* and *Boehmeria tenacissima*. It is grown abundantly in China, Japan, India, and other countries. When separated from the cementaceous pectic matters it is of great lustre and tenacity. The methods employed in separating the fibres from the stem and bark in linen, hemp, etc., cannot be employed for China grass, as the fibres themselves are thereby separated into the ultimate fibres and cannot be recovered from the other portions of the stem. They are usually separated whilst the stems are still green by passing them through a machine which breaks up the stem and bark without affecting the fibres, the latter being easily separated by washing with a powerful jet of water. The fibre consists essentially of cellulose (80 per cent.), is polygonal in section, and contains a central cavity; the ultimate fibres are about 1 inch long and have a diameter of 0·0016 to 0·0032 inch. It is easy to bleach, but is difficult to dye full shades without injuring the lustre of the fibre.

Other Vegetable Fibres.

The vegetable fibres mentioned are practically the only ones finding textile application in this country. The following should, however, be mentioned, and information concerning them may be found in the *Bulletins of the Imperial Institute: New Zealand flax, Manila hemp, coco-nut fibre*, fibres from the *leaves of aloes, bananas, palms*, etc.

ARTIFICIAL SILK.

This fibre has now become of very great importance and promises to be even more important in the future. In this country alone, over £35,000,000 is invested in the industry. Artificial silk enters into the making of all varieties of fabric, plain and pile, knitted and woven. The dyer and cleaner handles it in self fabrics and mixed with other fibres such as silk, cotton, mercerised cotton, and wool, and in the form of trimmings, linings, etc. Following the lead of the Textile Trades of America, the Silk Association has adopted the name **Rayon** to indicate artificial silk, and this name is becoming more widely used ; it is gradually replacing the abbreviation *Art. silk*, which is so misleading.

All commercial varieties of artificial silk are of vegetable origin, being prepared from the raw material cellulose, either in the form of *cotton linters* (short-stapled cotton), or *wood pulp* from spruce or pine.

Artificial silk may be classified into four groups :—

(1) *Nitro*—prepared from *nitro-cellulose*, e.g. *Chardonnet*.
(2) *Cuprammonium*—prepared from *cellulose*, e.g. *Brysilka*.
(3) *Viscose*—prepared from *cellulose*, e.g. *Courtaulds*.
(4) *Cellulose Acetate*, e.g. *Celanese*.

Of these, **viscose artificial silks** constitute by far the greatest proportion of the world's output, probably over 75 per cent. *Celanese* (*cellulose acetate*) is remarkable in being the only artificial silk not consisting of regenerated cellulose. The fibre itself is *cellulose acetate*, and it is found that this variety differs considerably in properties from other artificial silks.

Chardonnet Silk.—This is the oldest of the commercial artificial silks. It is usually named after the inventor, *Count de Chardonnet*, but it is also known as *collodion silk* and *nitro silk*. The raw material used in its manufacture consists of *cotton linters*,

which are treated with a mixture of sulphuric acid and nitric acid to form *nitrocellulose*. After thorough washing, the nitrocellulose is dissolved in a mixture of alcohol and ether to obtain a viscous solution, which is forced through fine jets to produce a thread. As the thread is wound on to bobbins the solvent evaporates and is recovered for re-use. In this form the artificial silk consists of nitrocellulose and is highly inflammable. It is necessary to *denitrate* it to make it commercially safe, and this is usually effected by treatment with a reducing agent such as ammonium sulphide while the artificial silk is in form of hanks. The process reduces the weight very considerably but improves the handle. *Chardonnet* has a high lustre and can be manufactured in very fine filaments.

Cuprammonium Silk.—So called because it is made by dissolving some form of cellulose (bleached *cotton linters* or *wood pulp*) in *ammoniacal copper hydrate* ; it is also called *Glanzstoff*. It is manufactured largely on the Continent. *Brysilka*, an artificial silk manufactured at Apperley Bridge, is a cuprammonium silk made by the *Stretch Spinning Process*, which gives a fibre closely resembling real silk in softness, covering power, and draping qualities. The method of manufacture requires most careful control, but briefly consists in forcing the viscous solution made by dissolving cellulose in ammoniacal copper hydrate through orifices, and stretching the fibres so produced during their passage through the coagulating bath. Cuprammonium silk is used in weaving underwear, knitting hose, and in the production of artificial silk plushes. It is also used for *effect threads* in woollen or worsted pieces.

Viscose.—This type of artificial silk is the most important one, probably because the quality is good, the cost of manufacture is less than that of the other varieties, and the raw material, *sulphite wood pulp*, is also less expensive and more abundant. A number of British firms work the viscose process ; e.g. *Courtauld's*, *Bulmer Rayon*, and *British Visada*. The raw material for viscose is bleached sulphite wood pulp, which is cut up and soaked in strong caustic soda. After removing excess of caustic lye the pulp is placed in a grinding machine to produce *alkali-cellulose* in a form known as *crumbs*. The alkali-cellulose has to be aged by storage at a temperature of about 75° F. It is then mixed in a cylinder with a definite proportion of carbon bisulphide admitted by means of a spray, and *cellulose xanthate*, of a dough-like consistency and orange colour, results. The xanthate is dissolved in weak caustic soda to form *viscose solution*, which is purified by filtration and allowed to *ripen*. It is then forced

through nozzles into a *coagulating medium,* such as sulphuric acid and sodium sulphate, and wound off.

Cellulose Acetate Artificial Silk.—This variety of artificial silk is the only one not consisting of cellulose itself. Chemically, the fibre is *cellulose acetate,* so that it follows that the properties of this artificial silk differ very materially from the other makes, which all consist of cellulose itself. The best-known acetate silk is *Celanese,* manufactured at Spondon, but there are other makes, differing somewhat in properties.

The raw material for making cellulose acetate can be either *cotton linters* or *wood pulp.* This is treated with acetic anhydride and sulphuric acid to introduce acetyl groups into the cellulose molecule, and the *degree of acetylation* largely influences the dyeing properties. Usually two or three acetyl groups are introduced. (The more acetyl groups the more waterproof the fibre and the more difficult to dye.) This explains in some measure the troubles appertaining to the dyeing of the earlier makes of this variety of artificial silk. The cellulose acetate produced is dissolved in acetone, and after filtering, the viscous solution is forced through fine orifices and the filaments reeled off in a similar manner to Chardonnet silk.

Celanese, the acetate silk manufactured by the *British Celanese Company,* is a beautiful fibre closely resembling real silk in many respects. Its property of retaining heat makes it suitable for manufacture into underwear. As it is also non-hygroscopic it is an excellent material for general wear. On account of its sensitiveness to excessive heat, precautions must be taken both in dyeing and finishing articles made of cellulose acetate silk to avoid delustring it by operating at too high a temperature.

It was found that cellulose acetate cannot be dyed by normal methods with direct cotton colours. A few of the ordinary acid dyes and most basic colours are taken up, but it was left to the dyestuff manufacturers, and particularly the *British Celanese Company,* to evolve new ranges of dyes suitable for this product.

METHODS OF DIFFERENTIATING ARTIFICIAL SILKS FROM REAL SILK.

It is very necessary to be able to recognise the various fibres, more especially cellulose acetate, because it is liable to damage by solutions ordinarily used in *spotting* ; *e.g.* acetone and

chloroform both dissolve cellulose acetate, and it is sensitive
to heat above 80° C., at which temperature it is gradually
delustred.

Burning Test.—A simple yet effective method of distinguish-
ing the fibres is to burn a few threads of the material under
test and carefully observe the result.   Real silk gives a peculiar
nitrogenous odour and forms a black bead.   Weighted silk burns
with the same odour, but leaves a mineral ash of the same shape
as the fibre.   Cellulose acetate silk melts and forms a black bead
which on cooling becomes very hard ; the flame carries more than
with real silk and shows sparking ; the odour when burnt is some-
what similar to burnt sugar.   Nitro silk, viscose, and cupram-
monium burn in a similar manner to cotton, and with the same
odour, but more rapidly.

Real silk can also be distinguished from artificial silk by treat-
ment with potassium hydroxide or sodium hydroxide.   These
dissolve real silk but do not dissolve artificial silk.

Cellulose acetate silk differs from other artificial silks in being
soluble in acetone.   This dissolves it immediately and probably
furnishes the most reliable and most convenient test for identi-
fying the fibre. .

Artificial silk loses the greater part of its strength on wetting,
but the strength recovers on drying, hence it requires very careful
handling while in a wet condition.   The following table shows
the relative strengths of real silk and artificial silk in kilos per
square metre [1] : —

	Dry.	Wet.
Chinese raw silk	53·2	46·7
French ,, ...	50·4	40·9
French silk, dyed and weighted . . .	7·9	6·3
Chardonnet silk, undyed	14·7	1·7
Lehner's silk	17·7	4·3
Strehlenert's silk	15·9	3·6
Cuprammonium silk (Glanzstoff) . .	19·1	3·2
Viscose silk	11·4	3·5

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[1] Strehlenert, *Chem. Zeit.*

2. ANIMAL FIBRES.

Wool.

Strictly speaking, this is the hair of the sheep, but under the same category it is usual to class the hair of certain goats—*e.g. Cashmere* and *mohair*, as also that of the alpaca and the camel, as they differ from wool only in physical structure.

Archer distinguishes thirty-two different varieties of sheep, but from the dyer's point of view wool is only divided into the *coarse and long-stapled lustre wools*, most of which are produced in this country, and the finer qualities of *merino* or *crossbred wools*, which are principally imported from Australia.

Cashmere wool is the product of a goat which abounds in Thibet ; the wool sometimes reaches 18 inches in length.

Mohair, the wool of the Angora goat, is characterised by its great lustre ; it is imported into this country from Turkey and the Cape.

Alpaca is the hair of a genus typified by the llama.

Camel's hair is collected when the camels shed their hair periodically.

Wool varies in quality with individual sheep, and according to the part of the body from which it is obtained. It is roughly classified according to the length of staple ; fibres exceeding $1\frac{1}{2}$ inch in length are termed *long-stapled*, and are employed in the spinning of *worsted yarn* ; those less than $1\frac{1}{2}$ inch are termed *short-stapled*, and are spun into *woollen yarn*.

Physical Properties.—Observed under the microscope, the wool fibres show a rod-like structure covered with broad scales projecting in the same direction ; the shape of the scales varies according to the origin of the wool, the structure being shown in figs. 2 and 3, which represent the various kinds of wool fibres. The outer scales cover the central or medullary cells, which in the case of black or coloured wools contain organic pigment matter. If woollen or worsted fabrics are subjected to friction in the wet state, especially in the presence of alkalies, shrinkage takes place owing to the entanglement or interlocking of the scales. The degree of shrinkage is governed to some extent by the temperature, but still more so by the presence or absence of friction.[1]

Wool differs from cotton in that the longest fibres are usually those of greater diameter; the average length of fibre for the

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[1] See Jackson, *Cantor Lecture*, 1907.

various classes of wool varies from $1\frac{1}{2}$ inches to 7 inches, and the diameter from 0·004 to 0·0018 inch.

The breaking strain varies directly as the diameter of the fibre, from $\frac{1}{4}$ ounce to nearly $1\frac{1}{2}$ ounces, and the elastic limits from 0·25 to 0·4 per cent. on the length of the fibre.

Wool is very hygroscopic; in a damp atmosphere it will absorb up to 40 or 50 per cent. of water without being palpably moist. When wool is dried at 100° C. it loses on an average 15·43 per
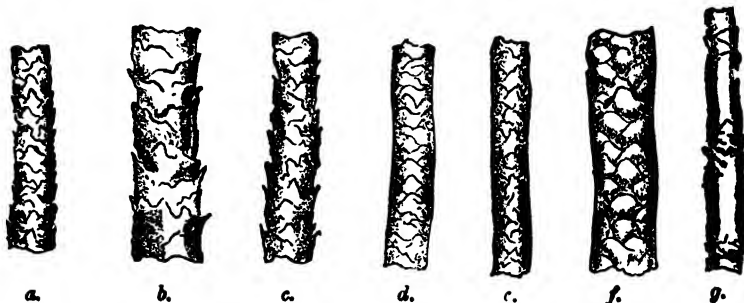
Fig. 2.—Wool Fibres.   Fig. 3. –Wool Fibres.

a, Fine merino; *b*, Lincoln wool taken from the coarsest part of the fleece after treatment with caustic soda and washing with alcohol and water; *c*, Lincoln wool taken from the shoulders of the same fleece as *b*; *d*, alpaca; *e*, mohair; *f*, coarse hair from Cheviot fleece; *g*, kempy fibre.

cent. of moisture. According to Bowman, the water is present in two conditions: (1) As water of hydration (about 8·25 per cent.); and (2) as hygroscopic water.

At 100° C. wool becomes somewhat plastic, the form imparted to it then being retained when it becomes cold; this plasticity is of great importance in certain methods of finishing yarn and piece-goods.

Wool burns with difficulty on ignition, leaving a black, carbonaceous bead; it emits when burning the peculiar smell common to all animal nitrogenous substances (feathers, horn, etc.), which serves to distinguish it from cotton and other vegetable fibres.

Chemical Properties.—The wool substance, which has been termed *keratin*, consists of carbon, hydrogen, oxygen, and nitrogen in approximately the same proportions as in gelatin, together with a small amount of sulphur. In the following table the figures for albumen are given for comparison :—

	Wool.	Gelatin.	Albumen.
C . .	49·25	50·0	52·8
H . .	7·57	6·5	7·1
O . .	23·66	26·0	22·9
N . .	15·86	17·5	15·6
S . .	3·66	..	1·6

A considerable proportion of the sulphur may be removed without the appearance, tenacity, or other properties of the fibre being affected.

Action of Acids.—Dilute acids have but little effect on wool, although they are absorbed by the wool and retained with great tenacity. They have, however, a tendency to open up the scales or imbrications, giving the fibre a harsh feel. Concentrated mineral acids, particularly when hot, have a disintegrating action, destroying and dissolving the fibre. Dilute nitric acid when applied at the boil turns the wool yellow, due to the formation of xanthoproteic acid; (if the strength does not exceed 3° to 4° Tw. this formation only takes place slowly).

Nitrous acid diazotises wool, the fibre becoming yellow in colour; it is then capable of combining and forming coloured compounds with alkaline solutions of phenols (e.g. β-naphthol gives a deep red), and with acid solutions of amido compounds (e.g. α-naphthylamine gives an orange shade).[1]

Sulphurous acid has no action on the fibre, but exercises a bleaching action upon the yellow colouring matter which it contains. It is absorbed and retained very tenaciously by the fibre; its removal may be effected by steeping in a dilute solution of soda, or by its conversion into sulphuric acid by means of hydrogen peroxide.

Organic acids are extensively employed in mordanting and dyeing wool, and have no destructive action upon the fibre.

Action of Alkalies.—Wool is readily affected by alkalies. Caustic alkalies, even in very dilute solutions, exert a very injurious action upon wool, the extent of the damage depending upon the alkali employed, the concentration and temperature of the solution, and the time during which it is applied.

Caustic soda and potash, even in dilute solutions used in the cold, have a destructive action, leaving the fibre harsh and tender, while hot solutions completely dissolve it.

[1] Richard, *J.S.D.C.*, 1888, and Bentz and Farrell, *J.S.C.I.*, 1897.

The alkaline carbonates (sodium and potassium carbonates) also have a destructive action on wool, but in a far less degree than the caustic alkalies. They may be employed in dilute solutions at temperatures not exceeding 120° F.

The milder alkalies (soap, borax, etc.) have very much less action on wool and, with the exception of a tendency to felt the fibre, have practically no injurious action.

Ammonia and ammonium carbonate have much less action than the hydroxides and carbonates of sodium and potassium.

Action of Other Chemicals.—Chlorine and hypochlorites act upon wool deleteriously, turning it yellow in colour and ultimately destroying the fibre. The regulated action of chlorine is to reduce the tendency to " felt," owing to the removal of the epithelial scales, and it is employed in the production of the so-called unshrinkable or " kymoed " under-garments. Chlorinated wool has an increased lustre, but becomes somewhat harsh to the touch ; it has an increased affinity for colouring matters, which is taken advantage of in printing wool and half-wool fabrics, and in preparing sheep-skin rugs, which are often chlorinated before dyeing. The production of lustre or sheen by means of hypochlorites is made use of in the chemical washing of Persian rugs.

The normal salts of the alkali and alkaline earth metals, such as common salt, sodium sulphate (Glauber's salt), potassium sulphate, calcium chloride, etc., are quite without action on the wool fibre.

When boiled with solutions of metallic salts, such as the sulphates of aluminium, iron, chromium, and copper, considerable quantities of the salt are taken up by the fibre. The chlorides and acetates of some of the metals act in the same manner.

The mordanting of wool prior to dyeing with adjective colouring matters is performed in this way, but as garment dyers do not employ mordant dyestuffs on wool (with the possible exception of logwood on chromium or iron mordant), the matter will not be dealt with more fully. Wool appears to contain bodies of an amino-acid character, but whether this has any bearing on the fact that it dyes with either acid or basic dyestuffs appears to be open to question, as the removal of the amino group by diazotising and boiling does not appear to affect its affinity for acid colours.[1]

Action of Light on Wool.—Continued exposure to light causes wool to lose strength. Woollen material loses its nap and its woolly nature, and on re-dyeing in a neutral bath it becomes soft.

[1] Bentz and Farrell, *J.S.C.I.*, 1897.

Such wool dries up stiff and brittle after dyeing. The faded wool has a marked affinity for dyes, and the fades dye more deeply than the unexposed portions. This is especially the case when the dyeing is done in a neutral bath, so that faded wool materials, *e.g.* wool curtains, are best dyed from an acid dye bath.

Silk.

Silk is the most valuable of the textile fibres ; it is excreted by the silkworm, which envelops itself in the fibre in the form of a cocoon when it enters into the transition or chrysalis period. The silks employed in the production of textile fabrics may be conveniently classed as domestic or artificially reared, and wild silks. The former are by far the more important.

The principal species of the domestic silkworm is the *Bombyx mori* or mulberry silkworm, which can be reared in most parts of the world ; as the reeling from the cocoons can only be carried out profitably with low-priced labour, it is chiefly confined to the Orient, the Near East, and some European countries (notably Italy and France). The magnitude of the industry may be gathered from the fact that the total weight of raw silk produced per annum amounts to over 60 million pounds. The eggs or *graine* are preserved until the period of the year for the full crop of leaves, and are hatched artificially to ensure maturity at the same time. One ounce of eggs will yield under proper conditions about 150 lbs. of cocoons ; this weight of eggs will give from 25,000 to 30,000 silkworms, and each worm during its four to five weeks' growth will consume about fifty times its weight of leaves.

The cocoons produced vary in colour from white (China, Japan, etc.), pale yellow (France, Kashmir-French eggs), darker yellow (Italy), to almost orange (Bengal). Most of the colouring matter is in the sericin coating of the silk fibre (fibroin), as on " boiling-off " or " de-gumming " all these silks yield a white or at the most a creamy thread.

Fig. 4 represents the moth in the various stages of its existence. The filaments of several cocoons are reeled to form a thread of raw silk (*grège*), the usual market sizes (varying with the number of filaments in the thread) being from about 11 deniers to 30 deniers. The hanks formed by the reelers are twisted into a head ; a bundle of these (usually 10 lbs.) forms a *book*, and a certain number of these forms a *bale*, which varies with the origin of the silk—100 lbs., Canton filature ; 1 picul (133 lbs.), China filature ; 100 kilograms, Italian, etc. The weaving of silk may be in the

gum, *i.e.* with the undischarged raw fibre, in which case *single* threads can be employed in the warp, or in the de-gummed state, in which case double threads, twisted to form *organzine*, must be employed in warp, while threads with little or no twist, known as *tram*, may be employed for weft.

Spun silk is the name given to the threads produced by spinning silk waste in the same manner as cotton and wool threads are formed.

FIG. 4.—The Silk Moth.

Structure of the Silk Fibre.—As it comes on to the market the raw silk has a harsh feel and but little lustre. The fibre drawn from a single cocoon varies in length from 400 to 2000 yards, and has an average diameter of 0·00067 inch. The fibre consists of two portions, the outer coating of silk gum or *sericin*, and the inner fibre or *fibroin*. The silk gum can be removed by boiling in solutions of alkalies or soap, the process being known as boiling off, during which a loss of about 25 per cent. occurs. With the removal of the gum the fibre becomes pliable and lustrous.

Seen under the microscope, two fibres (which have issued from the two spinnerets of the silkworm) are found to be cemented together by the outer coating of silk gum (fig. 5) ; they present the appearance of a structureless, transparent, rodlike fibre.

Physical Properties.—Silk is very hygroscopic, and, like wool, can absorb considerable quantities of moisture (up to 30 per cent.) without feeling damp. Raw silk is always " conditioned " before buying, the standard of moisture on which the weight of the silk is calculated being 11 per cent.

Silk has a specific gravity of 1·367. When dry it is a bad conductor of electricity, and easily becomes electrified by friction. It is very elastic, and can be stretched up to one-fifth of its length

without breaking, raw silk possessing greater elasticity and tensile strength than the de-gummed silk.

Action of Acids.—Silk is rapidly attacked and dissolved by concentrated mineral acids. Hydrochloric acid of a density of
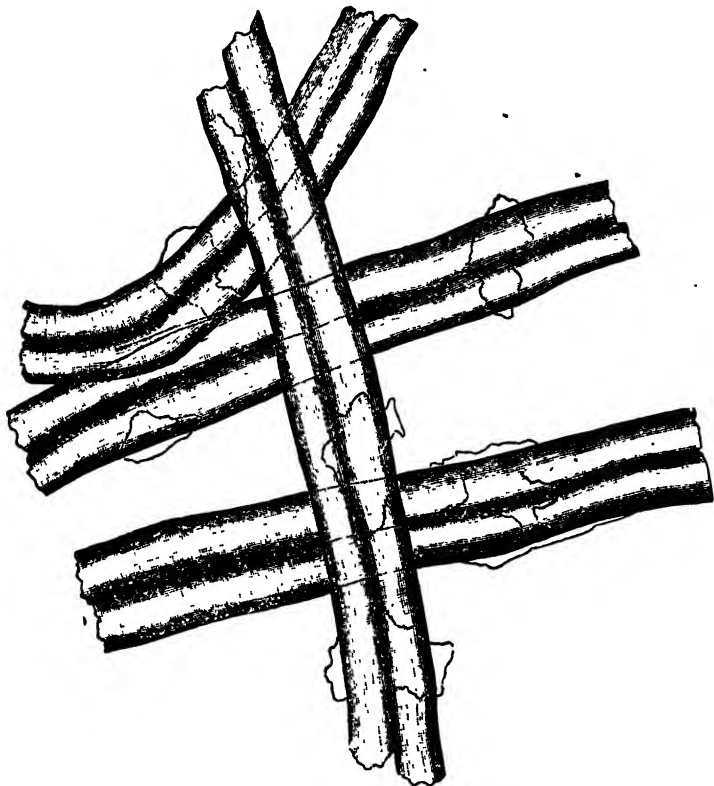
Fig. 5.—Silk Fibres.

26° Tw. contracts silk fabrics to about four-fifths of their original dimensions; by printing gum or wax resists, crepon effects may be obtained.[1]

Sulphuric acid at a density of 140° Tw. produces a similar effect, but the fabric is destroyed before the acid can be removed by washing in water. The action is much slower and less pronounced with Tussah silk.

[1] Farrell, *J.S.D.C.*, 1905.

Dilute hydrofluoric acid has no action on silk, and is used in determining the percentage of weighting in adulterated silks.

Concentrated nitric acid dissolves silk, giving a yellow solution, while dilute nitric acid turns the fibre yellow through the production of xanthoproteic acid.

Nitrous acid turns the fibre yellow with the production of a diazo compound from which coloured compounds can be produced with alkaline solutions of phenols, and acid solutions of aromatic amino compounds. The silk-diazo compound is very sensitive to light, and a process for the production of photographs upon silk fabrics has been based on this property.[1]

Silk absorbs acids from dilute aqueous solution and retains them tenaciously ; at the same time the lustre of the fibre is increased and the silk acquires a peculiar feel or *scroop*, emitting, when compressed in bulk, a crackling sound. To produce this effect the silk is worked in a dilute solution of acetic, formic, tartaric, or sulphuric acid, and dried without rinsing.

Action of Alkalies.—In its behaviour towards alkalies, silk stands between wool and cotton. At low temperatures caustic soda and potash solutions up to 50° Tw. do not injure silk if the time of exposure is short, and the action is further reduced by the presence of glycerine or glucose. This method is employed in the production of crepon effects in silk and cotton fabrics, the cotton becoming contracted and throwing the silk into folds.

In hot solutions of caustic alkalies silk is completely dissolved.

The alkali carbonates act upon silk in a less energetic manner than upon the wool fibre.

Soap is usually employed in the " boiling-off " process, and has no action on silk. Borax may be also employed in " boiling-off," but prolonged boiling tends to weaken the fibre.

Ammonia and ammonium carbonate have but little action on silk.

Action of Other Chemicals.—Metallic oxides may be deposited upon silk from suitable salt solutions ; advantage is taken of this in the production of *weighted* silks. White and coloured goods are usually weighted with tin compounds, immersion in stannic chloride being followed by immersion in sodium phosphate, sodium silicate, etc. Blacks are usually weighted with iron in combination with tannic acid. The practice of silk weighting with tin has now been extended to all varieties, light and heavy, *e.g.* crêpes-de-chine and georgettes are usually weighted, and as

[1] Farrell, *J.S.D.C.*, 1906.

the dyeing properties of weighted and pure silks differ, special precautions are necessary in dyeing these silks.

Chlorine and the hypochlorites turn silk yellow in colour and ultimately destroy the fibre. They must not be employed in bleaching cotton or linen fabrics trimmed or stitched with silk.

Tannic acid is absorbed by silk, bleached sumach extract being sometimes employed for slightly weighting coloured silks in the production of " 16-ounce " dyeings (i.e. 12 ounces of silk are weighted up to 16 ounces).

Potassium permanganate is decomposed with the deposition of brown manganese dioxide, which may be subsequently removed by treatment with sulphurous acid, this method being sometimes employed in bleaching dark-coloured silks, also in stain-removing (spotting). Too strong a solution of potassium permanganate disintegrates the fibre.

Silk resembles wool in its behaviour towards colouring matters ; there are a few exceptions, which will be dealt with under " Dyeing."

Wild Silks.

Tussore Silk.—The only wild silk which comes to this country in considerable quantity is that known as Tussah or Tussore. It is imported into this country from India and China, very frequently in native woven pieces.

The Indian Tussore is the product of *Antheræa Mylitta*, and the Chinese is the product of another species of the same genus, viz. *Antheræa Pernyi*.

The Tussore silk moth is larger than the Bombyx and has a larger cocoon. The fibre has a brownish colour and a peculiar siliceous lustre. The brown colouring matter is very difficult to remove, although the fibre will withstand a fairly considerable amount of alkaline and acid treatment. The diameter of the fibre is about three times as great as that of mulberry silk. It appears under the microscope as a flat, double fibre, each fibre being composed of several fibrillæ (fig. 6).

Raw Tussore contains a considerable quantity of mineral matter. Baston and Appleyard[1] found that the fibre contained 5·34 per cent. of mineral matter, of which about one-tenth was silica. Boiled with soap to remove the sericin, it loses in weight to the same extent as mulberry silk—about 25 per cent. After boiling off, the colour of the fibroin is still brown, whereas many of the yellow mulberry silks (e.g. Bengal) give a fibre

[1] *J.S.D.C.*, 1888.

which is practically white. The brown colour may be reduced by bleaching with hydrogen peroxide, but the production of a colour even approaching a "white" is a matter of very great difficulty.

Tussore silk is more resistant towards acids and alkalies than mulberry silk, and they may be employed in greater concentration and at a higher temperature in bleaching the silk, without the same risk of injury. It is more difficult to dye than ordinary silk, especially in light shades (due to the colour) and very dark shades (due to the peculiar speckled appearance of the fibre).
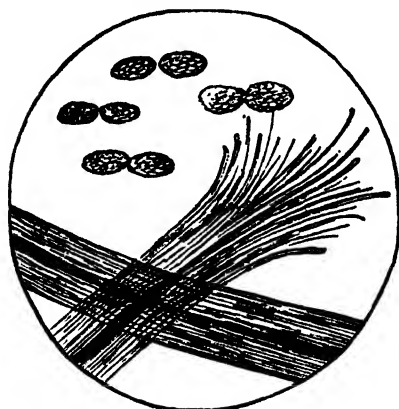
FIG. 6.—Tussore Silk Fibres.

Other wild silks which should be mentioned are :

Eria silk, the product of *Attacus Ricini,* which is found in various parts of India ; it resembles Tussore.

Atlas silk, from *Attacus Atlas.*

Muga silk, from *Antheræa Assami,* a native of Assam ; the fibre is lighter in colour and easier to dye than Tussore.

Yama-mai silk, the product of *Antheræa Yama-mai,* a native of Japan ; with the exception of its greater diameter, it closely resembles mulberry silk.

DRY CLEANING.

Reception of Goods.—Articles received for dyeing or cleaning are first carefully examined to determine whether the customer's instructions can be satisfactorily and safely carried out. Owing to the fact that nearly all the articles submitted to the dyer and cleaner have had a certain amount of wear and exposure, it is the custom of the trade to undertake all orders at the " owner's risk." The following wording has been adopted as a general practice of the trade, and with minor verbal alterations is printed on the price lists, etc. of dyers and cleaners throughout the kingdom :—

" *Non-liability.*—In accordance with the custom of the trade, no responsibility can be accepted for shrinkage or for damage to any article, or for defects becoming apparent during treatment, which are due to defective manufacture, to adulteration and deterioration, or to wear and exposure."

If an examination renders it obvious that a satisfactory result is very unlikely, the customer should be advised, and permission to proceed at his risk and expense obtained. The following are some points concerning which it is found necessary to communicate with customers :—

Obvious frailty of lace and other curtains due to exposure, etc.

Selection of unsuitable shades for re-dyeing articles (suitable alternatives should be suggested).

Extra expense involved through the necessity to unpick and re-make articles which can generally be treated whole—*e.g.* chintz curtains, etc., fitted with linings dyed with fugitive colours or with woollen linings which would be spoilt in the cleaning and finishing processes.

Marking.—When the articles have not been marked at the receiving shop, they must be allotted a number or other mark corresponding with the entry in the book (or, where the Card Index System is employed, on the card) wherein the customer's name and address, list of articles, instructions, etc.. are recorded.

This mark may be in marking ink where the goods are to be cleaned, or in marking cotton where the goods are to be dyed.

For dyed goods tinsel thread is sometimes employed, as the tinsel remains bright and easily decipherable after the dyeing operation, whereas the marking cotton is frequently dyed the same shade as the goods, rendering it somewhat difficult to determine the mark, thus leading to confusion and errors. To avoid delay arising in sorting and checking dyed work when marked with ordinary cotton, goods intended for dyeing light colours may be marked with ink on tape in a similar manner to cleaned work, in which case the marking ink stands out quite clearly after dyeing. For dark colours and black, various methods of marking are now being used as alternatives to marking cotton and tinsel thread, for example :—

(1) **Perforated Tabs.**—These are marked with letters and numbers by means of an automatic perforating machine, using a tough cotton material so that the perforation marks do not tear away in dyeing.

(2) **Immunised Tape.**—This is a tape manufactured from immunised cotton [1] which resists dyeing with direct cotton colours. In some cases this special tape is marked with ink in a similar manner to cleaned work. With all but the darkest colours and black, the ink stands out well. In all cases the tape remains sufficiently clear for the mark to be readable.

(3) **Resist Tape,** with a cellulose acetate face and a cotton back, is also used in marking; also an all-Celanese tape. As the acetate silk on the face remains undyed with most direct cotton colours, the mark stands out quite clearly after the dyeing process.

The mark in either case may be placed directly on the article (*e.g.* with marks on gloves) or on a separate piece of tape, which is sewn or otherwise fixed on to the article. The mark allotted should convey to the worker as much information as possible ; it should combine the registered number of the article, the number of pieces or articles in the batch, and with articles which have to be finished a certain size, *e.g.* window blinds, casement curtains, etc., the size of the article. It is an advantage and may save delay if any defects in an article are noted on the tab.

For example, in a set of chintz curtains and covers, comprising thirteen pieces, each piece might be marked $\dfrac{\text{A } 12,468}{13}$. In this

[1] *J.S.D.C.*, 1925, p. 165.

case the letter would indicate the receiving shop, van district, etc. A window blind belonging to a set of eight to be finished $46\frac{1}{2}$ inches wide (the width is the important dimension in this case) might be marked $\dfrac{B\ 4690}{8 \times 46\frac{1}{2}}$.

Articles for dyeing are frequently marked with a letter or letters indicating the colour which they are to be dyed.

All articles are then thoroughly examined, and any trimmings or attachments likely to become damaged during treatment, or to cause damage to other articles, must be removed and marked for subsequent identification. For example, rings, hooks, and pins must be removed from curtains, draperies, etc.; glass, china, enamel, and metal buttons, and metal and paste buckles from costumes and jumpers, and buttons and buckles from waistcoats. Dress hooks must be knocked down, as they are liable to catch in lace or trimmings, etc., in the cleaning machines, causing considerable damage. They can be raised again in the process of finishing. (Hooks need not be removed if a piece of tape or calico be tacked over them.) Garments, etc. received for dyeing in an unpicked state (or which have to be unpicked at the works—a very rare occurrence) must be tacked together, as otherwise small pieces may be lost in the dye vats, etc.

The processes to which articles are submitted by the dyer and cleaner may be roughly classified as follows :—

> Dry Cleaning,
> Wet Cleaning,
> Dyeing (including Dry Dyeing) ;

these processes being followed by suitable methods of

> Finishing.

Of these processes the most important at the present time is that known as Dry Cleaning.

Dry Cleaning.

This process is known variously as Dry, French, and Chemical Cleaning, and by its French equivalent *nettoyage à sec*. It is based on the fact that a considerable amount of the dirt and dust on articles of wearing apparel, curtains, draperies, etc., is held in position by greasy or fatty substances. If this grease or fat is removed by a suitable solvent, the dirt is readily removable mechanically. The term " dry " cleaning does not appear to be easily understood by the layman. He does not understand how

a process which involves immersion of the articles in a liquid can be a "dry" one. Articles immersed in the liquids usually employed in the "dry" cleaning process are not "wetted" in the ordinary acceptance of the term; an elaborately trimmed gown rinsed in petroleum benzine, for example, retains its shape in every way; the same article immersed in water would become a shapeless mass; a piece of accordion-pleated material retains the pleating in benzine, but loses it in water. This is due to two principal causes: firstly, most of the substances employed in the dressing of finished fabrics are soluble in water; and secondly, the fibres absorb the water, becoming hydrated and very much modified in their physical properties. The water causes the fibres to become limp and to alter (in many cases) in shape and size, the diameters of the ultimate fibres increasing, and the lengths of the threads (especially where they are at all highly spun) contracting considerably. Thus the relative positions of the fibres and threads are altered, and with them the shape of the fabric.

Benzine and the other liquids employed in dry cleaning are chemically inert as regards the fibres, as also are other liquids not containing water—*e.g.* ether, chloroform, carbon tetrachloride, turpentine, etc. On the other hand, methylated spirit, which contains a certain percentage of water, produces in a reduced degree much the same effect as water. If its water is removed by dehydration and distillation, the absolutely dry alcohol produced acts in the same manner as benzine. This indicates that the chemical and physical changes which take place when a fabric is "wetted" in water are not due to the mere fact that water is a liquid, but to the inherent and peculiar chemical properties of water, and these changes are only produced by water or by liquids containing water. Consequently the immersion of articles in a liquid which does not produce the ordinary effects of "wetting" may be quite correctly termed a "dry" process.

No process of surface cleaning, sponging, or spotting can satisfactorily replace a thorough impregnation of every fibre. Mere surface treatment may give a temporary fresh appearance, but it becomes evident during wear that the grease left in the heart of the fabric, and not removed by superficial brushing, gradually works its way to the surface, and as a result the garment in a very short time becomes as dirty as before. Such processes cannot be termed "dry cleaning"; they are neither hygienic nor satisfactory in other respects.

The "dry" process appears to have been first employed commercially about the middle of the last century. M. Jolly, President of the *Paris Syndicate of Dyers*, made a special com-

munication on behalf of the author to the Syndicate, and states that the old members recall having worked at dry cleaning with "essence" about 1856, but his father recalled the employment of the process as early as 1848. At this earlier date it would appear that the spirit employed was not petroleum benzine, or benzol, but "camphene," an oil of turpentine specially distilled for burning in lamps. Thomas Love, in his *Practical Dyer and Scourer*, published in London in 1854, gives directions for cleaning articles with camphene (describing the process as "Dry" or "French" cleaning); but he does not appear to have been acquainted with the use of any other spirit. It would therefore appear probable that the date mentioned by M. Jolly, viz. 1856, indicates the first introduction of benzine or benzol.

Dry cleaning was first introduced into the United Kingdom by Messrs J. Pullar & Sons of Perth in 1866, both petroleum benzine and benzol (or solvent naphtha) being employed, the methods and men being taken from the Paris house of *Petit-Didier*; but whereas the process had only been carried out by hand in Paris, machinery was very quickly introduced at Perth, thus forming the basis of the huge industry which now exists.

The primary requirements of a satisfactory dry cleaning spirit are :—

(1) Good solvent action on oils and fats.
(2) No effect on colours or fabric even when heated, as in closed-circuit system.
(3) No offensive odour.
(4) Not too volatile—incidental loss from evaporation.
(5) Not too heavy—cost of recovery and smell in goods.
(6) Non-toxic—effect on workers.
(7) Not too expensive.
(8) Chemically inert, as to be stable on storage and repeated distillation.

It is desirable that the solvent should not be miscible with water, as otherwise methods of recovering the spirit for further use are more difficult and more costly.

The following solvents practically satisfy all these conditions :—

> Petroleum benzine ;
> Benzol, 90 per cent. ;
> Solvent naphtha, 90 per cent. at 160° C. ;
> White spirit ;

and in a lesser degree carbon tetrachloride, trichlorethylene (*Westrosal*) and tetrachlorethane (*Westron*). These latter are excellent spotting agents, but are not so suitable for large-scale dry cleaning.

Petroleum Benzine.—This is the most important liquid employed in dry cleaning, and is obtained during the refining of American, Borneo, Sumatra, and Scotch shale petroleum. The benzines from American and Borneo petroleum are most largely employed. Benzine is a light, mobile spirit, having a specific gravity of from 0·700 to 0·780. Formerly, spirit of specific gravity 0·700 was principally employed for gloves and 0·730 to 0·740 spirit for other work ; but owing to the great demand for light spirit for motors many cleaners now employ 0·790 to 0·800 spirit, known as *white spirit*. This heavier spirit is usually lower in price than the lighter spirits. As white spirit has a flash-point of over 80° F., it is also much safer, and the risk of explosion is reduced. Petroleum spirit gives off an inflammable vapour at the ordinary temperature, and must therefore be used with every possible precaution against fire. It has not a stationary boiling-point, but consists of a series of hydrocarbons boiling over a wide range of temperature ; the spirit employed for dry cleaning begins to distil at about 50° C., and portions remain undistilled at 150° C. The following table [1] gives comparative analyses by fractional distillation of samples of petroleum benzine from various sources, and shows the variation in the range of boiling-points :—

	American Benzine.	Sumatra Spirit.	Scotch Shale Spirit.	Borneo Spirit.
Specific gravity . . .	0·727	0·710	0·739	0·782
Condensation commenced at	64° C.	60° C.	65° C.	65° C.
	Per cent.	Per cent.	Per cent.	Per cent.
Volume distilling below 60° C.	..	..	..	..
,, ,, 70° C.	0·5	15·0	0·5	1·5
,, ,, 80° C.	1·5	17·0	1·0	1·5
,, ,, 90° C.	8·0	20·0	1·5	3·0
,, ,, 100° C.	18·0	19·0	5·0	14·0
,, ,, 110° C.	36·0	14·0	12·0	26·0
,, ,, 120° C.	16·0	9·0	24·0	22·0
,, ,, 130° C.	8·0	3·0	18·0	12·0
,, ,, 140° C.	6·0	2·0	20·0	10·0
,, ,, 150° C.	4·0	1·0	10·0	6·0
,, above 150° C.	2·0	..	8·0	4·0
	100·0	100·0	100·0	100·0

[1] Garry and Watson, *J.S.C.I.*, 1904,

The choice of the best and most economical spirit depends in some measure upon the process the dry cleaner employs in his works ; if he uses the " closed-circuit " system (Barbe or Smith), factors come into operation which do not apply in a like degree to the ordinary method.   For the ordinary process the best and most economical spirit is that with a large percentage volume distilling between 80° C. and 120° C.   The portions distilling below 80° C. are very volatile and lead to losses during the cleaning processes from volatilisation ; the high boiling portions (*i.e.* above 120° C.) involve a long period of drying before the articles are free from smell, and (where vacuum distillation is not employed in the recovery of the spirit) a larger quantity of water to be separated from the condensed spirit after steam distilling.   Of the samples shown in the above table it will be seen that the percentages distilling between 80° C. and 120° C. are as follows :—

American benzine	.	.	.	78 per cent.
Sumatra spirit	.	.	.	62 ,,
Scotch shale spirit	.	.	.	42·5 ,,
Borneo spirit	.	.	.	65 ,,

Other things being equal, the values would therefore be in this order : American benzine, Borneo spirit, Sumatra spirit, Scotch shale spirit.   (This order, of course, only refers to the samples in question.)   Particular attention is directed to the large percentage of Sumatra spirit distilling below 80° C., viz. 32 per cent.   This would involve a heavy loss from volatilisation during usage.

Analyses of benzine by fractional distillation must always be carried out under precisely the same conditions, as otherwise widely divergent results may be obtained.

In the following table the results are given of tests on a sample of 0·730 sp. gr. spirit, employing different forms of apparatus.[1]

The rate of distillation in each case was 2½ c.c. per minute.

The results indicate that distillation analyses may be very misleading unless carried out in exactly the same manner, but if this is done they are of great value to the dyer and cleaner.

Trotman [2] suggests the following apparatus and conditions, and finds that very consistent results are thereby obtained :—

One hundred cubic centimetres of the sample are placed in a round-bottomed flask of 150 c.c. capacity and having a short neck 1 inch in length.   The latter is connected to a Young's rod and disc fractionating column with sixteen chambers, the distance from the neck of the flask to the lateral exit tube being 13 inches. The bulb of the thermometer is placed 1 inch below the lateral

[1] Garry and Watson, *J.S.C.I.*, 1904.   [2] *J.S.C.I.*, 1906.

	A.	B.	C.	D.	E.	F.	G.
Condensation commenced at . .	63° C.	68° C.	58° C.	58° C.	73° C.	64° C.	88° C.
Below 70° C. . .	0·5	0·5	2·5	2	..	1	..
,, 80° C. . .	3·5	2·5	9·5	17	4	12	..
,, 90° C. . .	40·0	43·0	37·0	26	38	35	1
,, 100° C. . .	32·0	28·0	27·0	30	34	28	44
,, 110° C. . .	16·0	15·0	15·0	15	15	15	43
,, 120° C. . .	5·0	5·0	3·0	4	5	4	5
,, 130° C. . .	1·0	3·0	3·0	2	2	2	2
,, 140° C. . .	1·0	2·0	2·0	2	1	2	2
,, 150° C. . .	1·0	1·0	1·0	2	1	1	1
Above 150° C. . .	0·0	0·0	0·0	0	0	0	2
	100·0	100·0	100·0	100	100	100	100

exit tube. The fractionator having been connected to a condenser with adapter, the flask is placed on a piece of asbestos, with a circular hole, and heated with a shaded direct flame from a small Bunsen burner, the gas supply being controlled by a screw clamp placed on the supply tube. The rate of distillation is arranged at approximately one drop per second. The distillation is started with a flame which will produce the required rate, and its height is only altered when the temperature or rate of distillation shows any inclination to fall. Trotman gives the following as examples of good and inferior spirits :—

Fraction Distilling.	Good.	Poor.	
Below 80° C.. . . .	3·0	25·0	6·0
Between 80° C.–90° C. . .	12·0	33·0	14·0
,, 90° C.–100° C. . .	82·0	16·0	33·0
,, 100° C.–110° C. . .	3·0	14·0	26·5
Above 110° C. . . .	..	12·0	20·5

The results indicate that the " good " sample is an extremely satisfactory one. A sample of spirit distilled according to the above conditions with not more than 5 per cent. coming over below 80° C. and not more than 10 to 15 per cent. remaining undistilled at 120° C., may be passed as a satisfactory one. With spirit of the higher specific gravity now frequently employed the

percentage remaining undistilled above 120° C. is frequently much higher than 15 per cent. Where a vacuum distilling plant is employed in the purification of the dirty spirit the higher boiling-point is not so objectionable, the loss due to the high boiling fractions retained by the grease and dirt being very much less than where the distillation is carried on at atmospheric pressure. Trotman [1] states that the ideal liquid for dry-cleaning purposes would be a petroleum benzine having a constant boiling-point of 95° C., but this never obtains in actual practice. The following results obtained by the author from a sample of Borneo spirit, sp. gr. 0·762, may be taken as typical of a heavy spirit of fairly good quality :—

Fraction Distilling.	Borneo Spirit, 0·762 sp. gr.
	Per cent.
Below 80° C. . . .	4
Between 80° C.–130° C. .	74
Above 130° C. . . .	22
	100

Where the Barbe continuous-circuit process of cleaning is employed other considerations carry some weight in the selection of the most suitable spirit. The drying in this case takes place in the machine, and as the plant is relatively more costly it is of the greatest importance that the maximum number of loads per day pass through it. Therefore, any undue prolongation reduces the output of the plant, and, incidentally, uses more steam. In the same way a spirit containing too great a high-boiling fraction takes a longer time and more steam to recover in distilling, and in this connection it is important to point out that a high-boiling spirit which distils easily with live steam will not necessarily distil so readily or so economically by the vacuum process. Hence in laying down a specification for spirit suitable for the Barbe or similar process, the author holds that such spirit should be suitable for economical recovery by either live steam distillation or vacuum distillation. Laboratory tests for such spirit should be carried out as far as practicable under works conditions as regards vacuum, steam, temperature, etc.

The author suggests the following specification as a fair one, as

[1] *J.S.C.I.*, 1906.

between supplier and user for spirit having a specific gravity of about 0·760 :—

Working with a vacuum of 22 inches of mercury, not less than 88–90 per cent. should be recoverable at a temperature of 120° C., 93–95 per cent. at 130° C., and 95–98 per cent. at 140° C. ; (the latter corresponds, approximately, to a steam pressure of 50 to 55 lbs.).

If a sample were to fall below these standards at 120° C. and 130° C., but come up to the standard at 140° C., the author would condemn it, because the relatively high percentage of high-boiling spirit would render it difficult to recover in a reasonable time.

In the following table, figures from actual analyses are given :—

[Distilled on oil bath: Vacuum = 22 inches mercury.]

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	Standard.
Specific gravity .	0·7510	0·7527	0·7550	0·7377	0·7567	..
120° C.	77	81	72·5	88	88	88/90
130° C.	89·6	90	85	94	96	93/95
140° C.	96	95	88	98	98	95/98

Consideration of these figures shows that No. 5 conforms very closely to the standard laid down ; No. 4 (which is a little lower in specific gravity) is also quite satisfactory, but the other samples could not be passed as satisfactory. No 1, although conforming at 140° C., shows too low a percentage both at 120° C. and 130° C. ; No. 2 is a little better, but not passable, while No. 3 is very bad.

A very simple test for the impurities causing the unpleasant odour in some samples of benzine consists in placing in a clean glass test-tube 10 c.c. of the sample and 1 c.c. of pure concentrated sulphuric acid, agitating for a few seconds, and then allowing to stand for ten minutes. The layer of sulphuric acid becomes coloured, the shade varying from a very pale yellow in good samples to a deep brown in bad ones. If the test is carried out as stated above, one in which the acid is not rendered deeper than a pale lemon yellow may be taken as indicating that the sample of benzine is a satisfactory one. (The impurities to which the odour is due are principally sulphur compounds, which may be removed by agitating the benzine with sulphuric acid, drawing off the acid and washing either with water alone or with caustic soda, and distilling.)

The presence of water in benzine is objectionable from a dry-cleaning standpoint, and can be tested for by shaking up a sample of the benzine with potassium permanganate in a state of impalpable powder. A pinkish colour indicates water. A trace of water can be shown by using as an indicator anhydrous copper sulphate (white), which shows the characteristic blue colour in the presence of water. To remove water from benzine it is customary to filter through a filter box containing freshly dried common salt. When its absorptive power is exhausted, the salt can be re-heated to drive off the water and used again until too dirty.

It is very unlikely that benzine will be found to be adulterated, but if the relative prices of benzine and benzol were such as to render adulteration with the latter profitable, it could be detected by nitration of the sample, and separation of the nitrobenzene by fractional distillation.

It has been stated by many writers on this subject that benzine possesses a considerable germicidal power. Farrell and Howles [1] investigated this subject, testing at the same time benzol and carbon tetrachloride. Using a pure agar-agar culture of *bacillus typhosus*, which was absorbed by sterile threads of silk, they found that immersion in petroleum benzine (sp. gr. 0·765) at the ordinary temperature for as long as 6½ hours did not kill the organism. With the addition of 1 per cent. by weight of benzine soap (*Saponine*) the same result was obtained. Benzol at the ordinary temperature did not kill the organism after 6½ hours' immersion ; not only do benzine and benzol possess no germicidal power at the ordinary temperature, but they do not appear to act as antiseptics, the organism in no case showing signs of attenuation, but growing as vigorously after 6½ hours' immersion as the original culture.

Carbon tetrachloride, on the other hand, killed the organism in all cases, with an immersion of thirty minutes.

Employing benzine and benzol at 60° C. the organism was in all cases killed by immersion for five minutes, but subjection to air at the same temperature kills the organism almost as rapidly ; this would appear to indicate that it is the heat only which is responsible for the sterilisation.

Benzene (Benzol) is obtained as a product of the distillation of coal tar and coke oven tar, each of which contains from 0·8 to 1 per cent. of benzene. The first fraction, known as the "light oil," consists of that spirit which passes over up to 150° C. and contains benzene, toluene, xylene, and smaller quantities of other substances. It is purified by washing with dilute acids to remove

[1] *J.S.D.C.*, 1908.

basic substances (pyridine, etc.), and with dilute alkalies to remove phenols, etc.   It is finally washed with strong sulphuric acid, and is then submitted to fractional distillation.   (The boiling-points of the chief constituents are benzene 81° C., toluene 111° C., xylene 142° C.)   The commercial benzols obtained are defined according to the percentage distilling above and below 100° C., those of most interest to dyers and cleaners being described as 90's and 50's. The proximate composition of these are given by Kraemer and Spilker as follows :—

	90 per cent. Benzol.	50 per cent. Benzol.
Water	0·060 per cent.	..
Paraffin	0·100 ,,	0·25 per cent.
Carbon disulphide . .	0·686 ,,	0·39 ,,
Substances absorbing bromine, including thiophene and the like .	1·202 ,,	1·23 ,,
Thiophene per se	0·264 ,,	0·264 ,,
Benzene	80·922 ,,	45·37 ,,
Toluene	14·850 ,,	40·32 ,,
Xylene	2·180 ,,	12·44 ,,

Excess of sulphur compounds causes the benzene to impart an unpleasant odour to articles cleaned in the spirit, which is only removed on prolonged stoving.

The following figures give the average specific gravities of commercial benzols :—

90 per cent. benzol.	0·880–0·883
50 per cent. benzol	0·875–0·877
Solvent naphtha, 90 per cent. at 160° C. .	0·874–0·880
Pure benzene	0·883–0·885
Toluene	0·870–0·871
Xylene	0·867–0·869

Benzene is a highly refractive, colourless, mobile liquid, and is very inflammable, the following being the flash-points of benzols, etc. :—

Pure benzene	—8° C.
90 per cent. benzol	under —4° C.
Toluene	+5° C.
Xylene	+21° C.
Solvent naphtha, 90 per cent. at 160° C.	+21° C.

In making fractional distillation tests with commercial benzol the same precautions must be observed as with petroleum benzine, as otherwise variable and misleading results will be obtained.

F. Frank [1] gives the percentage composition of commercial benzols, ascertained by distilling 1 kilo of the sample in a specified copper flask fitted with a Le Bel-Henninger dephlegmator 60 cm. in length, as follows :—

PERCENTAGE COMPOSITION.

Distillation Temperature Range.	90 per cent. Benzol.	50 per cent. Benzol.
Up to 79° C.	1·0 per cent.	0·3 per cent.
79° to 85° C.	78·8 ,,	18·3 ,,
85° to 105° C. . . .	10·0 ,,	47·5 ,,
105° to 115° C. . . .	8·0 ,,	23·7 ,,
Residue (xylol) . . .	2·0 ,,	10·0 ,,
Loss by distillation . . .	0·2 ,,	0·2 ,,

Thiophene can be detected by the blue colour produced on shaking the sample with sulphuric acid and a small quantity of isatin. Schwalbe [2] states that this test is perfectly trustworthy when employed quantitatively within the limits of 0·5 per cent. and 0·05 per cent., which are said to be the maximum and minimum proportions of thiophene found in commercial benzols. The requisite solutions are a number of test solutions of benzene containing the following percentages of thiophene : 0·5, 0·25, 0·1, 0·075, 0·05, 0·025, 0·01 ; a solution of 0·5 gram of isatin in 1000 grams of pure, concentrated sulphuric acid. Two 100-c.c. measures are each charged with 25 c.c. of the isatin solution and 25 c.c. of pure concentrated sulphuric acid. To one of the measures 1 c.c. of one of the thiophene test solutions is added, and to the other 1 c.c. of the benzol to be examined. Both solutions are then shaken for five minutes and the colours viewed on a white base.

Carbon disulphide is tested for by the addition of a few drops of phenylhydrazine, giving when present a crystalline precipitate on standing. It is determined quantitatively by conversion into potassium xanthate by alcoholic caustic potash, separation with water, and estimation in the washings by acidifying with acetic acid and titrating with a solution of copper sulphate. (12·475

[1] *J.S.C.I.*, 1901.   [2] *Chem. Zeit.*, 1905.

grams of crystallised salt in 1 litre of water: 1 c.c. $\equiv 0.0076$ gm. CS_2.)
The end point is ascertained by the red colour produced when a
drop of the liquid is brought into contact with a drop of potassium
ferrocyanide on filter paper.

The presence of hydrocarbons of the paraffin series (petroleum
benzine, etc.) can be detected by the nitration of the sample with
nitrosulphuric acid. If benzine is absent no unnitrated hydro-
carbon will be obtained on distillation in steam.

To ascertain the presence of unsaturated compounds (hydro-
carbons of the ethylene series), 5 c.c. of the sample are shaken for
five minutes with 15 c.c. of pure concentrated sulphuric acid, when
the acid layer should only be slightly darkened. (Barrett wash
test for purity.)

Benzol (preferably 90's because of its lower boiling-point) is an
excellent solvent for grease and gives highly satisfactory results
in dry cleaning. Unless used under closed-circuit conditions, *e.g.*
the Barbe process, the incidental loss from evaporation is very
great, and on account of its low flash-point the danger from fire
is correspondingly high. It is not so extensively employed in
this country as petroleum benzine, as the latter is generally lower
in price (except under abnormal local conditions). Moreover,
Goehrig [1] states that petroleum benzine is better for the workers
than benzol, as the vapour of benzol has dangerous toxic pro-
perties; also that a mixture of benzol and petroleum benzine
produces analogous effects to those produced by benzol alone.

D. H. Killefer [2] states that breathing the vapours of benzene
is particularly dangerous in the case of young women. In small
and frequent doses it may lead to chronic anæmia, whilst larger
doses are often fatal. Toluene and xylene (present in solvent
naphtha, 90 per cent. at 160° C.) are much less poisonous than
benzene.

Solvent Naphtha.—The solvent naphtha used in dry cleaning
is the heaviest fraction obtained on re-distilling the light oil from
coal tar, to which reference was made under the heading "Ben-
zene." It is the grade known commercially as 90 per cent. at
160° C., meaning that 90 per cent. of its volume distils below a
temperature of 160° C. at ordinary atmospheric pressure. It
consists chiefly of xylene and higher homologues and is an
excellent solvent for oils and fats. Solvent naphtha, 90 per cent.
at 160° C., is largely used for dry cleaning, though not to the
same extent as formerly, owing to the extension of the use of
heavy petroleum solvents, "white spirit." Arup (*Industrial*

[1] *Soc. Ind. de Mulhouse,* 1903.
[2] *Ind. and Eng. Chem.,* 1925, pp. 820, 822.

Organic Analysis) gives the following specification for solvent naphtha :

Solvent Naphtha.

Specific gravity .   .   0·8775 at 15·5° C.

Distillation Data.

100° C.	120° C.	130° C.	160° C.
nil.	nil.	8–30 per cent.	90 per cent.

The spirit should be clear, water-white in colour, and sweet-smelling. It should contain only a small percentage of hydrocarbons boiling at a higher temperature than 160° C. A rank smell and yellowish colour indicate the presence of impurities, such as sulphur compounds, which would give rise to smell in dry-cleaned goods. To test for such impurities shake a sample with concentrated sulphuric acid in a stoppered bottle (21 c.c. solvent naphtha *plus* 7 c.c. conc. sulphuric acid). The acid layer is darkened more or less according to the quantity of impurity present. In a good sample this layer should only be turned slightly brown.

The following table represents an average commercial sample :—

Specific gravity 0·858 at 15·5° C.
Distillation—100 c.c., using Engler flask.
First drop in condenser at 115° C.
First drop in receiver at 124° C.

Temperature.	Distillate.
Up to 130° C.	10 per cent.
,, 140° C.	54 ,,
,, 150° C.	84 ,,
,, 160° C.	95 ,,
,, 166° C.	99 ,,

90 per cent. at 153·3° C.

Solvent naphtha is more used in this country for dry cleaning than 90 per cent. benzol. As its flash-point is very much higher it is safer in use. The effect of the vapours of 90 per cent. benzol and solvent naphtha on the worker have been investigated by Rambousek, who found that the vapour of solvent naphtha was

much the less noxious of the two; while benzol vapour acts on the brain centres, that of solvent naphtha is almost non-poisonous.

White Spirit.—The use of high flash-point (over 80° F.) petroleum spirit of specific gravity 0·780 to 0·805 and distilling between 160° C. and 190° C. has now become general, especially in the larger dry-cleaning works where modern distilling plant and other methods of recovery of soiled spirit are in operation. The higher cost of re-distilling due to heavier steam consumption is partially offset by the lower initial cost of the spirit itself as compared with petroleum benzine or solvent naphtha. White spirit is a good grease solvent and fulfils all requirements as a dry-cleaning medium, but its high distillation range necessitates the use of efficient hydro-extractors and excellent drying arrangements for the cleaned goods to remove all traces of odour.

In order to be suitable for dry cleaning, the white spirit should be clear, water-white, and free from any rank odour. The following tables show two typical commercial grades of good quality. The distillation was carried out in a 100 c.c. Engler flask in accordance with the standard method of the *Institution of Petroleum Technologists*:

Example 1. **"Close Range" White Spirit.**

> Specific gravity 0·802 at 15° C.
> Distillation—100 c.c., I.P.T. method.
> First drop in condenser at 142° C.
> First drop in receiver at 151° C.

Temperature.	Percentage Distilled.
Up to 160° C.	3 per cent.
„ 170° C.	46 „
„ 180° C.	90 „
„ 190° C.	98 „

Example 2. **White Spirit.**—(Good commercial quality suitable for dry cleaners' use.)

> Specific gravity 0·779 at 15·5° C.
> Flash-point 98° F.
> Initial boiling-point 132° C.
> Final boiling-point 197° C.

Temperature.	Percentage Distilled.
Up to 160° C.	20 per cent.
,, 170° C.	64 · ,,
,, 180° C.	88 ,,
,, 190° C.	95 ,,

Total distilled, 98 per cent.

It is recommended that white spirit should be tested for non-volatile ingredients and oily matter, as these would give rise to odour in goods and loss during recovery. The following are the standard tests of the *Institution of Petroleum Technologists* :—

1. Non-Volatile Matter.—Evaporate 50 c.c. of the sample from a dish 10 cm. diameter and 4 cm. high placed on a water-bath and heated for four hours. The residue is weighed and represents the proportion of non-volatile matter.

2. Oily Matter.—Place 0·2 c.c. of the sample in the centre of a piece of ashless filter paper 11 cm. in diameter, and suspend the paper from a hook for one hour. Any residue on the paper should be observed.

Specification for Dry-Cleaners' White Spirit.

The spirit shall be free from undissolved water and suspended matter, and be water-white in colour. Not more than 2 per cent. to be soluble in concentrated sulphuric acid. The initial boiling temperature not less than 137–138° C., with an end point not higher than 204·5° C. The residue in the flask after distillation is completed not to show acid reaction. It must not contain aromatic hydrocarbons such as benzene, toluene, etc. The odour must be sweet.[1]

The dry-cleaning agents previously mentioned are all highly inflammable, and, moreover, the vapours when mixed with air (the proportions of the mixture being within fixed limits [2]) are liable to explode near a source of flame, or from sparking caused by difference of potential set up by movement of goods. There is, therefore, always a certain risk attending the use of petroleum and coal-tar spirit solvents.

[1] L. E. Jackson, *Ind. Eng. Chem.*, 1926, xviii. 237–238.
[2] Major Cooper Key, *Storage of Petroleum*, 1½ to 6 per cent. of vapour mixed with 94 to 98½ per cent. of air.

Non-Inflammable Solvents.

Various non-inflammable solvents have been proposed for dry cleaning, the most important being the chlor-hydrocarbons of which the best known are :—

    (1) Carbon tetrachloride.
    (2) Trichlorethylene (*Westrosol*).
    (3) Tetrachlorethane (*Westron*).

These solvents are considerably more expensive than petroleum benzine, etc., the difference being more apparent when one compares the cost of equal volumes, the chlor-hydrocarbons usually being sold by weight. In establishments where they are used, the lower fire-insurance premiums obtainable should in some measure reduce the net cost. Non-inflammable solvents have a very definite field in the cleaning of indoor furnishings, etc., which cannot be removed conveniently to the works. Further, they should find a place in the spotting room, as they are excellent solvents for resins, paints, etc., and are less liable to leave a ring or halo round the stain in unskilled hands than is benzine. For use on a large scale, chlor-hydrocarbons have the drawback of being less stable than petroleum products in storage. The presence of moisture, grease, and other impurities incidental to dry-cleaning operations may cause some decomposition, with development of acidity (hydrochloric acid) and consequent damage to metal tanks and fittings.

1. Carbon Tetrachloride.—In recent years the price of carbon tetrachloride has been considerably reduced, rendering it possible to employ it to some extent in dry cleaning. It is methane in which all the hydrogen atoms have been replaced by chlorine— CCl_4. It is closely allied to chloroform, which contains one less atom of chlorine—$CHCl_3$. It is a stable, colourless liquid, and does not decompose even with boiling alkalies. Its odour is very similar to that of chloroform when pure, but some commercial qualities contain traces of sulphur compounds and carbon bisulphide, which give rise to an unpleasant odour.

It has a specific gravity at 15° C. of 1·604, and it boils at 76° to 77° C. The latent heat of vaporisation is 51 calories as compared with benzine=90 calories. Goehrig [1] considers that it is unsuitable for degreasing fabrics, stating that it produces upon the workmen anæsthetic effects similar to those produced by chloroform, but the author has not observed any ill-effects upon workmen using it continuously over a long period, provided the

[1] *Soc. Ind. de Mulhouse*, 1903.

workrooms are well ventilated. The complaint most frequently made by workers is that they cannot get rid of the " taste " of carbon tetrachloride, *e.g.* at meals, taken several hours after working with it, all the foods taste of carbon tetrachloride.

It is important that the solvent should be free from chloroform, as the latter in the presence of air and light gradually undergoes decomposition, with the formation of carbonyl chloride (phosgene gas, $COCl_2$), which is very poisonous. It is possible that some of the ill-effects attributed to carbon tetrachloride are due to the formation of this substance. In any case there is little doubt that it is generally looked upon as more unpleasant to work with than petroleum solvents.

Carbon tetrachloride is an efficient degreasing agent and (if hydrochloric acid and free chlorine are not present) has no action upon the most delicate colours and fabrics.

Its advantages are :—

(1) Its absolute non-inflammability.
(2) Its low heat of vaporisation, ensuring small cost for distilling and condensing.
(3) It is a definite chemical compound with a definite boiling-point, and can be completely evaporated at normal pressure by means of closed steam.
(4) It has a greater solvent power for some substances, *e.g.* resins, than benzine.

Its disadvantages are :—

(1) Its high cost, volume for volume, as compared with benzine.
(2) Its high specific gravity, rendering it necessary to employ twice as much by weight to do the same amount of work as benzine.
(3) Its low boiling-point and greater loss in working (by volatilisation).
(4) The possibility of ill-effects on the health of the workers, particularly if it is not pure.

Its non-inflammability outweighs its disadvantages for some purposes, as it may be employed when it would be quite impossible to employ benzine, *e.g.* in cleaning silk panels, furniture, etc., *in situ.*

It has been stated that benzine and benzol may be rendered non-inflammable by the addition of a varying quantity of carbon tetrachloride, and an English patent has been taken out to cover the use of the latter for this purpose. Experiment, however, has shown that while the liquid produced by the addition of 20 to

40 per cent. of carbon tetrachloride to these spirits may be non-inflammable, when the articles which have been immersed in the liquid are dried, the carbon tetrachloride (with its lower boiling-point) evaporates first. The vapour coming off subsequently contains increasing quantities of benzine or benzol and is highly inflammable. It is therefore desirable that samples of so-called non-inflammable benzine should be exhaustively tested under working conditions.

2. Trichlorethylene (Westrosol).—This is a water-white solvent with a not unpleasant smell. Its specific gravity is 1·47, and boiling-point 88° C. Its action on iron in the presence of water is only slight. It is a very good solvent for fats and resins, and is used by itself as a dry-cleaning agent, and in wet cleaning as a constituent of many spirit soaps.

3. Tetrachlorethane (Westron).—This solvent is heavier than the previous one and has a much higher boiling-point ; specific gravity 1·6, boiling-point 147° C. It attacks iron in the presence of moisture to a greater extent than trichlorethylene, so that particular attention should be given to its storage. It dissolves fats, oils, resins, paints, etc., very readily, and on this account is a most useful spotting agent.

Dry Cleaning—Machinery and Methods.

The goods which are submitted to the dry-cleaning process include nearly all articles of wearing apparel (except underwear and rubber proofs), household drapings and furnishings, fancy articles, etc., of which the following may be mentioned as examples :—

Ladies' Apparel, etc.—Costumes, evening-gowns, tea-gowns, jumpers, knitted wear, motor coats, jackets, furs, gloves, fancy shoes, laces, scarves, sunshades, and hats.

Children's Apparel.—Frocks, coats, overcoats, jackets, boys' suits, etc.

Gentlemen's Apparel.—Suits, overcoats, knitted goods, ties, gloves, soft felt hats, gaiters, etc.

Household.—Curtains and draperies in nearly all fabrics (satin, plush, velvet, damask, repp, tapestry, cloth, cretonne, tissue, etc.), furniture covers, cushion covers, tablecloths, table centres, lamp-shades, eiderdown quilts, carpets, rugs, etc.

The special advantages of the process are that no shrinkage takes place, no dressing or stiffening is removed from fabrics, no alteration or running of colours occurs (with rare exceptions), and the most delicate fabrics, garments, and trimmings are not damaged or altered in shape or finish. Dry cleaning is generally

found to give a superior result on wool and silk articles, but is not quite so successful on goods made entirely of cotton. Articles made of Rayon and cellulose acetate usually dry clean quite successfully.

After the preliminary examination during the marking process (*vide ante*), when glass buttons, metal buckles, etc., were removed, the pockets of all garments must be thoroughly searched for matches and—with boys' garments—explosive caps. These may inflame or explode through the friction produced when handling into or out of the washing machines, during the rinsing process, hanging up, etc. The bottoms of the linings of coats, waistcoats, etc., must be carefully gone round by hand, as matches occasionally get through small holes in the pockets into the space between the cloth and the lining. Special care must be taken in searching for pockets, as they are sometimes found in unexpected places, *e.g.* ticket pockets (which frequently contain matches), in the sleeves of overcoats, inside other pockets, etc. Matches have also been found in such unlikely places as the folds of curtains and draperies, inside the pocket of a sheepskin perambulator rug, etc. All the pockets of garments should be turned quite inside out; the bottoms of trousers, etc., should be turned down, and articles which are liable to have accumulated fluff (*e.g.* the bottoms of " plus fours," etc.), should be turned inside out and the fluff brushed out.

The articles are now roughly sorted, according to their colour, fabric, and condition, into several classes :—

White and cream silks, flannels, etc.

White or cream articles with dark trimmings.

Light colours (fancy silks, delaines, etc.).

Black garments.

Light-coloured curtains, draperies, etc. (damask, cretonne, etc.).

Dark curtains, draperies, etc.

Gloves, sunshades, lamp-shades, shoes, suède and leather coats, skin rugs, furs, felt hats, and other articles treated either by hand or by special methods.

The trimmings on articles must be very carefully examined, as there are many fancy trimmings now on the market which are only stuck together and which come apart during the cleaning process. Feather trimmings are very frequently made in this way, as also are chenille medallions, etc. Spotted fabrics, particularly plain cloths with velvet and cloth spot effects, are often produced by sticking spots of other fabrics or even a mass of loose fibre on to the base fabric. These must not be cleaned, as the result is invariably disastrous. Articles with imitation suède trimmings,

consisting of powdered fibre stuck on a canvas backing, should be picked out and treated separately at customer's risk. At this stage also articles made of cellulose acetate (*Celanese*) should be placed on one side and any treatment these receive subsequently should have regard to the sensitiveness of Celanese to heat and to certain spotting agents, *e.g.* acetone, chloroform, and tetra-chlorethane.

Light articles with dark trimmings must be carefully tested, as some portion of the colour may be dissolved by the benzine in the
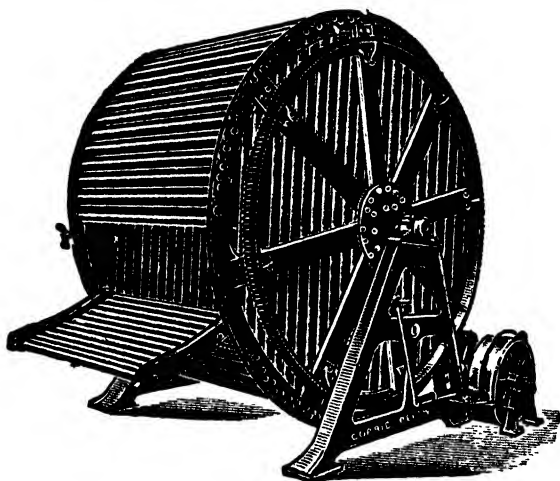

Fig. 7.—Circular Dust Wheel.

cleaning process and discolour the light fabrics in the same batch. Also where such trimmings have been dyed with basic colours, or with a substantive colour " topped " with basic colours, the latter is sometimes found to be soluble to an appreciable extent in a solution of benzine soap in benzine. Dress " preservers " containing indiarubber must be removed from dresses, bodices, etc., as the rubber will be wholly or partially dissolved in the cleaning process and may produce stains.

The superficial dust is now removed from all gentlemen's clothes, cloth and tweed dresses, curtains, draperies, and all other articles not liable to be damaged or " broken " in the process (as are silk-faced frock and dress coats, etc.), by revolving them in a dust wheel (fig. 7).

This machine may be either cylindrical or star-shaped, the latter being employed only for carpets, rugs, heavy curtains, etc. It is

essentially a revolving cage, varying in diameter from 5 feet to 14 feet, being constructed of wooden bars or rods set slightly apart, so that the dust, etc., loosened by the articles rubbing against each other in the slow process of revolution, may fall between them. It is advantageous to enclose the dust wheel in a chamber through which a current of warm air passes (some firms hang up all work in a drying room before putting into the dust wheel). This serves the double purpose of carrying away the dust (which can afterwards be separated in a "vortex filter" or similar device) and of removing any moisture from the contents of the machine. This ensures a more rapid penetration of the benzine, with quicker and more efficient cleaning, and keeps the spirit in a "dry" condition. The removal of the superficial dust by the dust wheel enables the benzine to be employed for a longer period before redistillation becomes necessary.

The portions of articles which are unduly dirty are now brushed on a slate or marble slab (marble being the more satisfactory in that stains can be more readily seen), with a strong solution of benzine soap to remove or loosen the dirt before the articles are placed in the machine. This is most frequently necessary with cuffs, collars, the bottoms of trousers, etc., which are very much stained.

Brushing slabs are slightly inclined, and fitted with a trough at the back to collect the spirit running off the slab and to lead it by means of a pipe to a tank or the solvent recovery plant.

The machines generally employed for dry cleaning may be divided into three classes ; special processes such as the " Barbe," etc., will be dealt with separately.

(1) Tumbler type.

(2) Inclined cylinder—" Sunflower " type.

(3) Ordinary horizontal type.

Tumblers.—The older type of tumbler machine consists of an iron cylinder from 3 to 4 feet long and about 1 foot 6 inches in diameter, revolving or oscillating upon bearings, whereby its contents tumble from one end to the other. The tumbler revolves through an arc of 180°, one complete cycle comprising the passing of the cylinder from a vertical position to a similar position with the other end of the cylinder upwards, and back along the same path to the original position.

A spirit-tight door fastened with wing nuts enables the goods to be introduced and removed, and a vent pipe passing through one of the bearings to about 1 inch above the highest point of the machine prevents the accumulation of gases under pressure inside the machine. The oscillating motion of this type of machine is

usually obtained by means of a rack and pinion.   To economise
space the tumbler may be mounted vertically against a wall; it
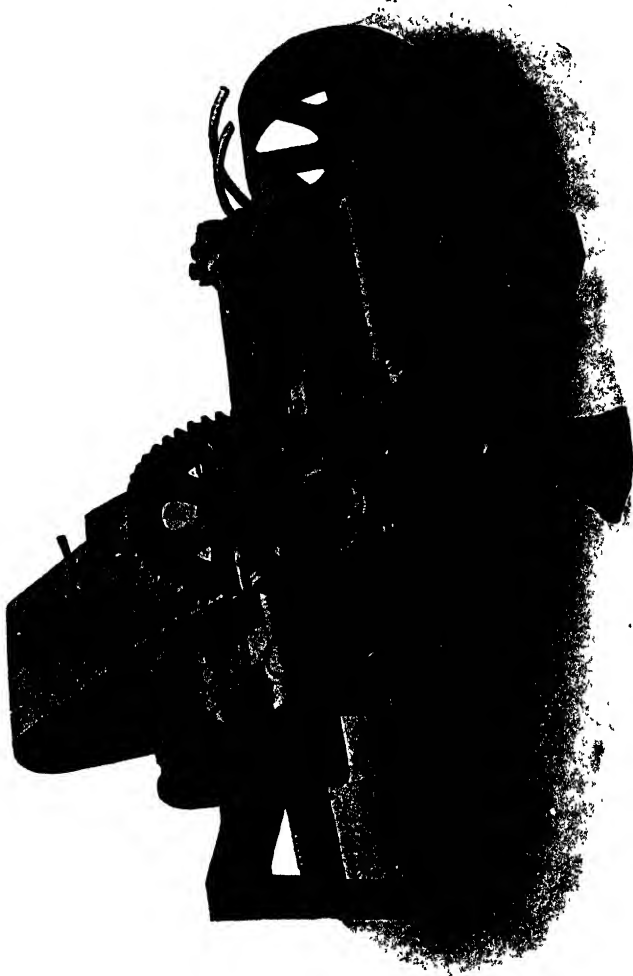

FIG. 8.—" Well " Tumbler.

is then necessary to unkey the pinion, move it round through 90°
and re-key it on the shaft after cutting a new keyway ; less space
also is taken by the tumbler mounted on the vertical framework.

Machines of this type are found to be convenient for cleaning small articles such as gloves, furs, jumpers, etc., and for the rapid cleaning of *specials*—*i.e.* articles required in a specially short time —and are very economical, as they require a comparatively small volume of spirit. They possess, however, the great disadvantage of leaving all the dirt removed from the soiled articles in suspension in the spirit. This finely divided dirt tends to get ingrained

Fig. 9.—" Sunflower " Dry-cleaner.

in the fibres of fabrics and in the glove skins, producing a greyness which is extremely difficult to remove. This will be referred to again later. The defect has been partially reduced by the introduction of a modified form of tumbler with a well (fig. 8) in which the dirt may to some extent settle.

Sunflower Type.—The inclined cylinder or *Sunflower* type of machine (fig. 9) is also very convenient for cleaning small articles. It is a very suitable machine for use with hand power, being of light construction and requiring very little power for driving. For dry cleaning, the cylinder is generally constructed

4

of copper or heavily tinned steel, with aluminium cover. The
diameter of the cylinder is rather greater than its length, and the
angle at which it is inclined and the size of the door are so arranged
that the spirit is a few inches below the lower edge of the door
when the machine is charged for working. The tilted barrel
gives an action that is very thorough yet not too strong, and
delicate articles as well as others can be cleaned in this type of
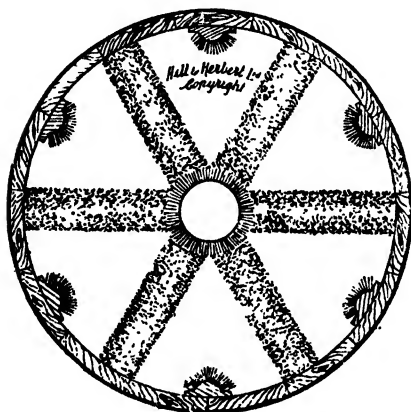machine. Ribs are fitted on to the inside periphery of the cylinder
to produce the necessary
rubbing action between
the articles in the machine
during the cleaning pro-
cess; also brushes (fig. 10)
when used for glove clean-
ing. The cylinder makes
three revolutions in each
direction, the belt-shifting
gear being operated by a
worm and worm-wheel.
The lid is fitted with a
small stopcock, which is
kept open during the
cleaning operations to pre-
vent accumulation of pres-
sure in the machine. This
type of machine labours
under the same disadvan-
tage as the tumbler type,

FIG. 10.—Sunflower Cleaning Machines;
showing arrangement of brushes.

in that frequent change of liquors is always necessary in
single-cylinder machines, as the dirt removed from the goods
remains in suspension; it is liable to cause greyness in whites
and light colours—a trouble, once arisen, very difficult to remedy.
An important point upon which the makers of the machine lay
great stress is that the cylinder is easily cleaned, simply by wiping
out, so that, if necessary, white articles can follow dark ones
without fear of discoloration. Another feature is that the " Sun-
flower " requires very little spirit in proportion to the quantity
of work turned out. Owing to the novel construction of the
machine, fixed inlet and outlet pipes cannot be arranged. To
empty the machine an outlet is placed at a point on the lower
side of the cylinder and the spirit flows into a funnel-shaped
trough connected with the dirty storage tanks.

Horizontal Cylinder Type.—The type of machine generally
employed in dry cleaning is the ordinary cylindrical washing

machine, revolving or oscillating about its axis. It consists of a fixed outer cylinder of metal, inside which is the revolving cylinder of slightly less diameter, in which are placed the articles for

FIG. 11.—Ibis Benzine Cleaning Machine.
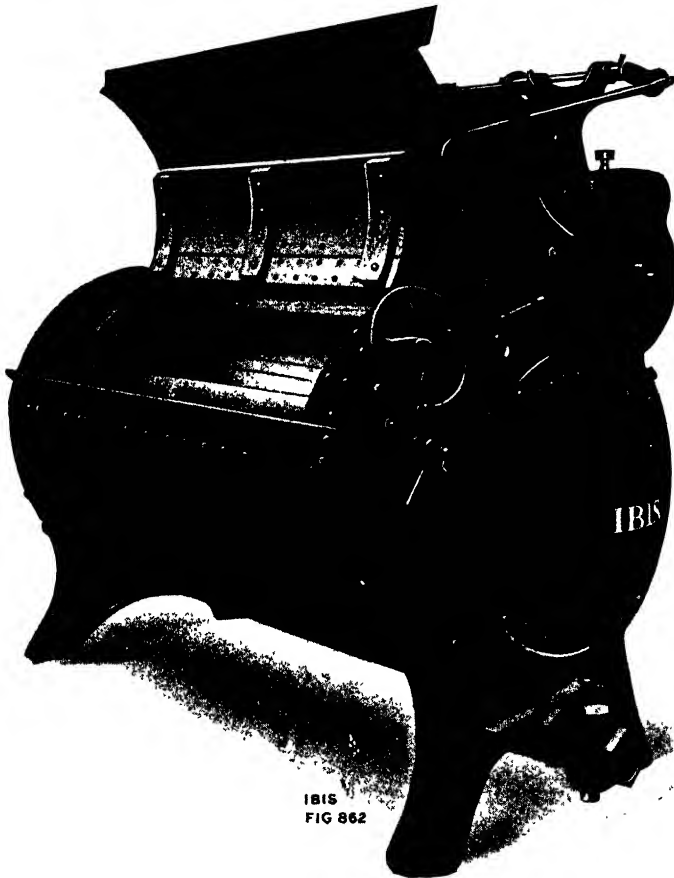
cleaning, a suitable door being provided for their introduction and withdrawal (figs. 11–14). The outer cylinder has a door giving access to the inner cage. The material of which the inner cage is constructed depends to some extent upon the class of work for which it is intended, those generally employed being wood (maple, beech, or plane), sheet or tube steel (plain, tinned, or

galvanized), brass or aluminium.   Wooden cages are constructed of rods with intervening spaces of from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch, or perforated segments with or without intervening spaces.   If constructed of perforated sheet metal the holes ($\frac{3}{16}$ inch to $\frac{1}{4}$ inch in diameter) should be well countersunk, so that there shall be no possibility of rough edges coming in contact with the contents of the machine.

When metal tubes are employed, care must be taken by the
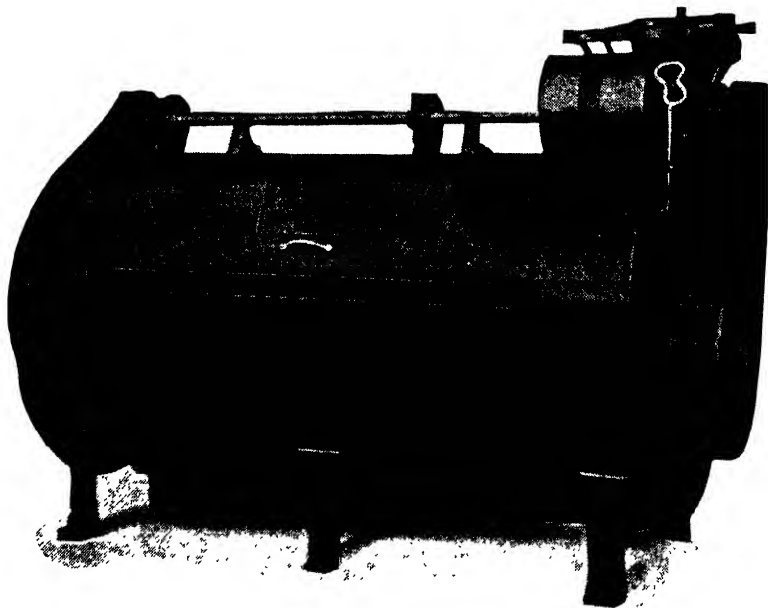
FIG. 12.—Benzine Cleaning Machine ; large size, double geared.

makers that no split tubes are used, and the ends must be plugged to prevent dirt extracted from goods accumulating in them. This is liable to come out into the clean spirit employed on a subsequent batch, and if white or light-coloured articles are being cleaned they may be discoloured.   This trouble is more frequently experienced in smaller works, where the same machine has to be employed for both light and dark-coloured articles.   Machines with open tubes must be particularly avoided in the cleaning of white woollen goods, or the dirt in the tubes will discolour certain fabrics, especially white and cream serges, to a greyish shade, which is very difficult to remove.

Wooden machines are not satisfactory for white work unless they are employed upon it exclusively, as some of the dirt and colouring matter extracted from darker goods is absorbed by the wood and may be dissolved out again by the clean spirit employed for a batch of white goods, resulting in the discoloration experienced with tube machines.
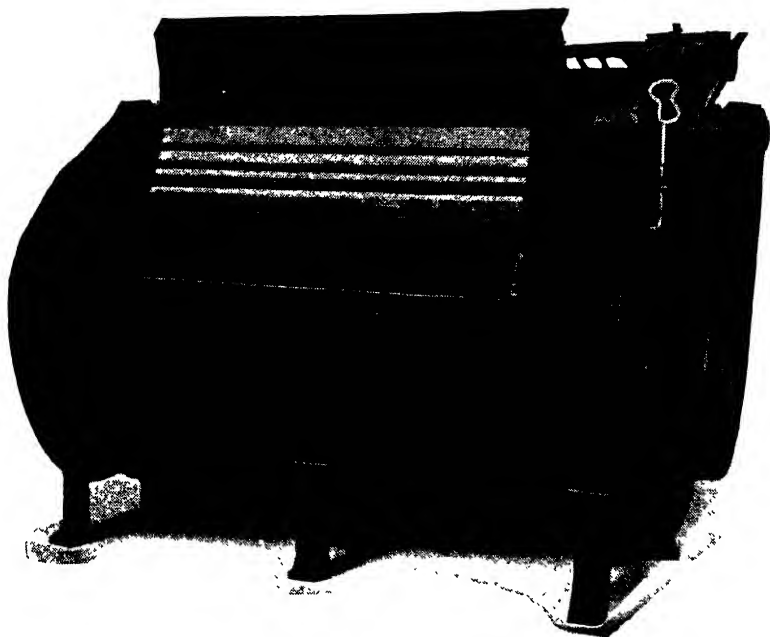
FIG. 13.—Benzine Cleaning Machine; large size, double geared, showing interior.

Satisfactory results on white goods are obtained with perforated tinned steel cages, but the best results are given by cages constructed of perforated sheet aluminium. With these machines there is no possibility of metallic stains being produced, aluminium oxide being white. As the cage is quite white, a visual examination of the inside will at once show if it is perfectly clean.

In all machines of this type baffles or " rubbers " are fixed around the periphery, which help to turn over the goods during the revolution of the cage, and facilitate the rubbing of the articles one against the other; this loosens and removes the dirt after the grease has been dissolved by the benzine.

The annular space between the inner and outer cages must not be too large, as an unduly large volume of spirit would then be required for each load of work ; on the other hand, it must not be so small that the dirt which is separated and falls to the bottom is stirred up into the goods again.   Many machines are provided with settling troughs at the bottom of the outer cage.

It is usual for the cage to perform three revolutions in each direction, though many cleaners are becoming convinced that
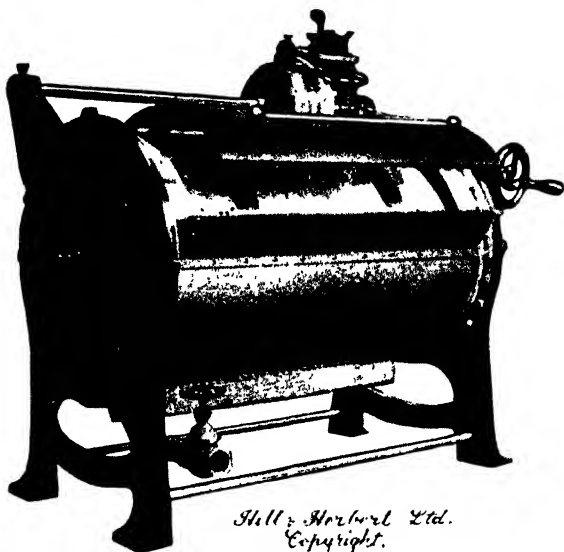
Fig. 14.—Metal Rotary Dry-cleaning Machine with Aluminium Cage.

oscillation backwards and forwards—*i.e.* about three-quarters of a turn in each direction—is equally efficient for cleaning and does not crease or entangle the contents to the same extent.

Where the former method is adopted, the reverse motion is usually obtained by means of fast and loose pulleys with a direct and cross drive, the belt-shifting forks being actuated by a worm and worm-wheel.   Where the oscillating motion is adopted, the worm and worm-wheel may also be employed, but it is better to use a rack-and-pinion motion.   This has the advantage of being " positive," whereas the degree of " slip " on the direct and cross belts is not the same ; consequently with a quick reverse (as in the three-quarter revolution) the cage will probably revolve the full three-quarters of a turn on the cross drive, but only half

a turn on the direct drive. This unequal revolution has a tendency to cause the articles to become more entangled than where the degree of revolution in each direction is exactly the same. Other well-known methods of obtaining the reversing action may be employed, but the methods described are those most generally in use.

Rinsing Tank.—Rinsing is generally carried out in the washing machines, but it is necessary to provide rinsing tanks, as articles are frequently dealt with which cannot be cleaned in machines.

The one usually employed is shown in fig. 15, and consists of a galvanised or tinned iron receptacle with or without a false bottom, and provided with pins or pegs over which the articles are thrown to drain ; it is fitted with a lid, which should be made to close automatically in case of fire.

Hydro - Extractors. — The hydro-extractors employed are generally of the under-driven type, as a tight-fitting lid may then be employed. The hydro-extracting should be thorough, as, of course, any spirit left in the goods represents direct loss unless during subsequent drying the vapour is collected from the drying room through an oil filter or by other means.

[FIG. 15.—Rinsing Tank.

The most satisfactory results are obtained with balanced cages, as higher speeds may be attained and consequently a larger quantity of benzine recovered. The machine takes less power to drive than a machine of the same size and speed made with a fixed spindle. Special attention is directed later to the importance of " earthing " hydro-extractors, as, owing to the large amount of " belt-slip " which takes place while the load is being gradually taken up by the driving pulley, a considerable amount of electricity is
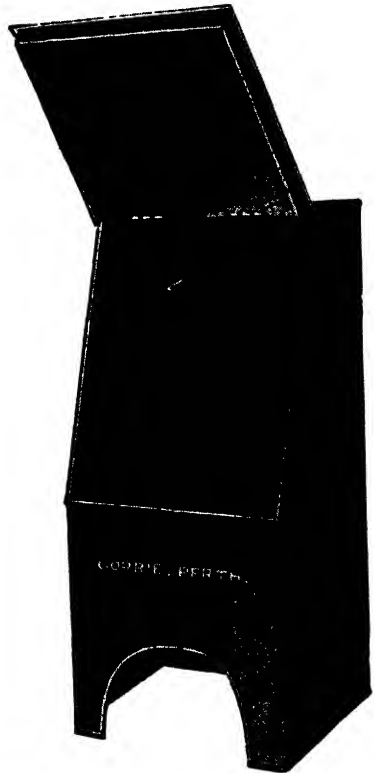
generated. In this connection attention may be called to the friction pulley type of hydro-extractor, where the load is picked up by means of wood blocks held by the centrifugal speed of the driving shaft against the inside rim of the driven pulley. Here there is no belt-slip at all, with obvious advantage to the life of the belt, and the generation of electricity is probably much reduced.

The relatively large amount of power taken in starting and driving hydro-extractors, and the importance (in spirit recovery) of having an efficient machine, make the selection of the right type of machine a matter for the fullest consideration.

The spirit extracted runs away and is collected. The speed of the cage depends upon the diameter, but the usual rate for a 26-inch diameter machine is 1200 revolutions per minute, down to about 700 revolutions per minute for one with a diameter of 48 inches. Efficient means of lubrication must be provided to minimise the risk of overheating. If the hydro-extractor is connected to the spirit tank, a gauze interceptor of the *Nonex* or similar type must be provided to prevent any flame passing down the pipes into the storage tanks.

In the early days of rotary washing machines, experiments were made with machines which would serve the dual purpose of cleansing the goods in process, and, after adequate rinsing, would remove superfluous liquid by running as hydro-extractors. In one machine of this type the cage was run horizontally for the cleaning portion of the process, and was swung into a vertical position for extracting. The mechanical difficulties are obvious, and even where the machine remained in one position for both processes, the high speed at which it had to run to render hydro-extraction adequate resulted in one of two things : either the constructional cost was prohibitive, or the wear and tear was equally prohibitive. The combination of dry cleaning and extracting in one machine—undoubtedly the economic ideal—was not successfully accomplished until the closed-circuit system (*e.g.* Barbe) brought heat and reduced pressure as accessories in the extraction portion of the process. By this means the very high speed essential for efficient extraction is in a large measure avoided, with consequential reduction in structural cost and upkeep expenses.

Arrangement.—The first principle which requires consideration in the laying down of a new dry-cleaning plant is " safety." To minimise the risk of fire—and it has now been reduced to an almost irreducible minimum—should be the object of the designer, and the careful attention which has been devoted to this aspect by the

authorities (notably the *Home Office* and the *Public Control Department of the London County Council*) has resulted in the accumulation of a great deal of valuable information. No prospective dry cleaner should fail to study carefully the *Home Office Memorandum on Dry Cleaning*, and whatever arrangement he may finally decide upon, he should see that it does not materially traverse the general principles there set forth ; they are the result of long experience and careful consideration. In a small plant the arrangement of the washing machines, rinsing tanks, hydro-extractors, clean spirit tanks, dirty spirit tanks, and still, should be such that as little pumping as possible is employed. One plan is to have the levels so arranged that the soiled spirit can run by gravity from the machines, hydro-extractors, etc., to the dirty spirit (settling) tanks, thence by gravity to the still, whence it is delivered by gravity to the clean spirit storage tanks. From these it is pumped to a distributing tank with a sufficient head for the spirit to be supplied to the various machines by gravity. The dirty spirit tanks, which are also employed as settling tanks, are so arranged that the spirit, after settling, can be pumped to within about 4 inches of the bottom of the tank into a " grey " spirit distributing tank. By this arrangement the cycle of handling the spirit is performed with only one pumping, and that with the clean (or partially clean—" grey ") spirit, which is the easiest to handle, there being no grit or dirt to get into the valves of the pump as is the case where dirty spirit has to be raised to a higher level.

Each washing machine is fitted with a trap or strainer box at the dirty spirit outlet to intercept any buttons, bones, fluff, etc., which are liable to collect in the bends, T-pieces, etc., of the pipes and cause blockage. The strainer box consists of a metal box with an easily removable spirit-tight lid for cleaning, fitted with a wire gauze partition which holds back any large articles, such as those referred to.

Dry-cleaning Soap.—Soaps soluble in benzine are employed for the dual purpose of assisting the cleaning process and to minimise the risk of fire. The soaps generally employed are stearates or oleates of potash, soda, or ammonia, one of the best on the market being that made by Grünwald & Stommel and sold under the name of *Saponine.* According to the specification, this is made by melting together equal or nearly equal parts of oleic acid and soap, the heating being continued until a clear liquid is obtained, after which it is allowed to cool. The patentees term the product an " acid oleate of alcali." Very satisfactory soaps, freely soluble in benzine giving a clear solution, may be made by dissolving caustic soda or caustic potash in the smallest

possible quantity of methylated spirit and stirring it into the theoretical quantity of oleic acid or melted stearic acid and heating the mixture on a water-bath. In place of soda or potash, ammonia (0·880 sp. gr.) may be employed with or without the addition of methylated spirit.

The following quantities give satisfactory results :—

	Parts by Weight.
Oleic acid	5
Caustic potash dissolved in	1
Methylated spirit	4

These quantities are arranged to produce a slightly super-fatted soap freely soluble in benzine. By increasing the quantity of oleic acid, the solubility of the soap in benzine is increased. For brushing on the slab an ordinary hard oil soap may be employed, green olive-oil soap or *Marseilles Soap* being perhaps the most satisfactory. The soap should have a high fatty acid and low water content. A brush dipped in benzine and rubbed on a bar of this soap dissolves enough to produce a plentiful lather when brushing the goods.

When a solid or semi-solid benzine soap is employed, *e.g. Saponine*, it is usual to make a stock solution (a 5 per cent. or 10 per cent. solution by weight) and to add the necessary amount of the stock to the machine. For use in the Barbe process neutral potash soaps must be employed, those containing free acid or ammonia being found to attack the galvanised fittings at the temperature to which the machine is raised.

Method.—The articles for dry cleaning having been sorted as described on p. 45, the white goods are always cleaned with freshly distilled spirit. These are the most difficult to turn out satisfactorily, as, if the spirit is not perfectly clean and dry, they are liable to become greyish in tone. Greyness of whites is (in the majority of cases at any rate) due to the presence of dirt and dust in a very fine state of division. They should therefore be cleaned in a type of machine which can be kept perfectly clean, and the cleaning operation should be as short as possible. To this end, the sorting should be very carefully done, very soiled white goods, requiring a longer period in the machine and also tending to soil the spirit, should not be mixed with white goods which are but slightly soiled. The benzine used for cleaning white goods should be dry, one of the best means of removing any residual moisture being to strain through common salt previously heated to dryness. The necessary amount of settled benzine is run into the machine, and if there is a probability of the spirit being slightly damp, a

piece of clean soft calico, taken direct from a warm drying room, is put into the spirit and the machine is run for a few seconds. The calico will absorb a considerable portion of the water which may be dissolved in the benzine. A sufficient quantity of the stock solution of benzine soap is now added to give a solution of from 0·5 per cent. to 1 per cent. by weight, and the goods are introduced. The door of the machine is closed, and it is run for from ten to fifteen minutes. If the goods are very much soiled it may be necessary to machine them for as long as half an hour, but this is rarely necessary with white goods; if found essential, it is better to run for a second period of fifteen minutes with fresh benzine and soap as before. Another very satisfactory method of cleaning white goods is to machine them for about ten minutes in benzine containing no soap and then to run them from ten to fifteen minutes in benzine and soap as before. This divides the removal of the dirt into two stages, that which is easily removed coming away in the first stage, and the smaller amount of dirt mixed with the benzine at each stage minimises the risk of discoloration, clearer whites being produced. If the rinsing is done in the machine, two separate rinses of clean benzine (without soap) are given, the machine being run in each case for about five minutes. The goods are then hydro-extracted, shaken out, and hung in a steam-heated stove room until quite free from benzine.[1] To remove the smell from dry-cleaned goods it is always advisable to dry with moderate heat and a good current of air rather than with strong heat and little air movement. White goods are not usually hydro-extracted to the same extent as other articles, as it has been found that leaving a fair amount of spirit in them improves the colour. The spirit and soap employed for a load of white goods may be employed without any purification for cleaning light or medium-coloured articles, and so on until the supernatant liquor from very dirty spirit, which has been allowed

[1] The necessity for efficient hydro-extracting is shown by the following figures giving the weight of benzine retained by various fibres after dipping in the spirit and allowing to drain without pressure. For comparison, the figures for water are also given (L. Vignon, *Comptes rendus*, cxxvii. (1), 73–75).

Liquid.	Weight Absorbed by 100 Parts by Weight of the Textile.		
	Silk.	Wool.	Cotton.
Water . . .	574	559	497
Benzine . .	592	571	506

to settle, or has been clarified by chemical means (*q.v.*), may be employed for very dark or black articles. In this way a considerable saving in soap is effected, and the loss which occurs on distillation is reduced to a minimum. For heavy goods and for articles liable to contain free acid (*e.g.* articles containing a considerable amount of perspiration, or hangings and draperies which are smoke-begrimed) a larger amount of soap must be employed than that specified for white goods, and if the articles are very much soiled, the duration of the machining must be prolonged.

Care must be taken that articles liable to be damaged in a rotary machine are cleaned by hand. Those which may be specially mentioned in this connection are articles made of taffeta or other stiff-weighted silks, which are usually very tender and particularly liable to be cracked or broken, or to drop into holes during the machining. Silks which have not been unduly weighted, and which have not had any hard wear, may be cleaned by machine ; but if on examination they appear to be cracked, to have had a fair amount of wear, or to be much stained under the arms with perspiration, it is safer to brush them by hand on a slab with a strong solution of benzine soap (5 to 10 per cent.), and finally to rinse them thoroughly in a rinsing tank. Jute curtains which have had a fair amount of exposure are frequently very liable to *drop* in the machine. If sufficiently sound to be cleaned by hand, that method may be employed, but otherwise they should be returned to the customer. Chiffon trimmed with sequins, beads, or other articles liable to catch on the threads of this delicate fabric should be cleaned by hand. Certain classes of silk fibres are very liable to slip or " fray " if rubbed even to a slight extent. This generally occurs in the shiny fabrics, such as brilliantes, and is due to the silk threads employed in the weaving having very little twist (in order to produce the brilliant effect in finishing). The fibres are thus able to slide one over the other with the greatest ease, the slight rubbing of a rotary washing machine being frequently quite sufficient to cause damage. In such cases the articles must either be cleaned by hand or in a machine in which the rubbing is reduced to a minimum (*e.g.* an oscillatory machine), and the time occupied in cleaning must be as short as possible.

Other articles which must be cleaned by hand are sunshades, shoes (leather, satin, etc.), fancy boxes covered in silk and other fabrics, lamp-shades in silk, etc. ; in fact, all articles which will obviously be damaged in a rotary machine. The method is the same in all cases. The article is brushed with a solution of benzine soap, special brushes being employed in some cases ; for example,

a triangular brush is employed to get into the pleats of a lamp-shade. After brushing, the articles are rinsed and allowed to drain (hydro-extracting being impossible), and are then dried in the stove room. Special care must be taken with sunshades, which are liable to be very frail from exposure to the sun ; also lamp-shades, which are frequently very tender from exposure to heat. Articles trimmed with gelatine sequins or trimmings, or imitation pearl beads, should be dried in a cool room, as the gelatine curls and the wax centres of the beads melt under any great heat. .

Mention must be made of white furs, which are frequently dry-cleaned. If these have not become yellow from exposure, cleaning by hand or machine (tumbler or sunflower) gives very satisfactory results ; but if discoloured by exposure, after rinsing, rub well into the hair a paste of benzine and French chalk, and allow to dry in the ordinary way. When dry, brush or shake out the French chalk, when the fur will generally be found much whiter.

The methods of dry cleaning which have been described do not remove the whole of the dirt and stains from garments, etc. After drying in the stove room or drying tumbler, all articles are carefully examined, and, if quite clean and free from stains, are passed on for the process of finishing. Those which are not satisfactory are retained for brushing or for spotting, which will be dealt with later under *Spotting*.

Glove Cleaning.—A very considerable business is done in glove cleaning, some portion of it being in the hands of those confining their operations solely to this section of the trade. Glove cleaning, especially amongst the smaller firms, is done largely by hand, but in large works machines have been intro-duced to reduce the manual labour as far as possible. The spirit employed in glove cleaning is generally of a lower specific gravity than that employed in garment cleaning. The object of using a lighter spirit is to reduce the time after which the gloves are free from smell to a minimum, especially with the smaller firms, where steam is not available for drying, and they have to be dried at the ordinary temperature. It is, however, quite possible to use heavier spirit, *e.g.* white spirit, 0·790 to 0·805 sp. gr., with satis-factory results, provided the drying arrangements are efficient. Ninety per cent. benzol, and solvent naphtha, are not very suitable for cleaning gloves by hand. A white kid glove saturated with either of these solvents appears dark and translucent, so that it is difficult to see stains clearly on the glove. Ninety per cent. benzol also is volatile, and unpleasant to work with in hand brushing, while the incidental loss from evaporation is very great.

It is necessary to bear in mind that the majority of the white gloves now worn are alum tanned, and that the tannage is very soluble in water; consequently water or liquids containing water should not be brought into contact with them. The tannage is frequently extracted by perspiration or by rain, and the portions affected are left hard and brittle.

In **Cleaning Gloves by Hand** the following appliances are requisite: vessels to hold the cleaning spirit, glove sticks, brushes, glove hands (for finishing) and cloths (for rubbing). The vessels to hold the cleaning spirit should be of zinc, tinned or galvanised iron, or glazed Doulton stoneware, and each should be fitted with a tight-fitting, self-closing lid. Satisfactory results are obtained with a rectangular vessel constructed with a lid fitted with a chain of such length that the lid will not open so far as to remain open when the hand is removed. By this means the loss of benzine by evaporation is minimised, and with it the risk of fire. The glove stick consists of a round, tapered stick of hard wood, and about 18 inches in length; the smaller end takes the finger of the glove, and the degree of taper is such that the wrist is on the thicker portion (about $1\frac{1}{2}$ inches in diameter). Glove sticks are also made with a small, round end to take the finger, and a broader, flat portion to take the wrist. The brushes employed in glove cleaning are made of best black bristle fastened into the back with string (wired brushes are not satisfactory, as the bristles are cut through and readily come out; bristles fixed in position with pitch are, of course, useless, as the pitch is readily dissolved by the spirit). Glove hands for shaping the gloves are made of hard wood cut to take the fingers, the thumb being shaped by the operator. It is general to employ glove hands with slots between the fingers to accommodate nickel slides, which fold the sides of the fingers into the slots, giving the " pleat " finish of new gloves.

The gloves must first be sorted according to colour, the white ones being separated from the fancy colours—chamois, greys, browns, and blacks. The white gloves are immersed in a solution of benzine soap in clean benzine, the time depending upon the condition of the gloves, but with those in average condition twenty minutes to half an hour is generally sufficient. They are then squeezed by hand to remove the dirty benzine, and brushed on the slab with a stronger solution of benzine soap. They are then placed on a glove stick, and the tips of the fingers and thumb and the creases of the wrist portion, which are generally more soiled than the rest of the glove, are well brushed. Perspiration marks, which are generally stiff and hard, must be carefully softened by

hand or with a pair of glove stretchers, and may be brushed with benzol containing about 25 per cent. of alcohol and a small amount of ammonia. The gloves are now thoroughly rinsed in clean benzine, and allowed to soak for a short time in spirit containing about 5 per cent. by weight of lanoline (wool fat) or white vaseline, or a mixture of the two, which replaces the natural oil (extracted in the cleaning process), and tends to preserve the suppleness and strength of the leather. They are well squeezed to remove as much benzine as possible, placed on a glove hand, fitted with the nickel slides, and rubbed with a clean cloth until nearly dry. The thumb is then carefully shaped and the glove hand with the glove on it is hung up until quite dry and free from smell. The glove is then polished and softened by rubbing with French chalk or white talc powder, and removed from the hand in a finished condition. Some glove cleaners prefer another method of drying which consists in blowing out the gloves on a glove blower connected with an air compressor and finally drying in a current of air and smoothing down with a white cloth rubber dipped in French chalk. While the general appearance of gloves finished in this manner is not quite so neat as the " pleat " finish, the glove leather (being well stretched by the pressure of air) has a remarkably soft handle.

Coloured gloves are cleaned in the same way, except that the amount of benzine soap should be reduced to a minimum to avoid reducing or altering the colours. The final polishing with French chalk and talc powder is also omitted, as also is the rinsing in lanoline or vaseline if the colours are rendered streaky thereby.

In the cleaning of coloured gloves, kid, suède, and buckskin, it is always noticeable that the gloves have a stripped appearance after process. In the main this is explained by the fact that the wear marks (which account for the stripped appearance) are covered by the dirt contracted in wear, and on removing the dirt, such wear marks become visible. Suède and buckskins in the new are also often loaded up with pigment colour, which is partially removed in cleaning.

To make the gloves presentable some process of colour restoring has to be resorted to. The simplest one consists in waxing the gloves and rubbing in powders of the correct tint to match the original. This method is suitable for kid gloves, but not for suède, and at best the result is very imperfect. With kid and suède gloves the most successful process is the application of alcoholic solution of dye by means of a spray, usually of the aerograph type. The wear marks can be covered in this way

and the original colour restored. With buckskins a process of pigmenting by means of a paste of suitable earth pigments and water, drying, and cleaning off, gives excellent results, the defects in the leather being covered extremely well, and the leather itself remaining as supple as in the new.

Cleaning by Machine.—Two methods are employed, viz. —

1. Washing in tumbler or similar machine, followed by hand or machine brushing.
2. Washing and brushing simultaneously.

The sorting into whites and similar colours must be carried out in the same way as when cleaning by hand. White gloves (from 50 to 100 pairs) are washed in a solution of benzine soap (about 1 per cent.), great care being taken that the time in the machine does not exceed ten to fifteen minutes. If a longer time be taken there is a possibility of the finely divided dirt in suspension in the spirit becoming ingrained in the leather, rendering it greyish in colour. Some skins appear to be more liable to be affected in this way than others, and it is sometimes found that a glove may be made from more than one skin and the thumb may be discoloured while the remainder of the glove remains quite white. The discoloration is very difficult to remove, even by prolonged brushing. After machining, the gloves are placed in a calico bag and hydro-extracted to remove as much dirty spirit as possible, and are then proceeded with in the manner described under Hand Cleaning, being brushed on the slab, on the stick, rinsed, allowed to soak in a solution of lanoline or vaseline, shaped, dried, and polished. The amount of brushing required is less than with hand cleaning, the tumbler removing more dirt than a simple soaking in benzine and soap. The amount of hand brushing on the slab that is found necessary naturally depends on the condition of the gloves and the type of machine. Brushing on the slab by hand may be to a large extent replaced by brushing by machine (fig. 16), and polishing by hand may be replaced by a polishing machine, consisting of renewable swansdown and calico mops driven by belt, and against which the glove is lightly held (fig. 17). The drying may be done in the ordinary steam-heated drying room. Particular care should be taken to avoid steam leakage in drying rooms, as this might result in shrunk and damaged gloves. While gloves free from moisture can be dried off at moderately high temperatures, *e.g.* 140–150° F., to remove the odour of spirit, such temperatures would result in shrinkage if much moisture were present in the gloves.

When the gloves are washed and brushed simultaneously very
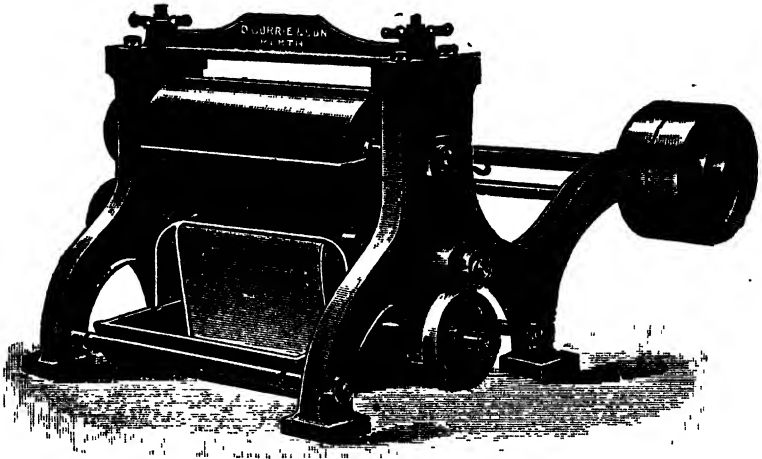
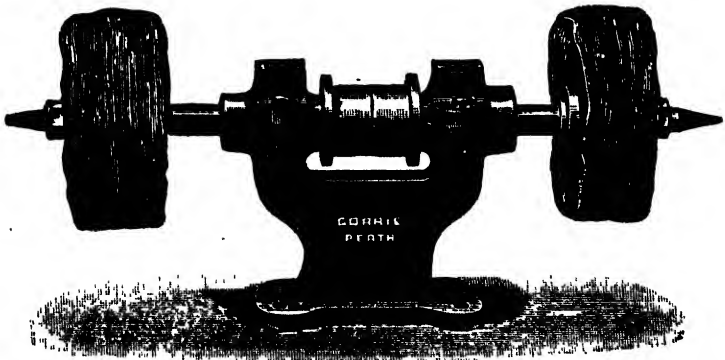Fig. 16.—Glove-brushing Machine.

Fig. 17.—Glove-polishing Machine.

good results are obtained with the oval paddle machine (fig. 18), which is made to take from a hundred pairs upwards. It is fitted with an oval well in the centre to take one bearing of the brush spindle, leaving an elliptical annular space in which is fixed the revolving paddle, on each blade of which is a brush, and an adjustable brush is fitted on the bottom of the machine against
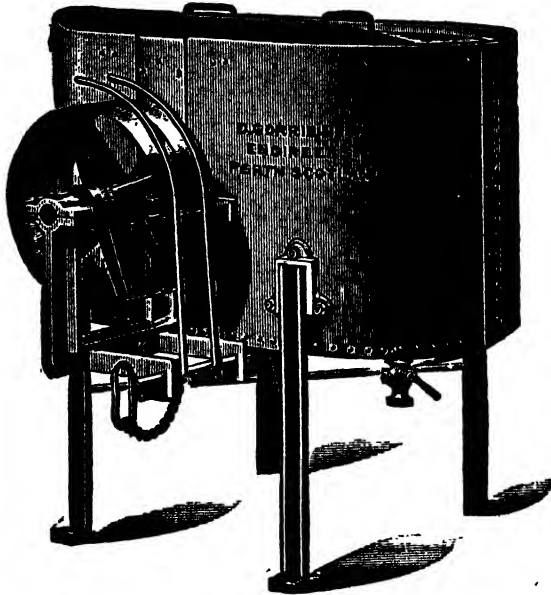

FIG. 18.—Gorrie's Oval Glove-cleaning Machine.

which the other brushes rub when revolving. The machine is filled to about one-third its depth with benzine and soap in the usual proportions, and the requisite number of gloves being placed in it, the revolving paddle is started. The gloves and spirit are thus kept rotating, the gloves passing between the brushes at each revolution. With gloves of average condition it is found that only from 5 per cent. to 10 per cent. require hand brushing after passing through this machine. Brushing (where necessary), rinsing, etc., follow as already described.

Ibis Glove Washer.—This machine (fig. 19) consists of a cylindrical casing with fixed brushes, and a rotating member having spring-mounted brushes working in contact with same. The central portion can be removed bodily from the central shaft,

which is bevel-driven through the pulleys at the side. It is stated by the makers that the method of fixing the brushes on springs reduces the risk of damage to a minimum.

FIG. 19.—Glove-cleaning Machine.

The *Sunflower* machine is also made for glove cleaning, with brushes arranged in the interior round a centre boss—radially on the bottom of the cylinder and vertically up the sides (fig. 10). The gloves rub against the brushes at each revolution of the machine.

Dry Cleaning by Closed-Circuit Methods.

The Barbe system of dry cleaning, the patents for which are held by the firm of Robatel, Buffaud & Co., of Lyons, and the Smith process are dealt with separately, as they differ in principle from the methods already described.

Barbe Process.—In this process the benzine moves in a closed circuit, the whole of the operations being carried on under
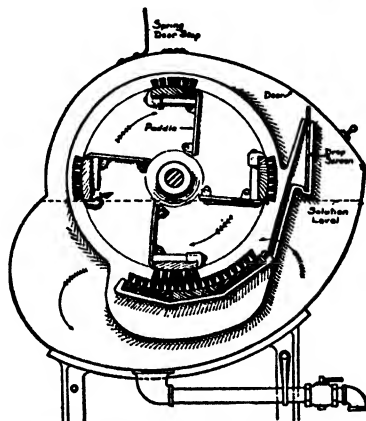

Fig. 20.—Sectional View of Interior of Glove-cleaning Machine.

seal, the articles to be cleaned being washed, rinsed, hydro-extracted, and dried in the same machine ; also these processes, instead of being applied in the presence of air, take place in an atmosphere of an inert gas, viz. carbon dioxide. The washing cylinder, which is of specially strong construction, is arranged for driving at two speeds, viz. a slow speed with oscillating movement for the washing process, and a high speed (about 300 revolutions per minute) when used as a centrifugal extractor.

In the diagrammatic illustration, fig. 21, A represents the washing machine, G_1 the clean spirit tank, G_2, G_3, and G_4 the tanks for settled benzine, C and D air pumps, F a tank for dirty benzine, J a cooler, M a receptacle for separating the benzine and carbon dioxide, K a steam heater (for carbon dioxide), L a still leading by way of a condenser to a clean benzine tank O, S a gas-holder for carbon dioxide, and E a holder for compressed carbon dioxide.

The articles to be cleaned by this process are first dried and freed from surface dust, etc., by means of a dust wheel in a

hot-air chamber. This operation takes from thirty to forty minutes, according to the class of goods under treatment. The

Fig. 21.—Barbe Process—General Arrangement.

articles are then sorted according to colour and fabric in the ordinary way, a load consisting of about 100 lbs. in the case of light silk goods or up to 200 lbs. in the case of heavy woollen materials.

The inner cage having been filled with the requisite quantity of goods, its door is closed, and then the air-tight door of the outer casing is also closed. By means of the vacuum pump the pressure of the air is reduced to 60 cm. below zero (*i.e.* the pressure is reduced by about three-fourths). Carbon dioxide is pumped from the gas-holder S to the vessel E in which the gas is stored for distribution at a pressure of about four atmospheres. The gas-holder conduit is then opened to admit carbon dioxide, and afterwards the benzine is run in to the required level (clean spirit from G_1 or " settled " spirit from G_2, G_3, and G_4, according to the colour of the goods) ; the gas-holder connecting pipe is left open. The machine is run (on the slow speed) for from ten to fifteen minutes, according to the goods, and afterwards the spirit is removed by centrifuging at the high speed for three or four minutes. (The soiled spirit runs through a filter which intercepts buttons, fluff, etc., into the tank F, whence it is lifted by pressure into the tanks G_2, G_3, and G_4.) The washing machine is replenished with benzine from G_1, and run again for ten or fifteen minutes. It is emptied while running slowly, and when the benzine has been almost entirely run out, transference is made to the high speed and the machine run as an extractor for three or four minutes. (This rinsing process may be repeated if necessary.)

The benzine still remaining in the goods is now removed by passing a current of hot carbon dioxide through the machine while it is revolving slowly. The following circuit is opened for this purpose : From the machine A to the cooler J, by way of a filter, which removes fluff and dust. From the cooler J by way of the vessel M (which is fitted with a gauge-glass) where the condensed benzine collects. From the vessel M by way of the pump D to the heater K and thence to the machine A.

Steam is admitted into the steam jacket of the outer casing of A so as to heat the machines slowly up to 60°–100° C., according to the nature of the articles. The pump is started and causes the carbon dioxide in the circuit to pass through the heater K to the machine A ; it then passes with the vaporised benzine through the filter to the cooler J, where the mixed gases are cooled, the benzine being condensed and collected in the receptacle M. To make sure of the proper operation of the plant, the liquid must be seen to circulate through the inspection glass *m* fitted at the inlet to M. The cooled carbon dioxide now passes through the pump and heater, back to the machine A, and the circulation is allowed to continue until observation at the glass *m* shows that evaporation is complete.

The goods are now ready for removal. To effect this the pump is stopped and all cocks in the circulating system are closed and the rotation of the washing machine is stopped. The machine A is connected with the suction pump and the gas-holder, and is exhausted to the extent of 25 cm. (pressure reduced to about 8 lbs.), the carbon dioxide being returned to the holder. The pump is now stopped, all cocks are closed, and the small cock fitted on the door is opened, admitting air until the gauge returns to zero. The outer door is now opened, and, after brushing away any fluff, the inner cage is opened and the goods are removed. From six to ten loads of work can be cleaned in each machine daily.

The spirit tanks G_2, G_3, and G_4 are connected with the still where the dirty benzine is purified; the condensed fluid, after passing through a receiver N, runs into the tank O, whence it is lifted by pressure to the clean spirit tank G_1.

The advantages claimed by the makers may be summed up as follows :—

1. The risk of fire is eliminated.
2. The annual losses of solvent are reduced by 80 per cent.
3. The cost of labour is reduced by 60 per cent.
4. Elimination of drying rooms and delivery of the goods two hours after their receipt.
5. The articles retain no odour.
6. More volatile solvents can be employed, which clean more effectively.
7. The operators work under better conditions, owing to the absence of benzine vapour.

The makers claim a reduction of 80 per cent. in the annual loss of solvent when benzine is employed, as a small portion of the light boiling fractions cannot be condensed and a very small amount of the high boiling fractions may remain in the goods which have been cleaned. There is also, of course, a small loss from leakage. In this connection it should be mentioned that the joints of the machine should be tight, as any considerable air leakage might result in an inflammable mixture in the machine which is more dangerous where heat is employed.

The disadvantage of the system is undoubtedly the heavy initial outlay compared with the cost of the ordinary benzine cleaning plant and the relatively small number of loads which can be treated daily. The lengthy process renders the Barbe method unsuitable for fragile goods, and the heat of recuperation makes it impossible to produce good whites. The advantages accruing

from the greatly reduced risk of fire and the great saving of solvent are worthy of very serious consideration.

The use of hot spirit for cleaning by the closed-circuit methods is beneficial so far as actual cleaning is concerned, but there is a certain amount of stripping of colours. The heat required for recuperation also results in a harsh handle and a frosty or starved appearance on dark-coloured work.

Smith Process.—This resembles the Barbe process in that it is also a closed-circuit method.

The Smith process, which was employed on the commercial scale by the patentees for some years before it was placed on the market, calls for description, as it differs from the Barbe process in one or two essential points. Whereas in the Barbe process the washing, rinsing, extracting, and drying take place in the machine, in the Smith system the washing, rinsing, and extracting take place in the machine, but the drying is effected in the ordinary drying chamber or drying tumbler. The makers claim that the system of drying the goods in the machine is injurious for the following reasons :—

" 1. The great heat generated in a limited and enclosed space, necessary to drive off the spirit, especially the last traces, which are the heavier fractions of the spirit, tends to give white or cream goods a yellow or grey cast.

" 2. Many colours are sensitive to heat, and change tone when exposed to it.

" 3. Wool and silk, and to a lesser degree cotton, are injured by great heat. The natural moisture is all driven off, and the fibre of the material is attacked, the goods losing the soft handle and suppleness which it is the chief effort of the finishing process to produce. Woollen goods, once exposed to an undue heat, always retain a harsh feeling."

A further important difference between the Barbe and Smith systems is that in the former the air is displaced by means of carbon dioxide, whilst in the latter the process is carried out under a partial vacuum, the circulation of the solvent being effected by the same means.

The makers of the Smith plant claim that the absence of air enormously increases the efficiency of their apparatus as a centrifugal extractor, stating that the average weight of spirit retained by the goods after extracting in the ordinary way is about 20 per cent., whereas the spirit retained by the goods after extraction in a partial vacuum is only 7 to 10 per cent., and that " under no system would it be possible to recover this small amount to pay for the cost of recovery."

The Smith apparatus is shown in figs. 22 to 24. The system is composed of three essential parts: the machine, the vacuum pump, and the absorption apparatus. The inner cage of the cleaning machine is strongly built to enable it to be run as an extractor, and is divided into three or four compartments, ensuring an equal distribution of the weight of the load. This method of construction further reduces the risk of the contents
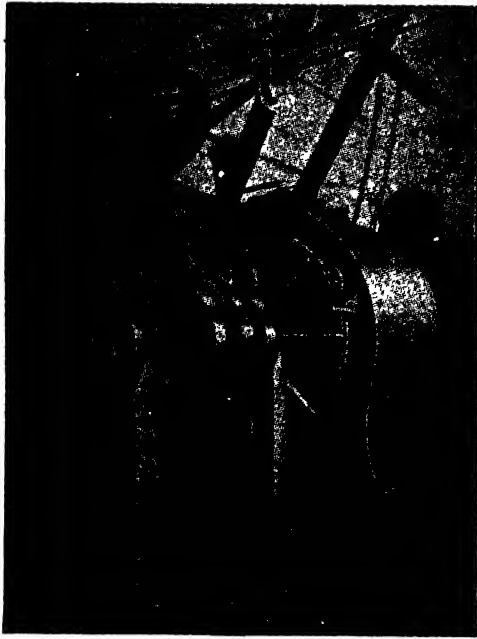

Fig. 22.—Smith's Patent Vacuum-cleaning Machine.

of the machine becoming unduly entangled during the cleaning process, and ensures that the goods shall be alternately immersed in the solvent and drained at each revolution of the cage.

The machine is provided with steam-pipes for heating the solvent to any desired temperature, though many firms clean cold.

The vacuum pump and the condensation plant do not call for any special description.

For a full load the four-compartment machine may be charged with 300 lbs. weight of garments, etc.; the air is exhausted by means of the vacuum pump, while the spirit (150 to 200 gallons) is introduced and heated to the required temperature, which

varies according to the class and colour of the goods.   The sequence
of processes is the usual one ; the makers claim " the improve-
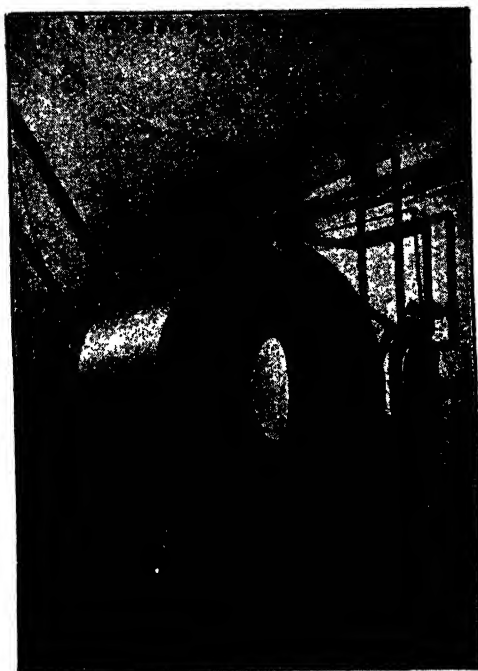

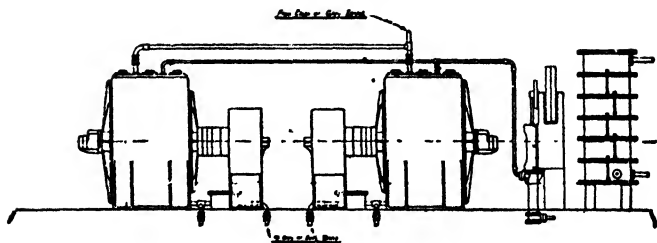FIG. 23.—Smith's Patent Vacuum-cleaning Machine.

FIG. 24.—Smith's Vacuum-cleaning Machine—Diagrammatic Illustra-
tion of Arrangement.

ment effected by the warm spirit and the whizzing between each
bath, reducing the number of baths required and the length of

time in each." They also say that, if desired, the machine can be so arranged that the goods can be completely dried before being taken out of the machine. The complete sequence takes about one hour, and the makers state that when necessary they can arrange to dry completely in the machine.

The chief advantages claimed are :—

1. More effective cleaning.
2. Economy ; the loss of spirit by this process is stated to be 1 gallon of spirit to every 100 lbs. weight of garments.
3. Simplicity of working.
4. Safety.

The Drying Room.

After thorough extraction, the goods still retain a considerable quantity of benzine. In an actual test, goods weighing 750 lbs., after hydro-extracting were found to have lost 150 lbs. of benzine during the drying process.

The drying room is heated with steam pipes, or by an independent heater of the Sturtevant type. In either case the ventilation must be such that the air in the room is changed so frequently that an explosive mixture of air and benzine vapour may not exist.

The loss of benzine in drying, after the ordinary methods of cleaning, being so considerable, it has been suggested that the vapour might be recovered by condensation. To this end the use of a closed stove and condenser attachment, similar to that employed in felt-hat manufacture for the recovery of methylated spirit, has been devised by Gorrie of Perth.

Another arrangement which would in all probability yield satisfactory and economical results would be to employ several stoves in series, the air passing from one to another on the countercurrent system, the percentage of benzine vapour gradually increasing. For example, we will assume an arrangement of four stoves, A, B, C, and D. A is being emptied, B has just been filled with goods, the contents of C are half-dried, and those of D are nearly ready for removal. Warm dry air will pass from a heater to D, thence to C, and finally to B, so that the air free from benzine will come in contact with the goods nearly dry, and the air when saturated will come in contact with the goods containing the greatest quantity of benzine. Thus when the contents of D are ready for removal, the air in that chamber will be free from benzine. A being now charged with work, and D ready for unloading, the air ducts will be so arranged that the fresh air passes to C, thence to B, and finally to A, and so on throughout the day in any desired order. By this means the cost of condensation

would be materially reduced, and the greater the percentage of benzine vapour present in the air, the less would be the loss of benzine. The recovery of benzine from the drying rooms by condensation methods is more profitable with the heavier benzine and white spirit now being used than with the lighter petroleum spirit, 0·720 to 0·740 sp. gr., formerly in use.

Suction Drying Tumbler.—A rapid and efficient means of removing residual benzine from dry-cleaned goods and delivering them in a fit condition for finishing consists in the use of a drying tumbler of special design. For a very large proportion of dry-cleaned work a tumbler may very well take the place of drying rooms with advantages from the point of view of production, condition of work, and economy of ground space.

The tumbler is provided with circulating fan and heating coils, and a large volume of heated air is drawn through the goods whilst they are moving round in the inner cage of the machine. Usually a period of fifteen to thirty minutes' drying is sufficient to ensure that the goods are free from odour.

When the machine is loaded with dry-cleaned goods the lid is closed down and the fan started to circulate hot air, which air is drawn from the atmosphere through a wire gauze grid over the heaters. Steam is also admitted for the first few minutes at the commencement of the drying operation to eliminate the explosion risk.

Towards the end of the drying process cold air is drawn through the goods to condition them.

A further safety device is the provision of explosion doors to the machine, though the risk of explosion appears to be very slight in the humid atmosphere of this country.

The suction drying tumbler not only takes away the odour of benzine, leaving the goods sweet, but owing to the rapid air movement it dusts very thoroughly and removes lint, which is often troublesome on dark-coloured materials. Two well-known makes of drying tumblers are the *Aladdin* (see fig. 85) and the *Vorclone*.

Purification and Recovery of Dry-Cleaning Solvents.

The soiled solvent after use contains in solution a proportion of benzine soap (usually potassium or ammonium oleate with excess of fatty acid), the oils and fats extracted from the goods, and a certain amount of colouring matter. It also has in suspension the dirt (inorganic substances, soot, etc.) and fibrous matter from the clothes themselves. To make the solvent fit for re-use, some method of purification is necessary.

On economic grounds, and to reduce the quantity of soiled solvent to a minimum, it is the practice in most works to use rinses as cleaning baths for fresh work by making an addition of benzine soap. Solvent that has been used on comparatively clean
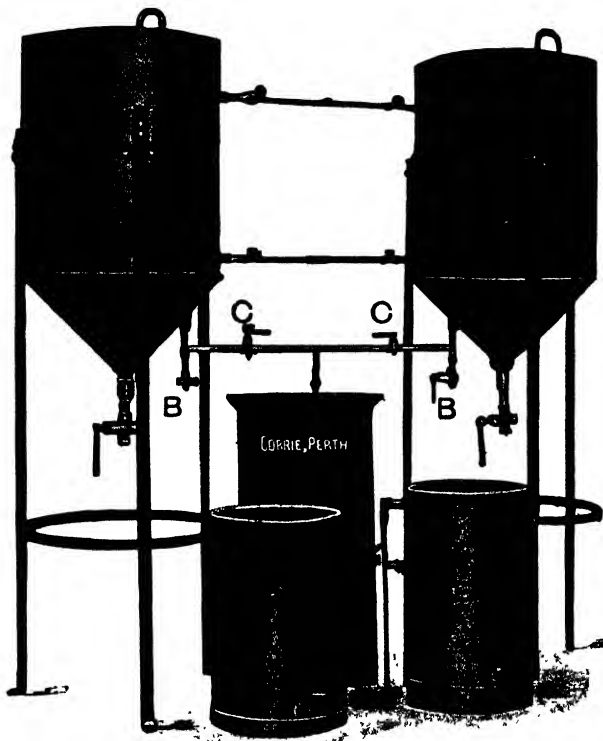

FIG. 25.—Petroleum Settling—Diagrammatic Illustration of General Arrangement of Tanks.

goods can be, and is, used for more soiled work by the simple process of settling by gravity in conical bottom tanks for a number of hours (fig. 25). After it has been allowed to settle in this way the solvent is usually termed " grey " spirit. It is not always advisable to use this " grey " or settled spirit for cleaning dark-coloured work—navy blues, blacks, etc.—as it contains " lint " in suspension, which spoils the appearance of the cloth and is most

difficult to remove. Improvements have been made in the direction of accelerating the rate of settling by chemical means.

The methods used for the purification of soiled dry-cleaning solvents can be classified as follows :—

1. Coagulating by chemical methods, followed by settling.
2. Centrifugal separation.
3. Distillation.
4. Filtration.

1. Coagulating by Chemical Methods, followed by Settling.

Simple settling by gravity is slow and has its limitations. Some of the lighter matter in suspension takes a considerable time to settle out, so that large stocks of spirit must be carried to make full use of the grey, settled spirit in cleaning.

Many investigators have worked on the problem of accelerating the rate of settling mainly by use of chemical reagents, followed by gravity methods. One of the earliest of such methods was the following :—

Acid-Alkali Method.—This removes both soluble and insoluble impurities (except non-saponifiable oils or fats, *e.g.* paraffin wax or mineral oil). Example : To 10 gallons of soiled benzine in an earthenware jar add ¾ lb. concentrated sulphuric acid, stir thoroughly and allow to settle all night ; the top liquid will now be comparatively free from dust and will contain the fatty acids, etc. Remove by syphon and add 1½ lbs. of caustic soda, 70 per cent., and stir well. Then allow to stand for some hours and syphon off the clear liquid, which will be ready for use. This method is obviously only suitable for small users. The chief objections to it are that it entails the use of corrosive chemicals, and the time required for both treatments is somewhat long. There is a danger also of traces of deposit remaining suspended in the solvent and lodging on the goods, thereby causing damage.

Caustic Soda Method.—The theory underlying this process is that the addition of a calculated amount of caustic soda neutralises the free fatty acid in the benzine soap to form a neutral soap, which, being less soluble in benzine, settles out, carrying the suspended dirt with it. To work the process successfully the caustic soda must be in the correct quantity, as a deficiency retards the settling, and an excess may cause damage to goods. By this method also, the dissolved colouring matter is not all thrown out.

Trisodium Phosphate and Activated Carbon Method.—In the U.S.A. the use of activated carbon as a decoloriser and purifier

for soiled solvent has increased during the last few years, and a method involving the use of this material, together with an alkali, is described (C. C. Hubbard) in *Technological Paper, No.* 280, of the *U.S.A. Bureau of Standards.* Tests carried out in actual dry-cleaning plants showed that trisodium phosphate in aqueous solution could be used quite successfully to replace the more dangerous caustic soda in neutralising the free fatty acid of the dry-cleaning soap, and when used with activated carbon produced a water-white spirit after separation of the soap, dirt, colouring matter and carbon as a sludge. It was found that one charge of trisodium phosphate and carbon was sufficient for the treatment of several successive batches of dirty solvent. After a number of batches had been treated the solvent retained its amber colour, so that this served as a guide to indicate that the charge was used up. An essential feature is that the precipitating reagents must be thoroughly mixed with the dirty solvent. This can be effected either with mechanical gear or compressed air. The equipment recommended consists of a conical-bottomed tank of 200–250-gallons' capacity, a $1\frac{1}{2}$-inch centrifugal pump, a super-heater, thermometer, gravity drainage line, and a mixing vessel arranged on a platform. The quantity of material for 200–250 gallons is 13 lbs. activated carbon and 12 lbs. trisodium phosphate. The method of working is as follows :—

Mix together $6\frac{1}{2}$ lbs. activated carbon with 10 gallons solvent in the mixing vessel. Pump into the 200–250 gallon tank. Repeat with a further $6\frac{1}{2}$ lbs. carbon, making 13 lbs. altogether. Dissolve 12 lbs. trisodium phosphate in 12 gallons water (hot if necessary), and pump the solution into the 250 gallon tank. Agitate with soiled solvent for 15 minutes and allow to settle for 10 minutes to 1 hour, according to time required. Draw off the clear solvent, which should be water-white, from above the sludge line.

A second, third, and successive batches of soiled solvent may be treated by mixing up the sludge from the previous treatment until the recovered spirit remains straw coloured, when a new charge of trisodium phosphate and activated carbon will be required for further batches. The sludge from the first treatment retains some solvent, the quantity not being increased with further batches. This sludge (about 30 gallons from a 250 gallon charge) is treated to recover the solvent entangled in it by mixing in a tank with an equal volume of water and allowing to settle for 12–24 hours. The clear solvent resulting can be syphoned or decanted off.

A modification of the process is to make use of a centrifugal clarifier, *e.g.* the de Laval, after agitation, and settle in the

cone-bottomed tank, the solvent being drained off above the sludge line, and passed direct through the clarifier, which removes the small amount of carbon in suspension and delivers a clear, water-white solvent.

Coagulation by the Use of Alkali and Castor-oil Fatty Acids or Castor-oil Soaps.—A comprehensive patent (H. Hey, British Patent No. 164931, 1921) protects the use of aqueous or alcoholic solutions of hydrates of potash, soda, or ammonia, strong aqueous solutions of the carbonates of potash, soda or ammonia, or other alkaline salts, such as borax, silicate of soda, aluminate of soda or the like, in the treatment of soiled dry-cleaners' solvents.   The clarification is quickened by the addition of castor oil, liquid castor-oil fatty acids, or liquid castor-oil soaps either separately or in admixture.   The fatty acids are converted into alkali soaps which are insoluble in the solvents and coagulate with the dirt to form a sludge which settles out.   The clear liquid is used again for cleaning purposes, while the sludge, which contains excess of reagent, can be used for clarifying further lots of dirty spirit.

The process is carried out in a closed cylindrical tank fitted with inlet pipes and valves for introducing dirty solvent and the reagents, and outlet pipes and valves for drawing off the clear solvent and the sludge.

The tank is connected with an air blower for thoroughly mixing the liquids by air circulation before allowing to settle by gravity. In an example the quantities recommended for 1000 gallons of dirty solvent are given as, $\frac{1}{2}$ gallon alcoholic or aqueous caustic soda, followed, after air circulation, by 1 quart of castor oil, liquid castor-oil fatty acid, or liquid castor-oil soap.

2. Centrifugal Separation or Clarification.

The clarification of dirty solvents is now being carried out by means of centrifugal separators, the best known in connection with dry-cleaning solvents being the *Sharples* and *de Laval*.

(*a*) **The Sharples Centrifugal Separator**, known also as the *Super Centrifuge* (figs. 26 to 28), runs at extremely high speeds. It is made in both belt-driven and steam-turbine types.   This is the hollow-bowl type of centrifuge.   The largest size, No. 6, has a bowl 36 inches long by $4\frac{1}{2}$ inches diameter and runs at 17,000 revolutions per minute.   It has a capacity of 600 to 1000 gallons per hour, this naturally depending upon the amount of matter in suspension in the solvent to be treated.   When first introduced for the clarification of dry-cleaning solvents, centrifugal separators
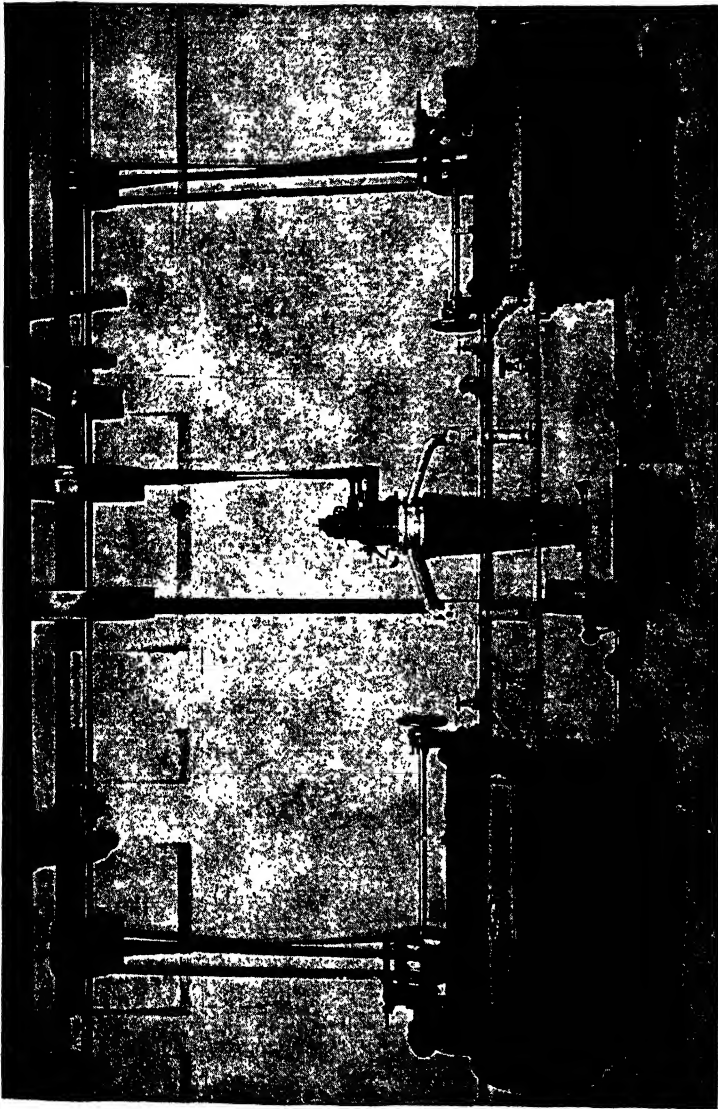
J. Stewart, Perth.

Fig. 28.—Benzine Cleaning Machines working in conjunction with "Sharples" Benzine Clarifier.

were used to substitute or supplement chemical methods of puri-
fying these solvents, and to remove suspended dirt from the
solvent before it entered the still for re-distillation, so avoiding
the furring of the tubes of the calandria.

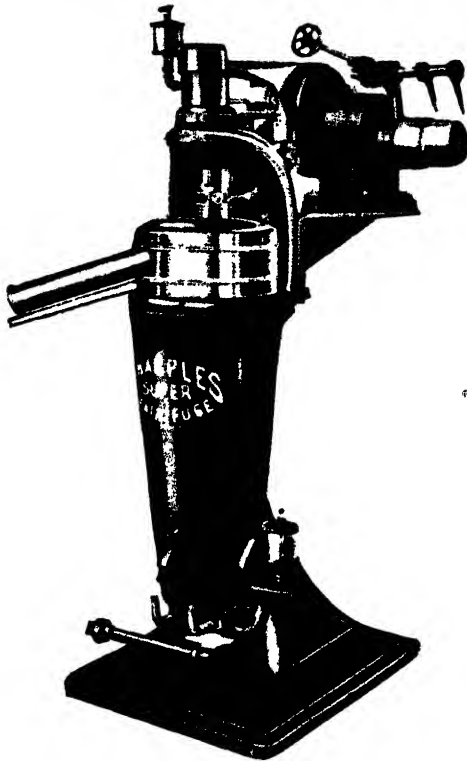While centrifuges can still be operated in this way they are

FIG. 27.—Sharples Super Centrifuge No. 5, with Belt Drive.

now being installed for use by the *Continuous Flow Process*. In
this method the clarifier is placed in direct connection with the
dry-cleaning machine itself. As the dirt is removed from the
garments the circulating pump delivers the dirty solvent (as it
becomes dirty) to the clarifier; the clarifier removes the dirt
and sends the clear solvent back to the cleaning machine.

The cleaning operation is complete in 20 to 30 minutes, after
which the solvent (as seen by the sight glass) clears up and

rinsing is continued in the same machine without the necessity of a fresh bath.

The makers claim that by the Continuous Flow Process it is possible to produce better work with less labour, at less cost, and in a shorter time.

(b) **The de Laval Separator.**—This is another well-known
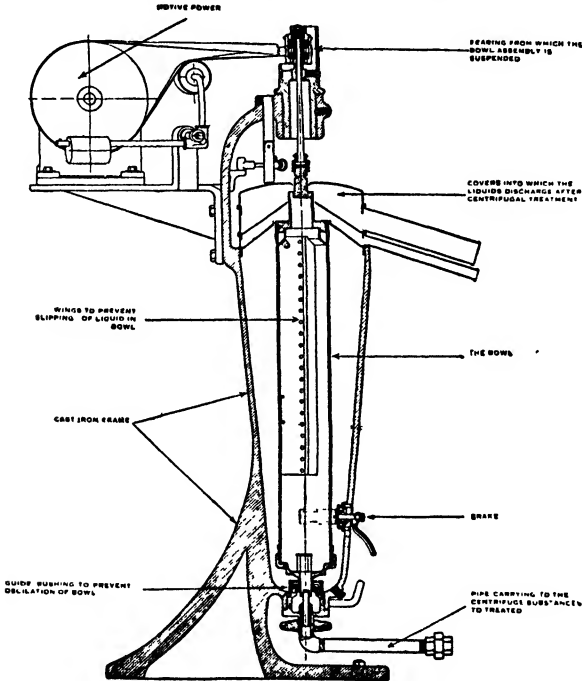

FIG. 28.—Section of Sharples Super Centrifuge No. 6.

centrifugal separator now being used by the continuous clarification method (figs. 29 and 30). The same principle applies of clarifying the dirty solvent by continuous flow from the cleaning machine to the clarifier and back again to the machine. The de Laval differs somewhat from the previous type of centrifuge.

It is not run at a higher speed than 6000 to 8000 revolutions per minute. This should result in a longer life to the working parts of the machine. The bowl of the machine is so constructed that the dirt collects in a special dirt space and does not clog up that part of the bowl used for clarification. There is thus no loss
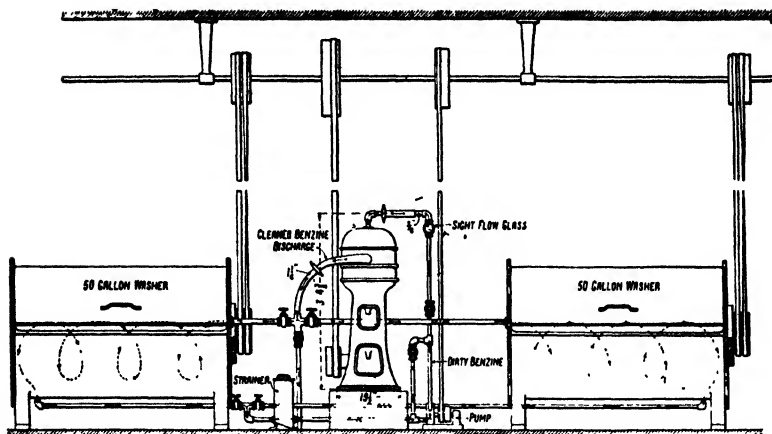
Alfa Laval Co.

FIG. 29.—" De Laval " Centrifuge with two Benzine Cleaning Machines.
Diagram of Continuous System.

Alfa Laval Co.

FIG. 30.—" De Laval " Centrifuge.

of efficiency from start to finish ; the machine can usually be run for several batches before it requires cleaning. The de Laval continuous clarification system has also been installed in connection with closed-circuit hot-spirit cleaning systems, *e.g.* the Barbe. One clarifier, Type 783, used with two large Barbe machines was found to reduce the cleaning period from 35 minutes to 10 minutes and to eliminate the need for separate rinsing. It was found when cleaning carpets by this method that only a light beating was required previous to cleaning to remove grit, etc., which might damage the valve faces. The dust wheel was not required for ordinary work, and the amount of spirit to be passed through the vacuum still for purification was very considerably reduced.

Amongst the advantages claimed for the de Laval clarifier, as against ordinary cleaning methods, are the following :—

(1) Less labour required, owing to shorter time of cleaning and elimination of rinsing.

(2) Finished work is better and colours brighter.

(3) Owing to rapid removal of loose lint, greys and dark colours can if necessary be cleaned together in the same load of work.

(4) Economy in solvent owing to less re-distillation being required, with a corresponding saving of steam and water.

(5) A lower stock of solvent and fewer machines required to turn out the same amount of work, or alternatively a larger output with the same plant.

The capital outlay involved in installing a centrifuge between each pair of cleaning machines is high. Against this may be set the economy effected on dry-cleaning spirit, as smaller stocks are necessary and less re-distillation is required. Cleaning is also completed in a shorter time by use of centrifuge as against ordinary methods involving separate rinse baths.

3. Distillation.

Two methods for purification of soiled solvent by distillation are employed, viz. distilling at normal pressure and at reduced pressure. The former method is usually employed in the smaller works, owing to the increased capital outlay necessary for a vacuum distillation plant.

A. **Distillation at Normal Pressure—Direct Steam Coil.**— The spirit usually employed boils over a range of from 80° C. to 150° C. and even higher, and as the temperature of steam at the pressure employed is very seldom higher and is generally

lower than 150° C., it is obvious that the heating of the spirit by coils will result in the higher boiling fractions remaining undistilled; the boiling-point is also raised by the matters in solution. It is therefore necessary to take advantage of the fact that live steam blown through benzine will vaporise and carry over with it spirit which has a boiling-point higher than the temperature of the steam employed. (Liquids boiling at a much higher temperature than benzine may be distilled in a current of steam in the same way, *e.g.* aniline B.P. 182° C., quinoline B.P. 239° C., etc.) This action depends on the fact that in distilling a mixture of two (or more) liquids boiling at different temperatures, *e.g.* liquid A with a boiling-point of 60° C. and B with a boiling-point of 150° C., all the fractions between 60° C. and 150° C. will contain both liquids, the lower fractions containing principally A and the higher fractions principally B. In this case the vapour of A boiling at 60° C. has been able to carry over a certain amount of B at temperatures much below the boiling-point of the latter.

The larger the proportion of high-boiling fractions contained in the benzine, the greater will be the amount of steam necessary to distil it, involving, of course, increased cost and an increased proportion of water in the mixed distillate.

The essential portions of a distilling plant (fig. 31) are:

> Still (with steam coil and " live " steam supply).
> Condenser.
> Separator.

The still consists of an iron or copper vessel varying in capacity from 20 gallons upwards, the size depending upon the volume of spirit requiring distillation. It is fitted with a steam coil for closed steam and a pipe or perforated coil for live steam, a gauge glass to indicate the amount of liquid in the still, an inlet for the dirty spirit, an outlet at the bottom for the undistilled residue, and at the top a swan neck leading to the condenser. The condenser consists of a copper coil in a cylindrical vessel through which water passes, the water entering at the bottom of the vessel and leaving near the top. The amount of cooling surface in the copper coil depends, of course, upon the capacity of the still.

The separator serves to separate the mixed distillate of water and spirit, and the method of employment is shown in the sectional drawing (fig. 32).

The capacity of the separator depends upon the size of the still, but for 100 gallons it should hold about 5 gallons, and so

on in proportion (the larger the separator in relation to the work it has to do, the more effective the separation of the benzine and water).

The benzine and water not being miscible, the two liquids enter-
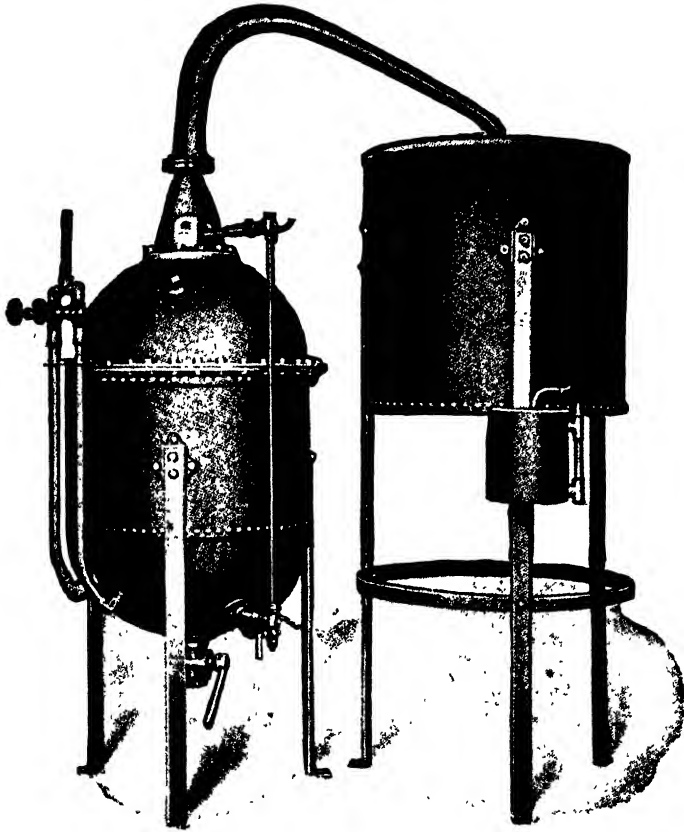
Fig. 31.—Benzine Distilling Apparatus.

ing the separator form two layers, the water with its higher specific gravity (1·0) being at the bottom, the benzine floating on the top. Coming out of the bottom of the cylinder is a **U**-tube B which acts as the outlet for the water ; the benzine outlet A is slightly higher than the point at which the water overflows. If we now

take the height of B as 10 inches and the height of A as 12 inches, it will be seen that a column of water 10 inches high can support a column of water and benzine (*i.e.* the liquids in the cylinder) 12 inches high when the proportions are as follows :—

Benzine (0·780 sp. gr.)	Water, 3 inches.
	Benzine, 9 inches.
Benzine (0·750 sp. gr.)	Water, 4 inches.
	Benzine, 8 inches.

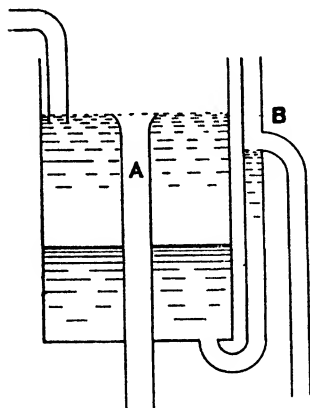Varying proportions of benzine and water in the distillate cannot affect the proportions in the separator, which depend solely upon the difference in height between the water overflow and the benzine overflow and the specific gravity of the benzine employed. In practice it is found advisable to have one or more gauze partitions in the separator, so that the distillate entering it may not stir up the liquid which is separating.

FIG. 32.—Sectional View of Separator.

The soiled spirit, having been agitated, is run into the still, the distillation is carried as far as possible with closed steam, after which the live steam is blown through the spirit until the gauge glass indicates that no spirit is floating on the surface of the water which has condensed in the still, and a sample of the distillate collected in a glass test-tube shows no indication of benzine. The spirit leaving the separator still contains a small quantity of dissolved water and some in a finely divided state in suspension, which may be removed by passing the spirit through a receptacle containing dry salt before running it into the clean spirit storage tanks, or by standing in settling tanks for several hours. The salt must, of course, be changed periodically (it can be employed again after drying). The water from the separator and the undistilled residue must not be run down the drain direct, as they may contain small quantities of benzine, but into a receptacle whence the semi-solid grease and dirt can be removed and disposed of, and the dirty water remaining may, after examination, be pumped into the drain, using a steam ejector for the purpose.

That benzine is soluble in water to an appreciable extent is

shown by E. Müller.[1]   The quantity dissolved depends upon the temperature of the water, and, in scrubbing a mixture of air and benzine vapour, upon their relative proportions.   With the temperature of the water at 16° C., the benzine dissolved amounts to 0·145 gram per 100 c.c. of water, and at 10° C., 0·190 gram per 100 c.c. of water.

B. **Vacuum Distillation.**—In order to re-distil the heavier petroleum spirit such as white spirit, 0·790–0·800 sp. gr., now being largely used, a vacuum still is almost a *sine qua non.*   When distilling under reduced pressure, the boiling-point of the solvent is lowered by lessening the atmospheric pressure on the liquid with a vacuum pump.   The form of apparatus usually employed is that of Messrs G. Scott & Son, Ltd., shown in fig. 33, and the plants in operation vary in capacity from 25 gallons per hour to 1500 gallons per hour or even more, the output naturally depending on various factors, *e.g.* the size of heating surface, the amount of steam available, and the boiling-point of the spirit being distilled.

The cylindrical vessel on the right-hand side of the illustration is the still, the heating surface being composed of a number of vertical tubes of different diameters so disposed that an extremely vigorous circulation is obtained, thus presenting a continually changed body of spirit to the heating surface.   By this intimate mixing of the still contents, a very full recovery of solvent is obtained, the proportion of spirit residues or " bottoms " being small.   In time, of course, the residues accumulate in the still, so that it is necessary to run these off periodically, say, at the end of the day.   The residues contain a proportion of the heavier fractions of solvent along with the benzine soap used in cleaning, and the oils and fats extracted from the clothes.   The heavier fractions mentioned may be recovered by direct steam distillation (already described).

In the modern type of Scott Vacuum Still, the still is made to permit of the use of steam up to, say, 120 lbs. pressure.   This enables heavy white spirit to be dealt with.   A pressure of 80 lbs. is usually quite sufficient, however.   A much deeper vapour top pan is also provided, to minimise the possibility of spurts of dirty spirit and soapy residues passing to the condenser.

For regulating the supply of dirty spirit to the still, an automatic vacuum feed control device (fig. 34) is provided.   This addition minimises the amount of attention required, and ensures that the still is worked under the most favourable conditions as regards feed level.   It is also an additional safeguard against the
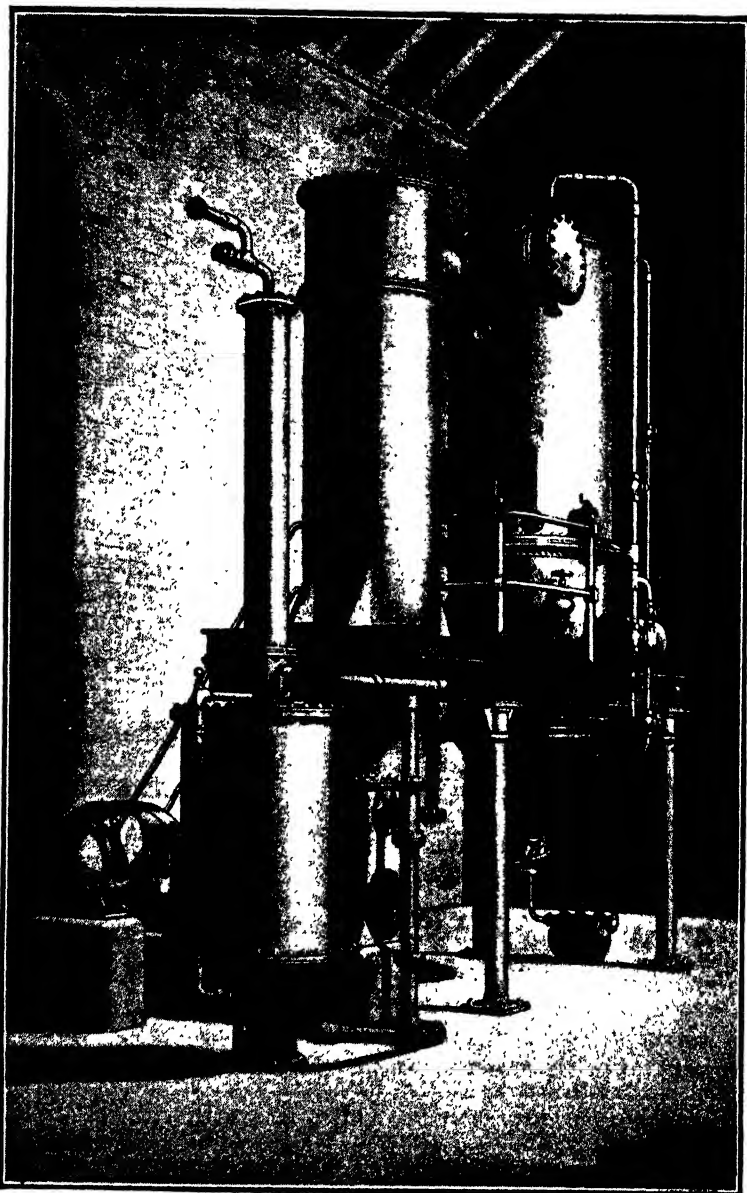
[1] *Journal für Gasbeleuchtung,* xli. (27), 433–435.

FIG. 33.—Scott Vacuum Still for Dry Cleaners (G. Scott & Son, London).

soiling of the distillate with the dirty spirit. When the feed control is set, the still can be worked at its maximum rate with little attention.

In working the still, the distilled vapour is conducted through a tubular heater condenser. (The horizontal cylindrical vessel at the top in the illustration.) This is placed between the still and the condenser, and is arranged to give two passages for the vapour and four passages for the dirty spirit entering the still. The spirit passes through the tubes, and is heated up practically to the same temperature as the contents of the still, by means of the outgoing vapour, while at the same time the vapour is cooled before entering the condenser proper.
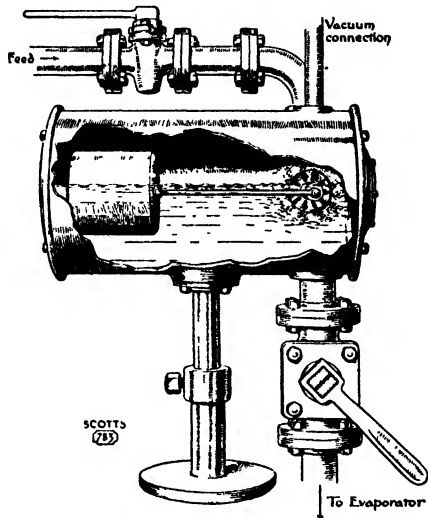
The condenser is of vertical, multi-tubular construction, with a large number of small tubes giving a large condensing surface. It is arranged so that the condensed spirit in the liquid form is directed over that part of the surface cooled by the coldest in-going water. The cooled condensed spirit is within about 2° F. of the temperature of the condenser water at the point of delivery into the receiver. The receiver is connected with the vacuum pump by a vapour pipe through which the vacuum on the whole apparatus is produced.

Fig. 34.—Scott-Bennett Vacuum Feed Control.

The vacuum pump is usually steam-driven, and is designed to permit of its being used for withdrawing the spirit. The water sealing of the pumps has now been eliminated, so that a dry distillate can be relied upon.

The advantages claimed by the makers for this apparatus are :—

1. Great economy in space, time, labour, steam, water, spirit.
2. No loss of product.

3. Safety from fire.   Whole operation entirely enclosed ; lower
   boiling-point ; cooler distillate.
4. Only exhaust steam necessary (except with high-boiling
   benzines).
5. No open steam used.
6. Superior distillate—bright, white, and dry.

They give as the mean figures taken on several trials of one
hour's duration, the following :—

Solvent naphtha distilled   .   . 400 gallons per hour.
Natural boiling-point .   .   . 230° F.
Specific gravity .   .   .   . 0·860.
Steam used   .   .   .   . 420 lbs.
Condensing water used   .   . 270 gallons.
Temperature of condensing water . In, 52° F. ; out, 184° F.
Temperature of distilled spirit   . 54° F.

The hot water from the condenser can, of course, be employed
in the dyehouse or in any operations where a regular supply of
heated water is required.

The process is a continuous one, the benzine being fed in by the
automatic feed valve, so that the feed just compensates for the
distillation.

In recovering benzine by either method of distillation a certain
amount of ammonia comes over with the distillates, being pro-
duced by the decomposition of ammonium salts and albuminoid
matters extracted from the clothes, etc.   Where live steam at
normal pressure is employed in distilling, this is largely washed
out of the spirit in the separator, owing to its great solubility in
water.   In distilling under reduced pressure, a considerable pro-
portion of the ammonia remains dissolved in the condensed spirit.
It is not particularly objectionable when the spirit is employed in
the ordinary type of cleaning machine, as, owing to its volatility,
it readily escapes.   When, however, the cleaning operations are
conducted in a closed circuit, as in the Barbe process, and the
distillation is carried on under a vacuum, the ammonia cannot
escape and increases slightly with each batch of articles cleaned
with the spirit.   The quantity of ammonia then present (especi-
ally when heated) may attack the copper in the fittings of the
machines, or the colours in fabrics, when the latter are such as
are readily affected by alkalies.   Where the benzine soap used in
cleaning consists of ammonium oleate the condenser tubes of the
vacuum still should not be made of copper, as this metal soon
corrodes with ammonia fumes.

4. Filtration.

The *Stream-line Filter*, embodying a new system of edge filtration, which is the invention of Dr. H. S. Hele-Shaw, is now successfully applied to the clarification of soiled dry-cleaning solvent. The experimental work in connection with the use of the " Stream-line Filter " has been largely carried on under the direction of Professor J. W. Hinchley.[1]

The stream-line filter used in works practice is built up of a number of units comprising filter columns with circular rings of specially prepared paper fitted on to square rods (fig. 35). These columns of paper can be compressed to any desired extent by the use of adjustable springs placed outside the filter (so that the machine need not be opened), and the amount of compression determines the size of the channels between the papers through which the solvent flows.

One of the difficulties is the presence of water in the dirty solvent in addition to the soap used for cleaning. This may be present in such quantity as to impede the rate of passage through the filter. According to the character of the dirty solvent the rate of flow may vary between 250 gallons and 1000 gallons per hour. It is found that by heating the dirty solvent to 70–80° C. before entering the filter, the process of filtration is facilitated.

The pre-heating of the solvent is effected by pumping it through a heat exchanger, and then through a small chamber heated by a steam coil controlled by a thermostat, on its way to the container of the filter ; the direction of flow is from the outside of the packs to the inside, the dirt remaining on the edges of the rings and the clear liquid passing between the compressed layers of paper to the inner spaces. It then passes up round the square rods in the centre of the packs through holes in the plate at the top and out of the filter through a pipe. The dirt collecting on the outside of the packs is cleared usually every hour by means of compressed air or carbon dioxide admitted by suitable cocks. This dirt, which accumulates in the cone at the base of the filter, is blown daily into a small steam-jacketed sludge still arranged with a stirrer to prevent caking of the dirt.

The advantage claimed for the stream-line filtration process of dealing with dirty solvent as against any method of chemical precipitation is that, there being nothing added to the solvent, there can be no danger to the goods from excess of reagent. The percentage loss of spirit is stated to be very small and the purity of the filtrate good.

[1] *J.S.C.I. Trans.*, March 1925, pp. 117–123.

As the soluble oils and fats remain in the filtered spirit, the dry-cleaned goods rinsed with it have a kinder feel than when rinsed
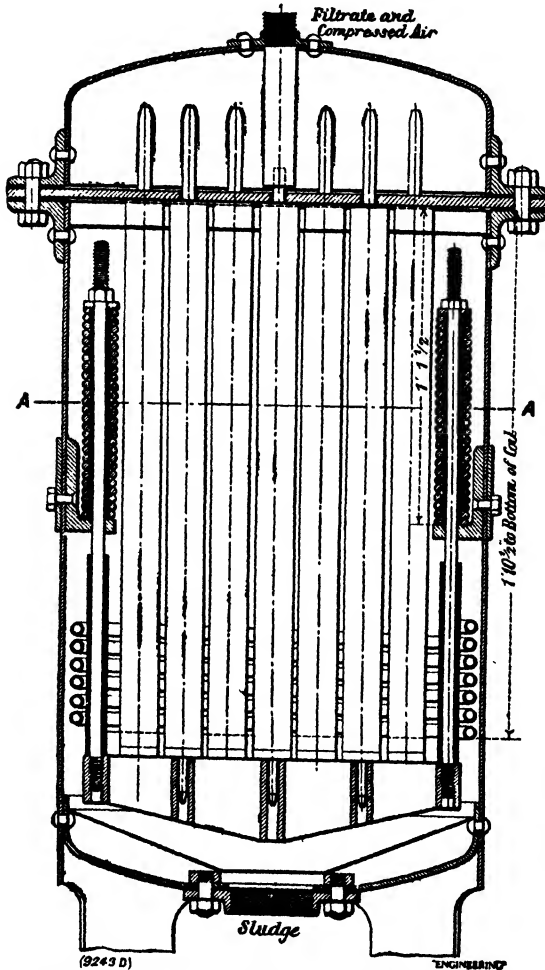

FIG. 35.—Stream-line Filter; Section showing Interior.

with a distilled spirit. On the contrary, it is of course necessary to distil a proportion of the dry-cleaning solvent, as otherwise an excessive amount of fat will accumulate and the spirit will also

become too dark in colour, owing to the accumulation of mineral oil from the clothes.

A noteworthy feature of the plant is the ease with which the sludges are dealt with, and as the satisfactory disposal of sludges is always a matter of difficulty, this point is of some importance.

Clarification by Means of Sulphonated Oil and Sulphon-ated-oil Soaps.—The flocculation of suspended matter in dry-cleaning solvents by means of sulphonated oil and sulphonated-oil soaps is protected in British Patent No. 176540 (1920), H. Hey.

The soiled solvent is intimately mixed with small volumes of sulphonated oil, water, and alcoholic solutions of sulphonated-oil soaps of potash, soda, and ammonia. After sulphonation the product can be used in the acid state or afterwards washed with saline solutions to remove excess of acid.

In an example, the proportions given are 100 gallons spirit, 1 pint sulphonated oil or 2 pints sulphonated-oil soaps. The soaps are diluted with petrol, benzol, or solvent naphtha. The sulphonated oil, when used as the coagulating medium, is added to the soiled spirit on its way to the settling tanks. The separation is rapid and is complete in about 20 to 30 minutes. Care should be taken that no acid sludges are entangled in the settled solvent when transferred to the tank system, or damage to the metal parts will result.

Clarification by Means of Finely Divided Silica.—An improved continuous process of dry cleaning which introduces finely divided, porous, cellular silica as a " filter aid " has been developed by E. A. Alliott, A. E. Hatfield, and Achille Serre, Ltd.[1]

By this process the goods are cleaned in any good type of rotary dry-cleaning machine, but the essential feature is that during the cleaning the soiled solvent is withdrawn very rapidly from the machine by means of a pump and is forced through a filter press and back again to the machine. The cleaning machines most suitable for the " Serre " continuous process are those of the enclosed vacuum type, *e.g.* Smith Multi-Compartment Machines. These are best run in pairs and worked alternately, the actual cleaning being carried on in one while the other is occupied in hydro-extracting, emptying and refilling with goods. A 6-feet Smith machine will take about 350 lbs. weight of clothes and 300 gallons of dry-cleaning solvent.

After loading with goods and solvent, the machine is set in motion and the soiled spirit withdrawn by the pump and forced through the filter press. (A Sweetland filter press is recommended

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[1] English Patent No. 266850, 21st December 1925; accepted 10th March 1927; *J.S.C.I.*, 1928, pp. 139–152; *J.S.D.C.*, 1928, xliv. 170–176.

because it is so much easier to clean than the ordinary Plate and Frame filter.) This intercepts the dirt and foreign matter, so that clarified solvent returns to the cleaning machine. The process is continuous, the treated and filtered liquid being returned to the cleaning machine at such a rate that the solvent therein is changed every 2 to 3 minutes.

The cleaning process is continued for 20 minutes and the circulation of solvent proceeds throughout the whole cleaning period, the solvent in the machine thus being changed seven or eight times. It would appear that it is in the extremely rapid and thorough clarification of the solvent that this process holds an advantage over earlier methods. The goods in fact are continually being flushed with clean solvent and the dirt removed almost as quickly as it falls from them. After 20 minutes cleaning, the goods are hydro-extracted in the machine, which is then emptied and charged with a further load of goods. Most ordinary work does not require rinsing, but white silks and wools are usually rinsed with fresh distilled spirit.

The Function of the " Filter Aid."—During the passage of the dirty solvent from the cleaning machine to the pump, a measured amount of " filter aid " in suspension in solvent is added. The function of the filter aid is to absorb moisture, entrap dirt, and keep the deposit on the filter sufficiently porous to allow the free circulation of solvent. Unless a suitable filter aid is used in the correct proportion, the slimy deposit soon forms a film, causes the filter to clog and the circulation of solvent to break down. By using the filter aid in sufficient quantity, a porous cake is built up in the press, which allows a free passage of clarified solvent.

In order to arrive at the correct proportion of filter aid a special mixer and agitator is provided, in which a weighed amount of " super-cel " or " filter-cel " is churned up with a definite volume of solvent. This feeds a proportioning apparatus which regulates the addition of the filter-aid suspension to the soiled solvent. The proportion of the filter aid can be regulated by operating a valve which controls the inflow of filter-aid suspension to the system.

Experience shows that the largest proportion of dirt is removed from the goods during the first few minutes of cleaning, and during that period the filter-aid suspension is fed in at a rapid rate. Towards the end of the operation very little is required to clear up the solvent, so that the inflow of filter aid is checked at that stage, with resulting economy. The rapid removal of dirt during the cleaning operation renders it possible to clean light- and dark-coloured clothes in the same liquor, though it is

the usual practice to separate such loads into the different compartments of the machine. No harm appears to result even from a loosely dyed article which temporarily stains the solvent, as the dye is trapped in the filter and the solvent so quickly cleared up that no staining of other goods in the machine takes place. As mentioned previously, most of the work is hydro-extracted straight from the solvent used in cleaning, and in this connection it is actually considered beneficial not to rinse as the small amount of olein left in the goods imparts to them a soft handle.

Dry-cleaning Soaps for Use in the Continuous Filtration Process.—A feature of the process is the use of a suitable dry-cleaning soap. The soap should have good solubility in the solvent, and dissociation should not take place when a very dilute solution (1 : 1000) is allowed to stand for 24 hours at a low temperature. Soaps considered particularly suitable are protected under British Patent No. 289582, 3rd May 1928 (A. E. Hatfield, E. A. Alliott, and Achille Serre, Ltd.), and are stated to give superior results in dry cleaning.

The fatty acid used is pure " frozen " oleic acid of low melting-point—below 36° F., preferably below 29° F.—which is wholly or partly saponified by ammonia, potassium or sodium hydroxide, or carbonate. If a neutral soap is prepared it may be diluted with cyclohexanol and a proportion of water or spirit. The introduction of a comparatively large proportion of water to the neutral soap as a true solution is claimed to increase the emulsifying effect on water soluble stains so that clothes dry cleaned with it require less spotting. Cyclohexanol may be replaced wholly or partly by one of the chlorinated hydrocarbons, *e.g.* pentachlorethane, trichlorethylene, or perchlorethylene, and of these the best results are claimed for a mixture of cyclohexanol and perchlorethylene.

Examples of suitable dry-cleaning soaps prepared under British Patent No. 289582 are as follows :—

(1) 100 lbs. of a spirit-soluble soap in which 25 to 35 per cent. of the fatty acid is left unsaponified.

70·58 lbs. of pure oleic acid are placed in a jacketed mechanical mixer and raised to a temperature of at least 170° F. To this is added slowly and with agitation an aqueous solution of 12·5 lbs. pure potassium carbonate, or an equivalent amount of sodium carbonate, or potassium or sodium hydroxide, or ammonia (sp. gr. 0·880). The solid alkalies are previously dissolved in 8 lbs. boiling water. The alkaline solution is added slowly, during which time ebullition takes place.

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When saponification has occurred to the extent of 65 to 75 per cent. an addition is made of 9 lbs. of alcohol or industrial methylated spirit, which is mixed in thoroughly. The soap thus prepared is diluted as required with solvent.

(2) 100 lbs. neutral spirit-soluble soap with chlorinated hydrocarbons.

45·55 lbs. pure oleic acid are placed in a mechanical mixer and raised to a temperature of at least 170° F. To this is added an aqueous solution of 11·38 lbs. pure potassium carbonate, or an equivalent amount of potassium or sodium hydroxide, or ammonia (sp. gr. 0·880). The solid alkalies are previously dissolved in 15·56 lbs. of boiling water. The alkaline solution is added slowly until saponification is complete. When the ebullition has subsided, 27·51 lbs. of perchlorethylene or pentachlorethane or trichlorethylene are added. The soap thus prepared can be diluted with solvent as required.

(3) 100 lbs. neutral spirit-soluble soap with cyclohexanol.

The soap is prepared as in (1), but in place of the chlorinated hydrocarbons, 27·51 lbs. cyclohexanol are added. More than this quantity may be added if required to increase the solvent action of the soap, or the cyclohexanol may be partly replaced by one of the chlorinated hydrocarbons mentioned under (2).

The Serre-Alliott continuous-filtration process is adapted for silks, wools, dress-work, and furnishings. Carpets and rugs can be cleaned by this method, but on account of the larger content of dust and dirt the period of cleaning is longer, 30 minutes being generally necessary instead of 20 minutes, the normal period for clothes.

As compared with other methods of cleaning, the " Serre " continuous-filtration method shows an economy in time, and the results in regard to quality of cleaning, handle of goods, and absence of dust and dirt are undoubtedly good. The process is also claimed to show economy in soap, as the soap remains in solution after filtration and smaller additions of soap may be made when cleaning subsequent loads. The same solvent is used repeatedly for cleaning further lots of work, until the colour becomes too dark on account of the accumulation of mineral oils from the clothes. It is then re-distilled. On account of the large number of loads cleaned by the same liquor (after filtration) the amount of distilled spirit required is small, so that stocks can be cut down. As the process is so much shorter than usual and only one liquor is necessary instead of two or more, as required for

the batch method, it follows that a larger number of loads can be cleaned per machine, so that a cleaning plant converted to this filtration method will turn out much more work with the same number of machines.

From the hygienic point of view an advantage is claimed in that most bacterial and germ life is trapped in the filter press.

Against the many advantages it is necessary to mention the heavy capital outlay, the cost of material, *e.g.* filter aid and special soaps, and the running costs.

Stain Removal, or " Spotting."

Articles which have been dry cleaned according to any of the methods described are frequently found to have retained stains which have not been affected (or only partially affected) by the benzine, and in addition to stains, a certain amount of ingrained road dirt may be found.

Among the stains which are frequently met with, the following may be specified :—

Paint, tar, wax, resin, pitch, and varnish stains.

Milk, water, white wine, scent, and other colourless liquid stains.

Stains from coloured foodstuffs, such as fruit, wine, beer, tea, coffee, etc.

Ink stains from writing, marking or copying inks.

Dyestuff stains (frequently colours which have " marked off " or " run " from other garments).

Blood and menstrual stains.

Perspiration.

Iron-mould.

Mildew.

Grass stains.

Articles are frequently found which have been stained with mud or with water to such an extent that local treatment is of little value. If there is any prospect of a satisfactory result being obtained, mud-stained articles are brushed on the slab with a strong (10 per cent.) solution of benzine soap, with or without the addition of methylated spirit, which is miscible with a strong solution of benzine soap in benzine, and with or without the further addition of ammonia, subsequently rinsing in clear benzine. With coloured goods care must be exercised in employing methylated spirit or ammonia, particularly the latter, as many colours are wholly or partially decolorised by it. A small portion

of the article should first be tested, especially if basic violets or green colouring matters appear to have been employed. It is therefore important to note that the following colours are wholly or partially decolorised by aqueous ammonia (25 per cent. NH_3) (Cain and Thorpe) ; the fabric employed in the test is indicated in brackets.

> Patent Blue V (silk).
> Red Violet 4 RS and 5 RS (wool).
> Acid Violet 2 B (wool).
> Acid Violet 4 BN (wool) ; colour returns in air.
> Alkali Violet (wool).
> Water Blue (wool).
> Methyl Violet B (wool).
> Azo Green (with chromium-mordanted wool).
> Light Green, yellowish (wool).
> Light Green, bluish (wool).
> Malachite Green (wool).
> Brilliant Green (wool).
> Neptune Green S.G. (wool).
> Acid Magenta (wool).
> Magenta (wool and cotton).
> New Magenta (wool and cotton).

If brushing in the manner described does not produce a satisfactory result, nothing further can be done with fabrics which cannot possibly be treated with water ; but with plain dyed or printed muslins, and soft silks, delaines, serges, etc., the articles are subjected to " *water brushing.*"

All the grease having been removed by the benzine, the cold water readily penetrates the fibres, rendering the use of soap unnecessary. With coloured articles it is advisable to add a small quantity of acetic acid to the water.

The articles to be water-brushed must be done as quickly as possible—that is, brushed, rinsed, sheeted up, hydro-extracted, and dried without delay. In this way many articles which could not possibly be wet-cleaned with ordinary soap, and which are but slightly improved by dry cleaning, yield very good results.

We now come to the removal of stains, or spotting, and in this connection it is of interest to note that the art of spotting is of considerable antiquity, a book on this subject having been published as early as 1583, being entitled *A Profitable Boke Declaring Dyuers Approoued Remedies to take out Spottes and Staines in Silkes, Veluets, Linnen, and Woollen Clothes . . . taken out of Dvtch and Englished by L. M. (Leonard Mascall).*

Spotting should be done in a well-lighted room (preferably roof-lighting with a north aspect), and the reagents employed may be applied by a glass wash-bottle (similar to those shown in the illustration of a spotting table, fig. 36), or may be applied with a small glass pipette or a piece of glass rod. It is sometimes necessary to heat a small portion of fabric under treatment; this is best done by a small steam jet with a vulcanite or other non-conducting holder, fitted to a flexible metallic steam pipe.

The agents employed in spotting must be very carefully selected, as they must not affect the colour or colours of the fabrics; the fibres must not be injured in strength or appearance; and no sweal mark or stain must remain after the original stain has been removed. The avoidance of this, however, is largely a matter of skill and practice. Whenever possible, organic solvents must be employed, as they are less liable to affect the colours, and they have no deleterious effect upon the fibres. In employing inorganic liquids or solutions it must be borne in mind that mineral acids have an injurious action upon vegetable fibres, and alkalies upon animal fibres, whereas vegetable fibres will withstand the action of alkalies, and animal fibres will withstand acids.

The principal organic solvents employed in spotting are :—

Acetic ether (Ethyl acetate).	Glycerine.
Acetone.	Chloroform.
Alcohol (Methylated spirit).	Phenol.
Amyl acetate.	Cresol.
Amyl alcohol.	Ether.
Aniline.	Pyridine.
Benzine.	Turpentine.
Benzol.	Trichlorethylene (*Westrosol*).
Carbon tetrachloride.	Tetrachlorethane (*Westron*).

These liquids are employed alone or in combination.

Celanese Spotting.—In connection with the use of organic solvents for spotting purposes special precautions must be observed with articles made of cellulose acetate, *Celanese* artificial silk. This fibre dissolves completely in several commonly used organic solvents, *e.g.* acetone, aniline oil, chloroform, pyridine, tetrachlorethane (*Westron*).

It is therefore important in the first place that the fibre should be recognised, the most reliable test being to place a thread in acetone. This dissolves cellulose acetate at once but does not affect other artificial silks or real silk.

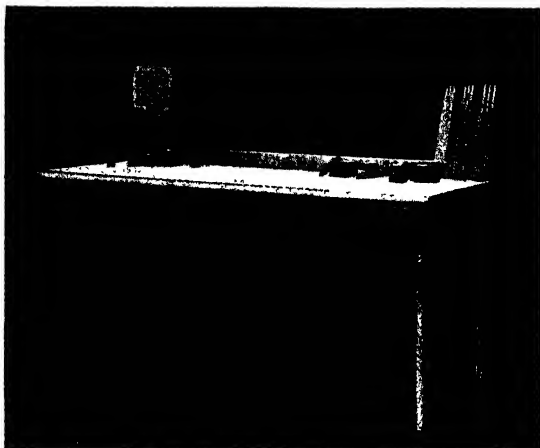M. H. Goldman and C. C. Hubbard have carried out investiga-
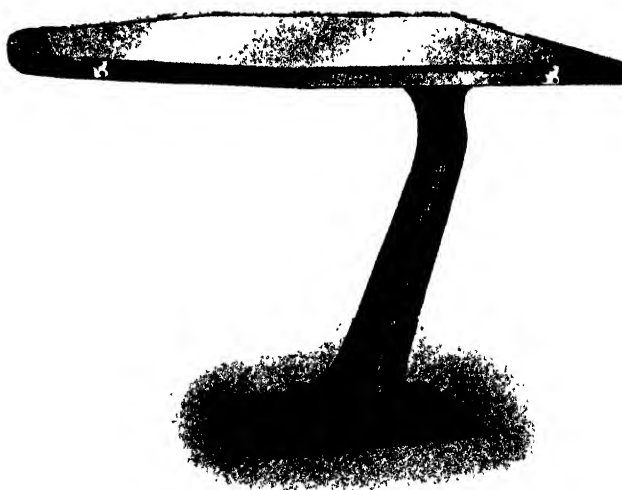
Fig. 36.—Spotting Table.

Fig. 37.—Spotting Table (on Stand).

tions to determine suitable methods for spotting Celanese (*U.S. National Bureau of Standards*).

The solubility of cellulose acetate in common spotting reagents was tabulated as follows :—

Soluble in—

Acetic ether (Ethyl acetate).	Formic acid.
Acetone.	Glacial acetic acid.
Alcohol *plus* benzol.	Nitrobenzene.
Alcohol *plus* ether.	Ortho-toluidine.
Amyl acetate.	Phenol.
Aniline.	Pyridine.
Chloroform.	Tetrachlorethane (*Westron*).
Cresol.	Triethyl phosphate.
Ethylene dichloride.	

Less soluble in—

Carbon tetrachloride.	Trichlorethylene (*Westrosol*).
Amyl alcohol.	Methyl alcohol.
Ethyl alcohol.	

Not soluble in—

Dilute alkalies.	Benzine.
Benzol.	Glycerine.
Carbon bisulphide.	Solvent naphtha.
Chlorhydrin.	Turpentine.

An interesting point that arises from the table is that benzol containing a small proportion of alcohol dissolves cellulose acetate at 50° C., while individually benzol has no action and alcohol only a very slight effect.

At 50°–55° C. alcohol and trichlorethylene delustre cellulose acetate.

It was found that glycerine, when used in admixture with solvents that ordinarily dissolve cellulose acetate, acted as a protective agent; for example, a solution consisting of 3 parts glycerine, 2 parts glacial acetic acid, and 1 part acetone, had no harmful effect. After identification of the fibre the approved method of spotting cellulose acetate is as follows :—

1. Select the most suitable spotting reagent for removing the stain and mix that reagent with an equal volume of glycerine.
2. Spot the stain as usual.
3. Sponge off with water until the reagent is removed.

Of inorganic substances (in fact, of all spotting agents) the most useful is water—hot or cold. A very large number of stains can be removed by its use—*e.g.* blood stains, food stains, etc. The stained area is laid upon a clean cloth, or, if possible, is stretched upon two closely fitting concentric rings (such as are employed in darning by machine, etc.). It is carefully sponged with cold or warm water, care being taken to avoid the use of more water than is absolutely necessary; after the removal of the stain the place is dabbed as dry as possible with a dry cloth to avoid the pro- duction of a sweal mark on drying. With silk fabrics a small
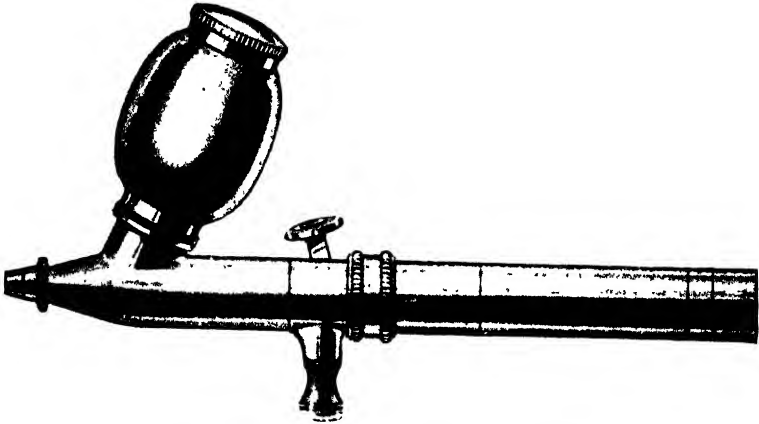

FIG. 38.—Aerograph Spray, Model " C," for Spotting.

quantity of acetic acid is used in the water; this preserves the scroop and lustre of the fabric. The other substances employed in spotting will be referred to in the following summary of the methods employed for removing the various stains which are encountered.

Grease, Oil, and Wax Stains.—These are generally removed during dry cleaning, unless the wax is present in any quantity, or the oil is one that has been rendered insoluble by oxidation (*e.g.* linseed oil). Wax may be removed by scraping carefully, after- wards employing benzol. Oils rendered insoluble in benzine by oxidation must be dealt with in the same way as paints. After the removal of oil stains it is frequently found that an iron stain remains. This is dealt with in the manner described under " Iron- mould."

Paint, Enamel, and Varnish Stains.—The removal of these stains, which frequently contain oxidised oils, depends to a large

extent upon the age of the stains. Fresh stains may sometimes be removed by benzine or benzol, in which case the ordinary dry-cleaning process is effective. If benzine or benzol will not remove paint stains, the following solvents may be employed, viz. chloroform, carbon tetrachloride, ether, acetone, nitrobenzene, aniline, trichlorethylene, or tetrachlorethane. Of these, ether is the most satisfactory, particularly with old stains, but should not be employed unless the other solvents fail, owing to its low boiling-point and the consequent loss by evaporation. Acetone is not so volatile as ether, and generally softens old paint stains satisfactorily. The solvent which gives the most satisfactory results in practice is aniline, as it is not so mobile as ether and acetone, and with its high boiling-point does not evaporate quickly. It should be used with care owing to its poisonous nature. Enamels frequently contain nitrocellulose, and are readily removed with a mixture of acetone and amyl acetate in equal parts or by acetone alone. This method is better than the employment of a mixture of ether and methylated spirit, which will not dissolve all nitrocelluloses.

Resin varnish and resin stains in general may be removed with aniline. Shellac varnish stains (and sealing wax) may be removed with methylated spirit in which the shellac is readily soluble.

Tar and Pitch.—If these stains have not been removed by benzine they should be treated with benzol. For pitch stains the most satisfactory solvent is aniline. Failing these reagents the stains may be removed by the use of ether.

Blood.—The stains are generally removed with water; with white linen and cotton goods this treatment can be followed by treatment with sodium hypochlorite solution; wool and silk goods may be treated with a solution of neutral soap in methylated spirit. Polyzime P, an enzyme product, also gives good results.

Fruit, Tea, Coffee, Wine, and Beer.—These must first be sponged with warm water, followed in the case of linen or cotton goods by treatment with a solution of sodium hypochlorite. White wool or silk goods are treated with a solution of potassium permanganate; this oxidises the colouring matter and leaves a brown stain of manganese dioxide, which, after sponging with water, is removed by treatment with a solution of sulphurous acid. Coloured goods must be carefully tested by taking a few threads from a seam or other portion which does not show, and if the colours are fast to dilute sulphurous acid, the stained portions may be treated with that reagent; in the same way hydrogen peroxide may be employed, after first testing the colours for fastness to

oxidation. If neither of these methods can be employed, sponging with warm water alone or with the addition of soap, and treatment with a solution of soap in methylated spirit, are the only safe processes to adopt. With tea stains, treatment with 5 per cent. acetic acid solution is usually effective.

Iron Stains.—These stains may be removed from white cotton and linen goods by spotting with titanous chloride, with or without the addition of a small quantity of hydrochloric acid. The titanous chloride must then be thoroughly rinsed out of the fabric. Titanous salts are not suitable for wool or silk. Iron stains can also be removed from linen and cotton goods with oxalic acid, but the former method will be found more expeditious. With woollen and silk fabrics oxalic acid may be employed, the stains being spotted with a strong aqueous solution ; or the spot may be moistened with warm water and a mixture of equal parts of powdered citric acid and cream of tartar rubbed into it. After the removal of the stain the place is well rinsed. White wool or silk fabrics may be treated with a warm dilute solution of hydrochloric acid to soften the stain before treating as above. Dilute hydrofluoric acid is more effective than hydrochloric acid. It should be kept in gutta-percha bottles.

A proprietary article known as *Erusticator*, which appears to contain hydrofluoric acid and fluorides and is supplied in lead squeezer tubes, is very useful as an iron stain-spotting agent. Even iron-mould of long standing will respond to treatment with this material. It is necessary to sponge off thoroughly after spotting the stain to avoid damage to colour or material.

Sodium hydrosulphite gives very good results in removing iron stains from all white fabrics and from coloured goods where the dyestuff is not affected by the reducing agent. Coloured materials should always be tried first, as most acid and direct cotton colours are affected by this inorganic salt.

The following recipes for removing rust are published by the B.C.R.A.,[1] 15th September 1925 :—

Dissolve   1 oz. Oxalic acid and
            1 oz. Acid potassium fluoride } in 1 quart water.
Or
            1 gm. Oxalic acid
            1 gm. Acid potassium fluoride } in 40 c.c. water.

Dab with solution until the stain disappears, rinse with water and finally with ammonia—no appreciable damage to cotton fabric in a period of 24 hours' contact results.

[1] British Cotton Research Association.

Ink Stains, Marking Ink.—The older type of marking ink which develops black with hot iron is a silver ink. This may be removed with potassium cyanide, which converts the silver into soluble silver cyanide. On account of the poisonous nature of the cyanide the greatest care should be exercised in its use.

Most marking inks now consist of solutions to produce aniline black in the fibre or solutions of aniline black itself. When the marking-ink stains are fresh they can generally be removed with aniline oil, but after thoroughly developing (old stains) they are most difficult to remove without damage to the material. Warm aniline oil, which is harmless to the fabric, may be used to take away the greater part of the stain, and potassium permanganate followed by sulphurous acid to clear up the remainder of the ink. A solution of benzine soap in chloroform is also useful as a medium for clearing marking ink. On coloured materials, unless aniline oil dissolves the ink, it is practically impossible to remove it entirely without damage to colour.

Copying Inks.—Violet and other copying inks generally consist of a solution of glue, glycerine (or other hygroscopic substance), and a basic colouring matter (methyl violet). They can generally be removed or decolorised by treating with a mixture of methylated spirit and ammonia [sp. gr. 0·880 (5 : 1)] for silk goods; and for white cotton and linen goods by a dilute solution of caustic soda or a 25 per cent. aqueous solution of ammonia. A good solvent for the basic colour in copying inks is amyl alcohol.

Writing Inks.—These are generally made from iron and substances containing gallic and tannic acids. They can be removed from silk and woollen goods by treatment with warm dilute sulphuric acid, hydrochloric acid, or oxalic acid. The same method may be employed for cotton and linen goods, but greater care must be exercised, owing to the destructive action of mineral acids on cellulose; for this reason it is better to spot the stains with strong acetic or formic acid, and allow the goods to lie for some time. This will frequently soften the stain and enable it to be removed without unduly long treatment with mineral acids.

Grass Stains.—These are removed by ether, in which the colouring matter of grass—chlorophyll—is soluble. Some spirit soaps are good solvents for grass stains.

Colour Stains.—With white cotton and linen fabrics employ titanous chloride. For white woollen and silk articles the best results are obtained with one of the stable hydrosulphites, with the addition of acetic acid and warming by means of a steam jet, etc. If the stains are from basic colours, a mixture of four parts of methylated spirit and one part of ammonia (0·880 sp. gr.)

may be employed (see p. 100 for list of colours decolorised by ammonia). In removing colour stains from coloured goods great care must be exercised, as the colours of the fabric may be more susceptible than the stain to the agents employed. It is generally possible to determine by experience the dyes which are likely to have been employed by the style of fabric, etc., but in case of doubt a few threads can be unravelled from a seam and tested with the reagent to be employed. Colour stains in coloured linen and cotton goods may be removed by immersion for a few minutes in a 10 per cent. solution of titanous chloride.

An interesting study of the *raison d'être* of stain removal has been made by D. B. Lake,[1] in which he traces the analogy between stain removal and the removal of dyestuffs from the fibres. He incorporates in his study a classification of the principles underlying stain removal based on this analogy, which has been proposed by Professor Bancroft, with examples in each group :—

1. *Mechanical removal :*

 Hand (with brush).

2. *Dissolving in a liquid :*

 Grass in alcohol, benzine.
 Sugar in water ; dyes in hot water.
 Iodine in alcohol.
 Syrup in warm water.

3. *Peptizing in a liquid :*

 Balsam of Peru with kerosene or alcohol.
 Dyes in hot water ; chocolate with hot water.
 Machine oil with turpentine.
 Grease with gasolene.
 Glue with warm water.
 Milk with cold water.
 Paraffin with benzine or kerosene.
 Pitch with benzine.
 Vaseline with turpentine.

 Coffee tannin with boiling water.
 Iron rust with kerosene.

4. *Peptizing with a solution :*

 Dyes with sodium carbonate, ammonium sulphate, borax.
 Blood with ammonia.
 Soot with sodium hydroxide (2 per cent. solution).
 Glue with acetic acid.
 Paint with sodium carbonate.

5. *Peptizing with peptized colloid :*

 Blood with soap.
 Soot and iron rust with soap.
 Cream with soap.
 Perspiration with soap.
 Kerosene with soap.
 Meat juice with soap.

[1] *Journal of Physical Chemistry* (U.S.A.), **xx. 9, 761.**

6. *Peptizing in two stages :*

>Tar with oil and soap.
>Grease with oil and soap.
>Tea with glycerine and soap.
>Black shoe polish with oil and soap.
>Grass with benzine and soap.
>Rosin with oil and soap.
>Coffee with glycerine and soap.
>Paint with oil and soap.
>Paint with oil and casein and soap.

7. *Adsorption by solid :*

>Grease by fuller's earth or blotting paper.
>Wax by French chalk.
>Starched white woollen shawls, lace curtains, with rice or potato starch, and treatment with enzymes.
>Dyes by freshly prepared alumina.
>Fruit stains by fuller's earth.
>Fruit stains by salt.

8. *Peptizing with a liquid and adsorption by solid :*

>Grease by alcohol or turpentine and pipe-clay or fuller's earth.

9. *Change of substance forming the stain :*

>Fruit stains oxidised by use of " bleaching " agents.
>Ink with salt and lemon juice.
>Ink with hydrochloric acid or oxalic acid.
>Dyes with bleaching agents, such as sulphur dioxide.
>Dyes with potassium permanganate and oxalic acid.
>Iron rust with hydrochloric acid.
>Iron rust with citric acid and cream of tartar.
>Perspiration with sodium hyposulphite (for silks and wools).
>Tobacco with hydrochloric acid and ammonia.

The use of casein in the removal of paint is interesting ; the paint stain is rubbed with olive oil and is afterwards treated with casein, the finely divided powder being rubbed in. The cloth is then immersed in warm soap solution for about five minutes. " We have an adsorption by the casein of the peptized paint followed by a peptization of the casein and its adsorbed products by the soap, and the subsequent removal."

General Notes.—Articles from which stains have been removed by organic solvents can be dried off at once ; but if there is a possibility of a sweal mark remaining, the goods can be rinsed through benzine in all cases where the spotting agent is soluble in benzine. Care must be exercised in using very mobile solvents such as ether, as they will very readily spread over a considerable

STAIN REMOVING—TABULAR SYNOPSIS.

Nature of Stain.	Silk Goods.	Woollen Goods.	Cotton and Linen Goods.
Grease, oil, wax.	Benzine, benzol (see also Paint and Iron-mould).	As silk goods.	As silk goods.
Paint.	Ether, aniline, acetone, nitrobenzene, chloroform, carbon tetrachloride, trichlorethylene, tetrachlorethane.	As silk goods.	As silk goods.
Enamel.	As Paint, or with a mixture of acetone and amyl acetate.	As silk goods.	As silk goods.

Varnish (oil).
   ,,   (resin).
 	
   ,,   (shellac).
	As Paint.
	Aniline, or methylated spirit, or carbon tetrachloride and a little methylated spirit.
	Methylated spirit alone, or with carbon tetrachloride.
		As silk goods.	As silk goods.

Sealing wax.	Methylated spirit.	As silk goods.	As silk goods.
Tar and pitch.	Benzine, benzol, aniline, or ether.	As silk goods.	As silk goods.
Blood.	Water, followed by solution of neutral soap in methylated spirit.	As silk goods.	Water, followed by sodium hypochlorite.
Sugar, glue, etc.	Water.	As silk goods.	As silk goods.
Fruit, tea, coffee, wine, beer.	*White Silk.* Water, followed by potassium permanganate and removal of the brown stain produced by sulphurous acid. *Coloured Silk.* Water, followed by sulphurous acid or hydrogen peroxide if the colours are fast to these reagents ; otherwise methylated spirit and soap. With tea stains, 5 per cent. acetic acid.	As silk goods.	*White Goods.* Water, followed by sodium hypochlorite. *Coloured Goods.* Aqueous soap solution and ammonia.
Iodine stain.	Ammoniacal alcohol, sodium thiosulphate.	As silk goods.	As silk goods.

Stain Removing—Tabular Synopsis (*continued*).

Nature of Stain.	Silk Goods.	Woollen Goods.	Cotton and Linen Goods.
Iron-mould.	Aqueous solution of oxalic acid. Dilute hydrofluoric acid Oxalic acid and potassium bifluoride. Sodium hydrosulphite. Cream of tartar and citric acid.	As silk goods.	Titanous chloride, with or without hydrochloric acid. Sodium hydrosulphite. Oxalic acid.
Ink stains. (1) Marking ink (Silver). Marking ink (Aniline black).	Solution of potassium cyanide. Aniline ; or a solution of benzine soap in chloroform.	As silk goods. As silk goods.	As silk goods. As silk goods.
(2) Copying pad inks.	Methylated spirit and ammonia. Amyl Alcohol	As silk goods.	As silk goods, or, on white goods, dilute caustic soda.
(3) Writing inks.	Dilute mineral acids or oxalic acid.	As silk goods.	Acetic or formic acid, followed by dilute mineral acids or oxalic acid.
Grass stains.	Ether, or soap in methylated spirit.	As silk goods.	As silk goods.
Colour stains (substantive and basic).	*White Goods.* Hydrosulphite and acetic acid or methylated spirit and ammonia, or hydrogen peroxide. *Coloured Goods.* As above; if colours are not affected thereby.	As silk goods.	*White Goods.* Titanous chloride (warm). *Coloured Goods.* Titanous chloride (cold and dilute).
Scorch stains.	Potassium permanganate followed by sulphurous acid, or hydrogen peroxide.	Hydrogen peroxide.	Hydrogen peroxide or sodium hypochlorite.
Perspiration stain.	Hydrogen peroxide.	As silk goods.	As silk goods ; also sodium perborate.
Perfume stain.	Ammonia and oxalic acid applied alternately.	As silk goods.	As silk goods.

area of the fabric, carrying with them in solution some of the substance which is to be removed, making the small stain into a very much larger one. After treatment with solvents, the fabric should be carefully dabbed with a dry cloth to avoid the production of a well-defined edge to the area which has been treated. It must be made to merge gradually into the surrounding fabric so as to be imperceptible, or practically so.

Where mineral acids have been employed on cotton or linen goods, or on fabrics containing these fibres, the place must be sponged with a weak solution of sodium acetate, which produces the sodium salt of the mineral acid and liberates acetic acid, which is quite harmless. This treatment is safer than merely sponging with water, which does not always remove all traces of sulphuric acid. All inorganic spotting agents employed in stain removal must be thoroughly removed with water, and in all cases (as with organic solvents) care must be taken to prevent a sweal mark being left on the fabric.

After the removal of a stain it is sometimes found that the colour of the fabric has been discharged or reduced, or in many cases the stained place is found on examination to be a spot where scent or other colourless liquid has discharged the colour of the fabric. In such cases the colour may sometimes be revived by sponging with acetic acid. If this has no effect the dried fabric may be carefully touched up with a solution of a suitable colour in benzine, or in methylated spirit, an aerograph spray or fine brush being used. For touching in small spots where colour has been removed or altered, a full range of coloured crayons should be available.

CHAPTER III.

WET CLEANING.

It may be taken as an axiom in cleaning that no article is soap cleaned if it can possibly be dry cleaned. The branch of wet cleaning known as "fancy" cleaning does not now hold the position of importance it once did, having been replaced by benzine cleaning alone, or followed by water-brushing. There are, however, many articles which can only be wet cleaned, e.g. muslin, lace, Swiss net and guipure curtains, chintz curtains and covers, window blinds in holland, coutil, etc. ; in fact, any articles in which the removal of the old starch and re-starching forms part of the cleaning process. Muslin, lace, and other cotton and linen dress fabrics frequently require wet cleaning, as the dirt is generally ingrained and is not removed by dry cleaning. Blankets and white tennis flannels are generally wet cleaned, as in addition to their being soiled they are frequently discoloured and have to be re-bleached. Cretonne, tissue, and similar printed fabrics in the form of curtains, bedspreads, and chair coverings give satisfactory results by dry cleaning, but if soiled to any extent must be wet cleaned. This is especially the case with furniture covers, which are sometimes discoloured in wear by dye, dirt, etc., rubbed off black or other dark-coloured dresses.

Goods for wet cleaning may be classified into three groups :—

(a) White flannels and blankets, wool and silk underwear, down quilts (if too dirty or stained for dry cleaning).

(b) Starched goods such as lace curtains, window blinds, sun blinds, chintz covers and hangings, carpet covers of brown holland, stair drugget, bedspreads, muslin and other cotton dresses, corsets, white pique vests.

(c) Articles containing rubber, e.g. rubber macintosh, since rubber would be dissolved or damaged by dry-cleaning spirit.

Wet cleaning includes hand cleaning and machine cleaning. There is no sharply marked line of division between the two, many articles are partly done in the machine and partly hand brushed. For hand cleaning it is necessary to provide earthen-

ware or wooden vessels, it being usual to employ a series of earthenware vessels each of about 10 gallons capacity for small articles and rectangular wood vats for the larger articles. Slate or marble slabs are also provided for hand-brushing.
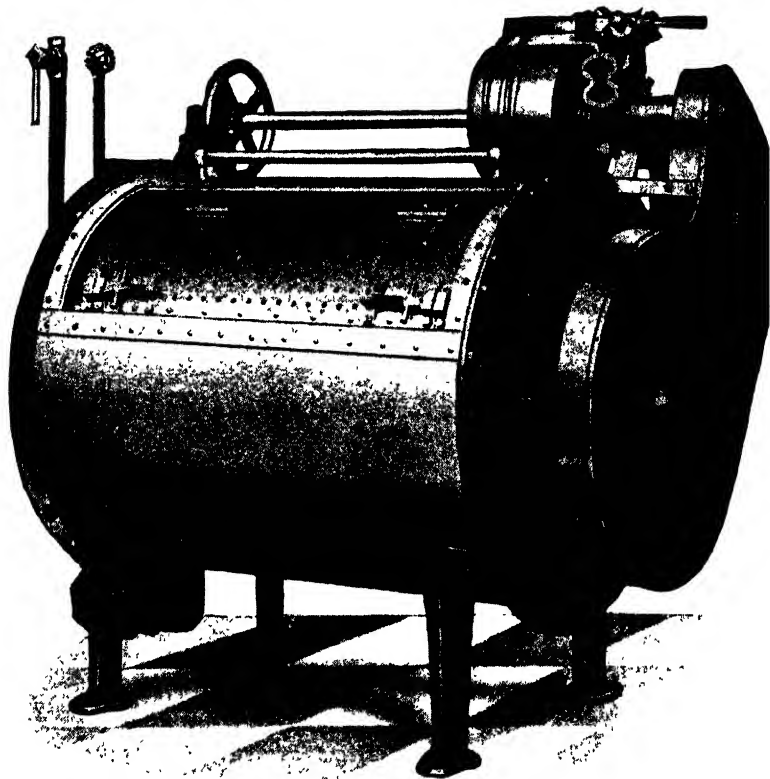
J. Stewart & Co., Perth.

Fig. 39.—All-metal Rotary Washing Machine.

For machine cleaning, the ordinary rotary washing machine with a wood, brass, or monel metal inner cage is employed. Fig. 39 shows the type of machine usually employed. For curtains, blinds, and other articles which are liable to be frail from exposure, Messrs. Hill and Herbert's " open-end " washer has been found to give very satisfactory results, as there is not the same

tendency for the articles to become entangled during the rotation of the machine, and also the cage may be unloaded without straining the goods. A series of wood vats with a pair of squeezing rollers between each pair may be employed for rinsing, and a starch trough with a pair of rubber-covered rollers for starching curtains, etc.

Other appliances will be described when referring to their mode of employment.

Soap.—As most articles for wet cleaning have to be treated at a low temperature (up to about 90° F.), it is necessary to use a soap which will not gelatinise at the ordinary temperature. For this reason tallow soaps (curd, mottled, primrose, etc.) should not be employed in wet cleaning; the most satisfactory soap is a neutral oil soap made from oleine, of which there are many varieties on the market. A soap of this type being perfectly neutral may be safely employed on woollens and on most coloured articles; it does not gelatinise on cooling, and is readily rinsed out of the articles which have been cleaned with it. Green olive-oil soap may also be used either alone or mixed with the oleine soap.

According to *Jackson*,[1] " the detergent properties of the oleates both in cold and hot solutions are sensibly greater than those of the other fatty acid soaps, this being due to their greater inherent emulsifying and perhaps lathering power." Careful comparative experiments made on wool with neutral potassium, sodium, and ammonium oleates showed no appreciable difference in the behaviour of the three soaps as far as the final condition of the wool was concerned.

Shukoff and Scheztakoff[2] conducted experiments on the practical detergent power of various soaps, using a specially prepared dirty material made by soaking cotton goods in a solution of lanoline in benzine mixed with lamp-black. Portions of the material were treated in the machine with the soaps to be tested.

According to the results obtained these investigators placed soaps in the following order :—

(1) Tallow soaps.
(2) Soaps from liquid vegetable oils and oleine.
(3) Coconut and palm-oil soaps.
(4) Resin soaps.

They also found that the greatest detergent effect was obtained with 0·2–0·4 per cent. solutions, concentrations greater or less than this having less effect.

[1] *Journ. Soc. Arts.*, 1907, p. 1222.
[2] *Chem. Zeit.*, through *J.S.D.C.*, 1911.

These results appear to confirm the experience of cleaners who frequently use tallow soaps, such as mottled and curd, when hot liquors are permissible, *e.g.* on lace curtains, and oleine soaps for cleaning at low temperatures, *e.g.* on flannels.

During recent years liquid detergents or " spirit soaps " have been introduced for wet cleaning, which incorporate a certain proportion of a fat solvent. Chemical analysis shows that these spirit soaps vary considerably in character. Some contain oleine or sulphonated castor-oil soap, or both. Some are prepared with a potash base, others with soda, and others again with ammonia. The fat solvent is usually either carbon tetrachloride, trichlorethylene, cyclohexanol, or xylene. Small proportions of other solvents, *e.g.* phenol, cresol, pyridine, etc., are sometimes added, no doubt to obtain certain properties in the finished soap. These detergents find some application in wet cleaning, as they are miscible with water in all proportions, are very efficient solvents of grease, and may be used either alone or in conjunction with ordinary soap and alkalies. The following is a summary of the properties claimed for a detergent of this type :—

(1) It gives, even in very hard water, a clear solution, as it does not form an insoluble lime soap, but will actually dissolve lime soap.

(2) It is unaffected by the acids generally used in textile processes.

(3) It cannot be salted out, except with great difficulty and by the use of a very large amount of salt.

(4) It is capable of dissolving and retaining in very large quantity other oils and fats, especially mineral oils.

(5) It will wet out and penetrate goods to an exceptional extent, and imparts to them a soft and full handle.

(6) It opens the fibre, increasing its power of capillary attraction, and leaves it in the best condition for finishing.

(7) Goods which have been treated with it can be stored almost indefinitely without acquiring an objectionable smell or unduly absorbing moisture.

(8) Colours are improved in appearance and brightness by its use.

One of the earliest of these detergents is known as *Tetrapol*; this appears to contain sulphonated castor-oil soap and carbon tetrachloride ; others, differing from one another in constitution and properties, are *Gartol, Verapol, Hydrapol, Luopan, Zolvereen, Westropol.* Some of these proprietary solvent soaps, e.g. *Hydrapol*, are made in different standards to satisfy different requirements.

Wet Cleaning of Cellulose Acetate, or Celanese.—The same precautions must be observed in the wet cleaning of Celanese articles as are necessary in " spotting," *i.e.* to avoid using any spirit soaps containing solvents detrimental to cellulose acetate, e.g. *Westron* (tetrachlorethane). If the origin or nature of the spirit soap is not known, careful tests should be carried out with it. The temperature of the cleaning liquors should be below 160° F. to 170° F., and the use of soda, 58 per cent. alkali, should be carefully controlled on account of the danger of de-lustring and "blinding." Pure neutral oil soap with a slight addition of ammonia can be used. *British Celanese Ltd.* have a speciality solvent soap, *Celascour*, which they recommend as a scouring medium for their product, either for use by itself or with oil soap and ammonia.

A point of importance in connection with the use of solvent soaps is that, prior to using them in machines that have been used for soap cleaning, any lime or magnesia soap that may have become furred on the machines should be removed, *e.g.* by means of hot dilute hydrochloric acid followed by soda. Unless this is done, the lime soap may be loosened and greyness caused owing to its being deposited on the goods.

Fancy Cleaning.—Wool and silk articles of wearing apparel in white or colours, and cotton and linen articles in colours, must be cleaned at a low temperature (not exceeding 90° F.), which is known to cleaners as a " hand " heat. This tends to prevent shrinkage of woollen articles and the running of colours in print and dyed fabrics. If experience shows that the colours of a fabric are particularly loose, it must be cleaned quite cold. The articles are first rinsed in water to remove surface dirt and any acid from wool and silk goods. They are then entered into the soap bath and are squeezed through the soap liquor by hand, the order of the articles being so arranged that white and cream goods are cleaned first, followed by light and finally dark colours. After squeezing through the soap several times they are placed on the slab and any dirty places brushed with soap solution by hand. They are then rinsed in two or more waters, followed by a rinse in dilute acetic or formic acid to " harden " the colours, and in the case of silk fabrics to brighten the fibre and to impart to it the necessary *scroop*. White silk and cotton goods may be cleaned at a higher temperature if necessary. An experienced wet cleaner can generally judge whether the colour of an article or coloured trimming will run in process, but where any doubt arises, it is advisable to test the effect of the soap liquor or other detergent upon some inconspicuous corner of the article and squeeze the liquor into

the hand.   If the coloration of the soap liquor is very slight only, then wet cleaning can be proceeded with, otherwise it is preferable to dry clean.   When coloured work of any description is being cleaned it is important to pass the articles through the various baths with as little delay as possible.   Acid colours are always more or less unstable whilst in an alkaline condition and are liable to mark off and bleed.   Articles dyed or printed with colours particularly loose should be cleaned by themselves, to allow of a quick passage through the various baths.   Whatever brushing is done should be such as not to displace or shrink the surface fibres of the material.

Silk articles require perhaps the most attention of any, but soft silks with careful treatment give quite good results in wet cleaning.   Owing to the danger of chafe marks all unnecessary friction must be avoided and the brushes used should have soft and supple bristles.   Before passing silks through the acid " hardening " bath, the soap should be thoroughly rinsed out, as any left in would be decomposed by the acid in the bath and give rise to oil spots and patches due to the fatty acid of the soap.   In course of time insufficiently rinsed goods develop a rancid smell.   Silks may be stiffened—where any stiffening is required—with gum tragacanth, gum tragasol, or gelatine.

Bleaching.

White wool and silk and cotton goods frequently become discoloured during wear, and it is necessary to make them a good white after cleaning.   With silk and cotton goods which are only a very pale cream tint this may be effected by *blueing*, the colours employed being ultramarine, or a coal-tar colour such as Alkali Blue 4B or Acid Violet 6BN.   Silk is not often required a pure white, but, if necessary, can be tinted with Methyl Violet or Acid Violet 6BN.   Woollen goods are not usually " blued " in this manner.   When the colour of the fabric is of such a depth that " blueing " is not satisfactory, bleaching must be resorted to (followed, if necessary, by " blueing ").

Bleaching Wool and Silk.

The old-fashioned method of bleaching wool and silk by means of sulphur is rarely employed by dyers and cleaners at the present date, and will not be described in detail.   Briefly, it consists in hanging the goods in a closed chamber in which sulphur is burnt, the bleaching being effected by the resulting sulphur

dioxide gas. The white produced is not permanent, as the colouring matter is not destroyed by the sulphur dioxide, but only reduced and decolorised, the original colour gradually returning on oxidation taking place. Moreover, the goods have an objectionable smell and a harsh feel (which is more pronounced when the article is worn), owing to the retention of sulphurous acid.

The most satisfactory results are produced with the peroxides, which oxidise and destroy the colouring matters; consequently the results produced are quite permanent.

Hydrogen Peroxide and its Use in Bleaching.—Hydrogen peroxide is usually supplied in 10- and 12-volume strengths and more recently in 100-volume strength. The commercial product is generally acidified, as an acid solution is more stable than one that is neutral or alkaline. It should be kept in a cool place, away from direct sunlight, as this decomposes it, liberating oxygen. The stability of hydrogen peroxide solutions is influenced by the presence of impurities, particularly iron and copper, which act as catalysts, so that it should always be stored in a clean earthenware or glass container. The lower strengths are also supplied in wooden casks. The following figures give the percentage decomposition of a sample of 10-volume hydrogen peroxide kept in direct sunlight for one month, and another sample kept in diffused daylight : [1]—

Original strength	.	.	.	9 vols.
Loss in sun	.	.	.	22·0 per cent.
Loss in shade	.	.	.	1·1 per cent.

The effect of traces of iron sulphate and copper sulphate upon the keeping qualities of a 1-volume bath of hydrogen peroxide at 100° F. for three hours has been studied by J. E. Weber.[2] In the case of the iron salt the bath lost all its oxygen in three hours, and with the copper salt the loss was two-thirds of the oxygen in the same time.

Hydrogen peroxide can be used for all fibres—silk, wool, cotton, as well as fancy goods such as straw hats, feathers, etc. It is, however, particularly suitable for silk and wool garments, flannels, blankets, etc. On cotton materials, while it can be employed, it shows no advantage as a general purpose bleach over the cheaper hypochlorites. When used for improving discoloured white flannels, any metal parts, such as buttons or buckles, should either be removed before bleaching or, if the goods are immersed for a short time only, may be covered with white material to prevent the marking of other work.

[1] C. A. Fawsitt, *J.S.C.I.*, 1902.   [2] *J.S.D.C.*, 1923, p. 209.

The vat for use in bleaching with hydrogen peroxide may be of white wood bolted together outside. No metal screws or metal of any kind must be exposed to the action of the liquor. On account of the disintegrating action of the peroxide baths on wood, Weber [1] recommends pegging and lining the vats with ½-inch concrete. If this is done, the concrete should be finished with a very smooth surface to avoid friction damage. For garment work probably the best vat is a glazed earthenware vessel which may be heated with a closed lead or tin coil, preferably the latter, covered with a perforated wood shield, and false bottom also of wood. Enamelled iron or steel vessels may be used, provided the enamel is quite sound. If chipped to expose metal, they are, of course, useless for peroxide bleaching. For a large-size bleach bath the tank may be built up of white glazed brick, but in this case care should be taken in heating the bath to avoid excessive vibration.

Method of Working.—The commercial 10- or 100-volume hydrogen peroxide is diluted with soft water (free from iron and organic matter) to a strength of about 2 volumes. The bath is made faintly alkaline with silicate of soda or ammonia. Silicate of soda is to be preferred to ammonia as with its use the evolution of oxygen is more regular, so that the bleaching is more satisfactory and better whites are obtained. No more silicate is to be used than is necessary to keep the bath just alkaline, as excess gives a harsh feel to wool and blinds the lustre of silk. The goods to be bleached are rinsed thoroughly to remove traces of soap, etc., and then placed in the peroxide bath, which is heated slowly to about 50° C. They are allowed to remain in the bath for several hours. As the oxygen liberated tends to lift the articles above the surface of the liquid, they must be pushed below from time to time. If in order to complete the process the goods have to be left in overnight, arrangements must be made to keep them below the surface by means of perforated white-wood gratings pegged together. After bleaching, the goods are rinsed and dried in the ordinary way.

Another method of bleaching with hydrogen peroxide, especially applicable to flannels and straw hats, is to soak the articles in a peroxide bath rendered alkaline with ammonia, drain, and allow to dry gradually while exposed to sunlight. The actual bleaching is thus completed during drying.

Hydrogen peroxide is useful in preparing faded wool and silk goods which have subsequently to be dyed in light colours. It has a pronounced levelling effect on fades. The cost of hydrogen

[1] *J.S.D.C.*, 1923, p. 210.

peroxide and the introduction of sodium peroxide have restricted the use of the former to some extent; but the ease with which it may be employed as compared with the latter and the entire absence of risk are distinct advantages.

Sodium Peroxide.—This substance, which contains about 19 per cent. available oxygen, provides the cheapest means of preparing peroxide bleach baths to be used for the same purposes as hydrogen peroxide. It is a light yellowish-coloured granular powder, which greedily absorbs moisture when exposed to air and should therefore be stored in a dry place in the metal canisters supplied until required for use, or it quickly deteriorates. It dissolves in water with a considerable amount of heat. It cannot be employed in bleaching without neutralising the caustic alkali, the usual method being to dissolve it in cold water containing sufficient sulphuric acid to neutralise all the caustic soda, with the formation of hydrogen peroxide and sodium sulphate. For transferring the powder from the tin an enamelled iron scoop may be used, and for smaller quantities glass or earthenware spoons. All utensils such as scoops and scale pans should be clean and *dry*. Copper and brass scoops and scale pans must not be used, and on no account must the material be weighed out on paper or cardboard, as the heat of reaction is sufficient to cause them to ignite.

Method of Working.—It is not advisable to dissolve the sodium peroxide directly into the vat used for bleaching. It is much better to prepare a stock solution in a separate vessel. The stock solution may be as strong as 4 lbs. sodium peroxide to 10 gallons of water, the actual bleach-bath strength seldom being more than half that. The necessary quantity of cold, soft water (free from iron) is run into the dissolving vat, and the calculated amount of sulphuric acid (also free from iron) is added in a thin stream. (The makers recommend pure hydrochloric acid in preference to sulphuric acid.) Sodium peroxide is sprinkled slowly on to the acidulated water with constant stirring, the liquor being stirred (not splashed about) for some time after all the sodium peroxide has been added, in order to dissolve the larger granules. The final condition of the bath should be slightly acid, as determined by frequent use of litmus paper, so that further additions of sodium peroxide or acid may be required until the bath is just acid and no more. The quantities of acid required to neutralise 10 lbs. of sodium peroxide are 9½ lbs. of 100 per cent. hydrochloric acid or 12¾ lbs. of 100 per cent. sulphuric acid. After allowing to stand the scum is removed, and the liquor may then be kept as stock and used as required for replenishing partially exhausted bleach-baths or to start fresh baths.

For use in bleaching, after transferring the requisite quantity of stock to the bleach-bath, it is necessary to dilute with water and make slightly alkaline to put the solution into bleaching condition. The method of working is then exactly the same as that described for hydrogen peroxide. For correcting the slight acidity, silicate of soda is generally recommended, though other alkalies such as ammonia, borax, and trisodium phosphate can be used.

Sodium peroxide bleach prepared in this way is applicable to the same goods as hydrogen peroxide. The goods should be clean, and rinsed free from soap before bleaching, and the same conditions as to temperature, etc., apply. For woollens a heat of 40° C. is sufficient ; silk may be bleached at 50° C. and Tussore silk at still higher temperatures. The bath may be heated with rubber hose, or tin or lead coil. On grounds of economy sodium peroxide is to be recommended, and given due observance of the precautions found by experience to be necessary, the risk in using it is very slight.

Sodium Perborate.—This again is a more recent product but is now manufactured and used on a considerable scale. The commercial article is a white powder containing 4 molecules of water of crystallisation and corresponding to the formula ($NaBO_3,4H_2O$). It contains approximately 10·4 per cent. of active oxygen. If kept dry, the powder is stable and there is not the same danger as with sodium peroxide should it come into contact with organic substances such as paper or cardboard. It is not so economical a source of oxygen as sodium peroxide, but being non-caustic and comparatively safe and simple to work with, it is used extensively. The salt was first produced by Tonatar, who obtained it by the oxidation of sodium orthoborate with hydrogen peroxide, and it is now manufactured commercially by various processes differing in detail.

Sodium perborate is soluble in cold water, by which it is partially dissociated into sodium meta-borate and hydrogen peroxide, and, with hot water, oxygen is freely evolved. As it can be mixed with soap and soda solutions, it may be added to the rotary machine in the cleaning of curtains and other articles which may require bleaching. It is also a constituent of many commercial washing powders.

Sodium perborate bleach-baths may be prepared in a similar manner to those containing sodium peroxide, *i.e.* by first acidifying with sulphuric acid and finally rendering slightly alkaline for use. The proportions required are 100 gallons water, 6½ lbs. sulphuric acid (168° Tw.), and 20 lbs. sodium perborate.

P. Heermann [1] has carried out a number of experiments to ascertain the effect of repeated treatments of cotton and linen cloth with a number of washing and bleaching agents. The agents included *Tetrapol,* soap and soda, soap and silicate of soda, soap and an oxidising agent, and a 1 per cent. solution of sodium perborate. The cloth was treated many times and its strength tested against the original. The order as given is that of increasing damage, i.e *Tetrapol* the least damaging, and sodium perborate the most damaging. On the contrary, a hypochlorite bleach containing 0·5 gram available chlorine per litre had very slight damaging effect. It is apparent from these results that oxygenous bleaching agents must only be used where really necessary to produce the required results. Repeated use on the same article is likely to result in some loss of strength.

Hydrosulphites.—The soluble hydrosulphites now on the market, whilst not yielding such permanent results as hydrogen peroxide, may with advantage be employed upon articles frequently in the hands of the cleaner and that have become discoloured, *e.g.* white flannel trousers, etc. They are easily applied and are much cheaper and quicker in use than hydrogen peroxide. In this connection it must of course be understood that hydrosulphites cannot displace peroxides in all cases, as some stains for which hydrosulphites are useless respond to peroxides, and *vice versa.*

Hydrosulphites, e.g. *Hydros.* (Hydrosulphite of Soda), should be applied from a neutral or alkaline bath. Any addition of acid causes cloudiness of the liquor owing to deposition of sulphur, and the same trouble occurs if the article to be bleached is in an acid condition when placed in the bath. Hydrosulphite may be applied to flannels as an addition to the ordinary soap liquor. If used as a separate bath for improving discoloured flannels, a strength of about 1 to 4 ounces of *Hydros* to 10 gallons of water is required. As flannels are liable to shrink, the treatment is carried out at a low temperature, not higher than 50° C. The bleaching action is rapid, and after a few minutes' immersion the flannels are rinsed well and dried up.

Bleaching Cotton and Linen.

These fibres are generally bleached with hypochlorites, the sodium salt usually being employed. Solutions of sodium hypochlorite are sold under various trade names, e.g. *Chloros, Parozone, Yarnite, Lavozone,* etc., or may be made from bleaching powder by double decomposition with sodium carbonate, or by

[1] *Z. f. angew. Chem.* through *J.S.D.C.*, 1923, p. 159.

the electrolysis of sodium chloride solution. Bleaching solution made by the cleaner from bleaching powder is not altogether satisfactory, as it usually contains free alkali and some calcium salts in solution. In making it by chemical method, the proportions of bleaching powder and sodium carbonate, "58 *Per cent. Alkali*," are about 6 : 5 parts by weight respectively. Each is dissolved in water, and on mixing the solutions, calcium carbonate is precipitated, and may be separated by settlement and decantation, followed by filtration, whilst the clear liquor consists of a solution of sodium hypochlorite. One method of bleaching curtains is to add the hypochlorite to the soap in the "boil." This cannot be done with bleach made from bleaching powder, as the calcium salts in solution decompose the soap with the formation of insoluble lime soaps. Hypochlorites made by the electrolysis of sodium chloride may be quite safely employed in this manner, as they contain no lime. The electrolysis of salt solution may be easily and economically carried out on the small scale, and various forms of apparatus have been designed for the purpose.

A modern electrolyser producing electrolytic sodium hypochlorite from brine at a low cost is the *Graphode* type of *Messrs Mather & Platt* (fig. 40). These electrolysers are made in four sizes, taking 5, 12½, 30, and 60 ampères direct current, and a number, depending upon the voltage available, may be connected in series.

The plant consists of the body of the electrolyser, made of vulcanite, the interior of which is grooved to receive the graphite electrodes, which form a number of cells. The whole stands in a vulcanite brine-container in which cooling water is circulated through lead coils, so that the temperature of the electrolyte does not exceed 104° F. to 113° F.

Salt solution is prepared in the dissolving tank to a strength of 12½ per cent., *i.e.* 1¼ lbs. salt per gallon of water, and after stirring for about five minutes the impurities are allowed to settle for an hour. The outlet from the brine tank must be about 4 inches above the bottom of the vessel to avoid disturbing the impurities which have settled. The containers are filled with clear brine to the correct working level indicated, and by passing an electric current the brine is converted into sodium hypochlorite. The bleaching liquor produced contains about 1 per cent. available chlorine, the output per electrolyser being at the rate of 3½ gallons per hour for the 30-ampère size. Basing cost for power at 1d. per unit and salt at 50s. per ton, the makers' estimate that the cost of producing the electrolytic hypochlorite is 0·78d. per gallon of liquor.

It is important when working the "Graphode," or any other

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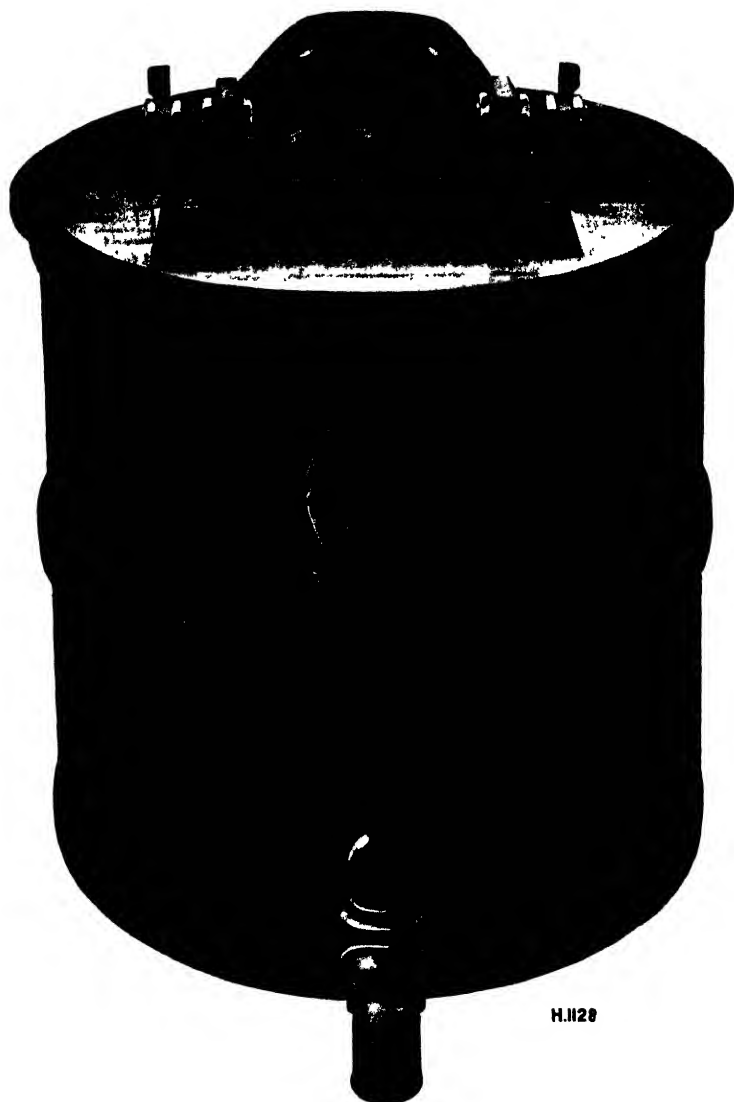
FIG. 40.—Thirty-ampère Graphode Electrolyser.

type of electrolyser, that the correct strength of salt solution be used, and the brine filled to the level indicated. If the working level is too low, the circulation of the brine is impeded, which results in weakened hypochlorite. If the level is too high, the current passes across the electrodes and undue wear takes place. The electrolyser should be flushed out with water at intervals to clear away any white scale that may have fallen from the face of the electrodes. Unless the apparatus is kept in good order, the content of active chlorine in the bleach liquor is bound to vary. The electrolytic sodium hypochlorite as prepared by the electrolysis of brine is not stable, and should be used, if possible, the same day as it is made.

Sodium hypochlorite supplied by the manufacturers is considerably stronger, usually containing 14 per cent. of available chlorine, and its uniformity can be relied upon. It generally contains a small proportion of caustic soda, which stabilises the solution. For most purposes this material is equally suitable, when diluted to the requisite strength, as sodium hypochlorite prepared from brine, and it is a matter for careful investigation to determine which of the forms of the sodium hypochlorite is the better proposition, after taking into account the cost of the apparatus, depreciation and renewals, labour, and salt and current.

Starch Solvents.

Malt Extract.—The employment of enzymic extracts of high diastatic power, such as *Brax, Brimal, Diastafor, Fiona*, etc., in the removal of starch-dressing from curtains, chintz, and other highly dressed fabrics is extending, and will doubtless become general in due course.

These enzymes or unorganised ferments are highly complex albuminoid bodies having no organised structure; they possess the power of converting the starches into soluble starches, dextrin, and finally sugars, bringing about changes quite disproportionate to their own mass.

In addition to their solvent action on starch, the enzymic constituents of these diastatic extracts exert a distinct action on other mucilaginous matters; the dirt and grease which are frequently adhering to the starch-dressing rather than to the fabric itself are removed much more readily by the subsequent cleaning process. With some of the fabrics submitted to the cleaner the colours are not invariably of notable fastness, hence the removal of a large proportion of the dirt without the use of soap is of considerable value.

In removing starch from curtains and other white fabrics, use for the *breakdown* the smallest possible quantity of water to thoroughly wet out the goods; heat up to 140° F. to 150° F.; mix in a bucket with lukewarm water half a pint of any standard high diastase extract for each thirty gallons of water in the machine; add this to the machine; run for a short time to penetrate the contents of the machine thoroughly, and allow to stand for 10 minutes. Run off the water, which will contain the starch and most of the dirt, and proceed with the cleaning in the usual way.

For chintz and other coloured articles the temperature must not exceed 105° F. to 110° F., and the quantity of extract must be increased to half a pint for each twenty gallons of water, as at the lower temperatures more is required to convert the same amount of starch.

In using malt extracts it is important to note that no addition of any kind must be made to the bath, as soap, soda, acids, etc., even in small quantities, destroy their power.

A temperature exceeding 150° F. must not be employed, as the enzyme may be destroyed thereby. Certain extracts contain a higher proportion of the liquefying enzyme, which will withstand a higher temperature than the saccharifying enzyme and may yield better results at 160° F. (or even 170° F.) than at 150° F. Unless the maker of a particular brand recommends a temperature higher than 150° F., the user runs a considerable risk of destroying the enzymic power almost entirely if he exceeds that temperature.

Novo Fermasol.—This is a fine, yellowish powder with characteristic smell. The active principle is *amylase*, an enzyme which converts ordinary starch into soluble starch, dextrin, and maltose. It is extracted from certain animal glands by the *Swiss Ferment Company*. It also contains biliary salts from ox gall which have a pronounced emulsifying action and assist in the rapid wetting out and penetration of the material.

Alkalies such as soap or soda must not be used with it.

Properties.—It is readily soluble in cold or warm water. A higher temperature than 90° F. should not be used when making up the solution, which should be cooled when made. Solutions as made are milky and will keep for several days in a cold place with addition of $\frac{1}{2}$ to 1 per cent. of boric acid. The powder will keep indefinitely if dry. Novo Fermasol works best in hard water. It is not so good in distilled or very soft water. When using the solution for de-starching, an addition of common salt at the rate of 1 lb. per 25 to 30 gallons of water is absolutely necessary, as it increases the action on starch and protects the ferment from destruction at temperatures as high as 130° F.

Novo Fermasol can be used to replace malt extract in any process suitable for malt. Its action is rapid.

The goods to be de-starched are treated with the solution of Novo Fermasol and salt at a temperature of 120° to 130° F. With sensitive coloured goods, which cannot be treated at as high a temperature as 120° F., the operation can be carried out in the cold by using a stronger solution or allowing a longer time.

Novo Fermasol is claimed to be about ten times stronger than the average commercial diastase, which gives an indication of the amount to be used as a substitute for malt. The concentration of the salt solution is the same irrespective of the quantity of Novo Fermasol employed. A special laundry quality of Novo Fermasol is supplied under the mark *Novo Fermasol L.*

Rapidase.—This contains another vegetable ferment, *biolase.* It is a slightly alkaline liquor which keeps quite well under normal storage conditions. When diluted with thirty to forty times its volume of water it gives a colourless and transparent solution, which is of importance in de-starching. It converts any kind of starch first into soluble starch and then into dextrin, and its action is more rapid than malt diastase. It will act at any temperature between 60° F. and 176° to 194° F. At the higher temperature the action quickens. In this respect it differs from malt diastase, the action of which weakens above 140° to 150° F. Rapidase can be used in a similar manner to malt diastase in a neutral bath. A slight alkalinity is not harmful, but acid should be avoided. If used in a standing bath this tends to become acid, and should be neutralised with sodium carbonate.

Polyzime P.—A more recent introduction for de-starching purposes is known as *Polyzime P.* This product is a highly concentrated enzymic substance in powder form claimed to be about eighty times stronger than the ordinary diastase. On account of its high concentration it is useful for the local treatment of certain stains.

The relative values of these various de-starching agents in cleaning practice must be determined having regard to the particular working conditions and the market price.

Wet Cleaning of Blankets and Knitted Goods.

Exceptionally fine blankets (silk edged) and some knitted articles are dry cleaned, but a large proportion, on account of stains and condition generally, must be wet cleaned to be hygienic. They may be cleaned successfully by machine, but to avoid "felting," the time of cleaning must be cut down to a few minutes,

and the speed of the machine should be slower than with other goods. Neutral oil soap should be employed, and if an alkali is used in addition it must either be ammonia or potassium carbonate (pearl ash). Neutral Potash Oil Soap is frequently used with excellent results. Some of the solvent spirit soaps already mentioned may be employed in blanket and flannel cleaning, and when using them the risk of affecting the coloured headings and borders is less than with ordinary soap. Both high temperatures and sudden variations of temperature tend to produce shrinkage, so that the temperature during the cleaning, rinsing, and drying must be approximately the same, viz. about 90° F. to 95° F.

Process.—The water used for blankets and flannels must be soft. If a base exchange or other softened water is not available, condensed water may be used. As a preliminary to the clean-·ing process proper the blankets are first passed through warm water at 90° F. containing ammonia. This not only neutralises any acid that may have been left in from a previous cleaning, but in the case of new blankets (*i.e.* first time of cleaning) the ammonia neutralises the sulphurous acid residues from the sulphur stoving, so that the soap used afterwards in·cleaning is not precipitated.

The blankets are introduced into the machine containing water and soap (the soap being in sufficient quantity to produce a good head of lather when the machine is working) and the machine is run for five minutes. The blankets are then passed through a rubber wringer, and treated in a similar way in fresh soap liquor (this soap liquor can be used as the first liquor for another batch).

They are now finished by one of two methods, viz. (1) by immersing in a " thin " liquor (*i.e.* a dilute solution of soap), hydro-extracting, and drying; or (2) by rinsing thoroughly in water at 90° F. to remove all traces of soap, running through a dilute acid bath (usually sulphuric acid), rinsing in water, hydro-extracting, and drying. The first method gives a soft handle, but the colour is not so good. The latter method is more frequently used, as the acid tends to lighten many stains, and brightens and fixes the coloured borders and headings.

After the blankets are taken from the hydro-extractor they must be thoroughly shaken by hand and hung up square in a cool drying-room at 95° F. in a current of air.

Stained or badly discoloured blankets will require special treatment with one or other of the bleaching agents already described, hydrogen peroxide being the most useful. *Hydros* (hydrosulphite

of soda) can seldom be used on blankets with coloured headings as it is a powerful strip for many coal-tar colours. A method that has been recommended for dealing with new blankets containing dressing is to steep them in a tepid solution of a malt extract preparation, e.g. *Diastafor*, the steeping being preparatory to the usual cleaning process.

"**Karntshrink**" **Machine.** — This machine for cleaning blankets and woollens was designed to eliminate friction and consequently "felting" from the cleaning process, and is shown in figs. 41, 42 and 42A. Cleaning is accomplished by alternate squeezing

FIG. 41.—"Karntshrink" Woollen Washing Machine.

and rinsing in suitable liquors. The machine consists of a shallow wooden tank provided with a pair of rubber-covered squeezing rollers (power-driven) at either end. Between the end rollers are placed, at intervals immersed in the liquor, three pairs of loose squeezing rollers. An ingenious arrangement of endless bands of tape working between wooden guide pegs carries the articles through the squeezing and immersing rollers and delivers them at the end of the machine. Two machines may be arranged in series—one for cleaning, which contains soap or other suitable cleanser, and the other for rinsing—the goods being guided by the tapes through both machines, and the rinse water in the second machine being continually replenished by fresh, running water, during the progress of the goods.

The usual method of working is to soak the goods in a neutralising bath, *e.g.* ammonia, in a tank placed in front of the machine,

place them on the end of the travelling brattice band, whence they are carried through the various squeezing rollers by the endless tapes. A large part of the dirt falls back into the preparing tank, so that the cleaning liquor in the machine is kept comparatively clean. If the "Karntshrink" machine is worked with suitable soap and with proper regard to the temperature of the liquors, it is capable of turning out excellent work without shrinkage. Woollens cleaned in the machine remain beautifully soft. Some economy in soap is shown when compared with the usual method of cleaning in the rotary washer.

Cleaning Curtains.

(*Lace, Swiss Net, Guipure, Etc.*)

Curtains may first be sorted into whites and creams, and then separated into their respective classes, such as Plain Nottingham Lace, and other curtains, muslin, Madras, printed and fancy embroidered, as well as those with artificial silk net, fringes, etc. The more these are subdivided for treatment the better the ultimate result. Curtains require very careful examination before cleaning, and those which are obviously frail and brittle from
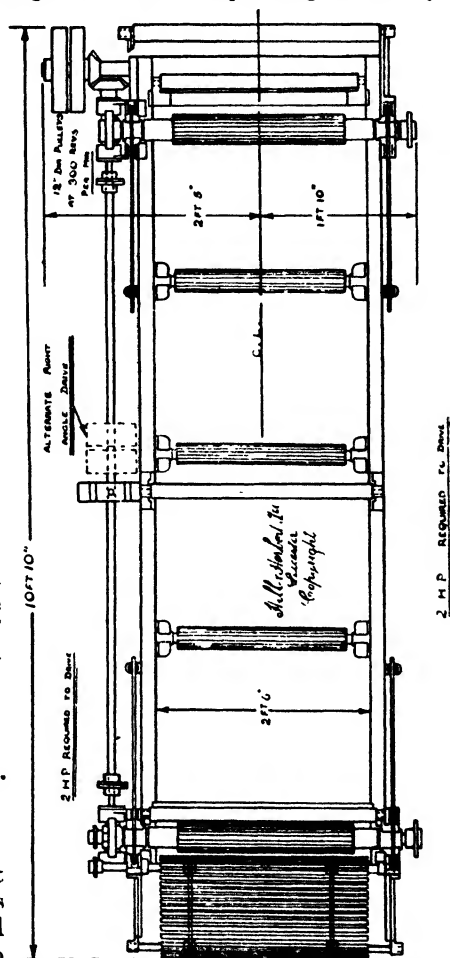
Fig. 42.—Plan of "Karntshrink" Woollen Washer.

GENERAL ARRANGEMENT OF
"KARNTSHRINK"
WOOLLEN WASHER.

FIG. 42A.

Hill & Herbert Ltd
Lincoln
Copyright
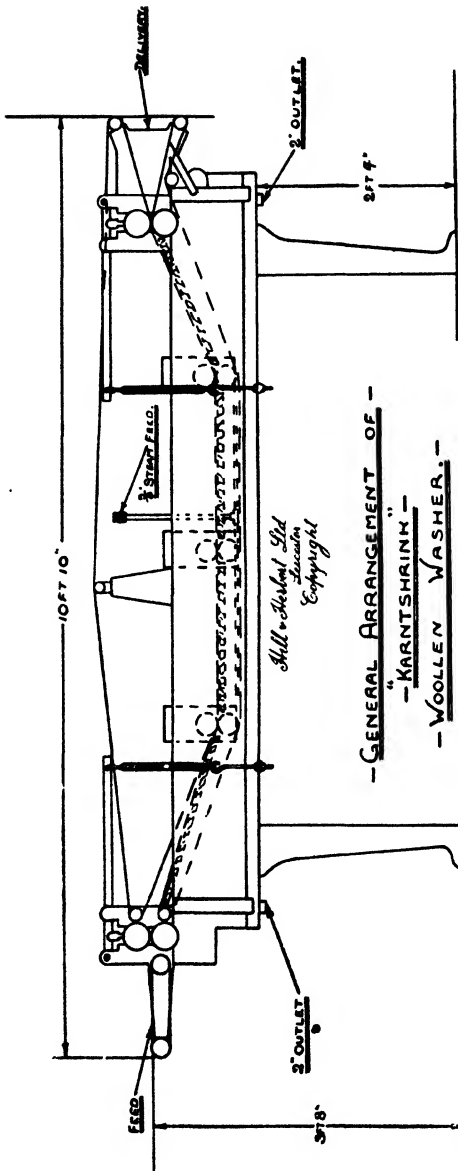
atmospheric exposure must be cleaned separately, preferably by hand. Some with coloured appliqué trimming, often made up on the raw edge of the material, are unsuitable for wetting, and in such cases the only safe course is to dry clean them. Curtains hold a large quantity of surface dirt and soot, as well as what may be termed "ingrained" dirt, and the best results are obtained if this dirt can be removed in stages. They can be freed from surface dust by preliminary soaking in cold or tepid water for from 1 to 2 hours and then passing through rubber-covered squeezing rollers. The remainder of the cleaning can then be done in the ordinary rotary machine. Those curtains which are sufficiently sound for machine cleaning may be placed directly in the washing-machine cage; but it is safer to put them into open-work string bags, as, although by so doing they take somewhat longer to clean than when free or in bundles, the strain on the curtain net is very much reduced.

Where the surface dust has not been removed by soaking in water, the first liquor in the machine is known as the *breakdown*; for this the machine is run up with water (about halfway to the door), and the curtains are run for about 10 minutes with the addition of 1 lb. of 58 per cent. alkali in the cold. As an alternative to the alkaline breakdown, it is now more usual to remove the starch by means of malt extract, e.g. *Diastafor* (see p. 126), which converts starch into soluble bodies such as dextrine and maltose, these being easily rinsed out during the turning of the machine. By dissolving the starch dressing in this way much of the dirt comes away at the same time, *i.e.* that portion adhering to the starch, leaving only the ingrained dirt to be dealt with subsequently. This effects a considerable saving, as the duration of the " wash " can be very much reduced.

The breakdown liquor having been run off, the first wash is prepared by running in about half the quantity of water employed in the breakdown and adding a sufficient quantity of stock soap solution (which is made by dissolving equal quantities of soap and 58 per cent. alkali) to produce a good lather. This is heated by steam to 140° F. and the machine run for 15 minutes. The liquor is run off and a second liquor of stock soap solution prepared. The machine is run for a short time, the solution gradually brought to the boil by turning on steam, and then run for 15 minutes. The liquor is then flushed over, and two hot rinses and a cold rinse follow.

Curtains contract a yellowish colour in wear owing to smoke, so that white curtains require bleaching to improve the colour. For this purpose sodium hypochlorite prepared either chemically or electrolytically is used, and can be added to the soap liquor in the machine during the cleaning process.

If a solution of chloride of lime (bleaching powder) is used, it cannot be added to the soap liquor, since lime precipitates soap in the form of lime soap. It must, therefore, be applied as a separate bath either before or after cleaning, though the latter is not advisable owing to the difficulty of removing it afterwards, even by thorough rinsing.

Where hypochlorites are used in a rotary cleaning machine built with a copper or brass inner cage or fittings, it is important not to allow the goods to remain at rest in contact with the metal for any length of time, as the copper acts as a catalyst and may cause local tendering and stains.

Sodium perborate and hydrogen peroxide are seldom used for bleaching lace curtains, being too expensive.

Cream and fancy coloured curtains are usually not bleached,

though where badly faded from light exposure it may be policy to bleach them to obtain a level ground preparatory to re-tinting (*q.v.*).

White bedspreads and other white cotton and linen goods are cleaned in the same manner as white curtains.

Printed muslin curtains, net curtains with coloured embroidery and appliqué trimming, are cleaned in a soap bath without the addition of alkali, and the temperature must not exceed 120° F.

After cleaning and hydro-extracting, the curtains are ready for starching and finishing.

Starching.—The starch employed for this purpose is " boiled " starch—that is, the starch is boiled with water to burst the granules before it is applied to the curtains.   The starches commonly used for curtain dressing are maize starch or farina (potato starch). These are both usually much lower in price than rice starch and wheat starch.   The strong starch mixing is made up in a starch kettle or boiler fitted with revolving blades to secure freedom from lumps.   The starch is stirred with cold water, and while being brought to the boil is thoroughly mixed with the mechanical stirrer to give a smooth paste.   The proportions of starch and water employed depend upon the nature of the curtains being starched, and vary from a few ounces to each gallon up to 12 ounces to the gallon, so that the strong starch paste in the kettle is used and diluted to the desired extent as required.   Occasionally insoluble weighting materials, such as mineral white (*gypsum*) or china clay, are added to give body, also a small proportion of suitable wax, such as Japan Wax.   If this is done, the additions are made to the stock mixture in the starch boiler.

The starching of the curtains is frequently carried out in a tank or trough fitted with a pair of rubber rollers and provided with a small, live steam pipe, the curtains being run through the starch solution and thence to the rubber rollers, where the super-fluous starch is removed.   Curtains are sometimes starched by immersion in the starch solution, followed by hydro-extracting instead of squeezing.   In this case the greater part of the starch remains on the curtains while the effluent from the hydro-extractor is mainly water.

Tinting Lace Curtains.—Though curtains can be tinted in water solution before starching, the usual practice is to add the tinting colour to the starch itself.   White curtains are shaded with blue in sufficient quantity to neutralise the yellowish tint, but not to show a bluish tone.   Either ultramarine or a soluble coal-tar blue or violet—for example, Soluble Blue or Acid Violet 6 BN—may be used.

Cream or écru-coloured curtains should, of course, be starched separately and the starch tinted cream with suitable substantive colours (*e.g.* Direct Cotton Orange), chosen on account of solubility, fastness to light, and ease of removal when again sent for cleaning. " Red iron liquor'" (basic nitrate of iron) is frequently employed for écru, as the colour produced thereby is exceptionally fast to light. The curtains are passed through a dilute solution of " nitrate of iron," followed by treatment with a weak solution of sodium carbonate, which raises the colour—that is, it precipitates hydrated ferric oxide in the fibre.

The framing of curtains will be dealt with under " Finishing."

Cretonne, Tissue (Toile Ombre), Etc.

Curtains, fitted furniture covers, bedspreads, etc., are now very largely made in printed fabrics, such as plain and figured cretonne, which are piece-printed ; shadow tissue (*toile ombre*) is yarn-printed (with a printed warp and a plain weft). We have similar fabrics in linen, linen and cotton, and cotton ; the majority of the effects in the better-class goods are produced in half-linen fabrics. If these are but slightly soiled they may be dry-cleaned, but in the greater number of cases wet cleaning has to be resorted to. They must be handled with very great care, as the colours employed (particularly the greens) are not at all fast to alkalies ; consequently they are usually cleaned by hand, as they are then under observation the whole time.

In some instances also, the colours appear to be printed pigments which rub off when dry and are considerably reduced in depth even by the friction necessary to dry-clean satisfactorily, and this does not only apply to the lower qualities of prints. It follows that, owing to the variety of colourings, these goods require particularly careful classification before putting into process.

Those that are found to be unsatisfactory in dry-cleaning, being too much soiled, and others again that may safely be wetted, are wet-cleaned in a rotary cleaning machine ; they are first run for a few minutes in cold water to remove surface dirt, and are then run for 10 minutes in cold, neutral oil soap. The articles are carefully examined and any places which are specially soiled may be hand brushed on the slab. They are then rinsed in separate lots of lukewarm water, followed by a rinse in dilute acetic acid. (Sulphuric acid is sometimes employed to brighten the colours, but it must be well rinsed out of the goods by cold water.) The articles are now sheeted up, well hydro-extracted, and dried ready for finishing. Some classes of cretonne are occasionally

slightly starched; in such cases the starching follows the acid rinse.

The wet-cleaning of cretonnes and printed linens is a branch of wet-cleaning in which spirit soaps such as *Hydrapol, Westropol,* and *Verapol* may be used with advantage to replace oil soap, or in some cases to replace part of the soap only. For sensitive prints they must be used without any addition of alkali, but if applied in this way and at a low temperature they are less liable to reduce the colourings or cause bleeding than ordinary soap. As a general rule, if the print will stand wetting it can be cleaned with a solvent soap. As the spirit soaps rinse out more readily than ordinary soap, it follows that the whole process can be controlled more easily.

Chintz Curtains and Covers.

Chintz articles are but rarely unpicked for cleaning; occasionally, however, linings dyed with loose colours or woollen linings are employed, or the curtains are trimmed with an expensive silk ball fringe. In such cases the articles must be unpicked and re-made after finishing. Chintz is cleaned in the same way as cretonne, with the difference that the old starch must be removed from it by means of lukewarm water or malt extract before it is soaped. After rinsing, the chintz is ready for starching; this may be done in several ways, as a large quantity of starch has to be absorbed by the fabric to produce the necessary degree of stiffness and gloss in the finished fabric. It used to be the practice to starch all chintz twice—that is, to starch and dry the material and then to re-starch it; as an alternative method, the chintz was dried after rinsing and entered in this condition into the starch solution, the quantity of starch absorbed by the dry fabric being greater than that absorbed by the wet material, the necessary stiffness being thus produced in one operation. Thin-boiling starches have been made which produce a " thin " solution even when dissolved in quantities of 2 lbs. of starch to each gallon of water, thus rendering it possible to starch the hydro-extracted chintz quite satisfactorily in one operation. The strength usually employed is about 1 lb. of starch to each gallon of water, but it varies to some extent; work which can be finished on a friction calendar requires less starch than work which must be finished on a reciprocating glazing machine; also, unlined chintz requires more starch than lined chintz.

The starch usually employed is a mixture of wheat starch and maize starch, the proportions being one part by weight of the

former to two parts of the latter. Maize starch may be used without any addition, also maize and rice starch, with satisfactory results ; but the use of too large a proportion of rice starch tends to make the work somewhat brittle. Japan Wax is frequently added to the starch solution.

The boiled starch is worked into the chintz in a punch tub, being rubbed well into the fabric by hand. After draining and squeezing, the chintz is hydro-extracted to remove the surplus starch and is then laid on the slab, and the starch is rubbed in by hand until the surface is perfectly clear and free from any smeariness. The articles are then hung in the drying-room, lined goods being well " picked " out—that is, the linings are separated from the chintz. If the linings are not separated in this way, or if the chintz is hung so that two pieces or two parts of the same piece stick together and dry in that condition, it is very difficult to separate them without damaging the fabric. The chintz when thoroughly dry is ready for finishing.

Window Blinds.

Window blinds are usually made of white or cream holland, linen, union, or coutil, with or without lace trimming and insertion. They are occasionally made of the same materials in red, blue, and other colours. They have necessarily had a considerable amount of exposure to the sun (depending in some degree on the aspect of the window) and to atmospheric influences in general. The lace and insertion and the bottom of the blind have generally been subjected to more exposure than the remainder of the blind, which is protected to a large extent by being rolled up on the blind-roller during the greater part of the day.

White and cream blinds without trimming or insertion may be cleaned in a rotary machine if careful examination shows that they are quite sound. Blinds trimmed with lace and insertion must invariably be cleaned by hand, as also must plain blinds not strong enough to stand machine-cleaning. The starch should first be removed from the blind by a preliminary soaking for 20 minutes to half an hour in lukewarm malt extract solution. Oil soap, with or without the addition of soda ash, is employed for cleaning, followed by thorough rinsing in clean water.

Plain blinds are starched in the same manner and with the same kind of starch as chintz. Insertion blinds, and blinds with lace ends in which the lace is not to be so stiff as the remainder of the blind, are starched on the slab, the solution of starch being brushed into the fabric and finally equalised by rubbing with a

clean, damp cloth. The blinds are now ready for framing. Other methods of finishing blinds will be given under " Finishing."

Carpets.

On account of liability to shrinkage if wetted, carpets are generally dry cleaned. If very stained or dirty, however, wet cleaning may have to be resorted to. The carpet is laid on a smooth stone or cement floor, provided with a fall for drainage purposes, and is cleaned by brushing with soap solution, an oleine soap being suitable as it can readily be rinsed out. For applying the soap solution, mechanical brushes, such as the Finnell Circular Brushing Machine (fig. 43), may replace hand labour with advantage.

After brushing the whole surface of the carpet, the excess of soap solution is removed by means of a squeegee, and the soap residues are rinsed out, using a good flush of water from a hose.

The colours of the carpet can be brightened by treatment with dilute acid, but care should be taken to rinse thoroughly afterwards to remove traces of acid, which are liable to cause tendering of the cotton or jute back.

Shampooing Carpets.— The process known as *shampooing* consists in brushing the pile or face only of the carpet, using a more concentrated soap solution than is employed in wet cleaning. By localising the treatment to the face of the carpet,

Fig. 43.—Finnell Circular Brushing Machine for Carpets.

shrinkage is for the most part avoided. In shampooing, electrically-driven circular machine brushes and vacuum suction to remove excess of soap are both used, a well-known equipment for the process being the "Connersville."

Hydro-Extractors.

The extractors employed for wet-cleaned work are similar to those for dry-cleaned work (figs. 44 and 45). They may be either of the over-driven suspended type, or under-driven; the latter type is to be preferred owing to the greater accessibility for loading and unloading. Belt drive may be replaced by direct electric motor

T. Broadbent & Co.

Fig 44.—Hydro-Extractor Suspended Directly and Electrically Driven.

drive, with greater capacity for speed. Water-turbine drive is sometimes used where conditions are suitable.

For made-up goods hydro-extractors are the only practical means for the mechanical removal of excess water, as the texture of the material is not damaged and both frail and strong fabrics can be treated with safety. The dryness is more uniform than that produced by other methods. Creases produced in the hydro-

Watson, Laidlaw & Co.

FIG. 45.—Pivot Electrically-driven Hydro-Extractor—" Vincraig " Type.

extractor are more easily removed than those produced by squeezers.

The following figures, given by Gothé (through *J.S.D.C.*), show the comparative percentages of water removed in 15 minutes by wringing, squeezing, and hydro-extracting on pieces composed of different fibres :—

RELATIVE EFFICIENCIES.

Process.	Wool.	Silk.	Cotton.	Linen.
Wringing . .	33·4	44·5	44·5	54·6
Squeezing . .	64·0	69·7	72·2	83·0
Hydro-extracting .	77·8	75·5	82·3	86·0

CHAPTER IV.

DYEING.

THE articles submitted to the " job dyer " comprise all descriptions of wearing apparel and all kinds of household furnishings—curtains, carpets, draperies, etc. The methods of dyeing used for the two kinds of work are similar though the particular dyes selected may be different, *e.g.* for curtains the colour must be as fast to light as possible, while for articles of personal wear fastness to rubbing and perspiration are very important factors. The job dyer has to overcome many difficulties which are not experienced by the piece dyer of new goods. In the first place, he does not deal with a fabric in the " grey," but with one which is already dyed with colours which may or may not be fast to washing, etc. Moreover, this colour is very frequently faded in the portions which have been most exposed to light, the faded portion being not only different in colour, but behaving differently towards certain dyestuffs owing to the oxidation of the fibre or fibres at the exposed portions. The degree of exposure that a particular article has had is not always apparent before re-dyeing. For example, a tweed suit dyed in fast mordant colours may show scarcely any sign of fading, yet it is only too noticeable on re-dyeing that the fibre on the exposed portions of such a suit has suffered much more chemical alteration than, for instance, that of a costume dyed with more fugitive dyes from which the colour is completely faded in parts by the sun. White goods show fades on re-dyeing equally prominent and perhaps more difficult to cover than is the case with coloured materials. Another source of difficulty in re-dyeing white woollen goods arises from the practice of sulphur bleaching in the new. Sulphur-bleached goods frequently dye unevenly in streaks and patches, probably owing either to uneven bleaching or unequal re-oxidation. Such articles are best treated with an oxidising agent, such as hydrogen peroxide, before re-dyeing. If the streakiness is not very pronounced it is sometimes sufficient to neutralise with a mild alkali, *e.g.* ammonia.

In the made-up articles sent to the dyer the fabrics may contain any or all of the fibres generally employed in the production of woven textile fabrics, viz. wool, silk (pure and adulterated), cotton, mercerised cotton, linen, Rayon (all kinds), Celanese, ramie, jute, etc. If it is a coat and skirt, the coat will probably be lined with artificial silk with sleeve linings of the same material, or with a figured linen or cotton lining. This complexity of composition renders it necessary for the garment dyer to exercise a considerable amount of judgment in deciding the process to be adopted for every article submitted to him. Lace, fancy feather, and other trimmings which can readily be removed and which would otherwise complicate the method of procedure, must be unpicked, dyed separately or cleaned, and replaced on the finished garment. It is also advisable to remove for special treatment expensive buttons, buckles, and ornaments.

Not the least of the difficulties of the garment dyer is that of re-dyeing on old grounds, as some allowance has to be made for the original shade when dyeing to a pattern. Where the original shade has been obtained with easily levelling acid colours, as is usually the case with ladies' dress materials, much of the colour strips away in the dye bath, and the problem is simplified. It frequently happens, however, that a fast colour has been used, and then some method of stripping is necessary before re-dyeing the goods to another shade (*q.v.*).

As all goods received for dyeing, whether as garments or furnishing materials, are in made-up form, the processes used for finishing new goods cannot be applied. Considerable improvements have been made in methods of handling the goods in the dye bath, and many machines and appliances introduced for finishing them, but even with these it is difficult, and in most cases impossible, to produce a " new " finish after re-dyeing.

The considerations which guide the dyer in determining the method which will be employed and the alternative methods which he has at his disposal will be duly dealt with. It is now necessary to consider the appliances and raw materials used by the dyer.

Equipment of the Dyehouse.—The dyehouse itself should be a ground-floor building with overhead lighting, free from secondary reflections from brick walls, etc. The roof lights should be almost vertical and facing north in order to allow a steady light of the correct quality for colour matching throughout the day. The accuracy of matching is greater by this arrangement than under conditions which necessitate the dyer taking pattern and job to the open air for matching purposes, and the

saving of time is considerable. An essential part of the dyehouse equipment is a daylight lamp which can be used whenever a true north light is not available. The K.B.B. " Macbeth " Lamp (figs. 46 and 47) is recommended, and for dyehouse work a " critical " filter is necessary. As the garment dyer is often called upon to match a shade in both daylight and artificial light, the most useful type of lamp is No. CP 40, which is provided with a two-way switch

FIG. 46.—K.B.B. " Macbeth " Lamp
for Colour Matching (Kelvin,
Bottomley & Baird).

FIG. 47.—K.B.B. " Macbeth " Lamp
for Colour Matching, showing
Filter Mounting in Detail.

giving daylight effect or ordinary electric illumination, as desired.

The " Lamplough Daylamp," which has a double filter, is also an excellent one for colour matching.

A plentiful supply of water, both hot and cold, should be available in the dyehouse, and with a view to effecting economies, the condensed water from finishing machines, cylinders, still-condensers, etc., should be collected and used for making up the dye liquors. This water must, however, be free from oil or grease. If only hard water is available, a softener should be installed. The Permutit type of softener giving zero water is recommended.

Appliances.—The vessels employed in job dyeing are of wood or copper, or more recently of monel metal, a natural alloy con-

taining about 67 per cent. nickel, 28 per cent. copper, and 5 per cent. other metals. Monel metal resists acid and alkaline dye liquors remarkably well; it is more expensive than copper, but not being easily corroded it lasts longer and has not the same dulling action on colours. Dye vats of monel metal can be easily cleaned out, so that delicate shades can follow darker shades in the same vat without risk of spoiling. Apart from these vessels made entirely of monel metal, sheet metal of about 20 gauge is used for drop-in linings for wooden vats. Copper pans are employed up to about 120 gallons capacity. In the larger coppers the dulling action on colours due to traces of copper being dissolved is not so marked as in the small sizes. Enamelled vessels, *Vitralite*, etc., can be used in place of coppers. They are readily cleaned, and provided the enamel is not chipped, are suitable where it is necessary to dye a variety of colours in succession.

The pans, whether made of copper, monel metal, or enamel, can be heated with live steam or by a steam jacket. The latter method of heating is to

FIG. 48.—Steam-jacketed Copper Pan.

be preferred, and with woollen articles is almost a *sine qua non* in small vessels, owing to danger of damage from steam blowing. The smaller-sized pans up to 40 gallons can be emptied by tilting the pans (being swung on trunnions), but in the larger sizes an outlet valve is fitted.

Large batches of work are dyed in wood vats or "barks," or in machines made to reduce manual labour to a minimum. Wood vats are usually of pitch pine and are square or rectangular in shape. They are made in various sizes from about 50 gallons to 200 gallons capacity. The vats are bolted together outside or through the wood itself so that no metal is in contact with the dye liquor. The absence of metal renders them suitable for all

classes of dye baths—acid, neutral, or alkaline—but wooden vats are in particular adapted for use with direct cotton colours. As the wood absorbs the dyestuff it is necessary to have a large range of such vats. As far as possible one vat should be kept for each
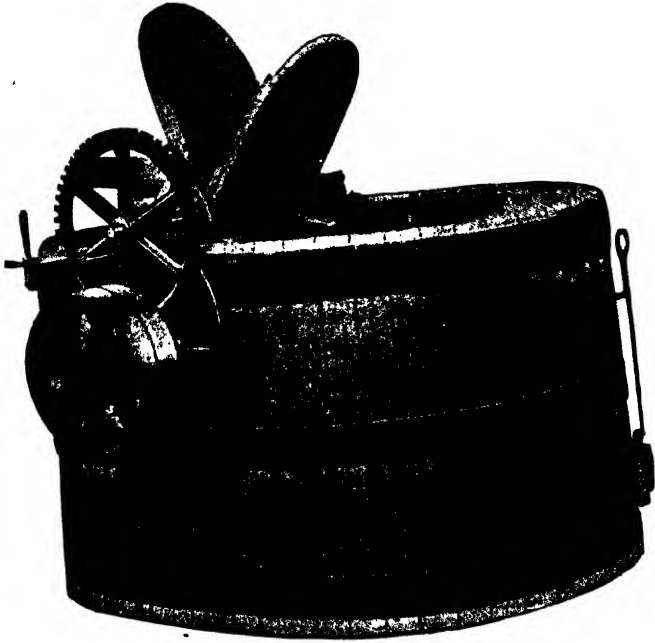
Fig. 49.—Oval Paddle Dyeing Machine.

colour, and standing liquors are necessary for dark shades. A perforated steam pipe is fitted on the bottom of the vat, and is generally covered with two perforated pieces of wood in the form of an inverted **V** known as the " feather," which prevents the dyed articles from coming in contact with the steam pipe. The garments, etc., are moved in the liquor by dye sticks.

Dyeing Machines.—In dyehouses where the quantity of work results in large batches up to 200 lbs. being required for one colour, e.g. blacks, the Perth oval garment dyeing machine (fig. 49) can be used. In this machine, after the first few strokes of the

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paddle, the goods and liquor are kept in active circulation, so that the amount of manual labour can be very materially reduced. The liquor may be heated with open or closed steam, and an overflow pipe is fitted, as too high a level of liquor often leads to goods being caught in the paddle. The oval dyeing machine is also an excellent one for rinsing both dyed and cleaned goods. For dyeing a large number of small articles—for example, hose—to one
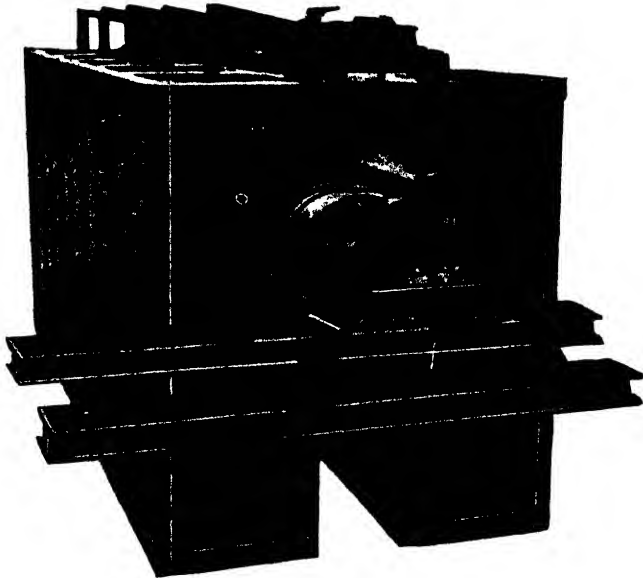
Fig. 50.—Frame Dyeing Machine.

shade, the *Dipitin* Rotary Dyeing Machine is to be recommended. This is a multi-compartment machine, each compartment being filled with an equal quantity of goods. The dyeing continues while the machine turns like an ordinary rotary cleaning machine, the liquor draining through the perforations in the drums, while the goods are alternately dipped and drained. An overhead dye tank, sufficiently large to take the dye liquor, may be used with the machine. After use, the dye liquor can be pumped to the overhead tank for re-use.

The advantages claimed for the machine include (1) economy in steam, with no steamy atmosphere ; (2) reduction in labour, as the machine keeps the goods moving and no poling is necessary ;

(3) economy in dye when storage tank is used. The rinsing may be carried out in the same machine.

Frame Dyeing.—The movement of made-up garments in dye liquors always results in a certain amount of displacement of the
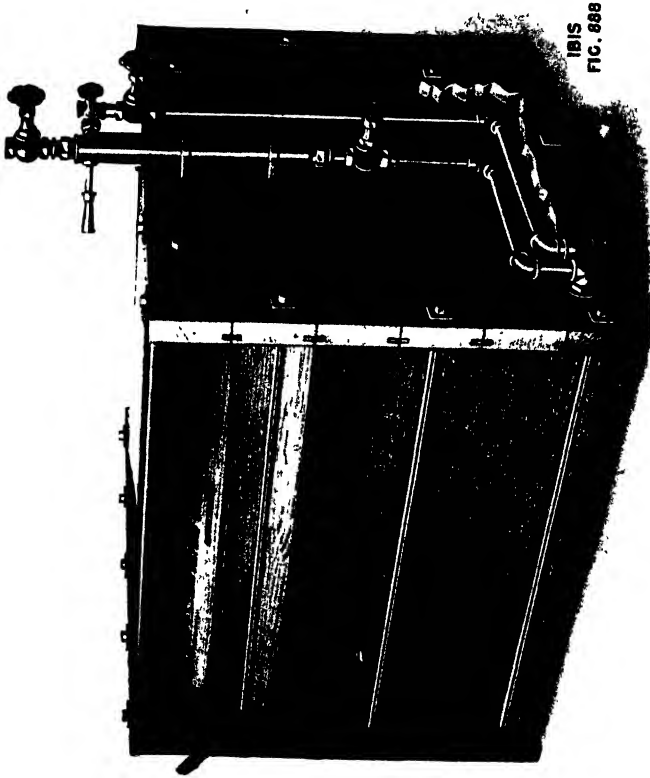
IBIS
FIG. 888

FIG. 51.—" Ibis " Patent Dyeing Machine.

padding on shoulders, fronts, etc., and some cockling of the material and disturbance of the general make-up of the garments. Fraying occurs, particularly with Rayon linings, and silks are *faced* to a greater or less degree. With the object of minimising these drawbacks the frame dyeing of garments in vats about 6 feet

deep has been adopted with a large measure of success. The garments, after being cleaned, are sewn on to frames of simple construction fitted with cross bars and made to hold two to six dresses or other garments. The frames carrying the goods are caused to move slowly up and down in the dye liquors by a reciprocating arm or some other means. A gentle movement of this kind places very little strain upon the goods, so that garments dyed on the frame are in very much better condition than when dyed in the open vat.

The difficulties of frame dyeing are chiefly those concerned with the production of level results, more especially on wool (silk being easier to dye level). Care should be taken to avoid air pockets, as these not only give rise to unevenness, but may drag the goods from the frames. The *dry* goods should be lowered slowly into the dye liquor, allowing time for the air to escape, and once wetted the goods should, as far as possible, be kept under the liquor until the dyeing is completed. The stitching must not be too tight and the dyeing process should be gradual. Normal dye baths, *i.e.* those containing the usual percentages of acid and Glauber's salt, are not successful in frame dyeing. Restraining agents are added to the dye bath, so that the dye is taken up slowly and evenly and channelling is avoided. The bath is not exhausted, so that standing liquors should be kept for reasons of economy.
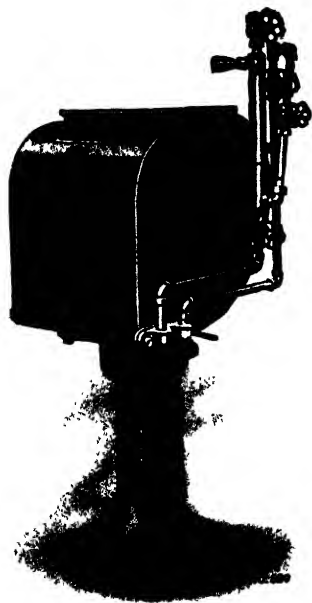
FIG. 52.—" Ibis " Patent Dyeing Machine (Small Size). Model " E," in Monel Metal.

Compressed Air Vats.—An interesting development in garment-dyeing practice consists in the use of compressed air for moving the goods in the dye liquor, thus doing away with the necessity for paddles, shafting, belts, and pulleys.

An improved vat for this purpose has been invented and patented by Messrs Clark & Co.—English Patent No. 260795,

The vat has one curved side, the curvature extending upwards and outwards from the bottom, and the other side extending vertically upwards for some distance and then curving inwards. The dye liquor and the garments are introduced through a space at the top between the two sides.

Two perforated pipes are fixed near the bottom of the vat, one supplying steam for heating, the other compressed air for circulating the materials and dye liquor. The two pipes are placed so that the one supplying the compressed air is in front of the perforated steam pipe and so prevents the articles being dyed from coming into contact with the live steam or the steam pipe. A device is arranged near the top of the vat for drying with hot air a small portion of the article being dyed, so that the matching can be done without the dyer leaving the machine.

The compressed air admitted by the perforated pipe sets up a vigorous circulation of the dye liquor and goods. The cooling of the liquor by the compressed air can be corrected if desired by admitting more or less steam. The condition of the garment work dyed in the air vat is remarkably good, very little fraying taking place. The vats are made in various sizes, from 2 feet wide upwards, in wood ; these are suitable for bulk loads of work, while monel metal vats about 14 inches wide, made on the same principle, are excellent for the dyeing of small articles such as jumpers, hose, etc.

Callebaut and de Blicquy (English Patent Nos. 259323, 266227) devised a compressed air vat in which the contour of the shell of the vat is somewhat different from that of the Clark vat. The claim made is that the shape of the vat ensures that the whole of the internal space is used in the movement of dyed goods and liquor. The curvature of the shell takes the form of an ellipse having its major axis vertical (fig. 53). In the form of construction preferred by the patentees the height of the vat is five-sixths of the width. The air and steam enter by the same pipe in this machine. Another machine in which the goods are moved by means of steam and/or air is the Pegson *Duoflow*. In this machine the dye liquors may be given any number of reversals per minute. It is chiefly supplied for hosiery dyeing, but may also be used for some classes of garment work. The claim is made that the " Duoflow " is a more efficient " circulating " machine than the other types owing to the fact that the direction of flow of the liquor is reversed automatically at pre-determined intervals, so that for a short period at each reversal the goods are travelling in a direction opposite to the liquor. This tends to ensure penetration of the goods and more level dyeing.
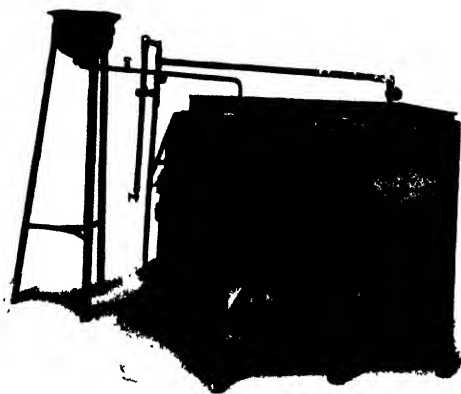
FIG. 53.—Callebaut and de Blicquy Dyeing Machine.

Longclose Engineering Co.
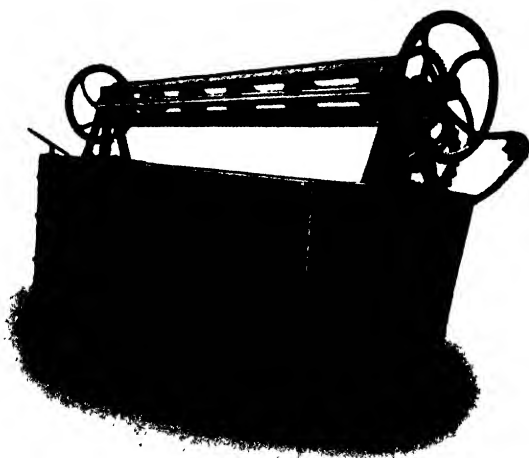
FIG. 54.—Carpet Dye Vat and Winch.

Colouring Matters.

The dyestuffs employed in the process of dyeing may be divided into two classes :

1. Natural colouring matters.
2. Artificial colouring matters.

The only natural dyestuffs met with in garment dyehouses at the present time are *logwood* (usually as hematine crystals or extract), *turmeric, fustic, orchil, cudbear,* and *cutch,* and these are losing in importance year by year, as the artificial colours are easier to apply, cheaper, and give a range of colours and shades impossible to attain with natural dyestuffs. *Logwood* is employed to some extent for the dyeing of blacks on chrome mordant, using for mordanting 3 per cent. sodium bichromate and 1 per cent. sulphuric acid, the oxidising mordant being found most suitable for the covering of fades. The cotton linings and stitching are dyed subsequently with direct cotton black or by means of tannin (*myrabolanes*) and " nitrate " of iron. As this method of obtaining a black is so cumbersome and lengthy, many of the frail materials now manufactured are not calculated to stand the process, and union blacks or suitable mixtures of coal-tar dyes are displacing logwood and hematine.

Feathers and skin rugs are still dyed with logwood, usually on an iron mordant.

Turmeric and *fustic* when used are employed with logwood to turn the shade from a violet black or blue black to a jet shade. *Cutch* is occasionally used on cotton with copper sulphate (*blue-stone*) for dyeing the well-known cutch brown for special purposes. This requires development in a separate bath with bichromate of soda or potash.

The artificial colouring matters may chemically be divided into a considerable number of groups ; but from the dyer's point of view of their behaviour towards the various fibres they may be divided into seven groups :

1. Direct or substantive cotton dyestuffs.
2. Acid dyestuffs.
3. Basic or tannin dyestuffs.
4. Dispersed dyestuffs for cellulose acetate—for example, S.R.A. colours for Celanese.
5. Mordant dyestuffs.
6. Vat dyestuffs.
7. Developed dyes.

Of these groups the first two are of the greatest importance to the garment dyer; the basic colours find a limited application, while the dispersed colours are exclusively used on cellulose acetate artificial silk. The other groups are not much used in garment dyeing.

1. **Direct or Substantive Cotton Dyes.**—Type, *Benzopurpurine 4B.*—This is an extremely valuable group of dyes from the garment dyer's standpoint, as it includes the colours of the *Diamine, Benzo, Congo, Chlorazol, Chlorantine, Paramine,* and similar series. The majority of the colours of this group are azo compounds derived from benzidine or from bases of similar constitution. They dye vegetable fibres direct from an aqueous bath containing the dyestuff, with the addition of common salt, sodium sulphate, etc. Many of them dye animal fibres (wool and silk) from a neutral or slightly acid bath, some of them in fact being better adapted for dyeing wool and silk than cotton. The colours of the Direct Cotton Group vary remarkably in their affinity for the several fibres at different temperatures and under different conditions, and their classification according to their behaviour in this respect will be dealt with later. Many of the substantive colours which contain free amino groups are employed for the production of *ingrain colours.* In such cases the dye on the fibre is treated directly with nitrous acid, which converts the amino group into the diazo group; this is then coupled with suitable naphthols or amines. The shades produced in this way are generally very fast to water and washing. A notable example of a dyestuff yielding ingrain colours is *primuline.* For example, on diazotisation and development with alkaline β-naphthol, a bright red is produced.

2. **Acid Dyestuffs**—Type, *Acid Magenta.*—These are the sodium salts of sulphonic acids and the nitro colours. They are substantive to the animal fibres, which they dye from an acid bath. Certain acid colours, however, will dye wool and silk from neutral salt baths, and are termed *neutral-dyeing acid colours.* These latter as a class are very useful to the garment dyer, as they can be used in conjunction with substantive cotton dyestuffs. With a few exceptions acid colours have little affinity for vegetable fibres such as cotton, linen, or Rayon. Applied from an acid bath they are well adapted for covering fades on wool and silk.

3. **Basic Dyestuffs**—Type, *Methylene Blue.*—As a class these are notable for brightness of shade and looseness to light and rubbing. They are substantive to wool and silk, but will only dye cotton on a tannic acid, Katanol or oil mordant or *topped* on to a substantive cotton dyestuff. Several of the basic dyestuffs will

dye cotton without the employment of a mordant, but the colours produced are very fugitive and of little practical value. Some basic colours are amongst the earliest of the coal-tar dyestuffs, and, as such, were the first artificial colours to be taken up in garment dyeing. It is interesting to note that the first coal-tar dye, *Mauve*, discovered in 1856 by W. H. Perkin, is a basic dyestuff, and that some of the earliest practical trials with it were made in the dyehouse of *Pullars* of Perth.

Basic dyestuffs are now less extensively used in garment dyeing, as the colours produced are not so fast to light and to rubbing as the same shades dyed with the acid dyestuffs usually employed. The colours are, however, very bright, and are not changed by artificial light to the same extent as those of the other groups; they may, therefore, be employed when fastness to light is not so important as the production of a bright gaslight shade, e.g. *Night Blue*. They are sometimes *topped* on to substantive cotton dyestuffs for shading purposes, e.g. *Methylene Blue* on black-dyed velveteen, or are employed for *filling up* cotton linings on an iron-tannin mordant. Their advantages and disadvantages for these purposes will be referred to later.

4. **Dispersed Colours.**—The dyes referred to under this heading are those specially prepared for the dyeing of cellulose acetate artificial silk. The corresponding bases are normally insoluble in water, but by colloidal means are brought to a very fine state of division. The S.R.A. dyes for Celanese are pastes, incorporating the sodium salt of sulphoricinoleic acid (*Turkey Red Oil*) as a dispersing agent; hence the lettering S.R.A. for this range of dyes. By colloidal solubilisation the dyes are dispersed completely in the dye liquor and absorbed therefrom by the Celanese fibre.

The S.R.A. dyes (*British Celanese Co.*), the *Dispersol Colours* (B.D.C.), *Duranol Colours* (B.D.C.), and also the *Celatene Dyes* (Scottish Dyes) are intended for dyeing Celanese. Before their introduction some basic and some mordant dyes were used, but there was not a complete series of dyes for this fibre. There is now a full range with the exception of green, which has to be dyed with a mixture of blue and yellow. *S.R.A. Black* 4 dyes a yellow shade direct, which, diazotised and developed with β-oxynaphthoic acid, gives a fast black.

The *Ionamines* (B.D.C.) are dyes chiefly for Celanese, some of which can be further diazotised and developed on the fibre. They give a range of shades from yellow to black. *Ionamine A*, diazotised and developed with β-oxynaphthoic acid, produces a fast black on cellulose acetate.

5. Mordant Dyes—Type, *Alizarine Red.*—True mordant dyes are not usually employed in garment dyeing owing to the difficulty of dyeing made-up articles with them. Wool and silk are dyed by one of two methods :—

(*a*) The fibre is mordanted and subsequently dyed.

(*b*) The mordant and dye are fixed in one operation (*Meta-chrome* or *Monochrome Method*).

A few alizarine colours, e.g. *Alizarine Cyanine Green* and *Alizarine Delphinol B*, are used in wool dyeing of garments and curtains owing to their excellent fastness to light, but they are applied in a similar manner to acid dyes, *i.e.* without a mordant.

Cotton is not in general dyed with mordant colours, except with *Turkey Red*, which is produced from alizarine and an alumina-lime and fatty acid (*Turkey Red Oil*) mordant.

6. Vat Dyes — Type, *Duranthrene Blue.* — These have only been introduced recently to garment dyeing, and their successful application to articles in made-up form presents some difficulty. They are not soluble in water, but are applied from a *vat* in a similar manner to indigo, *i.e.* the colour is first reduced to a soluble *leuco* form with caustic alkali and hydrosulphite and is afterwards re-oxidised on the fibre. Many vat colours are of outstanding fastness to light and other agencies. For that reason their particular field in garment dyeing is in connection with the dyeing of casement curtains and hangings that are subjected to a considerable amount of exposure. In re-dyeing, vat dyes do not penetrate seams so well as direct cotton dyes, nor do they cover fades equally well. Care must be taken with badly faded curtains, as in the alkaline vat the faded parts which may be already tender are liable to give way.

7. Developed Dyes.—These dyes are produced in the fibre from substances which are not dyestuffs, and may be divided into two classes :

(*a*) Those produced by the combination of naphthols, etc., with diazotised amino compounds.

(*b*) Aniline Black.

(*a*) The fibre is impregnated with the *developer, e.g.* β-naphthol, and the colour is produced by immersion in an ice-cooled solution of a suitable diazotised amino compound. For example :

p-Nitraniline diazotised and developed with β-naphthol gives a scarlet colour.

Dianisidine diazotised and developed with β-naphthol gives a blue colour.

(b) *Aniline Black* is produced by oxidation of an aniline salt on the fibres, or by heating the fibres in a solution of an aniline salt and an oxidising agent. This black is only produced on vegetable fibres, and is largely employed in the manufacture of marking inks.

The table on p. 156 (Schaposchnikoff) gives a chemical classification of the dyestuffs in relation to their behaviour towards the fibres. For further particulars the reader is referred to Cain and Thorpe's *Synthetic Dyestuffs* (Griffin) and to W. P. Dreaper's *Chemistry and Physics of Dyeing*.

Assistants.-- This is the name applied to all those chemical substances other than dyes added to the dye bath with the object of obtaining more level results, better penetration of the material, more complete exhaustion of the dye bath, or in any other way assisting the dyeing process. The assistants generally used in garment dyeing are (1) neutral salts, (2) acids, (3) wetting-out and levelling agents.

1. **Neutral Salts.**--The salts usually employed are sodium chloride (common salt), $NaCl$, and sodium sulphate (Glauber's salt), Na_2SO_4, $10H_2O$. The latter, especially when calcined, is not always absolutely neutral, but may contain traces of acid sodium sulphate or hydrochloric acid. As sodium sulphate is used by the garment dyer as an addition to neutral, alkaline, or acid dye baths, it is important that it should be neutral and reasonably free from iron, and in these respects Glauber's salt is to be preferred to calcined sodium sulphate.

As an assistant to the acid dye bath in dyeing wool and silk, Glauber's salt acts as a levelling and restraining agent, the colour exhausting more slowly and better penetration of seams, etc., is obtained. A hot, neutral Glauber's salt bath is also used to reduce or strip the colour from wool or silk previously dyed with acid colours. When used for stripping in this way, actual boiling should be avoided, as Glauber's salt gives an alkaline reaction at the boil and is liable to soften wool, more especially where faded by exposure. Both Glauber's salt and common salt are used as assistants in dyeing with substantive cotton dyestuffs. By decreasing the solubility of the dye they increase its affinity for the fibre, so that deeper shades are obtained and better exhaustion of the bath. On the other hand, if used in excess, penetration is not so good and the colours are looser. For dyeing union materials or wool garments with cotton linings in a standing bath, common salt is better than Glauber's salt, as its softening action on wool is less pronounced. For all cotton or linen

Class I. COLOURS WITH ACID CHARACTER.		Class II. COLOURS HAVING THE CHARACTER OF SALTS.	Class III. COLOURS WITH BASIC CHARACTER.	Class IV. COLOURS WITH INDIFFERENT CHARACTER.	
Group I. DYESTUFFS THAT DYE IN AN ACID BATH.	Group II. DYESTUFFS THAT DYE ON METALLIC MORDANTS.	Group III. DYESTUFFS THAT DYE IN NEUTRAL OR ALKALINE BATHS.	Group IV. DYESTUFFS THAT DYE IN A NEUTRAL BATH.	Group V. DYESTUFFS DEVELOPED ON THE FIBRE.	Group VI. DYESTUFFS CAUSED TO ADHERE MECHANICALLY TO THE FIBRE.
(1) Nitro-dyestuffs.	(6) Certain azo-dyestuffs (*Alizarine Yellow, Diamond Yellow, Azarine*, etc.).	(12) Dyestuffs from tetrazo-salts (derivatives of benzidine, etc.).	(15) Basic azo-dyestuffs (*Chrysoïdine*, etc.).	(19) Metals.	(25) Albumen colours (dyestuff fixed on the fibre by means of albumen, casein, etc.).
(2) Most azo-dyestuffs (amidoazo-, azoxy-, and diazo-dyestuffs).	(7) Oxyquinone and quinone-oxime dyestuffs.	(13) Thiazole dyestuffs (*Primuline*, etc.).	(16) Di- and triphenyl methane dyestuffs.	(20) Insoluble azo-compounds.	
(3) Sulphonic acids of the triphenylmethane, induline, and quinoline dyestuffs — *Indigo-Carmine*.	(8) Some quinoneimide dyestuffs (*Gallocyanine*).	(14) Certain natural colouring matters, sulphine dyestuffs.	(17) Most of the quinoneimide dyestuffs (Indamines, thiazines, oxazines, azines, etc.).	(21) Mineral colours.	
(4) Hydrazone and pyrazolone dyestuffs.	(9) Oxy-ketone, xanthone, and flavone dyestuffs.		(18) Quinoline and acridine dyestuffs.	(22) Indigo and indophenol.	
(5) Chromotropes (also belong to the next group).	(10) Phthaleine and rosolic acid dyestuffs.			(23) *Aniline Black.*	
	(11) Natural dyestuffs.			(24) Certain natural colours (*Catechu*, etc.).	

materials, *e.g.* cotton raincoats, Glauber's salt gives superior results.

Sodium phosphate is sometimes recommended as an assistant with direct cotton colours, but any advantages it may possess over common salt or Glauber's salt are not commensurate with its higher price. Soap may also be employed where clear, pale shades are dyed on cotton with substantive dyestuffs. It is valuable as a levelling agent when dyeing silk and artificial silk. For this purpose an oil soap, *e.g.* a good grade of green olive-oil soap, is suitable, as it promotes even dyeing and can be rinsed out readily from the dyed goods.

Monopol Soap (Sulphonated Castor Oil Soap), applied either alone or with slight addition of an alkali, is frequently used in dyeing cotton, mercerised cotton, and artificial silk garments. It retards the rate of dyeing and tends to produce more level shades, at the same time improving the handle and appearance of the goods.

2. **Acids.**—The acids commonly employed in dyeing with acid dyes are sulphuric acid, acetic acid, and formic acid. Hydrochloric acid may also be employed, but being volatile, the vapour is objectionable and has a corrosive action on metal· fittings. Goods dyed with hydrochloric acid in the bath feel harsh to the touch. Oxalic acid is occasionally used in dyeing with acid colours on garments ; it is useful for clearing up iron stains on an article during the dyeing process. A branch of dyeing in which oxalic acid is largely used is ostrich feather dyeing. Mineral acids, *e.g.* sulphuric acid, are liable to render such feathers somewhat brittle, and to injure the " flue."

In garment dyeing sulphuric acid is rarely used alone, sodium sulphate being also used, with the formation in the bath of acid sodium sulphate. Nitre cake (sodium bisulphate), which for dyehouse purposes may be regarded as a mixture of Glauber's salt and sulphuric acid, is also used, but the difficulties of storage and transit and the variation in acid content (usually about 30 per cent.) militate against its more extended employment.

Dyeing generally takes place more quickly with mineral acids such as sulphuric acid than with organic acids such as formic or acetic acid, and the baths exhaust better, but the colours produced in many cases are not so level and the penetration is not so good. It may be taken as a general rule that the level-dyeing and penetrative qualities of a dye are inversely proportional to the rate of dyeing—that is, they are poor with a quick dyeing bath and good with a slow dyeing one. For this reason it is advisable to employ organic acids whenever there are thick seams, etc., on a garment. Sulphuric acid is generally preferred by

include a blank test, *i.e.* dyeing by the ordinary method without any addition of the wetting-out material.

To compare the wetting-out value of the substances being tried, a number of vessels containing water should have additions of the wetting-out agents made in the proportions recommended, making sure that the substances are thoroughly dissolved—if necessary previously in hot water. Equal-sized pieces of woollen material are now placed on the surfaces of the various solutions, and the times taken to wet-out the wool at various temperatures are noted.

Tetracarnit.—One of the more commonly used penetrating agents is known as Tetracarnit. This is a pale yellowish liquid with an odour of pyridine. It is miscible with water and volatile in steam, so that the odour is not retained by the goods after dyeing. Tetracarnit can be used in the presence of alkali or acid, but in garment dyeing it is more especially of value in dyeing wool with acid colours. For this purpose it is added to the dye bath in the proportion of about 6 to 8 ounces to 100 gallons of dye liquor and the dyeing process carried out as usual. In redyeing felt hats which have to be cut afterwards, tetracarnit assists in obtaining penetration. Garments with thick seams, carpets with long, close pile, which are found to be troublesome, are improved in appearance by an addition of tetracarnit to the dye bath.

Nekal A, Nekal BX.—Nekal A is a yellowish powder, soluble in water. Nekal BX is a fine, almost white powder, readily soluble in water, particularly when warm. Both are excellent wetting-out agents, the BX brand, which is of more recent introduction, being the more effective of the two. Nekal is recommended for pasting and dissolving dyestuffs and as an assistant to the dye bath for promoting the penetration of seams, thick materials, hat felts, etc. The amount required is about 4 ounces to 100 gallons of liquor, or, if applied from a standing bath, one-fifth to one-tenth of that quantity. It is not generally recommended for use with basic dyestuffs. For penetrating thick felts the amount of Nekal may be increased. It can also be added to the shellac proofing for felt hats, with the result that the hats are more thoroughly impregnated and the proofing more evenly distributed.

Many other wetting-out agents are available, the relative merits of which should be tested under working conditions, having regard to the cost and the improved results. A few of the best known are *Oranit F* and *FW*, usually supplied as brown liquids but also obtainable in powder, and *Penetrol A, B*, and *H*, which are liquids valuable as wetting-out and penetrating agents.

Preparation of Goods for Dyeing.—The garments received for dyeing have to undergo some preparation, the nature of which depends upon their texture, condition, and colour, and the shade which they are to be dyed. They are usually soiled, more or less stained with grease, road dirt, etc., and the colour is frequently uneven from fading. In some cases it is only necessary to remove the dirt, grease, stains, and dressing from the articles, the colour selected for dyeing being such that none of the original colour need be removed, or only such as may be removed in the cleaning of the goods.

Stripping the old colour is not resorted to if it can possibly be avoided, as the process is somewhat expensive and tends to impoverish the material.

Various methods of cleaning before dyeing are followed in different works. Goods liable to shrink are frequently dry cleaned, *e.g.* wool, jersey, and stockinette materials. Light colours in wools and silks are wet cleaned, while for dark colours and black a preparation with warm soda (58 per cent. alkali) is often regarded as sufficient.

Dry Cleaning before Dyeing.—The goods are machine cleaned in benzine without soap, hydro-extracted, and dried. Any stains may be treated individually afterwards, and the goods rinsed with a weak solution of alkali followed by a cold water rinse.

Wet Cleaning before Dyeing.—When it is only necessary to clean the goods without the removal of the colour (except such as may incidentally be removed in the cleaning process), wool or half wool is treated with a cold or warm soap solution with or without the addition of soda or ammonia, either by hand or in a rotary machine, followed by thorough rinsing in warm water. The rinsing is very important when the goods are subsequently to be dyed in an acid bath, as the fatty acid precipitated in the goods from any soap which has not been thoroughly rinsed out of them tends to impart an unpleasant odour which can only be removed with difficulty. Another trouble arising from the same cause is that the dye will not readily penetrate the seams, and the goods are more liable to shrink during the dyeing process. In cases of insufficient penetration of the seams from the cause just mentioned, the best plan is to dry the goods up and dry-clean to remove the fatty acid in the seams before re-dyeing. The ordinary oleine soap used in preparing goods for dyeing may be replaced by spirit soaps, such as *Westropol, Hydrapol, Verapol,* etc. Their advantages over ordinary soap are that they are excellent grease solvents, and being easily rinsed out they do not give rise to the trouble in re-dyeing sometimes experienced with

ordinary soap. Woollens cleaned with spirit soap are less liable to shrink. The spirit soaps may be used either alone or with a small amount of alkali, *e.g.* ammonia, or soda (58 per cent. alkali).

Preparing with Alkali before Dyeing.—If used with care in dilute solution and either cold or at a moderate temperature, soda alone may be employed and gives very satisfactory results, and there is no possibility of any fatty acid being fixed in the fibres. This method is the one most commonly employed for bulk loads of dark shades such as brown, navy blue, and black. The preparing is often done in a paddle machine, and the temperature of the bath should not be higher than 90° F. Thorough rinsing afterwards is important, particularly if the goods are to be neutral dyed, as a trace of alkali carried over to the dye bath may cause damage to wool at the high temperatures necessary for dyeing.

In tailor-pressing new garments (particularly men's clothes) soap is frequently employed to assist the process ; when preparing such goods for re-dyeing, the soap must be well worked out during the cleaning, as otherwise the precipitation of fatty acids in the thick portions (round the button-holes, etc.) may prevent the penetration of the dye.

Preparing Silk Goods for Dyeing.—These are usually dyed with acid colours, which are removed in a soap bath. Unweighted silks (jap, spun, tussore) can be boiled in soap, but weighted silks —and these constitute by far the larger proportion—must be treated in lukewarm soap baths. Especial care must be taken with silks weighted with tin, as these are liable to *drop*, if at all tender, whilst in the soap liquor. Tendering may occur on weighted silks in those places where the article has been subjected to perspiration or exposed to the sun. Silk articles of all kinds must be handled with caution at every stage to avoid *facing* the surface and so producing scurf marks. Where sticks are used for moving the goods they should be of smooth, hard wood of close grain, *e.g.* lancewood. After cleaning, the goods are rinsed thoroughly in several baths of warm water, and finally in cold water, before dyeing. Some of the most expensive and elaborate silks are dry-dyed, and these are prepared for process by dry cleaning. Stiff silks and satins which are to be frame dyed may also be prepared on the frame to avoid *scurfing*. In cases where silks have been dyed with colours fast to the soap liquors used in cleaning, *e.g.* some basic dyes, the colours have to be reduced by chemical methods—stripping. Mordant colours can be removed by the method employed for stripping mordant

colours from woollen goods, *q.v.* Silk and cotton goods are prepared for dyeing by similar methods to all silk materials. Silk and wool materials (Marocains, etc.) are treated like silk, except that hot soap liquors must not be used on account of damage to the wool. As these goods are especially liable to shrink they should be measured before putting into process. Cotton and linen goods may be boiled in alkaline solutions unless they have had much exposure, when warm liquors only are used. It is found that when goods of any kind—wool, silk, or cotton—are somewhat tender in places through exposure to light they are most liable to give way whilst in the alkaline cleaning liquor. If cotton goods intended for dyeing have been heavily starched, *e.g.* chintz or blinds, the starch should be removed by treatment with lukewarm malt extract—*diastafor*; see under *Cleaning.*

After cleaning by one or other of the methods described, the goods are, in the majority of cases, ready for the dye bath. Some process of stripping must be resorted to if the shade required is unlikely to cover inequalities of colour showing up after cleaning ; for example :

(1) Part of a garment may be dyed with a fast colour which does not yield to ordinary cleaning methods.

(2) An article may be so uneven after cleaning owing to fades or stains that it appears certain that these defects would not be covered in the required shade.

(3) An article may be received for dyeing to a shade lighter than the original, *e.g.* black for dyeing navy.

The last case should not often occur, at any rate with wool, as the practice of accepting goods for a much lighter shade than the original is attended with some risk. However careful the handling, it follows that stripping is an extra process that must entail a certain amount of detriment to the goods. Furthermore, it not infrequently happens that when one attempts to strip a dark colour, especially black, and dye to a lighter shade, stains or other defects become apparent after stripping that could not be seen before treatment.

It must be admitted, however, that with the extensive range of chemical stripping agents now available, much more stripping can be attempted than formerly, and the demands are correspondingly more exacting.

When stripping is found to be necessary, a mild stripping agent should, of course, be used in preference to more drastic ones, though, if possible, a cutting from the article should first be tried in order to find out which process will be most effective, and thus avoid " experimenting " with the article itself. The object

of stripping should always be to obtain as level a ground as possible, lighter than the shade required. A complete strip is not necessary.

Stripping Processes.—The methods generally employed may be divided into four classes :—

1. Stripping in neutral or alkaline baths.
2. Stripping in acid baths followed by alkaline baths.
3. Stripping with oxidising agents.
4. Stripping with reducing agents.

The first method is one in which the colour is removed as such from fibre to liquor without actually destroying the dyestuff. By methods (3) and (4) the dyestuff is bleached or altered to a colourless or less highly coloured compound by chemical means. Generally speaking, stripping processes included in the first category are milder than the chemical methods included in the other classes, and, being inexpensive, are used whenever applicable. In making a choice of the most suitable method, a knowledge of the colouring matters generally employed on any given fabric is of great assistance, but frequently the class of fabric and the colour will be sufficient guide to the experienced dyer. The garment dyer is often expected to match patterns under both daylight and artificial light, and to satisfy this demand it may be necessary to effect the almost complete removal of the old colouring matter from the fibre·before re-dyeing with colours which follow the pattern in both lights. The following is a resumé of the principal stripping methods :

1. Boiling Water.—This has a remarkable stripping effect on easily levelling acid colours, such as are generally found on ladies' woollen dresses, and on curtains and draperies. Usually acid colours respond to boiling-water treatment, *boiling sweat*, sufficiently to re-dye in level shades. Where, however, boiling water alone does not exert a sufficiently strong action, it can still be used as a preliminary treatment. An addition of *Tetracarnit* to the boiling water in the proportion of 2 to 6 ounces per 100 gallons materially assists the stripping action of the bath, and it has the advantage of being non-alkaline, an important point when dealing with badly faded goods. In some cases a solution of 5 to 10 per cent. sodium sulphate (Glauber's salt) applied at the boil will remove a considerable amount of colour. Water alone, or water and *Tetracarnit*, are, however, preferable, as a boiling Glauber's salt bath has a softening effect on woollen material, particularly when faded, and takes away the natural curl from mohair fabrics, *e.g.* Angora table covers, etc.

Weakly Alkaline Baths.—Acid dyestuffs that are not suffi-
ciently stripped by the previous methods will frequently respond
to a treatment with hot dilute ammonia. The question of tem-
perature is here most important, as ammonia even in very dilute
solution has a pronounced softening action on wool at the boil.
(Strong solutions dissolve it entirely.) It should be applied at
a temperature not higher than 65° to 70° C., and of a strength
of about ½ pint ammonia (sp. gr. 0·880) to 100 gallons. Used
in this way ammonia is comparatively safe. A weak solution
of borax is occasionally used in place of ammonia, but is scarcely
so effective. When dealing with materials that are in any degree
tender through exposure, alkaline strips are best avoided, as
alkalies appear to exert a far more destructive action on such
materials than on sound ones. Where stripping is necessary
with materials tendered through exposure, acid or neutral baths
are safer than alkaline ones, and when they fail it is advisable
to go no farther. Soap is not often used for stripping woollens;
it is more suitable for silks, from which it will strip the colour
at the boil. With woollens, soap (except in so far as it strips
loose colour in the cleaning process preparatory to dyeing) is
generally unsatisfactory as a stripping agent; it often leads to
uneven shades, and, in addition, it induces shrinkage. When used,
the limit of temperature should be 90° F., and the soap should
be neutral, free from caustic alkali. Boiling-soap baths with
an addition of 58 per cent. alkali may be used for stripping cotton
materials.

2. Acid Baths followed by Alkaline Baths.—Where the
colour on wool or silk will not yield to treatment with either
boiling water, Glauber's salt, or mild alkalies, the article is prob-
ably dyed with a mordant colour, substantive, or vat colour.
Mordant colours can only be removed by the decomposition of
the colour lake. As mordant colours owe their fastness to an
actual combination or colour lake in the fibre itself, it follows
that in order to loosen the colour it is necessary to split up this
combination. This is best effected by dissolving the metallic
salts or mordants in a suitable acid or mixture of acids, and then
treating with a mild alkali (*e.g.* ammonia) to remove the un-
combined colouring matter. The most suitable acids to use for
the first bath are hydrochloric or oxalic acids. These acids both
form soluble salts (chlorides or oxalates) with the usual mordants.
Sulphuric acid can be used but is not quite so good, the resulting
sulphates not being so soluble. A mixture of hydrochloric and
oxalic acids is frequently used; the method followed is to treat
the goods in a ½ to 1 per cent. solution at a temperature just under

the boil for 20 minutes to half an hour. This removes the mordant, and at the same time some of the colour comes away. After rinsing, a fresh bath is prepared with dilute ammonia at 60° to 70° C., which removes more of the colour. Instead of the ammonia, boiling water may in some cases be used, with the advantage of being effective in removing colour without causing injury to fibre.

3. **Oxidising Stripping Agents.**—The oxidising agents which may be employed for stripping are—

> Nitric acid.
> Chromic acid (potassium or sodium bichromate and sulphuric acid).
> Peroxides (hydrogen peroxide, sodium peroxide, sodium perborate).
> Hypochlorites (bleaching powder, sodium hypochlorite).

Nitric Acid.—Of the oxidising strips nitric acid was at one time very largely used on woollen goods, but is now less frequently used, having been superseded by less destructive strips belonging to the " reducing " class. Its advantages were its economy and the fact that it " cut up the fades "—that is, it oxidised the fabric evenly, so that the faded and the unfaded portions of the fabric could be dyed a level shade. Its disadvantages were the deep yellow colour which it imparted to the goods, rendering it impossible to produce many colours (pale blues, for instance), and the destructive action of the bath upon the cotton threads, linings, etc. The cotton stitching was frequently tendered to such an extent that the various portions of the garment would come apart. Commercial nitric acid is better than the pure acid for stripping purposes, as it is more active on account of its containing dissolved oxides of nitrogen. The nitric acid bath is made with about 1 gallon of concentrated acid to every 10 gallons of water, earthenware or vulcanite vessels being employed with lead steam pipes. Owing to the operation being usually carried out in an earthenware vessel the process was often termed *potting.* Nitric acid is a very powerful strip, many colours being removed by it that are fast to other agencies; on this account it was formerly looked upon as the last resource of the garment dyer, but it has now fallen into disuse.

Chromic Acid.—The oxidising bath usually employed for stripping woollen goods is that made from potassium bichromate (or sodium bichromate) and sulphuric acid, the active agent being chromic acid. It " cuts up the fades " in the same way as nitric acid, without tendering the cotton threads to quite the same degree. Like nitric acid it has the disadvantage of leaving the

goods a brownish yellow shade, which may, however, be reduced to some extent by after treatment. A chrome *bottom* is not so deep as the one produced by the nitric acid strip. The stripping bath is prepared with 3 to 5 per cent. of bichromate and 6 to 10 per cent. concentrated sulphuric acid, the amount of acid always being about twice the weight of bichromate. Some of the sulphuric acid can be substituted by oxalic acid with better results in many cases. It is usually employed at the boil; finer goods may be entered at the boil and the bath allowed to cool off with occasional turning of the goods. A short time in a full strength bath is preferable to a long time in a weaker bath. During process the goods should be kept below the surface of the liquor to avoid tendering of the cotton stitching by the large amount of acid used.

The chromic acid strip is in general use; it levels up the fades very well, and leaves the fibre very receptive to the dyestuff. The brownish-coloured ground which results from stripping with chromic acid renders it unsuitable for dyeing light or medium blues. Goods stripped by this method can be dyed most dark and medium shades of which yellow is a component, but the range may be increased by further treatment, *e.g.* the stripped goods are rinsed, passed through a warm acid bath, and thoroughly rinsed again, and treated in a dilute bath of hydrogen peroxide. This treatment lightens the chrome bottom to some extent, but should be used very carefully on account of the risk of tendering. A safer method is to treat the chromed goods with hydrosulphite, particulars of this being given under *Reducing Agents.*

Potassium permanganate and potassium persulphate may also be employed as oxidising stripping agents, but the risk of tendering the fibre prevents their use to any extent; potassium permanganate is sometimes used as a bleach for straw hats, but otherwise its chief field is in stain removing or spotting.

Peroxides in Stripping.—The safest oxidising agents are undoubtedly the peroxides, but their employment as stripping agents is limited by their cost and by the fact that they are much less energetic than chromic acid, many colours not being affected by them. The peroxides must therefore be regarded more as bleaching agents than in connection with the stripping of colour from dyed materials. They find a useful application, however, in the preparation for dyeing of white and cream woollen goods. These have very frequently been sulphur bleached, and the original yellow colour reappears gradually, probably through the oxidation of the reduced pigment. This reappearance of the yellow colour is not always even, those portions of the garment most exposed

to the sun being more affected than those which have been more or less protected. The sulphur stoving itself, also, is not always evenly done, so that pieces show streaks and patches when dyed. Such articles are very difficult to dye level in pale or medium shades, unless they are bleached in a peroxide bath. To prepare a hydrogen peroxide bath for this purpose the bath is made up in a wooden, enamel, or earthenware vessel, preferably the latter, with 10 gallons of hydrogen peroxide (10 volumes) to every 100 gallons of water, and made faintly alkaline with ammonia. The goods are put in the bath over night, and in the morning are squeezed and rinsed in water. Sodium peroxide may be used for the same purpose, the bath being made up as described under *Bleaching*.

Faded woollen and silk articles for re-dyeing pale shades, *e.g.* children's garments for pale pink, pale blue, etc., obviously cannot be stripped by methods which leave a dark-coloured ground such as that produced by chromic acid. It is found when such faded articles are treated with peroxide as a preliminary step to re-dyeing, the fades are levelled up and the original colour is sufficiently reduced to re-dye level shades. Sodium perborate can be used for the same purposes as the peroxides. It has also been suggested as an addition to the dye bath itself in dyeing faded goods, with the object of stripping and dyeing at one operation.

Hypochlorites in Stripping.—As in bleaching so in stripping of dyed materials bleaching powder and sodium hypochlorite are used. Hypochlorites are only suitable for stripping *vegetable* fibres, *e.g.* cotton, linen, mercerised cotton, and artificial silk (including Celanese or cellulose acetate). They must not be used on articles containing wool or silk, as these fibres are turned a yellow colour by a short treatment and destroyed by a prolonged immersion. It is therefore necessary to examine articles which may be stitched with silk (*e.g.* white waistcoats) before bleaching them with hypochlorites.

Most direct cotton colours, with the exception of a few yellows, can be stripped with hypochlorites. They level up slightly faded material very well, and carefully used they are safe stripping agents. The methods of applying hypochlorites in stripping are similar to those described under *Bleaching*. The dyed articles from which the colour is to be removed are worked in the liquor all the time to obtain an even result. Where bleaching powder is used it is applied as a clear solution at a strength of $\frac{1}{2}°$ to 1° Tw. After treating the goods in the cold until stripped, they are rinsed, passed through cold dilute acid, and rinsed again. A solution of *anti-chlor*—sodium thiosulphate—is sometimes used as a final

bath to remove the last traces of chlorine, which might cause tendering.

Sodium hypochlorite can be used instead of a solution of bleaching powder and is applied as described under *Bleaching*. For stripping dyed artificial silk goods—knitted jerseys, scarves, etc.—sodium hypochlorite is certainly preferable, as it is more easily rinsed out and preserves the sheen. Bleaching powder, on account of the lime present, somewhat dulls the lustre of these materials and is more prone to cause damage. Articles made from mercerised cotton and artificial silk frequently contain silk threads. A scarf may be made of artificial silk with a silk fringe. Lace may consist of real and artificial silk. Before using hypochlorite such articles should be very carefully tested, and if silk is present other methods of stripping must be employed.

It is not advisable to use hypochlorites for stripping materials already showing signs of tendering—for example, badly faded curtains. These are better stripped with one of the reducing stripping agents, such as hydrosulphite. Before stripping curtains with hypochlorites any brass hooks should be removed, as these cause local tendering owing to the catalytic action of the copper.

4. Stripping with Reducing Agents.—(1) *Hydrosulphite Compounds.*—Sodium hydrosulphite, which was formerly very difficult to prepare in a stable form, is now marketed in the form of a dry, white powder; it is, however, more stable in some of its additive compounds. It may be prepared on a small scale by the action of zinc dust upon sodium bisulphite, but the quantity so made should not exceed one week's requirements, and even then the solution should be preserved in well-filled bottles or barrels tightly fastened to exclude air.

Hydrosulphites are known to form stable compounds with aldehydes, and the introduction of these stable derivatives first led to their extensive commercial use. Those used are compounds of sodium hydrosulphite and formaldehyde, the reaction which takes place being expressed by the following equation : [1]—

Sodium hydrosulphite is represented as an anhydrous salt derived from equal molecules of sulphurous and sulphoxylic acids, according to the researches of Bernthsen :

$$O\begin{cases} S-ONa \\ SO-ONa. \end{cases}$$
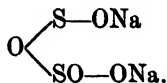
[1] Green, *J.S.D.C.*, 1906.

This salt in aqueous solution reacts with formaldehyde :

$$O\begin{cases} S\text{—ONa} \\ SO\text{—ONa} + H_2O \end{cases} + 2CH_2O = \begin{matrix} HO.CH_2.O.S\text{—ONa} \\ \text{and} \\ HO.CH_2.O.SO.ONa. \end{matrix}$$
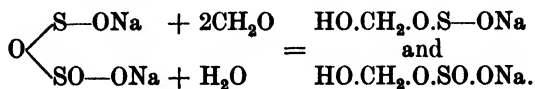
It was at first thought that this product was a compound having the empirical formula

$$Na_2S_2O_4,\ 2CH_2O,\ 4H_2O.$$

It is on the market in the form of white lumps readily soluble in water. It was found, soon after its introduction,[1] that it is a mixture in molecular proportions of sodium bisulphite-formaldehyde, $NaHSO_3.CH_2O$, and a new compound to which Bernthsen gave the name sodium sulphoxylate-formaldehyde, $NaHSO_2.CH_2O$. The latter can be separated by fractional crystallisation, and has double the reducing power of the mixture.

The zinc salt of formaldehyde-sulphoxylic acid is more stable than the sodium salt. The sodium salt of formaldehyde-sulphoxylic acid is soluble in water, and is employed as a discharging agent in calico printing. It is also used as a spotting agent for removing colour stains. It decomposes too quickly in the acid stripping bath to be employed economically as a general purpose stripping agent. For stripping goods with thick seams it is sometimes advantageous owing to the clearness of the bath. The zinc salt is insoluble in water but is soluble in acids, and is only decomposed in the boiling bath. It is supplied in the form of a heavy, greyish-white powder, which keeps for an almost unlimited time, even if exposed to moist air.

Sodium hydrosulphite and its compounds strip nearly all aniline colours (except mordant colours) on all fibres, the colour in many cases being reduced to a very pale buff or cream *bottom*, on which pale and medium fancy shades may be produced. It is, therefore, an extremely valuable stripping agent. Silk, artificial silk, and cotton may be treated without injury. Carefully applied it can also be used for removing colour from woollen material, though wool suffers some loss in weight when stripped at the boil. Goods requiring stripping are first cleansed in a dilute, lukewarm solution of soda, followed by a good rinsing.

Method of Application of Sodium Formaldehyde-Sulphoxylate (*Sodium Formosul*) ($NaHSO_2.CH_2O.2H_2O$). (This substance is also known as *Rongalite C, Hydrosulphite NF Conc.,*

[1] Baumann, Thesmar, and Frossard, *Bull. de la Soc. ind. de Mulhouse,* 1904, 348.

Hyraldite C).—The method of using this compound is based on the fact that it is split up in solution by the addition of an acid, and during the heating of the bath the active agent is liberated, which acts upon the dyes, reducing them to less highly coloured compounds.

The stripping bath is charged with—

2 to 3 per cent. formosul ;
and 1½ to 2½ per cent. formic acid (90 per cent.) ; or
4 to 6 per cent. acetic acid (30 per cent.).

A slight excess of acid is not harmful. Formic acid is preferable to acetic acid, and appears to be rather more powerful.

The bath is lukewarm when the goods are entered and is gradually raised to the boil and maintained at that temperature for 10 to 15 minutes. The bath must remain acid to litmus paper the whole time, further quantities of formic or acetic acid being added if required. The vessel employed should be of wood or sound enamelled iron ; ordinary copper must not be used, as the strip is decomposed thereby, and any exposed steam pipes must be wrapped in cotton cloth to prevent the articles from coming into direct contact with the metal, which is liable to produce stains most difficult to remove. After stripping, the goods are rinsed well, first in warm then in cold water.

A standing bath for stripping can be kept up though it is a doubtful economy to do so, for several reasons. The bath rapidly loses strength ; a certain amount of sulphur is precipitated, which is partially deposited on the goods and causes trouble in re-dyeing. The stripping bath also becomes more or less fouled in time by the accumulation of colour which has been stripped from previous lots of material. There are many colours that appear to be stripped completely whilst in the stripping bath, but which re-develop by oxidation on the material after rinsing. These colours would be liable to stain succeeding batches of work in a standing bath.

Zinc Formosul.—(Basic Zinc Salt of Formaldehyde-sulph-oxylic Acid : Also known as *Decroline, Hydrosulphite AZ, Hyraldite Z*).—This is now in more general use for stripping purposes than the sodium salt. It is a greyish-white powder, insoluble in water but soluble in acids. It has no smell, and being non-hygroscopic is more stable than sodium formosul, so that it can be stored without the necessity of taking special precautions against dampness or access of air. It is applied with acid in a similar manner to sodium formosul, but differs in that the bath does not reach its full activity until near the boiling-point.

The bath is prepared with the following quantities :—

> 2 to 4 per cent. zinc formosul ;
> and 2½ to 5 per cent. formic acid (90 per cent.) ; or
> 8 to 10 per cent. acetic acid (30 per cent.) ; or
> 1 to 2 per cent. sulphuric acid (168° Tw.).

A slight excess of acid is not injurious. The acids most frequently used are formic acid and acetic acid. Of these, formic acid gives a more complete strip when comparing molecular equivalents of the two acids, and therefore, on economic grounds, is to be preferred. On the other hand, acetic acid leaves the material in better condition and is adapted for more delicate work. Sulphuric acid cannot be recommended as an addition to the zinc formosul in stripping garment work, though there is no objection to adding a little towards the end of the process. It is important that the stripping bath should remain acid the whole time, and the liquor should be tested occasionally with litmus paper.

Note on Stripping with Stable Hydrosulphites.—If the goods (wool and silk) stripped with *Sodium Formosul* or *Zinc Formosul* are to be subsequently dyed *hard*, *i.e.* in an ordinary acid dye bath with sulphuric acid and Glauber's salt, it is advisable after rinsing to work them in a fresh, hot, acid bath charged with formic or acetic acid preparatory to dyeing them. By so doing any remaining hydrosulphite is decomposed, and the goods then take up the dye more evenly and with better penetration in the next bath. Where any residues from the stripping bath remain, the dye is absorbed unevenly and any wool present tends to become brittle in the sulphuric acid dye bath. In place of the hot formic acid or acetic acid bath the stripped goods may be allowed to remain in a cold, dilute, sulphuric acid bath for 20 minutes to half an hour, finally rinsing thoroughly before dyeing.

If it is intended to dye the stripped goods in a neutral bath they should be thoroughly rinsed with water, passed through a dilute ammonia bath to neutralise, and again rinsed. Unless badly faded, goods stripped with the stable hydrosulphites dye better in a neutral than in an acid bath. Wool, in particular, has a better handle, and is more easily dyed level.

It is frequently found that with certain articles some of the colour returns on rinsing or upon exposure to air, although apparently completely stripped when immersed in the liquor. In such cases it is probable that the dye has been temporarily reduced in the bath to *leuco* compounds which afterwards re-oxidise to the original colour. This occurs, for example, with some colours

of the triphenylmethane series. To strip the re-oxidised colour completely it is of no advantage to keep the goods in the same stripping bath for a longer period, as the colour is again only temporarily reduced. A fresh bath of *Sodium Formosul* or *Zinc Formosul* will reduce it somewhat, but as a rule a subsequent treatment of the goods in a lukewarm, dilute ammonia bath or even in a boiling-water bath will be more effectual. For stripping goods with tight seams an addition of *Tetracarnit* to the bath helps towards the complete penetration of the hydrosulphite and the more even distribution of the reduced colouring matter. When using a standing bath for stripping purposes it gradually becomes loaded with colouring matters of the class that re-oxidise on exposure, so that it is bad practice to keep a standing bath too long. An article to be dyed a light shade should not be placed in an old stripping bath.

Stripping with Sodium Hydrosulphite (*Hydros*).—The anhydrous salt, which is the *Hydrosulphite Concentrated*, also known as *Hydros* (Brotherton), is produced in large quantities by home manufacturers and is now used for stripping purposes. It is a greyish-white powder which dissolves freely in both cold and hot water. If kept in a cool, dry place and in a tight metal container the material is fairly stable. It is a satisfactory stripping agent for most acid colours and direct cotton colours, and shows an advantage over Sodium Formosul and Zinc Formosul in being simpler to use and easier to rinse out. On the other hand there are some colouring matters that can be stripped by Sodium Formosul or Zinc Formosul and that do not readily respond to treatment with " Hydros." A preliminary test can be made in case of doubt.

Method of Stripping with Hydros.—After cleaning the articles with soda or other alkali, and rinsing, they are placed in an aqueous solution of " Hydros," without any addition. The hydrosulphite is active in the cold, but its activity increases with rise of temperature. The goods may be entered at about 50° C. and the bath heated gradually almost to the boil. The percentage of Hydros required naturally depends upon the depth of shade of the article to be stripped, as well as on other factors, but as the stripping bath requires no other addition it is convenient to commence with 2 per cent. on the weight of goods and freshen up the bath with more Hydros if found necessary after 20 minutes.

Precautions when Stripping with Hydros.—As acid decomposes sodium hydrosulphite with deposition of sulphur, no acid must be added to the stripping bath, but a small amount of alkali is beneficial rather than otherwise. Care should be taken not to

introduce acid in the goods themselves, *i.e.* any article that has been passed through an acid bath should be neutralised with alkali and rinsed before placing it in the "Hydros" stripping bath. Silk and cotton materials may be stripped in a boiling soap bath containing "Hydros."

Effect of Hydrosulphite Stripping Agents on the Fibre.—These stripping agents are adapted for the treatment of all fibres, and if applied correctly have little detrimental action. On cotton and other vegetable fibres the effect is so slight as to be negligible. Artificial silks can be stripped without injury, but the more soluble compounds, *e.g.* " Hydros," should be used to avoid dulling the lustre. The operation should also be carried out at a temperature not higher than 165° F. so that the strength of the fibre is maintained.

Pure silks again may be treated without damage, but care should be taken in working these goods to avoid chafing the material, and the bath should be free from sediment. The more soluble compounds should be used also for silks. Tin-weighted silks are liable to develop a greyish tone when stripped owing to the interaction of the metallic salts constituting the weighting and the hydrosulphite. Hydrosulphites have a slight tendering action on wool, the effect being greater at the boil than at lower temperatures. Wool that has been stripped with hydrosulphite is somewhat brittle and deficient in elasticity ; it is also a trifle harsh to the touch. There is some loss in weight, so that the material feels poorer, the effect being more pronounced where the wool is faded. Unless absolutely necessary, therefore, Hydros should not be used for stripping wool, and when it is applied, the stripping process should be carried out *under* the boiling temperature.

Stannous Chloride finds but little application as a stripping agent in garment dyeing, especially since the introduction of titanous chloride (or sulphate).

Titanous Salts.—(1) *Titanous Chloride*, $TiCl_3$, (2) *Titanous Sulphate*, $Ti_2(SO_4)_3$. These are powerful reducing agents, first advocated by Knecht for stripping and discharge purposes. They are marketed as dark purple, syrupy liquids, containing in solution about 37 per cent. of the salt and some free acid. In this concentrated form the solutions are stable, but once diluted they dissociate, and lose strength on standing. Titanous salts are many times more powerful than stannous chloride (" tin crystals "). Tests to ascertain the comparative reducing power on azo colours of stannous chloride and titanous chloride [1] showed that titanous

[1] Spence, *J.S.D.C.*, **xx.** 63.

chloride was at least twenty times stronger. To decolorise *Benzopurpurine* 4*B* it required 28·5 times as much stannous chloride as titanous chloride. To strip *Chrysophenine*, 37·2 times as much was required.

Titanous salts may be employed both for animal and vegetable fibres, but are principally used for decolorising dark shades on cotton and such colours on cotton as are not affected by chlorine and other stripping agents. Wool, although it may be stripped with titanous salts is rendered harsh in feel, while the lustre of silk is somewhat impaired. Titanous salts will reduce certain colours that are unaffected by the usual stripping agents, e.g. *Oxyphenine R.*, or *Diamine Fast Yellow B.*

Application.—Titanous salts are applied in a hot aqueous solution, the quantity used varying from 1 per cent. (on the weight of the goods) for pale shades up to 10 per cent. for dark shades. An equal volume of hydrochloric acid is added to prevent the precipitation on the fibre of grey titanic oxide, or hydrate, which represents a loss in bleaching power, soils the goods, and frequently interferes with the subsequent dyeing operations (especially if basic colours are to be employed). The deposition of titanic hydrate is due to the instability of the titanic salts formed by the oxidation of the titanous salts, as illustrated by the following equation :—

$$2TiCl_3 + 2HCl + O = 2TiCl_4 + H_2O.$$
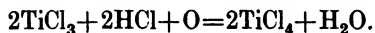
The titanic chloride is readily hydrolysed, yielding the insoluble hydrate

$$TiCl_4 + 4H_2O = 4HCl + Ti(OH)_4.$$
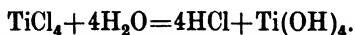
The stripping bath should not be boiled as at this temperature the free acid present is liable to tender cotton and other vegetable fibres.

In place of hydrochloric acid, oxalic acid is frequently used. In this case the bath becomes yellowish in colour. The danger of tendering the cotton is not so great when using oxalic acid.

Hibbert [1] states that the tendency of the fibre to take up titanic hydrate may be overcome by the addition to the stripping bath of potassium oxalate, as the double titanic potassium oxalate which is formed does not undergo hydrolytic decomposition. It is stated that in some cases (e.g. *Benzopurpurine*), the addition of the potassium oxalate slightly retards the stripping action, whereas in others (e.g. *Chrysophenine*) its action is rather beneficial than otherwise. Knecht [2] recommends titanous sulphocyanide,

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[1] *J.S.D.C.*, 1906.   [2] *Ibid.*, 1911.

made by mixing solutions of titanous sulphate and barium sulpho-cyanide. By using a 1 to 2 per cent. solution at 70°. to 90° C. the colours are stripped without injury to the fibre.

During the process of stripping with titanous salts the goods are opened out and kept below the surface of the liquor as much as possible, to avoid tendering. The reducing action on the colour is very rapid; frequently 10 to 15 minutes is sufficient time to allow. Afterwards the goods are rinsed first in dilute acid (thus preventing hydrolysis and consequent " greying " of the fibre), then in warm water, followed by a cold rinse.

Stripping with titanous salts should take place in earthenware or enamelled vessels or in wood vats—not in coppers.

A bath containing oxalic and sulphuric acid is occasionally employed as a reducing stripping bath for goods dyed with *Cochineal Scarlet.*

Selection of Processes.—The selection of the processes for preparing and dyeing the various articles handled by a garment dyer requires a considerable amount of judgment and experience. As already stated, stripping processes must be avoided if possible, but very frequently the removal of the old colouring matter is essential to produce the shade desired by the customer. Where goods are badly faded it is necessary in any case. Woollen or half-woollen fabrics which are sun-faded to such an extent that the fibre has been appreciably oxidised, must be stripped by an oxidising agent, though where the oxidation has only affected the colouring matter (particularly in blues and violets), stripping with a reducing agent (sodium hydrosulphite) may be employed, and with suitable colours for dyeing, yields level results. The dyeing process is varied somewhat if the article to be dyed has been stripped. The process of stripping causes a certain amount of alteration in the fibre, which has to be allowed for. If an oxidising stripping agent has been used, *e.g.* chromic acid, the fibre is oxidised, and in that condition tends to absorb the dyestuff more quickly. This difficulty is overcome by using less acid in the dye bath, or in some cases by dyeing entirely without acid. It is not advisable to dye stripped jobs in the same liquor as those not stripped, as the rate of absorption of the dye is very different.

Dyeing of Faded Goods.—Practically all the goods sent for dyeing, both articles of furnishing and dress work, are more or less faded, and this fact has to be borne in mind when choosing the most suitable dyes and the best method of applying them. In this connection it is interesting to note that faded wool itself appears to behave differently in dyeing according to the duration of exposure to light, according to the source of light, and according

to whether the exposure has been conducted under glass or direct. W. von Bergen [1] has carried out tests with thirty-four dyes of different groups, on exposed and unexposed wool, and has compiled a table embodying the results. Some dyes were found to produce darker shades on exposed wool (*positive effect*), whilst others produced lighter shades (*negative effect*). The maximum effect was produced after about 300 hours' exposure to direct sunlight, and wool exposed for shorter periods of 100 hours and 200 hours was found in many cases to behave differently to the same dye. The results on subsequently dyeing the faded wool with acid colours were found to be strongly dependent upon the dyeing process employed. *Alizarine Cyanine Green E*, when dyed from a neutral or acetic acid bath, showed a negative effect, *i.e.* dyed the fades lighter, whereas when dyed from a sulphuric acid bath it exhibited a highly positive effect, *i.e.* dyed the fades darker. Further, exposed wool differed from unexposed wool in that it had an acid reaction to litmus and methyl orange, whereas unexposed wool showed an alkaline reaction.

These results are for the most part in agreement with the general experience of garment dyers, who find that the behaviour of faded wool varies greatly according to the degree of exposure. Goods that are badly faded are always more or less tender in the fades. Such goods are very susceptible to alkaline treatment of any kind and also become soft when dyed in a neutral bath. Faded work of this nature should be dry-cleaned before dyeing, as wet cleaning may cause the fades to give way before the actual dyeing begins.

Acid colours as a class, when applied from an acid bath, dye faded wool more satisfactorily than neutral-dyeing acid colours or direct colours, and as the faded and tendered wool is *hardened* in the acid dye bath this process of dyeing is the one usually adopted for badly faded work. The more strongly acid dye baths are better from the point of view of covering fades than feebly acid ones; it is necessary to bear in mind, however, that the amount of acid it is permissible to use in practice is limited, since excess of mineral acid weakens any cotton stitching or vegetable fibre present in the form of linings or trimmings. Mineral acids, such as sulphuric acid, in the dye bath give better results on fades than organic acids, such as acetic or formic acids. Although acid colours applied in a sulphuric acid dye bath usually cover fades very well, they are by no means all equally satisfactory in this respect—for example, *Victoria Violet 4BS* does not cover fades at all well, while *Acid Violet 6BN* is reasonably good.

[1] *Textilber*, 1926, through *J.S.D.C.*

Suitable colours are to be found in the range of easily-levelling acid colours.

Faded goods that are not too tender may require an oxidising strip to assist in obtaining a level result. Nitric acid is now seldom used, being too drastic, but chromic acid is useful if the shade required can be obtained on the chrome " bottom." Paler shades, blues, for instance, can be dyed successfully if prepared previously in a bath of hydrogen peroxide. In this case chromic acid treatment is out of the question, owing to the buff-coloured ground.

A method of preparing moderately faded goods for the dye bath, that has a levelling effect on fades, is to treat them in a mild chlorinating bath made up with sodium hypochlorite. This also tends to reduce shrinkage, and is a suitable treatment for bulk loads of garment work. If the goods are very badly faded and already tender, chlorination is too dangerous, as the fades appear to be selectively attacked, and may become *slimy*, so that such goods should be excluded. When applying hypochlorites in this way, care should be taken that the hypochlorite of soda is mixed and diluted to working strength in the bath before entering the goods, as, if any concentrated hypochlorite should come into contact with wool or silk, the goods are irretrievably ruined. The chlorination process must be carefully carried out, as it is quite impossible when dyeing the goods to obtain level shades upon unevenly chlorinated wool.

To obtain the best results it follows from the previous remarks that goods for dyeing should be carefully classified according to their nature and condition. If the fibre as well as the colour is faded, the wool and silk should be acid dyed and the cotton filled in at a lower temperature.

Moderately faded goods (and in this class one should include those in which the original colour is faded, but the fibre is little affected) may be dyed successfully in a single bath with union colours. The best union colours for fade covering are.those consisting of a mixture of neutral dyeing acid colours and direct cotton colours leaving wool thin at temperatures near the boil.

Fades on Cotton and Linen.—Sun-fades on cotton and linen, for example on casement curtains, are a somewhat different proposition to fades on wool or silk. Where any fades resist dyeing with direct cotton colours, indicating the presence of oxycellulose, this may often be corrected by topping with a weak basic colour which stains the fades more than the unfaded parts, so that the procedure in such cases after stripping the original colour with hydrosulphite is to dye with direct cotton colours and top slightly (if found to show fades) with basic colours.

Dyeing Half-wool Fabrics.—From the garment dyers' stand-point, goods may be regarded as half-wool if made up of wool with cotton stitching, cotton or Rayon lining or trimming, which must be dyed approximately the same shade. It also applies to articles of wool and cotton union fabric. In some cases the goods may consist chiefly of wool, in others chiefly of cotton, but where large batches of work are dyed the proportion of cotton to wool averages fairly well.

In dyeing half-wool goods there are at least five distinct methods which may be employed :—

(1) The wool is dyed with " acid-dyeing " acid colours, the cotton being dyed in a separate bath at a low temperature with direct colours which do not colour the wool (or only go on to it slightly).

(2) The wool is dyed with a " neutral dyeing " acid dyestuff (*i.e.* one which dyes it in a salt bath), the cotton being dyed (generally in the same bath) with a direct colour, principally dyeing the latter.

(3) The wool and cotton may be dyed in one bath with a direct colour, giving a practically uniform shade on both fibres.

(4) The wool and cotton may be dyed different shades as follows :—

(*a*) The wool is dyed with an acid colour, leaving the cotton white ; the cotton may subsequently be dyed a different shade with a direct colour which does not go on to the wool.

(*b*) The cotton may be dyed with a direct colour, the wool being left white.

(5) The *three bath* process is occasionally employed, in which the wool is dyed with acid colours, the cotton being subsequently mordanted with tannic acid and iron, and dyed with basic colours. This process may be shortened by replacing the two-bath tannin and iron method by the one-bath method, using *Katanol O* as a mordant.

The older processes were two and three bath, but the modern tendency is towards the greater use of the single bath process wherever practicable. The first method (two bath) is generally used in dyeing browns, frequently for other colours, but seldom for blacks. It is employed in dyeing wool garments trimmed with lace made from cotton or Rayon. It is used in cases where the proportion of cotton is very small, as in the case of woollen curtains with cotton stitching or braid. It is also employed whenever

articles are badly faded ; the goods must in such cases be stripped
with an oxidising agent (usually sodium bichromate and sul-
phuric acid), and they should only be accepted for colours which
can be dyed on the " bottom " thus obtained. In dyeing the
wool with acid colours the shade must be kept a little lighter than
the pattern to allow for any direct dyestuff which may go on to
the wool from the cotton *filling in* bath. Before entering into
this bath, all traces of acid must be rinsed out of the goods,
as the presence of small quantities of acid increases the amount
of direct colour which goes on to the wool, causing the latter to
become too dark, particularly in the seams—*thick seams*—and
in the faded portions. Owing to the persistence with which
wool retains acid it is advisable not to rely upon rinsing only,
even if done thoroughly, as a means of removing the acidity
of the wool. Better results are obtained when the goods
are neutralised with alkali by passing them through a weak
bath of soda or ammonia before filling in the cotton with direct
colours.

To overcome the difficulty caused by direct colour *riding* on
the fades, some dyers fill up the cotton in faded goods with
tannic acid (*Myrabolans*) and nitrate of iron, then tone with a
small percentage of a suitable basic colour, e.g. *Bismarck Brown*,
Methylene Blue, etc. This method, however, is falling into disuse
on account of the length of process and the possibility of bronzi-
ness and rubbing of the basic colour. In such cases better results
are obtained and the wool is kept clearer by filling in with direct
colour and making an addition of *Katanol W* to the filling-in bath.
Katanol acts as a resist to animal fibres, so that when using it,
the filling-in can be carried out at a higher temperature, *i.e.* up
to 140° F., without the danger of the direct cotton colour flush-
ing on to the wool. The Katanol *resist method* is found to be
advantageous in the case of suits, which have usually been sub-
jected to more exposure than ladies' dress work.

The method adopted for dyeing wool or half-wool goods with
cotton or Rayon linings may depend upon the process which was
employed in dyeing the linings, and whether the colour originally
used on the linings is fast or not. Where preparatory cleaning
by weak alkalies shows that the colour of the lining has been very
little affected, and the face fabric is all wool, the goods may be
dyed in an acid bath by method (1).

When the linings have been originally dyed with substantive
cotton colours some of the colour may be stripped from them if
dyed in an acid dye bath and *ride* on the wool unevenly. These
goods are better dyed by the single-bath method (2). If the single-

bath method is not considered suitable on account of fades or for some other reason, the direct colour on the lining should be reduced with boiling water or sometimes by means of hydrosulphite before re-dyeing the wool in an acid bath by method (1).

Method (2) is the single-bath process found to be most useful for work that is not too severely faded, and it can be used for a very large proportion of the goods sent for re-dyeing. In this case the wool and cotton or Rayon are dyed in the same salt bath with a neutral dyeing acid colour for the wool and a substantive colour, principally dyeing the cotton, for the cotton and Rayon. This method gives very satisfactory results, and by a suitable selection of dyestuffs it is possible to dye well-balanced shades on all fibres. As compared with the two- and three-bath processes it scores on the grounds of quicker output and less damage to goods owing to the shorter process involved. There is also the obvious economy in labour and steam. An over-dyed shade obtained by this method is easier to correct than when dyed with a direct colour only, as the shade may be thinned down by means of boiling water.

Method (3) is often used where absolute solidity is important and where the proportion of cotton is great as compared with wool. This method requires substantive colours only, of which there is a fairly wide range which yield level shades on both fibres. Adjustments of shade are also made with ease as, in general, the wool dyes a fuller shade at the boil, while the cotton may be dyed a deeper shade by reducing the temperature of the bath.

Method (4) is frequently employed in producing cross-dyed effects on union damask, wool and cotton or Rayon union materials, etc. It is also used in dyeing light shades on articles trimmed with cotton or Rayon lace or trimmings, the latter if left white producing a pleasing effect. In such cases it is always desirable to select acid colours which will not stain the cotton or Rayon, of which there is an extensive range. Occasionally also the garment dyer may be required to dye the cotton or Rayon in a crème shade or in some contrasting colour. As far as possible he should endeavour to reproduce the combinations of colour usually found in the new, as the result is always more acceptable to a customer than the possession of an article which obviously has been re-dyed.

Method (5) is occasionally employed in the dyeing of faded goods. For economic reasons a dyer should never select a multi-bath method if it is possible to obtain a really satisfactory result in a single bath. Again, some materials are not strong enough to stand a lengthy dyeing process.

Wool, Silk, Rayon and Cotton Mixtures.—This combination is very often handled by the job dyer, both in garments and in furnishing fabrics. In garments a wool or half wool fabric is frequently trimmed with silk or Rayon, or a wool and silk fabric has a cotton or Rayon lining or cotton stitching. Wool and silk, and wool and Rayon mixtures find very wide use in dress fabrics. In curtains and draperies many wool and silk fabrics are employed (*Roman Satin*, etc.) with cotton linings. The notes given under Silk as to the careful handling required by all silk goods, and particularly those composed partially of spun silk, apply with equal force to the above-mentioned mixtures. The dyeing of these fabrics is very similar to the dyeing of half-wool goods. The only stripping required in most cases is a weak, alkaline treatment, followed by boiling *sweat*. If badly faded, a weak oxidising stripping bath may be necessary, special care being bestowed upon the silk ; as silk is very readily acted upon by chromic acid, bichromate baths should not be used unless the proportion of silk is quite small. Nitric acid may be employed with caution, though it is now seldom used. In general, the silk in mixed fabrics is thrown into greater prominence than the wool and a slight deficiency of colour on the faded wool is not so important if the silk is level. In all such cases the faded fabric should be carefully stripped in a hydrosulphite bath and dyed according to method (2) or (3), the choice of process depending upon the amount and prominence of the Rayon and cotton.

As a general rule there is a tendency for the wool to become too dark, especially if the fabrics have been cleaned in an alkaline bath ; the best results are obtained by dyeing at a temperature *under* the boil. Silk and wool mixtures dyed with neutral dyeing acid colours are better if not scrooped after dyeing, as the wool " handles " better if it contains no acid. The shades are also liable to alteration by scrooping, which renders matching more difficult.

Wool.—The all-wool garments sent for re-dyeing are generally woollen jerseys, knitted jumpers, and dresses. So far as garments made from woven materials are concerned these are usually lined with Rayon or cotton or have cotton stitching, so that they cannot be treated as all-wool. Furnishings are met with as *wool repp*, *wool damask*, etc., though not so much as formerly. All-wool articles are almost invariably dyed with acid colours, as the equalising effect of the acid bath on slightly faded work is so beneficial. If badly faded, an oxidising stripping bath (chromic acid) should be used when the shade required allows. If the fabric contains hard, twisted wool, knots, etc., more level results and

better penetration are obtained by dyeing with neutral dyeing acid colours.

Cotton, Linen, Rayon.—These materials are often met with as casement curtains, summer dresses, knitted Rayon jumpers, etc. Cotton fabrics are prepared for dyeing by removing the old colour if necessary by (1) alkalies ; (2) sodium hydrosulphite (*Hydros*) ; (3) hypochlorites ; (4) titanous chloride or sulphate, the processes being selected in the order named ; they are always re-dyed with substantive colours in neutral baths. If bright colours are desired the materials may be topped in a separate bath with basic colours. It must, however, be remembered that basic colours dyed in this way are not very fast to light. For casement curtains, fastness to light is a *sine qua non*, and the fastest of the substantive cotton colours are satisfactory in this respect. Vat colours are sometimes used for dyeing all cotton casements, though the process of applying them is not very well adapted for made-up curtains that are already faded. The penetration of the seams by the vat process leaves something to be desired, and fades do not *shut in* at all well. Some of the colours in this range are pre-eminently fast to light, and on this account they are likely to be more extensively used where sun-fastness is a prime consideration.

Silk.—Unweighted silks (*japs*, some *crêpes de chine*, etc.) may be cleaned in soap baths and dyed with acid colours in acid baths without special precautions. It is, however, advisable to ensure first that the fabric *is* unweighted ; formerly all piece-dyed silks (*crêpes de chine, ninons chiffons*, etc.) were unweighted whilst most yarn-dyed fabrics were weighted. This differentiation no longer obtains, as most of the piece-dyed silks now manufactured are weighted " *in the piece* " prior to the process of dyeing. Very high percentages of weighting relate more particularly to yarn-dyed fabrics. In these the fabric is ready for sale as soon as it leaves the loom and has not to withstand any further processes, but with piece-weighted fabrics the material has to undergo the processes of dyeing and finishing at the hands of the manufacturer ; hence the degree of weighting which is added to the fabric must not be sufficient to weaken the material to an impracticable extent. Piece-weighting rarely exceeds 65 per cent. to 75 per cent. on the *boil-off* weight, which is equivalent to 20 to 22 ounces for the original 16 ounces of gum silk.

If the weighting has been carried out satisfactorily and the tin compounds are properly formed, the fabric will re-dye quite well after ordinary usage and exposure. Tin-weighted silks are liable to become tender where subjected to perspiration, and articles stained in this way should be handled very carefully and

at customer's risk.   The dyer should test a thread of the fabric before he commences operations ; it is usually possible to extract a few fibres from one of the seams ; if, on burning, the usual black, carbonaceous bead is obtained, the fabric is unweighted ; if, on the other hand, an ash remains which retains the shape of the original fibre it is a weighted fabric.   A moderately weighted crêpe-de-chine may be dyed with success, especially if stripped in a hydrosulphite bath, which serves the double purpose of removing the colour and rendering the fabric less liable to become tender during dyeing.

Silks should be handled as little as possible during cleaning and dyeing, especially spun silks, as they are very liable to show traces of any mechanical chafing or rubbing due to the splitting of the ultimate filaments, resulting in white marks appearing on the surface ; these white marks (sometimes known as *mildew*) are very difficult to obliterate, as the split filaments will not dye, and the more the fabric is handled the worse they become.   Whenever possible, silks, particularly stiff silks (*taffetas*) and satins, should be dyed on frames.   The silks are tacked on to the frames, which are let down into the dye bath and worked in the dye liquor by a slow up-and-down movement, so that friction is avoided.

White silks sometimes show brown discolorations ; these are due to catalytic oxidation during storage, and such articles should not be dyed, as the brown places are almost invariably very tender.

Basic colours are only employed on silk goods if very bright *gaslight* shades are required ; the colours produced are not fast to light, but, for special purposes, this is not always of importance.

Silk and Wool Unions (Gloria, Etc.).—If badly faded, these may be stripped with nitric acid, but as the silk is frequently the more prominent fibre, hydrosulphites should be used in preference, whenever possible, though they should be applied carefully and below the boil owing to danger of tendering the wool.   Silk and wool may be dyed with acid colours in an acid bath, but more solid shades are obtained in neutral baths with neutral dyeing acid colours (*vide ante*).

Silk and Cotton (Satin, Etc.).—Preparing with boiling soap is generally sufficient, but if a stripping agent is required, hydrosulphite or titanous chloride are used.   The dyeing is usually done with substantive colours in a neutral bath, followed, if necessary, by topping in a separate acidified (acetic acid) bath with acid or basic colours, the former dyeing the silk only, the latter going on to both the cotton and the silk.   Cross-dyed effects may be obtained by employing suitable acid colours on the silk, the cotton remaining white ; the latter may subsequently be dyed in a

separate bath at a low temperature with suitable substantive colours. Useful effects may be obtained in this way by dyeing pale shades on silk blouses with lace insertion, the lace being left white, or tinted cream in a separate bath. In pale shades the cotton stitching will not show very much, but a similar effect in medium shades can only be obtained if the article is stitched with silk. This method is also frequently employed in re-dyeing silk casement curtains, which are often made with cream cotton lace insertion.

Selection of Dyes.—To determine the relative value of any dyestuff the following properties must be considered :—

1. Solubility in water.
2. Equalising (or levelling) power.
3. Fastness to light.
4. Behaviour towards other influences—perspiration, rubbing, ironing, and washing.

The tables of dyestuffs given on the following pages are not necessarily complete. Other dyes will be found to be equally suitable. The numbers placed in front of the names of many dyes (*e.g 365 Chrysophenine G*) are those in the *Colour Index*, published by the *Society of Dyers and Colourists*. By reference to the *Colour Index*, information can be obtained as to the names and makers of chemically synonymous dyes. The latter will be found to have the same dyeing properties as the examples given in the tables. Before deciding upon a particular dyestuff the questions of colour strength, brightness, and price have also to be considered.

Solubility.—Colouring matters should be dissolved in pure water when possible, but if this cannot be done the lime in the water must be corrected by the addition of acetic acid or soda, according to the properties of the dyestuffs, as some dyestuffs form insoluble compounds with lime. Acid colours should never be dissolved directly in acid dye baths. The precipitation of substantive cotton dyestuffs in standing baths is generally due to the use of hard water, unless the dyestuff has been *salted out* by excess of sodium sulphate or sodium chloride in the bath.

Equalising Power.—This depends upon the affinity of the dyestuff for the fibres. Colours which are taken up by the fibre slowly generally yield more even dyeings than those which exhaust quickly. The addition to the bath of sodium sulphate tends to retard the absorption of acid colouring matters possessing strong affinity for the fibre ; consequently, more even dyeings are obtained when using it. Of the acid dyestuffs, the yellow and

orange colouring matters as a class equalise better than the reds, blues, and violets. The "neutral dyeing" acid colours, dyed from a neutral bath, generally dye more level than those requiring the addition of an acid, the equalising powers of the acids usually employed being in the following order, the first named giving the most satisfactory results : (1) Formic acid ; (2) acetic acid ; (3) sulphuric acid.

The production of level dyeings depends largely upon the regulation of the temperature of the dye bath ; good results can usually be obtained if the temperature is carefully raised during the process, as this tends towards the more regular absorption of the dye.

Fastness of Dyestuffs.—In general the requirements as to fastness are not so great in re-dyeing goods as when dyeing in the new. In all cases the dyes must withstand the ordinary finishing processes, *e.g.* hot pressing, steaming, etc., but in addition, greater or less demands are made according to the uses to which the goods may be put in wear, *e.g.* :—

Curtains must be fast to light and rubbing.

Carpets must be fast to light, lime (street dirt), and rubbing.

Bunting must be fast to light, water, and washing.

Garments must be fast to rubbing, perspiration, lime, and light.

Fastness to Light.—This is very important, particularly in the dyeing of curtains, etc., which are more or less continually exposed to direct sunlight. Only dyestuffs possessing good fastness to light should be employed ; as a rule the red, yellow, brown, and black dyestuffs surpass the green, blue, and violet dyes. Many of the acid and substantive dyes are very fast to light, whereas the basic dyes are, on the whole, fugitive. The substantive dyes are usually faster to light on wool and silk than they are on cotton—for example, *419 Direct Fast Red F* (*CAC*), is very fast on wool and silk, but only moderately fast on cotton. Where no colours are particularly fast—for example, violets on half-wool fabrics—the best available dyestuffs are given.

The following is a selection of acid dyeing colours which may be recommended for their fastness to light. They can be used for compound shades as well as self colours on wool. There are a number of acid blacks fast to light, but these are not included in the list because acid blacks are seldom used in mixture shades.

Acid Colours Fast to Light.

AZO EOSINE. (I.G.)

252 BRILLIANT CROCEINE. Various makes.

31 KITON RED G. (CAC.)

57	LISSAMINE RED 6B. (BDC.)
29	XL CARMOSINE 6R. (BDC.)
	KITON FAST RED 4BL. (CAC.)
124	CHROMAZONE RED A. (GY.)
27	FAST LIGHT ORANGE G. (LBH.)
151	ORANGE II. All makes, fairly fast.
639	XYLENE LIGHT YELLOW 2G. (S.)
	LISSAMINE FAST YELLOW 2G. (BDC.)
	NEOLAN GREEN B. (CAC.)
1054	ALIZARINE DELPHINOL BDN. (BDC.)
	DUROCYANINE 3FL. (BDC.)
	ALIZARINE ULTRA BLUE B. (BDC.)
	NEOLAN BLUE 2G. (CAC.)
	ACID VIOLET 4R. (CAC.)
	LISSAMINE VIOLET 2R. (BDC.). Fairly fast.
	ALIZARINE DIRECT BROWN RL, GL. (S.)

The following direct colours are recommended for their fastness to light on cotton, and are therefore suitable for dyeing cotton casement curtains and the like which must stand exposure. Many direct colours, if after-treated with a solution of copper sulphate, are rendered much faster to light, but this process is not often used by the garment dyer, as the available range of direct-dyed colours that are fast without after-treatment is much more extensive than formerly.

Direct Colours Fast to Light.

278	CHLORAZOL FAST RED K. (BDC.)
	BENZO FAST BORDEAUX 6BL. (I.G.)
	CHLORAZOL FAST BORDEAUX LK. (BDC.)
	SIRIUS CORINTH B. (I.G.)
	CHLORAMINE FAST PINK 2B. (S.)
353	CHLORAZOL FAST PINK BK. (BDC.)
653	PYRAZOL ORANGE G. CONC. (S.) Fairly fast.
	CHLORAZOL FAST ORANGE AG. (BDC.)
620	TOLUYLENE FAST ORANGE LX. (I.G.)
	CHLORAZOL FAST BROWN RK., 2RK. (BDC.)
	TOLUYLENE FAST BROWN 2R. (I.G.)
	CHLORANTINE FAST BROWN 3GL. (CAC.)
346	CHLORAMINE FAST YELLOW 4GL. (S.)
365	CHRYSOPHENINE G. All makes.
814	CHLORAZOL FAST YELLOW B. (BDC.)
	CHLORANTINE FAST GREEN BL. (CAC.)

BENZO FAST BLUE 4GL., 8GL. (I.G.)
CHLORANTINE FAST BLUE 2GL., 4GL., 8GL. (CAC.)
CHLORAZOL FAST BLUE 2BN. (BDC.)
319 BRILLIANT FAST BLUE B. (I.G.)
CHLORAMINE FAST VIOLET 2RL. (S.)
CHLORANTINE FAST GREY BLN, GLN, RLN. (CAC.)
CHLORANTINE FAST BLACK L. (CAC.)

Fastness to Perspiration.—Most of the colours mentioned are sufficiently fast to perspiration with the exception of the few acid colours which dye cotton, e.g. *Brilliant Croceine.*

Fastness to Rubbing can be usually obtained by avoiding basic dyestuffs. Certain acid dyestuffs that are not very clean to rubbing, e.g. *Alkali Violet, Soluble Blue,* should only be used in small quantities for brightening purposes. The goods should be thoroughly cleaned either by dry or wet process before dyeing, as any dye, even if normally quite clean, will rub if dyed upon grease or dirt. Over-dyeing, superficial dyeing (bronziness), and dyeing from a bath made up with hard water, will result in rubbing off. Some acid colours, for example those of the *Violamine* series (*758 Fast Acid Violet 2R*, etc.), that can be dyed either neutral or acid, are more liable to rub when dyed acid than when applied from a neutral bath.

Fastness to Washing.—Half-wool garments for outdoor wear should be dyed with colouring matters fast to washing. Most of the substantive cotton dyestuffs are satisfactory for this purpose so far as loss in depth of shade is concerned, if dyed in combination with suitable neutral-dyeing acid colours. Some substantive colours can be rendered faster to washing by after-treatment with formaldehyde, others by diazotising and developing, and others again by means of suitable metallic salts, *e.g.* potassium bichromate and copper sulphate, *q.v.*

Fastness to Alkalies (Lime ; Street Dirt).—Most acid dyestuffs are satisfactory, but basic dyestuffs should not be used. Some acid colours, e.g. *Acid Magenta, Soluble Blue, Acid Green,* are not very fast and should be avoided, especially in re-dyeing carpets.

Fastness to Water.—This is of importance in re-dyeing bunting which must stand exposure to rain. A sufficient degree of fastness may usually be obtained by selecting acid colours requiring a feebly acid (acetic acid) bath, e.g. *Sulphon Yellow.*

Dyeing of Half-Wool (Wool and Cotton) Fabrics.—*Method* 1. (Wool dyed first, cotton dyed afterwards.)—This is a

two-bath process, the wool being dyed with an acid colour in an acid bath, the cotton being subsequently dyed in a separate bath at a lower temperature with direct colours that dye cotton but have little or no affinity for wool under these conditions. It is one of the oldest methods of dyeing half-wool garments, etc., but is now usually employed with goods which are faded to such a degree that a single bath method would be considered unsuitable. As already mentioned, a sharply acid bath has a beneficial action in levelling fades, and mineral acids are better than organic acids in this respect. The assistants used are sulphuric acid and sodium sulphate (Glauber's salt) ; or with goods which are difficult to penetrate or to dye evenly, acetic or formic acid replaces the sulphuric acid with advantage (the risk of tendering the cotton is also obviated by the employment of the organic acids). The amount of dyestuff employed depends upon the tinctorial power of each colouring matter ; it averages from 0·1 per cent. for light shades up to 2 to 6 per cent. for dark shades (calculated upon the weight of the goods), with the addition of 10 to 20 per cent. of Glauber's salt and 4 to 5 per cent. sulphuric acid or equivalent amounts of acetic or formic acid. With colours which do not equalise well the acid may be added a little at a time as the dyeing proceeds ; in such cases the quantity of Glauber's salt may also be increased. When organic acids are employed the bath may be cleared by the addition of a little sulphuric acid when it appears to be nearly exhausted. The rate of exhaustion when using formic acid alone is approximately the same as when using an equivalent quantity of sulphuric acid together with Glauber's salt.

Dyeing in an acid bath by this method, only the wool is dyed ; the silk trimmings are more or less covered according to the particular acid dyes used, whilst the cotton linings, stitching, etc., are merely stained in the acid dye bath. The acid also exercises a stripping action upon the dyed lining and stitching, the larger the percentage of acid, the greater the stripping effect. When organic acids are employed in place of sulphuric acid the stripping of the cotton is very much reduced.

The goods are entered into the acid dye bath at 120° F., the temperature being slowly raised to boiling-point and maintained at that temperature for 30 to 45 minutes. Faded goods must be boiled as little as possible. Blacks are very rarely dyed on unions by this method, as the single bath process gives good results. Most other colours are dyed by two-bath methods when the articles to be dyed are faded when received. It is advisable to dye the wool a trifle lighter than the shade required, in order to allow

for a little of the direct cotton colour from the filling-in bath staining it. Most of the fashion shades demand the use of two or more colours, and dyestuffs should be chosen which will mix with one another and dye level shades. There are very few level dyeing Acid Browns, so that browns, when produced by this method, are usually dyed with an acid orange, e.g. *Orange II.*, saddened with an acid blue, shaded if necessary with red or yellow. In a similar manner navy blue shades are often dyed with a mixture of a violet and green, shaded with orange. For scarlet shades there are a number of Acid Scarlets, which, while not in the first rank for level dyeing properties, are still quite good and suitable for self shades, e.g. *Brilliant Croceines*.

Acid Blacks are almost exclusively used for the dyeing of blacks, and the requirements as to level dyeing properties are not so exacting as when dyeing mixture shades. The following is a selection of easily levelling acid dyestuffs suitable for dyeing the wool in unions in an acid dye bath.

Level-Dyeing Acid Colours.

	Azo Eosine. (IG.)
31	Azo Geranine B. (BDC.)
57	Lissamine Red 6B. (BDC.)
29	XL Carmosine 6R. (BDC.)
748	Xylene Red B. (S.)
	Fast Acid Magenta G. (IG.)
	Alizarine Rubinole R. (IG.)
151	Orange II. All makes.
27	Orange GG. Various makes.
640	Acid Yellow 79210. (BDC.)
639	Xylene Light Yellow 2G. (S.)
637	Kiton Yellow S. (CAC.)
636	Fast Light Yellow 3G. (LBH.)
801	Quinoline Yellow. Various makes.
666	Acid Green G. (BDC.)
735	Lissamine Green V Conc. (BDC.)
737	Wool Green S. (CAC.)
1054	Alizarine Delphinol B. (BDC.)
712	Disulphine Blue V. (BDC.)
715	Xylene Cyanol FF. (S.)
1075	Alizarine Celestol B. (BDC.)
699	Eriocyanine A. (Gy.)
696	Fast Acid Violet 10B. (IG.)
698	Coomassie Violet R. (BDC.)

717   ACID VIOLET 6BN.   (CAC.)
1074   ALIZARINE CYANOL VIOLET R.   (IG.)

$\left\{\begin{array}{l}246 \\ \\ 308\end{array}\right.$ NAPHTHOL BLUE-BLACK.   Various $\left.\begin{array}{r} \\ \end{array}\right\}$ For dyeing blacks
        makes.   only.
     Acid Black D.   (CAC.)

Covering the Cotton Linings, Etc.—After the wool is dyed to shade, the goods are thoroughly rinsed to remove acid, the presence of which would cause some of the direct colour in the *filling-up* bath to go on to the wool, more especially at the seams. The dyeing of the cotton and Rayon is then carried out in a separate cold or lukewarm bath with direct colours which have little or no affinity for wool.   The selected direct colours should be sufficiently soluble at low temperatures and possess good affinity for cotton. The depth of shade obtained on the linings depends more upon the concentration of the dye bath than upon the use of definite percentages of dyestuff calculated on the weight of goods being dyed.   Short liquors should be worked, and as the baths do not exhaust it is usual to keep *standing* baths of the colouring matters principally employed for dark and medium shades, *e.g.* navy blue, brown, green, etc.   The amount of dyestuff to every 10 gallons of liquor may be from 1 ounce upwards, but naturally varies according to the strength of the dye and the depth of shade required. The dye is dissolved in boiling water and sieved into the bath. An addition of either 1 lb. Glauber's salt or $\frac{1}{2}$ lb. common salt to every 10 gallons is made.   Up to these proportions the addition of a neutral salt results in a deeper shade, but an excess of either common salt or Glauber's salt must be avoided as it may *salt* out the dyestuff at the low temperature of working, and is also liable to cause the linings to be loose to rubbing.   Smaller quantities than those indicated should be added to a standing bath when freshening up with more dyestuff.

A small addition of $\frac{1}{2}$ ounce of 58 per cent. alkali to 10 gallons of liquor is also made to the filling-up bath.   The alkali increases the solubility of the direct cotton dye, and reduces its affinity for wool, so that the shade on the wool is clearer.   The cotton and Rayon are dyed fuller and are better penetrated.   The alkali also serves the useful purpose of neutralising any acid retained by the acid-dyed wool.   When filling-up successive batches of work in a standing bath it would ultimately be found, unless regular additions of alkali were made, that the bath would become acid owing to the repeated introduction of acid by the acid-dyed wool.   An acidified " filling-up " bath will not dye cotton in a *full* shade but will dye wool, and particularly faded wool;

so that these are conditions which must be carefully guarded against.

On the contrary, an excess of alkali is also objectionable on account of the danger of stripping the acid colours from the wool.

The temperature at which the cotton is covered may be from cold up to 110° F. If carried out cold, the wool is a trifle clearer (*i.e.* is not so much stained by the direct colour), but a much more highly concentrated filling-up bath is required than when dyeing at 110° F. to obtain the same depth of shade on the linings. A large proportion of the colour washes away when rinsing and the cold-dyed linings are looser in wear. At 110° F. faster, fuller, and cleaner shades are obtained.

As more direct colour goes on to the wool at 110° F. than in the cold, it is necessary to make some allowance for this when previously dyeing the wool.

Procedure.—The goods, after acid-dyeing the wool, are thoroughly rinsed and hydro-extracted ; the latter prevents the dilution of the filling-up bath and facilitates the entry of the dye-liquor into the seams of the garments. They are then worked in the filling-up bath for 30 to 45 minutes, squeezed free from surplus liquor, and rinsed cold. As a final process they are sometimes passed through a weak acetic acid bath to brighten and harden the wool.

Use of Katanol.—A modification of the method of " filling-up " linings consists in the use of *Katanol W. (I.G.).* This is a yellowish powder synthetically prepared (Eng. Pat. 173313), which has a direct affinity for cotton and can be used as substitute for tannic acid in mordanting cotton for basic colours. When added to the direct cotton filling-up bath for cotton linings it acts as a resist for the wool. By using *Katanol W* in this way the temperature of the filling-up bath can be safely raised to 135° F.–140° F. without increasing the staining of the wool with direct colour. The amount of Katanol required for a standing bath is 1 to 1½ per cent. and 3 per cent. for a starting bath. The usual direct colours are employed for filling in, though Katanol appears to be more effective with certain direct colours than with others. The higher temperature of the filling-in bath results in shades faster to rinsing and rubbing, and some economy in dyestuff. A British made product, *Resistone K*, can be used in a similar way to *Katanol W* and gives excellent results.

Only a limited number of direct cotton dyestuffs satisfy the requirements as to solubility and affinity for cotton at lower temperatures. The following are a number of suitable colours :—

Direct Cotton Dyes Suitable for Filling-Up Linings at Low Temperatures.

128	DIAMINE ROSE BD. (IG.)
358	CHLORAZOL FAST PINK BK. (BDC.)
382	CHLORAMINE RED B. (S.)
376	CONGO RUBINE. Various makes.
	BENZO BORDEAUX 6B. (IG.)
278	CHLORAZOL FAST RED K. (BDC.)
621	CHLORAZOL FAST ORANGE D. (BDC.)
459	CONGO ORANGE R. (IG.)
	DIAMINE FAST ORANGE ER. (IG.)
622	CHLORANTINE YELLOW GG. (CAC.)
620	DIRECT YELLOW R. (CAC.)
365	CHRYSOPHENINE G. Various makes.
589	CHLORAMINE GREEN B. (S.)
	BENZO DARK GREEN B. (IG.)
583	CHLORAZOL DARK GREEN PL. (BDC.)
518	CHLORAZOL SKY BLUE FF. (BDC.)
520	CHLORAMINE SKY BLUE A. (S.)
477	CHLORAZOL BLUE 3B. (BDC.)
406	DIRECT BLUE 2B. (CAC.)
472	CHLORAMINE BLUE BXR. (S.)
	CHLORAZOL FAST BLUE 2B. (BDC.)
	PARAMINE BLUE 3G. (LBH.)
401	CHLORAZOL BLACK BH. (BDC.)
	MELANTHERINE JH. (CAC.)
420	DIRECT BROWN M. (CAC.)
	DIAMINE FAST BROWN GB. (IG.)
	CHLORAZOL BROWN HX. (BDC.)
	CHLORAMINE BROWN 2R. (S.)
388	CHLORAZOL VIOLET R. (BDC.)
325	DIAMINE FAST VIOLET BBN. (IG.)
	DIAMINE HELIOTROPE B. (IG.)
	DIRECT VIOLET R. (CAC.)
	DIAMINE BLACK RMW. (IG.)
	DIRECT BLACK VT. (IG.)
	CHLORAZOL BLACK SD. (BDC.)

The various direct cotton dyes applied at low temperatures can be worked together to obtain any desired shade, *e.g.* a mixture of *Chlorazol Sky Blue FF* and *Chrysophenine* for the production of a bright green.

Method 2.—(Single Bath.)—As already indicated under *Selection of Process* this method consists in dyeing half-wool fabrics with direct colouring matters (principally dyeing the cotton) and " neutral dyeing " acid dyestuffs for the wool in one bath. It is employed when direct dyestuffs alone will not produce sufficiently bright shades, when the goods contain but little cotton (except linings, etc.), and when it is necessary to match a pattern exactly. The single-bath method is used whenever possible on account of the economy in time, labour, steam, and plant, as compared with other multi-bath processes. This process is not adopted for badly faded goods as direct cotton colours usually dye the faded parts of woollen articles dull and heavy. It is not very successful on sulphur-bleached white woollens ; these are best dyed from an acid bath. The neutral dye bath is also found to have a detrimental effect on mohair and lustre goods as it is apt to take out the curl, consequently this process is not advised for such goods as mohair mats and rugs, angora table covers, etc.

Goods that have received the average amount of exposure usually dye well by the single-bath method. Silk and artificial silk trimmings are well covered, and, given a suitable selection of dyes, tone-in well with the other fibres present. Most of the so-called *Union Colours* are based upon a mixture of neutral dyeing acid colours and substantive cotton colours.

Blacks are almost always dyed by the one-bath method, though where an article is trimmed with lace it is sometimes necessary to give a further treatment with the object of deepening the tone of black on the lace, *q.v.*

The dyeing is carried out at or near the boil in a neutral bath with the addition of 1 lb. Glauber's salt, or ½ lb. common salt, per 10 gallons of liquor for pale shades, up to double these quantities for dark shades. The goods are entered lukewarm and the bath gradually brought up to the boil. Most of the " neutral dyeing " acid colours equalise well in a neutral bath and may be added at the boil for shading purposes. The advantage of this method in *Pattern Dyeing* over the dyeing of unions with direct colours alone, depends on the ease with which some of the colour may be removed from the wool if the shade produced is too dark. This is effected by entering in a fresh bath and bringing to the boil, whereby a considerable amount of the acid dyestuff is removed. Additions may then be made of further quantities of dyestuff to bring up to pattern.

Neutral dye baths do not exhaust, so that standing baths are employed for standard colours. For this reason it is important

that the dyestuff itself shall contain little or no free alkali, as any accumulation of alkali in a standing bath would impoverish the wool at the boil and also cause shrinkage. If Glauber's salt is used it should be neutral and contain no free acid, and the goods themselves should be free from acid, which, of course, will be the case if they are previously cleaned.

Comparing Glauber's salt and common salt as assistants in the neutral dye bath, most dyers prefer common salt in dyeing union garments, as Glauber's salt appears to have a softening action upon wool at the boil. Arndt [1] found that an aqueous solution of Glauber's salt gives an alkaline reaction at the boil whilst a solution of common salt remains neutral. Perhaps this fact accounts for the detrimental effect of boiling Glauber's salt on wool and justifies the dyers' preference for common salt as an addition to the neutral bath.

Fort [2] attributed the harmful effect of Glauber's salt upon the lustre of the wool to the removal of one constituent of hydrolysed wool by the caustic alkali liberated. He found the addition of glue to be distinctly beneficial both in regard to the strength and the elasticity of the wool. In his experiments it restrained the deleterious action of Glauber's salt and gave increased strength to the wool. The lustre of the wool was also retained. He found that the glue had no appreciable effect on the absorption of either acid or direct cotton dyes, and recommended an addition of 10 per cent. glue in dyeing lustre goods.

It is certainly advantageous to add to the dye bath a protective agent for the wool in dyeing half-wool goods from a neutral bath, more especially if the wool is at all tender in places from exposure. Three to five per cent. *Protectol* (*I.G.*) can be used for this purpose, and prevents damage resulting from the boiling neutral dye bath.

Selection of Colours.—It has been found in practice that the best results in the single-bath dyeing of garments are obtained by selecting as far as possible those direct colours dyeing the cotton in a full shade at the boil and leaving the wool thin, and relying almost exclusively upon the neutral dyeing acid colours to obtain the required shade on the wool. This course is advisable for reasons stated below.

1. The shades produced on the wool with neutral acid colours are usually clearer than those obtained with direct cotton colours.

2. It is easier to correct an over-dyed shade if acid colours have been mainly used than if the material has been dyed with

[1] *J.S.D.C.*, 1911.   [2] *Ibid.*, 1913.

direct cotton colours. The latter are much faster on wool than on cotton, and attempts to thin the shade of the wool by means of a boiling *sweat* usually result in stripping the cotton more than the wool, which may necessitate re-dyeing.

3. The direct cotton colours (with a few exceptions) are attracted by the faded parts of a woollen article to a greater extent than the neutral dyeing acid colours, thus giving rise to a type of unevenness very difficult to rectify.

The following is a range of acid colours which can be dyed in a neutral bath and which are suitable for use along with direct cotton colours for dyeing union materials.

Neutral-Dyeing Acid Colours for Wool and Silk.

1091	ALIZARINE RUBINOLE R. (IG.)
443	COOMASSIE MILLING SCARLET G. (BDC.)
250	CROCEIN AZ. (IG.)
176	FAST RED A. Various makes.
430	POLAR RED G, RS. (GY.)
758	FAST ACID VIOLET 2R. (BDC.)
151	ORANGE II. All makes.
	POLAR ORANGE GS, R CONC. (GY.)
	SULPHON ORANGE G. (IG.)
143	CITRONINE R CONC. (BDC.)
	ALPHANOL BROWN B. (IG.)
	SUPRAMINE BROWN G, R. (IG.)
	CLOTH FAST YELLOW GR. (CAC.)
146	CITRONINE Y CONC. (BDC.)
	POLAR YELLOW G. (GY.)
	SULPHON YELLOW 5G, R. (IG.)
	MILLING YELLOW O. (IG.)
667	DISULPHINE GREEN B. (BDC.)
691	FAST GREEN CR. (IG.)
1078	ALIZARINE BRILLIANT GREEN EF, G CONC. (LBH.)
	ALKALI FAST GREEN 3G. (IG.)
289	COOMASSIE NAVY BLUE GNX, 2RNX. (BDC.)
714	DISULPHINE BLUE A. (BDC.)
	ERIO FAST BRILLIANT BLUE 3R. (GY.)
	BRILLIANT MILLING BLUE B. (IG.)
833	WOOL FAST BLUE GL, BL. (IG.)
	BRILLIANT WOOL BLUE G EXTRA. (IG.)
758	ACID VIOLET 4R, 4RN. (IG.)
698	COOMASSIE VIOLET R. (BDC.)
	ERIO FAST PURPLE A. (GY.)

700   ALKALI VIOLET.   Various makes.
      ACID ALIZARINE GREY G.   (IG.)
    - POLAR GREY.   (GY.)
307   COOMASSIE FAST BLACK B.   (BDC.)
      GLORIA BLACK N.   (IG.)

For the production of clear pale blue shades on wool the various brands of *Alkali Blue* are dyed at 175° to 195° F. with the addition of 4 to 5 per cent. borax ; after dyeing, the goods are rinsed in water and the colour is raised in a hot bath containing a small quantity of sulphuric acid (see p. 205).

The substantive cotton dyestuffs which are used in combination with the above " neutral-dyeing " acid colours are preferably those which have little or no affinity for wool ; some of these are included in the list, which will be found on p. 193.

Method 3.—This method resembles the preceding one in being a " neutral bath " process, the dyestuffs employed being substantive cotton colours which dye cotton and wool to an approximately equal depth at or near the boiling temperature.   It may be combined with the previous method by largely depending upon the direct colours for the production of the colour desired, but shading or brightening the wool by the addition of a small quantity of a " neutral-dyeing " acid colour. .

There is now a large range of direct dyestuffs available for the dyeing of practically solid shades on half-wool goods, and the range is almost complete with the exception of blues ; these, with a few exceptions, dye animal fibres considerably redder than the cotton and Rayon, so that the wool and silk require shading with suitable acid colours in neutral bath.   The *Union Blues* are generally made up somewhat on these lines with mixtures of acid and direct dyestuffs.

Though the shades obtainable by Method 3 with direct colours only, are not so bright as those dyed with acid colours in the bath, this is not always of primary importance, and the simplicity of the process has led to its employment to a very considerable extent, especially in the production of dark shades.   Blacks are often dyed by this method, as well as by Method 2, with neutral-dyeing acid colours in the bath.

The dyeing takes place with the addition of 20 to 30 per cent. Glauber's salt, or preferably with an equivalent amount of common salt, and it may be taken as a general rule that the wool is dyed a fuller shade at the boil, and the cotton a fuller shade at lower temperatures (160°–180° F.).   Continued boiling tends to strip the colour from the cotton and Rayon on to the wool.   The pro-

duction of a solid shade therefore depends upon the careful regulation of the temperature of the bath, and in that respect this method differs from Method 2, in which the shading of the various fibres is effected mainly by adjusting the proportions of neutral acid colours and direct cotton colours. The cotton lining and stitching should be dyed a trifle darker than the wool, and if cotton forms part of the material itself (*e.g.* cotton warp), it should certainly be slightly darker. When dyed lighter the effect is to give a starved appearance to the dyed article. If the cotton does not show the necessary depth of shade, it can be shaded with suitable colouring matters especially adapted for dyeing cotton at low temperatures, of which a list has been given (p. 193).

In all cases when wool is to be dyed in a neutral bath, special care must be taken in rinsing out the alkali employed in the preparatory cleaning of the goods, as even in small quantities alkali has a detrimental effect upon wool in the boiling dye bath. The goods are usually entered into the bath at about 140° F., the temperature being gradually raised to the boil and the bath allowed to cool down towards the finish.

When the wool is faded and somewhat tender, an addition of 3 to 5 per cent. *Protectol* (*IG*) assists in preserving it from damage in the neutral dye bath. In fact this addition is beneficial in all cases when dyeing neutral, as when using it the wool handles better after dyeing. The following dyestuffs give practically solid shades on wool and cotton fabrics when dyed at the boil by the method described :—

448   BENZOPURPURINE 4B.   All makes.
495   BENZOPURPURINE 10B.   All makes.
419   DIRECT FAST RED F.   (CAC.)
382   CHLORAMINE RED B, 3B.   (S.)
436   DIPHENYL RED 8B.   (GY.)
376   CONGO RUBINE.   Various makes.
130   ERIKA B.   (S.)
131   ERIKA G.   (S.)
128   DIAMINE ROSE BD, GD.   (IG.)
415   CHLORAZOL ORANGE RN.   (BDC.)
459   CONGO ORANGE R.   Various makes.
478   DIRECT ORANGE G.   (CAC.)
446   TOLUYLENE ORANGE R.   Various makes.
653   PYRAZOL ORANGE G.   (S.)
814   CHLORAZOL FAST YELLOW B.   (BDC.)
365   CHRYSOPHENINE G.   Various makes.
813   TITAN YELLOW G.   (BDC.)
      CHLORANTINE FAST YELLOW 4GL.   (CAC.)

589 CHLORAMINE GREEN B. (S.)
593 DIRECT GREEN B. Various makes.
594 DIRECT GREEN G. Various makes.
512 CHLORAZOL BLUE RW. (BDC.) Wool slightly redder.
   DIAMINE STEEL BLUE L. (IG.)
590 CHLORAMINE BLUE 3G. (S.)
596 CHLORAZOL BROWN G. (BDC.)
420 DIRECT BROWN M. (CAC.)
561 CHLORAZOL BROWN LF. (BDC.)
598 CONGO BROWN G. Various makes.
   DIAMINE CATECHINE 3G, G. (IG.)
   CHLORAMINE VIOLET 2R. (S.)
394 DIRECT VIOLET N. (CAC.) Wool and silk redder.
387 CHLORAZOL VIOLET WBX. (BDC.) Cotton fuller.
581 CHLORAZOL BLACK E EXTRA. (BDC.)
539 CARBIDE BLACK S. (CAC.)
592 PARAMINE BLACK HW. (LBH.) Greenish-black for flattening.
267 NEUTRAL GREY G. (IG.) For grey shades.

In any of the three foregoing methods the cotton may be brightened by *topping* in a separate bath with a small amount of basic dyestuff. If too large a quantity of basic colouring matter is employed the colour produced is liable to rub. The basic colouring matters used for topping purposes are :—

AURAMINE	MAGENTA.
BRILLIANT GREEN CRYSTALS .	SAFRANINE.
MALACHITE GREEN CRYSTALS .	METHYL VIOLET.
CHRYSOIDINE	METHYLENE BLUE.
BISMARCK BROWN . . .	RHODAMINE.

The goods after dyeing as usual with direct dyestuffs are rinsed thoroughly and passed into a fresh bath containing acetic acid, to which a solution of the basic dyestuff is added a little at a time. The temperature may be raised to 120° F. or 130° F. but should never be higher than 140° F., and the goods are worked for about 20 minutes, then rinsed. This process must not be employed for topping cotton dress linings, as the colour will rub on to white undergarments ; nor should it be employed for curtains and other articles liable to continued exposure to light, as the basic colours dyed in this way are very fugitive to light. On account of these very serious drawbacks basic colours applied in the manner described are now very little used in garment dyeing. They are

never employed unless it is impossible to obtain the requisite brightness by other methods.

Method 4.—Two-colour effects are produced by this method by dyeing the wool with acid colours which do not stain the cotton or artificial silk, the latter being left white or subsequently dyed a different shade from the wool with direct colours which do not go on to the wool ; most of the acid dyestuffs leave the cotton and artificial silk white, or practically so, though some colours are especially good in this respect. In dyeing the wool, the white on the cotton becomes purer as the bath is made more acid. The best results are obtained by using the acid colours given under Method 1 on p. 190, which equalise well in a sulphuric acid dye bath. If the cotton or artificial silk is to remain white (*e.g.* lace trimmings), the final rinse should contain a small quantity of acetic or formic acid. The following acid colours leave cotton effects unstained :—

31	Azo Geranine 2G. (BDC.)
57	Lissamine Red 6B. (BDC.)
	Azo Eosine. (IG.)
27	Orange 2G. (BDC.)
639	Xylene Light Yellow 2G. (S.)
636	Fast Light Yellow 3G. (LBH.)
735	Lissamine Green V Conc. (BDC.)
737	Wool Green S. Various makes.
712	Disulphine Blue V. (BDC.)
715	Cyanole Extra, FF. (IG.)
1180	Indigo Carmine. Various makes.
1075	Alizarin Celestol B. (BDC.)
1054	Alizarin Delphinol BDN. (BDC.)
696	Fast Acid Violet 10B. (IG.)
246	Naphthol Blue Black. Various makes.

The cotton may be *cross-dyed* in a contrasting shade with direct colours at a low temperature. An addition of common salt or Glauber's salt may be required. The dyestuffs referred to on p. 193 as having little or no affinity for wool give the best results. Two-colour effects are seldom expected in re-dyeing goods, but some articles, for example figured union damask, give very pleasing results if the wool is first acid dyed in some bright shade and the cotton or artificial silk filled-in to a fawn or grey. By following this method the dyer can avoid giving the goods a *dyed* appearance, and it is often possible to match the new colours of the damask. The use of *Katanol* in protecting the wool from being stained when filling-in the cotton with direct colour has already been referred to, but in the production of con-

trasting colouring on the two fibres Katanol is perhaps of still greater service, as the brightness of the wool remains unimpaired during the filling-in operation. The usual direct cotton colours are used, but an addition of 3 to 5 per cent. *Katanol W* is made to the filling-in bath, which may with safety be raised to a temperature of 130° F. to 140° F. without the dyes appreciably staining the wool. *Resistone K* can be used for the same purpose.

Cross-dyed effects may be obtained in one bath by employing neutral dyeing acid colours and suitable direct colours, but the results are not sharp enough and the two-bath process is recommended.

Method 5.—This is one of the oldest methods of dyeing halfwool goods, and though not in general use is occasionally employed in dyeing faded goods medium and dark shades of brown, blue, green, maroon, etc. It is usually known as the *three-bath process*, and consists in dyeing the wool with acid dyestuffs, the cotton being subsequently filled-up by mordanting with iron and tannic acid (see p. 210), and dyeing with basic colouring matters at a low temperature. The grey *sumach and iron* mordant gives a dark base on the cotton. By this method the faded wool is liable to become darker than the unfaded wool, but not to so great an extent as may occur in Methods 1, 2, or 3. There is also a tendency for the colour on the wool to *rub*. This is due to the presence of imperfectly fixed basic dyestuff on the wool.

Wool, Silk and Cotton Fabrics.—A large proportion of the garments and furnishings come under this category on account of the presence of silk trimmings which must be covered in dyeing. They are dyed by the same methods as half-wool fabrics; if dyed according to Method 1, care must be taken to avoid acid dyestuffs which do not cover the silk (*e.g.* indigo extract). The following is a selection of acid colours dyeing wool and silk almost equally; at the boil the colour goes more on to the wool, and at a lower temperature more on to the silk, uniform shades being obtained by the regulation of the temperature of the bath. The goods are entered at 140° F. and the bath is slowly raised to the boil, maintained at the boil for 15 to 30 minutes, and then allowed to cool-off to bring the silk to shade. If necessary, further additions of suitable acid colours can be made at about 140° F. to tone the silk.

Acid Colours Dyeing Wool and Silk to a practically Uniform Shade from an Acid Dye Bath.

- 758 ERIO FAST FUCHSINE BL. (GY.)
- 176 FAST RED A. Various makes.
- 151 ORANGE II. All makes.

146	CITRONINE Y CONC. (BDC.)
666	ACID GREEN G. (BDC.)
670	WOOL GREEN 2G. (S.)
667	DISULPHINE GREEN B. (BDC.)
735	LISSAMINE GREEN V CONC. (BDC.)
737	LISSAMINE GREEN B. (BDC.)
704	ALKALI BLUE 4B, etc. Various makes. Dyed from an alkaline bath by special process, see p. 197.
712	DISULPHINE BLUE V. (BDC.)
714	DISULPHINE BLUE A. (BDC.)
715	XYLENE CYANOLE FF. (S.)
698	COOMASSIE VIOLET R. (BDC.)
717	ACID VIOLET 6BN. (SCI.)
696	FAST ACID VIOLET 10B. (IG.)
246	NAPHTHOL BLUE BLACK. Various makes.

To add *body* to the silk a *small* amount of basic dyestuff may be added to the bath towards the finish, or to a fresh, lukewarm acetic acid bath (the wool will take up some of the dyestuff). Only very small quantities of basic colours must be used or the goods will be liable to rub, and the following are suitable for the purpose : *Bismarck Brown, Chrysoidine, Brilliant Green, Magenta, Malachite Green, Methylene Blue, Safranine.*

The cotton linings and stitchings are filled-up in a separate bath at a low temperature (about 100° to 110° F.) with direct colours which do not go on to the wool (see p. 193). It is usually found if the process is carried out at 110° F. that the direct colours of the filling-up bath dye the silk trimmings sufficiently to make up for any lack of body on the silk, which is apparent after the acid-dyeing stage, and renders the use of basic colours for topping the silk unnecessary.

The simplest method of dyeing goods containing wool, silk, and cotton, consists in employing direct colours in neutral baths with or without the aid of " neutral dyeing " acid colours (see p. 196).

The cotton substantive colours given on p. 198 as dyeing full shades on cotton and wool give in many cases solid shades on silk also, but where the silk is *thin* (*e.g.* in some of the blacks) it can be topped with acid colours in a lukewarm bath with acetic acid (*e.g.* with *Naphthalene Black N New* (*BDC*)). The dye-stuffs given in the following table give practically uniform shades on all three fibres ; it may be taken as a general rule that the cotton and silk dye best at 160° to 180° F. and the wool at the boil. The goods are entered at 120° F. and brought to the boil in a quarter

of an hour, dyed at the boil for 10 to 15 minutes, the steam turned off, and the dyeing continued in the cooling bath. Blacks are frequently entered boiling, dyed at the boil for 5 minutes, and the dyeing then continued in the cooling bath.

List of Dyes giving practically Solid Shades on all Fibres.

448	BENZOPURPURINE 4B.	All makes.
376	CONGO RUBINE.	Various makes.
419	CHLORAZOL FAST RED F.	(BDC.)
	CHLORAZOL FAST RED 10B.	(BDC.)
128	DIAMINE ROSE BD, GD.	(IG.)
377	CONGO ORANGE G.	(IG.)
415	CHLORAZOL ORANGE RN.	(BDC.)
478	TOLUYLENE ORANGE G.	Various makes.
446	TOLUYLENE ORANGE R.	Various makes.
653	PYRAZOL ORANGE G CONC.	(S.)
365	CHRYSOPHENINE G.	Various makes.
813	TITAN YELLOW G.	(BDC.)
589	CHLORAMINE GREEN B.	(S.)
594	CHLORAZOL GREEN G.	(BDC.)
593	DIRECT GREEN B.	(CAC.)
512	CHLORAZOL BLUE RW.	(BDC.)
596	CHLORAZOL BROWN G.	(BDC.)
581	CHLORAZOL BLACK E EXTRA.	(BDC.)

The substantive colours which dye fuller shades on cotton than on wool and silk (see p. 193) in combination with "neutral dyeing" acid colours give very good results.

Wool Fabrics.—Fabric dresses can seldom be treated as all-wool on account of the cotton stitching, and cotton or artificial silk linings and trimmings, which are almost invariably present. All-wool articles such as knitted jerseys, jumpers and dresses, curtain repps, mohair curl fabrics, etc., are usually dyed with acid colours in acid baths, the mode of procedure being the same as that described for dyeing the wool under Method 1 for half-wool fabrics. If for any special reason it is desirable to use direct colours in a neutral bath, any of the dyestuffs which give uniform shades on half-wool may be employed. This method is sometimes used when it is necessary to produce shades fast to washing on all wool flannel, bunting, etc. Wool is not usually dyed by garment dyers by the other well-known methods, viz. with mordant colours, basic colours, and vat dyes; it is, therefore,

unnecessary to describe the methods employed for dyeing wool with colouring matters of these groups.

Acid dyeing is well adapted for woollen articles that are faded by exposure, easily levelling acid colours being used and applied in a strongly acid bath (for list of colours see p. 190). Silk trimmings are covered by selecting colours that dye silk equally with wool, of which a list has been given (p. 201). The bath is charged with 3 to 5 per cent. sulphuric acid and 10 to 20 per cent. Glauber's salt, the percentage being calculated on the weight of goods. The amount of dye required varies from a trace only up to 8–10 per cent. for black. The dyestuff is dissolved separately in boiling water (not in the acid dye-liquor), and stock solutions should be kept. Any necessary additions to the dye bath should be made in solution through a sieve, as required. The various easily levelling acid colours can be worked together in the dye bath to obtain any desired fashion shade (e.g. *Cyanole Extra, Xylene Light Yellow 2G, Kiton Red G* as the blue, yellow, and red components). The acid accelerates the rate of absorption of the colour by the wool, gives greater depth of shade and quicker exhaustion of the dye bath. On the other hand too much acid drives the colour on too quickly, so that it does not penetrate the material, especially at the seams, and may give rise to unlevel results.

The Glauber's salt in the dye bath acts as a retarding and levelling agent and promotes penetration.

Method of Working.—The cleaned goods are entered into the prepared dye bath at about 160° F. and the bath raised gradually to the boil. The liquor should not be vigorously boiling, especially if the goods are faded, as the fades tend to become more pronounced, and the goods are shrunk.

After dyeing for about 30 minutes, or until to the required shade, the goods are opened out, rinsed free of acid, and spread on a horse to drain. In the drying stoves violent changes of temperature should be guarded against, as breaks, creases, and shrinkage may occur. As acid dye baths exhaust very well, there is no real economy in using a short liquor or standing bath. Woollen articles are particularly liable to shrinkage if too short a liquor is used. There should be sufficient liquor to allow of the goods being opened out the whole time.

Although sulphuric acid is the acid most commonly employed in acid dyeing, other acids occasionally replace it with advantage. Formic acid gives better penetration and may be used for goods with thick seams. In the same percentage as sulphuric acid it gives almost equal depth of shade. It exhausts the bath better

than acetic acid, and in equal strengths it is cheaper. For faded woollens, however, sulphuric acid is undoubtedly the best acid to use, as it tends to equalise the fades better than any other acid.

With regard to the effect of the different acids upon the handle and lustre of the wool, it has been shown that dyeing in an acid bath gives wool an improved lustre and handle, the acids being placed in the following order of preference : (1) Acetic acid ; (2) formic acid ; (3) sulphuric acid ; (4) hydrochloric acid. Goods dyed in a neutral bath were found to be inferior in appearance and handle to acid-dyed goods. Certain acid dyestuffs are applied to wool by methods other than those normally used, e.g. *Alkali Blue* (*Nicholson's Blue*). Pale blue shades are sometimes dyed on woollen articles such as children's frocks with this colour ; a special process is required. Although an acid colour, the colour acid of *Alkali Blue* is insoluble in water, so that the dyestuff must be applied in a weakly alkaline bath in the form of its sodium salt. The process is effected in two stages : (1) Dyeing ; (2) raising or developing the colour.

The dye bath is prepared with 2 to 3 per cent. borax on the weight of goods, and the colour, previously dissolved in hot water with borax, is added to the bath. The goods are entered at 120° F., the temperature raised to 190° F., and the dyeing continued at that temperature for about 30 minutes. After dyeing, the goods are rinsed and the colour developed in a fresh, hot bath (not higher than 180° F.) prepared with 1 to 4 per cent. sulphuric acid, in which the goods are moved for 20 minutes. As the colour is not apparent until the second bath, it is advisable to try a cutting for matching-off before developing the whole job. When the developed shade is found to be not quite to pattern, it can be toned by making a slight addition of an ordinary level-dyeing acid blue to the acid developing bath, e.g. *Cyanole FF*.

Rhodamine and Eosine.—Resorcine dyestuffs of the *Rhodamine* and *Eosine* groups are sometimes required for dyeing bright pinks and flame-coloured shades on wool. These dyes are best applied from an acetic acid bath. The bath is prepared with—

> 2 to 4 per cent. acetic acid (30 per cent.), and
> 10 to 15 per cent. Glauber's salt,

the dyestuff being added in several portions. If necessary, ordinary acid dyes may be added to the bath for shading purposes. Examples: 749 *Rhodamine B*; 752 *Rhodamine 6G*; 768 *Eosine YS*.

Sulphoncyanine Colours.—Colours of the above type (*Colour Index* 288 and 289 *Coomassie Navy Blues*, etc.) are dyed upon

wool in a neutral or faintly acid bath and are much used for the production of fast-wearing shades, especially navy blues. Although opinions differ amongst garment dyers as to whether these colours should be dyed neutral or slightly acid, the bath must certainly not be alkaline or the shade will be browned and lose its bloom; with hard water, therefore, a slight addition of acetic acid is beneficial. Sulphuric acid must not be used with these colours as it drives the colour on too quickly, resulting in unevenness, lack of penetration, and reddening of the shade. Overboiling is very detrimental, more so in a neutral than in a faintly acid bath. The best results are obtained when dyeing at about 200° F. An addition of 0·25 to 0·5 per cent. bichrome to the dye bath helps to produce faster and more level shades.

Method 1.—The dye bath is charged with 10 to 25 per cent. Glauber's salt and the requisite quantity of colour, 2 to 4 per cent.; the goods are entered at 140° F., and the bath is raised gradually to the boil and kept just under the boil for half an hour. If necessary an addition of 1 to 2 per cent. acetic acid may be made to exhaust the liquor.

Method 2.—This method is the one most frequently recommended. The bath is charged with 3 to 5 per cent. ammonium acetate and 10 to 25 per cent. Glauber's salt; the former decomposes at the boiling temperature with liberation of ammonia, so that the bath becomes gradually more acidulated with acetic acid. Here again a final slight addition of acetic acid may be made to exhaust the bath. It may be mentioned here that good results are obtained with colours of the *Sulphoncyanine* group by dyeing from a plain bath without any addition. Reference has already been made to the fact that these colours can be applied in conjunction with suitable direct cotton colours from a neutral bath in the dyeing of half-wool.

Other colours applicable to wool by the same methods as the sulphoncyanine type of dyestuff are :—*Cloth Fast Colours (CAC)* ; *Polar Colours (Gy)* ; *Sulphon Colours and Alphanol Colours* ; *Tolyl Colours (IG)* ; *Erio Fast Colours (Gy)* ; and *Coomassie Fast Colours (BDC)*. These, along with individual members of other series of acid colours, can be applied from a neutral or weakly acid bath for dyeing fast wearing shades.

Neolan Colours (CAC).—A group of "fast to light" colours worthy of special notice is the Neolan series. These acid colours are described as soluble salts of metals, chiefly chromium. They are applied to wool from a sulphuric acid dye bath, rather more acid than the normal amount of 4 per cent. being necessary to obtain the full measure of fastness. Up to 8 per cent. acid is

used, which may be added in several portions. Some of the colours of this series are particularly level dyeing, and may be used in admixture with ordinary level-dyeing acid colours for compound shades. The following Neolan dyestuffs are recommended for their level-dyeing properties : *Neolan Pink B, Neolan Yellow G, Neolan Green B, Neolan Blue GG, Neolan Violet R.*

On account of the shortage of "fast to light" acid dyeing blues, *Neolan Blue 2G* is useful as a blue component of mixture shades with easily levelling acid reds and yellows, amongst which there are a large number fast to light.

Cotton or Linen.—Fabrics consisting solely of these vegetable fibres comprise only a small proportion of the goods dyed by the garment dyer. The two fibres are dyed by similar methods differing only in detail. Cotton and linen are met with as summer frocks usually for light shades, overalls, cotton raincoats, cotton casement curtains, cotton velvet, linen plush, cretonne, and printed linen. The dyestuffs used are :—

1. Direct cotton colours (for most purposes).
2. Basic colours (for specially bright shades).
3. Vat colours (for shades fast to light and washing, on curtains).

The direct cotton colours are in general use and are sufficiently fast for ordinary requirements. For curtain work those members of the series that are of exceptional fastness to light should be used (see p. 187).

The usual method is to dye with the addition of 20 to 40 per cent. Glauber's salt or common salt, and 1 per cent. of 58 per cent. alkali, entering the goods at the boil, then shutting off the steam and allowing them to dye in the cooling bath. Very pale shades, *e.g.* sky blue, pale pink, etc., may be dyed with the addition of soap in place of the alkali, clearer shades being produced thereby ; soap is also added to the bath when dyeing linen and half-linen goods which are difficult to penetrate. *Monopol soap* (sulphonated castor oil soap) is sometimes used for the same purpose, and has advantages, especially when hard water only is available. For dark shades the soda may be omitted, and as the baths do not exhaust well, standing liquors are usually kept. In comparing the effect of Glauber's salt and common salt in the dye bath, Fort [1] found that shades dyed with common salt in the bath were more brownish, and with Glauber's salt more bluish in tone. The impurities in common salt had the effect of causing the shades to be deeper and duller. The duller shades

[1] *J.S.D.C.*, 1912.

obtained with common salt were faster to light and slightly faster to washing than those obtained with Glauber's salt. A greater tendency towards unevenness was noticeable when dyeing with common salt. Fort found the function of soda in the dye bath is to promote solubility of the dye, while the addition of soap prevents the deposition of loose colour on the fibre, thus improving shade, fastness, and handle.

The volume of dye liquor has great bearing on the depth of shade. With the same percentage of dyestuff the more water is used the weaker the shade. Except in the case of pale shades, it is economical to work with a short liquor (20 to 1 of goods). Pale shades require plenty of liquor in order to obtain level results. Such materials as hard twisted cotton lace are difficult to dye through and require special attention. The precautions to be taken are to use colours of good solubility and good levelling power. Pale shades should be dyed from an alkaline bath containing soda and Monopol oil or Monopol soap, but no Glauber's salt. Dark shades require the same additions, but Glauber's salt may also be added towards the end. In place of Monopol soap or oil, a good olive oil soap bath can be used. Full ranges of direct dyestuffs suitable for cotton dyeing have already been given under half-wool dyeing. Some direct cotton colours are adapted for various methods of after-treatment which improve fastness to light or washing.

Methods of After-Treatment.

As the garment dyer now has available a full range of colouring matters giving fast shades on cotton in a single bath, the processes of after-treatment about to be described have become relatively less useful in this branch of the industry.

The following is a brief résumé of the more important methods of after-treatment :—

1. Copper sulphate.
2. Diazotisation and development.
3. Formaldehyde.

1. Copper Sulphate.—Used occasionally for cotton curtains required fast to light. The dyed goods are well rinsed in water and are then treated in a separate bath at 120° to 140° F. with 1 to 3 per cent. copper sulphate and a little acetic acid for 10 to 15 minutes. The shade is in some cases dulled somewhat, but all colours named are made very fast to light. It is important to avoid using an excess of copper sulphate as it causes the goods to have an objectionable handle and a dull appearance.

2. Diazotising and Developing.—This method is sometimes employed, especially in the production of fast navy and black, *e.g.* on velveteen, cotton raincoats, cotton hose. There is a marked improvement in the fastness to washing, but the fastness to light is not improved. Usually the shade is deepened, *e.g.* *Chlorazol Black BH* develops with β-naphthol to a navy blue, and with metaphenylene diamine to a deep black.

Process.—After rinsing, the diazotisation is carried out in a *cold* nitrous acid bath prepared by dissolving 3 per cent. of sodium nitrite in water and stirring in 9 per cent. of hydrochloric acid (or an equivalent quantity of sulphuric acid), wooden or earthenware vessels being employed. The goods are immersed in this bath (which must be freshly prepared) for 10 to 15 minutes, care being taken at this stage to avoid exposure of the goods to direct sunlight, as the diazo compounds of the dyestuffs which are formed are very quickly decomposed by light—patchy results being obtained. The goods are quickly rinsed in cold water and are transferred to the cold *developing* bath, usually β-naphthol or metaphenylene diamine. If β-naphthol is employed, 1 per cent. is dissolved in its own weight of caustic soda solution, (70° Tw.). With metaphenylene diamine, 0·6 per cent. is dissolved in 2 per cent. alkali (58 per cent.). After development the goods are rinsed and soaped hot, if necessary, to remove bronziness.

3. Formaldehyde.—This process, like the preceding one, has a marked effect upon the fastness of the shades to washing. The bath is made up with 1 to 3 per cent. formaldehyde (40 per cent.) with or without the addition of 1 per cent. acetic acid (40 per cent.). The dyed goods, after rinsing, are worked in this bath for 20 to 30 minutes at 140° to 160° F. The process is occasionally used by garment dyers for improving the fastness of blacks.

The following dyestuffs, which include some of those already mentioned, are suitable for after-treatment by one or other of the methods given :—

Direct Colours Suitable for After-Treatment.

ROSANTHRENES (all brands) (CAC); 2.
812 PRIMULINE (all makes); 2.
653 PYRAZOL ORANGE G CONC. (S); 1.
410 CHRYSAMINE G (various makes); 1.
502 BENZO-AZURINE G (various makes); 1.
503 BENZO-AZURINE 3 G (various makes); 1.
518 CHLORAZOL SKY BLUE FF (BDC); 1.
DIAMINE BRILLIANT BLUE G (IG); 1.

512   CHLORAZOL BLUE RW (BDC); 1.
420   DIRECT BROWN M (CAC); 1.
560   CUPRANIL BROWN B (CAC); 1.
596   CHLORAZOL BROWN G (BDC); 1.
      DIAMINE CATECHINE 3 G (IG); 1.
401   CHLORAZOL BLACK BH (BDC); 2.
      CHLORAZOL BLACK SD (BDC); 2.
      CARBIDE FAST BLACKS (CAC); 3.
      CHLORAZOL BLACK DV (BDC); 2.
      FORMAL FAST BLACKS (Gy); 3.
592   PARAMINE BLACK HW (LBH); 2.

Topping direct dyeings with basic colours on cotton has already been described. Dyeing with basic colours on mordanted cotton is rarely employed in garment dyeing, but as the method is used occasionally by some dyers for filling-up cotton linings in wool dresses which have been dyed with acid colours, the mode of procedure will be given.

Tannic acid is usually employed as the mordant for light shades and sumach extract or myrabolans for dark shades. The mordanting bath is prepared with 2 to 5 per cent. tannic acid according to the depth of shade, or from 4 to 8 times the quantity of sumach or myrabolans, the amount varying according to the tannin content. The goods are worked in the bath for a short time at 120° F. and are then allowed to remain in the bath for several hours (or overnight). They are then squeezed and *fixed* in a cold bath prepared with 1 to 3 per cent. tartar emetic if tannic acid has been employed, or "nitrate of iron," 2° to 4° Tw., if sumach or myrabolans have been used. The goods are rinsed well and are then ready for dyeing. The dyeing takes place in a separate bath with the addition of 1 to 2 per cent. acetic acid or 5 per cent. alum, and owing to the rapidity with which the mordanted fibre absorbs the dyestuff, the goods must be worked cold until the bath is almost exhausted, otherwise uneven shades are produced. As a further precaution it is advisable to add the dyestuff solution in several portions. When the bath is practically exhausted the temperature is slowly raised to 100°–120° F. In employing this method to dye the linings of wool dresses, etc., the mordanting and dyeing must be carried out in the cold, using stronger liquors than those given for cotton alone. Even with these precautions the surface of the wool may take up some of the dyestuff; it may be *cleared* with weak hydrochloric acid or lukewarm soap or soap bark (*quillaia*).

Katanol O and Katanol W (IG) as Mordants.—*Katanol* is a

yellowish powder intended to serve as a substitute for tannic acid and tartar emetic. It is a patented product prepared with *o*-chlorophenol, sulphur, and sodium hydroxide.[1] *Katanol O* is soluble in hot water with addition of sodium carbonate, and has a direct affinity for cotton. *Katanol W* will dissolve in water without soda. The advantages of these substances as mordants over tannin and tartar emetic is that the mordanting is carried out in one bath only, no separate fixing bath being required.

Method.—The cotton is mordanted in a short liquor for 1 to 2 hours at 140° F. with 6 per cent. Katanol O and 30 to 50 per cent. common salt; it is then rinsed and dyed with basic colours as usual.

The shades obtained are similar to those on a tannin mordant, being usually slightly yellower and sometimes clearer and brighter. The fastness to washing on Katanol mordant is better than on tannin, but the fastness to light is somewhat inferior.

Katanol can also be applied after dyeing to obtain greater fastness to water and perspiration in a similar manner to a *back tanning* bath. When used in this way a weaker bath can be employed than in mordanting before dyeing. *Katanol O* is chiefly recommended for mordanting cotton, and *Katanol W* as a resist for animal fibres when filling-up linings with direct cotton colours.

"Vat" Colours on Cotton and Linen.—Owing to the difficulties met with in applying the vat dyestuffs to made-up articles, they are not very largely used by garment dyers. As, however, many dyestuffs of this class are eminently fast to light, as well as to washing and other influences, they are on this account employed to a limited extent in the re-dyeing of casement curtains, and the like, that are required to be "unfadeable." As the name implies, these dyes are applied from a "vat," in a similar manner to indigo. They include members of the *Duranthrene*, *Indanthrene*, *Caledon*, *Alizanthrene*, and *Cibanone* series, which belong to the anthraquinone group, these as a class being faster than dyestuffs of the indigoid group. To obtain good results when re-dyeing with these colours it is advisable to unpick all seams and headings of curtains to allow the dye to penetrate. The original colour should be stripped with hydrosulphite or by other means to obtain a level ground before re-dyeing with the vat colours.

The general method of dyeing is from the alkaline hydrosulphite vat with caustic soda and sodium hydrosulphite (*Hydros*), using wooden vats provided with iron steam pipes, as copper pipes

[1] Bayer, Eng. Pat. 173313.

cannot be used. For made-up casement curtains a dipping frame is probably the best means of manipulating the goods. The proportions of the various ingredients of the vat vary according to the particular colour and the depth of shade required, but it is important to have sufficient hydrosulphite and caustic soda present to keep the colours in solution during the whole time of dyeing, and the goods should not be entered until the vat is in proper condition. Dark shades require larger additions of caustic soda than pale shades. During the dyeing the goods should not be exposed to the air unduly, or premature oxidation results, with uneven shades. Care should also be taken not to stir the liquor violently or air will be introduced. The addition of restraining agents, *e.g.* fish glue, helps towards better penetration.

The dyeing is carried out at a temperature of 80° to 120° F., with from 1 to 5 lbs. colour paste, 2 to 3 lbs. hydrosulphite, 3 to 4 pints caustic soda (76° Tw.). The shade is developed by means of air oxidation, or by passing the goods through a separate bath of sodium perborate.

Sulphur Colours.—Cotton piece goods are now largely dyed with sulphur colours (*Thionol, Pyrogene, Eclipse,* and similar series) in alkaline baths, but it does not appear probable that these will be applied in the garment-dyeing trade to any considerable extent. *Sulphur Black* is sometimes used in the re-dyeing of cotton and artificial silk hose. The dyestuffs are dissolved in sodium sulphide and the dyeing carried out with the addition of soda and Glauber's salts at the boil. They may be rendered faster to light and washing by after-treatment with copper sulphate or sodium bichromate, but the present trend is towards the use of sulphur colours not requiring any after-treatment.

Neither the vat colours nor the sulphur colours are adapted for use when animal fibres such as wool trimming or silk stitching are present, and it is necessary in such cases to make an addition of a protecting agent such as *Protectol* 1 to the bath to preserve these fibres from the effects of the caustic soda and sodium sulphide.

Silk Dyeing.—The silk fabrics submitted to the garment dyer may be divided into those which are " weighted " or loaded and those which are pure. Until a few years ago it could be assumed that silk goods woven in the " gum " state and piece-dyed were pure, while most of the yarn-dyed silks were weighted in some degree ; in the former class were included crêpes-de-chine, ninons, chiffons, georgettes, some satins, etc. Now, however, it is the general practice to weight piece-dyed silks, usually with tin, though some pure crêpes-de-chine are still marketed. For

example, most crêpes-de-chine made with a spun silk warp are unweighted, and net silk crêpes-de-chine made especially as washing fabrics are also usually pure.

It is very rare that Tussore silks are weighted, as the cost of the process is prohibitive.

Speaking generally, yarn-dyed silks are weighted to a greater degree than those which are piece-weighted and piece-dyed. In the latter class it is not usual to find goods weighted to a greater extent than 60 to 75 per cent. on the boiled-off weight. Goods which have been satisfactorily weighted to this degree are usually sound and will undergo the stripping of the colour in soap or hydrosulphite baths and subsequent re-dyeing quite well. It cannot be too strongly emphasised that the degree of weighting has much less effect on the strength of the fabric than the manner in which the process has been carried out. It is possible to have sound strong fabrics with 100 per cent. of weighting (on boil-off weight), and tender fabrics containing only 25 to 30 per cent. of weighting.

This makes it very difficult for the dyer to decide whether or not to undertake the re-dyeing of a particular silk garment. In a general way a silk fabric which feels harsh to the touch is fairly heavily weighted, and, if it is possible to test a small portion (e.g. in a seam) by breaking between the fingers, the strength can be determined. Unfortunately, however, this test is by no means infallible, because local oxidation in exposed portions (fades) must also be considered, as the material in a seam will not have been so exposed. Weighted silks are frequently found to be tender in places that have been splashed with scent or other liquids, also where the fabric has been subjected to the action of perspiration (e.g. under the sleeves of jumpers and frocks).

When examining silk articles before putting into process, the dyer should look for brownish or pinkish stains on weighted white silks, and stains showing change of colour locally on coloured silks. The fabric in the region of such stains is very often quite rotten. Experience will indicate whether a silk garment has the requisite degree of strength to warrant proceeding with the dyeing.

In all cases silk articles should be handled as little as possible, to avoid " chafing." Soft silks such as crêpe-de-chine, chiffon, and other fabrics containing thrown or highly twisted silk, may be dyed in coppers, but smooth lancewood sticks should be used for moving them. Stiff silks, spun silks, satins, and other face silks are better dyed on frames.

Articles consisting of silk are almost invariably dyed with acid or direct dyestuffs, basic colours being employed only for bright gaslight shades for evening wear, e.g. *Night Blue, Glacier Blue,* etc. Substantive colours are used where fastness to washing and water is necessary and where cotton stitching or artificial silk trimming is present and requires covering. In dyeing silk with acid colours the goods are entered at about 120° F., and the temperature of the bath is gradually raised to about 190° F., 3 to 6 per cent. of 30 per cent. acetic acid, 1 to 2 per cent. of 90 per cent. formic acid, or $\frac{1}{2}$ to 1 per cent. of sulphuric acid (168° Tw.) being added. In nearly all cases acetic or formic acid will replace sulphuric acid with advantage, the better exhaustion produced by the latter being negligible in silk dyeing, whereas the organic acids result in better levelling baths. Glauber's salt is not used.

Silk fabrics are usually easy to penetrate, but hard portions are sometimes found in closely woven fancy fabrics (*e.g.* silk shawls and knotted fringes). In such cases a substitute for "boiled-off liquor," which is not obtainable in a garment dye-house, may be made by dissolving 1 lb. of neutral oil soap and $2\frac{1}{2}$ ounces of leaf gelatine in 4 gallons of water. A sufficient quantity of this solution is added to the dye bath (usually one-fifth the volume of the bath) and sulphuric acid is gradually stirred in until the bath is slightly acid; the emulsion produced is made lukewarm. The goods are well wetted-out in this bath and then lifted, while the dissolved, filtered dyestuff is added; the goods are again entered, the bath being slowly raised to 190° F. All-silk goods, after rinsing in water, are *scrooped* in a dilute acetic acid bath to impart to them the peculiar *handle* or *scroop* possessed by silk fabrics in the new. With a few exceptions, all acid colours dye silk satisfactorily, though the percentage of colour required is usually greater than for an equal depth of shade on wool,.as the affinity of silk for acid colours is not so great. For black, 12 to 15 per cent. or more may be required. The following dyestuffs are recommended for dyeing silk from an acid dye bath :—

Dyes Suitable for Dyeing Silk from Acid Bath.

    88 ACID BORDEAUX. (BROTHERTON.)
  184 AMARANTH. (BROTHERTON.)
  748 XYLENE RED B. (S.)
  179 CARMOISINE WS. (BDC.)
  176 FAST RED A. (BDC.)
  194 DOUBLE BRILLIANT SCARLET S. (BROTHERTON.)
  196 ACID SCARLET 2R. (S.)

252 BRILLIANT CROCEINE. Various makes.
151 ORANGE II. Various makes.
143 ORANGE IV. Various makes.
146 CITRONINE Y CONC. (BDC.)
145 INDIAN YELLOW R. (LBH.)
138 METANIL YELLOW. Various makes.
801 QUINOLINE YELLOW. Various makes.
147 AZOFLAVINE FF. (IG.)
639 XYLENE LIGHT YELLOW R. (S.)
670 WOOL GREEN 2G. (S.)
735 LISSAMINE GREEN V CONC. (BDC.)
737 LISSAMINE GREEN B. (BDC.)
712 DISULPHINE BLUE V. (BDC.)
714 DISULPHINE BLUE A. (BDC.)
861 INDULINE WATER SOLUBLE. Various makes.
715 CYANOLE EXTRA, FF. (IG.)
698 COOMASSIE VIOLET R. (BDC.)
717 ACID VIOLET 6BN. (CAC.)
246 NAPHTHOL BLUE BLACK. Various makes.
865 NIGROSINE WATER SOLUBLE. Various makes.
295 VICTORIA BLACK B. (IG.)
306 FAST SULPHON BLACK. (S.)

Most of the neutral-dyeing acid colours mentioned in connection with the dyeing of half-wool also dye silk well from a neutral bath.

Alkali Blue on Silk.—For bright pale blue shades on silk materials, alkali blue is frequently used. This colour is applied to silk from a soap bath containing 10 per cent. on the weight of goods of neutral oil soap, to which the colour, previously dissolved in soap solution, is gradually added. The dyeing is continued at 190° to 195° F. for half an hour. The goods are rinsed in warm water, and the colour raised in a fresh acid bath containing 1 to 3 per cent. of sulphuric acid at 140° F.

Basic Colours on Silk.—As already stated, these are only used on silk when bright gaslight shades are required that need not necessarily be fast to light. Care should be exercised in dissolving these colours, to avoid spotting. Basic colours are usually dissolved in water to which a little acetic acid has been added, hot water being added after the colour has dissolved. Where there is difficulty in effecting complete solution, addition of methylated spirit is sometimes made to the stock solution. In dyeing with basic colours the dye bath is charged with 10 per cent. of neutral oil soap. The requisite amount of filtered colour

solution is added, the goods are entered at about 85° F., and the temperature slowly brought up to 140° to 160° F. After dyeing, the goods are well rinsed and " scrooped " in an acetic acid bath.

Examples of suitable basic colours are *Rhodamine B and 6G, Night Blue, Setopaline.*

Direct Colours on Silk.—Direct colours are employed in dyeing shades on silk fast to water and washing. Those direct colours suitable for diazotisation and development are treated in the manner described for cotton fabrics. When after-treated in this way, the developed shades are fast to soaping. Direct colours are applied from a neutral bath containing 10 per cent. of Glauber's salt. Any cotton stitching is covered at the same time. The goods are entered into the dye liquor at hand heat, the temperature raised to the boil, and the dyeing continued for half an hour under the boil. After dyeing, the goods are scrooped with acetic acid. It follows that the direct colours selected for silk dyeing should be fast to organic acids in order that the acid brightening bath may not dull the shade.

Suitable Direct Colours for Dyeing Silk.

382 { CHLORAMINE RED B. } (S.)
    { CHLORAMINE RED 3 B. }

BENZO FAST BORDEAUX 6BL.   (IG.)

419   DIRECT FAST RED F.   (CAC.)

278   CHLORAZOL FAST RED K.   (BDC.)

653   PYRAZOL ORANGE G CONC.   (S.)

365   CHRYSOPHENINE G.   (BDC.)

CHLORANTINE FAST YELLOW 4 GL.   (CAC.)

594   DIRECT GREEN G.   (S.)

593   DIRECT GREEN B.   Various makes.

518   CHLORAZOL SKY BLUE FF.   (BDC.)

590   CHLORAMINE BLUE 3G.   (S.)

387   CHLORAZOL VIOLET WBX.   (BDC.)

319   BENZO FAST HELIOTROPE BL, 2RL.   (IG.)

353A BENZO FAST HELIOTROPE 4BL, 5RH.   (IG.)

394   DIRECT VIOLET N.   (CAC.)

596   CHLORAZOL BROWN G.   (BDC.)

420   DIRECT BROWN M.   (CAC.)

598   CONGO BROWN G.   Various makes.

BENZO FAST BROWN 3 GL, RL.   (IG.)

CHLORAZOL FAST BROWN 2 RK.   (BDC.)

592   PARAMINE BLACK HW.   (LBH.)

CHLORAZOL FAST BLACK BK.   (BDC.)

Tussore Silk.—Articles made of Tussore silk, such as jumpers, dresses, casement curtains, etc., are dyed similarly to ordinary silk, but require larger percentages of colour for the same depth of shade. Although the fibre is exceptionally strong, the edges are liable to fray—buttonholes, for instance—so that articles made of Tussore require careful handling. The quality of Tussore varies, some being pure silk, other grades being more or less filled. It appears to be most satisfactory when dyed in bright, luminous shades. When dyeing pale shades on Tussore, the material must first be bleached with hydrogen peroxide, or sodium peroxide, to reduce the natural buff-coloured ground. Acid colours are generally used, though direct cotton colours are also employed, especially when any cotton is present. When dyeing with acid colours, the cleaned goods are entered at 120° F. into a dye bath made weakly acid with about 3 per cent. of 30 per cent. acetic acid or 1 per cent. of 90 per cent. formic acid. The bath is raised gradually to the boil, and dyeing continued at the boil for 30 minutes. Easily-levelling acid colours are used, and the colours may be added to the bath in several portions. An addition of sulphuric acid is made towards the end of the process when dyeing medium to full shades to exhaust the bath. Difficulty is experienced in obtaining a full black on Tussore, owing to the peculiar fibrillæ construction of the fibre, which disperses the light, thus causing the fabric to assume a greyish appearance. In dyeing blacks, direct cotton colours are frequently used, sometimes after-treated by diazotising and developing with meta-phenylene diamine to give increased depth. *Gloria Black N* may also be used to give bloom, either alone or with direct black, and is applied from a neutral bath. Even a full black, however, appears greyish on Tussore. The same colours are used for dyeing Tussore as for ordinary silk, but larger percentages are required in the bath to obtain the same depth of shade.

Wool and Silk.—These goods may be dyed in acid or neutral baths, the latter method being the one usually employed. In dyeing level shades with acid dyestuffs, similar methods to those described for dyeing all-wool materials are used. By careful regulation of the temperature of the bath, solid shades can be obtained. Boiling tends to drive the colour on to the wool at the expense of the silk, while at lower temperatures the silk absorbs the bulk of the dye. The method followed is to keep the bath at the boil, using acid colours dyeing solid shades on wool and silk. If necessary, further additions of colour may be made at about 140° F. to tone the silk.

Neutral baths are used for goods which are very closely woven

and hard to penetrate ; a list of suitable colours has already been given.   Whether dyed in neutral or acid baths, the goods may be finally rinsed in a weak acetic acid bath to brighten the silk.

By selecting acid colours which leave the silk white, cross-dye effects may be produced.   For this purpose the goods are dyed at the boil with the addition of 10 to 20 per cent. of acetic acid, well rinsed, and treated for half an hour at 100° F. in a wheat-bran bath to clear the silk ; after rinsing, the goods are " scrooped " in acetic acid and dried.   Another method of " clearing " the silk is to work the goods in dilute acetate or oxalate of ammonia ; in some cases warm water alone suffices.   The following acid dyestuffs employed in the manner described leave the silk practically white :—

Acid Colours for Dyeing Wool and Leaving Silk Unstained.

692	ACID MAGENTA. All makes.
179	CARMOISINE WS. (BDC.)
27	ORANGE GG. Various makes.
10	NAPHTHOL YELLOW S. All makes.
640	TARTRAZINE. All makes.
208	FAST ACID BLUE RH. (BDC.)
1180	INDIGO CARMINE. Various makes.
1053	ALIZARINE DELPHINOL SEN. (BDC.)
1054	ALIZARINE DELPHINOL B. (BDC.)
53	COOMASSIE VIOLET AV. (BDC.)

The silk may be subsequently dyed in a *cold* bath with the addition of acetic acid, basic or suitable acid colours being employed if two-colour effects are desired.

Silk and Cotton Fabrics.—This combination of fibres is frequently met with in satins (silk face and cotton back), silk and cotton union damask, silk jumpers trimmed with cotton lace, or with cotton stitching, silk curtains with cotton lace, embroidery or trimming, etc.   They may be dyed solid shades, or the silk may be dyed leaving the cotton white, or the cotton dyed leaving the silk white ; in either of the two latter cases the white fibre may be cross-dyed another colour.   In dyeing solid shades the one-bath or two-bath method may be used, the process selected depending upon the amount of cotton which shows plainly and upon the shade required.   In cases where the silk is most prominent (as in cotton back satins), or when pale bright shades are to be dyed, the silk is dyed with an acid colour and the cotton in a separate bath with a direct colour.   In this process either

fibre may be dyed first; but when it is necessary to match the silk to a pattern (particularly in pale shades) it is advisable to dye the cotton first in a lukewarm soap bath, afterwards dyeing the silk in a cold or lukewarm acetic acid bath.

In dyeing with direct colours giving level shades on cotton and silk, the bath to which Glauber's salt or common salt and a little soap, soda, or borax has been added is kept just below the boil (195° to 205° F.); lowering the temperature causes the cotton to become darker, whilst boiling deepens the shade of the silk. It is advisable in any case to keep the cotton a little darker than the silk, as this usually gives a better effect than dyeing the silk darker than the cotton.

For full shades and black on silk and cotton articles, the single-bath method with union colours giving approximately solid shades in a boiling neutral dye bath is employed. Similar methods are adopted to those followed with half-wool fabrics, and the same range of colours including neutral dyeing acid colours can be used.

Direct Colours giving Solid Shades on Cotton and Silk.

448	BENZOPURPURINE 4B. All makes.
382	CHLORAMINE RED B. (S.)
	CHLORAZOL FAST RED 10B. (BDC.)
375	CONGO CORINTH GW. (BDC.)
461	CONGO CORINTH B. Various makes.
376	CONGO RUBINE. Various makes.
419	CHLORAZOL FAST RED F. (BDC.)
128	DIAMINE ROSE GD. (IG.)
459	CONGO ORANGE R. Various makes.
478	TOLUYLENE ORANGE G. Various makes.
653	PYRAZOL ORANGE G, R, 2R. (S.)
365	CHRYSOPHENINE G. All makes.
814	CHLORAZOL FAST YELLOW B. (BDC.)
410	CHRYSAMINE G. Various makes.
813	TITAN YELLOW G. (BDC.)
589	CHLORAMINE GREEN B. (S.)
594	DIRECT GREEN G. Various makes.
593	DIRECT GREEN B. Various makes.
590	CHLORAMINE BLUE 3G. (S.)
512	CHLORAZOL BLUE RW. (BDC.)
472	CHLORAMINE BLUE BX, BXR. (S.)
596	CHLORAZOL BROWN G. (BDC.)
598	CONGO BROWN G. Various makes.

420   DIRECT BROWN M. (CAC.)
394   CHLORAZOL VIOLET N. (BDC.)
581   CHLORAZOL BLACK E EXTRA. (BDC.) ''
582   CHLORAZOL BLACK LF. (BDC.)
592 · PARAMINE BLACK HW. (LBH.)

In dyeing blacks a small quantity of green or yellow may be added for shading pnrposes and the silk may be topped with an acid blaek, if necessary, in a separate bath, taking care to avoid bronziness. Any of the above colours may be topped with basic or acid dyestuffs. When dyeing bright pale shades the best results are obtained by dyeing the cotton in a cold or lukewarm soap bath and the silk in a separate cold bath with acid colours. Combinations can readily be made for the purpose of producing solid shades or for cross-dyed effects (e.g. in union damask). The table gives direct colours which, dyed in a soap and soda bath (10 per cent. and 1 per cent. respectively), leave the silk practically white. The same dyestuffs may be employed for cross-dyeing at lower temperatures.

Direct Colours Leaving Silk practically White when Dyed in a Soap Bath.

327   CHLORAZOL FAST SCARLET 4BS. (BDC.)
130   ERIKA B. (S.)
621   CHLORAZOL FAST ORANGE D. (BDC.)
814   CHLORAZOL FAST YELLOW B. (BDC.)
622   CHLORAZOL FAST YELLOW FG. (BDC.)
      CHLORAZOL FAST YELLOW AG. (BDC.)
620   CHLORAZOL YELLOW GX. (BDC.)
406   DIRECT BLUE 2B. Various makes.
477   CHLORAZOL BLUE 3B. (BDC.)
472   CHLORAMINE BLUE BX, BXR. (S.)
518   CHLORAZOL SKY BLUE FF. (BDC.)
520   CHLORAMINE SKY BLUE A. (S.)
428   DIRECT VIOLET R. (CAC.)
401   CHLORAZOL BLACK BH. (BDC.)
      MELANTHERINE JH. (CAC.)

The two last named may be diazotised and developed to produce blacks or navy blue shades. Nearly all the acid colours leave cotton practically white when dyed in an acetic acid bath, so that it is not necessary to particularise them.

Two-colour effects may be produced in one bath by combining the above direct colours with neutral acid-dyeing colours.

Artificial Silk.—This fibre, also known as *Rayon*, is met with very largely as braid, embroidery, lace, and cord trimmings on garments composed of other fibres; as linings, and in union fabrics mixed with silk, wool, and cotton. The dyeing process should be such as to dye the various fibres in a solid shade in one bath, this being achieved by selecting suitable direct cotton colours and neutral acid colours, and by a careful regulation of the temperature of the bath. A very large proportion of knitted coats and knitted dresses and hose are of artificial silk, also hose in which the *panel* is of artificial silk and the tops and feet of cotton or some other fibre.

Being a vegetable fibre, the dyeing properties of artificial silk are similar to those of cotton, but the difference in physical and chemical characteristics renders it necessary to take certain precautions when dyeing to obtain level shades and to preserve the lustre and softness of the material. Generally speaking, artificial silks absorb direct dyestuffs more greedily than cotton, and when dyed, the shades are faster to water and consequently more difficult to correct by the usual methods if dyed too full.

Amongst the several kinds of artificial silks the chief are *Viscose, Cuprammonium,* and *Chardonnet,* and of these *Viscose* is easily the most important in this country. *Chardonnet* differs from the other two in having a natural affinity for basic colours, which dye it directly without the need of any preparation such as tannin mordant. Direct cotton colours dye all artificial silks of the above groups, though *Chardonnet* less readily than *Viscose* or *Cuprammonium.* As the garment dyer has no ready means of identifying the particular variety of artificial silk he may be handling, it is best always to use direct cotton dyestuffs, only resorting to basic colours for particularly bright shades.

Preparation.—Before dyeing, the goods are thoroughly wetted-out in water at about 120° F., an important point, especially in the case of embroidery, etc., with tightly twisted threads difficult to dye through. Owing to the fact that artificial silk becomes considerably weaker when wet, it is essential to exercise every care in handling it when in this condition. If the original shade necessitates stripping before re-dyeing in a new shade, a weak solution of sodium hypochlorite may be used, cold. Where real silk or wool is present, hypochlorites cannot be used, and in such cases a reducing stripping agent (*Hydros*) may be employed, but the temperature of the stripping bath should be kept below 140° to 160° F.

Many of the articles sent for re-dyeing are stitched or trimmed with real silk, which may not be apparent from a casual examina-

tion, so that it is safer, if stripping is necessary, to use " Hydros," which is applicable to all fibres.

Dyeing.—In preparing the dye bath a long liquor should be used, as it is desirable that the goods should have plenty of room to allow of even dyeing. The dye bath is made up with a small amount of soda (58 per cent. alkali) and either *Monopol Soap* or *Monopol Oil*, the latter serving to keep the goods supple ; without this addition artificial silk material tends to dry somewhat brittle. The soda promotes the solubility of the dyestuff and assists penetration and level-dyeing properties. The percentages required are :—

> ½ to 1 per cent. Soda.
> 2 to 4 per cent. Monopol Soap or Monopol Oil.

When dyeing pale shades it is best to commence without any addition of Glauber's salt, but if necessary this may be added afterwards to assist in exhausting the dye liquor. The percentage of Glauber's salt may be from 5 per cent. for medium shades to 20 per cent. for dark shades and black. Standing baths are kept if dyeing more than one lot, as the liquors do not exhaust. Further lots can be dyed by freshening-up with about two-thirds the original quantity of colour. The temperature of the dye bath and the duration of the dyeing are most important when dyeing artificial silk. The temperature should not exceed 185° F. Higher temperatures are detrimental to both the lustre and strength of the material. Steam should not be on while the goods are in the liquor. The dyeing process itself should occupy as short a period as possible, as prolonging the dyeing impairs the lustre. Quick matching is essential, and in most cases the dyeing should be complete in 30 minutes. When the goods are up to shade they are rinsed in water and brightened in a fresh bath containing acetic acid with a slight addition of Monopol oil or Monopol soap, hydro-extracted, and then dried at a low temperature.

Practically all direct cotton dyestuffs will dye artificial silks, but those giving the best results should satisfy the following conditions :—

1. Good solubility in water at the temperature of dyeing.
2. Good fastness to organic acids, so that no change occurs in the brightening bath.
3. Should fall on to the fibre at 150° to 185° F.

As artificial silk is frequently associated with other fibres in the same garment, *e.g.* with mercerised cotton and real silk, it is advisable to select direct dyes that give fairly solid shades on

all these fibres. The silk can be toned if necessary with neutral-dyeing acid colours in the same bath. The following is a list of direct cotton dyestuffs suitable for use on artificial silk. Those adapted for various methods of after-treatment such as diazotisation and developing, etc., can be after-treated on artificial silk exactly as if dyed on cotton.

Direct Cotton Dyestuffs Suitable for Artificial Silk.

	BENZO FAST BORDEAUX 6BL.
327	CHLORAZOL FAST SCARLET 4BS. (BDC.)
326	CHLORAMINE FAST SCARLET 2B. (S.)
419	CHLORAZOL FAST RED F. (BDC.)
278	CHLORAZOL FAST RED K. (BDC.)
417	PARAMINE FAST BORDEAUX B. (LBH.)
436	DIPHENYL RED 8B. (GY.)
	CHLORAZOL FAST ORANGE G. (BDC.)
653	PYRAZOL ORANGE G, 2R. (S.)
621	CHLORAZOL FAST ORANGE D. (BDC.)
	CHLORANTINE FAST YELLOW 4GL. (CAC.)
346	CHLORAZOL FAST YELLOW 5GK. (BDC.)
365	CHRYSOPHENINE G. Various makes.
577	CHLORAZOL BROWN 2G. (BDC.)
420	CHLORAZOL BROWN M. (BDC.)
596	CHLORAZOL BROWN G. (BDC.)
	CHLORANTINE FAST GREEN BL. (CAC.)
	BENZO FAST BLUE 4GL, 8GL. (IG.)
	CHLORAMINE FAST BLUE BS. (S.)
406	DIRECT BLUE 2B. Various makes.
353A	BENZO FAST HELIO 4BL. (IG.)
319	CHLORAZOL FAST HELIO BK. (BDC.)
	CHLORAZOL BLACK SD. (BDC.)
	CHLORAZOL FAST BLACK BK. (BDC.)
539	CHLORAMINE BLACK FF. (S.)
	DIRECT FAST BLACK B. (CAC.)
581	CARBIDE BLACK E. (CAC.)

Where it is not possible to obtain the necessary brightness of shade by means of direct cotton colours, basic dyes must be used. These may be applied as in dyeing cotton, *i.e.* the artificial silk garments are mordanted with tannic acid and fixed with tartar emetic. The goods are then dyed with suitable basic colours from a bath containing 1 to 2 per cent. acetic acid, the colour being added in several portions, and the dyeing commenced

cold, finishing at about 140° F.   Katanol O can be used to mordant artificial silk before dyeing with basic colours instead of tannic acid and tartar emetic.   It is less sensitive to variations in the quality of the silk ; it appears to give more even results in dyeing, and the handle of the goods is better than when tannin and tartar emetic are used.

Chardonnet artificial silk may be dyed with basic colours in pale to medium shades without a mordant.

Basic colours may also be used for *topping* direct dyeings when the shade lacks brightness, but the amount used should be very small as the colour so applied is not fast.

To dye approximately solid shades on garments made up of artificial silk, cotton, and mercerised cotton is chiefly a question of the temperature of the dye bath.   The lower the temperature the deeper the cotton becomes in relation to the artificial silk ; the higher the temperature the darker the artificial silk, until at the boil it is possible to dye the artificial silk very dark, while the cotton remains thin in shade, provided suitable colours are selected.   With most direct cotton colours uniform shades are obtained on cotton and artificial silk at some temperature between 90° and 140° F., the actual temperature varying according to the particular colour used.   Direct cotton colours that dye full shades between the temperatures given should be selected.

Acetyl-Cellulose.—The artificial silks referred to in the previous pages consist of regenerated cellulose, and as such are dyed with the same dyestuffs as are applied to cotton, which is almost pure cellulose.   Acetyl-cellulose artificial silks on the other hand are definite chemical compounds of cellulose and acetic acid, the best-known acetyl-cellulose fibre in this country being the one produced by *British Celanese, Ltd.*, under the name *Celanese*. The dyeing properties of " Celanese " differ so fundamentally from those of artificial silks that it is necessary to treat this fibre separately.   A large quantity of Celanese is now made into fabrics, *e.g.* marocain, and mixed with other fibres in woven materials, as linings, knitted garments, jumpers, dresses, etc., and in the form of Celanese *Tricot* which bears a close resemblance to silk Milanese.

It is important in the first instance that the Celanese fibre should be recognised, the simplest tests being those already mentioned, *i.e.* burning test (Celanese burns with an odour somewhat resembling burnt sugar and leaves a hard black bead), and the test of a thread with acetone, in which Celanese first softens and then dissolves.

Preparing for the Dye Bath.—If in fairly good order, articles made of Celanese sent for re-dyeing may have a preliminary dry

cleaning with petroleum spirit. If this is done, care must be taken not to use a solvent likely to cause damage to this material such as chloroform or *Westron* (tetrachlorethane), either in the solvent itself or in the dry-cleaning soap. Garments may alternatively be wet cleaned using a good neutral oil soap (*e.g.* green olive oil soap) of a strength about 1 ounce to 1 gallon of water, together with a small amount of ammonia in the bath. Although soda ash (58 per cent. alkali) can be employed in moderate amount, and would definitely assist in the scouring process previous to dyeing, the makers advise against its use on account of the attendant risk of partial saponification of the fibre. A warning is also issued against wet cleaning or scouring Celanese with spirit soaps of unknown composition, as the solvent may be one which delustres or otherwise damages Celanese. Soaps in which xylene is introduced as the solvent can be used with safety. *British Celanese, Ltd.* market a solvent soap under the name *Celascour*, which can be added to the wet-cleaning bath when preparing Celanese goods for dyeing. It is of special value when the goods are greasy. After cleaning for about 30 minutes at 160° to 165° F. the goods are thoroughly rinsed and are ready for the dye bath.

If it is necessary to strip or bleach the original colour of all-Celanese articles they may be treated in the cold with a weak solution of sodium hypochlorite, the strength recommended being a 0·25° Tw. solution. This should be followed by treatment with an " antichlor."

When the Celanese is mixed with silk or is on a garment trimmed with silk, hypochlorites cannot be used on account of damage to the silk which would result. In such cases stripping may be effected with sodium hydrosulphite (*Hydros*) at a temperature not higher than 160° to 165° F. Sodium hydrosulphite may also be used in conjunction with soap and ammonia used in cleaning.

Dyeing Celanese.—Celanese has dyeing properties peculiar to itself. A few acid dyestuffs (*e.g. Fast Red A*) have some affinity for the fibre, but the results on dyeing are not very satisfactory, and in any case a complete range of such colours is not available. Basic dyestuffs, many of which dye Celanese in full shades, are used occasionally where special brightness is desired, but as a class they are not fast. A large amount of research has been done, and special ranges of dyes have been introduced for the successful dyeing of this fibre. Probably the most satisfactory method for Celanese garment dyeing consists in the use of *S.R.A.* colours of *British Celanese, Ltd.*, *Duranol colours* (*BDC*), and *Celatene colours* (*Scottish Dyes*).

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Mention should be made also of the Ionamines, *e.g. Ionamine A* (*BDC*), which dyes an orange-yellow direct, but when diazotised and developed with β-oxynaphthoic acid dyes a fast black of good tone.

The S.R.A. dyestuffs for Celanese are made up in paste form with a suitable medium (*Turkey Red Oil*—Sulphoricinoleic acid) and are applied to Celanese from a soap bath. A full range is available for dyeing Celanese direct, with the exception of green and black. Green is dyed with a mixture of blue and yellow, for example, *Blue 4* and *Pure Yellow 2*, while a fast black can be produced by dyeing with *Black 4* and diazotising and developing with β-oxynaphthoic acid.

For use in dyeing, the S.R.A. colour is dissolved to a stock liquor with boiling soap and the solution added to the bath through a sieve as required. The dye bath is charged with olive oil soap of a strength of ½ to 1 gram of soap per litre and the colour in solution is added as required, in several portions, to obtain the desired shade. The dyeing is carried out at a temperature of 165° to 170° F. When to shade, the goods are rinsed first in warm water, then in cold water, and treated finally in an oil emulsion, or with Turkey Red Oil and soap, to produce a soft handle.

The S.R.A. range of colours is continually being extended, but the following are in general use, some of them being remarkably fast and all of serviceable fastness. The fastest members of the series are prefixed by the name " *Fast* "—thus, *S.R.A. Fast Violet 2*. As a class they do not appreciably stain cotton or artificial silk, but do stain wool, and to a less extent silk also. When cotton and artificial silk are present in the same garment they may be dyed along with the Celanese by adding to the dye bath suitable direct cotton dyestuffs.

Range of S.R.A. Colours.

S.R.A. Pure Yellow 1 and 2.
S.R.A. Golden Yellow 8, 9, and 10.
S.R.A. Golden Orange 1 and 3.
S.R.A. Orange 1, 2, and 3.
S.R.A. Red 1, 3, 5, 6, and 7.
S.R.A. Heliotrope 1.
S.R.A. Violet 2.
S.R.A. Blue 3, 4, 5, and 7.
S.R.A. Grey 1.
S.R.A. Black 4.

The percentage of dyestuff required may be from 0·5 to 20 per cent., according to the depth of shade required.

The S.R.A. range does not include a direct dyeing black, and to produce a fast black it is necessary to dye with *Black 4*, then diazotise and develop with β-oxynaphthoic acid. The following are the proportions recommended by *British Celanese, Ltd.* It will be noted that both the diazotising and the developing baths are stronger than those normally used in cotton dyeing. Development is carried out hot, which is also a variation from the usual procedure. To obtain a good tone of black, the developing bath should react slightly acid and the developer should be present in excess.

Black on Celanese.—

Dye with 15 to 20 per cent. *S.R.A. Black 4* from a soap bath at 176° F. for 1½ hours.

Rinse well.

Diazotise : Sodium nitrite 5 per cent.
Hydrochloric acid 16 per cent. } ½ hour, cold.

Rinse.

Develop : β-Oxynaphthoic acid, 3 per cent.
Caustic soda, 0·7 per cent.
Glue, 5 per cent.
100 per cent. Acetic acid, 5 per cent.

Raise from 95° F. to 140° F. in ½ hour, then work for ½ hour at 140° F. Soap with olive oil soap at 115° F. for 10 minutes.

Other colours suitable for the dyeing of cellulose acetate artificial silks are the *Duranol* and *Celatene* colours. These are dispersed dyestuffs belonging to the *anthraquinone group.* They also are characterised by very good fastness properties.

Duranol Colours (BDC).—These are paste colours having a good affinity for cellulose acetate. They are dyed direct from a plain bath without addition or from a soap bath. The same precautions as to temperature apply—the maximum being 175° F. Some of the colours of this series are very bright in shade, e.g. *Duranol Red G* and *2B*, and being fast are useful for the dyeing of fast shades not easily obtained by other methods. *Duranol Black* dyes a good tone of black direct, but a very large percentage is required in the bath to obtain sufficient depth.

Celatene Colours (Scottish Dyes).—This is another fast to light series of dyestuffs in paste for cellulose acetate which dye the fibre directly, and can be applied from a plain bath without addition or from an alkaline or acid bath if necessary. Dyeing

is commenced at 140° F. and the temperature of the bath raised to 175° F. Standing baths are required as the baths do not exhaust. *Celatene Black*, which belongs to this series, is a good shade of direct-dyeing black, but a heavy percentage is required to obtain a black. Other colours recommended for the dyeing of cellulose acetate artificial silks are (1) *Cellit Fast Colours (IG)*, which are applied from a bath of Glauber's salt and acetic acid; (2) *Cibacete Colours (SCI)*; these dye from a soap or *Turkey Red Oil* bath; (3) *Setacyl Colours (Geigy)*, and (4) *Imacol Colours (Sandoz)*. The last named dye cellulose acetate from a plain dye bath without addition, but further details as to the application and properties of these colours should be obtained from the manufacturers.

General Notes.—Celanese garments received for dyeing are often found on examination to show glaze marks due to the use of too hot an iron. The same defect is sometimes noticeable on pleated goods, the material being glazed at the pleats. To remedy the defect *British Celanese, Ltd.* recommend for their material steeping the goods for a quarter of an hour in a cold solution of 8 ounces per gallon of ammonium thiocyanate to swell out the flattened fibre, afterwards washing off.

Another difficulty concerns the treatment of *home-washed* or attempted *home-dyed* Celanese garments. When received, these are often delustred in patches owing to the use of boiling liquors, and they are usually badly broken and creased. Where the damage is not too pronounced the lustre may be regained before dyeing by steeping the goods in a cold 20 per cent. solution of acetic acid for several hours.

Apart from the special precautions to be observed as to temperature, Celanese goods should receive the same care in dyeing as when handling silk, to avoid chafing and breaks. Knitted articles, if in good shape before dyeing, should be measured, and after dyeing should be dried to the original shape as nearly as possible. Excessive heat in drying and finishing should be avoided, and when ironing a very cool iron should be used.

Celanese and Artificial Silk or Cotton.—As previously mentioned, Celanese is frequently associated with ordinary artificial silk on the same garment, *e.g.* Celanese shot linings, etc. If the other fibre has to be dyed the same shade as the Celanese (which is usually the case), the colours for the artificial silk may be added to the same bath. In the dye bath each colour falls on to its own particular fibre and solid shades can be obtained by the use of suitable mixtures. Shot effects can also be obtained by taking the precaution of using for the artificial silk contrasting direct cotton colours which do not stain Celanese. The dyestuff

manufacturers have ranges of direct colours found to satisfy these requirements.

Celanese and Wool and **Celanese and Silk.**—Celanese colours are apt to stain wool more than silk. To obtain solid shades on garments composed of a mixture of fibres, the two-bath process consists in first dyeing the Celanese in the garment by the usual methods (already described), rinsing, and afterwards dyeing the wool or silk in a separate bath made acid with formic acid at 170° F. The formic acid exercises less stripping effect upon the Celanese colour than a mineral acid such as sulphuric acid. The colours used for dyeing the wool are such as will not stain the Celanese. A good range of such colours are sent out by the dyestuff manufacturers; these non-staining colours are sometimes termed CR (Celanese Resist). By a careful selection of dyes it is sometimes possible to dye all the fibres to the correct shade in one bath. For this purpose the wool is dyed with colours which will dye from a neutral bath, leaving Celanese unstained, and the Celanese is dyed with S.R.A. colours from a soap bath.

Ramie is dyed in the same way as cotton and linen.

Jute.—This fibre is handled by the garment dyer in a variety of forms, such as imitation wool carpets and plush curtains. Many wool carpets have jute backs. Materials composed of jute are usually prepared for the dye bath by treatment with warm soda, followed by souring in a bath of formic or acetic acid. To make the ground somewhat lighter to work upon, an addition of oxalic acid may be made to the sour bath, but chlorine compounds (sodium hypochlorite, etc.) should not be used. Jute appears to absorb all classes of dyestuffs, acid, basic, and direct; it may be dyed with basic colours in an acetic acid bath with or without the aid of a tannin mordant. All basic colours are applicable to jute, the shades produced excel in brightness and are fast to washing, but they are loose to rubbing and to sunlight. They do not penetrate the material so easily as acid colours and are more difficult to dye level.

Acid Colours are dyed on jute with an addition of 2 to 5 per cent. acetic acid (30 per cent.), or an equivalent quantity of formic acid (90 per cent.), or 2 to 5 per cent. alum. Mineral acids, such as sulphuric acid, have a detrimental effect upon the fibre at the boil and should not be used. The affinity of jute for acid colours is not very strong; the baths do not exhaust except in the case of light shades. Acid colours suitable for dyeing jute mainly belong to the " neutral-dyeing " class. They are better than basic colours in fastness to light, penetration, and cleanness to rubbing.

Acid Colours for Jute.

176 FAST RED A. Various makes.
252 BRILLIANT CROCEINES. Various makes.
276 FAST SCARLET B.
143 ORANGE 4. Various makes.
 26 RAINBOW ORANGE. (BROTHERTON.)
146 CITRONINE Y. CONC. (BDC.)
145 INDIAN YELLOW R. (LBH.)
667 DISULPHINE GREEN B. (BDC.)
707 SOLUBLE BLUE 3M. (BDC.)
833 WOOL FAST BLUE BL, GL. (IG.)
702 ACID VIOLET 7B. (CAC.)
175 ACID BROWN R. (BDC.)

Direct colours are also important in the re-dyeing of jute. They give shades sufficiently fast to washing, rubbing, and general wear, which, however, lack richness and brilliance. The level-dyeing properties are good and the penetration good. Suitable acid colours can be added to the same dye bath to improve the brightness of shade.

Jute is dyed with direct cotton colours in a similar manner to cotton from a liquor containing Glauber's salt or common salt. The goods are entered at the boil and dyed under the boil for 1 hour. A slight addition of soda to the bath helps penetration and gives a better shade in the case of blacks, but this addition must not be made if wool is present.

Direct Colours Suitable for Jute.

448 BENZOPURPURINE 4B. All makes.
376 CONGO RUBINE. Various makes.
326 DIRECT FAST ORANGE SE. (CAC.)
478 TOLUYLENE ORANGE G. Various makes.
365 CHRYSOPHENINE G. All makes.
814 CHLORAZOL FAST YELLOW B. (BDC.)
594 CHLORAZOL GREEN G. (BDC.)
518 CHLORAZOL SKY BLUE FF. (BDC.)
398 DIRECT VIOLET RN. (CAC.)
596 CHLORAZOL BROWN G. (BDC.)
420 DIRECT BROWN M. (CAC.)
581 CHLORAZOL BLACK E EXTRA. (BDC.)
582 CHLORAZOL BLACK LF. (BDC.)

General Notes on Dyeing.—In the foregoing tables a large number of dyestuffs have been given from which the garment dyer may make his selection. Having regard to the increasing complexity of fibres in garments and furnishings sent for re-dyeing, and the more exacting demands as to shade and fastness, it is not possible to limit one's stock of dyestuffs to the thirty or forty that would at one time meet all requirements. To cut down the number to a minimum the dyer should, as far as he can, select colours which will serve more than one purpose. For example, acid dyestuffs may be selected which equalise well in acid bath, which cover silk trimmings, are fast or comparatively fast to light, and are, moreover, economical in use. The tables of dyestuffs are by no means complete, and other dyestuffs may be equally suitable for the various purposes indicated. By careful collation of the tables, dyers will find that they can fulfil their particular requirements with a smaller selection than would be possible otherwise. Reference should be made to the numbers preceding the names of the dyestuffs in the tables ; these are the numbers given in the *Colour Index* of the *Society of Dyers and Colourists*. As the same colour is marketed by different manufacturers under a variety of commercial names the Colour Index should be consulted if the names of corresponding dyestuffs are desired, and for other information concerning them.

All articles containing silk should be given a final rinse in a weak acetic acid bath to brighten and *scroop* the silk ; this bath must, however, be omitted when dyestuffs sensitive to acid have been employed (e.g. *Benzopurpurine 4B*).

If silk fabrics require a slight stiffening after dyeing, gelatine or a mixture of gelatine and white dextrine may be employed, and should be added to the final rinse, which may also contain acetic acid for scrooping. The ordinary garment work (woollen dresses, etc.) with cotton or artificial silk linings requires stiffening in nearly all cases, as the dyer should always endeavour to reproduce as closely as possible the appearance and handle of new goods. For this purpose, boiled starch alone is not entirely suitable, as, although it stiffens the linings satisfactorily, it is also liable to adhere to the surface of the wool fabric, producing an unpleasant effect. This difficulty may be overcome by using a soluble starch which has been introduced under the name of *gum feculose.* This dissolves to a clear solution of which a small quantity is added to the last rinse water, and while stiffening the lining sufficiently it does not adversely affect the colour, feel, or appearance of the wool. Many other substances are used in garment dyeing to give the requisite *body* to dyed work, e.g.

Quellin, Algin, Gum Tragasol. These may be used either alone or mixed with soluble starch or thin boiling starch. Whatever stiffening material is used care must be exercised to make a smooth paste, which should be passed through a fine sieve into the stiffening bath. In rinsing articles containing wool, they must not be taken direct from the boiling bath to a cold rinse water, or shrinkage will occur; if thrown over a "horse," opened out and allowed to *cool off* before rinsing, the risk of shrinkage is very much reduced. Neglect of these precautions may also result in dyers' breaks or creases, which no process of finishing will remove.

After rinsing and stiffening, if necessary, the goods are hydro-extracted, with the exception of velvets, heavy satins, and any other articles which are liable to retain creases permanently. Such articles are shaken out to remove as much moisture as possible and then dried-off. The drying rooms employed for dyed work may be classified as stationary and continuous. The stationary room is usually a steam-heated chamber, exhaust steam being generally employed, and suitable means for hanging up the garments, etc., are provided. Where any quantity of work is being handled, the continuous process may be preferred. In this case the articles are carried by clips on an endless chain or band through a heated chamber in which the air is kept circulating by means of a fan. At the other end of the chamber the clips open automatically, and the dried goods fall into a basket, trolley, or other receptacle. Drying is more satisfactory when there are frequent changes of warm air than when excessive heat is used. Various makes of continuous drying rooms are on the market which are considered economical for the drying of dyed work. Certain goods need special attention at the drying stage, for example, knitted articles, which should retain their original shape and size, must not be subjected to any stress during drying. These may be dried on trays or upon wire shapes placed in the drying rooms.

The drying of articles made of cotton velvet may often be advantageously carried out in a drying tumbler which leaves the velvet pile in fine condition for finishing. Down quilts, when these are dyed, should be dried in a suction tumbler dryer, which loosens the down and turns out a much fuller quilt than any system of stationary drying.

After drying, the goods are ready for finishing. In some cases goods are not dried, but are taken direct to the finishing departments; these will be referred to under that heading.

CHAPTER V.

DRY DYEING.

THE process known as *dry* dyeing bears the same relation to ordinary or " wet " dyeing as " dry " cleaning does to aqueous or " wet " cleaning ; that is to say, the articles are not wetted in the ordinary sense of the word, benzine or benzol being employed as the dyeing medium. Methylated spirit had been employed as a medium in the process known as " spirit " dyeing, but the results obtained were very unsatisfactory, and were, moreover, very expensive to produce. The employment of methylated spirit with pleated and other fabrics liable to lose their shape or finish by immersion therein is quite impossible.

Whereas many coal-tar colours are soluble in methylated spirit, very few are soluble in benzine or benzol, and in most cases in such small quantities that the colour solutions obtained are of no practical value.

Cain and Thorpe [1] give the following acid and basic dyestuffs as being " soluble in traces " in benzol : *Ponceau 4GB, Chrysoidine, Scarlet for Silk, Biebrich Scarlet, Brilliant Green, Methyl Violet B* (moderately soluble on heating), *Acid Violet N, Fast Acid Violet B, Eosine BN, Erythrosine, Phloxine*, and *Rose Bengale 3B* ; *Crystal Violet* is " somewhat soluble," and *Picric Acid* and *Induline* (spirit soluble) are readily soluble in benzol.

The basic colouring matters which, as hydrochlorides, are only " soluble in traces," may be rendered readily soluble in benzine or benzol by conversion into oleates, stearates, or resinates. These colours, known as *fat colours*, may be obtained from nearly all the colour manufacturers, or they may be made from the basic dyestuffs by double decomposition with the sodium or other soluble salt of the fatty acids.

The usual method of preparation is to dissolve the basic colour in water, adding to the solution obtained a solution of a tallow soap or oil soap, or the colour and soap may be dissolved together. Hydrochloric acid is added to the cold mixture, which precipitates

[1] *Synthetic Dyestuffs*, Griffin.

a mixture of fatty acid and *fat colour* ; this rises to the surface and may be collected, washed, and dried.

The drying is performed by melting, and separating from any contained water by cooling and removing the solid fat layer. The quantities required vary with the colouring matters employed, but the following figures may be taken as an example :—

Dissolve in 100 parts of hot water 1·25 parts *Methyl Violet*, 5 parts curd or white oil soap.   When cold, add 2·5 parts concentrated hydrochloric acid.

The resinates are prepared in a similar manner.   Resin is dissolved in a solution of caustic soda and mixed with an aqueous solution of basic colouring matter, a mineral acid, or a solution of alum being employed to precipitate the *fat lake*.   Gouillon (*Manuel Méthodique du Teinturier-Degraisseur*) recommends the following quantities :—

Colophony	500 grams.
Soda crystals	150 ,,
Caustic soda	50 ,,
Water	5 litres.

The colour solution is made by dissolving

Magenta (or other suitable colouring matter)	30 grams, in
Water	2 litres.

These solutions are mixed and the colour resinate is precipitated by adding a solution of

Alum	100 grams, in
Water	500 ,,

The *fat colours* prepared by either of the above processes dissolve very readily in benzine or benzol, but the production of satisfactory results from the solutions is a matter of considerable difficulty.

The dyeing takes place immediately the previously cleaned goods are entered, and the production of level dyeings requires a great deal of manipulative skill.   After dyeing it is very difficult to remove the superfluous colour solution without obtaining patchy results, as any folds, creases, or thicker portions of the fabric retaining the colour solution for a longer period than other portions become darker, owing to the concentration of the colour solution due to the rapid evaporation of the solvent.   The removal of the superfluous colour solution by hydro-extracting is

not satisfactory, the most level results being produced by rinsing out and well shaking by hand while drying.

Rinsing in a bath of clean benzine to remove the adhering colour solution also removes the dyestuff from the fibre ; in fact, continued rinsing removes practically the whole of the colour.

It has been found that more satisfactory results may be obtained with the " fat colours " by the addition of 5 to 10 per cent. of benzine soap (e.g. *Saponine*) or oleic acid to the dye bath ; these substances tend to retard the dyeing, giving more even results and placing the operations more under control. It has also been found [1] that the basic colours will dissolve directly in a 10 per cent. solution of benzine soap in benzine, thus avoiding the separate preparation of the " fat colours."

Although the process of " dry dyeing " with " fat colours " has been in vogue for several years, it has not been found satisfactory except for a limited application in the dyeing of alum-tanned gloves, etc. In dyeing fabrics its great disadvantages have been the difficulty of producing level dyeings, the readiness with which the colours " rub," the extremely fugitive character of the colours towards light, and the difficulty of rinsing in benzine without the removal of a considerable portion of the colour. These difficulties have been overcome by the employment of acid dyestuffs in " dry " dyeing in the process described by Farrell and May.[2]

Many acid dyestuffs are freely soluble in alcohol (absolute or methylated) ; but whereas absolute alcohol is miscible in all proportions with benzine or benzol, methylated spirit (64 o.p.) is practically insoluble therein. Solutions of suitable acid dyestuffs (e.g. *Fast Acid Violet A 2R*) in absolute alcohol are miscible with benzol or benzine in all proportions, and the colour solutions thus obtained may be employed for dyeing silk and other fabrics. The employment of absolute alcohol is, however, debarred by its very high price.

It was found that although methylated spirit (64 o.p.) is insoluble in benzine or benzol, it is miscible with solutions of benzine soap in benzine or benzol, the quantity of methylated spirit which will dissolve depending upon the amount of the soap present. The soap employed in most of the experiments was Grünwald and Stommel's *Saponine*, and the following tables show the number of volumes of methylated spirit (64 o.p.) dissolved by 10 volumes of the soap solution (benzine, benzol, and carbon tetrachloride). (For the preparation of a suitable *anhydrous* soap, see p. 58.)

It will be seen from the solubility table for benzine solution of

[1] Farrell and May, *J.S.D.C.*, 1908.   [2] *Ibid.*

soap that with 25 per cent. of soap present, methylated spirit (64 o.p.) is soluble in all proportions. These tri-solutions, containing benzine, methylated spirit, and soap, may be diluted with benzine without separation occurring, provided that by such dilution the reduction in the ratios of soap to benzine and methylated spirit to benzine are not at variance with the figures given in the table.

TEMPERATURE 15° TO 16° C.

Percentage of Saponine in Benzine (Sp. gr. 0·765).	Volumes of Methylated Spirit (64 o.p.) dissolved by 10 volumes of Benzine Soap Solution.
0·0	Trace.
1·25	0·35 vol.
2·5	0·4 ,,
5·0	0·6 ,,
7·5	0·7 ,,
10·0	0·8 ,,
15·0	2·3 vols.
25·0	All proportions.

TEMPERATURE 11° TO 12° C.

Percentage of Saponine in Benzol.	Volumes of Methylated Spirit dissolved by 10 volumes of Benzol Soap Solution.
0·0	Trace.
1·0	,,
2·0	0·8 vol.
2·5	0·85 ,,
3·0 and above.	All proportions.

TEMPERATURE 10° TO 11° C.

Percentage of Saponine in Carbon Tetrachloride.	Volumes of Methylated Spirit dissolved by 10 volumes of Carbon Tetrachloride Soap Solution.
0·0	Trace.
1·0	0·3 vol.
2·0	0·5 ,,
3·0	0·75 ,,
4·0 and above.	All proportions.

For example, a 25 per cent. solution of soap in benzine will dissolve an equal volume of methylated spirit (64 o.p.). The addition of 7·5 c.c. of benzine to 10 c.c. of this solution would reduce the soap to 10 per cent. on the benzine present ; we see from the table that a 10 per cent. solution is capable of dissolving only 8 per cent. of methylated spirit, whereas there is present 5 c.c. or 28·5 per cent. ; consequently separation takes place. On the other hand, a mixture of 9 c.c. of 25 per cent. *soap* solution and 1 c.c. methylated spirit diluted with 13·5 c.c. of benzine gives a solution containing 10 per cent. of benzine soap on the benzine present and 4·2 per cent. of methylated spirit, against 8 per cent. which can be dissolved by a 10 per cent. solution ; hence no separation occurs.

The presence of colouring matters in solution in the methylated spirit does not affect its solubility in solutions of soap in benzine, consequently by this process colouring matters soluble in methylated spirit can be dissolved in benzine containing but a small percentage of methylated spirit.

The acid dyestuffs which are soluble in methylated spirit belong principally to the sulphonated triphenyl methane series.

Azo colours are on the whole but slightly soluble, though there are a few exceptions, such as *Indian Yellow, Orange II.*, etc. *Rhodamine B, Eosines*, and other members of the phthalein group are readily soluble in methylated spirit.

The following table contains colouring matters giving satisfactory results, though many others can be employed :—

Colours Suitable for Dry Dyeing.

698	ACID VIOLET 4 BNS. (S.)
179	CARDINAL 3B. (BDC.)
252	BRILLIANT CROCEINES. Various makes.
715	CYANOLE EXTRA, FF. (IG.)
758	ERIO FAST FUCHSINE BL. (GY.)
145	INDIAN YELLOW R. Various makes.
146	INDIAN YELLOW G. Various makes.
138	METANIL YELLOW. All makes.
712	DISULPHINE BLUE V. (BDC.)
714	DISULPHINE BLUE A. (BDC.)
151	ORANGE . II. All makes.
749	RHODAMINE B. All makes.
774	PHLOXINE. Various makes.
640	TARTRAZINE. Various makes.

In order to use the minimum quantity of methylated spirit the solutions of the colours should be as concentrated as possible. After dissolving, the solutions are filtered to remove insoluble impurities, diluents, etc., and the necessary quantity of the colour solution is mixed with several times its volume of a 25 per cent. solution of *Saponine* in benzine. This solution is then added to a 10 per cent. solution of Saponine in benzine, the solution obtained being the bath employed for dyeing. In most cases the quantity of methylated spirit present in the dye bath does not exceed 1 or 2 per cent., but in no case should it be greater than 10 per cent. The goods having been cleaned in a strong solution (5 to 10 per cent.) of benzine soap are entered direct into the dye bath. The dyeing, unlike *dry* dyeing with fat lakes, takes place slowly, and is easily controlled. It is advisable to prepare the colour solution of such a strength that the dyeing is not complete in less than half an hour, as the results produced by more rapid dyeing have a greater tendency to be uneven, and are not quite so fast to rinsing. The greatest advantage of this process is that the goods may be taken direct from the dye bath to a clean benzine rinsing bath. In this the goods are quickly rinsed, after draining to remove the superfluous colour solution, and are then taken to a second benzine rinse in which no further colouring matter is removed. The goods may now be hydro-extracted and dried.

The dye baths do not exhaust and a considerable number of articles may be dyed in the same bath with little or no replenishing. If they are allowed to stand for any length of time the baths must be filtered before using, as a small amount of dyestuff may have separated out (particularly in cold weather).

Cassella's Process of Dry Dyeing.—L. Cassella patented the following process,[1] the novelty being the addition of formic acid to the bath :—

Example : 10 parts *Formyl Violet S 4B* are dissolved at a slight heat in 890 parts of alcohol ; 100 parts of formic acid (100 per cent.) are added and the solution when clear is introduced into a mixture of 1950 parts of carbon tetrachloride and 50 parts of Saponine. The goods are treated in this bath for half an hour or longer, during which time the bath is heated to 30° C. They are then squeezed off and rinsed in carbon tetrachloride. ·

Other acid colours are applicable by the same process.

Homberg & Jorn's Process.[2]—Fabrics, especially lace, ribbons, feathers, and artificial flowers, can be dyed in solutions

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[1] Eng. Pat., No. 22876, 1910.   [2] German Pat., No. 227648, 1911.

of benzine if amyl acetate is added to the bath. The specification states that a bath composed of

60 parts benzine,   20 parts alcohol,
20 parts amyl acetate

will dissolve almost any dye, and that the dye goes on to both animal and vegetable fibre from such a bath in a very short time, especially if the bath is slightly warmed.

Fort's Dry-Dyeing Process.—A method of " dry dyeing " animal fibres with acid colours in which use is made of carbolic acid and related phenols as colour solvents was published by M. Fort.[1] The phenol used is commercial cresol, boiling-point 190° to 200° C., which is considered the cheapest and most satisfactory solvent. Cresol alone, or cresol with 5 per cent. water, is found to be unsuitable on account of its shrinking action on animal fibres, especially wool, but the animal fibres can be protected from shrinkage by using various non-aqueous solvents as the main constituents of the dye bath. Suitable solvents named are benzene, benzine, benzoline, solvent naphtha, nitrobenzene. The bath is made up with one or other of the solvents as the main constituent and a smaller quantity of a cresol solution of the dyestuff. To obtain normal fastness comparable with that of acid colours applied by ordinary methods, the dye bath is heated to 50° C., and on that account a preference is declared for high boiling naphtha (over 100° C.) for most purposes. Nitrobenzene is considered to be advantageous where a higher temperature is required for the penetration of very thick, dense materials. An addition of formic acid (commercial) is made to the cresol when dissolving acid dyes. This assists solution, and heavier shades are obtained with increasing percentages of acid.

Typical Dye Baths.

1. **Blue Shades.**—The bath is made up by mixing in the order named, 0·1 part *Patent Blue Superior*, 0·5 part water, 0·5 part formic acid, and 10 parts cresol ; it is warmed and agitated with solvent naphtha, making up to 100 parts. Dyeing is carried out at 50° to 80° C. for from 5 to 30 minutes. A fine delaine garment dyed in this bath was not shrunk or altered in length or width and the shade was equal to that obtained on the piece by wet dyeing.

2. **Yellow Shades.**—*Naphthol Yellow S* is used and only half as much solvent naphtha.

[1] *J.S.D.C.*, 1918, pp. 226–227.

3. Red Shades.—*Crystal Ponceau* or *Crystal Scarlet* is used.

4. Mixed Shades can be obtained by the use of the three dyes above mentioned, the shades being level and quite satisfactory. The process is found to be suitable for silk, pure or weighted, the shades being level and bright and the fabric bright and highly scrooped. Cotton is stained.

5. Black Shades.—These present more difficulty, but good results are obtained with *Nerol B* (*IG.*). The dye bath is made up with 1 part dye, 2 parts water, 2 parts formic acid, 30 parts cresol, and this mixture diluted to 100 parts with solvent naphtha. Dyeing is carried out at 80° to 85° C. for half an hour, and the blue-black shade obtained is found to be fast to rubbing and hot or cold water and to weak soap.

After dyeing, the goods are squeezed or hydro-extracted and thoroughly rinsed with benzoline or naphtha containing 5 per cent. cresol. The latter removes loose dye and gives shades fast to rubbing; subsequently, ordinary dry cleaning is advised to remove the cresol odour. The recovery of cresol and solvent naphtha for further use can be effected by fractional distillation. This process of dry dyeing does not appear to be used on the large scale. The use of cresol in the proportions stated, particularly for blacks, is attended with some risk, and repeated handling of goods from dye baths containing such large percentages of cresol would probably cause skin irritation and other troubles.

In the method of Farrell & May, *Saponine*, a potash-benzine soap, is used, but other types of benzine soap, *e.g.* ammonia soap, are also suitable. The following method, stated to be used on the large scale, is described by C. M. Whittaker : [1]—

First make a benzine soap as follows :—

Four gallons of oleic acid are saponified with ¾ gallon of ammonia (22 per cent.); finally 20 gallons of benzine are added. A half per cent. solution of the colour in methylated spirits is made, and the salt, etc. in the colour allowed to settle; then the clear solution is poured off—all the colours do not dissolve perfectly clear, but go clear when added to the benzine soap—and this solution of colour will mix in any proportion with the above benzine soap. The depth of shade obtained depends upon the strength of the solution and length of time of dyeing; the shades may be washed in benzine without loss of colour.

The process of dry dyeing cannot, on account of its cost, be recommended in cases where the ordinary process of dyeing gives good results, but it can be used with great advantage for all silk and wool fabrics which will be injured by wet dyeing, such as

[1] *Dyeing with Coal Tar Dyestuffs.*

laces, silk velvets, poplins, satins, etc. It is also very useful for dyeing made-up articles, such as silk lamp-shades, etc., which it is impracticable to unpick, dye, and remake.

Leathern articles, gloves, shoes, belts, bags, etc., are readily dyed by this process, either by brushing or by immersion. Furs also may be dyed, though the process is much slower than with silk and wool goods, and the pelt is dyed a much deeper shade than the fur itself.

Dry dyeing has its limitations ; the process is not very suitable for articles stained with perspiration, water-stained goods, etc. Such stains do not cover in a dry dye bath, so that the goods require previous wetting. Goods trimmed with metal tinsel brocade are more inclined to tarnish, especially when ammonia is used. Unlike the ordinary method of dyeing fabrics, the colour already on the goods can very seldom be removed unless subjected to a separate stripping process. If the articles have been dyed with basic colours a considerable portion of the dyestuff is removed by immersion in a 10 per cent. solution of Saponine in benzine; colouring matters of other groups cannot be removed in this way, and the colour already on the fabric must always be allowed for in dry dyeing.

Acid dyestuffs dyed by this process are found to be equally fast to light, as the same dyestuffs dyed on the same fabrics by the wet process. The fastness to water and perspiration is not so good as in wet dyeing. The spent dye baths may be distilled in the ordinary way, the benzine being recovered and the small amount of methylated spirit which is present in the distillate being washed out with the water in the separator.

Bancroft [1] says that many aniline dyes which are insoluble in benzine can be peptised by a soluble colloid, such as so-called zinc or magnesium resinate.

[1] *Jour. Phys. Chem.*, **xx.** 108.

CHAPTER VI.

SPECIAL METHODS—CLEANING AND DYEING SKIN RUGS, FEATHERS, AND HATS.

THE articles mentioned above require special methods of treatment owing to their peculiar physical and chemical properties. They do not represent a very large section of the garment cleaner's business, and many of the smaller firms do not carry out the work themselves, but send such articles to firms which specialise in fur dyeing, feather cleaning, dyeing and curling, or hat cleaning, dyeing, and blocking ; consequently they will only be dealt with briefly.

Skin Rugs.—White and light-coloured rugs, if not soiled or faded to any great extent, may be cleaned by the dry process (see p. 61). In wet cleaning skin rugs it must be remembered that they have usually been alum-tanned, and this tannage is not fast to water at a temperature higher than 104° F.

The operation of cleaning skin rugs by the wet method is performed with *neutral* oil soap. If the rugs are fitted with linings the latter must be removed and cleaned separately, dry cleaning woollen linings, and wet cleaning, starching and glazing canvas linings. A solution of soap is prepared and a bath is made at a temperature of about 100° F. in which the skins are worked. (Shallow troughs are employed in this and in all other operations with skin rugs to economise the liquors, or the cleaning may be done on the slab.) The soap is worked into the skin by hand, repeating the process with fresh soap (with the addition of ammonium carbonate if necessary—soda turns the wool yellow and makes it difficult to dye pale shades), and finally rinsing in water. Skins which have been cleaned in this way are generally white enough for dyeing ; but if they are to be finished white or very pale shades, bleaching must be resorted to. For this purpose, sulphur, sulphurous acid, potassium permanganate (followed by sulphurous acid), and hydrogen peroxide may be used. The last gives the most satisfactory results, as the white produced by sulphur bleaching is not permanent, and the permanganate process is not so safe as the use of hydrogen peroxide. The peroxide bath is prepared in the same manner as for bleaching

woollen fabrics, as described on p. 119. The skins are placed in the faintly alkaline cold bath for 1 hour, after which they are rinsed in a dilute (0·1 per cent.) solution of sulphuric acid ; and if they are to be finished white they are rinsed in water, hydro-extracted, and re-tanned if necessary by painting the flesh side with a tepid solution of alum or basic alum and salt (5 per cent. aluminium sulphate and 15 per cent. common salt). A suitable basic alum is prepared by slowly mixing, with constant stirring, separate solutions of 1 part of 58 per cent. alkali for every 10 parts of aluminium sulphate. The skins are then tacked or stretched on frames and dried at a low temperature.

When dry they may be worked on the flesh side with a special knife to soften them ; oil (castor or other non-oxidising oil) is sometimes rubbed into the flesh side of the dried skins to soften them. The fur is then combed out and the skins are trimmed and re-mounted.

Skins which have been cleaned or bleached for dyeing are *chlored* to increase their affinity for dyestuffs. This consists in immersing them in a clear dilute solution of bleaching powder (about 5 per cent.) ; the solution must be cold, and the immersion may last for several hours. They are then rinsed in dilute sulphuric acid, excess of which must be subsequently neutralised if the rugs are to be dyed with basic colours. Owing to the solubility of the alum tannage at temperatures exceeding 40° C. the basic dyestuffs are generally employed with or without the addition of Glauber's salt to the dye bath. Any of the basic dyestuffs mentioned in other sections may be employed, but the results produced are not very fast to light or to rubbing. The tendency to rub may be overcome by passing the articles through a sumach bath.

When acid colours are employed, formic acid is to be recommended as an assistant in preference to sulphuric acid and Glauber's salt. The following acid dyestuffs are considered most suitable by J. W. Lamb : [1]—

ACID ORANGE G.	ACID GREENS.
CITRONINE.	NIGROSINES.
TARTRAZINE.	NAPHTHOL GREENS.
NAPHTHOL YELLOW.	DISULPHINE BLUES.
RESORCINE BROWN.	MILLING SCARLETS.
QUINOLINE YELLOW.	ALKALI BLUES.
CARDINAL RED.	ALKALI VIOLETS.
ACID SCARLETS.	NAPHTHYLAMINE BLACK.

[1] *Industrial Chemist*, 1927, p. 79.

Cassella & Co. introduced the following (*patented*) process for dyeing with acid dyestuffs. The skins, well cleaned with soap, are rinsed in water and prepared by dipping in a solution containing—

1·8 ounces	Chromium oxychloride	
3·6 „	Basic sulphate of aluminium	per 22 gallons.
3·6 „	Common salt	
5·4 „	Acetate of soda (cryst.)	

After leaving the skins for a few hours in the liquor (which is sufficient for ten skins), the leather is tested by cutting, in order to see whether it has been properly saturated by the liquor ; if this is the case another 3·6 ounces of chromium oxychloride are added, and the skins are left in the liquor for 24 to 36 hours, being given an occasional turn. They are then lifted, thoroughly rinsed, and hydro-extracted. The skins are then entered into a cold bath of 1¾ pints of hydrochloric acid per 22 gallons water, where they are left for a quarter of an hour, and are then put into a clear, bleaching-powder bath. Having worked them in the liquor for 20 minutes, ¾ pint of hydrochloric acid is added and they are worked for a further 10 minutes ; they are then put back for another quarter of an hour in the first bath of hydrochloric acid, which has been strengthened in the meantime by the addition of a pint of acid. The skins are then well rinsed. To the last (lukewarm) rinsing water, 3 to 4½ ounces of hyposulphite of soda (sodium thiosulphate) per 10 gallons are added, which is followed by a final thorough rinsing. After hydro-extracting, it is stated that the skins may be dyed with any acid dyestuff in baths up to 167° F. without fear of damaging the leather. The dyestuffs must, however, be added slowly, and the temperature must be low in the beginning, slowly rising to 167° F. In all methods of dyeing, the skins, after hydro-extracting, should be painted on the back with alum and salt as described under the Cleaning of Skins.

Blacks are dyed with logwood by the one-bath or two-bath process. The following quantities are recommended by Lamb : [1]—

One-Solution Method.—100 lbs. Logwood extract, 18 lbs. fustic, 10 lbs. copper acetate, dissolved in 400 gallons water. The bath is maintained at a temperature of 40° C. and the skins are entered and allowed to remain in this liquor for 3 to 4 hours, and then 3 gallons of acetate of iron (black iron liquor) are added, and the goods are kept in the solution until black, usually requiring

[1] *J.S.D.C.*, 1905.

an immersion of 30 to 40 hours. Other single-bath liquors may be prepared as follows :—

(a) 200 lbs. Logwood extract, 3 lbs. potassium bichromate, 3 gallons lactic acid, 300 gallons water.

(b) 15 parts Logwood extract, 10 parts sumach extract, 2 parts copper acetate, 5 parts iron liquor.

Two-Solution Method.—In this case the goods are placed in a solution made in the following proportions : Logwood, 50 lbs. ; fustic extract, 12 lbs. ; water, 500 gallons. After remaining in this for 4 to 5 hours they are transferred to a solution of potassium bichromate. If a sufficiently intense black is not obtained, the skins are placed in the first bath again, after strengthening it, being finally finished in the bichromate bath. The skins dyed by any of the above methods are drained and allowed to oxidise for some time. They are then well washed in warm water and scoured with neutral oil soap and ammonium carbonate to obtain the necessary gloss. After washing and draining they are re-tanned with alum and salt, framed, and dried.

The blacks dyed with potassium bichromate have a tendency to become greenish in shade.

J. W. Lamb [1] gives the following method for obtaining a black on *unchlored* skins by the use of Fur Bases : Immerse the skins for 10 hours in a solution containing for every 10 gallons of liquor 8 ounces of copper sulphate and 4 ounces of potassium bichromate, then transfer to a bath containing 8 ounces of paraphenylene diamine and 8 lbs. or $\frac{4}{5}$ gallon of 20 volumes hydrogen peroxide. A small quantity, say $\frac{1}{4}$ part, of metaphenylene diamine is added if a blue-black is required. Allow the skins to remain in the liquor 24 hours, drain, allow to oxidise well, wash and soap.

After dyeing in either blacks or colours the wool is brightened, the leather is softened, and any loose dye is removed by drumming in sawdust after the skin rugs have been thoroughly dried off at a low temperature.

The gloss of coloured rugs is much improved by passing them through a warm *fat liquor* or fat emulsion. This is made by emulsifying a suitable oil (castor, neatsfoot, or olive oil) with a solution of a neutral potash soap. After passing quickly through a weak emulsion the skins are dried, softened, combed out, beaten, and trimmed ready for mounting. Light coloured fur necklets, muffs, etc., may be very satisfactorily re-dyed by the dry process ; *e.g.* pale greys give very good results by this method.

Fur Dyeing.—This is a highly specialised branch of dyeing that calls for a good knowledge of furs as well as of dyeing methods.

[1] *Industrial Chemist*, 1927, p. 78.

As the great majority of the furs handled by the garment dyer are re-dyes they do not require *killing* with lime or caustic soda, as that operation will have already been done. They should, however, be dry cleaned before dyeing, to remove grease, so that they will more readily take up the dye.

The ordinary methods of dyeing are not applicable in the case of furs, partly because the pelt would be damaged by heat (so that low temperature dyeing is a *sine qua non*), and partly because furs are of a harder and less penetrable nature than wool. The method in general use for the production of all fur shades, black, brown, and grey, is to employ Fur Bases which are oxidised on the fibre. For black, paraphenylene diamine (*Fur Base 1*) is used; browns may be obtained with *p*-amidophenol, *o*-amidophenol, and pyrogallic acid, these being mixed together in varying proportions and applied on different mordants for intermediate shades. The earlier members of this series of Bases were introduced for fur dyeing in 1894 by the *Berlin Aniline Co.*, under the name *Ursols*. Since that date the range has been considerably extended. All members of the series are practically colourless themselves but form intensely coloured oxidation products in the presence of a mild oxidising agent such as hydrogen peroxide. They are now marketed by different firms under a variety of names, such as *Fur Bases, Furogenes, Furrols, Peltols, Fourrines, Nako Dyes,* etc.

To apply the fur bases, the furs are usually mordanted with sodium bichromate, copper sulphate, or copperas (ferrous sulphate). Copper mordant is mainly used for blacks, chrome for browns, and iron for greys, while pale shades may be dyed without a mordant. The cleaned furs are soaked in a solution of the mordant of a strength of $\frac{1}{2}$ to 1 ounce to 1 gallon water at 100° F. for 12 hours, or overnight, rinsed well, and dyed by immersing in a solution of Fur Base of a strength of $\frac{1}{2}$ to 1 ounce to 1 gallon water for 12 hours at 100° F. An addition of 1 pint of hydrogen peroxide, 12 volumes per gallon, is made to the bath to develop the colour. Blacks are produced by *Fur Base 1* on copper mordant. By itself, this base produces a reddy black, but the shade can be improved by making a slight addition to the dye bath of metatoluylene diamine, metaphenylene diamine, or *Fur Base 10*.

In the dyeing of furs the mordants may be mixed together, with the exception of bichrome and ferrous sulphate, and the fur bases also mixed in the dye bath with the object of obtaining any desired shade. The following table, Lawrie,[1] shows the shades obtained with certain fur bases on different mordants:

[1] *J.S.D.C.*, 1923, p. 244.

Fur Base B.D.C.	Unmordanted.	Chrome Mordant.	Copper Mordant.	Iron Mordant.
I.	Dark brown-black.	Brown-black.	Deep black.	Black.
III.	Light brown.	Dark reddish-brown.	Dull brown.	Greenish-brown.
VI.	Dull yellow.	Reddish-brown.	Yellowish-brown.	Dull yellow.
VIII.	Light grey.	Reddish-grey.	Neutral grey.	Neutral grey.
XI.	Light grey.	Light grey.	Greenish-grey	Bluish-grey.

Fur Bases I and III are frequently used together for dark browns on a chrome mordant; *Fur Base I* and pyrogallic acid for light browns, and so on.

After dyeing, the furs are thoroughly rinsed to remove excess and incompletely fixed colour. This is very important on account of the danger of *dermatitis* from loose, incomplete fixation of the base, especially paraphenylene diamine blacks. To ensure thorough oxidation of the base a separate bath of copper sulphate, $\frac{1}{2}$ to 1 ounce to 1 gallon water, may be used after dyeing. The dyed furs should be soaked in this for 3 hours. If the furs are to be dyed to match natural furs, *e.g.* sable or skunk, in which the under colour and top colour are different shades and require matching, they are dyed by dipping to the under colour, and the colour of the tips is obtained by brushing. The following is a formula for a black topping which is also used for improving faded skins and touching up unevenness.[1]

Six ounces of *Fur Base I* are dissolved in 1 gallon of water, cooled to 80° F., and immediately before use 6 lbs. hydrogen peroxide (12 volumes) are added. In order to cover hard top hairs two or three applications by means of a brush may be required, drying between each.

Fancy colours on furs intended for trimming can be obtained by chrome tanning the pelt, using basic chrome alum and subsequently dyeing at 150° F. in a formic acid bath with acid dyestuffs. The final process after drying is known as *drumming*, which is a regular treatment of dyed furs with hardwood sawdust

[1] Lawrie, *J.S.D.C.*, 1923, p. 245.

in a revolving drum.   This removes loose colour, polishes the fur and softens the pelt ; before drumming, the furs must be placed on suitable racks and thoroughly dried, this being done in a current of air at a temperature not higher than 100° F.

Feather Cleaning and Dyeing.—Feathers are cleaned in soap baths to which mild alkalies (ammonia, sodium carbonate, etc.) may be added, at a temperature of 100° to 120° F.   If a creamy white is obtained in cleaning soiled white feathers they may be *blued* with *Methyl Violet.*   If bleaching is necessary, hydrogen peroxide gives the most satisfactory results, and is applied in the same manner as for wool (see p. 119).   Sulphur bleaching is also used to some extent.

In dyeing feathers, they are first cleaned in an alkaline bath and are then dyed with acid or basic colours, the natural dyestuffs being rarely employed (blacks are sometimes dyed with logwood). The basic colours are used to a considerable extent, but the shades produced are very fugitive to light, and do not dye the quills sufficiently ; whenever possible, acid colours should be employed. Basic colours are dyed in neutral baths at a temperature of 80° to 100° F., acid dyestuffs are dyed near the boil for dark shades, and at 120° F. for pale shades, with the addition of sulphuric, acetic, or formic acid.   Many feather dyers select colours soluble in alcohol and make stock solutions in methylated spirit, but there does not appear to be any advantage in this mode of procedure. The acid colours should, however, be of the easily levelling class and of good solubility, to obtain penetration of the stems.

Feathers must be handled with care, and excess of acid and violent boiling, particularly when dyeing ostrich feathers, must be avoided, as the flue of the feathers is easily injured.   Sulphuric acid should not be used in ostrich feather dyeing, formic, acetic, or oxalic acid being more suitable and less likely to impoverish the flue.   All the acid dyestuffs mentioned as suitable for silk may be used for feathers.   For blacks on fancy feathers *Naphthalene Black* 4*B* gives good results, and may be shaded, if necessary, with *Indian Yellow G* and *Acid Green*, acetic or formic acids being employed as assistants.   The bath should be small in size, and in dark colours standing liquors may be kept.

The above process is not so suitable for dyeing blacks on ostrich feathers, as it is difficult to obtain sufficient depth and bloominess of shade with coal-tar colours.   For that reason logwood, generally in the form of logwood extract or hematine paste, is still employed for blacks, several coal-tar acid blacks being used as *bottoming* blacks, previous to mordanting and dyeing with logwood.   In dyeing blacks with logwood several

methods may be employed. The following gives a logwood-iron-chrome black :—

The feathers, having been thoroughly freed from grease, are placed in a cold bath prepared by adding 1 part of red iron liquor (nitrate of iron), 80° Tw., to 3 parts of water, and allowed to remain therein overnight. They are then well washed, the last rinse containing a little ammonia. The logwood bath is made up with—

Logwood extract	.	.	.	6 parts
Fustic extract	..	.	.	1 part
Water	.	.	.	.	200 parts

(Soap may also be added to the bath.)

The feathers are worked in this bath just below the boil until the black is developed ; they are then rinsed in water, followed by a warm soap bath. After rinsing in warm water, they are placed for 2 or 3 minutes in a cold bath of potassium bichromate ($\frac{1}{2}$ per cent. solution) and are then well rinsed.

Other mordanting baths for feathers are made with (*a*) copperas (ferrous sulphate), potassium bichromate and tartar ; (*b*) copperas, blue-stone (copper sulphate) and tartar. The dye bath is made up in the same way as in the above method.

A number of acid colours are suitable for use as bottoming blacks under logwood in ostrich feather dyeing, and are usually applied from an acetic or formic acid bath, e.g. *Wool Black GR* (*IG*), *Wool Black N 4B* (*IG*) ; *Victoria Black B* and *Gloria Black N* are also suitable.

Various methods have been suggested for dyeing feathers (and likewise furs) depending upon steeping them in solutions of certain compounds of the aromatic series, followed by oxidation. They do not, however, appear to have been adopted for feathers to any extent.

Feathers are sometimes dyed in graduating shades, beginning at one end with a very pale shade and finishing in a dark shade of the same colour. Two methods are employed in the production of these effects. In the first a weak dye bath is prepared and the whole feather is dyed a pale shade ; the bath is then slightly strengthened and three-quarters of the length of the feather is dipped in it, and so on, gradually strengthening the bath and then immersing less of the feather, until only the end is dyed in the last bath. In the second method the bath is made up sufficiently concentrated to dye the dark shade on the end of the feather, and the strength is reduced in stages by diluting with water and immersing more and more of the feather. In this method a more even graduation is effected.

Feathers and articles made of feathers (trimmings, edging, etc.) which have been cleaned or dyed have a very bedraggled appearance when wet, the *flues* of the feathers being matted together. To open up the flues, the feathers are dipped in cold water containing starch or farina. After drying, the starch is gently beaten
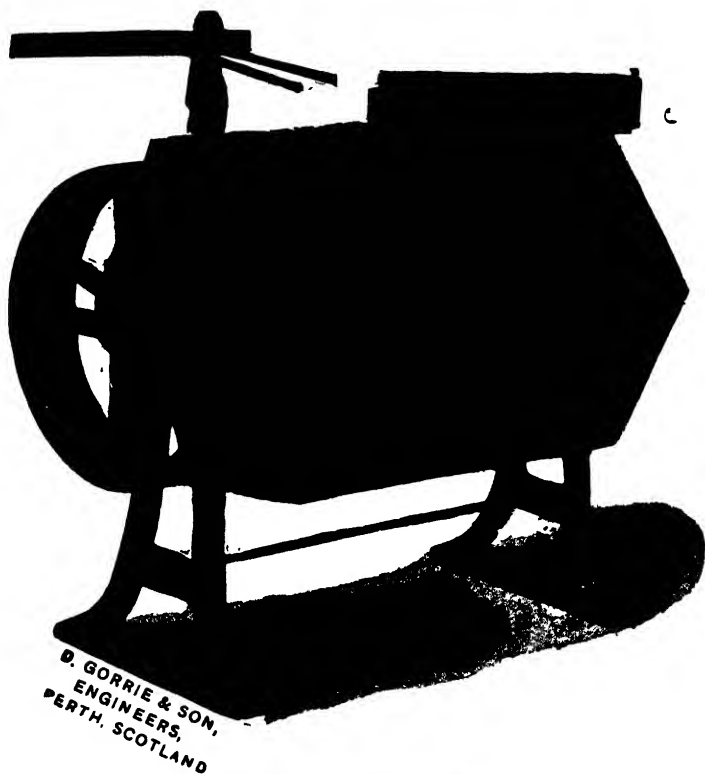
Fig. 55.—Feather Starching Machine.

or shaken out, and the flues open up to their original condition and are ready for curling. When a large number of feathers are handled, the machine shown in fig. 55 can be used to work the dry starch or farina into the wet feathers, the machine illustrated in fig. 56 being employed for drying off the feathers and shaking out the starch or farina. It consists of a woven wire cage which oscillates in a current of hot air, the starch or farina being collected in a receptacle at the bottom.

Feathers are curled by hand with a special knife after being slightly steamed to soften them, the curl being fixed by drying before a suitably heated stove.
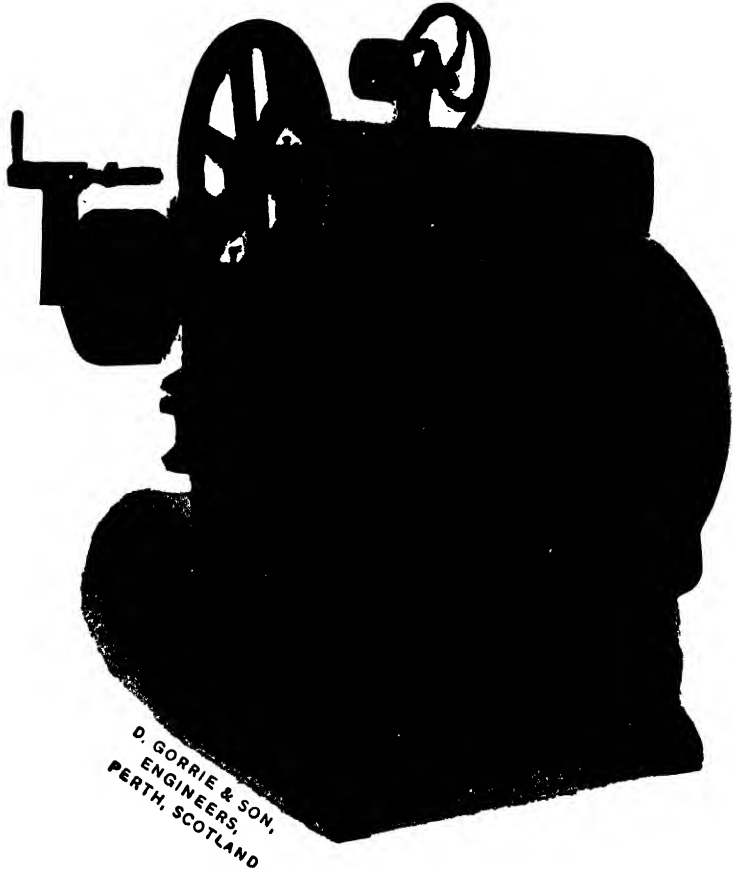
FIG. 56.—Feather Drying Machine.

Feather boas, which consist of flat feathers stitched together and twisted (and incidentally shortened in length) to give them the round, full appearance, open out flat again when wetted and must be retwisted. For this purpose a small appliance has been made (fig. 57), the ends being clipped and the centre held out by hand.

Feathers may be successfully *dry dyed* in pale shades. This method is very useful in dyeing wired pom-poms, etc., which cannot be wetted without taking to pieces, with subsequent re-making ; in most cases the price which could be obtained would not prove remunerative if this had to be done.

Hat Cleaning and Dyeing.—Hats are manufactured in a great variety of materials, without reckoning those made of ordinary fabrics (velvet, cloth, etc.) made up on wire frames. The materials usually met with are—

FIG. 57.—Feather Boa Curler.

Straws of various kinds, *e.g.* ordinary wheat straw, Pedal, Tuscan, Italian, etc.

Grass.—Panama, etc.

Chip.—Usually willow, though other woods are employed.

Satin Chip.—Wood chip combined with artificial silk and other fibres.

Artificial Silk, *e.g.* crinolines, which consist of artificial silk stiffened with glue, etc. Acetyl silk is also used in the making of this variety of plait and braid.

Felt. (Wool and fur.) Beaver and velour.—Gentlemen's hard felt hats are not generally cleaned or dyed.

The dyeing and cleaning of hats, which includes re-blocking to the same or other shapes, is mainly handled by the larger concerns, and the results on both *straws* and *felts* are on the whole satisfactory provided the hats have not suffered an undue amount of exposure to the weather.

Straw.—This material is very resistant to cleaning and dyeing operations, owing to the natural siliceous coating, which prevents liquids penetrating readily to the centre. Preparatory to bleaching or dyeing, straw is cleaned with a 2 per cent. solution of soda ash ; this softens it and removes stiffening and varnish if any.

For cleaning and dyeing pale shades it may be necessary to bleach. The materials employed in bleaching straw are sulphur (as sulphur dioxide in a sulphur stove), oxalic acid, and hydrogen peroxide or sodium peroxide. Potassium permanganate applied cold from a sulphuric acid bath is also used, but should be very

carefully used on account of the danger of tendering the very fine cotton stitching used for sewing the plait; it regulates fades very well.

Where sulphur stoving is employed the decolorisation is not permanent, but the process is still adopted to a considerable extent. It is not advised as a treatment for hats that have to be dyed afterwards. When straw hats are not very badly discoloured, oxalic acid alone will generally give satisfactory results, both in clearing the colour of cleaned hats and as a suitable method of preparing hats for dyeing. In employing peroxides, the following process is recommended by Konigswarten and Ebell :—

Dissolve $1\frac{1}{2}$ lbs. of oxalic acid in 10 gallons of cold water, and add, while constantly stirring, 1 lb. of sodium peroxide. The bath reacts acid, and sufficient silicate of soda ($1\frac{1}{2}$ lbs. at 55° to 75° Tw.) is added to cause the liquor to become slightly alkaline. (To produce quicker bleaching, about twice the strength may be employed.) Enter the goods at 60° to 80° F. and allow to lie in the bath until a satisfactory bleach is obtained; then rinse in soft water and dry at the ordinary temperature. Straw must always be dried cold as otherwise it becomes brittle. Dyed straw intended for re-dyeing to another shade may be stripped with sodium hydrosulphite (*Hydros*) by similar methods to those used for cotton, etc.

Straw may be dyed with basic colours for bright shades, being entered lukewarm, the temperature raised in half an hour to the boil, and maintained at the boil for an hour. Direct cotton colours are sometimes employed, and are applied in the same way as basic colours; these cover the cotton sewing threads satisfactorily. Many acid colours will also dye straw, particularly " neutral dyeing " acid colours referred to under *Union Dyeing* (p. 196). Those members of the series that are fast to light on wool and silk are also relatively fast on straw. Blacks are frequently dyed with logwood saddened with iron, though direct cotton blacks of the *E Extra* type are also used, e.g. *Chlorazol Black E Extra*.

Chip is very much easier to dye than straw—basic, acid and substantive colours being employed. For light shades the chip should be bleached. Basic colours are applied without any addition to the bath, the dyeing taking place at the boil. Direct colours are dyed at the boil with the usual addition of Glauber's salt or common salt. Many neutral dyeing acid colours will dye chip.

Satin Chip.—The lustrous appearance of this substance is obtained by causing threads of artificial silk to adhere side by side with glue, and plaiting the band so obtained with ordinary

chip. As soon as the resulting plait is immersed in water, the glue is dissolved and the threads separate, the plait falling to pieces. The glue may be rendered insoluble prior to wetting by exposing it for about half an hour to the vapour of formaldehyde, after which it may be dyed (but at not too high a temperature) with basic colours.

Acetyl Silk plait may be dyed by similar methods to those used for cellulose acetate artificial silk.

Artificial Silk alone is now employed in the production of *crinolines.* Sometimes a round fibre is employed, but frequently the ultimate thread is a flat ribbon of artificial silk so made by the shape of the spinning orifice. Sometimes these flat threads are plaited (with a cotton thread to form a firm edge or *selvedge*) into wider ribbons, employed to build up hats. These are sometimes stiffened with glue, and before they are dyed the glue should be made insoluble with formaldehyde ; otherwise, unless handled very carefully, the artificial silk may break or fray during the process of dyeing. It may be dyed with basic colours, but the best results are obtained with substantive colours. " Crinoline " hats may also be " dry " dyed.

Felts, Beavers, and Velours.—These, after removing leathers and trimmings, are dyed like ordinary wool fabrics with acid colours. The process must be modified somewhat with the object of (1) covering fades, (2) securing penetration of the felt. A faded hat (and most hats sent for dyeing are faded) should be dyed in acid dye bath ; this tends to level fades. Formic acid may be used in place of sulphuric acid, though its levelling effect on fades is not so good.

To ensure the best possible penetration of the felt, the dyeing process should be commenced without acid, and the acid added gradually to exhaust the bath.

An addition of one or other of the levelling and penetrating agents should be made to the dye bath. The following method, using *Tetracarnit* as the penetrating agent, is recommended by Sandoz.

" Enter the previously boiled-out felt into a dye bath, prepared with the requisite quantity of colour, along with 3 per cent. sodium acetate, ½ per cent. Tetracarnit, and 10 per cent. Glauber's salt, calculated on the weight of the material at 50° C. Raise to the boil, and when fully penetrated exhaust with ½ to 1 per cent. *Vitriol* (DOV), and then boil for a further 45 minutes."

A variation of this process for the penetration of thick felts is to dye at the boil with acid colours with additions to the dye bath of 10 per cent. of Glauber's salt, 3–5 per cent. of acetic acid, and 5 c.c. of Tetracarnit per litre.

A list of suitable easily-levelling acid colours has already

been given under *Wool Dyeing* (p. 190), and these colours are the most successful in penetrating felt.

Hats are stiffened before finishing with gums, resins, starch, soluble starches (*feculose*, etc.), glue, casein, according to the materials of which they are made. Starch or feculose are used for paper (imitation panama) hats; gelatine for straws, crinolines, etc., and shellac, both spirit and dissolved in water with the aid of borax or ammonia, for felts, velours, etc. After sizing (if necessary) the hats are dried, damped, blocked, and (when required) wired. While a large number of the straw hats handled by the dyer and cleaner are made from plait of various kinds of fancy straw sewn together, an increasing proportion are one-piece crochet hats in the form of hoods, which can be cleaned or dyed, stiffened, and re-blocked to the same or some other fashionable shape without any re-making being necessary.

CHAPTER VII.

FINISHING.

ARTICLES which have been cleaned or dyed must be finished before they can be returned to the customer. Those which have been dry cleaned or dry dyed require the least finishing, as they have not altered materially in shape, and they retain the original dressing and finish of the new fabrics of which they are made up. On the other hand, articles which have been dyed require very careful and skilful finishing, as in most cases they have been boiled during the dyeing process, and have, consequently, lost the dressing, appearance, and shape of the original fabric ; and, in addition, they may have become shrunken to some extent, due, in many cases, to the original cloth having been *overstretched* by the manufacturer. These and any other defects must be remedied if the article is to please the customer.

Examination.—The goods on reaching the finishing department are first carefully examined to see that the processes of cleaning or dyeing have been carried out in a satisfactory manner. In cleaned work, stains which have escaped the notice of the spotter may be discovered, and in dyed work the colour is compared with the pattern, examined for evenness and freedom from bronziness, rubbing, etc. If there is a possibility of effecting an improvement (sometimes, owing to some peculiarity in the fabric or to the original shade, the result produced is the best possible under the circumstances) the goods are rejected for further treatment. Defects sometimes develop in the subsequent finishing processes ; stains frequently reappear during the process of steaming or ironing.

Although there is no sharp dividing line, it will be found convenient to divide the finishing into two classes :

1. The finishing of articles of wearing apparel.
2. The finishing of furnishings (blinds, curtains, draperies, etc.).

Wearing Apparel.

In finishing articles of wearing apparel the hand iron is still largely employed, although steam presses (Hoffmann's, etc.) have

replaced it to a considerable extent. Silk, Rayon, and cotton garment work both dry cleaned and dry dyed is hand ironed, and all re-pleating of dyed dresses, etc. must of necessity be re-set by hand iron-work, which requires a more than ordinary degree of skill. The pleats on dry-cleaned work can be re-set by steam press if they are not too fine. A large proportion of steam-pressed work has also to be finished off where necessary with a hand iron. The ironing takes place on ordinary ironing tables or skirt boards, the latter being employed in most cases. The boards are covered with one or more layers of a specially manu-factured grey ironing felt and a layer of fine calico (also specially
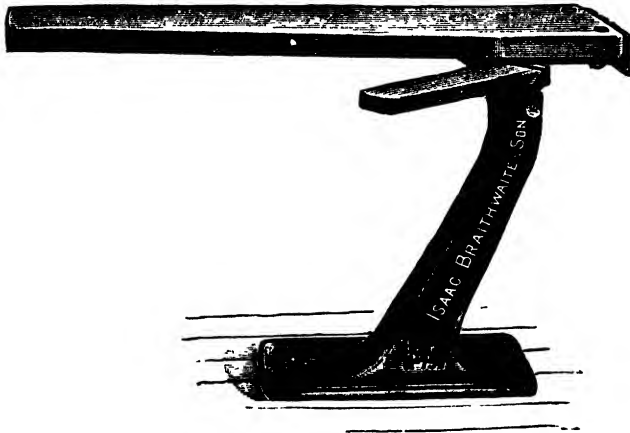
Fig. 58.—Skirt Board with Sleeve Board.

made for the purpose). The skirt boards may be fixed per-manently to the wall, or may be self contained. The latter (fig. 58) are very useful in a business having busy and slack seasons, as they may be taken to pieces and put on one ·ide when not in use. For sleeves and small articles a sleeve board (fig. 59) is used, which is padded in the same manner as the skirt board.

The irons, which weigh from about 4 to 10 lbs. each (except tailors' and " crown " irons, which are much heavier), may be heated by separate coke or gas stoves, by internal combustion of gas, or by electricity.

Stove irons are still used for hand ironing, as the worker is not hampered by any tube or other connection ; they admit of variation of the temperature over a wide and easily controlled

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range, and are fairly satisfactory for use in works of moderate
size where the finishers have to do dyed, wet-cleaned, and dry-
cleaned work.   Gas irons are also suitable, especially in large
works where the finishers are engaged in one class of work con-
tinuously, requiring a more or less constant temperature.   An
economical form of gas iron is the " pressure gas iron," such as
the Keith Blackman or other makes.

For very large establishments electric irons give good results, and
are economical where the factory is generating its own current.
With the modern types the temperature can be adjusted to any
desired extent by means of suitable resistances, and the irons

FIG. 59.—Sleeve Board.

can be used for all classes of work, cleaned or dyed, the latter,
of course, requiring a somewhat higher temperature.   In large fac-
tories the electric iron has also the additional advantage over the
gas iron of not using up the air of the room, so that the working
conditions are healthier.

Each ironing board should be provided with a basket or other
receptacle to prevent portions of garments which are being
finished becoming soiled by touching the floor.

Nearly all articles (with the exception of dry cleaned silks) are
prepared for finishing by the process of steaming.   This is carried
out with the perforated apparatus shown in fig. 60.   In use, the
perforated plate is covered with one or more layers of calico.
The process of steaming is a most important one as, properly
carried out, it reduces the labour and time of finishing to a very
large extent.   Whilst the steam is passing through the garments,
they are well brushed to remove creases, hydro-marks, etc., are
carefully pulled into shape, the lapels, folds, etc. are *set* by

pressing with a small wooden block, and the garment is then hung on a wooden *hanger* ready for the finisher.

Knitted jumpers and dresses, velour coats, and dyed work generally, should be brought to the correct shape on the steamer before pressing. Shrunken knitted articles can be placed on wires, steamed, and stretched to shape. Woollen goods must not be over-steamed or shrinkage may occur.

The articles, whether previously steamed or not, are not ironed direct but through a piece of damp calico. Dry-cleaned work
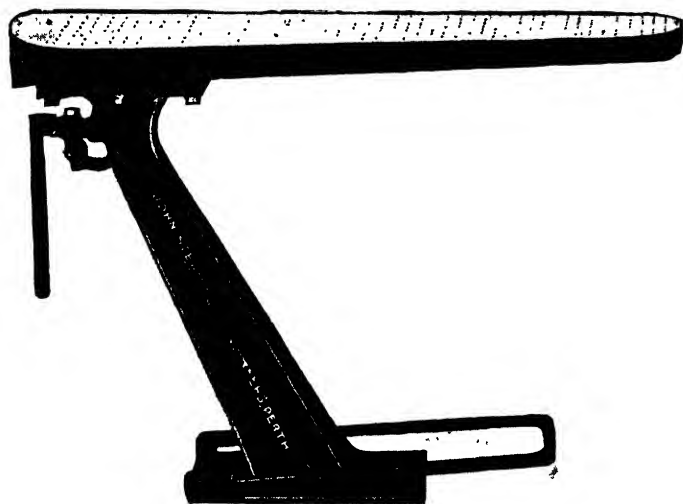
FIG. 60.—Perforated Steaming Table with Foot Lever for Steam Valve.

rarely requires as much finishing as wet-cleaned or dyed work. In the case of dry-cleaned silks, steaming should be omitted. Pleated articles that have been dry cleaned will require the pleats re-set by hand iron or steam press, whilst dyed work pleating must be entirely re-done.

The steam-heated cone (fig. 61) is employed in skirt finishing, especially for dyed skirts which have shrunk slightly. The steam cone is made of tinned copper and is heated with steam at a few pounds pressure, a reducing valve, pressure gauge, and safety valve being generally fitted to each cone or set of cones. A smaller cone is required than formerly on account of the short, narrow skirts now in vogue.

Pistol sprays (fig. 62) fitted to an air compressor and to tanks for the supply of water, and gelatine or other stiffening materials are employed in conjunction with the cone. The method of
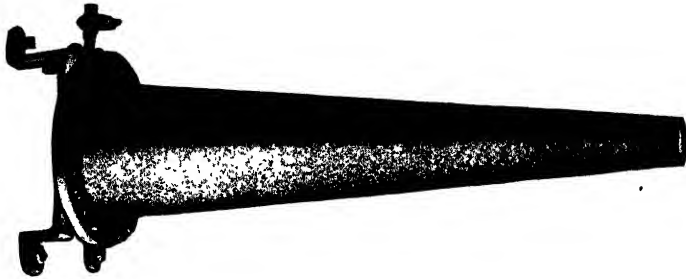
FIG. 61.—Narrow Copper Cone.

FIG. 62.—Aerograph Spray Gun. " F.S." Model for Large Work.

finishing a skirt by means of the cone consists in first spraying the skirt to dampen it and then slipping it over the heated cone, so that the waist is at the small end, and the body of the skirt along the top of the cone. The fulness is drawn tightly by hand on either side, and when the material is dry another portion of the

skirt is treated in the same way, and so on until the whole skirt has been finished. The number of operations usually amount to two or three. Hand ironing may be required to finish the skirt where gathered and to smooth over the lining, if any. Any pleating required is done by hand iron after coning. When required, the lining (if any) of the skirt may be stiffened by spraying it with starch or gelatine solution before coning ; in many cases this method of stiffening linings by means of the spray is more satisfactory than the method described under *Dyeing*. Sleeves of coats may be finished on a small cone or bolt, straight or conical, according to the shape of sleeve.

In finishing all descriptions of wearing apparel, steam bolts of various shapes and sizes are found to be very economical. They are extremely simple in use, the articles being held tightly by hand on the heated surface for a few seconds. They are employed in finishing the shoulders of coats, the sleeves of frocks, etc., the " fulness " or irregularly shaped surfaces of any articles which cannot be ironed satisfactorily, small frills of ribbon, lace, etc., and trimmings on babies' bonnets ; in fact there are not many articles of ladies' dress in which some portion is not finished on a bolt. They are made in a very large number of shapes and sizes to meet various requirements. Some of the shapes are illustrated in figs. 63 and 64.

Hoffmann Press.—This finishing machine (fig. 65) is specially adapted for the pressing of cleaned or dyed garments of all kinds, but it can also be used for other articles. Unlike other types of presses and ironing machines it has no exposed metal surface to come into contact with the articles which are to be finished, so that the interposition of a damp cloth between the heated surface and the garment is not necessary.

The machine is made in various shapes and sizes to suit different garments or portions of garments. It consists of a padded base or buck (work-holder) upon which the garment rests, and a padded *head* working on a hinge which is brought down by hand upon the garment. The buck is steam heated with closed steam, while the metal surface of the head is perforated to allow for the passage of steam through the padding and on to the work being pressed. The steam pipe on its way to the padded head passes through a chamber over a gas jet which superheats the steam immediately before it reaches the head. The work to be pressed is smoothed out on the buck by hand, the head is brought down and a trigger operated by the finger to admit the steam to the head. On releasing the pressure a foot lever is depressed to connect with a vacuum which exhausts the steam through the

buck, draws through cold air and sets the article. Meanwhile the operator uses a wooden banger or brush to shape the garment. The rapid series of movements is repeated with other parts of the garment. A number of developments have taken place in connection with the Hoffmann type of press, to enable the press to be used for a great variety of work. In some of the later
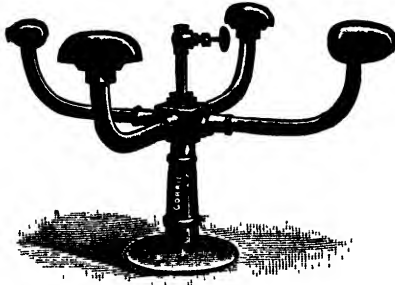
FIG. 63.—Steam Bolts.
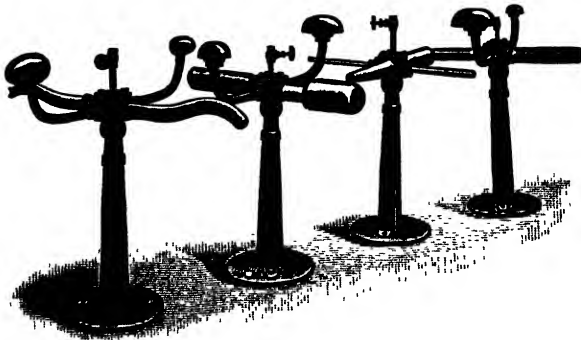
FIG. 64.—Steam Bolts.

machines steam is admitted to both the head and the buck. Many are provided with a locking device. In others no provision is made for superheating the steam. With reasonably dry steam this should not be necessary where a vacuum is used. Some machines are fitted with a small steaming head alongside the press proper for finishing shoulders of coats and tops of sleeves. For the pressing of flat work, *e.g.* underwear, a suitable type of Hoffmann press has a flat plate, not padded.

The clothing of the Hoffmann press consists of a wire gauze next to the heating surface to distribute the steam, and in the case of the head, a thin felt blanket and a cotton cover. The buck has a similar wire gauze, with a very thick felt and cotton cover.

Where large quantities of work are done, the arrangement of the presses should be such that an operator can finish one part of the garment on one press, and another worker complete the job on another press adjacent to it, *e.g.* in finishing a suit, the

Fig. 65.—Hoffmann Steam Garment Press, "Klear-Buk."

trouser legs can be pressed on the CE machine, the tops of the trousers on the BB, the vests on the M machine, and the coat on the DD. Knitted work could be pressed on a flat machine such as the CC type.

Where the work is small in quantity a general purpose valeting machine (fig. 65) will serve for mixed dyed and cleaned work. The work-holder of this machine is 31 inches long and $10\frac{1}{2}$ inches wide at one end, and 7 inches wide at the other. A type of machine for trouser pressing is also made, the work-holder being 41 inches long and the width tapering from 18 to 9 inches.

The good quality of finish produced by the Hoffmann type of press is partly due to the fact that the temperature of pressing is practically uniform the whole day, whereas with an iron great variation must occur. Moreover, the tendency to *gloss,* or

glare the fabric is very much less, the finish of the cloth giving a much *fuller* handle. Some cloths cannot be finished satisfactorily by means of an iron, but can be treated successfully with a Hoffmann press—*e.g.* a garment made from velour cloth is
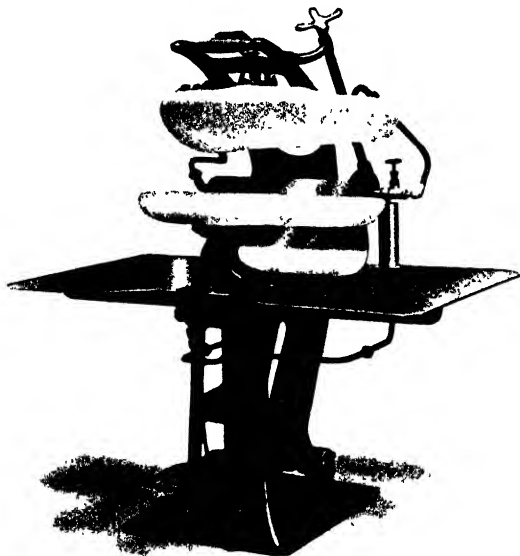
R. G. Whitaker, Ltd.

FIG. 66.—" Aerovac " Press, Type A555, for Coat Backs.

turned out in excellent style when finished by a Hoffmann press, but cannot be hand ironed, with the exception of the lining. With a skilled worker the machine is very economical owing to the large output which can be obtained.

Furnishings.

The articles employed in furnishing cover a very wide range, and finishing methods vary according to the particular fabric used and the preliminary treatment which it has undergone. The principal machines and appliances employed are as follows :—

Curtain frames (for lace, Swiss net, guipure, and other curtains, window blinds—preparatory to glazing, etc.).

Silk frames (for fabrics of all descriptions—velvet, plush, etc., in curtains and draperies, unpicked or partially unpicked

dresses, cloaks, etc., dyed curtains in various fabrics, especially such as have shrunk in dyeing, etc.).

Steaming table (for dyed and cleaned fabrics; *e.g.* serge curtains, etc.).

Finishing machine (for merinos, repps, cashmeres, etc.).

Cylinder (for unpicked dresses, ribbons, laces, small curtains,

R. G. Whitaker, Ltd.

FIG. 67.—" Aerovac " Press, Type B151, for Vests.

embroidered net curtains and window blinds, alternative to framing).

Glazing machines (for glazing chintz and druggets, glazing cretonne on the back, or fitted with felt roller and steam block for finishing cretonne, satin, etc.).

Glazing calender (for glazing window blinds, lengths of chintz, drugget, etc.).

Decoudun, or similar calender (for finishing lace curtains after framing, lengths of material, dimity, etc.).

Goffering machines (for goffering the frills of curtains, etc.).

Carding machines (for raising the nap on blankets).

Ordinary or special irons for hand ironing (for cretonne, soft silk curtains, etc.).

Hot press (for damask, etc.).

The articles which may be sent for dyeing and cleaning from the household cover such a wide range, varying from small
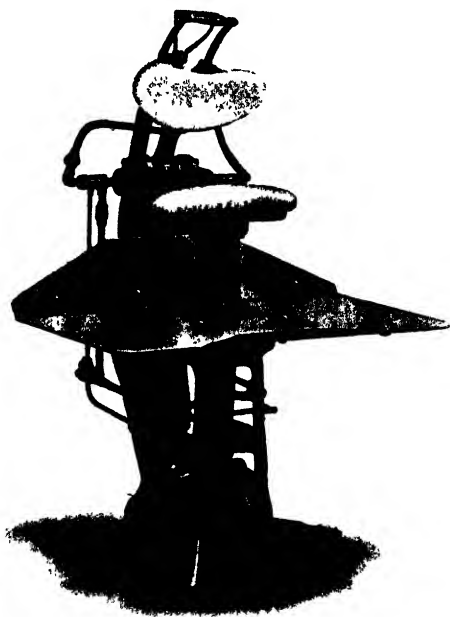
FIG. 68.—" Aerovac " Press, Type B454, for Large Collars and Lapels.

articles such as curtain bands, fancy table centres, etc., to large curtains and draperies in every possible fabric, that it is impossible to specify every article and the method or methods of finishing the same, but the principal methods in use and the chief articles for which they are employed will be given, and from these the processes to be adopted for allied articles can be deduced.

Curtain and Window Blind Finishing.—Frames are employed in drying curtains of Nottingham lace, Swiss net, guipure, muslin, etc., window blinds of holland, linen, coutil, etc. They

may be divided into *horizontal* and *vertical* frames, these terms referring to the position taken by the frames during the drying process. A *set* of frames varies from five upwards, the number being generally so arranged that the workers can frame the curtains, etc., continuously ; *e.g.* with a set of five frames the drying power is such that by the time the fifth frame is filled and placed in the drying chamber, the curtains on the first frame are dry and ready for removal. The question as to whether horizontal or vertical frames shall be employed depends to a considerable extent upon the space available and on the workers who are to operate the frames. Vertical frames which are to be emptied and filled in a horizontal position are somewhat heavy for female labour to lift into the vertical position ; but, on the other hand, a very much larger number of frames can be accommodated in a given space.

Fig. 69 shows a vertical frame in position on the rail leading to the drying chamber. It consists of a rectangular frame fitted on one side with a flanged wheel at each end to fit on to the overhead rail. The top and left-hand side are fitted with steel " pinning " with a wood guard to prevent it from being damaged in running in and out of the drying chamber. There is also a movable horizontal rail and a movable vertical rail fitted with *pinning,* which can be fixed by thumbscrews or other device in any position, so that the frame will take any curtain smaller than the dimensions of the full-sized frame. Frames are also made with a second horizontal rail between the fixed and the movable sets of pinning, bearing upon it a double set of pinning. When narrow curtains are being framed, two sets can be put on one frame by this appliance, the first set being framed on the fixed pinning and one side of the centre bar, and the second set on the other side of the centre bar and the outside movable pinning.

To ensure the movable side being quite parallel with the fixed side, the table on which the frame is placed during framing may have two parallel lengths of angle iron or wood which may be moved in either direction by racks and pinions, the latter being keyed on a rod which is turned by a handle from the end of the frame. The parallel lengths, by resting against the fixed and movable sides, ensure the latter remaining absolutely parallel, and, moreover, afford a means of stretching blinds, etc. which may have shrunk in cleaning. The curtains, starched and wet from the cleaning house, are sorted into pairs and placed on the frames by means of brushes which *tap* the edges or points of the curtains on to the pins. Usually one pair is placed
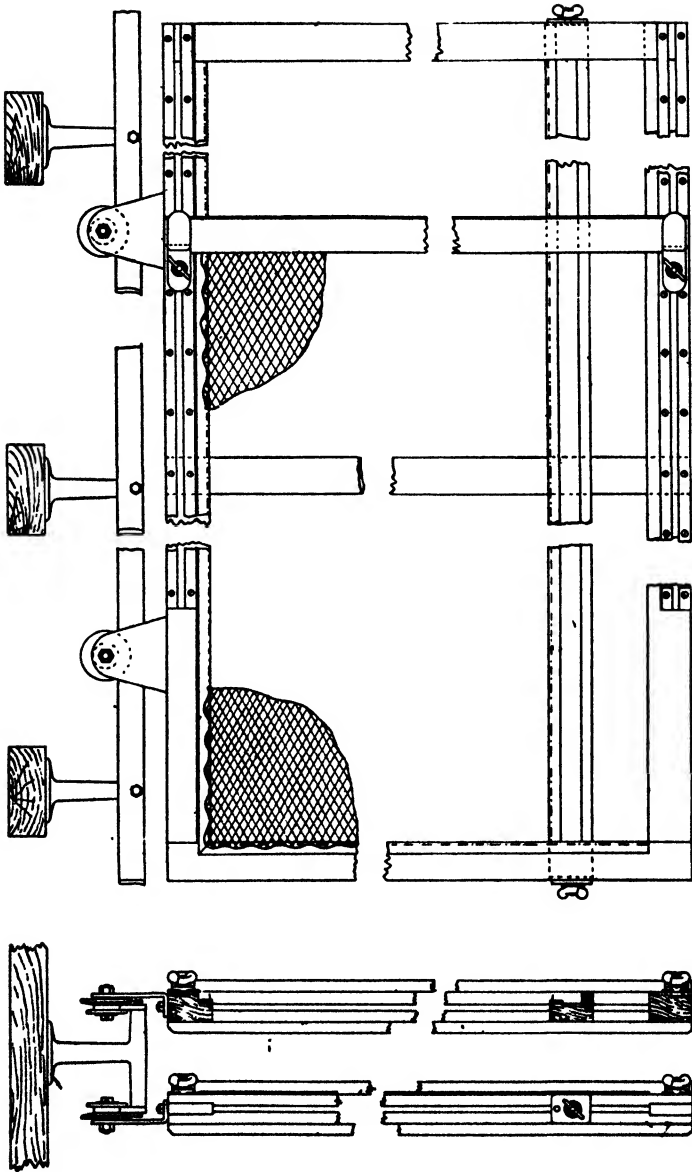
Fig. 69.—Vertical Curtain Frame.

on each frame, but if there are others of exactly the same size, two pairs may be placed on one frame. The movable side and end having been fixed, the frame is lifted on to the rail, the door of the drying chamber corresponding with that rail opened, and the frame pushed into the chamber, which is heated with steam pipes, and may or may not be fitted with a fan. Still air is frequently employed, as the dust which is drawn in and kept in movement by a fan readily adheres to the damp, starched curtains. When the contents of the frame are dry the frame is withdrawn from the drying chamber, placed upon the table, and the movable side and end are *slackened* so that the curtain may be readily removed without risk of damage. Horizontal frames differ from those described in that the drying chamber is fitted with rails, on which the frames rest one above the other, in a horizontal position. A frame fitted with a pair of rails is arranged outside the drying chamber, and is counterbalanced so that it can be raised or lowered and locked opposite any of the pairs of rails inside the chamber. The curtain frame is then drawn out on to the movable frame and raised or lowered to a convenient height for taking off or putting on curtains. · In these curtain frames two wheels on each side are provided, but in all other respects the frames do not differ from the vertical types. They do not, however, possess the advantage of the parallel stretching device, which can be fitted to the table used for the vertical frames.

Curtains which have been framed should have the points and the *headings* ironed by hand to remove the pin marks, or, with the exception of frilled and heavily embroidered net curtains, they may be passed through a decoudun or similar calender to remove the slightly rough surface left by framing. The decoudun (fig. 70) consists of a steam-heated bed and a steam-heated padded roller revolving in the bed, the curtains or other articles being fed through a *lip*, and passing between the roller and the bed. Curtains which are to be calendered subsequent to framing may with advantage be taken off the frames while they still contain a small amount of moisture.

Curtains with frills are not calendered ; but the frills and the headings of the frills are ironed out and goffered by hand or by machine. The latter is not usually found satisfactory for muslin and light fabrics, as the result is not so permanent as that produced by goffering with hand tongs. The machine is made with various sized flutings on a stand or to fit on a table (figs. 71 and 72), and produces fairly satisfactory results where the fabrics are of somewhat heavier material (*e.g.* Nottingham lace).
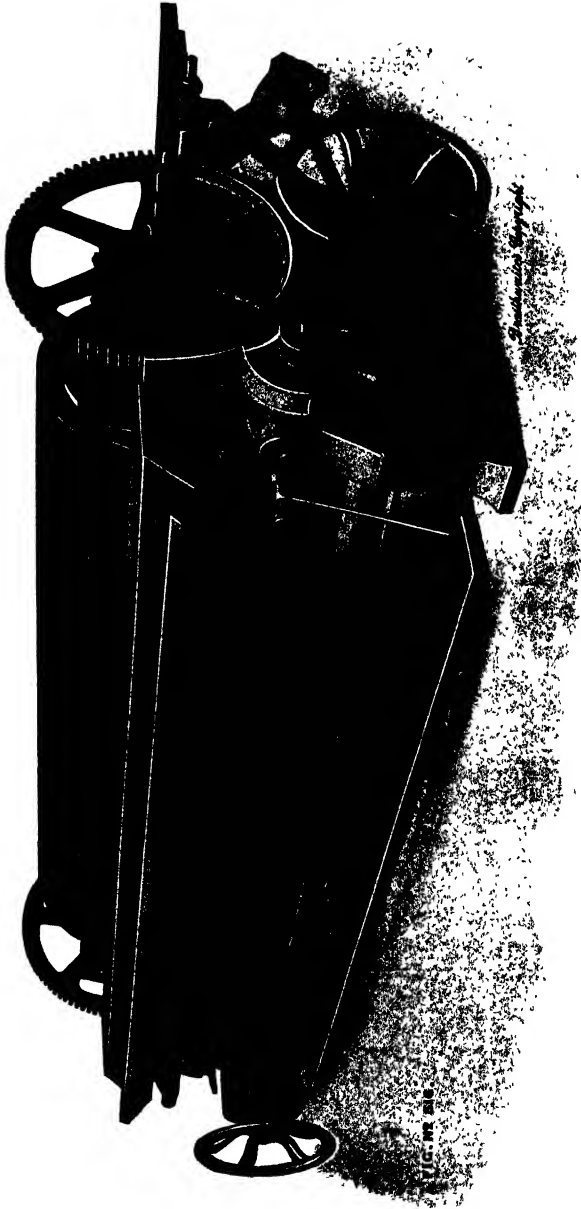
Fig. 70.—" Ibis " Decoudun (Feeding Side).

Curtains with highly raised embroidery are sometimes starched on the curtain frames to keep the raised portions quite soft. The unstarched curtain is placed on the frame with the embroidered face downwards, and the back is carefully sponged with a solution of boiled starch. Such curtains may also be finished on the steam cylinder, being brushed on by hand with starch solution. This method is also employed for finishing curtains which are of special value, or which are too frail to stand the slight tension of framing.

WORM WHEEL
RUNS IN

FIG 602   *Braithwaite's Copyright*

Fɪɢ. 71.—Table Goffering Machine.

It is not, however, economical for general curtain and blind finishing, owing to the large condensing surface and consequent heavy steam consumption.

Window blinds in holland, etc. may be framed or cylindered, the former being the more satisfactory process, as it affords a means of stretching to their original dimensions blinds which have shrunk in the process of cleaning. Window blinds are cleaned and finished with or without unpicking the side hems. If unpicked, the pin marks are not so obvious; and in the case of blinds which have shrunk, the hem may be made a little narrower in re-making, permitting the blind to be re-made to the original size. On the other hand, the unpicking and re-making add to the cost of the process. When the slight additional cost is not of paramount importance, it is advisable to unpick the hems, as there is a possibility of the *paper* bowl of the glazing calender becoming indented by the double thickness of the hemmed portion. If possible, blinds which are to be glazed on a friction calender should be framed about a half inch wider than the finished width to allow for the slight contraction in width which takes place.

The blinds having been framed, are steamed or sprayed to dampen them slightly, and are then ready for glazing. The friction calender consists of a chilled steel top bowl, heated by steam, a centre bowl of highly compressed paper or cotton, and a bottom
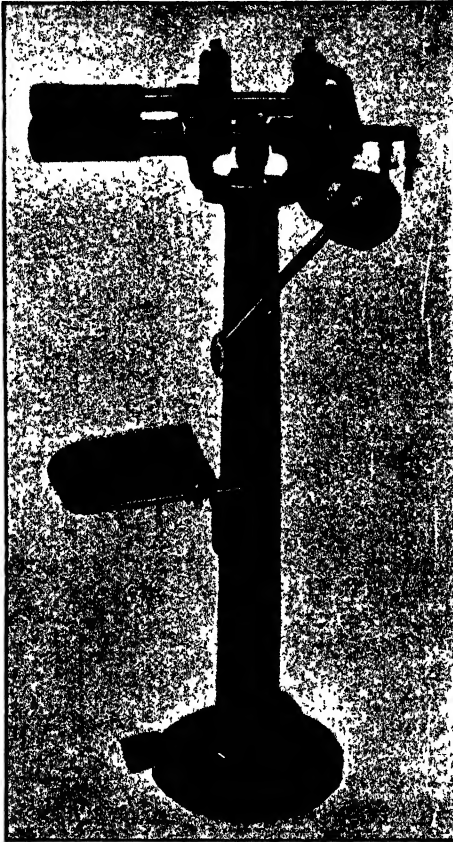
Hill & Herbert.

Fig. 72.—Stand Goffering Machine.

bowl of steel to enable heavy pressure to be placed on the centre bowl. The top bowl is geared to run at a higher speed than the centre bowl.

In the *Downham* calender, shown in fig. 73, the top bowl lifts about an inch from the centre bowl by means of belt-driven cams.

This is very useful when glazing blinds trimmed with lace at the ends, as the lace end may be passed through the opening, the top bowl dropped into place and the machine started, thus
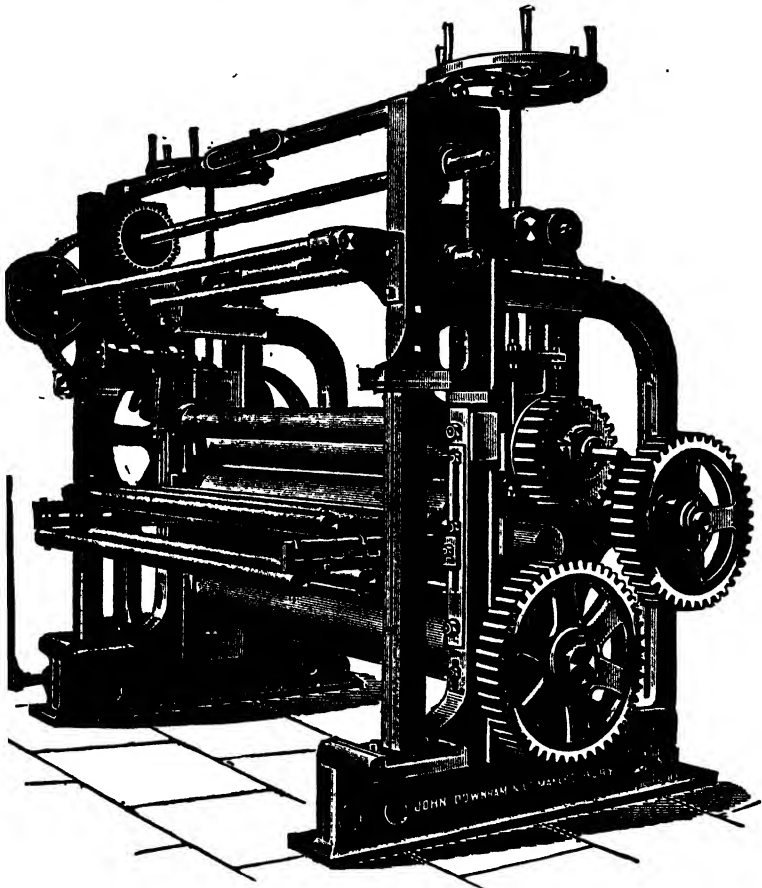
FIG. 73.—Downham " Lifting " Calender.

glazing the holland and leaving the lace untouched. Blinds are usually passed through the calender twice, each side being glazed. In other glazing calenders the bowls are arranged to reverse by operating a lever; lace-ended blinds are then fed in with the plain end first, and the bowls are reversed just as the lace reaches

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the *nip* of the calender. Calenders are also made with over-
hanging bowls, *i.e.* one end of the machine is open ; by means of
such machines, blinds wider than the rolls may be finished by
glazing one half at each operation. It is, however, somewhat
difficult to finish a blind absolutely *square* by this means.
Duchesse blinds, in which the embroidery does not finish in a
straight line, may be glazed on a calender as far as the embroidery,
the rest of the holland being finished on the ordinary reciprocating
glazing machine.

In some instances blinds are finished without any glaze (*e.g.*
coutil), in which case they are taken direct from the frame or
cylinder, and after topping up the lace (if any) by hand, are
ready for re-making.

The glazing calender is also employed in finishing straight
lengths of drugget, chintz, and linings which have been unpicked,
etc. If the paper bowl of the calender accidentally becomes
marked or indented, the marks, if small, may be worked out by
damping with cold water or a weak solution of neutral soap in
water, this being applied from time to time while the top bowl
is heated and the calender allowed to run. By this means the
surface of the bowl may gradually be worked up again. If the
bowl is deeply indented it must be placed in a lathe and turned
down until the marks are removed.

Chintz Glazing.—The finishing of unpicked chintz by the
glazing calender has been referred to briefly ; in most cases chintz
is not unpicked, but is finished in the form of curtains, hangings,
chair covers, seat covers, ottoman and sofa covers, etc., in the
made-up condition. When received from the drying-room the
chintz is very stiff and must not be handled carelessly, as in this
condition it readily cracks and tears. It is damped with water
by an atmospheric pressure spray, and when it has lain by for
a short time and has become softened, it is pulled into shape,
if necessary, and rolled up tightly for some hours to allow the
slight amount of moisture in it to equalise, after which it is
ready for glazing.

The glazing tools shown in figs. 74 and 75 consist of a compressed
felt bed about 2 inches wide and of varying length, which may be
raised by a foot lever. The polishing tool is a piece of flint or
agate with a round surface and rounded edges of the same width
as the felt bed ; it is fixed in the reciprocating arm of the machine,
the length of stroke depending on the throw of the eccentric on
the driving shaft, and is the same as the length of the felt bed.
The machines are usually supplied in sets of four, the smallest
having a stroke of 2 inches, being employed in finishing frills,

covers, etc., and the largest, having a stroke of about 2 feet, being used for curtains, etc. The intermediate sizes are used for chair covers, etc., though frequently the same curtain or cover will have various parts glazed on all four machines. Care must be taken to avoid *pinching*—*i.e.* the formation of small pleats in the fabric, as these are liable to show as cuts when the fabric is cleaned again. The machines are frequently used for finishing
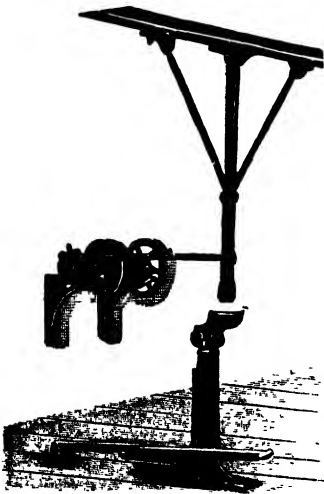
FIG. 74.—Glazing Machine.
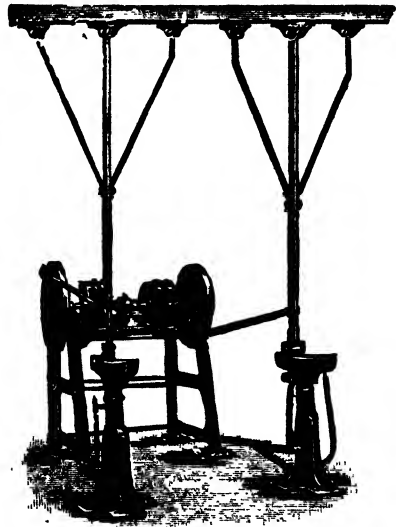
FIG. 75.—Glazing Machine and Roller and Steam Block.

cretonne, tissue, and similar fabrics in curtains, covers, etc. ; in such cases the back of the fabric is glazed, giving a smooth un-glazed finish on the face. They are also supplied with a compressed felt roll in place of the flint, and a steam-heated bed instead of the felt block for finishing cretonne, etc. on the face, a better finish being obtained in this way than that producible by hand ironing (fig. 75). This machine is also employed in finishing dyed satin goods, etc.

Gorrie's patent variable stroke glazing machine (fig. 76) differs from the ordinary machine in that the stroke can be varied from ¾ inch to 4 inches by simply slackening one thumbscrew. This machine is very useful for glazing the corners of covers, frills, etc. which are usually too small for the ordinary machine.

Cretonne is also finished by hand ironing, using ordinary irons, or the large surface or " Crown " irons.   The latter are economical in use and easy to operate ; they are not lifted on to a stand when not required, but slide on to a sloping rest which is fixed on the ironing table.

As already indicated, on p. 257, hand irons of various sizes are still largely used for finishing and part finishing articles which can-

FIG. 76.—Short Stroke Glazing Machine.

not be completely finished by machine.   Reference has been made to stove irons and high-pressure gas irons.   A good type of electric iron is shown in figs. 77 and 78.   By the arrangement of the heating elements in vertical slots in the base of the iron (fig. 77) the heat is directed to the sole, where it is actually required for finishing the goods.   This type of construction, shown in detail in fig. 79, is also calculated to withstand the rough treatment (vibration, etc.) that an iron receives when constantly used in a factory.

When the electric iron is required to meet conditions under

which the use of cord or flex is a serious disadvantage, the cordless system shown in fig. 80 may be adopted. In this method the
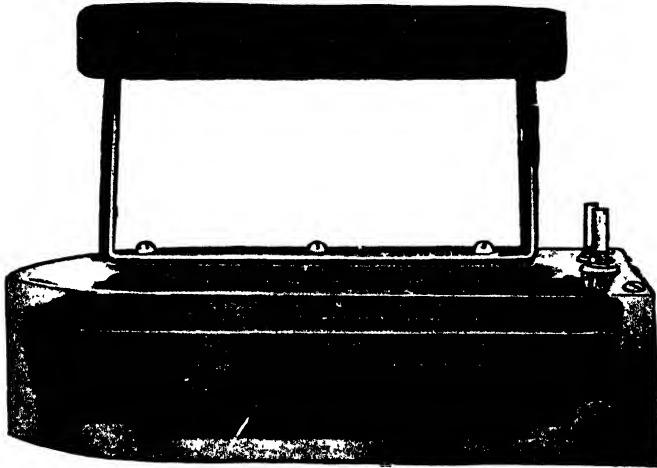
Dowsing Radiant Heat Co.

FIG. 77.—" Hot-Point " Electric Iron, showing position of Heating Elements in Body of Iron.

irons are usually worked in pairs, contact with the electric circuit being established when the iron is slipped into the slot shown ; the base of the iron rests, meanwhile, upon the bed of the stand, which is covered with strips of uralite or other non-conducting material to conserve the heat. While one iron is in use the other is being electrically heated on the stand.

Pile Fabrics. — Velvets and other pile fabrics which have been dry cleaned can generally be finished by brushing on a steaming table of the pattern shown in fig. 60, or that shown in fig. 81. Those which have been dyed cannot be finished in this manner, as the pile is not sufficiently raised thereby ; the pile can only be raised satisfactorily on a *silk frame*. This consists of a metal framework, the two sides of which are fitted with metal
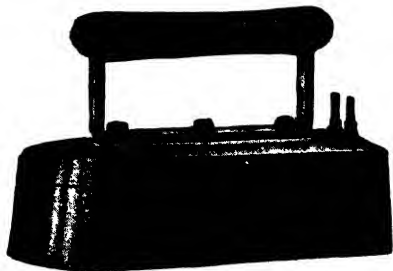
Dowsing Radiant Heat Co.

FIG. 78.—" Hot-Point " Electric Iron— Tailors' Goose Iron.

pinning, which is usually fitted into a metal strip instead of wood (as in curtain frames), to allow of considerable tensions
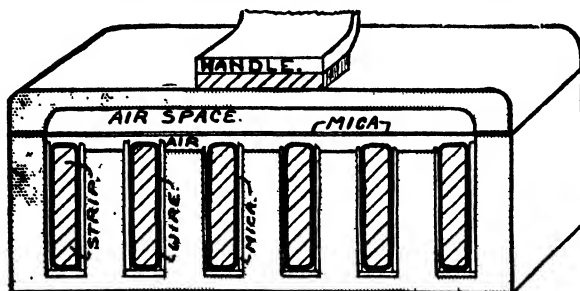
Dowsing Radiant Heat Co.

FIG. 79.—" Hot-Point " Electric Iron—Section of Iron.
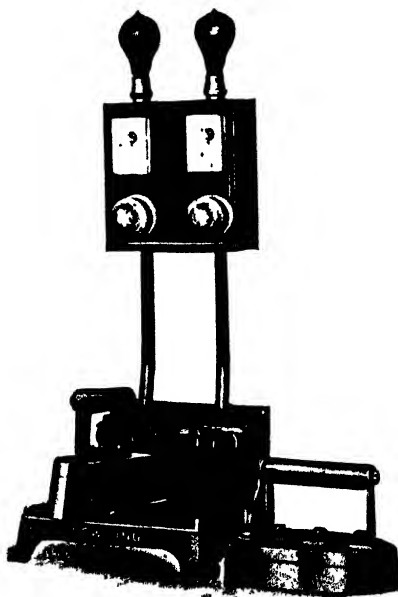
FIG. 80.—" Hot-Point " Electric Iron, Cordless System.

being employed. The underframe is provided with rails on which run two trolleys carrying, respectively, gas burners and steam

jets fitted in pans running transversely on the trolleys, the gas and steam being supplied by flexible tubes. By this means the gas pan or the steam pan may be brought under any portion of the fabric which is upon the frame. Articles which are not rectangular in shape have *tacking cloths—i.e.* pieces of calico— stitched round them ; these are fixed on to the pins so that the velvet (portion of a dress, etc.) may be stretched quite evenly.
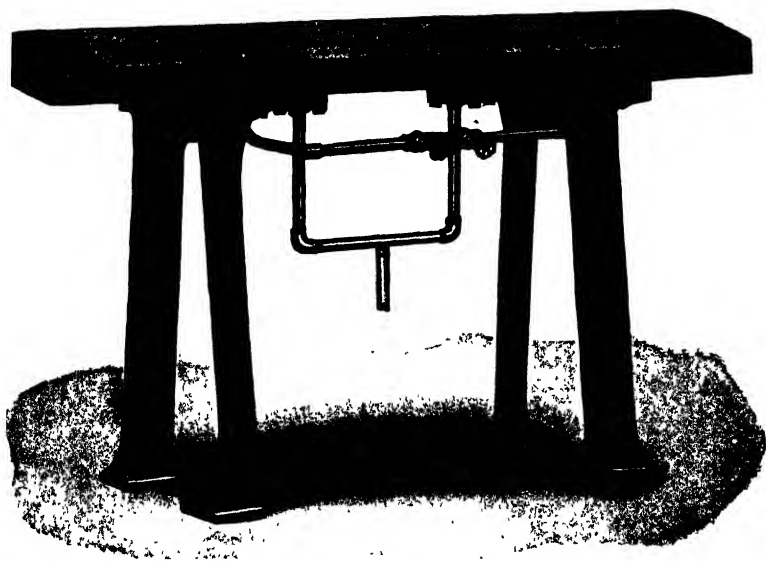
J. Stewart & Co., Perth.

FIG. 81.—Perforated Steaming Table for Woollens, Carpets, Etc.

Crossbars fitted with pinning are provided for the ends of the curtains, etc., to which they are attached directly or by means of tacking cloths.

Velvet curtains which are too long for the frame may be finished one half at a time ; the finished portion must be carefully protected while the other half is being treated. A curtain having been placed on the frame, the latter is tightened by means of the hand screws provided, and steam is blown through the fabric, working from one end to the other and brushing the whole time by hand. By means of a circular motion with the brush the pile is disentangled and opened up, and is finally brushed one way— up to the heading of the curtain, when no marks of broken places should be visible. The fabric is then dried by means of the gas

pan, brushing the pile at the same time towards the top of the curtain. Velvet pile table covers, etc., which have been dry cleaned, are frequently finished by steaming, followed by brushing with fine emery cloth ; this *cleans* the pile by removing adhering particles of fluff, fibre, etc.

The silk frame may also be used with advantage in finishing any dyed curtains which have become cracked or *broken* during the dyeing—*e.g.* satin, silk damask, Roman satin, etc., the satin being faced down on the steamer before framing. It is also used for stretching and squaring dyed curtains which have shrunk or lost their shape to any extent in dyeing (felt, etc.). Satins, velvets, and other fabrics having a *face* side are sometimes slightly stiffened on the back while on the frame by sponging with a weak solution of gelatine containing a little acetic acid (feculose and similar soluble starches may also be employed).

Eiderdown Quilts.—These, whether previously wet cleaned, dry cleaned, or dyed, are dried in a tumbler (fig. 85) to loosen the down and so regain the original fulness. They are then squared on the frame. Some may require sponging with gelatine while on the frame to improve the finish and to tighten up the material to make it down-proof. The chief trouble arises with those quilts not made up with an inner case to hold the down.

Serge, Chenille, Etc.—Curtains in these fabrics which have been cleaned or dyed may be finished in many cases on the steaming table, followed by topping-up by hand where necessary. Damask (if it is not trimmed with fringe, etc.) may be finished on a decoudun or similar machine, any undesirable gloss imparted to the fabric being removed by a slight steaming. Where possible, however, damask is finished by hot pressing in the ordinary hydraulic press, which gives a superior and more permanent finish.

For repps, serges, cashmeres, and other plain woollen or partially woollen fabrics, the finishing machine (fig. 82) gives very good results. It consists of an endless felt, the tension of which can be adjusted, passing round the greater portion of the circumference of a steam-heated cylinder. A modification of the same machine with an arrangement for keeping the goods at full width (Palmer stretcher) is largely used in the finishing of new piece silk goods.

Soft Silk Curtains and small articles, such as curtain bands, table centres, sideboard cloths, etc., are usually finished by hand. Embroidered linen cloths of various kinds are also finished by hand iron or on the cylinder. The latter is a tinned copper cylinder made in various sizes, the one most generally used being 12 feet

in length and about 4 feet in diameter (fig. 83). The steam is supplied through a reducing valve, and the cylinder should be fitted with a safety valve and pressure gauge. As already pointed out, it is an expensive machine to use, owing to its large steam consumption. It is, however, very useful in finishing embroidered
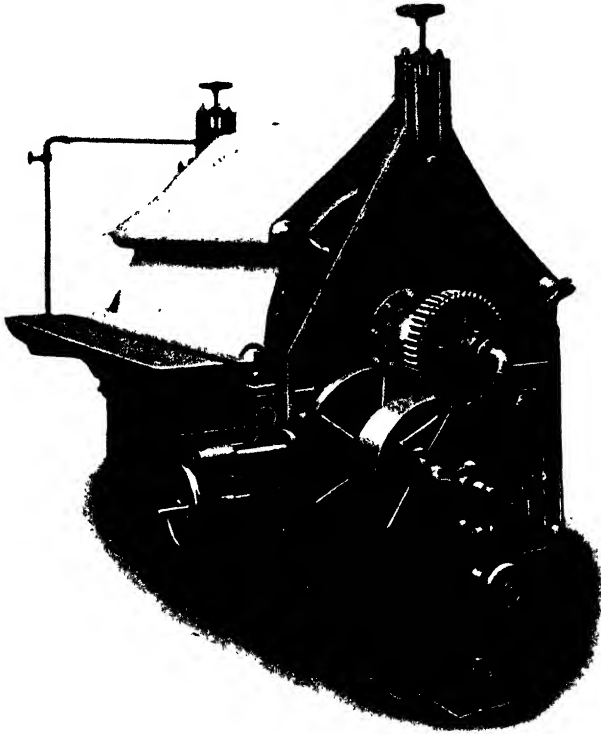
FIG. 82.—Finishing Machine.

articles of all descriptions—curtains, bedspreads, counterpanes, tray cloths, etc.—as the raised portions are not flattened in the slightest degree. It is also used for finished shaped articles—lace, ribbon, pieces of unpicked dresses, etc.—as the articles are brushed on to the cylinder whilst wet and arranged in the correct shape, and are not removed until dry and set in that shape.

The wet articles are brushed on to the surface of the cylinder with a brush or sponge damped with water, starch water or

gelatine solution, according to the finish required, and remain in position until quite dry, when they are peeled off. Lace which is to be finished quite soft must not be cylindered. It must be pinned out on to a padded table and not removed until quite dry.
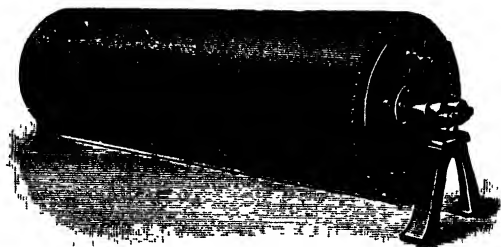
FIG. 83.—Cylinder.

Blankets.—These must be *carded* to soften them and to raise the nap. This process may be carried out by hand or by machine. In the former process the blanket is stretched on a frame (fig. 87) and the *carder* (a piece of wood on which has been tacked *carding cloth—i.e.* cloth fitted with fine metal pinning inclined at
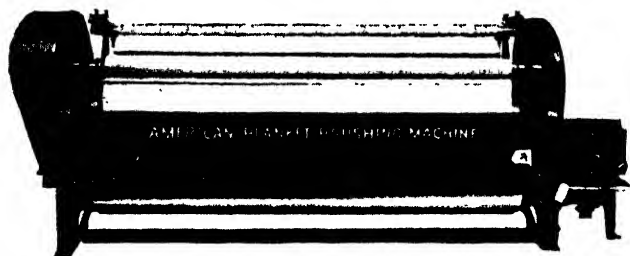
FIG. 84.—Blanket Brushing Machine.

an angle, such as is employed in carding raw cotton) is drawn by hand down the blanket, raising a nap, with a practically negligible loss of wool to the blanket. For carding large numbers of blankets a machine (fig. 84) should be used. In carding by machine the blankets are brushed with a revolving wire brush mounted on a roller, the wire of the brush being longer, finer, and more flexible than that of the ordinary hand card. The blankets are fed into the machine singly, and are picked up by a card-covered roller which depresses the surface of the blanket against the revolving brush. Both sides of the blanket are

brushed by putting through twice, the result produced being
similar to that of the hand process, but more regular, and less

Fig. 85.—Aladdin Drying Tumbler.
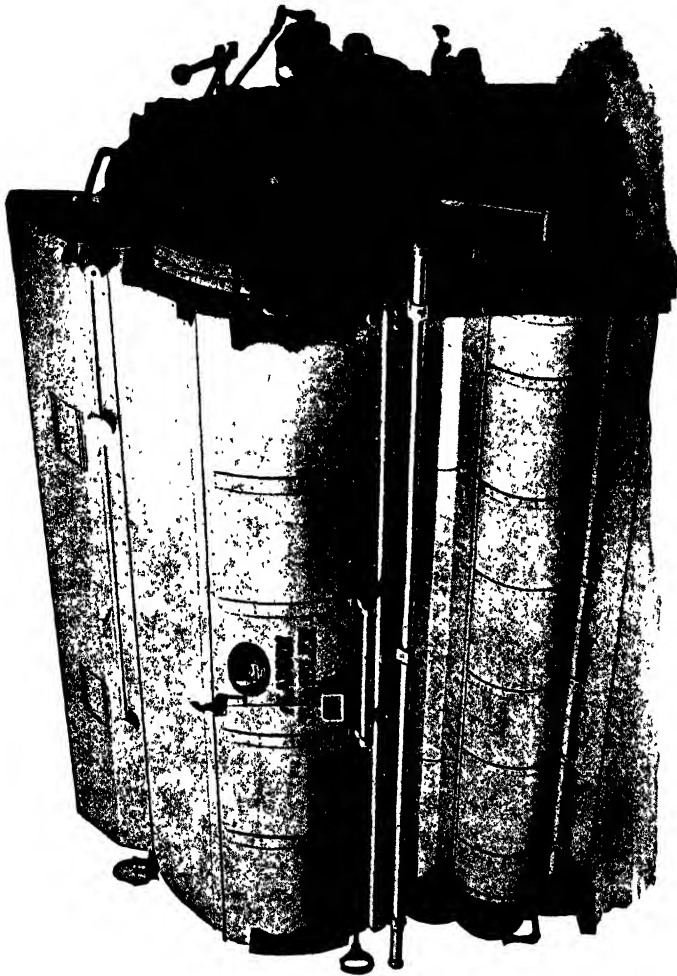
British-American Laundry Machinery Co., Ltd.

wool is removed.   Blankets bound at the edges with satin cannot
as a rule be carded by machine owing to the danger of scratching
the satin binding.   These are carded by hand.   Another type
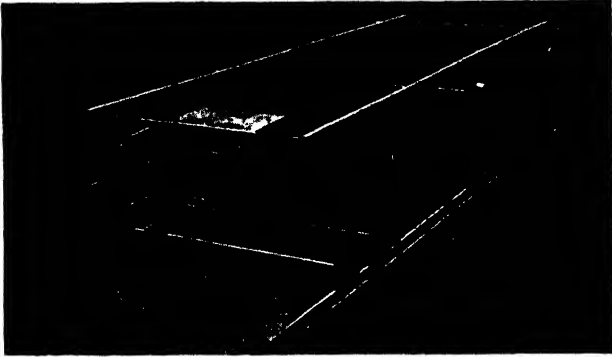
Fig. 86.—Finishing Frame.

Fig. 87.—Carding Frame for Blankets and Pile Materials.
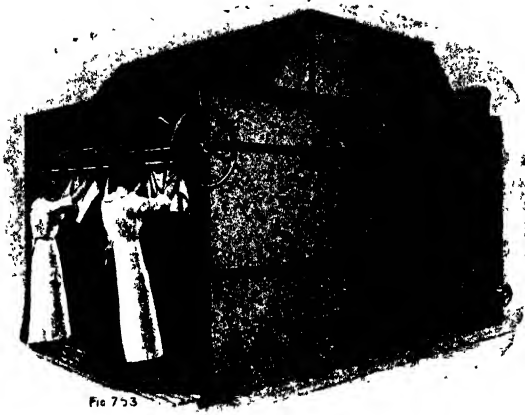
Fig. 88.—Braithwaite's Automatic Drying Machine.
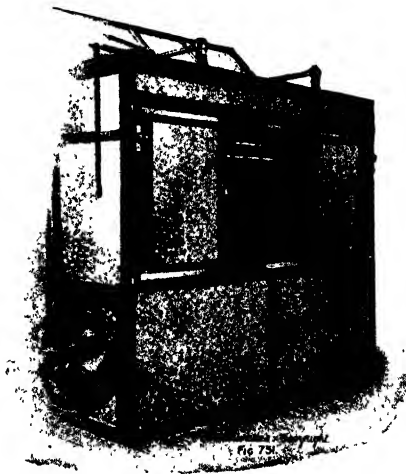
Fig. 89.—Braithwaite's Automatic Drying Machine.   Back View,
showing Delivery End.

of machine used for blanket carding is the ordinary *teasel gig*, such as is used in cloth raising. When this is employed the blankets must be fastened end to end and carded before drying. This gives a close approximation to the new finish.

The descriptions which have been given cover most of the finishing appliances in general use. While it is impossible to specify every article which may come into the hands of the dyer and cleaner, he may deduce the mode of procedure in any particular case from the methods and appliances which have been described.

APPENDIX A.

Colour-Harmony Chart.

IN the following Chart the letter B means blend or combination of related colours, and C means combination of contrasted colours. White in conjunction with any colour intensifies it, and black has the opposite effect. When three colours are used the best effect is obtained if two of the colours are blends and the third is a contrast. In these harmonies the effect is less prominent and the third colour is subordinate.—Extracted from *The Dyer and Calico Printer*, 1st May 1922. (Reprinted from the *Haberdasher*.)

	Dark Brown.	Brown.	Tan.	Cream.	Grey.	Lavender.	Purple.	Helio or Red Purple.	Wine or Maroon.	Red.
LIGHT BLUE	Bad O	Bad O	Good C	Good C	Good B	Good B	Bad B	Bad B	Bad O	Bad O
BLUE	Good O	Good O	Good O	Good O	Good B	Good B	Good B	Good B	Bad C	Bad O
NAVY	Good O	Good O	Good C	Good C	Good B	Good B	Good B	Good C	Good O	Good O
MYRTLE GREEN	Bad O	Bad C	Good C	Good C	Good B	Bad B	Good B	Good C	Bad C	Good C
LIGHT GREEN	Good C	Good C	Good C	Good C	Good B	Good B	Good B	Good C	Good C	Good C
GREEN	Good C	Good C	Good C	Good C	Good B	Good B	Good B	Good C	Good O	Good C
OLIVE	Good B	Good B	Good B	Good C	Bad C	Good C	Bad C	Bad C	Good C	Good C
YELLOW	Good B	Good B	Good B	Good B	Good C	Good C	Good C	Good C	Good C	Good O
ORANGE	Good B	Good B	Good B	Good B	Good C	Bad C	Good C	Good C	Bad C	Good B
PINK	Bad O	Bad C	Bad C	Good B	Good C	Good B	Good B	Good B	Good B	Good B
RED	Good B	Good B	Bad C	Good C	Good C	Bad C	Bad B	Good B	Good B	
WINE OR MAROON.	Good B	Good B	Good C	Good C	Good C	Bad B	Good B	Good B		Good B
HELIO OR RED PURPLE.	Good B	Good B	Good C	Good C	Good B	Bad B	Good B		Good B	Good B
PURPLE	Good B	Good B	Good C	Good O	Good B	Good B		Good B	Good B	Bad B
LAVENDER	Good B	Good B	Good C	Good C	Good B		Good B	Bad B	Bad B	Bad O
GREY	Bad B	Bad B	Bad B	Good B		Good B	Good B	Good B	Good C	Good O
CREAM	Good B	Good B	Good B		Good B	Good C	Good C	Good O	Good O	Good O
TAN	Good B	Good B		Good B	Bad B	Good C	Good C	Good O	Good C	Bad O
BROWN	Good B		Good B	Good B	Bad B	Good B	Good B	Good B	Good B	Good B
DARK BROWN		Good B	Good B	Good B	Bad B	Good B	Good B	Good B	Good B	Good B

	Pink.	Orange.	Yellow.	Olive.	Green.	Light Green.	Myrtle Green.	Navy.	Blue.	Light Blue.
LIGHT BLUE .	Good O	Bad O	Bad O	Good C	Bad B	Good B	Good B	Good B	Good B	
BLUE . .	Bad O	Good C	Good C	Good O	Good B	Good B	Bad B	Good B		Good B
NAVY . .	Bad C	Good O	Good O	Bad C	Good B	Good R	Good B		Good B	Good B
MYRTLE GREEN	Bad C	Bad C	Good C	Bad B	Good B	Good R		Good B	Bad B	Good B
LIGHT GREEN	Good O	Good O	Good B	Good B	Good B		Good B	Good B	Good B	Good B
GREEN . .	Good C	Good O	Good B	Good B		Good B	Good B	Good B	Good B	Bad B
OLIVE . .	Good O	Good B	Good B		Good B	Good B	Bad R	Bad C	Good C	Good C
YELLOW .	Bad O	Good B		Good B	Good B	Good B	Good R	Good C	Good C	Bad C
ORANGE .	Bad C		Good B	Good B	Good C	Good C	Bad C	Good C	Good C	Bad C
PINK . .		Bad C	Bad C	Good C	Good C	Good C	Bad C	Bad C	Bad C	Good C
RED . .	Good B	Good B	Good C	Good C	Good C	Good C	Good C	Good C	Bad C	Bad C
WINE OR MAROON.	Good B	Bad C	Good C	Good C	Good C	Good C	Bad C	Good C	Bad O	Bad C
HELIO OR RED PURPLE.	Good B	Good C	Good C	Bad O	Good O	Good C	Good C	Good C	Good B	Bad B
PURPLE. .	Good B	Good O	Good C	Bad O	Good C	Good C	Good B	Good B	Good B	Bad B
LAVENDER .	Good B	Bad C	Good O	Good O	Good B	Good B	Bad R	Good B	Good B	Good B
GREY . .	Good O	Good O	Good C	Bad O	Good B	Good B	Good B	Good B	Good B	Good B
CREAM . .	Good B	Good B	Good B	Good C	Good C	Good C	Good C	Good C	Good C	Good C
TAN . .	Bad O	Good B	Good B	Good R	Good C	Good O	Good O	Good O	Good O	Good O
BROWN . .	Bad O	Good B	Good B	Good B	Good O	Good O	Bad C	Good O	Good O	Bad O
DARK BROWN	Bad O	Good R	Good B	Good R	Good O	Good O	Bad C	Good O	Good O	Bad C

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APPENDIX B.

ADULTERATION OF DRESS SILKS.

(Memorandum issued by the Incorporated Association of London Dyers and Cleaners.) [1]

Adulterated Dress Silks.

(Copyright. Entered at Stationers' Hall.)

Caution to Ladies.

THE Association, having had numerous complaints from its members that many weighted silk articles of dress (chiefly blouses) have split or dropped into holes under the gentlest treatment, calls the attention of ladies to the unfair extent to which adulteration is now carried in silk manufacture. It is hardly too much to say that nearly all the foreign dress-silks sold are unduly weighted—some to such a scandalous extent as to make their sale a matter of the greatest deception. This is done in the dyeing of the silk in the skein, before it is woven into the piece. No defence can be made for it ; the only object in view is to produce an abnormally cheap article and to deceive the buyer. Most ladies know that black silks have been weighted for many years with sugar, tannin, iron in various forms, and other substances which have helped to cause a shiny appearance after a short time in wear. Pure silks do not wear shiny. By the aid of chemical science the dyer can now weight *all silks*— black and coloured, and even white. The weighting is done by impregnating the skein with a metallic salt (generally tin or iron) preliminary to the process of dyeing. The technical result is not only to increase the weight of the silk, but to cause each silk fibre in the skein to swell thicker ; so that every yard of dress silk or ribbon woven, requires much less weight of pure silk in the weaving. It will hardly be credited to what a scandalous extent this weighting is carried on by Continental

[1] Copyright by the Incorporated Association of London Dyers and Cleaners.

dyers. A pound of silk of 16 ounces may be manipulated in the dyeing process so that it can be, and is, returned dyed in colours and white to the manufacturer for weaving weighing from 24 ounces to 40 ounces, and when dyed black, weighing from 64 to 96 ounces. This is so skilfully done that even an expert finds it difficult to detect by the feel and appearance of the dress-piece after weaving that any adulteration has taken place. The manufacturer knows that his silk will not wear at all; but his sales depend on artistic effect, beauty of colour, and chiefly price. That he sells a pure article is of no advantage to him. The buyer of the wholesale house, or draper, is indifferent as long as he gets an article that will sell, and the public imagine that what they get is " silk." After a little wear the article becomes brittle and tender, chiefly in the parts exposed to the sun's rays and to perspiration. The heat sets up a chemical action in the weighting substance, which in a short time rots the texture of the silk, causing it to split in the folds and drop in holes. It will even become tender from a short exposure in a draper's window. The mischief is most noticeable on the shoulders and backs of bodices and blouses, which parts are most exposed, while the other parts remain comparatively sound.

Tens of thousands of blouses made of this adulterated silk are sold in England which are not worth one-half the price paid for them.

The remedy is that ladies should refuse to be imposed on by this gross form of adulteration—no matter how artistic the design or beautiful the colour of the article ; and if a guarantee of purity cannot be obtained, or the amount of weighting be declared, to buy elsewhere. Until a healthy public opinion is formed, and ladies insist that they be supplied with a genuine article—" a pure, unweighted silk "—so long will this deceptive practice be carried on, to their injury and at their cost.

The Association advises its members to accept no responsibility for defects in these weighted silks which appear after re-dyeing, wet and dry cleaning.

APPENDIX C.

Thermometer Conversion Table.

C = Celsius or Centigrade ; F = Fahrenheit.

C.	F.	C.	F.	C.	F.	C.	F.
−17	+ 1·4	+13	+55·4	+43	+109·4	+72	+161·6
−16	3·2	14	57·2	44	111·2	73	163·4
−15	5·0	15	59·0	45	113·0	74	165·2
−14	6·8	16	60·8	46	114·8	75	167·0
−13	8·6	17	62·6	47	116·6	76	168·8
−12	10·4	18	64·4	48	118·4	77	170·6
−11	12·2	19	66·2	49	120·2	78	172·4
−10	14·0	20	68·0	50	122·0	79	174·2
− 9	15·8	21	69·8	51	123·8	80	176·0
− 8	17·6	22	71·6	52	125·6	81	177·8
− 7	19·4	23	73·4	53	127·4	82	179·6
− 6	21·2	24	75·2	54	129·2	83	181·4
− 5	23·0	25	77·0	55	131·0	84	183·2
− 4	24·8	26	78·8	56	132·8	85	185·0
− 3	26·6	27	80·6	57	134·6	86	186·8
− 2	28·4	28	82·4	58	136·4	87	188·6
− 1	30·2	29	84·2	59	138·2	88	190·4
0*	32·0 *	30	86·0	60	140·0	89	192·2
+ 1	33·8	31	87·8	61	141·8	90	194·0
2	35·6	32	89·6	62	143·6	91	195·8
3	37·4	33	91·4	63	145·4	92	197·6
4	39·2	34	93·2	64	147·2	93	199·4
5	41·0	35	95·0	65	149·0	94	201·2
6	42·8	36	96·8	66	150·8	95	203·0
7	44·6	37	98·6	67	152·6	96	204·8
8	46·4	38	100·5	68	154·4	97	206·6
9	48·2	39	102·2	69	156·2	98	208·6
10	50·0	40	104·0	70	158·0	99	210·2
11	51·8	41	105·8	71	159·8	100 †	212·0 †
12	53·6	42	107·6				

* Freezing-point.   † Boiling-point.

Rules for Converting Temperatures from One Scale to Another.

(*a*) To convert *Centigrade degrees into Fahrenheit degrees*: Multiply the number of degrees by 9, divide the result by 5, and add 32. *For example,* 36° C. into ° F. :—

36 × 9 = 324 ; 324 ÷ 5 = 64·8 ; 64·8 + 32 = 96·8 ; *i.e.* 96·8° F.

In the case of temperatures below the freezing-point, 0° on the Centigrade scale, the rule is to multiply by 9, divide the result by 5, take the difference between the number so obtained and 32, if it be the larger number add the sign — to the result, if the smaller, add the sign +. The following examples illustrate these rules :—

(1) —8° C. to ° F., and (2) —40° C. to ° F.
  (1) 8 × 9 = 72 ; 72 ÷ 5 = 14·4 ; 32 — 14·4 = 17·6 ; *i.e.* +17·6° F.
  (2) 40 × 9 = 360 ; 360 ÷ 5 = 72 ; 72 — 32 = 40 ; *i.e.* —40° F.

(*b*) To convert *Fahrenheit degrees into Centigrade degrees.* Subtract 32, multiply the result by 5, and divide this result by 9.
Thus : Convert 82° F. into ° C.

82 — 32 = 50 ; 50 × 5 = 250 ; 250 ÷ 9 = 27·8° C.

When the temperatures are between 32° and 0° F., take the difference between 32 and the given degrees and proceed as before, adding a — sign to the result. For example, reduce 24° F. to ° C. :

32 — 24 = 8 ; 8 × 5 + 40 ; 40 ÷ 9 = 4·4 ; *i.e.* —4·4° C.

If below 0° F. add 32 to the given degrees and proceed as before, adding a — sign to the result. For example, reduce —18° F. to ° C. :

18 + 32 = 50 ; 50 × 5 = 250 ; 250 ÷ 9 = 27·8 ; *i.e.* —27·8° C.

APPENDIX D.

REGULATIONS AND FIRE PRECAUTIONS.

PETROLEUM benzine and benzol being inflammable, it is only natural that before the importance of adopting certain precautions was understood, many serious fires occurred during their transport, storage, and use. These precautions, which were the outcome of cumulative and progressive experience, were gradually embodied in the various Acts, regulations, and local licence conditions adopted by the various authorities in whom the administration is vested. The bearing of these on the safe conduct of dry-cleaning establishments is of such supreme importance that those of value are printed either in epitomised form or *in extenso*. It may, indeed, be fairly claimed that the properly constructed and carefully conducted dry-cleaning establishment is now practically immune from fire risks.

The transport, storage, and use of petroleum benzine, etc., in the United Kingdom are regulated primarily by the *Petroleum Acts* (1871 to 1881), but the various authorities in whom their administration is vested have wide discretionary powers as to the conditions which may be imposed upon users. The following is a copy of relevant sections of the Interim Report of the Departmental Committee for Dangerous Trades :—

Dry Cleaning.

70. The process of *dry cleaning*, sometimes called *French* or *chemical* cleaning, originated in France, where it is known as *Nettoyage-à-sec*.

As carried out on a small scale in many works in London and elsewhere, this is an extremely simple process. The gloves or garments are scrubbed with a small brush, soap, and benzine ; then they are rinsed in benzine, and " made up." The Committee are informed that this has been carried on in kitchens and small rooms where cooking was going on at the same time, and in rooms above the ground floor, from which escape in case of fire would

be sometimes impossible. When done on a large scale it becomes an elaborate business, involving the use of much carefully devised machinery, employing large numbers of workpeople, and necessitating most careful precautions.

The Process.

71. Two forms of benzine are used in the dry-cleaning process; one is the spirit of petroleum or manufactured mineral oil, and the other the spirit distilled from coal tar (benzene).

72. When the goods arrive at the works all the pockets and linings are searched for matches or for any articles which might produce a fire. They are then sorted, as different fabrics have to undergo different processes. Some with ink, coffee, or other stains go to their separate department, while others, costly and valuable goods, or those with tinsel trimming, are treated with special care. When the sorting process is finished, the goods, with the spirit, are placed in a machine which either revolves on a horizontal axis, or which itself remains stationary while cylinders inside it revolve. The latter is the commoner form of machine; it is covered over with a lid, which, in the best factories, is not fastened down. The lid should be provided with a counter-weight by which it is easily opened and shut. From these machines the garments, tablecloths, curtains, etc., go to the hydro-extractor, which is a simple centrifugal machine revolving on a vertical axis; there the surplus spirit is removed and run off by a pipe to settlers, where the dirt is allowed to fall to the bottom. The spirit is decanted off, either by a syphon or some other means, and is redistilled. The goods from the hydro-extractor are rinsed in clean spirit, put through the hydro-extractor again, dried, finished, and sent out.

In describing a process such as this, one is met by the difficulty that no two firms employ exactly the same means to perform practically the same work. And even in the same works the operations vary with the nature and the texture of the articles to be cleaned. For example, some forms of goods are not allowed to go into a machine at all; some articles have to be treated with one spirit, some with the other.

The Dangers of Working.

73. As in the case of inflammable paints the risks encountered by the operatives in this trade are: (1) The danger of fire; (2) the injurious effects of inhaling volatile spirit.

1. The Danger of Fire.

In spite of all precautions which can be and usually are taken in the larger and more carefully conducted factories—among others, searching the workpeople's pockets—small fires seem to be inevitable. Sometimes they result from carelessness ; a match is left in the pocket or lining of a garment, or is dropped on the floor by a worker emptying his own or somebody else's pockets. But they also not infrequently originate from an electric spark, generated by the friction of rinsing or rubbing a silk fabric on a close, thundery day. The spontaneous combustion of benzine may be avoided by the addition of a small quantity of oil soap.

76. Having regard to these circumstances it seems most necessary that every precaution which reason and experience can suggest should be adopted by dry cleaners. As has been indicated, the best firms come up to a very high standard in the manner in which the health and lives of their workpeople are safeguarded, and, in the opinion of the Committee, there seems no reason why other less careful employers should be permitted to expose the lives of their employees to incalculable risk, and to compete unfairly with their more humane and provident neighbours by saving the expense involved in such precautions.

77. As an example of the number of fires which occur, the owner of a dry-cleaning establishment in Liverpool informed the Committee that in fifteen years there had been eight fires. Accidents resulted in two cases ; in one case two men were burnt, in the other one man, though neither fatally.

78. To illustrate the want of system and the carelessness brought to the notice of the Committee, the following incident may not be without interest. A carpet, which was valued at a high figure, had been sent to be cleaned by the dry process, to a firm in London. It had been cleaned and rinsed, only just before closing time arrived. The foreman, knowing it to be valuable, took it home, after it had been hanging up only about half an hour at the factory. He seems to have placed it in front of the fire to dry, where his two children of eleven and six years respectively were playing. The carpet caught fire, and both the children were so severely burnt that they died in the course of twelve hours. He had only brought it home for ten minutes when it took fire. Other fatal accidents have come to the knowledge of the Committee where the work has been done in unsuitable premises.

2. The Dangers to Health.

.79. Similar effects are noticeable in this trade as have been traced in indiarubber works to the inhalation of naphtha fumes, and in docks to the use of inflammable paints. The workers complain of giddiness, nausea, vomiting, and headache, sometimes of tasting the spirit, and usually loss of appetite, intoxication with hysterical symptoms, sleepiness, and, in the more severe cases, loss of consciousness.

These effects are more noticeable and severe among the young workers, and in some people more than in others. Men who have been fifteen and twenty-four years in the trade say that they have felt no bad effects from it, but after a little questioning and examination they have generally admitted either that their eyes smarted while at work, or that, in heavy weather, they experienced a certain giddiness and headache, which they have attributed to pressure of work, owing to the fact that the busy season is from April to July, when the weather is hot. In nearly every case these men, who go on working at it for years, admit that it is not a healthy trade.

In one place visited by the Committee, the girls in the glove-cleaning department told them that they had to come out for fresh air " pretty often," and that the spirit got into their heads and made them " act silly." One of the girls said this might occur twice a day, another three or four times a day. Only one of the four girls examined at this factory suffered from headache, and, although they tasted the spirit in the morning and also in their food, they said they had good appetites. The girl who suffered from headache said the intoxicating effect was more frequent on the days when she was so suffering. She felt very tired and sleepy in the evenings.

Recommendations.

80. If a machine in which a fire takes place has a carefully constructed lid, very often the force of the expanded atmosphere has pushed the lid up with sufficient violence to cause it to close down again immediately, by which means the fire is extinguished without any of the goods in the machine being even singed. Evidence confirming this, as an actual experience, was given by several witnesses from different factories.

(i.) The Committee recommended that all machines, tanks, vessels for rinsing, or hydro-extractors, should be provided with a balance lid or cover, which should be closed,

but not fastened down, during the operation of cleaning or rinsing. They should be so constructed that upon the occurrence of an explosion or fire they will, after being forced open, fall down again by their own weight. The Committee are aware that in the process of rinsing it is not often practicable to keep the vessel covered over. In such cases there should be attached to the ceiling, pillar, or beam above the rinser a cover door of iron. This should be so constructed and adjusted that in case of fire, by pulling a string or touching a catch, it will instantly fall down upon the vessel, and cut off the supply of air from the burning spirit. In practice, advantage has been derived from having the string or catch at some distance from the extinguishing cover.

(ii.) The soiled spirit from all washing and rinsing machines and hydro-extractors should, whenever practicable, be run off to the settlers or distilling apparatus in closed pipes.

(iii.) Sand should be kept in abundance close to all places in which benzine or naphtha is used.

(iv.) Blankets should also be kept in readiness in case of fire.

(v.) Men working in the processes in which spirit is used should wear woollen shirts and clothing.

(vi.) All rooms above the ground floor in which any of the processes of dry cleaning, involving the use of spirit, are carried on, should be provided with an outside emergency staircase.

(vii.) All dry-cleaning factories should be provided with hydrants, hoses, and an efficient water supply.

(viii.) Whenever possible, incandescent electric light should be used. Each incandescent light should be enclosed not only in the small glass globe which usually surrounds it, but also in an outer air-tight envelope of glass. In cases where electric light cannot be procured, the rooms in which mineral spirit is used should be lit from the outside, the light being separated from such a room by a thick air-tight partition of glass.

(ix.) Ventilation and air space in these processes are of paramount importance. In all places, rooms, or shops in which spirit is used there should be not less than 500 cubic feet of space to each worker. There should also be ventilators both near the floor and the ceiling of such rooms.

(x.) All young persons and women should be examined once per month by the certifying surgeon for the district,

who shall have power to order temporary or total suspension.

(xi.) A register should be kept of the date and result of his visit, and any requirement made by him.

(xii.) No food should be eaten in a place or room in which benzine, naphtha, or volatile spirit has been used, or in which goods saturated with such spirit have been placed, during that day.

(xiii.) Where more than twenty people are employed, the occupier should provide a dining-room for the workpeople.

81. In place of the permissive powers conferred upon local authorities by the *Petroleum Acts* and the *Explosive Substances Acts*, the Committee recommend that the duties of controlling and regulating the storage and use of benzine or other mineral spirit should be made compulsory. The *Factory Department, Home Office*, issued in July 1924 a memorandum on Dry Cleaning, from which the following has been extracted :—

Danger of Explosions.

The principal cause of explosions in dry-cleaning works is that textile fabrics moved about in benzine, either in the cage of a revolving washing machine or when being rinsed by hand in a tank, become charged with static electricity which may cause sparking and so ignite the mixture of air and vapour in the machine. It is possible to electrify benzine by passing it through pipes from one tank to another. This production of electricity is more likely to occur when the articles which are being washed are perfectly dry, as on a hot day ; actual experiments have shown [1] that when petroleum spirit was introduced into a tank under 5 or 6 atmospheres' pressure and with a humidity of 75 to 95 per cent. saturation, no electrical charges were produced, whilst with the air containing 57 per cent. of humidity and less, charges were invariably formed. It is interesting to observe in this connection that sparking due to the accumulation of a static charge appears more likely to occur when material with metallic trimming or tinsel is being cleaned. Probably the tinsel assists in the accumulation of a charge sufficient to cause a dangerous spark.

Several accidents have occurred just at the moment when the " wet " materials were being removed from a washing machine or rinsing tank. In these cases it is very possible that the electricity was discharged by a spark passing to the framework of

[1] *J.S.C.I.*, xxxix., 16th February 1920.

the machine or tank. The earthing of the machine, although recommended by some authorities, would not reduce this risk. It would appear that the only way of getting rid of such a charge safely is by allowing the machine to stand for some minutes, so as to give the charge time to leak away before opening the cover, and where this is done the efficient earthing of the machine is an additional advantage.

Precautions to Prevent Fire or Explosion.

Use of High-flash Spirit.—In one works petroleum spirit of sp. gr. 0·800, flash-point 80° F., and boiling between 143° F. and 220° F. is used and the risk of explosion is correspondingly reduced. With such heavy spirit the formation of a dangerous mixture of vapour and air is not so likely to occur. The disadvantage of such a system is that the recovery of the spirit has to be effected by vacuum distillation.

Use of Humidifiers.—All rooms in which spirit is used should be humidified by jets of steam or water so as to maintain a condition of at least 70 per cent. saturation. Wet- and dry-bulb thermometers should be provided in such rooms, and should be read several times a day, a suitable record of the readings being kept beside the thermometers.

This provision of artificial humidity is probably one of the most important methods available for preventing fires.

Use of Special Soaps.—The use of magnesium and aluminium oleates mixed with the benzine with a view to improving its conductivity, and so rendering the accumulation of a static charge less likely, is recommended.

Exclusion of Air from Machines.—Washing machines, centrifugal and rinsing machines, etc., should be fitted with lids provided with springs, so that if an explosion occurs the lid will be thrown back to the closed position and thus cut off the air supply. If the machine is used normally with the lid open, as in the case of rinsing machines, the lid should be held open against the action of a weight on it by an easily fusible link which will melt in the case of fire and allow the lid to close.

Where drying tumblers are used for the purpose of removing the last traces of spirit from cleaned clothing, they should be provided with safety-spring covers which will return to the closed position after an explosion, thus cutting off the air supply. Some machines are now available fitted with spring lids, which, if blown open by an internal explosion, open valves and admit steam or carbon dioxide gas to the inside of the machine.

American authorities suggest that live steam should be turned on to drying tumblers for 5 minutes after the dry-cleaned garments are placed in the cage, so that any static charge may be dissipated.

In some special dry-cleaning processes the air in the washing machines is replaced by carbon dioxide gas. The machines are used in the first place as ordinary washers, and, when the washing is complete and the spirit has been run off, the cage is rotated rapidly so as to remove the last traces of benzine by centrifugal force. In processes of this type there is little danger of ignition, and there is no doubt that, even in the case of ordinary washing machines, prevention of fire would be attained by connecting each machine to a carbon dioxide cylinder, so that this gas could be used to replace the air in the machine at the beginning of an operation, a final injection being given just before the machine is opened for emptying.

Conveyance and Storage of Benzine.—In the larger works benzine, both dirty and clean, is stored in underground tanks and conveyed to and from the various machines in pipes. It is very desirable that these methods of storage and conveyance should be followed generally. In some German factories the spirit is stored in tanks the free space of which is filled with carbon dioxide gas under pressure. The pipe lines have double skins, the main tube conveying the liquid and the outer pipe the carbon dioxide gas, so that in the event of a breakage the gas escapes and the drop in pressure causes the liquid to run back to the reservoir.

Intercepting cocks should always be fitted between storage tanks and the machines which they supply, and it is desirable that arrangements should be made so that it is possible to control these cocks from outside the building.

Arrangement of Building.—In every dry-cleaning room the floor should be of concrete or similar material, and each doorway should be provided with a deep sill designed so as to contain the whole of the benzine used in that particular room if by an accident it is spilled. The still room and storage rooms should be entirely separated from the dry-cleaning room by means of fireproof walls, and in the case of underground storage or still rooms particular care should be taken to provide a ready means of escape.

In some dry-cleaning rooms the roofs are provided with relief openings fitted with covers, which lift upwards and relieve the pressure in case of an explosion, and so prevent damage to the main structure. The covers should be so designed that they will be self-closing.

Means of Escape.—The doors of each room should be arranged to open outwards and should be fireproof, so that in the event of a fire the room can be isolated whilst steam or some other extinguishing gas is injected. Sliding doors are not desirable, as they may prevent the rapid escape of persons from the room.

Ventilation.—Every room in which benzine is used should be well ventilated. In the case of an underground storage or still room it is specially important that mechanical exhaust should be provided at the ground level with sufficient overhead inlets for fresh air as recommended by the *Petroleum Committee.* Any exhaust ducts which are used should be so arranged that they will not in case of fire draw the flames from one room to another.

Apart from the risk of fire and explosion, good ventilation is necessary in order to mitigate the intoxicating effect of benzine vapour. When this is not considered, fainting and hysterical symptoms are not uncommon, especially in women under twenty-five years of age. Other symptoms have been irritation and pain in the eyes, headache, dizziness, excitability, followed (late in the afternoon) by drowsiness and a sense of exhaustion.

Natural Lighting.—The windows should be of reinforced glass, so as to prevent splintering of the glass and admission of air in case of fire, and they should be so arranged that they can be closed from outside. Other openings, such as ventilators, vent tubes, and doors, should also be controlled from outside the building.

Artificial Lighting and Use of Electricity.—Every dry-cleaning room should be lighted if practicable by electricity. The fuses and switches should be outside the room, and the leads should be properly enclosed in fireproof tubes. All lamps should be provided with gas-tight covers. If gas is used, the lamps should be placed outside the windows.

Electric motors, if used, should either be enclosed so as to prevent danger from sparking, or be installed outside the room.

General Arrangement of Plant.—All machines containing spirit should be provided with some kind of vent or relief attachment, so that in case of a rise in temperature the pressure may be relieved. Fires have been rendered much more disastrous through the bursting of vessels on which such relief has not been provided.

Where washed material, still "wet" with benzine, has to be removed from the cleaning machine to the centrifugal machine, it is most important that this should be done by means of a properly covered container on wheels, the lid of which is close fitting and the bottom of which is provided with a perforated grid, or draining plate, to allow the spirit to drain into a bottom compartment of the vessel. The container should be so shaped

that it can be run close to the washing machine, and thus prevent wetting of the floors. The wheels of all trolleys should be of gun metal or brass, or be rubber-tyred, in order to avoid sparking. All movable vessels used for holding benzine should be of such design that they are not easily overturned, and should always be provided with covers. Tanks containing spirit should never be placed in the direct passage between a dry-cleaning machine and the door.

Waste spirit should never be allowed to run into drains, and any rinsings from brushing tables, etc., should be at once drained by suitable pipes to a proper receptacle. Where necessary, drains should be provided with intercepting traps.

General Precautions.—Materials should never be dried directly before being washed, since a static charge is more likely to be formed if the materials are free from moisture.

No person should be allowed to smoke, or to take into any part of a dry-cleaning works any naked light, lamp, matches, or any apparatus for producing a naked light or spark.

No person should be allowed to work alone in a dry-cleaning process.

Empty barrels which have contained petrol are extremely dangerous, and they should be clearly marked. Several fatal accidents have arisen from explosions caused by persons using naked lights to examine the inside of empty barrels which had previously contained inflammable liquid.

As a fire might cut off the ordinary exit by the door there should be alternative means of escape by an inside staircase ; if the room is not on the ground floor all persons employed should have clear instructions what to do in case of fire, and a periodic fire drill is to be recommended.

Means of Extinguishing Fire.—It is recommended that any tank above ground should be fitted with a carbon dioxide supply pipe, so that in the event of a fire, carbon dioxide may be blown upwards through the liquid so as to extinguish the flame. It is much more satisfactory to inject the gas through the liquid in an upward direction, since in some cases an injection of gas at the top of the tank has failed, the flames from the tank causing an upcast current of hot air which carried the carbon dioxide gas to one side and so prevented it from blanketing the flame. Where such tanks or other vessels are fitted with gauge glasses, it is desirable that these should be protected from accidental breakage. In one factory control wires are provided, so that in the event of a fire the gauge cocks can be turned off from outside the building. Through lack of such arrangements a fire at a factory was rendered

much more serious, the gauge glasses breaking and liberating the benzine.

In America the use of tell-tale float gauges is recommended instead of glass gauges.

For the purpose of extinguishing benzine fires various methods are in use, including the provision of asbestos sheets, sand, and chemical fire extinguishers. There should be ample water supply, with hydrants and hose, in order to prevent the extension of flames, but water should *not* be used in attempts to extinguish burning spirit. For the latter purpose blankets and a supply of sand should be kept in readiness. The extinguishers, which produce soapy foam and so smother the fire, are said to be particularly effective.

Where sand is provided, it is advisable that spades should also be available.

If the building is suitably constructed, as described above, it should be possible in the event of a fire, by means of the various appliances mentioned, to close all openings entirely by means of the outside controls, and to inject gas or steam.

Notes on Memorandum.

1. The degree of moisture or dryness of the air can be determined readily by means of the hygrometer. There are several forms of this instrument obtainable at small cost. The one in common use is known as the wet- and dry-bulb hygrometer; instructions as to its use will be given on application to H.M. Inspectors.

2. To prepare a suitable dry-cleaning soap, dissolve 1 kilo of caustic potash or caustic soda in 4 kilos alcohol. To each litre of this solution add $1\frac{3}{4}$ litres oleic acid and heat the mixture. To keep the salt in solution add to every 100 parts of the mixture, either before or after heating, 250 parts carbon tetrachloride, benzol, benzine, or other suitable solvent. Any other soluble oleate may also be employed.

The *Incorporated Association of London Dyers and Cleaners* was invited to "cause a considered statement to be prepared, setting out the conditions under which petroleum spirit is used, etc., in the process of cleaning, with any recommendations or observations which they might wish to make."

The Council of the Association gave much time and attention to the subject, and the following is the statement and schedule of recommendations which they submitted to the Departmental Committee.

STATEMENT AND RECOMMENDATIONS.

Dry-cleaning Machinery and Modern Methods of Cleaning.

The goods which are submitted to the dry-cleaning process include articles of wearing apparel, household drapings and furnishings, fancy articles, etc.   They are roughly assorted according to their colour, fabric, and condition into several classes.   The superficial dust is sometimes removed by revolving them in a dust wheel.   The portions of the articles which are unduly dirty are brushed on a slate or marble slab with a strong solution of benzine soap before the articles are placed in the cleaning machine. Brushing slabs are slightly inclined, and fitted with a trough at the back to collect the spirit running off the slab, and this is led by means of a pipe to a tank or other closed receptacle.

The machines generally employed for dry cleaning may be divided into two classes, viz. :—

A. **Open-circuit type.**
B. **Closed-circuit type.**

The former type is subdivided into three classes, viz. :

Class A.—Open-circuit Machines.

Tumblers.—The older type of tumbler machine consists of an iron cylinder from 3 to 4 feet long and about 1 foot 6 inches in diameter, revolving or oscillating upon bearings, whereby its contents tumble from one end to the other.   A spirit-tight door fastened with wing-nuts enables the goods to be introduced and removed, and a vent pipe passing through one of the bearings to about 1 inch above the highest point of the machine prevents the accumulation of gases under pressure.

Inclined Cylinder.—The inclined type of machine is used for dry cleaning, and is suitable both for steam and hand power.

Horizontal Cylinder.—The type of machine generally employed in dry cleaning is the ordinary cylindrical cleaning machine, revolving or oscillating about its axis.   It consists of a fixed outer cylinder of metal, inside which is the revolving cylinder of slightly less diameter, in which are placed the articles for cleaning, a suitable door being provided for their introduction and withdrawal.   The outer cylinder is provided with a door giving access to the inner cage.   The material of which the inner cage is constructed depends to some extent upon the class of

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work for which it is intended, the materials generally employed being wood (maple or beech), sheet or tube steel (plain, tinned, or galvanised), brass or aluminium.

Rinsing Tank.—Rinsing is generally carried out in the cleaning machines, but it is usual to provide rinsing tanks, as articles are frequently dealt with which cannot be cleaned in machines. The one usually employed consists of a galvanised or tinned iron receptacle with or without a false bottom, and provided with pins or pegs over which the articles are placed to drain, and fitted with a lid. If the rinsing is done in the machine, two separate rinses of clean benzine (without soap) are given, the machine being run in each case for about 5 minutes. The goods are then put into a centrifugal machine, shaken out, and hung in a steam-heated room until quite free from benzine.

Centrifugals.—Those employed are generally of the under-driven type, as a tight-fitting lid may then be employed. The most satisfactory results are obtained with balanced cages, as higher speeds may be attained, and consequently a larger quantity of spirit recovered for subsequent use.

Method with Class A.—The articles for dry-cleaning having been sorted, the white goods are cleaned with freshly distilled spirit. The necessary amount of spirit is run into the machine, and a sufficient quantity of the stock solution of benzine soap is now added to give a solution of from 0·5 per cent. to 1 per cent. by weight, and the goods are introduced. The door of the machine is closed, and it is run from ten to fifteen minutes. If the goods are much soiled it may be necessary to machine them for as long as half an hour.

Class B.—Closed-circuit Machines.

The principal method employed is that patented by Barbe, and several installations are now working in this country. In this process the operations of cleaning, rinsing, centrifuging and drying, all take place in the cylinder, and, to avoid the risk of explosion, the air in the apparatus is displaced by carbon dioxide.

The cleaning cylinder is of the ordinary type, but of specially heavy construction to permit it being run at a high speed when employed as a centrifugal. The outer casing of the machine is jacketed, and can be steam-heated when required; it is fitted with an air-tight lid for introducing the articles to be cleaned. The chief advantages of the above process are practically the elimination of the risk of fire and the recovery of almost the whole of the solvent employed.

Glove Cleaning.

This work as properly and safely carried out consists in first cleaning the gloves by hand, sometimes in a " brushing machine," in which they are brushed while immersed in spirit; they are then transferred to a covered metal vessel from which they are taken for the following processes : for examination, for brushing (when necessary) the individual fingers, etc. on a stick to remove dirt not taken out by machine brushing, shaping on a wooden or metal " hand," and drying. After drying they are frequently polished or softened before removing from the " hand."

Appendix on Hand Glove Cleaning, Etc.

Gloves and other small articles are cleaned very frequently surreptitiously by small traders having no mechanical appliances. In many cases it will be found that the work is done under extremely primitive conditions, being carried out in kitchens and other living rooms, which are heated by open fires or illuminated by exposed gas-jets. As the quantity of spirit dealt with is frequently not large enough to make it worth while to send the dirty spirit back to the distiller, it is used until a semi-solid, greasy, inflammable mass is obtained, which is thrown on to the ground or down the drain.

If the process is not carried out in the house it is done in a shed in the yard, or otherwise in close proximity to a dwelling-house. We are of opinion that the whole process so conducted is from beginning to end a source of serious danger.

Remarks Preliminary to Recommendations.

1. It should be said that many of the recommendations here made have been previously issued in the documents of the Home Office and the L.C.C.

2. The high standard of structural conditions set up is a " counsel of perfection " and perhaps not reached even by the best-appointed cleaning houses in the United Kingdom. The Council submit that such severe structural requirements ought not to be enforced on existing licensed premises, which have been constructed or altered at various times at great expense, to meet the conditions of the Licensing Authorities, and fully meet their requirements at the present time. It would create great hardship, for it would necessitate the closing of many cleaning houses

in the Metropolitan District in which the trade has been carried on for many years with practically immunity from accident.

3. Most of the suggestions here made have no value at all in workshops which are exclusively devoted to the Barbe or similar closed-circuit process (by which, however, all classes of work cannot be done), and this ought to be made clear in any memorandum issued. The almost absolute safety of this process is much in its favour.

4. The term *spirit* shall be held to include petroleum benzine, solvent naphtha and other inflammable spirits, as defined in the *Petroleum Acts*, 1871–1881.

RECOMMENDATIONS.

Structural Conditions.

With regard to dry-cleaning houses, the Council think the following are among the chief points of construction desirable :—

1. They should be on the ground floor only, free as much as possible from the sun's heat, constructed of non-combustible materials, with ample space, not overcrowded with machinery and appliances, well ventilated at the floor and ceiling levels, the roof lightly constructed of incombustible materials, and the doors not opening inwards. A cement floor from the cleaner's point of view is the most desirable, and, in a well-ventilated workshop, perfectly safe. It should, if possible, be lower than the level outside the building, so that all spirit may be retained inside the building in case of fire. This result may be easily attained where such an arrangement is not possible by putting a raised step at the door.

2. The distilling and storage should be separated in every case, if possible, from the cleaning house, by a party wall without openings. With very large licences all the buildings should be detached.

3. An alternative means of escape should be provided, unless the Licensing Authority is of the opinion that under reasonably safe conditions it is unnecessary.

4. In those having licence for over 40 gallons, facilities for injecting steam in adequate quantities should be provided.

5. The access of spirit to the public sewer from the licensed buildings should be made practically impossible by an efficiently constructed trap or traps.

Internal Arrangements.

They are of opinion that the following arrangements are desirable in every cleaning house, distillery, store, and drying room :—

Lighting.

1. Such artificial light as would ignite inflammable vapour should be excluded. Incandescent electric light in air-tight globes is the only safe artificial illuminant. Leads should be enclosed in screwed metal barrels efficiently earthed, and all switches, fuses, etc., fixed outside the building.

2. Where electric light is not available, thick glass air-tight windows should be constructed, through which light may be transmitted to the room.

Ventilation.

Thoroughly efficient ventilation should be provided, so as to prevent an accumulation of spirit vapour at the floor level. In situations where it is impossible to obtain natural ventilation, a mechanical system should be adopted.

Safety Fittings.

1. Cleaning machines and rinsing tanks should, as far as practicable, be kept closed, and the spirit be conveyed to and fro by means of pipes. At a suitable point or points, traps impervious to flame should be fitted. The machines should be constructed entirely of metal, and have covers lightly balanced, or outlets arranged in the roof of machine, constructed so that if forced open by explosion, the cover of machine, or small flap covering of the outlet, should fall by its own weight.

2. Rinsing tanks for the same reason should be provided with balanced lids attached to a chain or cord run over grooved pulleys to a counter-balance weight or release lever at some distance from the tank. When only one or two men are employed in the cleaning house the lid should be held balanced by a cord or chain, passing down the back, and entering the tank with a fusible wire fastening fixed above the level of the spirit in the tank.

3. Cleaning machines, rinsing tanks, etc., should have an intervening control cock between them and the storage tanks, fitted outside the cleaning house wherever possible.

Earthing Machines, Etc.

Cleaning machines, rinsing tanks, and shafting should be electrically earthed.

Fire Extinguishers.

The demonstration at the testing station of the *British Fire Prevention Committee* has conclusively proved :—

(a) That asbestos sheets are an effectual means of extinguishing burning spirit, even over large surfaces, under conditions relatively possible in the dry-cleaning industry. They should therefore be provided in sufficient quantities and in positions easily accessible.

(b) That steam is also an effectual extinguisher. Pipes for an ample supply of " live " steam where available (note previous recommendation) should be fitted round the walls about 7 feet or 8 feet from the ground with openings at intervals inside the cleaning house. The valves should be fixed outside and be easy of access in case of emergency.

Sand and spades for shovelling should also be kept in ample quantities within easy reach.

Health and Clothing.

Females should not be employed, and food should not be taken, in the dry-cleaning houses. The Council attach very little importance to the requirement " that all persons employed should wear woollen or other non-inflammable outer garments." It is irritating to the men, difficult to enforce, and of little practical value. The same may be said with regard to " boots or shoes with exposed iron." The cleaning houses are constantly visited by engineers, porters, and messengers for various purposes. If the floor level of the room is efficiently ventilated no such provision is necessary.

The question of ventilation, not only for reasons of safety from fire, but also for the health of the workers, is of supreme importance.

The Sale and Distribution of Spirit for Cleaning Purposes.

The Council are strongly of opinion that the present regulations controlling the distribution and sale of spirit are very inadequate.

Spirit is conveyed through the streets of London daily in large quantities in cans containing from 2 to 10 gallons. There is a regular system of delivery to cleaners, and also collection of soiled spirit for redistillation, making it difficult for the Inspectors to detect infringement of the licences.

They recommend :—

1. That the amount allowed to be kept on any unlicensed premises should not exceed 1 gallon, and that clause 7 of 34 & 35 Vict. cap. 105 should be altered accordingly.

2. That it be an offence for a vendor to sell or deliver spirit to any unlicensed person in larger quantities than 1 gallon.

3. That a licence be required in every case in which more than 1 gallon is kept on the premises, and the purpose for which it may be used should be stated in the licence, and its use for that purpose only should be restricted under penalty. Where a licence for user only is granted, any sale of spirit by the licensee should be prohibited.

4. That a counterfoil order book be supplied by the Licensing Authority to every licensee in its district, the amount for which the premises are licensed being stamped on each order. That no spirit be supplied to any licensee except on receipt of an order from this book, and that it be an offence for the vendors to deliver spirit without such order. It shall be an offence for a vendor to make a delivery in excess of the maximum quantity specified upon the order. The order books shall be open for examination by the Inspector of the Licensing Authority at all times.

5. That every vendor of spirit shall be required to keep a register and enter therein an account of his sales to licensees.

6. That power be given to the Local Authority to obtain from any vendor information as to quantities sold to any person or delivered to any licensed premises, and to inspect books for that purpose, if the Inspector has reason to believe that such spirit is for use in unlicensed premises, or that the terms of any licence are being infringed.

7. That it be an offence to throw spirit down the gully of any drain in connection with a public sewer.

Personal Injury.

In every case where a fire from petroleum spirit takes place upon unlicensed premises, and any person or persons are injured, the medical man attending such persons shall report the occurrence to the Licensing Authority.

General Observations.

1. The Report of the Departmental Committee of the Home Office, 1896, states that precautions in London are strictly maintained and enforced by the L.C.C. Steps should be taken to ensure an equal standard in all parts of the United Kingdom, and it should be compulsory on the Local Authorities to enforce it, otherwise the London cleaning trade is unfairly handicapped in competition.

2. The Memorandum on Dry Cleaning issued by the Chief Inspector of Factories (Form 824—1906) seems to us to mix up the two questions of injury to health and danger to life on the one hand, and injury to property on the other. With the latter they submit the Home Office has nothing to do—it concerns the Licensing Authority only ; and although it may be considered advisable for the information not only of dry cleaners who may be building, but also of the Local Authority, to include in the *Memorandum* recommendations on structural questions—the administration of such regulations ought to be left in the hands of the Local Authority. They are aware, on the other hand, that some Local Authorities frame conditions for licences on points which we submit are *ultra vires* ; for instance, the provision as to woollen clothing. Two authorities overlapping in such regulation is most undesirable and harassing to trade. The line of demarcation ought to be clearly drawn.

3. The same Memorandum recommends :—

(*a*) " That steam be injected into the building to correct the dryness under certain atmospheric conditions." They submit this recommendation from the cleaners' point of view is inadmissible. Dampness is injurious to good cleaning. The drier the goods the better the cleaning. Wool particularly is very hygroscopic. An open vessel containing water standing in the room is sufficient safeguard against the atmosphere becoming too dry.

(*b*) " That small quantities of certain soaps be used with the cleaning spirit to render it less liable to ignition by electric sparks." They think that the use of soap of various kinds is almost universal in cleaning, and sufficient is carried over even to the last rinse to provide satisfactorily for safety. These soaps are made by different manufacturers, and some firms make their own. No recipe is therefore necessary.

4. Instructions be given to fire brigades on no account to use water in attempting to extinguish blazing spirit.

In conclusion, it must be understood that my Council make no claim to speak for the cleaning trade as a whole, but only for that portion of it carried on in London and the six home counties represented by our Association.

<div style="text-align:center">I am, Sir,
Your obedient Servant,
(Signed)   W. B. NEWMAN,
<i>Secretary.</i></div>

To Major T. H. Crozier,
    Secretary, Petroleum Committee,
        Home Office,
            Whitehall, S.W.

<div style="text-align:right"><i>25th February</i> 1909.</div>

In addition to the " considered Statement " of the Incorporated Association, two members were deputed to give evidence before the Committee ; the First Report of the Departmental Committee (Cd. 5775), in dealing with the Statement, says it " gives very full recommendations both for the structural conditions and internal arrangements of dry-cleaners' establishments, which deserve the closest consideration by all connected with this trade or its regulation.

" It is true that they describe their recommendations as to the structural conditions as a ' counsel of perfection,' that they advocate these only for new buildings, but even so they serve as an admirable guide, and the Committee is in general agreement with them."

The Report also refers to the endeavours of the London County Council to discourage the practice of domestic dry cleaning— " perhaps the most prolific source of fatal accidents at the present time."

In the *Times* of 2nd January 1909 appeared a letter from the Chairman of the Public Central Committee of the L.C.C. (Mr Wm. Haydon) dealing with this subject.   The concluding paragraph is reprinted in full :—

" Much advice has been tendered as to the precautions to be taken in using petrol in the home.   It is only a shade less mischievous than teaching a child how it may safely play with fire.   There is only one proper course.   Words of caution are

neglected, or never properly reach the intelligence of the user of the spirit, or are forgotten at the critical moment. Dry cleaning should be done only on the premises of the licensed dry cleaner, where skilled workpeople are employed, suitable apparatus provided, and all precautions taken against accident."

General Notes.

Construction.—The construction of premises, ventilation, and artificial lighting have been fully considered in the Statement of the *Incorporated Association of London Dyers and Cleaners*, and only needs the amplification of certain important points.

It cannot be too strongly emphasised that in a well-constructed and well-conducted works the danger is very small, and many of the precautions which have been insisted upon in the past are quite unnecessary if efficient ventilation and satisfactory construction exist. For example, the insistence of the use of boots without exposed iron is quite superfluous if thorough ventilation makes it impossible for an explosive mixture to exist.

It is an advantage where glass is employed in side windows that it should be made with embedded wire, which may crack in case of fire, but will not fall to pieces or allow flames to pass.

In arranging for the ventilation of rooms, the fans or outlets should be placed on the floor level, the vapour of benzine being considerably heavier than air. The duct for discharging the mixture of air and vapour must be above the roof level of the building. Efficient ventilation fulfils the double purpose of minimising the risk of fire and of rendering the process more healthy for the operators.

Machinery and Fittings.—In all moving parts where there is a possibility of electricity being generated by friction, the machines or parts in question must be efficiently earthed ; *i.e.* they must be connected by copper wire with a copper plate buried in the earth (in the same manner as with a lightning conductor). As most dry-cleaning rooms are fitted with concrete floors, it will be found that unless earthed through pipe fittings the machines are insulated and will store up any current generated until it is of sufficient potential to produce a spark when approached by a body of lower potential, *e.g.* an operator who may be earthed through holding on to a pipe or machine which is earthed ; the spark, of course, may ignite any benzine vapour mixed with air through which it passes. Special attention must be paid to overhead hydro-extractor counter shafts, as electricity is frequently generated by the " slip " of the belt when first thrown from the loose to the fast

pulley. Certain classes of silk and wool fabrics, when dry, are readily electrified by friction ; and as dry benzine is a non-conductor, the goods when brought in contact with the edge of the machine in unloading may produce a spark. This risk is largely reduced by the fact that benzine may be converted into a conductor by the addition of a small quantity of magnesium oleate. Any electricity is conducted to the metal of the machine as soon as generated, and at once dissipated if the latter is efficiently earthed.

This property of magnesium oleate was discovered by M. M. Richter in 1893, who found that the addition of 0·02 to 0·05 per cent. rendered the benzine incapable of (so-called) spontaneous combustion. Other oleates act in the same way, though in a less degree, a larger amount than 0·02 per cent. being required. The quantity of potassium oleate (or other soluble oleate) employed as benzine soap is more than sufficient to convert the benzine into a conductor of electricity. It is in the process of rinsing, where, of necessity, no benzine soap is employed, that " spontaneous " fires usually occur, as certain articles become electrified during the friction of rinsing, and spark when brought in contact with the edge of the machine when being withdrawn. To reduce this risk as much as possible when rinsing in open tanks, a metal plate or grid should be placed inside the tank and should be properly earthed. Each time the goods are raised or lowered in rinsing they should be drawn over this plate to remove any electric charge which has been generated.

The lids of all machines should be counter-balanced, and in the length of cord or chain employed there should be a unit consisting of two pieces of brass soldered together with " fusible alloy " melting at a low temperature—say 110° C. to 120° C. In the event of a fire occurring, the solder would melt and the lids of all machines would close at once.

The damage in case of fire is not so great as that caused by an explosion due to the flames passing down the pipes, etc., to tanks containing benzine and air. This danger may be removed by the employment of various makers' safety fittings. These consist of a combination of the Davy safety-lamp principle with a fusible or gravity plug and plunger, which automatically releases the gases from the benzine before the pressure can cause the tank or machine to wrench, leak, or explode. It is in the form of a cylinder, and is fitted to the inlet and outlet of each machine or tank ; no flame can pass it.

Leakage.—The benzine must be distributed to the various machines under seal in pipes, and where permanent fittings

cannot be employed (as in the Sunflower machine), flexible metallic couplings, fitted with screw caps when not in use, must be coupled and uncoupled each time the machine is filled or discharged. All joints must be well made to avoid leakage, and in this connection it is necessary to point out that ordinary jointing material (*e.g.* red lead) cannot be employed, owing to the solubility in benzine of the oil which it contains. Glue with or without the addition of a small quantity of potassium bichromate or chrome alum (to render it insoluble in water) gives the best results in pipe and other joints where benzine is employed. It is better to avoid all joints in pipes and in tanks by employing welded pipes and welded tanks, when leakage (except from faulty workmanship) is impossible. Such pipes and tanks can now be obtained for most of the purposes of dry cleaning—storage tanks, stills, pipe work, etc. The Steel Barrel Co. make electrically welded tanks for Barbe installations suitable for storing hot benzine under a pressure of $1\frac{1}{2}$ atmospheres. They also make an electrically welded still. The advantage of the balanced hydro-extractor over the fixed spindle type is noticeable here, as with the reduced vibration of the outer casing the risk of joints being broken is minimised.

Fires.—The methods of dealing with fires due to benzine have been thoroughly investigated by the *British Fire Prevention Committee,* and the results of the tests made have been published in Red Book No. 133.

The series of tests was made on 2nd December 1908 at the testing station of the British Fire Prevention Committee, and included the use of asbestos sheets, sand, and steam as applied to burning petroleum benzine.

The asbestos sheets employed in the tests measured about 6 feet square, and were about $\frac{1}{32}$ inch thick; they were soft and pliable and very readily handled for use. The tests were made with rinsing tanks, open tanks, open troughs, trolleys, brushing-tables, etc.

Tests.—Using an ordinary rinsing tank, the lid of which could be released by a rope, 6 gallons of petroleum benzine, sp. gr. 0·756, were put into the tank, and garments saturated with the spirit were hung on the peg. After ignition the lid was closed by releasing the rope; the lid did not entirely cover the opening, and the fire was only partially smothered; asbestos cloths were applied, and the fire was extinguished.

In another test it was assumed that the lid was out of order, rendering it impossible to close the tank. The men, owing to the protection offered by the asbestos sheets, were able to approach the blazing tank quite safely; the opening was covered

by the sheets, which were held in position by hand, the fire being extinguished in 52 seconds.

In the tests with a 'brushing-table, a slate slab 6′×3′ was employed, there being placed upon it clothes saturated with spirit, bowls containing spirit, etc. In this test asbestos sheets were quite effectual in putting out the fire; in a similar test in which sand was employed, eight bucketsful extinguished the fire in 1 minute 25 seconds.

Equally successful results were obtained with a trolley containing blazing spirit and textile material, the fire being extinguished in 44 seconds.

To test the effect of steam in the extinction of spirit fires, a room was employed measuring 10′ 0″×22′ 3″×8′ 0″ high; it was fitted with a 1-inch steam-pipe supplying four ½-inch outlets. The initial boiler pressure was 85 lbs.; but the boiler being of somewhat small size, the final pressure was much lower.

In this test a table 6′×3′ was in the centre of the room; on it were four shallow tins each containing spirit, and textile goods saturated with spirit. After ignition the doors were closed and steam turned on. The fire was extinguished in 20 seconds in one test, and 32 seconds in a second test.

The Red Book gives the following summary :—

" The following is a summary of the results of the tests by the Committee—

" The tests demonstrated the complete efficiency of asbestos cloths in putting out burning spirit vapour.

" In the case of burning materials it was demonstrated that asbestos cloths could be of use in confining the fire until other appliances were brought into play.

" *Note.*—The efficiency of sand was demonstrated where it can be employed to soak up spirit, the vapour of which is ignited.

" The efficiency of steam, as applied, was demonstrated where a building in which the fire is burning can be closed up, so as to exclude as much draught as possible."

Foamite.—The use of ordinary "chemical" extinguishers, depending upon the generation of carbon dioxide to force out the water or aqueous solution contained therein, is not usually satisfactory for blazing benzine. One reason for this is that water, being heavier than the benzine, sinks through it, and any carbon dioxide generated is dissipated before it has any opportunity of acting as an oxygen excluder.

The inventors of *Foamite* applied the novel principle of incorporating in their solution a viscous substance capable of imprisoning the bubbles of carbon dioxide in a finely divided

form in tenacious envelopes, thus giving in effect a blanket of inert gas which floats on the burning liquid and extinguishes it by the exclusion of air.

The substance employed (*Foamite*) is an extract of liquorice root in a highly concentrated form, containing about 50 per cent. of water. The solutions recommended by the makers as giving the best results are :—

<div align="center">

No. 1.

</div>

Foamite	3 per cent.
Sodium bicarbonate . . .	8 ,,
Water	89 ,,

<div align="center">

No. 2.

</div>

| Aluminium sulphate . . . | 11 per cent. |
| Water . . . . . | 89 ,, |

These two solutions, when mixed, produce approximately ten times their volume of carbon dioxide, which is held in the form of a very fine but very tenacious fluid foam.

It may be employed in a fixed plant or in portable extinguishers ; in the United States it has been used with great success in connection with large oil containers. The arrangement recommended consists of two storage tanks for the two solutions ; from each tank a suction line runs to a duplex pump and the two delivery lines, one for each solution, run to a mixing tee outside the tank to be protected. Here the solutions combine and react, the fine and tough foam overflowing and spreading over the surface of the oil. This system of " positive " distribution ensures the very rapid delivery of the foam, and could be readily adapted to dry-cleaning machines ; the foam could be delivered into any or all of the machines merely by starting the pumping plant.

The makers lay particular stress on the mixing of the solutions as close as possible to the protected machine ; admixture at or near the pump results in reduced efficiency, and much larger pipes and valves are required.

It is not essential that the mixing should be done at the point of protection ; the foam can be used through an ordinary fire hose and directed on to any machine by hand. For ordinary purposes of calculation it is found that a quarter of a gallon of each of the solutions is sufficient for each square foot of oil surface, though half the amount will frequently prove effective.

The author has carried out experiments on small test fires

with *Foamite,* using a type of portable extinguisher. The results obtained were quite satisfactory.

The " foam," after drying, brushes away without any trouble, so that any articles undamaged by fire are not damaged seriously by the " foam."

Simonis' Continuous Foam Generator.—A patent continuous foam generator using a single powder has been introduced by Simonis, Ltd. The apparatus is connected to an ordinary water hydrant, and the foam-producing powder is fed into the apparatus from a hopper on the top. A by-pass of the water inlet wets the powder as it falls from the hopper, and as the water and powder become mixed, they leave the apparatus as foam. The pressure of the inlet water is utilised for propelling the foam by ejector action. The quantity of foam generated is equal to about eight times the quantity of water passed into the apparatus. In order to throw a jet of sufficient length, the minimum water pressure is 45 lbs., and at this pressure the standard fire-brigade size of foam generator has an output of 200 gallons of foam per minute.

A great advantage of this type of foam machine is that, as long as a supply of the powder is available, the machine will produce an unlimited supply of foam. With the usual portable or run-about type of extinguisher, immediately the machine is empty it ceases to be of further service until refilled.

Recording Percentage of Humidity in the Air.—All dry cleaners should keep a hygrometer fixed in the room or rooms where benzine is employed, and to ensure that it is noted each day a record of the percentage of humidity should be entered in a book. For daily use the most convenient form of hygrometer is the *Hygrodeik*; by moving a pointer along the temperature curves of the two bulbs the point of intersection gives a direct reading of the percentage of humidity, and if it is required, a table shows the actual weight of moisture per unit volume.

The danger-point is probably determined more by the actual weight of water per unit volume than by the percentage of humidity, but until some more definite basis is laid down it should be taken that 65 to 70 per cent. is the danger limit. If a fall below this occurs, special precautions should be taken by hanging up wet cloths or by using a humidifier.

Should a fire occur, *water must not be used*; the lids of machines should be (if possible) closed, and the fire should be smothered by means of asbestos sheets, blankets, sand, or, if these are found to be unsatisfactory, *Foamite* extincteurs used. In actual practice the

author has found that workers have great confidence in asbestos sheets, as they are able to approach the flames with safety to themselves. In fact, confidence in the appliances available is of the utmost value, and occasional tests with the appliances on waste land give the workers the necessary faith in the means at their disposal. The workers should thoroughly understand that the structural precautions adopted in modern plants are such that there is very little likelihood of a fire spreading ; they should also understand that nearly all fires are due to the carelessness of operatives, and can be avoided if they exercise all possible precautions. Should there appear to be any danger of a fire spreading, the fire-proof doors should be closed and steam should be blown into the room affected.

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