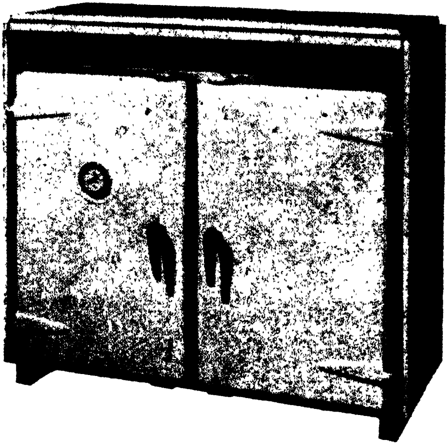

R.C 451

MOLESWORTH'S
AERONAUTICAL ENGINEERS
POCKET-BOOK

MOLESWORTH'S AERONAUTICAL ENGINEERS POCKET-BOOK

COMPRISING INFORMATION AND DATA USEFUL TO THOSE ENGAGED IN THE DESIGN OF AIRCRAFT AND THEIR ENGINES

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Second Edition

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PREFACE TO SECOND EDITION

ORIGINALLY prepared during the war years, this Second Edition of *Molesworth's Aeronautical Engineer's Pocket Book* has been subject to considerable modification and delay. These modifications have been due to the Editor's sincere desire to publish as much up-to-date and useful information as practicable; the delay has been caused by the extreme difficulties experienced by the publishers owing to shortages of both labour and materials.

Hence it has failed in its original object—to assist the war effort—but the Editor feels justified in presenting it in its present form since it contains so much matter of vital, everyday importance to designers, draughtsmen and technicians, not only in the Aircraft Industry but throughout the whole range of the engineering professions. The Editor is in possession of a very great quantity of additional material, so modern that it has not been released in time for inclusion in the present volume. Hence the Third Edition, when it appears, will be found to fill the gaps left in the Second Edition caused by the circumstances under which it was prepared.

In January 1916 the Editor, then an officer in the Royal Flying Corps, was made responsible by General McInnes of the Military Aeronautics Directorate for the safety of design of all British military aircraft. He retained this position until towards the end of 1917, when he was placed in charge of metal construction of aircraft for the Air Board, which subsequently became the Air Ministry in April 1918. During this period the Editor evolved in conjunction with contemporary aircraft designers the standard methods of strength calculation and testing of aircraft and presented the results of his practical experiences in the form of confidential reports and a secret handbook. Out of the latter grew the Handbook of Strength Calculations, and, later, A.P. 970.

When the Second World War started it was the Editor's desire to produce a specialised edition of Molesworth for general use in the aircraft industry, but most of the information in his files was not available for publication. The Second Edition represents a complete revision of the first volume, with much of this new matter added. It has also been arranged in sections for ease of reference. This edition contains new tables of special interest to designers, very comprehensive strength and weight data, notes on Drawing Office practice, I.C.A.N. altitude tables, material specifications, details of modern constructional methods, a full range of conversion factors, etc. It must be mentioned that much of the strength data is taken from Hawker Aircraft practice and the figures arrived at give a slightly higher factor of safety than standard practice—an admirable feature ensuring soundness and general robustness of design.

So many eminent people and institutions have co-operated in producing the subject matter for this book that it is difficult to give them all adequate acknowledgement. The Editor is particularly indebted to S. Camm, Esq., C.B.E., F.R.Ae.S., and Messrs. Hawker Aircraft, Ltd.; the Air Ministry; The Society of British Aircraft Constructors; The Royal Aeronautical Society; H.M. Stationery Office; the British Institute of Standards; Messrs. Rolls Royce, Ltd.; C. C. Walker, Esq., A.M.I.C.E., F.R.Ae.S., and the de Havilland Aircraft Co., Ltd.; and C. Attwood, Esq., and the Ford Motor Co., Ltd. Finally to H. B. Howard, Esq., B.A., B.Sc., F.R.Ae.S., M.I.A.S., Assistant Director of Research (Structures), Ministry of Supply, and F. H. M. Lloyd, Esq., Sales Manager of Hawker Aircraft, for kindly reading the proofs and rendering much valuable assistance.

A. P. T.

PREFACE TO FIRST EDITION

In view of the rapid expansion of the Aeronautical Industry, to-day regarded as the highest form of engineering, where every structural problem is made more difficult by the requirement of minimum weight, the Editor of *Molesworth's Pocket-Book of Engineering Formulæ* decided that Aeronautical Data given there should be further added to and published as a separate work under the title of *Molesworth's Aeronautical Engineers Pocket Book*.

This book is a serious attempt devoted solely to meet the full requirements of Aeronautical Engineers with regard to data. As much of the work carried out in an aerodynamical office consists in the design of Jigs which necessitate the use of ordinary structural materials, particulars of these materials are included.

It is hoped that this Pocket-Book will, like the parent " Molesworth," become the " Bible " of the Aeronautical Engineer, and every endeavour will be made to deserve this title.

Thanks are due to *The Aeroplane* for permission to publish many of the illustrations of aeroplane detail construction.

The Editors will welcome criticism which tends to make the book more useful.

A. P. T.
W. O. M.

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SECTION I

GENERAL INFORMATION

Associations

The Royal Aeronautical Society. Founded 1866. (Incorporating the Institute of Aeronautical Engineers.) Offices: 4, Hamilton Place, London, W.1.

The Royal Aero Club of the United Kingdom. Founded 1909. (Affiliated to the Federation Aeronautique Internationale.) Offices: 119, Piccadilly, London, W.1.

The Royal Air Force Club. Founded 1918. Offices: 128, Piccadilly, London, W.1.

The Society of British Aircraft Constructors, Incorporated 1916. Offices: 32, Savile Row, London, W.1.

The Guild of Air Pilots and Air Navigators of the British Empire. Founded 1929. Offices (Temporary): 309, Crofton Road, Orpington, Kent.

Air League of the British Empire. Incorporated 1909. Offices: Kinnaird House, 1a, Pall Mall East, London, S.W.1.

The British Gliding Association. Offices: 119, Piccadilly, London, W.1.

Journals and Publications

Great Britain

Aeronautics. Monthly, price 2/-. Editor: Oliver Stewart, M.C., A.F.C. Published by C. Arthur Pearson, Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

The Aeroplane. Weekly, price 1/-. Published by Temple Press, Ltd., Bowling Green Lane, London, E.C.1.

The Aeroplane Spotter. Fortnightly, price 3*d*. Published by Temple Press, Ltd., Bowling Green Lane, London, E.C.1.

Aircraft Engineering. Monthly, price 2/-. Editor: Lt.-Col. W. Lockwood-Marsh, O.B.E., F.R.Ae.S., M.S.A.E., F.I.Ae.S. Published by Bunhill Publications, Ltd., 12, Bloomsbury Square, London, W.C.1.

Air Corps Gazette. Monthly, price 6*d*. Editor: Leonard Taylor. Published by the Air League of the British Empire, Kinnaird House, 1A, Pall Mall East, London, S.W.1.

Flight. Weekly, price 1/-. Editor G. Geoffrey Smith, M.B.E. Published by the Flight Publishing Co., Ltd., Stamford Street, London, S.E.1.

Journal of the Royal Aeronautical Society. Monthly, price 7/6. Published by the Royal Aeronautical Society, 4, Hamilton Place, London, W.1.

Reports and Memoranda of the Aeronautical Research Council, Technical papers published from time to time by His Majesty's Stationery Office, Adastral House, Kingsway, London, W.C.2.

EDINBURGH, 2: 120, George Street.

MANCHESTER, 1: 26, York Street.

CARDIFF: St. Andrew's Crescent.

BELFAST: 80, Chichester Street.

Prices vary. Particulars and lists on application.

INTERNATIONAL AIRCRAFT MARKINGS

Under the International Convention for Aerial Navigation, ratified on April 12th, 1920, each nation has allocated one or two letters as its national mark, to be followed by a series of four or three letters which may be used in various combinations to give registration markings for individual aircraft. This scheme is followed by all nations which are members of the I.C.A.N. (International Commission for Air Navigation). The full list given below includes all countries of the world, with further notes in the case of non-members of the I.C.A.N.

National and registration markings must be reproduced on the upper and lower surfaces of the wings and also on each side of the fuselage. On the wings the tops of the letters must be adjacent to the leading edge and on the fuselage sides reading horizontally in order from left to right.

The letters themselves must be block capitals of uniform size and in a colour to contrast with the background colour. The width of each letter must be two-thirds of its height and the thickness equal to one-sixth of its height. A hyphen, equal in length to the width of a letter, must be painted between the national letter or letters and the registration letters.

Letters should be as large as possible without extending to the outline of the surface upon which they appear, but need not exceed 8 ft. as a maximum.

Markings	*Country*
A followed by *numbers*	Austria
AN–AAA to AN–ZZZ	Nicaragua
CC–AAA to CC–ZZZ	Chile
CF–AAA to CF–ZZZ	Canada
CL–AAA to CL–ZZZ	
CM–AAA to CM–ZZZ	Cuba
CN–AAA to CN–ZZZ	Morocco
CB or CP–AAA to CB or CP–ZZZ	Bolivia
CR–AAA to CR–ZZZ	Portuguese Colonies
CS–AAA to CS–ZZZ	Portugal
CX–AAA to CX–ZZZ	Uruguay
CZ–AAA to CZ–ZZZ	Monaco
D followed by *numbers*	Germany
D–AAAA to D–ZZZZ	Germany
EC–AAA to EC–ZZZ	Spain
EI–AAA to EI–ZZZ	Eire
EL–AAA to EL–ZZZ	Litherian Republic
ES–AAA to ES–ZZZ	Estonia
ET–AAA to ET–ZZZ	Ethiopia
EZ–AAA to EZ–ZZZ	Saar territories
F–AAAA to F–ZZZZ	France and French Colonies and Protectorates less Monaco
G–AAAA to G–ZZZZ	Great Britain
HA–AAA to HA–ZZZ	Hungary
HB–AAA to HB–ZZZ	Switzerland
HC–AAA to HC–ZZZ	Ecuador
HH–AAA to HH–ZZZ	Haiti
HI–AAA to HI–ZZZ	Dominican Republic
HK–AAA to HK–ZZZ	Colombian Republic
HR–AAA to HR–ZZZ	Republic of Honduras
HS–AAA to HS–ZZZ	Thailand
I–AAAA to I–ZZZZ	Italy and Italian Colonies
J–AAAA to J–ZZZZ	Japan
LG–AAA to LG–ZZZ	Guatemala
LI–AAA to LI–ZZZ	Liberia
LN–AAA to LN–ZZZ	Norway
LR–AAA to LR–ZZZ	Lebanon
LV–AAA to LV–ZZZ	Argentine Republic
LX–AAA to LX–ZZZ	Luxembourg
LZ–AAA to LZ–ZZZ	Bulgaria
NX followed by *numbers*	United States (civil aircraft with experimental licence)
NC followed by *numbers*	United States (civil aircraft with an Approved Type Certificate)
OB–AAA to OB–ZZZ	Peru

Markings	*Country*
OH–AAA to OH–ZZZ	Finland
OK–AAA to OK–ZZZ	Czechoslovakia
OO–AAA to OO–ZZZ	Belgium and Belgian Colonies
OY–AAA to OY–ZZZ	Denmark
PH–AAA to PH–ZZZ	Holland
PI–AAA to PI–ZZZ	Philippines Commonwealth
PJ–AAA to PJ–ZZZ	Curacao (Netherlands West Indies)
PK–AAA to PK–ZZZ	Netherlands East Indies
PP or PT–AAA to PP or PT–ZZZ	Brazil
PZ–AAA to PZ–ZZZ	Surinam (Netherlands Guiana)
RV–AAA to RV–ZZZ	Iran
RX–AAA to RX–ZZZ	Republic of Panama
RY–AAA to RY–ZZZ	Lithuania
SE–AAA to SE–ZZZ	Sweden
SP–AAA to SP–ZZZ	Poland
SU–AAA to SU–ZZZ	Egypt
SX–AAA to SX–ZZZ	Greece
TC–AAA to TC–ZZZ	Turkey
TF–AAA to TF–ZZZ	Iceland
TI–AAA to TI–ZZZ	Costa Rica
UH–AAA to UH–ZZZ	Hedjaz
UL–AAA to UL–ZZZ	Luxembourg
URSS followed by registration *number*	U.S.S.R.
VH–AAA to VH–ZZZ	Australia
VO–AAA to VO–ZZZ	Newfoundland
VP–AAA to VP–ZZZ	Gold Coast with Ashanti and Territories in British Togoland
VP–BAA to VP–BZZ	Bahamas
VP–CAA to VP–CZZ	Ceylon
VP–FAA to VP–FZZ	Falkland Islands
VP–GAA to VP–GZZ	British Guiana
VP–HAA to VP–HZZ	British Honduras
VP–JAA to VP–JZZ	Jamaica
VP–KAA to VP–KZZ	Colonies and Protectorate of Kenya
VP–LAA to VP–LZZ	Leeward Islands
VP–MAA to VP–MZZ	Malta
VP–NAA to VP–NZZ	Protectorate of Nyasaland
VP–PAA to VP–PZZ	Islands under the rule of the Western Pacific Commission
VP–RAA to VP–RZZ	Northern Rhodesia
VP–SAA to VP–SZZ	Protectorate of Somaliland
VP–TAA to VP–TZZ	Trinidad and Tobago
VP–UAA to VP–UZZ	Protectorate of Uganda
VP–VAA to VP–VZZ	St. Vincent

Markings	*Country*
VP-WAA to VP-WZZ	Weihaiwei
VP-XAA to VP-XZZ	Colonies and Protector of Gambia
VP-YAA to VP-YZZ	Southern Rhodesia
VP-ZAA to VP-ZZZ	Protectorate of Zanzibar
VQ-BAA to VQ-BZZ	Barbados
VQ-CAA to VQ-CZZ	Cyprus
VQ-FAA to VQ-FZZ	Fiji Islands
VQ-GAA to VQ-GZZ	Grenada
VQ-HAA to VQ-HZZ	St. Helena
VQ-LAA to VQ-LZZ	St. Lucia
VQ-MAA to VQ-MZZ	Mauritius
VQ-PAA to VQ-PZZ	Palestine
VQ-SAA to VQ-SZZ	Seychelle Islands
VR-BAA to VR-BZZ	Bermuda
VR-GAA to VR-GZZ	Gibraltar
VR-HAA to VR-HZZ	Hong Kong
VR-JAA to VR-JZZ	Johore
VR-LAA to VR-LZZ	Colonies and Protectorates of Sierra Leone
VR-NAA to VR-NZZ	Colonies and Protectorate of Nigeria including British Cameroons
VR-RAA to VR-RZZ	Federated Malay States
VR-SAA to VR-SZZ	Straits Settlements
VR-TAA to VR-TZZ	Tanganyika Territory
VR-UAA to VR-UZZ	State of Brunei
VT-AAA to VT-ZZZ	India
XA-AAA to XB-ZZZ	Mexico
XH-AAA to XH-ZZZ	Honduras
XT-AAA to XT-ZZZ	China
XY-AAA to XY-ZZZ	Burma
YA-AAA to YA-ZZZ	Afghanistan
YI-AAA to YI-ZZZ	Iraq
YJ-AAA to YJ-ZZZ	New Hebrides
YL-AAA to YL-ZZZ	Latvia
YM-AAA to YM-ZZZ	Danzig
YN-AAA to YN-ZZZ	Nicaragua
YR-AAA to YR-ZZZ	Rumania
YS-AAA to YS-ZZZ	Republic of Salvador
YU-AAA to YU-ZZZ	Jugoslavia
YV-AAA to YV-ZZZ	Venezuela
ZA-AAA to ZA-ZZZ	Albania
ZK-AAA to ZK-ZZZ	New Zealand
ZP-AAA to ZP-ZZZ	Paraguay
ZS-AAA to ZS-ZZZ	Union of South Africa
Registration to be selected at a future date	Syria

Slide Rule

The common slide rule consists of 4 scales; A and D fixed, and B and C sliding. All are spaced as the logarithms of the numbers they represent, so that by sliding one scale against another, logarithmic functions are mechanically performed.

A and B are identical in their divisions as are C and D, the divisions of these scales being twice the size of those on the other scales, or spaced as the logarithms of the square roots of the other scales.

Examples of Working the Slide Rule

In the following examples the letters A, B, C, D denote the respective scales on which the reading is to be found; P denotes the gauge point (see below); d=diameter, or side of square; l=length; w=weight, or cubic contents; B_1 and B_2 denote the first and second half of B scale respectively. In questions involving the square root: if the number of digits be *odd*, the working must be on A_1 or B_1; but if the number of digits be *even*, it must be on A_2 or B_2, as the case may be. In questions not involving any root or power it is immaterial whether the working is on the first or second half of the scale.

	Case	1st term	2nd term	3rd term	4th term
		Set	On	And against	Is answer
1. Multiplication	12×23	1 B	23 A	12 B	276 A
2. Division	$54 \div 24$	24 A	1 B	54 A	2·25 B
3. Proportion	7 : 54 : : 31	7 B	54 A	31 B	239 A
4. Inverse proportion (invert slide)	7:54::x:239	7 D	239 A	54 D	31 A
5. Circle circumference (P = 3·14)	for d = 15	1 B	3·14 A	15 B	47·1 A
6. Circle area (P = ·785)	for d = 6·35	1 A	·785 B	6·35 D	31·7 C
7. Strength, weight, or contents	$d^2 \div P$	P A	1·B	d D	w C
8. Mensuration of solids	$ld^2 \div P$	P A	l B	d D	w C
9. Contents of sphere or cube	$d^3 \div P$	P A	d B	d D	w C
10. Squaring	$(5{\cdot}5)^2$	1 D	1 C	5·5 D	30·25 A_2
11. Square root (digits odd)	$\sqrt{6{\cdot}5}$	1 C	1 D	6·5 A_1	2·55 D
12. Ditto (digits even)	$\sqrt{65}$	1 C	1 D	65 A_2	8·06 D
13. Diagonal of square or rectangle	$\sqrt{25 \times 76}$	10 B_2	76 A_2	25 B_2	43·6 D
14. Cube	$(7{\cdot}3)^3$	10 C	7·3 C	7·3 C	389 A

The "gauge-point" P=the number of units of the dimension contained in the unit of the answer. Thus if answer and dimensions are all in feet, P=1; for answer in feet with dimensions F.I.I. (feet × inches × inches), $P=1\times12\times12=144$; for answer in inches with dimensions F.F.I, $P=1\times\frac{1}{12}\times\frac{1}{12}=\cdot00694$; etc.

On some slide rules 1 A is opposite 4 D, in which case the gauge points for the ordinary slide rule must be divided by 16 (4^2).

The slide rule is a proportional instrument, and a given case should be reduced to the proportional form $a:b::c:x$. Terms a and b or c and x must never fall on the same line.

If A and B be set to any proportion, then all the numbers against each other in the same lines will be in the same ratio; thus if the gauge point for the circumference of a circle on B be set on 1 A, all the numbers on B will represent a table of circumferences due to the diameter represented by the figures on A.

With the gauge point, P, for areas on B, set against 1 A, the scale C forms a table of areas of circles for diameters represented by the figures on D. With 1 B set on 1 D, the scales B and D are tables of squares and square-roots respectively for the numbers of the scales opposite to them.

Cases of $x=\sqrt[n]{a^m}$ or $a^{\frac{m}{n}}$ may be readily solved by the aid of an equal parts scale applied to a slide-rule line. Thus for $\sqrt[3]{\cdot16^3}$, if the distance from ·16 to 1 of a slide rule measure 378 on a scale of 80, then $378\times\frac{3}{8}=22\cdot7$, and from 0 to 22·7 on the 80 scale reaches back from 1 to $\cdot333=x$ on the slide rule scale.

To find True Airspeed by the slide rule find 60 plus the height required in 1,000s of feet on the C-scale and set this against 60 on the D-scale. The True Airspeed is then read off on the C-scale opposite the Indicated Airspeed reading on the D-scale.

EXAMPLE.—I.A.S. 192 m.p.h. at 12,000 ft. Set $60+12=72$ on C-scale against 60 on D-scale. Read off answer (True A.S.) on C-scale opposite 192 on D-scale—230 m.p.h.

Note, however, that this is only a very approximate rule and takes no account of Position Error, nor of effects of higher Mach number.

SECTION II

AERODYNAMICS

Symbols and Abbreviations

A — aspect ratio; aerodynamic force; transverse moment of inertia.
A.I.D.— Aeronautical Inspection Directorate.
A.N.D.— Air Navigation Directions.
A.P.—Air Publication.
A.R.C.— Aeronautical Research Council.
A.S.I.— airspeed indicator
a — leverage of aerodynamic force about C.G.; slope of lift curve; aerodynamic centre; velocity of sound in air; axial inflow factor (airscrews).
α — angle of attack; angle of incidence.
α_0 — angle of attack (or incidence) measured from zero lift chord.
α_i — induced angle of attack.
α_T — tail setting angle.
B — gas constant; longitudinal moment of inertia.
B_1, B_2 — stability coefficients.
B.A.— British Association.
B.G.A.— British Gliding Association.
B.S.— British Standard.
B.S.F.— British Standard Fine.
B.S.I.— British Standards Institution.
B.S.S.— British Standard Specification.
β — angle of attack of tailplane; angle of attack for zero lift measured from geometric chord.
β — transverse dihedral angle.
b — span; rotational interference (airscrews).
C — directional moment of inertia; cross-sectional area of wing tunnel.
C_1, C_2 — stability coefficients.
C.A.T.— Compressed Air Tunnel.
C_L, C_D, C_R, etc.— non-dimensional coefficients of Lift, Drag, Resultant, etc.
C.G. or c.g.— centre of gravity.
C.L.A. — centre of lateral area.
C.R. or C of R — centre of resistance.
C.P. or c.p. — centre of pressure.
c/s—constant speed.

C.P.B.— centre of pressure back.
C.P.F.— centre of pressure forward.
c — chord (of wing or aerofoil).
c_U, c_L — chord of upper and lower wings, respectively, of biplane.
γ — tan D/L; gliding angle; ratio of specific heats.
D — drag; diameter.
D_1, D_2 — stability coefficients.
Diam. or dia.— diameter.
D.T.D.— Directorate of Technical Development.
Δ — thickness of boundary layer; displacement.
E — Modulus of Elasticity (Young's Modulus).
E_1, E_2 — stability coefficients.
E.H.P. — excess horse-power.
E.M.P. — experimental mean pitch.
ϵ — angle of downwash.
F — force (general).
G.M.P. — geometric mean pitch.
g — acceleration due to gravity.
H.P. or h.p. — horse-power.
H — absolute ceiling.
h — altitude; height; gap; service ceiling.
H.P.a — horse-power available.
H.P.r. — horse-power required.
I.C.A.N. (C.I.N.A.) — International Commission for Aerial Navigation.
I.H.P. — indicated H.P.
η — elevator angle; efficiency.
θ — blade angle (airscrews); angle of climb; angle of pitch.
I — moment of inertia.
suffix i — denoting induced.
J — advance per revolution in terms of diameter (airscrews).
K — circulation.
k — radius of gyration; Munk's span factor.
k_A, k_B, k_C — inertia coefficients.
K_L, K_D, K_R, etc.— old style non-dimensional coefficients of Lift, Drag, Resultant, etc. $C_L=2K_L$, $C_D=2K_D$.
L — lift; rolling moment.
L.E. — leading edge.
L.F.—load factor.
l — length; tail leverage.
M — pitching moment — Mach number.
max.— maximum.
min.— minimum.
μ — coefficient of viscosity; coeff. rolling friction.
N — yawing moment; revs. per min.; no. of blades (Airscrews).
N.A.C.A.— National Advisory Committee for Aeronautics.

N.P.L.— National Physical Laboratory.
N.T.P.— normal temperature and pressure.
n — revolutions per second.
η — efficiency.
P — total pressure; pitch (G.M.P. implied).
p — pressure or stress.
suffix p — relating to profile.
q — dynamic pressure; resultant fluid velocity.
Q — torque.
ρ — density of air.
ρ_0 — standard density of air (at 0 feet).
R — Reynolds Number; resultant force; radius.
R.N.— Reynolds Number.
R.A.E.— Royal Aircraft Establishment.
R and Ms — Reports and Memoranda.
r — radius.
r.p.m.— revolutions per minute.
r.p.s.— revolutions per second.
S — surface area (e.g. wing area).
S_T — area of tailplane.
S_U, S_L — area of upper and lower wings, respectively, of biplane.
s — semi span; solidity (airscrews).
s.g. or S.G.— specific gravity.
ϕ — angle of roll or bank.
σ — relative air density; Prandtl's biplane factor; solidity (airscrews).
T — thrust.
T.E.— trailing edge.
T.H.P.— thrust horse-power.
T.R.— Technical Reports. } issued by the N.A.C.A.
T.M.— Technical Memoranda } issued by the N.A.C.A.
T.N.— Technical Notes } issued by the N.A.C.A.
ϕ — stagger.
ψ — stream function; angle of yaw.
U — velocity.
V — velocity; airspeed (general).
V — indicated airspeed.
V_{min}, V_{max}, V_s, etc.— minimum airspeed, maximum airspeed, sinking speed, etc.
V.P.— variable pitch.
ν — kinematic viscosity of air.
W — weight (total)
w — downwash velocity.
ω or Ω — angular velocity.
W_P — power loading.
W_S — wing loading.

Fundamental Units

English or foot-pound-second system.
C.G.S. or metric—centimeter-gramme-second system.

Derived Units

Gravitational unit = slug = $g \times$ poundal = 32·2 lb.

The corresponding metric unit (9·81 Kg. mass = ·782 slugs) has no accepted name.

Standard value of g = 32·1740 ft./sec.^{2}
= 980·655 cm./sec.^{2}

Slug, Definition of.—If a force of one pound applied to a mass for a period of one second produces a velocity of the mass amounting to one foot per second then that mass is called a slug.

Poundal, Definition of.—The poundal is the force which, if applied to a mass of one pound for one second, will produce on that mass a velocity of one foot per second.

Reference Axes

Forces and moments are generally referred to three mutually perpendicular axes, and three types of such axes are in use.

Wind Axes.—These move with the aeroplane or aircraft and are employed for all general analysis. The *Lift axis* is directed upwards (positive), the *Drag axis* is parallel to the wind direction positive downstream), and the *Cross-wind axis* (positive right to left) perpendicular to the wind direction.

Fixed Axes or *Body Axes.*—These are generally employed in stability calculations. The *longitudinal axis* is made parallel to some convenient datum, such as the thrust line; the *normal axis* is directed upwards and passes through the C.G., the *lateral axis* is horizontal, also passing through the C.G.

Gravity Axis.—*X axis* parallel to the direction of flight, *Z axis* perpendicular through the C.G., and the *Y axis* perpendicular to the X and Z axes.

Air and the Atmosphere

Approximate Composition of Air at Sea-Level.

Nitrogen	78·03	per cent.	by volume.
Oxygen	20·99	,,	
Argon	·94	,,	
Carbon dioxide	0·04	,,	

Remainder small traces of neon, helium, and other gases.

I.C.A.N. Standard Atmosphere.

This has been established in order that all data resulting from various tests, etc., may be related to or reduced to a certain definite standard. Brief properties of standard air are:—

Sea-level temperature = 15° C.

Barometric height (reduced to 0° C.) = 760 mm. mercury.

Weight (composition as above) = ·07656 lb. per cu. ft.
= 1·2257 Kg. per cu. metre.

Uniform value of $g = 32·174$ ft./sec.
= 980·665 cm./sec.

Mass density, $\rho_0 = ·002378$ slugs/cu. ft. at zero height.

Within stratosphere lower limit, i.e. from zero feet up to 36,000 ft. (11,000 metres).

$$\text{Temperature, } T_h = 15 - ·0065h$$

where h is the height in metres.

Above 11,000 metres, *i.e.* in the stratosphere, the temperature remains constant at $-56·5°$ C.

For altitudes up to 11,000 metres

$$\frac{T_h}{T_0} = \left(\frac{P_h}{P_0}\right)^{·19}. \quad \frac{P_h}{P_0} = \left(\frac{T_h}{T_0}\right)^{5·263} = \left(\frac{288 - ·0065h}{288}\right)^{5·263}$$

For altitudes above 11,000 metres

$$\log_{10}\frac{P_e}{P_h} = \frac{H - 11,000}{14,600}$$

where P_e refers to conditions at $h = 11,000$ metres.

Standard Atmosphere

In the Standard Atmosphere, Density, Pressure, and Temperature are related by the following formulæ:—

$\theta = \sigma^{·235}$.

$\theta = p^{·19}$

$p = \sigma^{1·235}$.

$\sigma = p^{·81}$.

$p_0 = 14·7$ lb. per sq. in.

$\rho_0 = ·0765$ lb. per cu. ft.

$\rho_0 = ·00237$ slugs per cu. ft.

$\theta_0 = 288°$ C. absolute.

1 Litre = 61 cubic inches.

I.C.A.N. Altitude Tables
(Rolls-Royce)

Altitude, ft.	Pressure,		Temperature,		Density, lb./cu. ft.	$\sqrt{\frac{\rho_0}{\rho}}$	$P^{\frac{1}{2}}\ \rho^{\frac{1}{2}}$ factor	Relative density
	"Hg.	lb./sq. in. P	°C. t	°C. abs. T	ρ			σ
0	29·92	14·70	+15·0	288·0	·0765	1·000	1·000	1·000
250	29·65	14·56	+14·5	287·5	·0759	1·004	·992	·993
500	29·38	14·43	+14·0	287·0	·0754	1·007	·984	·984
750	29·12	14·30	+13·5	286·5	·0748	1·011	·976	·977
1,000	28·86	14·17	+13·0	286·0	·0743	1·015	·968	·971
1,250	28·59	14·04	+12·5	285·5	·0737	1·019	·960	·964
1,500	28·33	13·92	+12·0	285·0	·0732	1·022	·952	·957
1,750	28·07	13·79	+11·5	284·5	·0726	1·026	·944	·950
2,000	27·82	13·66	+11·0	284·0	·0721	1·030	·936	·943
2,250	27·57	13·54	+10·5	283·5	·0716	1·034	·929	·936
2,500	27·31	13·41	+10·0	283·0	·0711	1·038	·921	·929
2,750	27·06	13·29	+9·5	282·5	·0705	1·042	·913	·922
3,000	26·81	13·17	+9·0	282·0	·0700	1·045	·905	·915
3,250	26·57	13·05	+8·5	281·5	·0695	1·049	·898	·908
3,500	26·32	12·92	+8·0	281·0	·0690	1·053	·891	·901
3,750	26·08	12·81	+7·6	280·6	·0685	1·057	·883	·895
4,000	25·84	12·69	+7·1	280·1	·0679	1·061	·876	·888
4,250	25·60	12·57	+6·6	279·6	·0674	1·065	·868	·881
4,500	25·36	12·46	+6·1	279·1	·0669	1·069	·861	·875
4,750	25·12	12·34	+5·6	278·6	·0664	1·073	·854	·868
5,000	24·89	12·22	+5·1	278·1	·0659	1·077	·847	·862
5,250	24·66	12·11	+4·6	277·6	·0654	1·081	·840	·855
5,500	24·43	12·00	+4·1	277·1	·0649	1·085	·833	·849
5,750	24·21	11·89	+3·6	276·6	·0644	1·090	·826	·892
6,000	23·98	11·78	+3·1	276·1	·0640	1·094	·819	·836
6,250	23·75	11·67	+2·6	275·6	·0635	1·098	·812	·830
6,500	23·53	11·56	+2·1	275·1	·0630	1·102	·805	·824
6,750	23·31	11·45	+1·6	274·6	·0625	1·106	·709	·817
7,000	23·09	11·34	+1·1	274·1	·0620	1·111	·792	·811
7,250	22·87	11·23	+0·6	273·6	·0615	1·115	·785	·805
7,500	22·65	11·12	+0·1	273·1	·0611	1·119	·778	·799
7,750	22·43	11·02	−0·4	272·6	·0606	1·124	·771	·792
8,000	22·22	10·91	−0·8	272·2	·0601	1·128	·764	·786
8,250	22·01	10·81	−1·3	271·7	·0597	1·132	·758	·780
8,500	21·80	10·71	−1·8	271·2	·0592	1·137	·751	·774
8,750	21·59	10·60	−2·3	270·7	·0587	1·141	·744	·768
9,000	21·39	10·50	−2·8	270·2	·0583	1·146	·738	·762
9,250	21·18	10·40	−3·3	269·7	·0578	1·150	·731	·756
9,500	20·98	10·30	−3·8	269·2	·0574	1·155	·725	·750
9,750	20·78	10·21	−4·3	268·7	·0569	1·159	·719	·744

I.C.A.N. Altitude Tables—*continued*

Altitude, ft.	Pressure, "Hg.	Pressure, lb./sq. in. P	Temperature, °C. t	Temperature, °C. abs. T	Density, lb./cu. ft. ρ	$\sqrt{\frac{\rho_0}{\rho}}$	$P^{\frac{1}{2}}\rho^{\frac{1}{2}}$ factor	Relative density σ
10,000	20·58	10·11	−4·8	268·2	·0565	1·164	·713	·738
10,250	20·38	10·01	−5·3	267·7	·0560	1·168	·707	·732
10,500	20·18	9·91	−5·8	267·2	·0556	1·173	·701	·726
10,750	19·99	9·82	−6·3	266·7	·0552	1·178	·695	·721
11,000	19·79	9·72	−6·8	266·2	·0547	1·182	·688	·715
11,250	19·60	9·63	−7·3	265·7	·0543	1·187	682	·709
11,500	19·41	9·53	−7·8	265·2	·0539	1·192	·676	·704
11,750	19·22	9·44	−8·3	264·7	·0535	1·196	·670	·698
12,000	19·03	9·35	−8·8	264·2	·0530	1·201	·664	·693
12,250	18·84	9·25	−9·3	263·7	·0526	1·206	·658	·688
12,500	18·65	9·16	−9·8	263·2	·0522	1·211	·652	·682
12,750	14·46	9·07	−10·3	262·7	·0518	1·216	·646	·677
13,000	18·28	8·98	−10·7	262·3	·0513	1·220	·640	·671
13,250	18·10	8·89	−11·2	261·8	·0509	1·225	·634	·665
13,500	17·93	8·81	−11·7	261·3	·0505	1·230	·629	·660
13,750	17·75	8·72	−12·2	260·8	·0501	1·235	·623	·655
14,000	17·57	8·63	−12·7	260·3	·0497	1·240	·618	·650
14,250	17·40	8·55	−13·2	259·8	·0493	1·245	612	·645
14,500	17·22	8·46	−13·7	259·3	·0489	1·251	·606	·640
14,750	17·05	8·37	−14·2	258·8	·0485	1·256	·601	·634
15,000	16·88	8·29	−14·7	258·3	·0481	1·261	·595	·629
15,250	16·71	8·21	−15·2	257·8	·0477	1·266	·590	·624
15,500	16·54	8·12	−15·7	257·3	·0474	1·271	·585	·619
15,750	16·38	8·04	−16·2	256·8	·0470	1·276	·579	·614
16,000	16·21	7·96	−16·7	256·3	·0466	1·282	·574	·609
16,250	16·05	7·88	−17·2	255·8	·0462	1·287	·569	·604
16,500	15·89	7·80	−17·7	255·3	·0458	1·292	·564	·599
16,750	15·73	7·73	−18·2	254·8	·0454	1·298	·558	·594
17,000	15·57	7·65	−18·7	254·3	·0451	1·303	·553	·589
17,250	15·41	7·57	−19·2	253·8	·0447	1·308	·548	·584
17,500	15·25	7·49	−19·7	253·3	·0443	1·314	·543	·579
17,750	15·10	7·42	−20·2	252·8	·0440	1·319	·538	·575
18,000	14·94	7·34	−20·7	252·3	·0436	1·325	·533	·570
18,250	14·78	7·26	−21·2	251·8	·0432	1·330	·528	·565
18,500	14·63	7·19	−21·7	251·3	·0429	1·336	·523	·561
18,750	14·48	7·12	−22·1	250·9	·0425	1·341	·518	·556
19,000	14·33	7·04	−22·6	250·4	·0422	1·347	·514	·551
19,250	14·18	6·96	−23·1	249·9	·0418	1·353	·509	·546
19,500	14·03	6·89	−23·6	249·4	·0414	1·359	·504	·542
19,750	13·89	6·82	−24·1	248·9	·0411	1·364	·500	·537

I.C.A.N. Altitude Tables—*continued*

Altitude, ft.	Pressure, ″Hg.	Pressure, lb./sq. in. P	Temperature, °C. t	Temperature, °C. abs. T	Density, lb./cu. ft. ρ	$\sqrt{\frac{\rho_0}{\rho}}$	$P^{\frac{1}{2}}\rho^{\frac{1}{2}}$ factor	Relative density σ
20,000	13·74	6·75	−24·6	248·4	·0408	1·370	·495	·533
20,250	13·60	6·68	−25·1	247·9	·0404	1·376	·490	·529
20,500	13·47	6·62	−25·6	247·4	·0401	1·382	·485	·524
20,750	13·33	6·55	−26·1	246·9	·0397	1·388	·481	·520
21,000	13·18	6·47	−26·6	264·4	·0394	1·394	·476	·515
21,250	13·04	6·40	−27·1	245·9	·0390	1·400	·472	·511
21,500	12·91	6·34	−27·6	245·4	·0387	1·406	·467	·507
21,750	12·77	6·27	−28·1	244·9	·0384	1·412	·463	·503
22,000	12·63	6·20	−28·6	244·4	·0381	1·418	·458	·498
22,250	12·50	6·14	−29·1	243·9	·0377	1·424	·454	·494
22,500	12·36	6·07	−29·6	243·4	·0374	1·430	·450	·490
22,750	12·23	6·01	−30·1	242·9	·0371	1·436	·445	·485
23,000	12·10	5·94	−30·6	242·4	·0367	1·443	·441	·481
23,250	11·97	5·88	−31·1	241·9	·0364	1·449	·437	·477
23,500	11·84	5·82	−31·6	241·4	·0361	1·455	·432	·472
23,750	11·71	5·75	−32·1	240·9	·0358	1·462	·428	·468
24,000	11·59	5·69	−32·5	240·5	·0355	1·468	·424	·464
24,250	11·46	5·63	−33·0	240·0	·0352	1·474	·420	·460
24,500	11·34	5·57	−33·5	239·5	·0349	1·481	·416	·456
24,750	11·22	5·51	−34·0	239·0	·0346	1·487	·411	·452
25,000	11·10	5·45	−34·5	238·5	·0343	1·494	·407	·448
25,250	10·98	5·39	−35·0	238·0	·0340	1·501	·403	·444
25,500	10·86	5·33	−35·5	237·5	·0337	1·507	·399	·440
25,750	10·74	5·27	−36·0	237·0	·0334	1·514	·395	·436
26,000	10·62	5·22	−36·5	236·5	·0331	1·521	·391	·432
26,250	10·50	5·16	−37·0	236·0	·0328	1·528	·388	·428
26,500	10·39	5·10	−37·5	235·5	·0325	1·534	·384	·424
26,750	10·27	5·04	−38·0	235·0	·0322	1·541	·380	·421
27,000	10·16	4·99	−38·5	234·5	·0319	1·548	·376	·417
27,250	10·05	4·94	−39·0	234·0	·0316	1·555	·373	·413
27,500	9·940	4·88	−39·5	233·5	·0313	1·562	·369	·410
27,750	9·831	4·83	−40·0	233·0	·0311	1·569	·365	·406
28,000	9·720	4·77	−40·5	232·5	·0308	1·577	·362	·402
28,250	9·612	4·72	−41·0	232·0	·0305	1·584	·358	·398
28,500	9·504	4·67	−41·5	231·5	·0302	1·591	·354	·395
28,750	9·398	4·62	−42·0	231·0	·0300	1·598	·351	·391
29,000	9·293	4·56	−42·5	230·5	·0297	1·606	·347	·388
29,250	9·188	4·51	−43·0	230·0	·0294	1·613	·343	·385
29,500	9·085	4·46	−43·4	229·6	·0291	1·620	·339	·381
29,750	8·982	4·41	−43·9	229·1	·0289	1·628	·336	·377

I.C.A.N. Altitude Tables—*continued*

Altitude, ft.	Pressure, "Hg.	Pressure, lb./sq. in. P	Temperature, °C. t	Temperature, °C. abs. T	Density, lb./cu. ft. ρ	$\sqrt{\frac{\rho_0}{\rho}}$	$p^{\frac{1}{2}} \rho^{\frac{1}{2}}$ factor	Relative density σ
30,000	8·880	4·36	−44·4	228·6	·0286	1·635	·333	·374
30,250	8·780	4·31	−44·9	228·1	·02835	1·643	·330	·370
30,500	8·680	4·26	−45·4	227·6	·02809	1·650	·327	·367
30,750	8·582	4·21	−45·9	227·1	·02783	1·658	·323	·364
31,000	8·483	4·17	−46·4	226·6	·02757	1·666	·320	·360
31,250	8·386	4·12	−46·9	226·1	·02732	1·674	·317	·357
31,500	8·291	4·07	−47·4	225·6	·02706	1·681	·313	·359
31,750	8·195	4·03	−47·9	225·1	·02681	1·689	·310	·351
32,000	8·101	3·98	−48·4	224·6	·02656	1·697	·307	·347
32,250	8·007	3·93	−48·9	224·1	·02631	1·705	·304	·344
32,500	7·915	3·89	−49·4	223·6	·02606	1·713	·300	·341
32,750	7·823	3·84	−49·9	223·1	·02582	1·721	·297	·338
33,000	7·732	3·80	−50·4	222·6	·02558	1·729	·294	·334
33,250	7·642	3·75	−50·9	222·1	·02535	1·738	·291	·331
33,500	7·553	3·71	−51·4	221·6	·02511	1·746	·288	·328
33,750	7·465	3·67	−51·9	221·1	·02487	1·754	·285	·325
34,000	7·377	3·62	−52·4	220·6	·02463	1·763	·282	·322
34,250	7·291	3·58	−52·9	220·1	·02440	1·771	·279	·319
34,500	7·205	3·54	−53·4	219 6	·02416	1·780	·276	·316
34,750	7·120	3·50	−53·9	219·1	·02393	1·788	·273	·313
35,000	7·036	3·46	−54·3	218·7	·02369	1·797	·270	·310
35,250	6·951	3·41	−54·8	218·2	·02346	1·806	·267	·307
35,500	6·868	3·37	−55·3	217·7	·02322	1·814	·264	·304
35,750	6·787	3·33	−55·8	217·2	·02299	1·822	·261	·301
36,000	6·708	3·29	−56·3	216·7	·02270	1·833	·258	·297
36,250	6·628	3·26	−56·5	216·5	·02254	1·840	·255	·294
36,500	6·549	3·22	−56·5	216·5	·02227	1·851	·252	·291
36,750	6·471	3·18	−56·5	216·5	·02201	1·863	·249	·288
37,000	6·394	3·14	−56·5	216·5	·02175	1·876	·246	·284
37,250	6·318	3·10	−56·5	216·5	·02149	1·887	·244	·281
37,500	6·243	3·07	−56·5	216·5	·02124	1·898	·241	·278
37,750	6·169	3·03	−56·5	216·5	·02098	1·909	·238	·275
38,000	6·096	2·99	−56·5	216·5	·02074	1·921	·235	·272
38,250	6·024	2·96	−56·5	216·5	·02049	1·932	·232	·268
38,500	5·953	2·92	−56·5	216·5	·02025	1·944	·229	·265
38,750	5·882	2·89	−56·5	216·5	·02001	1·955	·227	·262
39,000	5·812	2·86	−56·5	216·5	·01977	1·967	·224	·258
39,250	5·743	2·82	−56·5	216·5	·01953	1·979	·221	·255
39,500	5·675	2·79	−56·5	216·5	·01930	1·991	·219	·252
39,750	5·608	2·75	−56·5	216·5	·01907	2·003	·216	·249

I.C.A.N. ALTITUDE TABLES—*continued*

Altitude, ft.	Pressure, "Hg.	Pressure, lb./sq. in. P	Temperature, °C. t	Temperature, °C. abs. T	Density, lb./cu. ft. ρ	$\sqrt{\frac{\rho_0}{\rho}}$	$P^{\frac{1}{2}} \rho^{\frac{1}{2}}$ factor	Relative density σ
40,000	5·541	2·72	−56·5	216·5	·01885	2·015	·214	·246
40,250	5·475	2·69	−56·5	216·5	·01862	2·027	·2111	·243
40,500	5·410	2·66	−56·5	216·5	·01840	2·039	·2086	·240
40,750	5·345	2·63	−56·5	216·5	·01818	2·051	·2061	·237
41,000	5·283	2·60	−56·5	216·5	·01797	2·063	·2036	·234
41,250	5·221	2·57	−56·5	216·5	·01775	2·076	·2012	·232
41,500	5·162	2·54	−56·5	216·5	·01754	2·088	·1988	·229
41,750	5·100	2·51	−56·5	216·5	·01734	2·101	·1965	·227
42,000	5·036	2·47	−56·5	216·5	·01713	2·113	·1941	·224
42,250	4·978	2·44	−56·5	216·5	·01693	2·126	·1918	·221
42,500	4·920	2·42	−56·5	216·5	·01673	2·139	·1895	·219
42,750	4·861	2·39	−56·5	216·5	·01653	2·151	·1873	·216
43,000	4·802	2·36	−56·5	216·5	·01633	2·164	·1851	·214
43,250	4·743	2·33	−56·5	216·5	·01613	2·177	·1829	·211
43,500	4·689	2·30	−56·5	216·5	·01594	2·190	·1807	·208
43,750	4·633	2·28	−56·5	216·5	·01575	2·203	·1786	·206
44,000	4·578	2·25	−56·5	216·5	·01556	2·216	·1765	·203
44,250	4·526	2·22	−56·5	216·5	·01538	2·230	·1744	·201
44,500	4·469	2·19	−56·5	216·5	·01519	2·243	·1723	·198
44,750	4·416	2·17	−56·5	216·5	·01501	2·257	·1703	·196
45,000	4,365	2·14	−56·5	216·5	·01484	2·270	·1683	·194
45,250	4·311	2·12	−56·5	216·5	·01466	2·284	·1663	·192
45,500	4·250	2·09	−56·5	216·5	·01449	2·297	·1643	·189
45,750	4·207	2·07	−56·5	216·5	·01432	2·311	·1623	·187
46,000	4·160	2·04	−56·5	216·5	·01415	2·325	·1604	·185
46,250	4·105	2·02	−56·5	216·5	·01398	2·339	·1585	·183
46,500	4·058	1·99	−56·5	216·5	·01381	2·353	·1566	·181
46,750	4·010	1·97	−56·5	216·5	·01365	2·367	·1547	·178
47,000	3·966	1·95	−56·5	216·5	·01349	2·381	·1529	·176
47,250	3·917	1·92	−56·5	216·5	·01333	2·396	·1511	·174
47,500	3·871	1·90	−56·5	216·5	·01317	2·410	·1493	·172
47,750	3·824	1·88	−56·5	216·5	·01302	2·424	·1475	·170
48,000	3·781	1·85	−56·5	216·5	·01286	2·439	·1457	·168
48,250	3·734	1·83	−56·5	216·5	·01271	2·454	·1440	·166
48,500	3·691	1·81	−56·5	216·5	·01256	2·468	·1423	·164
48,750	3·648	1·79	−56·5	216·5	·01241	2·483	·1406	·162
49,000	3·604	1·77	−56·5	216·5	·01226	2·498	·1389	·160
49,250	3·560	1·75	−56·5	216·5	·01211	2·513	·1373	·158
49,500	3·518	1·73	−56·5	216·5	·01197	2·528	·1356	·156
49,750	3·474	1·71	−56·5	216·5	·01183	2·543	·1340	·155
50,000	3·436	1·69	−56·5	216·5	·01169	2·558	·1324	·153

English Summer and Tropical Summer Altitude Tables

Height in ft. (pressure basis)	Relative pressure I.C.A.N.	I.C.A.N. conditions		English summer conditions		Tropical summer conditions	
		Temp. °C.	Relative density	Temp. °C.	Relative density	Temp. °C.	Relative density
0	1·000	15·0	1·000	23·0	·973	41·0	·917
1,000	·964	13·0	·971	21·4	·944	39·2	·890
2,000	·930	11·0	·943	19·8	·915	37·4	·863
3,000	·896	9·0	·915	18·1	·887	35·6	·836
4,000	·864	7·1	·888	16·4	·860	33·8	·811
5,000	·832	5·1	·862	14·6	·833	32·0	·786
6,000	·801	3·1	·836	12·8	·808	30·1	·761
7,000	772	1·1	·811	10·9	·783	28·2	·738
8,000	·743	−0·8	·786	9·0	·759	26·3	·715
9,000	·715	−2·8	·762	7·0	·735	24·3	·692
10,000	·688	−4·8	·738	5·0	·712	22·3	·671
11,000	·661	−6·8	·715	3·0	·690	20·3	·650
12,000	·636	−8·8	·693	1·0	·668	18·3	·629
13,000	·611	10·7	·671	−1·0	·647	16·2	·609
14,000	587	−12·7	·650	−3·1	·627	14·1	·589
15,000	·564	−14·7	·629	−5·2	·607	12·0	·570
16,000	·542	−16·7	609	−7·3	·587	9·8	·552
17,000	·520	−18·7	·589	−9·4	·568	7·6	·534
18,000	499	−20·7	·570	−11·6	·550	5·3	·517
19,000	479	−22·6	·551	−13·8	·532	2·9	·500
20,000	460	−24·6	·533	−16·1	·515	0·4	·484
21,000	441	−26·6	·515	−18·4	·498	−2·2	·469
22,000	·423	−28·6	·498	−20·8	·482	−4·9	·454
23,000	·405	−30·6	·481	23·3	·467	7·6	·439
24,000	·388	−32·5	·464	−25·9	·452	10·4	·425
25,000	·371	−34·5	·448	−28·5	·437	−13·3	·411
26,000	·355	−36·5	·432	−31·2	·423	−16·2	398
27,000	·340	−38·5	·417	−34·0	·409	−19·2	·386
28,000	·325	−40·5	·402	−36·9	·396	22·3	·373
29,000	·311	−42·5	·388	−39·9	·384	25·5	·361
30,000	·297	−44·5	·374	−43·0	·372	−28·8	·350

Table for Converting Boost Pressure in Lb./Sq. In. (Gauge) to Inches of Hg (Absolute) *

Negative boosts

		¼	½	¾
0	29·92	29·41	28·90	28·39
−1	27·88	27·38	26·87	26·36
−2	25·85	25·34	24·83	24·32
−3	23·81	23·30	22·79	22·29
−4	21·78	21·27	20·76	20·25
−5	19·74	19·23	18·72	17·21
−6	17·70	17·20	16·69	16·18
−7	15·67	15·16	14·65	14·14
−8	13·63	13·12	12·61	12·11
−9	11·60	11·09	10·58	10·07
10	9·56	9·05	8·54	8·03
11	7·52	7·02	6·51	6·00
12	5·49	4·98	4·47	3·96
13	3·45	2·94	2·43	1·93
14	1·42	0·91	0·40	—

Positive boosts

		¼	½	¾
0	29·92	30·43	30·94	31·45
1	31·96	32·47	32·97	33·48
2	33·99	34·50	35·01	35·52
3	36·03	36·54	37·05	37·56
4	38·06	38·57	39·08	39·59
5	40·10	40·61	41·12	41·63
6	42·14	42·65	43·15	43·66
7	44·17	44·68	45·19	45·70
8	46·21	46·72	47·23	47·74
9	48·24	48·75	49·26	49·77
10	50·28	50·79	51·30	51·71
11	52·32	52·83	53·33	53·84
12	54·35	54·86	55·37	55·88
13	56·39	56·90	57·41	57·92
14	58·42	58·93	59·44	59·95
15	60·46	60·97	61·48	61·99
16	62·50	63·01	63·51	64·02
17	64·53	65·04	65·55	66·06
18	66·57	67·08	67·59	68·10
19	68·60	69·11	69·62	70·13
20	70·64	71·15	71·66	72·17

Temperature Correction of Observed B.H.P.*

Formula:—$BHP_c = BHP_0\sqrt{\frac{273 + t_0}{288}}$

t_0 °C.	*Subtract %*		t^0 °C.	*Add %*	
−4	3·35		15	0	
		3·26			0·09
−3	3·16		16	0·17	
		3·07			0·26
−2	2·98		17	0·35	
		2·89			0·43
−1	2·80		18	0·52	
		2·71			0·60
0	2·61		19	0·69	
		2·52			0·77
1	2·43		20	0·86	
		2·35			0·94
2	2·26		21	1·03	
		2·18			1·12
3	2·09		22	1·20	
		2·00			1·28
4	1·91		23	1·37	
		1·83			1·45
5	1·74		24	1·54	
		1·66			1·62

* By courtesy of Rolls Royce, Ltd.

Temperature Correction of Observed B.H.P.—*continued.**

t_0 °C.	*Subtract %*		t_0 °C.	*Add %*	
6	1·57		25	1·71	
		1·48			1·79
7	1·39		26	1·88	
		1·31			1·96
8	1·22		27	2·05	
		1·14			2·13
9	1·05		28	2·22	
		0·96			2·30
10	0·87		29	2·39	
		0·79			2·47
11	0·70		30	2·56	
		0·61			2·64
12	0·52		31	2·73	
		0·44			2·81
13	0·35		32	2·90	
		0·26			2·98
14	0·17		33	3·07	
		0·09			3·15
15	0		34	3·24	

Figures in the right-hand columns show the corrections corresponding to the half-degrees of temperature midway between those shown in the left-hand columns.

Correction of Observed B.H.P. for Exhaust Back Pressure *

Formula:—$BHP_c = BHP_0\left[1+\frac{P_e-29\cdot92}{137\cdot8}\right]$ Expressed as a percentage of Observed B.H.P.

Back pressure, in. Hg. abs.	0	1	2	3	4	5	6	7	8	9
29·5	−0·31	0·30	0·29	0·28	0·28	0·27	0·26	0·26	0·25	0·24
29·6	−0·23	0·23	0·22	0·21	0·21	0·20	0·19	0·18	0·18	0·17
29·7	−0·16	0·15	0·15	0·14	0·13	0·13	0·12	0·11	0·10	0·10
29·8	−0·09	0·08	0·07	0·07	0·06	0·05	0·04	0·04	0·03	0·02
29·9	−0·01	0·01	0	0·01	0·01	0·02	0·03	0·04	0·04	0·05
30·0	+0·06	0·07	0·07	0·08	0·09	0·10	0·10	0·11	0·12	0·12
30·1	+0·13	0·14	0·15	0·15	0·16	0·17	0·17	0·18	0·19	0·20
30·2	+0·20	0·21	0·22	0·22	0·23	0·24	0·25	0·25	0·26	0·27
30·3	+0·28	0·28	0·29	0·30	0·31	0·31	0·32	0·33	0·33	0·34
30·4	+0·35	0·36	0·36	0·37	0·38	0·38	0·39	0·40	0·41	0·41
30·5	+0·42	0·43	0·44	0·44	0·45	0·46	0·46	0·47	0·48	0·49
30·6	+0·49	0·50	0·51	0·51	0·52	0·53	0·54	0·54	0·55	0·56
30·7	+0·57	0·57	0·58	0·59	0·59	0·60	0·61	0·62	0·62	0·63
30·8	+0·64	0·64	0·65	0·66	0·67	0·67	0·68	0·69	0·70	0·70
30·9	+0·71	0·72	0·73	0·73	0·74	0·75	0·75	0·76	0·77	0·78

* By courtesy of Rolls Royce, Ltd.

CORRECTION OF OBSERVED B.H.P. FOR EXHAUST BACK PRESSURE—*continued*

Back pressure, in. Hg. abs.	0	1	2	3	4	5	6	7	8	9
31·0	+0·78	0·79	0·80	0·81	0·81	0·82	0·83	0·84	0·84	0·85
31·1	+0·86	0·87	0·87	0·88	0·89	0·90	0·90	0·91	0·92	0·92
31·2	+0·93	0·94	0·94	0·95	0·96	0·96	0·97	0·98	0·99	0·99
31·3	+1·00	1·01	1·02	1·02	1·03	1·04	1·04	1·05	1·06	1·07
31·4	+1·07	1·08	1·09	1·09	1·10	1·11	1·12	1·12	1·13	1·14
31·5	+1·15	1·16	1·17	1·17	1·18	1·19	1·19	1·20	1·21	1·22
31·6	+1·22	1·23	1·24	1·24	1·25	1·26	1·27	1·27	1·28	1·29
31·7	+1·30	1·30	1·31	1·32	1·32	1·33	1·34	1·35	1·35	1·36
31·8	+1·37	1·38	1·38	1·39	1·40	1·41	1·41	1·42	1·43	1·43
31·9	+1·44	1·45	1·46	1·46	1·47	1·48	1·48	1·49	1·50	1·51
32·0	+1·51	1·52	1·53	1·54	1·54	1·55	1·56	1·57	1·57	1·58
32·1	+1·59	1·59	1·60	1·61	1·62	1·62	1·63	1·64	1·64	1·65
32·2	+1·66	1·67	1·67	1·68	1·69	1·70	1·70	1·71	1·72	1·73
32·3	+1·73	1·74	1·75	1·75	1·76	1·77	1·78	1·78	1·79	1·80
32·4	+1·81	1·81	1·82	1·83	1·83	1·84	1·85	1·86	1·86	1·87
32·5	+1·88	1·89	1·89	1·90	1·91	1·91	1·92	1·93	1·94	1·94
32·6	+1·95	1·96	1·97	1·97	1·98	1·99	1·99	2·00	2·01	2·02
32·7	+2·02	2·03	2·04	2·05	2·05	2·06	2·07	2·07	2·08	2·09
32·8	+2·10	2·10	2·11	2·12	2·13	2·13	2·14	2·15	2·15	2·16
32·9	+2·17	2·18	2·18	2·19	2·20	2·21	2·21	2·22	2·23	2·23

VELOCITY OF SOUND IN AIR

The velocity of sound in any gas depends upon the nature of the gas and its temperature only. Thus beyond the lower stratosphere limit the velocity of sound in air remains constant at 968·3 ft. per sec. At ground-level the velocity of sound in air is 1,116·8 ft. per sec. The above values refer to standard air.

Newton's fundamental equation $a=\sqrt{\frac{E}{\rho}}=\sqrt{\frac{\gamma P}{\rho}}$

which may be written $a=\sqrt{\gamma g B T}$

or $a=1,120\left(\frac{T}{T_0}\right)^{\frac{1}{2}}$

where T is the absolute temperature.

Approximate expression for variation with altitude $a=1,120-\cdot 004h$.

Mach Number

$$\text{Mach number}=\frac{\text{Actual velocity (air).}}{\text{Velocity of sound.}}$$

Mach angle.

Mach angle $= \sin^{-1} a/v$.

where a = velocity of sound in front of shock wave.

v = velocity of air in front of shock wave.

VELOCITY OF SOUND IN AIR AT VARIOUS ALTITUDES
(Standard I.C.A.N. Atmosphere)

Altitude, ft.	Velocity of sound, ft./sec.	Altitude, ft.	Velocity of sound, ft./sec.
0	1116·8	11,750	1070·9
250	1115·8	12,000	1070·0
500	1114·8	12,250	1069·0
750	1115·9	12,500	1067·9
1,000	1112·9	12,750	1066·9
1,250	1111·9	13,000	1065·9
1,500	1111·0	13,250	1064·8
1,750	1110·0	13,500	1063·8
2·000	1109·1	13,750	1062·8
2,250	1108·1	14,000	1061·7
2,500	1107·1	14,250	1060·7
2,750	1106·1	14,500	1059·7
3,000	1105·2	14,750	1058·6
3,250	1104·2	15,000	1057·6
3,500	1103·2	15,250	1056·6
3,750	1102·2	15,500	1055·6
4,000	1101·1	15,750	1054·5
4,250	1100·3	16,000	1053·5
4,500	1099·3	16,250	1052·5
4,750	1098·4	16,500	1051·5
5,000	1097·4	16,750	1050·9
5,250	1096·4	17,000	1049·4
5,500	1095·4	17,250	1048·4
5,750	1094·5	17,500	1047·4
6,000	1093·5	17,750	1046·3
6,250	1092·5	18,000	1045·3
6,500	1091·5	18,250	1044·3
6,750	1090·5	18,500	1043·2
7,000	1089·6	18,750	1042·1
7,250	1088·6	19,000	1041·2
7,500	1087·6	19,250	1040·1
7,750	1086·6	19,500	1039·1
8,000	1085·6	19,750	1038·0
8,250	1084·6	20,000	1037·0
8,500	1083·7	20,250	1036·0
8,750	1082·7	20,500	1035·0
9,000	1081·7	20,750	1034·0
9,250	1080·7	21,000	1032·9
9,500	1079·7	21,250	1031·9
9,750	1078·7	21,500	1030·9
10,000	1077·7	21,750	1029·9
10,250	1076·8	22,000	1028·8
10,500	1075·8	22,250	1027·8
10,750	1074·8	22,500	1026·8
11,000	1073·8	22,750	1025·8
11,250	1072·9	23,000	1024·7
11,500	1071·9	23,250	1023·6

VELOCITY OF SOUND IN AIR AT VARIOUS ALTITUDES—*continued*

Altitude, ft.	Velocity of sound, ft./sec.	Altitude, ft.	Velocity of sound, ft./sec.
23,500	1022·6	37,000	968·3
23,750	1021·5	37,250	968·3
24,000	1020·5	37,500	968·3
24,250	1019·4	37,750	968·3
24,500	1018·4	38,000	968·3
24,750	1017·3	38,250	968·3
25,000	1016·3	38,500	968·3
25,250	1015·2	38,750	968·3
25,500	1014·2	39,000	968·3
25,750	1013·1	39,250	968·3
26,000	1012·1	39,500	968·3
26,250	1011·0	39,750	968·3
26,500	1009·9	40,000	968·3
26,750	1008·9	40·250	968·3
27,000	1007·8	40,500	968·3
27,250	1006·8	40,750	968·3
27,500	1005·7	41,000	968·3
27,750	1009 6	41,250	968·3
28,000	1003·5	41,500	968·3
28,250	1002·4	41,750	968·3
28,500	1001·3	42,000	968·3
28,750	1000·2	42,250	968·3
29,000	999·2	42,500	968·3
29,250	998·1	42,750	968·3
29,500	997·0	43,000	968·3
29,750	996·0	43,250	968·3
30,000	994·9	43,500	968·3
30,250	993·8	43,750	968·3
30,500	992·7	44,000	968·3
30,750	991·6	44,250	968·3
31,000	990·6	44,500	968·3
31,250	989·5	44,750	968·3
31,500	988·4	45,000	968·3
31,750	987·3	45,250	968·3
32,000	986·3	45,500	968·3
32,250	985·2	45,750	968·3
32,500	984·1	46,000	968·3
32,750	983·0	46,250	968·3
33,000	981·9	46,500	968·3
33,250	980·8	46,750	968·3
33,500	979·7	47,000	968·3
33,750	978·6	47,250	968·3
34,000	977·5	47,500	968·3
34,250	976·4	47,750	968·3
34,500	975·3	48,000	968·3
34,750	974·2	48,250	968·3
35,000	973·1	48,500	968·3
35,250	972·0	48,750	968·3
35,500	970·9	49,000	968·3
35,750	969·8	49,250	968·3
36,000	968·8	49,500	968·3
36,250	968·3	49,750	968·3
36,500	968·3	50,000	968·3
36,750	968·3		

By courtesy of Rolls Royce, Ltd.

RAYLEIGH'S FORMULA

A general formula giving aerodynamic force, A, in terms of ρ, V, l, and μ may be obtained by the principle of homogeneity of dimensions. For convenience the quantity $\frac{\mu}{\rho}$, *i.e.* the kinematic viscosity of the fluid, is denoted by ν.

$$A = f(\rho, V, l, \nu)$$

or

$$A = \Sigma \rho^w V^x l^y \nu^z$$

where w, x, y, and z are yet to be determined.

Writing the general equation in dimensional form

$$\frac{ML}{T^2} = \left(\frac{M}{L^3}\right)^w \left(\frac{L}{T}\right)^x L^y \left(\frac{L^2}{T}\right)^z.$$

Solution for homogeneity of dimensions:

Dimensions L.H.S. = Dimensions R.H.S.

i.e.

$$M = 1, \text{ giving } w = 1$$
$$L = 1, \text{ giving } -3w + x + y + 2z = 1$$
$$T = -2, \text{ giving } -x - z = -2.$$

Hence $w = 1$ and $x = w = 2 - z$.

The general formula now becomes $A = \Sigma \rho V^{2-z} l^{2-z} \nu^z$

$$= \Sigma \rho V^2 l^2 \left(\frac{Vl}{\nu}\right)^{-z}.$$

Which may be written $A = \rho V^2 l^2 \,.\, j\left(\frac{Vl}{\nu}\right)$.

The variable $\left(\frac{Vl}{\nu}\right)$ is known as the *Reynolds Number* and is denoted by R or R.N.

i.e. $\text{R or R.N.} = \frac{Vl}{\nu}$

where V = velocity in ft. per sec.

l = length (or chord) in feet of body paralle to the airflow.

ν = kinematic viscosity. For air at 15° C. and 29·9 in. press. = $1{\cdot}59 \times 10^{-4}$ ft.^{2}/sec.

= ·148 cm.^{2}/sec.

Expressed in Simple Form.—Reynolds Number = 6,300 × V (ft./sec.) × chord (ft.).

BERNOULLI'S EQUATION

$$\int\frac{dP}{\rho}+\tfrac{1}{2}q^2=\text{const.: or}\Big/\frac{P}{w}+\frac{V^2}{2g}+Z=H$$

where P/w=pressure head, $\frac{V^2}{2g}$=velocity head, Z=potential head, w=specific weight of fluid, and H is a constant.

General expression

$$P+\frac{\rho}{2}V^2=\text{const.: or/ } P+q=\text{const.:}$$

i.e. static pressure—dynamic pressure, total pressure.

STREAM FUNCTION, ψ

$$\psi=\int_{x_0,\,y_0}^{x,\,y}(vdx-udy)=\psi(x,y)-\psi(x_0,y_0)$$

and determines the amount of fluid streaming across a curve connecting two points (x, y) and (x_0, y_0) in a fluid. u and v are axial components of the fluid velocity.

STREAMLINE

In a streamlined flow ψ a constant, or $d\psi=0$, and thus no fluid passes across curve as defined above.

CIRCULATION, Γ

Circulation is defined as the flow *along* a boundary, as opposed to flow across.

$$\Gamma=\int V_r\cos\theta\,.\,ds$$

where V_r is the resultant velocity making an angle θ with the element of curve ds.

Resolving velocity into its tangential components

$$\Gamma=\int(u\,.\,dx+v\,.\,dy).$$

KUTTA-JOUKOWSKI THEOREM OF LIFT

$$L=\rho\Gamma V$$

i.e. the lift per unit length of a wing on infinite span varies directly as the circulation.

2

General Equations for Lift and Drag

$$\left.\begin{aligned} L &= C_L\frac{\rho}{2}SV^2 = C_L qS \,. \\ D &= C_D\frac{\rho}{2}SV^2 = C_D qS \,. \end{aligned}\right\} \text{Standard notation.}$$

Where L = lift in pounds, ρ = air density (slugs/cu. ft.)
D = drag in pounds. S = surface area in sq. ft.
V = velocity in ft. per sec.

C_L and C_D are the lift and drag coefficients, respectively.

British System (Now Obselete)

$$L = K_L\rho SV^2$$
$$D = K_D\rho SV^2$$

Engineering System (Obsolete)

$$L = K_y\frac{\rho}{\rho_0}SV^2 = K_y\sigma SV^2.$$

$$D = K_x\frac{\rho}{\rho_0}SV^2 = K_x\sigma SV^2.$$

where S = area in sq. *feet*; V = velocity in *miles per hour*.

The coefficients, K_x and K_y, give drag and lift, respectively, of 1 sq. ft. of surface at a velocity of 1 mile per hour in standard air.

Relationship between Coefficients

$C_L = 2K_L = 391K_y$ $\quad$ $K_y = \cdot002558C_L = \cdot005116K_L$.
$C_D = 2K_D = 391K_x$ $\quad$ $K_x = \cdot002558C_D = \cdot005116K_D$.

Rolling, Pitching, and Yawing moments are expressed in similar form to the Lift and Drag equations, with the introduction of a factor of length. This is either the span, b, or the chord, c, of the wings.

Rolling moment, $L = C_l\frac{\rho}{2}bSV^2 = k_r\rho bSV^2$.

Pitching moment, $M = C_m\frac{\rho}{2}cSV^2 = k_m\rho cSV^2$.

Yawing moment, $N = C_n\frac{\rho}{2}bSV^2 = k_n\rho bSV^2$.

The centre of pressure coefficient, $k_{c.p.}$, is simply related to k_m:—

$$k_M = -k_L \times k_{c.p.}$$

Centre of Pressure, C.P.

$$\text{C.P.} = \cdot 25 - \frac{C_{M_{c/4}}}{C_L} \quad (C_{M_{c/4}} = \text{moment-coeff. about 25\% chord}).$$

or $$\text{C.P.} = a - \frac{C_{M_a}}{C_L}$$

where a = aerodynamic centre.
and C_{M_a} = moment about aerodynamic centre.

Wind-Tunnel Interference

Tests on model aeroplanes or wings in wind tunnels require correction for the effect of the tunnel walls. This is usually done by the authority issuing the test reports, but in old reports or exceptional cases it may be omitted. Wind-tunnel figures should always be corrected for this effect before being used.

List of Symbols

α = Angle of incidence in radians.
α_T = Angle of tail setting in radians.
C = Cross-sectional area of tunnel.
h = Height of tunnel normal to wing span.
b = Breadth of tunnel.
x = Distance of tailplane from centre of gravity.

The other symbols used are given in general list.

The following are the corrections:—

Angle of incidence $\quad \Delta\alpha = E_1 = \dfrac{\delta S C_L}{C}$ (radians).

Tail setting $\quad \Delta\alpha_T = E_2 = \dfrac{\delta_1 x S C_L}{hC}$.

Downwash angle $\quad \Delta E = E_1 + E_2$.

Drag coefficient $\quad \Delta C_D = E_1 C_L = \dfrac{\delta S C_L^2}{C}$.

$$(\Delta\alpha) = 57{\cdot}3\,\delta \frac{C_L S}{C} \text{ (degrees)}$$

$$\Delta C_{Di} = \delta \,.\, \frac{C_L^2 S}{C}.$$

The value of the coefficients δ and δ_1 are as follows:—

Wind tunnel	δ	δ_1
Circular	·125	—
Rectangular ($b=2h$) . . .	·137	·292
Square	·137	·240

These corrections are for closed tunnels.
Glauert, *Aerofoil and Airscrew Theory.*

Applied Wing Theory

Induced drag, D_i.

$$C_{Di}=\frac{C_L^2}{\pi A}=\frac{C_L^2 S}{\pi b}.$$

$$\left.\begin{aligned} C_{D2}&=C_{D1}+\frac{C_L^2}{\pi}\left(\frac{S_2}{b_2^2}-\frac{S_1}{b_1^2}\right)\\ &=C_{D1}+\frac{C_L^2}{\pi}\left(\frac{1}{A_2}-\frac{1}{A_1}\right)\end{aligned}\right\}$$ Variation of drag coefficient, C_D, with change of aspect ratio.

Induced angle of attack, α_i.

$$\alpha_i=\frac{2L}{\pi\rho b^2V^2}=\frac{L}{\pi q b^2}.$$

$$\left.\begin{aligned}\alpha_2&=\alpha_1+\frac{C_L}{\pi}\left(\frac{S_2}{b_2^2}-\frac{S_1}{b_1^2}\right)=\alpha_1+\frac{C_L}{\pi}\left(\frac{1}{A_2}-\frac{1}{A_1}\right)\text{ radians}\\ \alpha_2&=\alpha_1+57{\cdot}3\frac{C_L}{\pi}\left(\frac{S_2}{b_2^2}-\frac{S_1}{b_1^2}\right)=\alpha_1+\frac{57{\cdot}3C_L}{\pi}\left(\frac{1}{A_2}-\frac{1}{A_1}\right)\text{ degrees}\end{aligned}\right\}$$ Variation of angle of attack with change of aspect ratio.

All above formulæ assume elliptical loading.

Modification for any loading :—

$$C_{Di}=\frac{C_L^2S}{\pi b^2}(1+\delta).$$

$$\alpha_1=\frac{C_LS}{\pi b^2}(1+\tau).$$

where $$1+\delta=\frac{\Sigma_n A_n^2}{A_1^2},\quad 1+\tau=\frac{1}{\mu}\left(\frac{\mu\alpha}{A_1}-\frac{\pi}{4}\right).$$

In general δ may be ignored, but τ may not.

MONOPLANE AEROFOILS

Effect of Aspect Ratio on Induced Drag
Slope of Lift Curve and Incidence

$$C_{Di}=XC_L^2 \qquad \alpha_i=YC_L$$

where $$X=\frac{S}{\pi b^2}(1+\delta),\ Y=\frac{S}{\pi b^2}(1+\tau)$$

S being the wing area, b the span and δ and τ constants given in the following Tables for rectangular aerofoils and for tapered aerofoils of aspect ratio a_0. C_{Di} is the coefficient of induced drag and α_i the change in incidence (radians) from the two-dimensional flow value ($A=\infty$).

a = slope of lift coefficient—incidence (radians) curve.
a_0 = value of a for two-dimensional flow ($=2\pi$ approx.).
A = aspect ratio.

Rectangular Aerofoils

A/a_0	a/a_0	τ	δ
0·25	0·426	0·05	0·007
0·50	0·587	0·10	0·019
0·75	0·675	0·14	0·034
1·0	0·729	0·17	0·049
1·25	0·767	0·20	0·063
1·50	0·794	0·22	0·076
1·75	0·815	0·24	0·086

Tapered Aerofoils—Aspect Ratio$=a_0=2\pi$ (approx.)

Tip chord / Central chord	a/a_0	τ	δ
1·0	0·729	0·17	0·049
0·75	0·742	0·10	0·026
0·50	0·754	0·03	0·011
0·25	0·757	0·01	0·016
0	0·729	0·17	0·141

Working Equations

$$C_{Di}=XC_L^2.$$
$$C_{D2}=C_{D1}+C_L^2(X_2-X_1).$$
$$\alpha_i=YC_L \text{ (degrees)}.$$
$$\alpha_2=\alpha_1{}^\circ+C_L(Y_2-Y_1).$$

where $$X=\frac{S}{\pi b^2}(1+\delta) \text{ or } \frac{S}{\pi b^2} \text{ (ignoring } \delta).$$

$$Y=\frac{57{\cdot}3S}{\pi b^2}(1+\tau).$$

General Theorem for Induced Drag of Multiplane

The induced drag of a multiplane is equal to the sum of the self-induced drags of the wings of the combination together with as many mutual drags as there are permutations of the wings in pairs.

Downwash

Theoretical $\epsilon = 2\alpha_i = \dfrac{2C_L}{\pi A}$ (where A = *effective* aspect ratio).

Working formula

$$\epsilon = \frac{52C_L}{A}(x+1)^{-.36}(y+1)^{-.23} \text{(Diehl)}$$

where x = distance downstream in chord lengths.
y = distance above or below wake in chord lengths.
A = effective aspect ratio.

N.A.C.A. Series of Aerofoils

This related family of aerofoils is built up on the principle of adding a streamlined fairing of varying thicknesses around a camber line, the camber and position of maximum camber of which is varied.

The aerofoils are designated by a four-digit number; the first digit giving the mean camber of the centre line, expressed as a percentage of the chord length; the second digit gives the location of the point of maximum camber in $\frac{1}{10}$th chord length; the third and fourth digits give the thickness of the section, expressed as a percentage of the chord length.

Thus aerofoil 5412 has a centre line camber of 5% of the chord; the maximum camber is located at $\frac{4}{10}$th, *i.e.* 40% of the chord and the thickness of the section is 12% of the chord.

The leading edge radius of the various sections is given by

$$r = 1{\cdot}10t^2.$$

The ordinates for any thickness, t, are given by

$$\pm y = 5t(0{\cdot}2969\sqrt{x} - 0{\cdot}1260x - 0{\cdot}3516x^2 + 0{\cdot}2843x^3 - 0{\cdot}1015x^4).$$

There is also a five-digit series with maximum camber at ·05 chord, ·10 chord, ·15 chord, ·20 chord, and ·25 chord. Corresponding designations for position of maximum camber consistent with the scheme of the first series are 10, 20, 30, 40, and 50. These designations then take the place of the second digit in the four-digit series.

Chief Criteria for Selection of Aerofoil Section

Value of C_{Lmax}. Value of C_L/C_{Dmax}.
Value of C_{Dmin}. Value of C_{M_0}.
Value of C_{Lmax}/C_{Dmin}.

The following are considered as subsidiary criteria :—

C_L at stall. C_L at $C_{D_{p\,min}}$.

C_L at L/D_{max}. C_L^3/C_D^2 (power factor).

Characteristics of Lift curve at stall.

AEROFOIL. CLARK Y. H. CO-ORDINATES FROM DATUM LINE

Chord from leading edge	Upper surface	Lower surface	Chord from leading edge	Upper surface	Lower surface
0	0·0350	0·0350	0·40	0·1140	0
0·0125	0·0545	0·0193	0·50	0·1051	0
0·025	0·0650	0·0147	0·60	0·0915	0
0·05	0·0790	0·0093	0·70	0·0742	0·0006
0·075	0·0885	0·0063	0·80	0·0562	0·0038
0·10	0·0960	0·0042	0·90	0·0384	0·0102
0·15	0·1068	0·0015	0·95	0·0293	0·0140
0·20	0·1136	0·0003	1·00	0·0205	0·0185
0·30	0·1170	0			

AEROFOIL. CLARK Y. H. AERODYNAMIC DATA

α	C_L	C_D	C_M
2·8	−0·011	0·0088	−0·0310
1·6	+0·076	0·0092	−0·0298
+0·6°	0·250	0·0115	−0·0270
2·8	0·420	0·0181	−0·0244
5·1	0·590	0·0242	−0·0230
7·4	0·760	0·0414	−0·0218
9·7	0·924	0·0584	−0·0216
11·8°	1·084	0·0806	−0·0218
14·0°	1·168	0·1032	−0·0218
16·3°	1·366	0·1260	−0·0228
17·4°	1·426	0·1384	−0·0224
18·5°	1·474	0·1506	−0·0232
19·4°	1·304	0·1960	−0·0500
20·4°	1·252	0·220	−0·0606
22·3°	1·102	0·278	−0·0886
25·4°	0·912	0·330	−0·0992
28·5°	0·854	0·396	−0·1150

R. and M., No. 1706.

R $6{\cdot}82 \times 10^6$.

A 6.

Pitching moments are referred to a position at ·25c from leading edge.

Aerofoil R.A.F. 34. Aerodynamic Data

a	C_L	C_D	C_M
−1·6°	−0·066	0·0088	−0·0048
−0·5°	+0·017	·0084	−0·0034
1·7°	0·185	·0101	−0·0014
3·9°	0·352	·0154	+0·0004
6·2°	0·520	·0242	+0·0010
8·3°	0·698	·0360	+0·0012
10·5°	0·848	·0512	+0·0004
12·6°	0·998	·0702	−0·0010
14·8°	1·150	·0912	−0·0022
17·0°	1·286	·1154	−0·0042
19·1°	1·306	·1518	−0·0198
21·1°	1·240	·2102	−0·0248
23·1°	1·090	·278	−0·076
25·2°	0·962	·328	−0·086
27·4°	·826	·360	−0·094
29·3°	·760	—	—

R. and M., No. 1706.

$R = 6{\cdot}47 \times 10^6$.

$A = 6$.

Pitching moments are referred to a position at ·25c from leading edge.

Aerofoil R.A.F. 34. Co-ordinates from Datum Line

Chord from leading edge	Upper surface	Lower surface	Chord from leading edge	Upper surface	Lower surface
0	0	0	0	0	0
·0125	0·0198	−0·0162	·50	0·0721	−0·0411
·025	0·0282	−0·0214	·55	0·0659	−0·0393
·05	0·0411	−0·0281	·60	0·0587	−0·0369
·10	0·0583	−0·0353	·65	0·0513	−0·0343
·15	0·0697	−0·0391	·70	0·0431	−0·0309
·20	0·0772	−0·0416	·75	0·0349	−0·0271
·25	0·0814	−0·0426	·80	0·0270	−0·0230
·30	0·0832	−0·0432	·85	0·0195	−0·0185
·35	0·0827	−0·0433	·90	0·0126	−0·0134
·40	0·0808	−0·0432	·95	0·0064	−0·0076
·45	0·0774	−0·0426	1·00	0·	0

Aerofoil N.A.C.A. 23012. Aerodynamic Data

α	C_L	C_D	C_M	α	C_L	C_D	C_M
−3·9°	−·2	0·0112	−0·008	9·7°	·8	0·0467	−0·007
−2·5°	−·1	·0090	− ·009	11·0°	·9	·0565	− ·005
−1·2°	·0	·0079	− ·009	12·3°	1·0	·0673	− ·007
·2°	·1	·0079	− ·008	13·7°	1·1	·0796	− ·006
1·6°	·2	·0090	− ·008	15·1°	1·2	·0928	− ·008
3·0°	·3	·0120	− ·007	16·4°	1·3	·1080	− ·009
4·3°	·4	·0167	− ·007	17·9°	1·4	·1260	− ·009
5·7°	·5	·0228	− ·007	19·2°	1·46	·144	− ·010
7·0°	·6	·0298	− ·006	19·6°	1·2	·197	− ·037
8·3°	·7	·0378	− ·007	21·0°	1·1	·229	− ·067

N.A.C.A. Report, No. 530. $R = 4{\cdot}25 \times 10^6$.

Pitching moments are referred to the aerodynamic centre, which is ·296*c* from leading edge and ·089*c* below upper surface.

Corrected for tunnel interference,

A = 6.

Aerofoil N.A.C.A. 23012. Co-ordinates from Datum Line

Chord from leading edge	Upper surface	Lower surface	Chord from leading edge	Upper surface	Lower surface
0	0	0	0	0	0
·0125	·0267	− ·0123	·40	·0714	− ·0448
·0250	·0361	− ·0171	·50	·0641	− ·0417
·05	·0491	− ·0226	·60	·0547	− ·0367
·075	·0580	− ·0261	·70	·0436	− ·0300
·10	·0643	− ·0292	·80	·0308	− ·0216
·15	·0719	− ·0350	·90	·0168	− ·0123
·20	·0750	− ·0397	·95	·0092	− ·0070
·25	·0760	− ·0428	1·00	0	0
·30	·0755	− ·0446			

Leading edge radius ·0158.

***N.A.C.A. Report*, No. 530.**
All figures are decimals of chord.

AEROFOIL DATA

Aerofoil	Reference
R.A.F. 14	R. and M. 323. R. and M. 195.
R.A.F. 15	R. and M. 774, 857, 859, 872, 888, 1,320, 929 (slots).
R.A.F. 25	R. and M. 915.
R.A.F. 26	R. and M. 943.
R.A.F. 27	R. and M. 1,027
R.A.F. 28	R. and M. 1,027, 1,269.
R.A.F. 30	R. and M. 928, 1,052, 1,063 (slots).
R.A.F. 31	R. and M. 928, 990, 1,320, 1,063 (slots).
R.A.F. 32	R. and M. 928, 1,006.
R.A.F. 33	R. and M. 928.
R.A.F. 34	R. and M. 1,071, 1,146.
R.A.F. 36	R. and M. 1,147.
R.A.F. 38	R. and M. 1,543.
R.A.F. 48	R. and M. 1,543.
R.A.F. 69	R. and M. 1,717.
R.A.F. 89	R. and M. 1,717. R and M. 1,706.
Göttingen 387	
Göttingen 388	
Göttingen 426	
Göttingen 429	R. and M. 1,243
Göttingen 436	N.A.C.A. T.R. 331.
Göttingen 449	
Göttingen 398	N.A.C.A. Report No. 628.
M. 2 (Munk)	R. and M. 1,070. N.A.C.A. T.N. 221.
M. 6 (Munk)	N.A.C.A. Report No. 260, 352.
M. 12 (Munk)	N.A.C.A. T.N. 243.
Clark Y.	N.A.C.A. T.N. 219, T.R. 502 (scale effect). N.A.C.A. 586 (slot).
Clark Y. H.	N.A.C.A. T.N. 240. R. and M. 1,706.
N.A.C.A. 0,012	R. and M. 1,708.
N.A.C.A. 23,012	N.A.C.A. Report No. 537, 586 (flaps), 610 (flaps).
N.A.C.A. 23,009	N.A.C.A. Report No. 610 (flaps).
N.A.C.A. 43 series	N.A.C.A. T.N. 391.
N.A.C.A. 63 series	N.A.C.A. T.N. 391.

The following N.A.C.A. Technical Reports are also of great interest and contain data on many hundreds of different aerofoils : 93, 124, 182, 221, 233, 244, 286, 315, 331, 357, 460, 492.

Zero Lift

Theoretical value of angle of zero lift, β (measured from geometric chord).

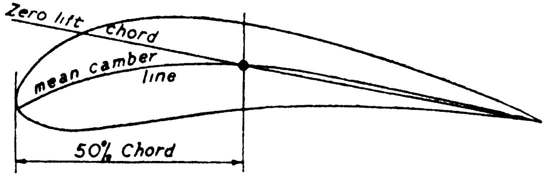
Camber line a straight line, $\beta=0$, *i.e.* geometric chord = zero lift chord.

Camber line an arc of a circle, $\beta=2y$, where y = camber.

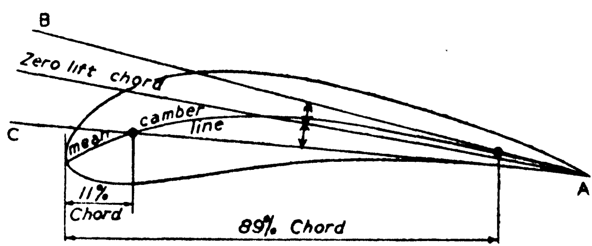
Camber line other than circular arc.

$$\beta=\int_0^1 \frac{y\,dx}{\pi(1-x)(\sqrt{x(1-x)})}=\int_0^1 y\,.\,f(x)\,.\,dx.$$

Approximate Construction for Zero Lift Chord



Accurate Construction for Zero Lift Chord



Zero lift chord bisects ∠BAC.

REDUCTION OF AIRCRAFT DRAG

(*By courtesy of Hawker Aircraft, Ltd.*)

INTRODUCTION

In the design of high-speed aircraft consideration of drag is of paramount importance.

With very " clean " aircraft, small excrescences will give rise to considerable percentage increase in basic drag with consequent loss of speed.

Careful attention to detail at the design stage is essential, in fact the importance of drag reduction on aircraft cannot be over-estimated and to emphasise this, a few comparisons are of interest:—

The drag of the Hurricane has been kept down to 50% of the Hart types, and the drag of the Typhoon is only 85% of the drag of the Hurricane.

However good these figures may seem, they can still be improved upon by reducing the number of excrescences to a minimum.

The ideal, of course, is to have no excrescences at all, but where it does become absolutely necessary to depart from the ideal contour, a careful study of this section will more than repay the time spent by the draughtsman.

Flight tests have proved that when the requirements laid down on pages 47–9 have been complied with, a notable improvement in performance was experienced.

A Hurricane was chosen for this experiment and the result was an increase in speed of 9 miles per hour.

It is estimated that if the Hurricane were free from all minor excrescences, leaks, and surface irregularities, an increase of 35 miles per hour could have been attained over the speed of normal production machines.

It must be emphasised that the values of B/A, quoted on pages 46 and 47, are only the minimum necessary and should be improved upon wherever possible.

BOLTS, HINGES, JOINTS, ETC.

Bolts, hinges, etc., should on no account be allowed to project into the airstream.

Hinges for access doors should, if possible, be positioned in the direction of flow rather than across it. On a curved surface, such as the leading edge of an aerofoil, this can be avoided by using " set-back " hinges, as used on the Typhoon cabin doors.

All skin joints must be made flush, as minimum drag can only be obtained when the surface does not deviate more than ·002 in. from the designed contour.

EXCRESCENCES ON AEROFOILS

When such excrescences cannot be avoided, they should be positioned more than $\frac{1}{10}$th of the chord aft of the maximum thickness of the wing and preferably on the bottom surface. Particular care should be taken to keep the nose of the aerofoil absolutely clean. When an excrescence is situated forward of the position given above, the drag of the wing itself is considerably increased over a section much wider than the excrescence itself.

DRAUGHT SEALING, FUSELAGE HOLES, ETC.

Tests have proved that a large decrease in the total drag can be obtained if all air leaks are properly sealed. Care should be taken therefore to seal off all holes in the fuselage and cowling, and, when this cannot be done directly (as in the case of the tail wheel and spinner gap), to isolate such openings from the remainder of the aircraft by a diaphragm.

A reduction of 5% in the drag was obtained on a Hurricane by sealing all leaks which were considered practicable, and a reduction of as much as 14½% was obtained on full-scale tests by completely sealing all leaks, including sealing and fairing gaps at control surfaces and flaps.

VENT PIPES, BREATHERS, ETC.

The ends of vent pipes and engine breathers, etc., should be finished flush and not allowed to project into the airstream. A collar, which will prevent leaks into the inside of the fuselage, should be fitted, provision being made for variations due to tolerances or ill-fitting panels, etc.

The best position for such vent pipes is in the vicinity of the radiator duct outlet and all vent pipes should be grouped together at their exit.

NARROW PASSAGES, SUDDEN EXPANSIONS, ETC.

Whenever there is a tendency for the airflow to be forced through a narrow passage (as in the case of the wing to fuselage junction on low-wing aircraft), careful attention should be paid to the design of the fillet.

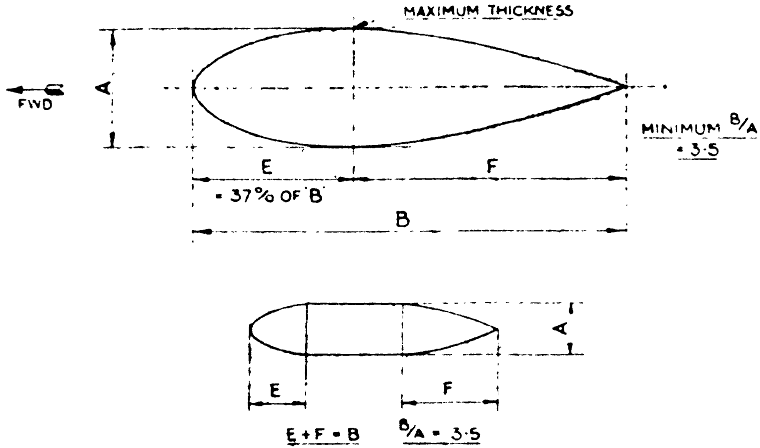
This also applies where sudden expansions of the airstream are likely to occur.

Therefore, the design of such items as main plane fillets, tail plane fillets, etc., should be carried out under the guidance of expert technical advice.

It is highly important that no excrescences should be allowed in the vicinity of an area in which the airflow is constricted.

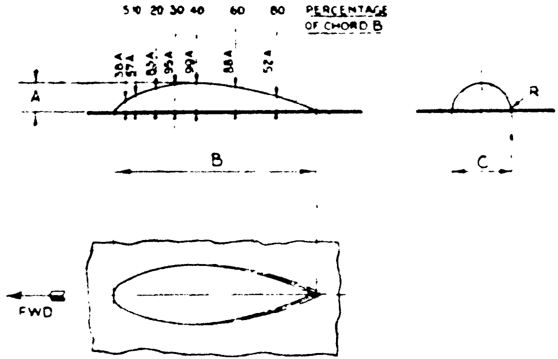
Solids of Revolution

Applicable to Balance Weights, External Tanks, etc.



Ordinates for cross-sections should approximate to those given on page 49, under the heading "Struts and Tubes in the Airstream." In the case of a body such as an external fuel tank, a cylinder may be interposed at the maximum thickness, and in this case the total lengths of the end fairings are taken to make up the value of "B" as in the diagram.

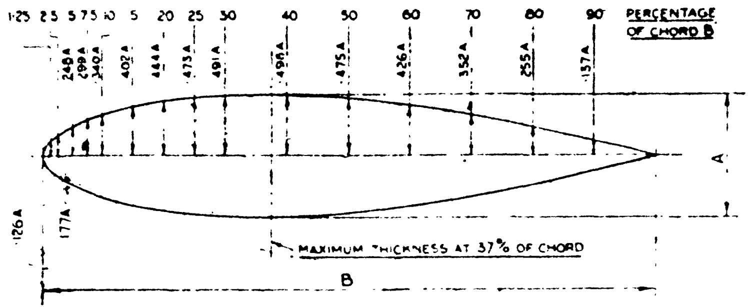
FAIRINGS FOR SMALL EXCRESCENCES ON WINGS AND FUSELAGE



Minimum values of B/A for various values of " C "	
C=A	B/A=5·5
C=2A	B/A=7
C=3A	B/A=8
C=4A	B/A=8·7
C=6A	B/A=9·5
C=8A or over	B/A=10

For intermediate values of " C," a value of B/A can be estimated in the table. Such fairings should on no account be positioned near the leading edge of the wing. The radius " R " should be kept small over the forward portion, but can be increased considerably toward the trailing edge, forming a slight fillet. The value of " C " must be the minimum which gives a satisfactory fairing over the excrescence, as this will ensure the least disturbance of the airflow.

STRUTS AND TUBES IN THE AIRSTREAM



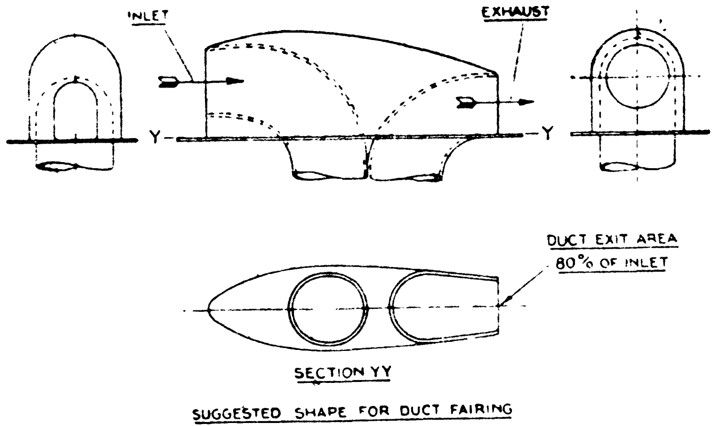
Typical Symmetrical Aerofoil Section

Minimum B/A for Struts and Tubes in the Airstream = 5

For struts and tubes in regions of low-speed air, such as immediately behind the radiator, minimum B/A = 3·5.

Every effort should be made to obtain a sharp trailing edge, although it is realised that many production difficulties are involved.

AUXILIARY COOLING DUCTS, ETC.



Cooling air for auxiliaries should, if possible, be taken from the radiator duct by a flush hole, in front of, and as close as possible to, the radiator matrix, where the air pressure is high. This air can be exhausted from a rearward facing duct in the vicinity of the radiator duct exit. If this is not possible, the ducts should be grouped together and led from a single air intake to the separate auxiliaries. In addition, the air can be exhausted in a similar manner from the same fairing, as indicated in the diagram. The nose of the fairing should be well rounded. The amount of air required for cooling all auxiliaries can be calculated.

Thickness of boundary layer, $\delta = 4{\cdot}5\sqrt{\frac{\nu x}{V}}$ (Van der Higge Zijnen)
x = distance from L.E. in feet.

SKIN FRICTION

Turbulent $C_F = {\cdot}144\left(\frac{\nu}{lV}\right)^{\cdot 2}$ (Karman after Blasius).

Laminar $C_F = 2{\cdot}654\sqrt{\frac{\nu}{lV}}$ (Blasius) or $K_F = {\cdot}663\left(\frac{Vl}{\nu}\right)^{-\cdot 5}$ (Prandtl).

Turbulent (experimental) $C_F = {\cdot}075\left(\frac{\nu}{lV}\right)^{\cdot 15}$

or $K_F = {\cdot}037\left(\frac{Vl}{\nu}\right)^{-\cdot 2}$ (Prandtl).

Transition point (approx.), where $\log_{10}\left(\frac{Vl}{\nu}\right) = 5{\cdot}7$.

where l = length of surface, parallel to direction of flow.

PARASITIC DRAG DATA

Parasitic drag data may be given in a variety of forms. The four chief methods in use are:—

(i) As an *Absolute Drag Coefficient*, C_D, when the drag is found by substitution in the formula

$$D = C_D\frac{\rho}{2}SV^2.$$

D is given in lb. S = surface area in sq. ft. V = velocity in ft. per sec.

(ii) *As an Engineering Drag Coefficient*, K, when the drag is found by substitution in the formula

$$D = K\sigma AV.$$

D is given in lb. A = maximum cross-sectional area in sq. ft. V = velocity in m.p.h.

(iii) As an *Absolute Drag Coefficient*, C_{D_A}, when the drag is found by substitution in the formula

$$D = C_{D_A}\frac{\rho}{2}AV^2.$$

A = maximum cross-sectional area in sq. ft. Others as in (i).

(iv) As *Actual Drag* in lb. per sq. ft. at an airspeed of 100 m.p.h. in standard air.

Relationship between Various Drag Systems

K = drag per sq. ft. of cross-sectional area at 1 m.p.h.
Actual Drag = 10,000K = $25{\cdot}58C_{D_A}$.

Flat Plate Drag
(Eiffel)

Square Plate Normal to Airstream. Velocity 10 metres per sec.

Length of side (cm.)	Reynolds number	C_D	K	Actual drag at 100 m.p.h. (lb./sq. ft.)
10	68,000	1·040	00266	26 6
15	102,000	1·055	00270	27 0
25	170,000	1 072	00274	27·4
37·5	255,000	1·140	00292	29·2
50	340,000	1·193	00305	30·5
70·75	482,000	1·234	00316	31·6
100	680,000	1 263	·00323	32 3

C_D approaches 1·28 at higher Reynolds numbers and this figure is often taken for calculation of equivalent flat plate area.

Rectangular Flat Plate (Normal to Airflow)

Langley Field tests give: $C_D = 1{\cdot}4$ for aspect ratio 6. (N.A.C.A. T.R. 317.)

Circular Discs (Normal to Airflow)

Reynolds number $210{,}000 - 4{\cdot}5 \times 10^6$. $C_D = 1{\cdot}077 - 1{\cdot}139$. Average value (generally taken for R.N. $< 6 \times 10^6$)

$$C_D = 1{\cdot}11.$$

AIRSCREWS

Geometric Mean Pitch at any radius, $P = 2\pi r \tan\theta$ (r = radius).
Geometric Mean Pitch, G.M.P. = 2·2 tan θ (θ = blade angle at ·7R).
Experimental Mean Pitch given by formula:—

$$J_0 = \frac{P_E/D + 1{\cdot}52(t/c)_s}{1 - {\cdot}31(t/c)_s}.*$$

$(t/c)_s$ = thickness: chord ratio at standard radius (*i.e.* ·7R).

PRACTICAL FORMULÆ

$$C_T = \frac{T}{\frac{\rho}{2}U^2\pi\frac{D^2}{4}}$$

$$C_Q = \frac{Q}{\frac{\rho}{2}U^2\pi\frac{D^3}{8}}$$

Continental practice, based on disc area $\pi\frac{D^2}{4}$ and tip speed U ($U = R\Omega = \pi n D$).

$$J = \frac{V}{nD}$$

$$k_T = \frac{T}{\rho n^2 D^4}$$

$$k_Q = \frac{Q}{\rho n^2 D^5} = \frac{\text{Torque H.P.} \times 550}{2\pi\rho n^3 D^5}$$

Standard British practice.

$$\eta = \frac{J k_T}{2\pi k_Q}.$$

American notation uses C_T and C_Q for k_T and k_Q respectively.

* *Handbook of Aeronautics*, Vol. III.

SECTION III

DRAWING OFFICE PROCEDURE AND DESIGN DATA

SIZES OF DRAWING PAPER

	in.
Demy	20 × 15
Medium	22 × 17
Royal	24 × 19
Super-Royal	27 × 19
Imperial	30 × 22
Columbier	34 × 23
Atlas	34 × 26
Double Elephant	40 × 27
Antiquarian	52 × 31
Tracing paper	20 × 30
,,	30 × 40
,,	60 × 40

Tracing cloth 18, 28, 36, 38, and 41 in. wide; 24 yds. long. Continuous cartridge paper 54 and 60 in. wide.

CHECKING OF DRAWINGS

(*By courtesy of Hawker Aircraft, Ltd.*)

(i) *Dimensions.*—Check for the following:—

(*a*) Common datum for dimensions.

(*b*) Decimals of an inch—except *o/d* of tubes, bolts, bolt holes, bar sizes, cutter radii, and standard widths of strip.

(*c*) Limits.

(*d*) Radii produced by milling cutters to agree with stock cutters (fractional inch sizes) and that the collet on the cutter spindle clears the work.

(*e*) Machining marks, etc.

(*f*) Standard width of strip (rising in $\frac{1}{16}$ in. increments) for clips, etc.

(*g*) The drawing is fully dimensioned and overall lengths given without duplication.

(*h*) That the development of plate fitting is possible and that handed parts can be made from the same blank.
(*i*) Undercuts and chamfers on screwed parts and where special diameter screw threads are used see that the number of T.P.I. agrees with B.S. Workshop Practice Handbook No. 2. These threads to be "medium fit."
(*j*) Scale—if this is greater than full size see that an outline full-size view is given for small parts.
(*k*) Lengths of all bolts, rivets, pins, standard clips, etc., taking into account that plate gauges may be the maximum allowed.
(*l*) Approximate lengths before bending of curved tubes, rods, etc. These lengths must be given for planning purposes.
(*m*) Bend Radii.
(*n*) Rivets are as close as possible to the bend radii of the plate.
(*o*) The limits of machined parts made from standard tubing fall within the variations of the tube size.
(*p*) Contour dimensions are given at mating points, *e.g.* where nose rib flanges intersect at spar flanges.
(*q*) Tooling holes in all bent-up plates.
(*r*) Intersection of constructional lines to be clearly "spotted."
(*s*) Plane in which dimensions are taken, *e.g.* along skin or parallel to datum, etc.
(*t*) Interchangeability—components matching.

(ii) *Standard Parts.*—Check possibility of using:—

(*a*) S.B.A.C. Parts, see Handbooks.
(*b*) A.G.S. Parts.
(*c*) B.S.S. Parts
(*d*) Manufacturer's Standard Parts.

(iii) *Notes and Tables.*—Check:—

(*a*) "Consider manufacture in conjunction with."
(*b*) Remove sharp edges.
(*c*) Title, material, specification, treatment, finish and drawing No.
(*d*) Drawing is well-lined-in with legible figures and wording to ensure good prints.
(*e*) Letters of the alphabet used to denote sections, arrows, etc., are not duplicated for different references.

(*f*) Specifications are not obsolete and that alternatives are given, preferably commercial where possible, also any special treatment required.
(*g*) Part number position.
(*h*) Important notes to be shown in bold type.

(iv) *Welding.*—Check:—

(*a*) Possibility of "bronze" process being used, but different processes of welding should not be called for on the same part.
(*b*) Welding called up specifically and indicated on drawing.
(*c*) Fillet of weld is on the outside of parts wherever possible, and kept to the minimum, which is ·10 in.
(*d*) Sockets that are welded to be cleaned out after welding.
(*e*) Flat surfaces, if important, must be cleaned up or straightened after welding.
(*f*) Parts have vent hole if completely closed by the welding process.

(v) *Stampings.*—Check:—

(*a*) Machining allowance and draft.
(*b*) Flash line and stamping No. position (where it will be removed by machining).
(*c*) Spigot for turning.
(*d*) Class.
(*e*) Table (top R.H. corner) and Machining Drawing No.
(*f*) Generous radii wherever possible.

(vi) *Castings.*—Check:—

(*a*) Machining allowance.
(*b*) Casting No. position (where it will be removed by machining wherever possible).
(*c*) Class.
(*d*) Pressure testing, if required.
(*e*) ·20 in. minimum machining allowance on Magnesium Castings.
(*f*) Generous radii wherever possible.

TRACINGS.

Drawing and dimensions.—Check:—

(*a*) Outline, dimension and centre lines, printing and figures for correctness and density. The latter is essential for production of good prints and velographs.

(*b*) Fractions and decimal points.
(*c*) Radii indicated by *one* arrowhead.

MISCELLANEOUS.

(*a*) Clearance holes, especially at anchor nuts.
(*b*) Stiff nuts for awkward positions in preference to burring over bolts.
(*c*) Soft metal rivets for such materials as wood, rubber, felt, etc.
(*d*) Long tapped holes should be avoided, examine possibilities of swaging method, example: S.B.A.C. AS.1283–1298.
(*e*) Long stiffeners should not have turned-up lugs, separate lugs are preferable.

NOTES ON S.B.A.C. STANDARD DRAWING OFFICE PRACTICE

The Drawing Office practice recommended by the S.B.A.C. has been adopted by a number of firms in the British aircraft industry.

In the S.B.A.C. system the Drawing No. consists of four parts.

Part 1. An alphabetical letter representing the name of the firm responsible for the preparation of the drawing, *e.g.*

A = Sir W. G. Armstrong Whitworth, Ltd.
B = Bristol Aeroplane Co. Ltd., etc.
Y = Blackburn Aircraft, Ltd.
Z = Vickers-Armstrong, Ltd., Supermarine's.

Part 2. Two characters, one alphabetical and one numerical, representing the aircraft for which the drawing has been prepared. Thus the first aircraft on which the standard drawing numbering system has been used at any Company would probably be A1, the second A2, and so on to Z9.

Part 3. Two numerals representing the section of the aircraft, *e.g.*

00 = General arrangement, data sheets, etc.
01 = Mock-up.
14 = Fuselage or hull fairings.
25 = Mainplane flaps, etc.

Part 4. The completion of the drawing number for which numerals are to be used.

The drawing number is always to be read in parts and not continuously, *i.e.* Y A1 31 99 and not YA13199.

The S.B.A.C. system recommends carrying a list of parts on the drawing itself which normally takes the place of separate schedules. Every item called for on the drawing is given a reference number—

this reference number is shown on the face of the drawing in a balloon with no further information or description except any explanation essential for manufacture. The reference number also appears in the list of parts on the drawing in the column entitled "Ref."

Reference numbers are allocated in the following order :— Assembly Drawings, Detail Drawings, Items which are to be made directly from the Drawing (handed parts first), Firms' Standard Parts, S.B.A.C. Standard Parts, A.G.S. Parts, B.S.I. Parts, Embodiment Loan Parts, Proprietary Articles.

The purpose of the reference number column is to serve purely as a key for the drawing. The reference number is not used on the actual parts. The part number as shown in the part number column is the identification that is to be used in the Shops, and stamped on parts where necessary.

Against each item and part number is then entered a description of the part, the specification of the material and any other essential information necessary for making the part and compiling a planning schedule.

Full details of the S.B.A.C. Standard Drawing Office System which was issued on 1st November, 1944, can be obtained on application to the Technical Secretary, Society of British Aircraft Constructors, Ltd., 32, Savile Row, London, W.1.

Abbreviations

(By courtesy of Hawker Aircraft, Ltd.)

A

Accumulator	ACUM.
Across corners	A/C.
Across flats	A/F.
Aerial	AE.
Air-Speed Indicator	A.S.I.
Alternative	ALTVE.
Aluminium	AL.
Amperes	AMP.
Approximate	APPROX.
As drawn	AS DRN.
As required	AS REQD.
Assembly	ASSY.
Automatic	AUTO.

B

Battery	BAT.
Bifurcated	BIF.
Blind Approach	BL.APP.
Bottom	BTM.
Bracket	BRKT.
British Association	B.A.
British Standard Fine	B.S.F.
British Standard Pipe	B.S.P.
British Standard Specification	B.S.S.

C

Cabin	CAB.
Cadmium	CAD.
Calculator	CALCR.
Carburettor	CARB.
Cartridges	CART.
Casting	CSTG.
Centre line	C.L.
Charge	CH.
Cheese Head	CH.HD.
Commercial	COMML.
Compressor	COMPR.
Connection	CONN.
Constant Speed	C.SP.
Constructional	CONSL.
Contents	CONTS.
Control	CONTL.
Countersunk	CSK.
Cylinder	CYL.

D

De Bergue Rivet	DE B. RIVET
Diagonal	DIAG.
Diameter	DIA.
Differential	DIFF.
Dimensions	DIMS.
Direction Finding	D.F.
Distance Tube	D. TUBE.
Downward	DNWD.
Drawing	DRG.

E

Earth	E.
Elektron	ELEK.
Elevator	ELEV.
Emergency	EMERGY.
Engine	ENG.
External	EXTL.
Extinguisher	EXTNG.

F

Flat Head	FT.HD.
Flexible	FLEX.
Flotation	FLOTN.
Forced Landing	F.LANDG.
Formation Lights	FORM.LGTS.
Forward	FWD.

G

General Arrangement	G.A.
Generator	GEN.
Gravity	GRAV.

H

Head	HD.
Hexagon	HEX.
High Tension	H.T.
High Tensile Steel	H.T.S.
Hydraulic	HYD.

I

Identification	IDENT.
Inboard	INBD.
Inclusive	INC.
Indicator	IND.
Inside Diameter	I/D.
Inspection	INSP.
Installation	INSTN.
Intercommunication	I/C.
Intermediate	INTER.
Internal	INTL.
Instrument	INST.

J

Jettison	JETN.
Joint	JT.

L

Landing	LANDG.
Left Hand	L.H.
Light	LGT.
Light Alloy	L.A.
Low Tension	L.T.
Lubricator	LUB.

M

Machine	M/C.
Magneto	MAG.
Marine Distress	MAR.DIST.
Microphone	MIC.
Mild Steel	M.S.
Mixture	MIX.
Mounting	MTG.
Mushroom Head	MUSH.HD.

N

Navigation	NAVN.
Nickel Alloy	NI.ALLOY
Non-return valve	N.R.V.

O

Opposite Hand	OPP.HAND.
Ordinary Nut	ORD.NUT.
Outboard	OUTBD.
Outside Diameter	O/D.
Overall	O/A.
Oxygen	OXY.

P

Part number	PT.NO.
Phosphor Bronze	PH.BR.
Pitch Circle Diameter	P.C.D.
Pitch Circle Radius	P.C.R.
Pressure	PRES.

R

Radiator	RAD.
Radius	R.
Recognition	RECOG.
Reference	REF.
Regulator	REG.
Reinforcing	RE-INF.
Revolution	REV.
Right Hand	R.H.
Round Head	RD. H/D.
Reconnaissance	RECON.

S

Scales—	
Full size	1/1
Half size	1/2
Twice full size, etc.	2/1
Schedule	SCHED.
Selector	SELCT.

Sheet	SHT.
Sight	SGT.
Signal	SIG.
Simmonds Nut	SIMM.NUT.
Slotted	SLTD.
Slow-running	S/RUN.
Snap Head	SN.HD.
Specification	SPEC.
Spherical Diameter	SPH.DIA.
,, Radius	SPH.R.
Split Pin	S.PIN.
Spring Steel	SPR.S.
Stainless Steel	S.S.
Stamping	STPG.
Standard	STD.
Standard Wire Gauge	S.W.G.
Starboard	STBD.

T

Taper Pin	T.PIN.
Tee-piece	T-PIECE.
Telephone	TEL.
Temperature	TEMP.
Terminal	TERM.
Thin Nut	T.NUT.
Threads per inch	T.P.I.
Tubular	TUB.

U

Undercarriage	U/C.
Upward	UPWD.

V

Vacuum	VAC.
Vee-groove	V-GROOVE.
Vertical	VERT.
Volts (Voltage)	VOLT.

W

Whitworth	WHIT.
Wood Screw	WD.SCREW.

Specification of Bolts

Type of bolt head	M.S.	H.T.S.	H.T. stainless	L.A.
Hexagon	A.1	A.15.Y	A.15.Z	A.17
Countersunk	A.S.1882	A.S.1242		A.S.1243
Raised countersunk	A.S.1883	A.S.1244		A.S.1245
Round	A.S.1884	A.S.1246		A.S.1247
Mushroom	A.S.1885	A.S.1248		A.S.1249

BOLTS. TABLE OF DIMENSIONS

Diameter		6 B.A.	4 B.A.	2 B.A.	1/4 in. B.S.F.	5/16 in. B.S.F.	3/8 in. B.S.F.	7/16 in. B.S.F.	1/2 in. B.S.F.	9/16 in. B.S.F.	5/8 in. B.S.F.
Symbol		A	B	C	E	G	J	L	N	P	Q
Range of plain length	Steel { + ·04 in. − ·00 in.	0·1–2·7	0·1–3·1	0·1–3·1	0·1–4·1	0·1–4·1	0 2–4·1	0 3–4·6	0·5–5·1	0·6–5·5	0·7–5·6
	L.A. { + ·04 in. − ·00 in.	—	0·1–3·1	0·1–3·1							
Diameter		6 B.A.	4 B.A.	2 B.A.	1/4 in. B.S.F.	5/16 in. B.S.F.	3/8 in. B.S.F.	7/16 in. B.S.F.	1/2 in. B.S.F.	9/16 in. B.S.F.	5/8 in. B.S.F.
Type		Max.	Max.	Max.	Max.	Max.	Max.	Max.	Max.	Max.	Max.
Hexagonal	Thickness of head	·068	·086	·113	·150	·180	·220	·270	·300	·350	·390
,, ...	Width across flats	·193	·248	·324	·445	·525	·600	·710	·820	·920	1·010
,, ...	Extreme width	·220	·290	·370	·510	·610	·690	·520	·950	1·060	1·170
,, ...	Threaded length	·30	·35	·40	·45	·50	·60	·65	·70	·80	·80
Countersunk	Thickness of head	—	·069	·081	·101	·125	·153	·171	·200		
,, ...	Diameter of head	—	·250	·320	·440	·550	·660	·760	·880		
,, ...	Threaded length	—	·35	·40	·45	·50	·60	·65	·70		
Raised	Thickness of head	—	·064	·081	·101						
,, ...	Diameter of head	—	·250	·320	·440						
,, ...	Projection of raised top	—	·050	·070	·090						
,, ...	Threaded length	—	·35	·40	·45						
Round	Thickness of head	—	—	—	·150						
,, ...	Diameter of head	—	—	—	·440						
,, ...	Threaded length	—	—	—	·45						
Mushroom	Thickness of head	—	·075	·100	·175	·180					
,, ...	Diameter of head	—	·375	·4375	·625	·750					
,, ...	Threaded length	—	·35	·40	·45	·50					

Method of calling up Bolts.
Specification number and Material code letter. Plain shank length in tenths of an inch. Symbol (from above table).
E.g. ¼ in. B.S.F. raised countersunk head bolt in H.T.S. plain shank length 1·50 in., is : A.S.1244–15E.

Specification of Nuts

M.S.	Stainless	L.A.
A.16 Y	A.16 Z	A.18*

* Plain and slotted nuts only.

Diameter			6 B.A.	4 B.A.	2 B.A.	1/4 in.	5/16 in.	3/8 in.	7/16 in.	1/2 in.	9/16 in.	5/8 in.
Symbol			A	B	C	E	G	J	L	N	P	Q
Plain	P	Thickness of nut	·110	·142	·185	·200	·250	·312	·375	·437	·500	·562
		Width across flats	·193	·248	·374	·445	·525	·600	·710	·820	·920	1·010
		Extreme width	·220	·290	·370	·510	·610	·690	·820	·955	1·060	1·170
Thin	T	Thickness of nut	·073	·095	·123	·133	·166	·208	·250	·291	·333	·375
		Width across flats	·193	·248	·324	·445	·525	·600	·710	·820	·920	1·010
		Extreme width	·220	·290	·370	·510	·610	·690	·820	·950	1·060	1·170
Slotted	S	Thickness of nut	—	—	·250	·260	·280	·312	·375	·437	·500	·562
		Width across flats	—	—	·324	·445	·525	·600	·710	·820	·920	1·010
		Extreme width	—	—	·370	·510	·610	·690	·820	·950	1·060	1·010

Method of calling up Nuts.
Basic specification. Material code letter. Symbol. Type: L for L.H. nuts. No symbol required for R.H. nuts.
P = plain
S = slotted
T = thin.

E.g. 2 B.A. Mild Steel Slotted Left-Hand Nut is: A.16Y C S L.
Note.—M.S. Nuts may be used with M.S. or H.T.S. Bolts. Only Stainless Nuts may be used with Stainless Bolts.

WASHERS

A.S. Specification Nos. 470, 471.
A.G.S. Specification Nos. 160, 161, 162, 163, 585, 586, 946, 947, 970.

A.G.S.

For bolt diameter		6 B.A.	4 B.A.	2 B.A.	1/4 in.	5/16 in.	3/8 in.	7/16 in.	1/2-in.	9/16 in.	5/8 in.
Stroke number		A	B	C	D	E	F	G	H	I	J
A.G.S.160—Steel; A.G.S.946—Stainless steel	Diameter	·300	·400	·500	·600	·750	·900	1·00	1·15	—	—
	Thickness	·050	·050	·050	·050	·065	·065	·065	·065	—	—
A.G.S.161—Steel; A.G.S.947—Stainless steel	Diameter	1·00	1·00	1·25	1·25	1·25	1·50	1·50	1·50	—	—
	Thickness	·060	·060	·060	·060	·060	·080	·080	·080	—	—
A.G.S.157—Light alloy	Diameter	1·00	1·00	1·25	1·25	1·25	1·50	1·50	1·50	—	—
	Thickness	·060	·060	·060	·060	·060	·080	·080	·080	—	—
A.G.S.970—Light alloy	Diameter	·300	·400	·500	·600	·750	·900	1·00	1·15	—	—
	Thickness	·050	050	·050	·050	·065	·065	·065	·065	—	—
A.G.S.162—Single spring	Thickness	·048	·048	·064	·064	·080	·104	·104	·128	—	—
A.G.S.585—Single spring (thin)	Thickness	·036	·036	·048	·056	·064	·072	·072	·080	·104	·104
A.G.S.163—Double spring	Compressed Thickness	·072	·072	·096	·128	·128	·144	·144	·144	·144	—
A.G.S.586—Double spring (thin)	Compressed Thickness	·036	·044	·056	·072	·080	·096	·112	·128	128	·144

WASHERS—*continued*

S.B.A.C.

For bolt diameter		6 B.A.	4 B.A.	2 B.A.	3/16 in.	1/4 in.	9/32 in.	5/16 in.	3/8 in.	7/16 in.	1/2 in.	9/16 in.	5/8 in.	11/16 in.	3/4 in.
Stroke number		A	B	C	D	E	F	G	J	L	N	P	Q	R	S
A.S.470—Light alloy	Diameter	·25	·31	·38	·50	·50	·63	·63	·69	·81	·94	1·06	1·19	1·25	1·38
	Thickness	·05	·05	·05	·05	·05	·05	·05	·05	·05	·05	·05	·05	·05	·05
A.S.471—Light alloy	Diameter	·25	·31	·38	·50	·50	·63	·63	·69	·81	·94	1·06	1·19	1·25	1·38
	Thickness	·10	·10	·10	10	·10	·10	·10	·10	·10	·10	·10	·10	·10	·10

SPLIT PINS

Suitable Split Pins for use with slotted nuts are tabulated below.

Note.—Stainless Steel Split Pins should not be used in contact with light alloy.

A.G.S.784—Non-corrodible steel	2 B.A.	1/4 in. B.S.F.	5/16 in. B.S.F.	3/8 in. B.S.F.	7/16 in. B.S.F.	1/2 in. B.S.F.	9/16 in. B.S.F.	5/8 in. B.S.F.
Stroke number	3	3	3	3	12	12	20	21
Overall length	1·0	1·0	1·0	1·0	1·25	1·25	1·25	1·5
Overall width	·063	063	·063	·063	·094	·094	·125	1·25

Additional sizes of A.G.S.784 Split Pins are available as follows:—

Diameter	Lengths
in.	in.
3/64	1/2, 3/4, 1
1/16	1/2, 3/4, 1, 1 1/4, 1 1/2, 2
[illegible]	1, 1 1/2
[illegible]	1/2, 3/4, 1, 1 1/4, 1 1/2, 2
3/64	1, 1 1/2

Diameter	Lengths
in.	in.
1/8	3/4, 1, 1 1/4, 1 1/2, 2, 2 1/2
[illegible]	3/4, 1, 1 1/4, 1 1/2, 2, 2 1/2
[illegible]	1, 1 1/4, 1 1/2, 2, 2 1/2, 3
1/4	1, 1 1/4, 1 1/2, 2, 2 1/2, 3

SIMMONDS NUTS

Mild steel	Stainless steel	Light alloy	Brass	Tungum	High tensile steel
1	2	3	4	5	6

Method of calling up.

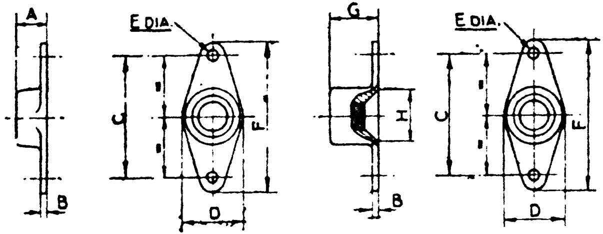
Quote type letters found from following tables, followed by numeral representing the material (from table above).

E.g. 7/16 B.S.F. Ordinary Corner Anchor Nut in Stainless Steel would be SIMMONDS LE.2.

ORDINARY HEX. NUT			
Size	Type	Extreme thickness	Width across flats
		in.	in.
6 B.A. . .	A.P.	·160	·193
4 B.A. . .	B.P.	·210	·248
2 B.A. . .	C.P.	·280	·324
3/16 in. B.S.F.	D.P.	·300	·413
1/4 in. B.S.F.	E.P.	·325	·445
9/32 in. B.S.F.	F.P.	·340	·525
5/16 in. B.S.F.	G.P.	·385	·525
3/8 in. B.S.F.	J.P.	·455	·600
7/16 in. B.S.F.	L.P.	·565	·710
1/2 in. B.S.F.	N.P.	·670	·820
9/16 in. B.S.F.	P.P.	·730	·920
5/8 in. B.S.F.	Q.P.	·750	1·010

THIN HEX. NUT			
Size	Type	Extreme thickness	Width across flats
		in.	in.
6 B.A. . .	A.T.	·125	·193
4 B.A. . .	B.T.	·160	·248
2 B.A. . .	C.T.	·220	·324
3/16 in. B.S.F.	D.T.	·227	·413
1/4 in. B.S.F.	E.T.	·235	·445
9/32 in. B.S.F.	F.T.	·270	·525
5/16 in. B.S.F.	G.T.	·310	·525
3/8 in. B.S.F.	J.T.	·355	·600
7/16 in. B.S.F.	L.T.	·460	·710
1/2 in. B.S.F.	N.T.	·520	·820
9/16 in. B.S.F.	P.T.	·565	·920
5/8 in. B.S.F.	Q.T.	·610	1·010

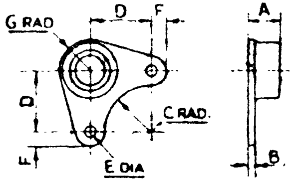
Note.—These nuts may be obtained up to 1·0 in. B.S.F.

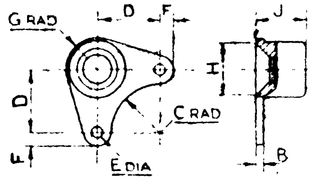


SIMMONDS NUTS—*continued*

Double Anchor (Ordinary)							
Size	Type (ordinary)	A	B	C	D	E	F
		in.	in.	in.	in.	in.	in.
6 B.A. . .	AG	·150	·050	·500	·260	·065	·680
4 B.A. . .	BG	·195	·060	·700	·375	·096	·940
2 B.A. . .	CG	·255	·060	·700	·375	·096	·940
3/16 in. B.S.F. .	DG	·265	·060	·850	·450	·096	1·090
1/4 in. B.S.F. .	EG	·270	·060	1·000	·500	·096	1·220
9/32 in. B.S.F. .	FG	·310	·060	1·000	·560	·096	1·240
5/16 in. B.S.F. .	GG	·350	·060	1·100	·600	·096	1·350
3/8 in. B.S.F. .	JG	·415	·080	1·000	·625	·096	1·312
7/16 in. B.S.F. .	LG	·535	·080	1·200	·750	·125	1·574
1/2 in. B.S.F. .	NG	·595	·080	1·300	·875	·125	1·674

Double Anchor (Countersunk)		
Type (counter-sunk)	G	H
	in.	in.
AH	·200	·192
BH	·265	·247
CH	·335	·323
DH	·370	·411
EH	·420	·442
FH	·420	·521
GH	·455	·523
JH	·585	·598
LH	·700	·704
NH	·795	·816

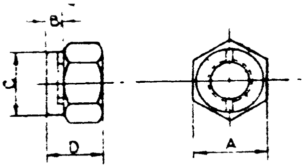




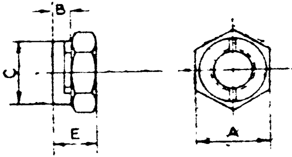
SIMMONDS NUTS—*continued*

Corner Anchor (Ordinary)								
Size	Type (ordinary)	A	B	C	D	E	F	G
		in.	in.	in.	in.	in.	in.	in.
6 B.A.	AE	·150	·050	·160	·250	·065	·090	·130
4 B.A.	BE	·195	·060	·230	·350	·096	·120	·188
2 B.A.	CE	·255	·060	·230	·350	096	·120	·188
7/32 in. B.S.F.	DE	·265	·060	·305	·425	096	·120	·225
¼ in. B.S.F.	EE	·270	·060	·380	·500	·096	·110	·250
9/32 in. B.S.F.	FE	·310	·060	·380	·500	·096	·120	·280
5/16 in. B.S.F.	GE	·350	·060	·425	·550	·096	·125	·300
⅜ in. B.S.F.	JE	·415	·080	·344	·500	096	·156	·313
7/16 in. B.S.F.	LE	·535	·080	·413	·600	·125	·187	·375
½ in. B.S.F.	NE	·595	·080	·463	·650	·125	·187	·437

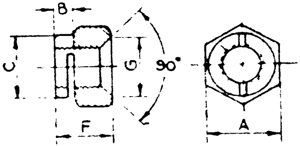
Corner Anchor (Countersunk)		
Type (counter-sunk)	H	J
	in.	in.
AF	·192	·200
BF	·247	·265
CF	·323	·335
DF	·411	·370
EF	·442	·420
FF	·521	·420
GF	·523	·455
JF	·598	·585
LF	·704	·700
NF	·816	·795



G K N STANDARD



G K N THIN



G K N COUNTERSUNK

G.K.N. Lock Nuts

Method of calling up.

Quote part number found from table below, followed by code number of material given above.

E.g. 4 B.A. Thin Stainless Steel G.K.N. Nut is BB.2.

Applicable to all Types			
Size	A	B	C
	in.	in.	in.
6 B.A.	·193	·055	·180
4 B.A.	·248	·071	·235
2 B.A.	·324	092	·311
1/4 in. B.S.F.	·445	·115	·430
5/16 in. B.S.F.	·525	·136	·510
3/8 in. B.S.F.	·600	·150	·585
7/16 in. B.S.F.	·710	·167	·695
1/2 in. B.S.F.	·820	·187	·805

Standard	
Part No.	D
	in.
AA	·160
BA	·208
CA	·272
EA	·310
GA	·381
JA	·457
LA	·537
NA	·619

Thin	
Part No.	E
	in.
AB	·123
BB	·161
CB	·210
EB	·243
GB	·297
JB	·353
LB	·412
NB	·473

Countersunk		
Part No.	F	G
	in.	in.
AC	·160	·152
BC	·208	·196
CC	·272	·257
EC	·310	·352
GC	·381	·416
JC	·457	·446
LC	·537	·564
NC	·619	·652

RIVETS

SNAP HEAD RIVETS

Diameter of shank	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8
Depth of head . .	·04	·06	·08	·09	·11	·13	·15	·19	·23
Diameter of head	·11	·16	·22	·27	·33	·38	·44	·55	·66
Radius of head .	·06	·09	·12	·15	·18	·21	·24	·29	·35

All dimensions in inches.

Std. No.	Material	Specification	Table ref.
A.S.155	Aluminium	L.36	1
A.S.156	Duralumin	L.37	1
A.S.157	Light alloy	D.T.D. 303 (M.G.5)	1
A.S.455	Mild steel	20/32 tons	1
A.S.456	45% Ni alloy	D.T.D.237 or 268	1
A.S.457	Monel metal	D.T.D.204A	1
A.S.458	Tungum	D.T.D.367	1
A.S.459	Copper		4

MUSHROOM HEAD RIVETS

Diameter of shank	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8
Depth of head .	·025	·038	·050	·036	·075	·088	·100	·125	·150
Diameter of head	·14	·21	·28	·35	·42	·49	·56	·20	·84
Radius of head .	·11	·17	·22	·27	·33	·39	·44	·55	·66

All dimensions in inches.

Std. No.	Material	Specification	Table ref.
A.S.158	Duralumin	L.37	2
A.S.159	Light alloy	D.T.D.303 (M.G.5)	2

Rivets—*continued*

90° Countersunk Head Rivets

Diameter of shank	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8
Depth of head	·023	·035	·047	·059	·070	·082	·094	·117	·141
Diameter of head	·109	·164	·218	·273	·328	·383	·437	·547	·656

All dimensions in inches.

Std. No.	Material	Specification	Table ref.
A.S.160	Aluminium	L.36	4
A.S.161	Duralumin	L.37	2
A.S.162	Light alloy	D.T.D.303 (M.G.5)	2
A.S.460	Mild steel	20/32 tons	1
A.S.461	45% Ni alloy	D.T.D.268	
A.S.462	Monel metal	D.T.D.204A	2
A.S.466	Tungum	D.T.D.367	2
A.S.467	Copper	—	4

120° Countersunk Head Rivets

Diameter of shank	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8
Depth of head	·018	·027	·036	·045	·054	·063	·072	·090	·108
Diameter of head	·125	·188	·250	·313	·375	·938	·500	·625	·750

All dimensions in inches.

Std. No.	Material	Specification	Table ref.
A.S.163	Aluminium	L.36	4
A.S.169	Duralumin	L.37	2
A.S.165	Light alloy	D.T.D.303 (M.G.5)	2
A.S.463	Mild steel	20/32 tons	3
A.S.464	45% Ni alloy	D.T.D.268	3
A.S.465	Monel metal	D.T.D.204A	3
A.S.468	Tungum	D.T.D.367	3

Flat Head Rivets

Diameter of shank	1/16	3/32	1/8	5/32	3/16	7/32	1/4
Depth of head	·016	·023	·031	·039	·047	·055	·063
Diameter of head	·125	·188	·250	·313	·375	·438	·500

Std. No.	Material	Specification	Table ref.
A.S.469	Copper	—	4

Method of calling up Solid Rivets.
Quote Standard number from above with part number found from tables below.
E.g. Duralumin 90° Countersunk Head Rivet, 5/32 in. diameter and 15/16 in. long becomes A.S.161/515.

RIVETS—*continued*

TABLE No. 1									
Diam. shank	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.	5/16 in.	3/8 in.
Length	Part numbers								
in. 1/8	202						For A.S.157 only.		
3/16	203	303	403						
1/4	204	304	404	504					
5/16	205	305	405	505	605	705			
3/8	206	306	406	506	606	706	806		
7/16	207	307	407	507	607	707	807		
1/2	208	308	408	508	608	708	808	1,008	
9/16	209	309	409	509	609	709	809	1,009	1,209
5/8	210	310	410	510	610	710	810	1,010	1,210
11/16	211	311	411	511	611	711	811	1,011	1,211
3/4	212	312	412	512	612	712	812	1,012	1,212
13/16	213	313	413	513	613	713	813	1,013	1,213
7/8	214	314	414	514	614	714	814	1,014	1,214
15/16	215	315	415	515	615	715	815	1,015	1,215
1	216	316	416	516	616	716	816	1,016	1,216
1 1/8		318	418	518	618	718	818	1,018	1,218
1 1/4		320	420	520	620	720	820	1,020	1,220
1 3/8		322	422	522	622	722	822	1,022	1,222
1 1/2		324	424	524	624	724	824	1,024	1,224
1 3/4						821	828	1,028	1,228
2							832	1,032	1,232

RIVETS—*continued*

TABLE No. 2

Diam. shank	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.	5/16 in.	3/8 in.
Length	Part numbers								
in. 1/8	202								
3/16	203	303							
1/4	204	304	404						
5/16	205	305	405	505					
3/8	206	306	406	506	606				
7/16	207	307	407	507	607	707			
1/2	208	308	408	508	608	708	808		
9/16	209	309	409	509	609	709	809		
5/8	210	310	410	510	610	710	810	1,010	
11/16	211	311	411	511	611	711	811	1,011	
3/4	212	312	412	512	612	712	812	1,012	1,212
13/16	213	313	413	513	613	713	813	1,013	1,213
7/8	214	314	414	514	614	714	814	1,014	1,214
15/16	215	315	415	515	615	715	815	1,015	1,215
1	216	316	416	516	616	716	816	1,016	1,216
1 1/8		318	418	518	618	718	818	1,018	1,218
1 1/4		320	420	520	620	720	820	1,020	1,220
1 3/8		322	422	522	622	722	822	1,022	1,222
1 1/2		324	424	524	624	724	824	1,024	1,224
1 3/4							828	1,028	1,228
2							832	1,032	1,232

RIVETS—*continued*

TABLE NO. 3

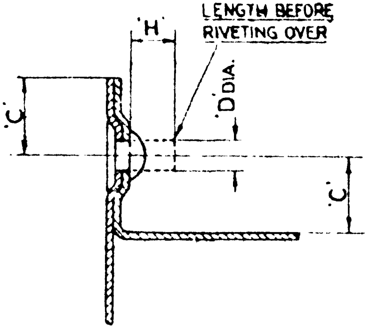
Diam. shank	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.	5/16 in.	3/8 in.
Length	Part numbers								
in. 1/8	202								
3/16	203	303							
1/4	204	304	404						
5/16	205	305	405	505					
3/8	206	306	406	506	606				
7/16	207	307	407	507	607	707			
1/2	208	308	408	508	608	708	808		
9/16	209	309	409	509	609	709	809		
5/8	210	310	410	510	610	710	810	1,010	
11/16	211	311	411	511	611	711	811	1,011	
3/4	212	312	412	512	612	712	812	1,012	1,212
13/16	213	313	413	513	613	713	813	1,013	1,213
7/8	214	314	414	514	614	714	814	1,014	1,219
15/16	215	315	415	515	615	715	815	1,015	1,215
1	216	316	416	516	616	716	816	1,016	1,216
1 1/8		318	418	518	618	718	818	1,018	1,218
1 1/4		320	420	520	620	720	820	1,020	1,220
1 3/8		322	422	522	622	722	822	1,022	1,222
1 1/2		324	424	524	624	729	824	1,024	1,224
1 3/4							828	1,028	1,228
2							832	1,032	1,232

Rivets—*continued*

Table No. 4

Diam. shank	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.
Length	Part numbers						
in. 1/8	202					Nos. above heavy lines are for A.S.459 and A.S.469 only.	
3/16	203	303	403				
1/4	204	304	404	504			
5/16	205	305	405	505	605		
3/8	206	306	406	506	606	706	806
7/16	207	307	407	507	607	707	807
1/2	208	308	408	508	608	708	808
9/16	209	309	409	509	609	709	809
5/8	210	310	410	510	610	710	810
11/16	211	311	411	511	611	711	811
3/4	212	312	412	512	612	712	812
13/16	213	313	413	513	613	713	813
7/8	214	314	414	514	614	714	814
15/16	215	315	415	515	615	715	815
1	216	316	416	516	616	716	816
1 1/8		318	418	518	618	718	818
1 1/4		320	420	520	620	720	820
1 3/8		322	422	522	622	722	822
1 1/2		324	424	524	624	724	824
1 3/4						728	828
2							832

De Bergue Rivets



Rivet dia-meter "D"	Projection "H" for two thicknesses 1·5D	Projection "H" for three thicknesses 1·6D	Gauge of plate	Pitch mini-mum	"C" mini-mum
in.	in.	in.		in.	in.
$\frac{1}{16}$	·094	·10	25, 26, 27, 28		
$\frac{3}{32}$	·141	·15	22, 23, 24	$\frac{13}{32}$	$\frac{9}{32}$
$\frac{1}{8}$	·187	·20	20, 21	$\frac{15}{32}$	$\frac{5}{16}$
$\frac{5}{32}$	·234	·25	18, 19	$\frac{19}{32}$	$\frac{13}{32}$
$\frac{3}{16}$	·281	·30	16, 17	$\frac{25}{32}$	$\frac{17}{32}$

This table is used as follows:—

Required rivet diameter is read off in same horizontal column as gauge of plate, *e.g.* 18 swg. plates would required $\frac{5}{32}$ in. diameter rivets.

Length of rivet required for plates of equal thickness = No. of plates × gauge of plate + H dimension or, generally, thickness of plates + H dimension. An allowance should be made for the insertion of dry jointing material (*e.g.* D.T.D. 295) when this is used.

Rivet lengths are called up to the nearest $\frac{1}{32}$ in.

RIVETS, POP (TUCKER)

Maximum thickness riveted	Mandrel	Break-head (B.H.)		Break-head (B.H.)	
	Metal	Nickel alloy (D.T.D. 237)		Aluminium alloy (B.S. L46, D.T.D.182A)	
	Type	Pop			
	Head	Dome	Counter-sunk	Dome	Counter-sunk
	Code	TNP/D	TNP/K	TAP/D	TAP/K
in.					
·05	3/32 in. diameter (use drill morse 35)	313	—		
·07		—	313		
·09		319	—		
·11		—	319		
·05	1/8 in. diameter (use drill morse No. 30)	413		414	—
·07		416	413	417	—
·08		—	—	—	414
·09		419	416	420	417
·11		—	419	—	—
·12		422	—	423	420
·14		424	422	—	—
·15		—	—	—	423
·16		—	424	—	—
·17		—	—		—
·19		429		429	—
·21		—	429		—
·22			—	—	429
·05	5/32 in. diameter (use drill morse No. 21)	515*	—		
·07			515*		
·08		519	—	518	—
·10		—	519	—	—
·12			—	—	518
·13		—	—	523	—
·14		524	—	—	—
·16		—	524	—	—
·17		527	—	—	523
·19			—	529	—
·20		530	527	—	—
·23		—	530	—	529
·25		537	—	537	—
·27		—	537	—	—
·29				—	537

RIVETS, POP (TUCKER)—*continued*

Maximum thickness riveted	Mandrel	Break-head (B.H.)		Break-head (B.H.)	
	Metal	Nickel alloy (D.T.D. 237)		Aluminium alloy (B.S. L46, D.T.D. 182A)	
	Type	Pop			
	Head	Dome	Counter-sunk	Dome	Counter-sunk
	Code	TNP/D	TNP/K	TAP/D	TAP/K
in.	$\frac{3}{16}$ in. diameter (use drill morse No. 11)				
·09		621	—	621	—
·12		624	621	625	—
·14		—	—	—	621
·15		627	624	—	—
·16		—	—	629	—
·17		630	—	—	—
·18		—	627	—	625
·20		633	630	—	—
·21		—	—	—	629
·22		—	—	635	—
·23		636	633	—	—
·25		639	—	640	—
·26		—	636	—	—
·27		—	—	—	635
·28		—	639	—	—
·30				—	640
·35				649	—
·40				—	649

" T " indicates Tucker; " N " Nickel Alloy; " A " Aluminium Alloy; " P " Pop type; " D " Dome Head; " K " Countersunk Head; and " F " Flat Head.

The diameters are expressed in the first digit, *e.g.*

$3 = \frac{7}{64}''$ $\qquad$ $6 = \frac{3}{16}''$

$4 = \frac{1}{8}''$ $\qquad$ $8 = \frac{1}{4}''$

$5 = \frac{5}{32}''$

The lengths are given by the last two digits.

E.g. 413 = $\frac{1}{8}$ in. diam., ·13 in. long.

All lengths are measured from under the head. The maximum thickness quoted refers only to break-head mandrels.

B.A. Threads

No.	Diameter o/d m/m	Diameter Core	Diameter o/d in.
		in.	in.
0	6·0	·1890	·2362
1	5·3	·1661	·2087
2	4·7	·1468	·1850
3	4·1	·1269	·1614
4	3·6	·1106	·1417
5	3·2	·0981	·1260
6	2·8	·0852	·1102
7	2·5	·0758	·0984
8	2·2	·0663	·0866

B.S.F. Threads

1/Dia. of pipe	Dia. over thread	Core dia.	T.P.I. whit.
in.	in.	in.	
$\frac{1}{8}$	·383	·337	28
$\frac{1}{4}$	·518	·451	19
$\frac{3}{8}$	·656	·589	19
$\frac{1}{2}$	·825	·734	14
$\frac{5}{8}$	·902	·811	14
$\frac{3}{4}$	1·041	·950	14
$\frac{7}{8}$	1·189	1·098	14
1	1·309	1·193	11
$1\frac{1}{4}$	1·650	1·534	11

Wood Screws

No.	Dia.	No.	Dia.	No.	Dia.
	in.		in.		in.
00	·060	8	·164	18	·304
0	·063	9	·178	20	·332
1	·066	11	·192	22	·360
2	·080	11	·206	24	·388
3	·094	12	·220	26	·416
4	·108	13	·234	28	·444
5	·122	14	·248	30	·472
6	·136	15	·262	32	·500
7	·150	16	·276		

Heading Allowances "H" to Form a Snap Head on Solid Rivets

Diameter	Heading allowance
in.	in.
$\frac{1}{16}$	·08
$\frac{3}{32}$	·12
$\frac{1}{8}$	·16
$\frac{5}{32}$	·20
$\frac{3}{16}$	·24
$\frac{7}{32}$	·28
$\frac{1}{4}$	·32
$\frac{5}{16}$	·40
$\frac{3}{8}$	·49

Heading allowance (1·3 × dia.) = length of shank proud of plate required to form head.

Heading Allowances "H" to Form a Countersunk Head on Solid Rivets

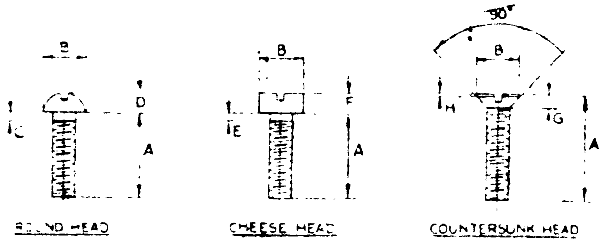
Diameter	Heading allowance
in.	in.
$\frac{1}{16}$	·05
$\frac{3}{32}$	·07
$\frac{1}{8}$	·09
$\frac{5}{32}$	·12
$\frac{3}{16}$	·14
$\frac{7}{32}$	·16
$\frac{1}{4}$	·19
$\frac{5}{16}$	·23
$\frac{3}{8}$	·28

Heading allowance (·75 dia.) = length of shank proud of plate required to form head.

Areas of Bolts or Rivets

Diameter	Full area
in.	sq. in.
$\frac{1}{16}$	·00307
$\frac{3}{32}$	·0069
$\frac{1}{8}$	·0123
4 B.A.	·0158
$\frac{5}{32}$	·0192
2 B.A.	·0268
$\frac{3}{16}$	·0276
$\frac{7}{32}$	·0376
$\frac{1}{4}$	·0491
$\frac{9}{32}$	·0621
$\frac{5}{16}$	·0767
$\frac{3}{8}$	·1105
$\frac{7}{16}$	·1503
$\frac{1}{2}$	·1964
$\frac{9}{16}$	·2485
$\frac{5}{8}$	·3068
$\frac{11}{16}$	·3712
$\frac{3}{4}$	·4418

B.A. Screws



Type	Steel	Stainless steel	Brass	Light alloy
Round head	A.G.S.245*	A.G.S.967	A.G.S.244*	A.G.S.564
Cheese head	A.G.S.247*	A.G.S.896	A.G.S.246*	
Countersunk head . .	A.G.S.249	A.G.S.968	A.G.S.248	

From the table above, select the A.G.S. number of the type of screw required and, from the table below, select the diameter and length. Where the diameter and length columns intersect will be found the appropriate part number.

Example.—A 2 B.A. steel round head screw $\frac{3}{4}$ in. long would be A.G.S.245/15.

* These A.G.S. screws are obtainable in lengths other than those listed in the table, and may be ordered by quoting the A.G.S. No., size and length of screw required. For *Example*,—A 4 B.A. round head screw 1[illegible] in. long (steel) would be A.G.S.245–4B.A.-1[illegible] in.

B.A. Screws—*continued*

	0 B.A.	1 B.A.	2 B.A.	4 B.A.	6 B.A.	8 B.A.	10 B.A.
B	in. ·413 ·405	in. ·365 ·357	in. ·324 ·316	in. ·248 ·242	in. ·193 ·188	in. ·152 ·147	in. ·117 ·113
C	·071	·063	·056	·043	·033	·026	·020
D	·189 ·181	·167 ·160	·148 ·141	·113 ·107	·088 ·083	·069 ·065	·054 ·050
E	·071	·063	·056	·043	·033	·026	·020
F	·177	·157	·139	·106	·083	·065	·050
G	·105 ·101	·092 ·088	082 ·078	·064 ·061	·050 ·047	·040 ·037	·032 ·030
H	·016	·014	·013	·011	·009	·008	·007

Length A	Part Nos.						
in. [illegible]	1	1A	10	19	28	37	46
¼	2	2A	11	20	29	38	47
⅜	3	3A	12	21	30	39	48
½	4	4A	13	22	31	40	49
⅝	5	5A	14	23	32	41	50
¾	6	6A	15	24	33	42	51
⅞	7	7A	16	25	34	43	52
1	8	8A	17	26	35	44	53
1¼	9	9A	18	27	36	45	54
1½	62			65			

Notes:—

•1. Part Nos. inside heavy lines are applicable to all A.G.S. B.A. screws.

2. Part Nos. 1, 1A, 2, 10, 36, and 44 are applicable to A.G.S. 244, 245, 246, 247, 248, 249, and 896 only.

3. Part Nos. 45, 52, 53, and 54 are applicable to A.G.S. 248, 249, and 896 only.

4. Part No. 65 is applicable to A.G.S. 244 and 245 only.

5. Part No. 62 is applicable to A.G.S. 244, 245, 246, 247, 248, and 249 only.

WOODSCREWS

Type	Steel	Brass	Stainless steel
Countersunk	A.G.S.251	A.G.S.250	A.G.S.893
Round head	A.G.S.253	A.G.S.252	A.G.S.894

Size No.	2	4	6	8	10	12	14	16
"A" Diameter	·08 in.	·108 in.	·136 in.	·164 in.	·192 in.	·220 in.	·248 in.	·276 in.
Drill No.	46	35	28	18	9	1	¼ in.	9/32 in.

From the table above, select the A.G.S. No. of the type of screw required and, from the tables below, the Size No. and length. Where the Size No. and length columns intersect will be found the appropriate part number.

Example.—A No. 2 steel round head woodscrew 1 in. long would be A.G.S. 253/7.

	A.G.S.250			A.G.S.252			
Length	2	4	6	8	10	12	14
in.							
¼	1	18	35	52	69	86	103
⅜	2	19	36	53	70	87	104
½	3	20	37	54	71	88	105
⅝	4	21	38	55	72	89	106
¾	5	22	39	56	73	90	107
⅞	6	23	40	57	74	91	108
1	7	24	41	58	75	92	109
1¼	8	25	42	59	76	93	110
1½	9	26	43	60	77	94	111
1¾	10	27	44	61	78	95	112
2	11	28	45	62	79	96	113
2¼	12	29	46	63	80	97	114
2½	13	30	47	64	81	98	115
2¾	14	31	48	65	82	99	116
3	15	32	49	66	83	100	117
3½	16	33	50	67	84	101	118
4	17	34	51	68	85	102	119

	A.G.S.251			A.G.S.893				
Length	2	4	6	8	10	12	14	16
in.								
¼	1	18	35	52				
⅜	2	19	36	53	70			
½	3	20	37	54	71	88	105	
⅝	4	21	38	55	72	89	106	123
¾	5	22	39	56	73	90	107	124
⅞	6	23	40	57	74	91	108	125
1	7	24	41	58	75	92	109	126
1¼	8	25	42	59	76	93	110	127
1½	9	26	43	60	77	94	111	128
1¾	10	27	44	61	78	95	112	129
2	11	28	45	62	79	96	113	130
2¼		29	46	63	80	97	114	131
2½		30	47	64	81	98	115	132
2¾		31	48	65	82	99	116	133
3		32	49	66	83	100	117	134
3½			50	67	84	101	118	135
4				68	85	102	119	136

WOODSCREWS—*continued*

	A.G.S.253						
Length	2	4	6	8	10	12	14
in.							
¼	1	18	35	52			
⅜	2	19	36	53	70		
½	3	20	37	54	71	88	
⅝	4	21	38	55	72	89	106
¾	5	22	39	56	73	90	107
⅞	6	23	40	57	74	91	108
1	7	24	41	58	75	92	109
1¼		25	42	59	76	93	110
1½		26	43	60	77	94	111
1¾		27	44	61	78	95	112
2		28	45	62	79	96	113
2¼			46	63	80	97	114
2½			47	64	81	98	115
2¾			48	65	82	99	116
3			49	66	83	100	117
3½				67	84	101	118
4				68	85	102	119
3½				69			

	A.G.S.894						
Length	2	4	6	8	10	12	14
in.							
¼	1	18	35	52			
⅜	2	19	36	53	70		
½	3	20	37	54	71	88	
⅝	4	21	38	55	72	89	106
¾	5	22	39	56	73	90	107
⅞	6	23	40	57	74	91	108
1	7	24	41	58	75	92	109
1¼		25	42	59	76	93	110
1½		26	43	60	77	94	111
1¾		27	44	61	78	95	112
2		28	45	62	79	96	113
2¼			46	63	80	97	114
2½			47	64	81	98	115
2¾			48	65	82	99	116
3			49	66	83	100	117
3½				67	84	101	118
4				68	85	102	119

TOLERANCES FOR HOLES

Nominal diameter	Under $\frac{7}{32}$ in.	$\frac{7}{32}$ in. to $\frac{3}{8}$ in.	$\frac{13}{32}$ in. to $\frac{1}{2}$ in.	$\frac{17}{32}$ in. to 1 in.	$1\frac{1}{16}$ in. to 2 in.	$2\frac{1}{16}$ in. to 3 in.	$3\frac{1}{16}$ in. to 4 in.	$4\frac{1}{16}$ in. to 5 in.	$5\frac{1}{16}$ in. to 6 in.
"A" fit Newall	in. +·00025 −·00025	in. +·00025 −·00025	in. +·00025 −·00025	in. +·0005 −·00025	in. +·00075 −·00025	in. +·0010 −·0005	in. +·0010 −·0005	in. +·0010 −·0005	in. +·0015 −·0005
"B" fit Newall	+·0005 −·0005	+·0005 −·0005	+·0005 −·0005	+·00075 −·0005	+·0010 −·0005	+·00125 −·00075	+·0015 −·00075	+·00175 −·00075	+·0020 −·0010

Newall Tolerances for Shafts

Nominal diameter		Up to $\frac{1}{2}$ in.	$\frac{9}{16}$ in. to 1 in.	$1\frac{1}{16}$ in. to 2 in.	$2\frac{1}{16}$ in. to 3 in.	$3\frac{1}{16}$ in. to 4 in.	$4\frac{1}{16}$ in. to 5 in.	$5\frac{1}{16}$ in. to 6 in.
Class F	Force fit	in. +·00100 +·00050	in. +·00200 ×·00150	in. +·00400 +·00300	in. +·00600 +·00£50	in. +·00800 +·00600	in. +·01000 +·00800	in. +·01200 +·01000
Class D	Drive fit	+·00050 +·00025	+·00100 +·00075	+·00150 +·00100	+·00250 +·00150	+·00300 +·00200	+·00350 +·00250	+·00400 +·00300
Class P	Push fit	−·00025 −·00075	−·00025 −·00075	−·00025 −·00075	−·00050 −·00100	−·00050 −·00100	−·00050 −·00100	−·00050 −·00100
Class Z	Close running fit	−·00050 −·00075	−·00075 −·00125	−·00075 −·00150	−·00100 −·00200	−·00100 −·00225	−·00125 −·00250	−·00125 −·00275
Class Y	Average running fit	−·00075 −·00125	−·00100 −·00200	−·00125 −·00250	−·00150 −·00300	−·00200 −·00350	−·00225 −·00400	−·00250 −·00450
Class X	Easy running fit	−·00100 −·00200	−·00125 −·00275	−·00715 −·00350	−·00200 −·00425	−·00250 −·00500	−·00300 −·00575	−·00350 −·00650

MORSE DRILL SIZES

No.	Size	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size
	in.		in.		in.		in.		in.		in.
1	·2280	10	·1935	19	·1660	28	·1405	37	·1040	46	·0810
2	·2210	11	·1910	20	·1610	29	·1360	38	·1015	47	·0785
3	·2130	12	·1890	21	·1590	30	·1285	39	·0995	48	·0760
4	·2090	13	·1850	22	·1570	31	·1200	40	·0980	49	·0730
5	·2055	14	·1820	23	·1540	32	·1160	41	·0960	50	·0700
6	·2040	15	·1800	24	·1520	33	·1130	42	·0935	51	·0670
7	·2010	16	·1770	25	·1495	34	·1110	43	·0890	52	·0635
8	·1990	17	·1730	26	·1470	35	·1100	44	·0860	53	·0595
9	·1960	18	·1695	27	·1440	36	·1065	45	·0820	54	·0550

Special Machining Limits

Where it is necessary to quote special machining tolerances they should comply with the following table:—

Process	Total tolerance, in inches		
	Normal with care	Minimum economical	Smallest possible with standard equipment
Boring	·005	003	001
Broaching	005	002	·001
Drilling	See	page 88	
Grinding—			
Cylindrical	003	·001	003
Surface	005	002	001
Holes—			
Centre distances (drilled, etc.)	005	002	001
Centre distances (pressed)	006	004	002
Lapping	001	0005	0001
Milling—			
Distances between two faces	010	005	002
Length of slots, etc	·020	015	005
Press work—			
Plate fittings (over profile)	010	005	002
Reaming	See	page 88	
Turning—			
Diameters—			
Ordinary	008	004	001
With roller box tool	·005	002	001
Lengths	·015	006	·003

(Hawker Aircraft.)

LIMITS FOR HOLES

Size	Clearance hole	Standard hole	Fit. " B" hole (Newall Limit)	Fit " A " hole (Newall Limit)
$\frac{1}{16}$ in. . .	Morse No. 51			
$\frac{3}{32}$ in. . .	,, ,, 40			
$\frac{7}{64}$ in. . .	,, ,, 33			
6 B.A. . .	,, ,, 32	Morse No. 33		
$\frac{1}{8}$ in. . . .	,, ,, 30			
4 B.A. . .	,, ,, 25	Morse No. 27		
$\frac{5}{32}$ in. . .	,, ,, 21			
2 B.A. . .	,, ,, 10	$\frac{3}{16}$ in. $+0{\cdot}003$ in. $-{\cdot}0$ in.		
$\frac{3}{16}$ in. . .	,, ,, 11			
$\frac{7}{32}$ in. to $\frac{3}{8}$ in.	$\frac{1}{64}$ in. over normal size	$+{\cdot}005$ in. $-{\cdot}0$ in.	$\pm{\cdot}0005$ in.	$\pm{\cdot}00025$ in.
$\frac{13}{32}$ in. to $\frac{1}{2}$ in.	$\frac{1}{64}$ in. over normal size	$+{\cdot}007$ in. $-{\cdot}0$ in.	$\pm{\cdot}0005$ in.	$\pm{\cdot}00025$ in.
$\frac{17}{32}$ in to 1 in.	—	$+{\cdot}007$ in. $-{\cdot}0$ in.	$+{\cdot}00075$ in. $-{\cdot}0005$ in.	$+{\cdot}0005$ $-{\cdot}00025$ in.

MACHINED END FITTINGS INSIDE AND OUTSIDE TUBES

The limits permitted for fittings which are to be inserted inside the ends of circular tubes are $\begin{matrix}-\cdot003\text{ in.}\\-\cdot005\text{ in.}\end{matrix}$; for parts which fit over tubes, the permissible limits are $\begin{matrix}+\cdot003\text{ in.}\\+\cdot005\text{ in.}\end{matrix}$ Maximum and minimum dimensions (not nominal diameters with plus and minus limits) should be quoted on all drawings of machined parts fitting inside or outside circular tubes. For example, the diameter of a plug end to fit inside a 2 in. o/d × 17 s.w.g. tube will be given thus:—

$$\begin{matrix}1\cdot885\text{ in.}\\1\cdot883\text{ in.}\end{matrix}\ \text{DIA.}$$

The internal diameter of a machined sleeve to fit over the same tube will be given thus:—

$$\begin{matrix}2\cdot003\text{ in.}\\2\cdot005\text{ in.}\end{matrix}\ \text{I/D.}$$

It should be noted that in the case of male parts, the tubes may have to be cleaned out to take the fittings.*

BEARINGS

Normal types of plain bearings will be quoted as Newall Fit " B" for the outer fit; for the inner part the appropriate Newall class " X " (running fit) dimensions will be given.

Note.—Specific limits for shafts and housings to suit ball bearings will be quoted on the drawings.

BUSHES

Brass or steel bushes to be driven into housings must be in accordance with the appropriate Newall limits for drive fits—*not force fits*.

The inside of the bush is to be finished to its final dimensions (*e.g.* Newall fit " B") before being driven in, so that only cleaning out (*i.e.* reaming and drilling) is necessary afterwards. This subsequent cleaning out will in all cases be called for on the drawing on which the bush is assembled.

* Parts to be joined by sweating require an allowance either—
$\begin{matrix}-\cdot006\text{ in.}\\-\cdot010\text{ in.}\end{matrix}$ on the male parts or $\begin{matrix}+\cdot006\text{ in.}\\+\cdot010\text{ in.}\end{matrix}$ on the female parts.

CHAIN DRIVING

(Renold and Coventry Chain Co., Ltd.)

Precision chains present an efficient method of transmitting power at short and medium centre distances.

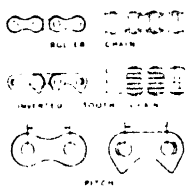
While the drive is positive, and so preserves a definite speed ratio and relationship between the driven and the driving shafts, a certain amount of resilience or flexibility is also present.

Differences in atmospheric conditions do not affect a chain drive, which is available for transmitting the full power of the electric motor or other prime mover immediately on starting up.

Static electrical effects are entirely absent.

Efficiency tests conducted at the National Physical Laboratory have demonstrated that the efficiency of a roller chain drive is in the neighbourhood of 98·5%.

Types of Chain.—Two types of chain are available for power transmission purposes—Roller type and Inverted Tooth type.



The roller chain is generally used in preference to the inverted tooth type, since it is simpler, cheaper, and requires less width for the transmission of a given power.

The inverted tooth chain is quieter than the roller chain, and in certain applications its greater weight is an asset.

The standardization of roller chains and chain wheels has been investigated by the British Standards Institution, who have issued British Standard Specification, No. 228—1934, to which reference may be made for further particulars.

Standardization of inverted tooth chains has not been undertaken.

Selection of a Suitable Chain for a given Duty.—The Renold and Coventry Chain Co., Ltd., issue publications for distribution containing simple selection charts to enable the correct chain for a given power and pinion speed to be determined. Drives up to 1,000 h.p. can be selected in this manner. The maximum desirable pinion speed for any pitch of chain and, similarly, the maximum linear speed of a chain can be determined from the rating tables also provided in these publications.

PLASTICS

(By courtesy of the S.B.A.C.)

Although plastics exist under many proprietary names, in general they may be divided under two headings:—

(*a*) Thermo-plastic.
(*b*) Thermo-setting.

(*a*) *Thermo-Plastic.*—Typical of this range is Cellulose Acetate. This material is usually in sheets and parts are made by moulding the sheet under heat and pressure, the form being obtained by means of wood patterns. No chemical change takes place during the moulding process. The material is easily formed at a temperature of 180° F. and quite large parts, such as dinghy stowages, may be made. It should not be used where the temperature is likely to exceed 100° F., as it then begins to soften. The material does not liquefy but sagging and malformation will probably be the result.

Tubes of thin gauge are manufactured from thermo-plastic materials, a typical example being P.V.C. (Polyvinyl Chloride). These tubes are generally employed as conduits for electrical cables, etc.

Perspex (D.T.D. 339), which is a synthetic resin sheet, also comes under this heading. It will withstand higher temperatures than Cellulose Acetate and should primarily be used for exterior transparent panels where good optical qualities are required.

Cellulose Acetate is usually obtainable in sheets ·06 in., ·08 in., or ·12 in. thick. It can also be obtained reinforced with a wire mesh, known as " Armourbex," which increases its rigidity considerably.

(*b*) *Thermo-Setting.*—A thermo-setting plastic is a material which undergoes an irreversible chemical change during the hot moulding process, yielding a hard product which cannot subsequently be softened. Parts manufactured under this heading are made from synthetic resin moulding powders and a typical example is Bakelite. They are formed in metal dies, the ingredients being melted and pressed under high temperature and pressure. In general, this process is only suitable for small parts in large quantities as the cost of making the dies is high.

Material used for thermo-setting plastics may be reinforced with wood meal, paper, fabric sheet, chopped fabric or fabric asbestos, the reinforcing being moulded into the finished article. Fabric, however, is more satisfactory and the plastic generally used is to Spec. B.S.S. 668.

Where electrical and radio applications are required and the mechanical properties are of secondary importance, Spec. D C.D.W.T. 1 000 should be used.

Sheet, tube, rod, and sections may be obtained as a thermo-setting product. These are usually made of laminated paper or fabric which is coated or impregnated with a resinoid solution finally being " bakelized " under heat and pressure. Sections may also be extruded but this should be avoided unless the dimensions of the extrusion are not of particular importance.

Design of Plastic Parts

Unless strength considerations rule otherwise, parts made from Thermo-setting materials may be replicas of metal counterparts, *e.g.* a cock body could be moulded complete with external thread. Metal inserts may be moulded *in situ* and to provide internal threads a screwed metal insert is recommended. The design of parts in Cellulose Acetate requires special technique and it is not satisfactory to design a part, say in dural, and merely to call for plastic as an alternative material. A separate drawing should be made and the part designed for this material.

In general, parts made in Cellulose Acetate will require to be about twice the thickness of the corresponding part in dural but, as the weight of plastic is half that of aluminium, the weight will remain approximately the same. Parts made in Cellulose Acetate may be made quite stiff either by using cross-sections in which swages are employed at frequent points, or by cementing on stiffeners. Flat areas have very little stiffness.

Existing methods of cementing synthetic resins should be treated with caution. Where a good joint is essential, rivets should be used.

Simmonds anchor nuts, fasteners, etc., may be riveted to plastic parts to provide attachment points. Burrs or washers should be used under rivet heads and wherever possible the head should be formed on metal. If the rivet is to be formed on a plastic surface a countersunk head will form easily under light blows and has the least tendency to crack the surface; in this case burrs are not necessary. Aluminium rivets are the most easily worked but light alloy rivets to Spec. D.T.D. 327 are generally used. The distance between centre of rivet and edge of sheet should be at least 2½–3 times the diameter of the rivet.

Drawing Office Instructions for General Guidance

The following hints are applicable to general mould and moulding design:—

1. Avoid Undercuts or any restrictive features preventing simple ejection from the mould.

2. CONSISTENT THICKNESS is desirable—allow generous radii for corner fillets at section changes, lugs, bosses, etc.

3. DRAFT on faces parallel with the direction of pressing to assist ejection from moulds should be defined on drawings. Usually ·008 in. per inch or ½° per side is normally required. Allow more where practicable.

4. TOLERANCES should be as wide as possible and clearly stated at all essential points. As a guide, it can be taken that in all dimensions not affected by the closing of the mould ·004 in. (±·002 in.) per inch is a close tolerance and ·006 in. (±·003 in.), or even ·020 in. (±·010 in.) per inch should be called wherever possible. If closer accuracy than ±·003 in. per inch on hole centre is required, holes must be jig drilled.

5. LONG THIN HOLES or cavities at right-angles to the direction of moulding pressure are often impractical and should be avoided.

6. KNURLING for finger grips should be in the form of parallel grooves to permit ejection from mould.

7. SCREW THREADS. Generally "free fit" tolerances to B.S.S. 84/1940 will be used; in no case should closer tolerances than "medium fit" be called for.

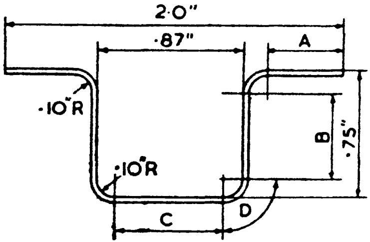
Minimum clearance on diameter of moulded threads required to engage with metal threaded components should be ·012 in. per inch of thread engagement. In cases where machined thread limits are essential, this clearance can be reduced by special tool making methods to normal clearances, but it should be avoided wherever possible. An additional allowance for ovality, which need not exceed ·001 in. per inch of diameter, may be required on mouldings with a wall thickness less than 0·1 in. Threads finer in pitch than 16 T.P.I. up to 2 in. diameter and 12 T.P.I. over that size should only be stipulated if considered necessary, but fine threads down to 32 T.P.I. can be produced on thin walls.

Threads should always be as coarse in pitch as possible; on male threads a small plain portion equal to the core diameter should be left at the start and a small plain portion equal to the crest diameter at the finish. To correspond, female threads should have the reverse plain portions left.

The depth of tapped holes should not exceed twice their diameter; small tapped holes (which in any case should not be less than 6 B.A.), should preferably be arranged for in metal inserts, the exteriors of which should be coarse-knurled and grooved.

Pytram.—This is not strictly a plastic but a papier mache product. It has an advantage over ordinary plastics under conditions where high temperatures are involved, *e.g.* as gun heating tubes immediately behind the radiator. It has a satisfactory temperature range from −70° C. to 130° C.

Method of Finding Developed Width of a Section
(Hawker Aircraft)



Thickness of material=20 *S.W.G.*

Example:—

(i) *Find Length of Flats.*

$$A=\frac{2\cdot0-\{\cdot87+2(\cdot10+\cdot036)\}}{2}=\cdot429 \text{ in.}$$

$$B=\cdot75-\cdot036-(2=\cdot10) \quad =\cdot514 \text{ in.}$$

$$C=\cdot87-(2\times\cdot10) \quad =\cdot670 \text{ in.}$$

(ii) *Find Length of Arcs.*

From table below.

$$D=90\times\cdot00206 \quad =\cdot1854 \text{ in.}$$

Thus developed width of section=

$$(2\times\cdot429)+(2\times\cdot514)+\cdot670+(4\times\cdot1854).$$
$$=\cdot858 \text{ in.}+1\cdot028 \text{ in.}+\cdot670 \text{ in.}+\cdot7416 \text{ in.}$$
$$=3\cdot2976 \text{ in.}$$

Method of Finding Developed Length of an Arc

The table below gives the developed length of an arc for an angle of 1° at a nominal radius. The computations are based on a bend-line at half thickness.

To find Length for a Given Angle and Radius:—

From table select, under the appropriate gauge, length for 1° and multiply this figure by the number of degrees in the angle.

Example:—

Total allowance for bend=·001291 × 137½=·1775 in.

TABLE OF LENGTHS OF ARCS
(Hawker Aircraft)

Thickness of material	26 S.W.G. (·018 in.)	25 S.W.G. (·02 in.)	24 S.W.G. (·022 in.)	23 S.W.G. (·024 in.)	22 S.W.G. (·028 in.)	21 S.W.G. (·032 in.)	20 S.W.G. (·036 in.)
Angle of bend	1°	1°	1°	1°	1°	1°	1°
Inside bend rad.							
in.	in.	in.	in.	in.	in.	in.	in.
·02	·000506	·000523	·000541	·000559			
·03	·000681	·000698	·000716	·000733	·000768	·000803	
·04	·000855	·000873	·000890	·000908	·000942	·000977	·001012
·05	·001030	·001047	·001065	·001082	·001117	·001152	·001187
·06	·001204	·001222	·001239	·001257	·001291	·001326	·001361
·07	·001379	·001396	·001414	·001431	·001466	·001501	·001536
·08	·001553	·001571	·001588	·001606	·001641	·001676	·001710
·09	·001728	·001745	·001763	·001780	·001815	·001850	·001885
·10	·001902	·001920	·001937	·001955	·001990	·002025	·002060
·11	·002076	·002094	·002112	·002129	·002164	·002200	·002234
·12	·002251	·002269	·002286	·002304	·002339	·002374	·002409
·13	·002426	·002443	·002461	·002479	·002513	·002548	·002583
·14	·002600	·002618	·002635	·002653	·002688	·002723	·002758
·15	·002775	·002792	·002810	·002827	·002862	·002897	·002932
·16	·002949	·002967	·002985	·003002	·003037	·003072	·003107
·17	·003124	·003142	·003159	·003176	·003211	·003246	·003281
·18	·003298	·003316	·003334	·003351	·003386	·003421	·003456
·19	·003473	·003491	·003508	·003525	·003560	·003595	·003630
·20	·003648	·003665	·003683	·003700	·003735	·003770	·003805

TABLE OF LENGTHS OF ARCS—*continued*

Thickness of material	18 S.W.G. (·048 in.)	16 S.W.G. (·064 in.)	14 S.W.G. (·080 in.)	12 S.W.G. (·104 in.)	10 S.W.G. (·128 in.)	8 S.W.G. (·160 in.)	6 S.W.G. (·192 in.)
Angle of bend	1°	1	1	1°	1°	1°	1°
Inside bend rad.							
in.	in.	in.	in.	in.	in.	in.	in.
·05	·001291						
·06	·001466						
·07	·001641	·001780					
·08	·001815	·001955					
·09	·001990	·002129					
·10	·002164	·002304					
·11	·002339	·002478					
·12	·002513	·002653	·002793				
·13	·002688	·002827	·002967				
·14	·002862	·003002	·003142				
·15	·003037	·003177	·003316				
·16	·003211	·003351	·003491	·003700			
·17	·003386	·003526	·003665	·003875			
·18	·003560	·003700	·003840	·004049			
·19	·003735	·003875	·004014	·004224			
·20	·003910	·004049	·004189	·004398	·004608		
·21	·004084	·004224	·004363	·004573	·004782		
·22	·004259	·004398	·004538	·004747	·004957		

TABLE OF LENGTHS OF ARCS—*continued*

Thickness of material	18 S.W.G (·048 in.)	16 S.W.G. (·064 in.)	14 S.W.G. (·080 in.)	12 S.W.G. (·104 in.)	10 S.W.G. (·128 in.)	8 S.W.G. (·160 in.)	6 S.W.G. (·192 in.)
Angle of bend	1°	1°	1°	1°	1°	1°	1°
Inside bend rad.							
in.	in.	in.	in.	in.	in.	in.	in.
·23	·004433	·004573	·004712	·004922	·005131		
·24	·004608	·004747	·004887	·005096	·005306	·005585	
·25	·004782	·004922	·005061	·005271	·005480	·005760	
·26		·005096	·005236	·005445	·005655	·005934	
·27		·005271	·005411	·005620	·005829	·006109	
·28		·005445	·005585	·005795	·006004	·006283	
·29		·005620	·005760	·005969	·006178	·006458	·006737
·30		·005795	·005934	·006144	·006353	·006632	·006912
·31			·006109	·006318	·006528	·006807	·007086
·32			·006283	·006493	·006702	·006981	·007261
·33			·006458	·006667	·006877	·007156	·007435
·34			·006632	·006842	·007051	·007330	·007610
·35			·006807	·007016	·007226	·007505	·007784
·36				·007191	·007400	·007679	·007959
·37				·007365	·007575	·007854	·008133
·38				·007540	·007749	·008029	·008308
·39				·007714	·007924	·008203	·008482
·40				·007889	·008098	·008377	·008657

Plate Bending Radii

S.W.G.	M.S., Brass aluminium	Dural, H.T.S., stainless steel
	in.	in.
26	·02	·03
24	·02	·05
22	·03	·06
20	·04	·07
18	·05	·10
16	·07	·13
14	·12	·16
12	·16	·21
10	·20	·26
8	·24	·32
6	·29	·39

Standard Wire Gauges

S.W.G.	Size		S.W.G.	Size	
	Nominal	Max.*		Nominal	Max.*
	in.	in.		in.	in.
1	·300	·314	16	·064	·072
2	·276	·290	17	·056	·064
3	·252	·266	18	·048	·056
4	·232	·246	19	·040	·046
5	·212	·226	20	·036	·042
6	·192	·206	21	·032	·038
7	·176	·188	22	·028	·034
8	·160	·172	23	·024	·028
9	·144	·156	24	·022	·026
10	·128	·138	25	·020	·024
11	·116	·126	26	·018	·022
12	·104	·114	27	·0164	·0204
13	·092	·102	28	·0148	·0188
14	·080	·088	29	·0136	·0176
15	·072	·080	30	·0124	·0164

* Max. thicknesses to be used when calculating lengths of bolts and rivets.

SECTION IV

WEIGHTS AND WEIGHT ESTIMATION

Rough Preliminary Weight Estimation

Gross weight $=\dfrac{a+b+c+d}{z}$.

where a = weight of power plant.
b = weight of crew and payload.
c = weight of fuel, etc.
d = weight of equipment, etc.
z = coefficient, generally lying between ·65 and ·7.

Structure weight = Gross weight (estimated) $-(a+b+c+d)$.

Rough check, Gross weight = Power loading $\div$ total H.P.

Notes on S.B.A.C. Weight Data

1. Weight of Sheet Metal

Nominal specific weights and thicknesses have been used in the preparation of the information given. For this reason current limits on plate thicknesses should be carefully studied and small corrections made where necessary.

(*a*) On dural sheet tolerances vary from $2\frac{1}{2}$–15% depending upon the gauge of the plate.

(*b*) Armour plate is nearly always thicker than specification values and an increase of $7\frac{1}{2}$% in weight is recommended.

(*c*) It is emphasised that the tolerances vary with different manufacturers and with change in methods, as, for example, bi-lateral tolerances were originally used for dural sheet and strip, these were later changed to uni-lateral tolerances and have since been changed back to bi-lateral. The effects of changes such as these on the weight sheets cannot be forecast and therefore a careful study of departures from nominal must be maintained.

2. Weight of Bolts

The bolts given are defined by " plain length " and the weights given are on the assumption that they have the standard thread length.

3. Weight of Paints and Finishes

Variation of ± 50% may be expected unless careful control is maintained.

S.B.A.C. WEIGHT DATA *

Specific Gravities and Weights of Aircraft Materials

Metals

Material	Sp.gr.	Weight, lb./cu. in.	Remarks
Alclad	2·80	·1015	
Aluminium	2·70	·0975	
Aluminium bronze	8·13	·293	
Aluminium manganese	2·7	·0975	
Armour plate	7·85	·283	See note No. 1.
Barronia	8·80	·317	D.T.D. 318.
Birmabright	2·69	·097	
Bismuth	9·85	·356	
Brass	8·5	·307	
Bronze	8·54	·308	
Copper	8·82	·318	
Duralumin	2·80	·1015	2·85 is maximum specification value.
Gun metal, 83%	8·48	·306	
Gun metal, 79%	8·69	·314	
Hiduminium	2·80	·1015	
Immadium bronze	7·80	·280	
Inconel	8·81	·307	
Iron, Cast	7·20	·260	
Iron, Wrought	7·85	·283	
Lead	11·37	·410	
Mercury at 60°	13·60	·491	
Magnesium	1·74	·063	
Magnesium alloys	1·80	·065	(Elektron) D.T.D. 59A, 88B, 118, 120A, 136A, 140A, 142, 259, 291, 285A, 289.
Light alloy, MG5 and MG7	2·63	·095	
Monel	8·86	·320	
Nickel	8·81	·318	
Phosphor bronze	8·85	·319	
Solder	9·40	·34	Pb, 67%; Sn, 33%.
Steel	7·85	·283	
Tin	7·29	·263	
Tungum	8·43	·304	
Zinc	7·00	·253	

* *By courtesy of the S.B.A.C.*

SPECIFIC GRAVITIES AND WEIGHTS OF AIRCRAFT WOODS

Material	Sp.gr.	Weight		Remarks
		Lb./cu. in.	Lb./cu. ft.	
Ash	·71	·026	44	Min. Spec. (V.4) Figures: 0·023 lb./cu. in.; 40 lb./cu. ft.
Balsa	·14	·005	8	
Beech	·75	·027	46	
Birch	·64	·023	40	
Birch compressed	1·05	·038	65	
Cedar, American	·75	·026	47	
,, Indian	·55	·020	35	
,, Lebanon	·64	·023	40	
Douglas Fir	·56	·020	35	Min. Spec. (D.T.D. 469) Figures: ·019 lb./cu. in.; ·32 lb./cu. ft.
Elm, English	·55	·020	34	
,, Canadian	·73	·026	45	
,, Canadian Rock	·74	·026	45	
Greenheart	·96	·034	60	
Guarea	·61	·022	38	
Hardwood	·83	·030	52	
Hickory	·69	·025	43	
Larch	·72	·026	45	
Lime	·56	·020	35	
Mahogany, Honduras	·63	·023	39	Min. Spec. (V.7) Figures: ·019 lb./cu. in.; ·32 lb./cu. ft.
,, Spanish	·85	·031	53	
Maple	·68	·025	42	
Noble Fir	·48	·017	30	Spruce substitute.
Oak, Baltic	·75	·027	48	
,, English	·80	·030	50	
Obechi	·39	·014	24	
Pine, American	·58	·021	37	
,, Kauri	·61	·022	38	
,, Northern	·58	·021	37	
,, Pitch	·80	·030	50	
,, White	·49	·017	30	
,, Yellow	·51	·018	32	
Poplar	·39	·014	24	
Quipo	·11	·004	7	
Satinwood	·96	·034	60	
Spruce	·45	·016	28	Min. Spec. (D.T.D. 36B) Figures: ·014 lb./cu. in.; ·24 lb./cu. ft.
Teak	·80	·030	50	
Walnut	·69	·025	43	Min. Spec. (V.5) Figures: ·020 lb./cu. in.; ·35 lb./cu. ft.
Western Hemlock	·50	·018	31	Spruce substitute.

Specific Gravities and Weights of Aircraft Plywoods

Material			Weight Lb./sq. in.	Weight Lb./sq. ft.	Remarks	
Beech . . .	V3/100	1/32 in.	·0011	·155		
,, . . .	V3/110	3/64 in.	·0016	·229		± 10%
,, . . .	V3/120	1/16 in.	·0021	·303		
,, . . .	V3/130	5/64 in.	·0026	·372		
,, . . .	V3/140	3/32 in.	·0031	·441		
,, . . .	V3/150	1/8 in.	·0039	·565	Ply	
,, . . .	V3/160	5/32 in.	·0047	·675	6.V.3	
,, . . .	V3/170	3/16 in.	·0055	·775	Grade B	
,, . . .	V3/180	1/4 in.	·0070	1·012		± 5%
,, . . .	V3/190	5/16 in.	·0093	1·336		
,, . . .	V3/200	3/8 in.	·0113	1·622		
,, . . .	V3/210	1/2 in.	·0145	2·090		
,, . . .	V3/220	5/8 in.	·0181	2·593		± 2½%
,, . . .	V3/230	3/4 in.	·0218	3·118		
Birch . . .	V3/100	1/32 in.	·0010	·148		
,, . . .	V3/110	3/64 in.	·0015	·210		
,, . . .	V3/120	1/16 in.	·0020	·288	3 Ply	± 10%
,, . . .	V3/130	5/64 in.	·0023	·331	6.V.3	
,, . . .	V3/140	3/32 in.	·0028	·404	Grade A	
,, . . .	V3/150	1/8 in.	·0036	·518		
,, . . .	V3/160	5/32 in.	·0044	·638		
,, . . .	V3/170	3/16 in.	·0052	·745		
,, . . .	V3/180	1/4 in.	·0068	·979		± 5%
,, . . .	V3/190	5/16 in.	·0088	1·270	Multiply	
,, . . .	V3/200	3/8 in.	·0108	1·555	6.V.3	
,, . . .	V3/210	1/2 in.	·0139	2·000	Grade B	
,, . . .	V3/220	5/8 in.	·0173	2·490		± 2½%
,, . . .	V3/230	3/4 in.	·0207	2·980		
,, . . .		·8 mm.	·0010	·138		
,, . . .		1·0 mm.	·0012	·170		
,, . . .		1·5 mm.	·0018	·254		
,, . . .		2·0 mm.	·0023	·33		
,, . . .		2.5 mm.	·0029	·341		
,, . . .		3·0 mm.	·0036	·516		
,, . . .		4·0 mm.	·0048	·696		
,, . . .		5·0 mm.	·0058	·828		
Canadian Birch		·8 mm.	·0011	·163		
Mahogany . .		1/16 in.	·0015	·215		
,, . .		1·5 mm.	·0018	·253		
Poplar . . .		3/32 in.	·0013	·266		
Spruce . . .		1/16 in.	·0013	·187		
,, . . .		1/8 in.	·0025	·365		
,, . . .		5/32 in.	·0031	·451		

SPECIFIC GRAVITIES AND WEIGHTS OF AIRCRAFT PLASTICS

Material	Sp.gr.	Weight			Remarks
		Lb./ cu. in.	Lb./ sq. in.	Lb./ sq. ft.	
Acrylate	1·58	057			
Acrolite	1·14	·041			
Bakelite	1·34–1·4	049–·051			Average figures for sheet and mouldings.
Catalin	1·30	·047			
Cellulose acetate . .	1·30	·047			
,, ,, 02 in.	,,	,,	·0009	·1350	
,, ,, ·03 in.	,,	,,	·0014	·2030	
,, ,, 04 in.	,,	,,	·0019	·2700	
,, ,, 05 in.	,,	,,	0023	·3380	
,, ,, 06 in.	,,	,,	·0028	·4050	
,, ,, 08 in.	,,	,,	0037	·5400	
,, ,, ·09 in.	,,	,,	0042	·6090	
,, ,, ·10 in.	,,	,,	·0047	·6760	
,, ,, ·12 in.	,,	,,	·0056	8120	
,, ,, ·16 in.	,,	,,	·0075	1·0800	
,, ,, ·20 in.	,,	,,	·0094	1·3500	
,, ,, ·24 in.	,,	,,	·0112	1 6200	
Formapex	1·33	·048			
Furfural phenol . .	1 44	·052			
Hallite	2·02	073			
Miocarta	1·33	·048			
Neo-K-Tex	0 86	031			
Paxolin	1·39	050			
Perspex	1·19	043			
,, 3/32 in.	,,	,,	·0040	·5800	
,, 1/8 in.	,,	,,	·0054	·7740	
,, 5/32 in.	,,	,,	·0067	·9650	
,, 3/16 in.	,,	,,	·0081	1·1610	
,, 7/32 in.	,,	,,	0094	1·3580	
,, 1/4 in.	,,	,,	·0107	1·5480	
,, 5/16 in.	,,	,,	·0134	1·9350	
,, 3/8 in.	,,	,,	·0161	2·3220	
Plaskon urea . . .	1·61	·058			
Polystyrene	1 05–1·14	038–·041			
Polyvinyl acetate . .	2·05	·074			
Polyvinyl chloride . .	1·30	·047			
Pytram	0·73	·026			
Rhodoid	1·19	·043			
Tufnol	1·34–1·38	·049–·050			

Specific Gravities and Weights of Miscellaneous Aircraft Materials

Material	Sp.gr.	Weight (lb.)	Remarks
Armour plate		·294 per cu. in.	
Asbestos, C10		·208 per sq. ft.	
,, C7		·194 ,,	
,, C6		·188 ,,	
,, C4		·167 ,,	
,, C3		·160 ,,	
,, C2		·137 ,,	
,, wool		·045 per cu. in.	
Balsa	See	page 100	
Bakelised fabric	1·27	·046 ,,	
Brass gauze, 120 mesh		·0011 per sq. in.	
,, 80 ,,		·0011 ,,	
,, 40 ,,		·0014 ,,	
,, 20 ,,		·0018 ,,	
Canvas, blue		·14 per sq. ft.	
,, Willesden green, light		·098 ,,	
,, ,, ,, heavy		·17 ,,	
Cloth, cabin lining		·071 ,,	
,, curtain blackout		042 ,,	
Cork	·28	·01 per cu. in.	
Duralumin	See	page 99	
Ebonite	1·38	·050 ,,	
Elastic, ⅛ in. braided		·034 per ft.	
Exton board		·010 per cu. in.	
Fabric, Spec. F.I.		·028 per sq. ft.	
,, ,, doped		·084 ,,	
,, for liner		·022 ,,	
,, flame proof		·046 ,,	
Felt, R.S./0 ¼ in.		·83–·99 ,,	
,, R.S./1 ¼ in.		·58–·61 ,,	
,, R.S./2 ¼ in.		·44–·47 ,,	
,, R.S./4 ¼ in.		·25 ,,	
,, R.S./5 ¼ in.		·25 ,,	
,, R.S./6 ⅛ in.		·17–·20 ,,	
,, R.S./6 ¼ in.		·33–·39 ,,	
,, R.S./7 1/32 in.		·004 ,,	
,, R.S./7 1/16 in.		·006 ,,	
Ferodo		·065 per cu. in.	
Fibre, red	1·36	·049 ,,	
,, grey	1·19	·043 ,,	
Glass, bullet proof	2·56	·093 ,,	
,, plate	2·77	·100 ,,	
,, safety, ⅞ in.	2·56	11·66 per sq. ft.	D.T.D. 402A
,, ,, 1½ in.	2·56	20·00 ,,	,,
,, Triplex, ¼ in.	2·15	1·40 ,,	
,, ,, 5/16 in.	2·15	1·75 ,,	
,, ,, ½ in.	2·38	3·10 ,,	
,, cloth, ·009 in., untreated		·061 ,,	
,, ,, ,, treated		·069 ,,	
,, ,, ·003 in., untreated		·027 ,,	
,, wool		·012 per cu. in.	
Graphite, D.T.D.77		·075 ,,	

SPECIFIC GRAVITIES AND WEIGHTS OF MISCELLANEOUS AIRCRAFT MATERIALS—*continued*

Material	Sp.gr.	Weight (lb.)	.. Remarks
Hairlock upholstery padding		·0014 per cu. in.	
Horsehair, Zetal rubberized		·0012 ,,	
Ivorine	1·25	·045 ,,	
Ivory	1·80	·065 ,,	
Langite		·012 ,,	
Leather upholstery		·03 ,,	Variable.
Leatheroid		·0076–·0120 per sq. ft.	
Linatex		·035 per cu. in.	
Madapolam cotton fabric		·015 per sq. ft.	D.T.D. 343
,, doped		·075 ,,	
Magnesium alloys	See	page 99	
Mazda board, ¼ in.		1·13 ,,	
Micanite moulding		·082 per cu. in.	
Millboard, ⅛ in.		·715 per sq. ft.	
Noil lagging wool		2·0 per cu. ft.	
Oil	See	page 105	
Onazote		·0035 per cu. in.	
Palmer rubber walkway		·54 per sq. ft.	
Petrol	See	page 105	
Porcelain		·081 per cu. in.	
Rexine		·055–·097 per sq. ft.	
Rubber, hard	1·66	·06 per cu. in.	
,, soft	·83	·03 ,,	
,, sponge		·0122 ,,	Variable.
,, synthetic	1·11	·040 ,,	Shore hardness 60.
,, for jointing		·09 ,,	D.T.D 107A; D.T.D. 251.
,, petrol resisting		·075 ,,	
Seapak soundproofing, ⅛ in.		·073 per sq. ft.	
Semape sponge rubber		·328–·416 ,,	Covers thicknesses from 3 to 5 mm.
Shock absorber cord, ⅜ in. dia.		·053 per ft.	
Soundproofing wool felt, $\frac{3}{16}$ in.		·297 per sq. ft.	
Steels	See	page 99	
Tape, Empire, ½ in. wide		·003 per ft.	
,, cotton, 2 in. wide		·005 ,,	
Vulcanite	1·28	·0463 per cub. in.	
Vulcanized fibre, D.T.D. 37A		·046 ,,	
Wax	0·97	·035 ,,	
Webbing, 1 in. wide		·0095 per ft.	White, upholstery.
,, 1 in. wide		·033 ,,	Khaki.

Specific Gravities and Weights of Fluids

Fluids *	Sp.gr.	Weight, lb./cu. ft.	Weight, lb./lb./gall.	Remarks
De-icing	1·11	69·12	11·1	
Glycol	1·11	69·12	11·1	
Methanol water	·90	55·9	9·0	
Oil, aero engine	·90	55·9	9·0	
,, non-freezing	·87	54·0	8·66	
Paraffin	·80	50·1	8·0	
Petrol, 87 octane	·75	46·7	7·5	
,, 100 octane	·72	44·9	7·2	
,, 130 grade	·7245	45·4	7·3	
,, 150 grade	·7345	46·0	7·35	
Water	1·00	62·35	10·0	

Weight of Duralumin Sheet

Specific Weight used for Table ·1015 lb./cub. in.

S.W.G.	Thickness (in.)	Weight (lb.) per sq. in.	Weight (lb.) per sq. ft
0	·324	·0329	4·736
1	·300	·0304	4·385
2	·276	·0280	4·032
3	·252	·0256	3·681
4	·232	·0235	3·339
5	·212	·0215	3·100
6	·192	·0195	2·805
7	·176	·0178	2·572
8	·160	·0162	2·340
9	·144	·0146	2·105
10	·128	·0130	1·870
11	·116	·0117	1·696
12	·144	·0105	1·520
13	·092	·0093	1·345
14	·080	·0081	1·170
15	·072	·0073	1·053
16	·064	·0065	·935
17	·056	·0057	·819
18	·048	·0048	·702
19	·040	·0040	·584
20	·036	·0036	·526
21	·032	·0032	·468
22	·028	·00284	·409
23	·024	·00244	·351
24	·022	·00223	·320

S.W.G.	Thickness (in.)	Weight (lb.) per sq. in.	Weight (lb.) per sq. ft.
25	·020	·00203	·292
26	·018	·00182	·263
27	·0164	·00166	·239
28	·0148	·00150	·216
29	·0136	·00138	·199
30	·0124	·00126	·181

Thickness	Weight (lb.) per sq. in.	Weight (lb.) per sq. ft.
¼ in.	·0254	3·65
5/16 in.	·0313	4·57
⅜ in.	·0382	5·48
7/16 in.	·0444	6·30
½ in.	·0507	7·31

* *By courtesy of the S.B.A.C.*

WEIGHT OF STEEL SHEET *

Specific Weight used for Table ·283 lb./cu. in.

S.W.G.	Thick-ness (in.)	Weight (lb.) per sq. in.	Weight (lb.) per sq. ft.
0	·324	·09170	13·204
1	·300	·08492	12·222
2	·276	·07811	11·246
3	·252	·07132	10·269
4	·232	·06566	9·452
5	·212	·06000	8·639
6	·192	·05434	7·822
7	·176	·04982	7·170
8	·160	·0453	6·519
9	·144	·0408	5·867
10	·128	·0362	5·215
11	·116	·0328	4·726
12	·104	·0294	4·238
13	·092	·0264	3·748
14	·080	·0227	3·260
15	·072	·0204	2·934
16	·064	·0181	2·608
17	·056	·0159	2·282
18	·048	·0136	1·956
19	·040	·0113	1·630
20	·036	·0102	1·467
21	·032	·0091	1·304
22	·028	·0079	1·141
23	·024	·0068	·978
24	·022	·0062	·896
25	·020	·0057	·815
26	·018	·0051	·733
27	·0164	·0046	·668
28	·0148	·0042	·603
29	·0136	·0039	·554
30	·0124	·0035	·505

Thick-ness	Weight (lb.) per sq. in.	Weight (lb.) per sq. ft.
1/4 in.	·0707	10·20
5/16 in.	·0885	12·74
3/8 in.	·1061	15·30
7/16 in.	·1238	17·80
1/2 in.	·1415	20·40

Thick-ness (mm).	Weight (lb.) per sq. in	Weight (lb.) per sq. ft.
4	·0445	6·42
5	·0556	8·01
6	·0670	9·65
7	·0779	11·21
8	·0891	12·83
9	·1000	14·48
10	·1112	16·03
11	·1226	17·65
12	·1339	19·29
13	·1450	20·85
14	·1559	22·45
15	·1671	24·03
16	·1785	25·70
17	·1891	27·21
18	·2008	28·89
19	·2116	32·50
20	·2229	32·09
21	·2339	33·65
22	·2451	35·60
23	·2565	37·00
24	·2672	38·50
25	·2785	30·10

* *By courtesy of the S.B.A.C.*

CONVERSION FACTORS

To find the weights of sheet in other materials, ascertain from the above table a figure for similar size sheet in steel and multiply the figure by the applicable conversion factor below.

Aluminium (Specific weight, ·0975 lb./cu. in.) . . . . . ·3445
Magnesium alloy (Specific weight, ·063 lb./cu. in.) . . . . ·2225

Weight of Round Steel Bar *

Lb. per inch run

Specific Weight used for Table ·283 lb./cu. in.

Dia. (in.)	·00	·01	·02	03	04	05	·06	07	·08	·09
0	—	·000022	·000088	000199	000355	000555	000800	00109	00142	00180
1	00222	·00269	·00320	00376	00435	00500	00569	00642	00720	00802
·2	00888	·00980	0108	·0118	0128	·0139	0150	·0162	·0174	·0187
3	0200	0214	0228	0242	0256	0272	0288	·0304	0321	0338
4	0356	·0374	0392	0410	0430	0450	0470	0491	0512	0533
5	0554	·0577	0600	0623	0647	0672	0697	·0722	0747	0773
6	0799	·0826	0853	0881	0909	0938	0968	0998	103	106
7	109	112	115	118	122	125	128	·132	·135	·139
8	142	·146	149	·153	·157	160	164	168	172	176
9	180	·184	·188	192	196	200	204	209	214	218
1 0	·222	·226	231	·236	240	245	250	254	·259	264
1·1	269	·274	·279	284	289	294	299	304	309	·314
1·2	·320	·325	330	336	342	348	353	359	·364	·370
1 3	376	·381	·387	393	399	405	·411	·417	·423	429
1 4	435	·442	·448	455	461	·467	473	·480	486	·493
1·5	·500	507	514	520	527	534	541	·548	555	·561
1 6	568	·576	583	590	598	605	612	620	·627	635
1 7	642	·650	658	665	673	681	689	697	704	712
1 8	·720	·728	736	745	753	761	769	777	786	·794
1 9	802	·811	·819	828	836	845	853	862	871	879
2 0	888	·897	906	915	924	934	943	·952	·961	·970
2 1	979	989	·998	1 008	1 017	1 027	1 037	1 046	1·055	1·065
2 2	1 075	1 085	1 095	1 105	1 115	1 125	1 135	1 145	1 155	1 165
2 3	1 175	1 186	1 196	1 207	1 217	1 228	1 238	1 249	1 259	1·270
2 4	1 280	1 291	1 302	1 313	1 324	1 335	1 345	1 356	1·367	1 378
2 5	1 389	1·400	1 412	1 423	1 434	1 446	1 457	1 468	1 479	1 491
2 6	1 502	1·514	1 526	1 537	1 549	1·561	1 573	1 585	1 596	1 608
2·7	1·620	1·632	1·644	16·57	1·669	1·681	1·693	1·705	1.718	1·730
2 8	1 742	1 755	1·768	1 780	1 793	1 806	1 819	1 832	1 844	1 856
2 9	1 869	1 883	1 896	1 909	1 922	1 935	1 948	1 961	1 974	1 987

* *By courtesy of the S.B.A.C.*

Conversion Factors

To find the weight of round bar in other materials, ascertain from the above table a figure for similar size in steel and multiply the figure by the applicable conversion factor below.

Duralumin (Specific weight, ·1015 lb./cu. in.) . . . . . ·3586
Magnesium alloy (Specific weight, ·063 lb./cu. in.) . . . . ·2225

Weight of Steel Hexagon Bar *

Specific Weight used for Table ·283 lb./cu. in.

Dimension across flats		Lb. per in. run
Fraction	Inches	Steel
1/4	·250	·016
5/16	·3125	·024
3/8	·375	·036
7/16	·4375	·047
1/2	·500	·061
9/16	·5625	·077
5/8	·625	·096
11/16	·6875	·117
3/4	·750	·138
13/16	·8125	·159
7/8	·875	·187
15/16	·9375	·215
1	1·000	·245
1 1/16	1·0625	·277
1 1/8	1·125	·311
1 3/16	1·1875	·346
1 1/4	1·250	·383
1 5/16	1·3125	·422
1 3/8	1·375	·464
1 7/16	1·4375	·506
1 1/2	1·500	·552

* *By courtesy of the S.B.A.C.*

Conversion Factor

To find weight of Duralumin Hexagon Bar, multiply figures given by above table by ·3586. (Specific weight of Duralumin = ·1015 lb./cu. in.)

WEIGHTS OF ROUND TUBE *

Tube O/D (in.)	Weight in lb. per linear foot (steel tubes—sp.gr. 7·84)											
	Thickness of tube (S.W.G.)											
	24	22	20	18	17	16	14	12	10	8	6	4
$\frac{3}{16}$	·0388	·0476	·0581	·0713	·0784	·0842						
$\frac{1}{4}$	·0534	·0662	·0821	·130	·116	·127	·145					
$\frac{5}{16}$	·0681	·0849	·106	·135	·153	·169	·198					
$\frac{3}{8}$	·0827	·103	·130	·167	·190	·212	·251	·300				
$\frac{7}{16}$	·0974	·122	·154	·199	·227	·255	·305	·369	·422			
$\frac{1}{2}$	·112	·141	·178	·231	·265	·297	·358	·439	·507			
$\frac{5}{8}$	·141	·178	·226	·295	·339	·382	·464	·577	·678	·793	·886	
$\frac{3}{4}$	·171	·215	·274	·359	·414	·468	·571	·716	·848	1·006	1·141	
$\frac{7}{8}$	·200	·253	·322	·423	·489	·553	·677	·854	1·019	1·219	1·397	1·589
1	·229	·290	·370	·487	·563	·638	·784	·993	1·189	1·432	1·653	1·947
$1\frac{1}{8}$	·258	·327	·418	·551	·638	·723	·891	1·131	1·359	1·645	1·908	2·207
$1\frac{1}{4}$	·288	·364	·466	·615	·712	·809	·997	1·270	1·530	1·858	2·164	2·516
$1\frac{3}{8}$	·317	·402	·513	·679	·787	·894	1·104	1·408	1·700	2·071	2·420	2·825
$1\frac{1}{2}$	·346	·439	·561	·742	·861	·979	1·210	1·547	1·871	2·284	2·675	3·134
$1\frac{5}{8}$	·376	·476	·609	·806	·936	1·064	1·317	1·685	2·041	2·497	2·931	3·442
$1\frac{3}{4}$	·405	·514	·657	·870	1·010	1·149	1·423	1·823	2·212	2·710	3·186	3·751
$1\frac{7}{8}$	·434	·551	·705	·934	1·085	1·235	1·530	1·962	2·382	2·923	3·442	4·060

* *By courtesy of Hawker Aircraft.*

WEIGHTS OF ROUND TUBE *—*continued*

Tube O/D (in.)	Weight in lb. per linear foot (steel tubes—sp.gr. 7·84) — Thickness of tube (S.W.G.)											
	24	22	20	18	17	16	14	12	10	8	6	4
2	·464	·588	·753	·998	1·160	1·320	1·636	2·100	2·552	3·136	3·698	4·369
2¼	·522	·663	·849	1·126	1·309	1·490	1·849	2·377	2·893	3·562	4·209	4·987
2½	·581	·737	·945	1·254	1·458	1·661	2·062	2·654	3·234	3·988	4·720	5·605
2¾	·639	·812	1·041	1·382	1·607	1·831	2·275	2·931	3·375	4·414	5·232	6·223
3	·698	·886	1·137	1·509	1·756	2·002	2·488	3·208	3·916	4·840	5·743	6·841
3¼	·756	·961	1·233	1·637	1·905	2·172	2·701	3·485	4·257	5·266	6·254	7·458
3½		1·036	1·328	1·765	2·054	2·342	2·914	3·762	4·598	5·693	6·766	8·076
3¾			1·424	1·893	2·204	2·513	3·128	4·039	4·939	6·119	7·277	8·694
4				2·021	2·353	2·683	3·341	4·316	5·279	6·545	7·788	9·312

CONVERSION FACTORS

To find the weights of tubes in other materials, ascertain from the above table the figure for a similar tube in steel and multiply the figure by the applicable converion factor below.

Aluminium (sp.gr. 2·71)	0·3456
Copper (sp.gr. 8·89)	1·1339
Duralumin (sp.gr. 2·85)	0·3622
Tungum (sp.gr. 8·41)	1·0727

RIVETS, WEIGHTS *

Duralumin Snap-head and Mushroom-head Rivets A.S.156 and AS.158.
Weights per gross and per 1,000 pieces.

Diameters	$\frac{1}{16}$ in.	$\frac{3}{32}$ in.	$\frac{1}{8}$ in.	$\frac{5}{32}$ in.	$\frac{3}{16}$ in.	$\frac{7}{32}$ in.	$\frac{1}{4}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.
Lengths	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
$\frac{1}{8}$ in. per gross . . .	·009								
,, 1,000 . . .	·061								
$\frac{3}{16}$ in. per gross . . .	·012	·029	059						
,, 1,000 . . .	·081	·206	412						
$\frac{1}{4}$ in. per gross . . .	015	036	·071	·117					
,, 1,000 . . .	·101	·250	·491	·809					
$\frac{5}{16}$ in. per gross . . .	·017	·042	·082	·134	208	302			
,, 1,000 . . .	·121	·295	·570	932	1 445	2 094			
$\frac{3}{8}$ in. per gross . . .	·020	·049	·093	·152	·234	337	466		
,, 1,000 . . .	·140	·339	·649	1·056	1 623	2 336	3 236		
$\frac{7}{16}$ in. per gross . . .	023	·055	·105	·170	259	371	511		
,, 1,000 . . .	160	·383	·728	1 180	1 801	2 578	3 552		
$\frac{1}{2}$ in. per gross . . .	·026	062	·116	·188	·285	406	·557	·949	
,, 1,000 . . .	·180	·428	·807	1·303	1 980	2·820	3·868	6 59	
$\frac{9}{16}$ in. per gross . . .	·029	·068	·128	·205	·311	441	·602	1·02	1·58
,, 1,000 . . .	·200	·472	886	1 426	2 156	3 062	4 184	7 08	10·99
$\frac{5}{8}$ in. per gross . . .	·032	·074	139	·223	·336	·476	·648	·109	1·68
,, 1,000 . . .	·219	·517	965	1·550	2 335	3·30	4·50	7·58	11·70
$\frac{11}{16}$ in. per gross . . .	·035	·081	150	·241	362	·511	·693	1·16	1·79
,, 1,000 . . .	·239	·561	1 044	1·673	2·512	3·55	4 82	8·07	12·41
$\frac{3}{4}$ in. per gross . . .	·037	·087	·162	259	·387	·545	·739	1·23	1·89
,, 1,000 . . .	·259	·606	1 123	1·796	2·690	3·79	5·13	8·56	13·12

* *By courtesy of the S.B.A.C.*

RIVETS, WEIGHTS—*continued*

Diameters	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.	5/16 in.	3/8 in.
Lengths	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
13/16 in. per gross ,, 1,000	040 279	·094 ·650	·173 1·202	·277 1·920	·413 2·87	·580 4·03	·784 5·45	1·30 9·06	1·99 13·83
7/8 in. per gross ,, 1,000	·043 ·30	·100 ·69	·184 1·28	·294 2·04	·438 3·05	·615 4·27	·829 5·76	1·38 9·56	2·09 14·54
15/16 in. per gross ,, 1,000	·046 ·32	·106 ·74	·195 1·36	·312 2·17	·464 3·22	650 4·51	·876 6·08	1·45 10·05	2·20 15·25
1 in. per gross ,, 1,000	·049 ·34	·113 ·78	·207 1·44	·330 2·29	·490 3·40	·685 4·75	·921 6·40	1·52 10·54	2·30 15·96
1 1/8 in. per gross ,, 1,000		·126 ·87	·230 1·60	·365 2·54	541 3·76	·75 5·23	1·01 7·03	1·66 11·53	2·50 17·38
1 1/4 in. per gross ,, 1,000		·138 ·96	·252 1·75	·400 2·78	·592 4·11	·82 5·72	1·10 7·66	1·80 12·51	2·71 18·81
1 3/8 in. per gross ,, 1,000		·151 1·05	·275 1·91	·436 3·03	·643 4·47	·89 6·21	1·19 8·29	1·94 13·50	2·91 20·23
1 1/2 in. per gross ,, 1,000		·164 1·14	·298 2·07	·472 3·28	·694 4·82	·96 6·69	1·29 8·92	2·09 14·49	3·12 21·65
1 3/4 in. per gross ,, 1,000						1·10 7·66	1·47 10·19	2·38 16·46	3·53 24·44
2 in. per gross ,, 1,000							1·65 11·45	2·66 18·44	4·04 27·34

For Snap-head and Mushroom-head Rivets in other material Specifications the above weights should be factored as follows:—

Aluminium (L.36). A.S.155 . . . . . Factor by 0·965
Light Alloy (D.T.D.303). A.S·157 and 159 . . . . . Factor by 0·934
Mild Steel 20/32 tons. A.S.455 . . . . . Factor by 2·748
45% Nickel Alloy (D.T.D.237 or 268). A.S.456 . . . . . Factor by 2·948
Monel Metal (D.T.D.204a) and Copper. A.S.457 and 459 . . . . . Factor by 3·117
Tungum (D.T.D.367). A.S.458 . . . . . Factor by 2·980

RIVETS, WEIGHTS *

Duralumin Countersunk. Head Rivets A.S.161 and A.S.164.
Weights per gross and per 1,000 pieces.

Diameters	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.	5/16 in.	3/8 in.
Lengths	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1/8 in. per gross . . . ,, 1,000 . . .	·007 ·047								
3/16 in. per gross . . . ,, 1,000 . . .	·010 ·066	·023 ·158	·042 ·280						
1/4 in. per gross . . . ,, 1,000 . . .	·012 ·086	·029 ·202	·054 ·374	·087 ·608					
5/16 in. per gross . . . ,, 1,000 . . .	·015 ·106	·036 ·247	·065 ·453	·105 ·731	156 1 086	·219 1·522			
3/8 in. per gross . . . ,, 1,000 . . .	·018 ·126	·042 ·291	077 ·532	·123 ·854	·182 1·261	·254 1·764	·340 2·361		
7/16 in. per gross . . . ,, 1,000 . . .	·021 ·145	·048 ·336	·088 ·611	·141 ·978	·208 1·441	·289 2·006	·385 2·677		
1/2 in. per gross . . . ,, 1,000 . . .	·024 ·165	·055 ·380	·099 ·690	·159 1 101	·233 1·619	·324 2·248	·431 2 993	·700 4·858	
9/16 in. per gross . . . ,, 1,000 . . .	·027 ·185	·061 ·424	·111 ·767	176 1 225	·259 1·797	·359 2·490	477 3 309	·771 5·35	1·148 7·97
5/8 in. per gross . . . ,, 1,000 . . .	·029 ·205	068 ·469	·122 ·848	·194 1·348	284 1 974	·393 2 731	522 3 625	·842 5·85	1·250 8·68
11/16 in. per gross . . . ,, 1,000 . . .	·032 ·214	074 513	·134 927	212 1·472	·310 2·152	·428 2·97	·568 3·94	·913 6·34	1·352 9·39
3/4 in. per gross . . . ,, 1,000 . . .	·035 ·244	·080 ·558	·145 1 006	230 1 600	·335 2·330	·463 3·22	·613 4·26	·98 6·83	1·46 10·10

* *By courtesy of the S.B.A.C.*

RIVETS, WEIGHTS—*continued*

Diameters	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.	5/16 in.	3/8 in.
Lengths	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
13/16 in. per gross	·038	·087	·156	·247	·361	·498	·659	1·055	1·56
,, 1,000	·264	·602	1 085	1·72	2·51	3 46	4·57	7·33	10·81
7/8 in. per gross	·041	·093	·168	265	·387	·533	·704	1·13	1·66
,, 1,000	·284	·647	1·164	1·84	2·69	3·70	4 90	7·82	11·52
15/16 in. per gross	·044	·100	·179	·283	·412	·568	750	1·20	1·76
,, 1,000	·303	·691	1 243	1 97	2 86	3·94	5·20	8·32	12·23
1 in. per gross	·047	·106	190	·301	·438	·602	·795	1 27	1·86
,, 1,000	·32	·74	1·32	2 09	3 94	4 18	5·52	8 81	12·95
1⅛ in. per gross		119	·213	336	·490	·67	89	1 41	2·07
,, 1,000		·82	1 48	2 34	3 40	4·67	6 15	9 80	14·37
1¼ in. per gross		132	·236	·372	540	·74	98	1 55	2 27
,, 1,000		·91	1 64	2 58	3·75	5 15	6 78	10 78	15·79
1⅜ in. per gross		·144	·259	·407	·592	81	1 07	1 69	2·48
,, 1,000		1 00	1 80	2·83	4 11	5 63	7·42	11 77	17·21
1½ in. per gross		·157	281	443	643	88	1 16	1·84	2 68
,, 1,000		1·09	1 95	3 08	4·46	6 12	8 05	12·76	18·63
1¾ in. per gross						1 02	1 34	2·12	3·09
,, 1,000						7 09	9 31	14 73	21·48
2 in. per gross							1 52	2·41	3·60
,, 1,000							10·58	16·71	24·32

For Countersunk Rivets in other material specifications the above weights should be factored as follows:—

Aluminium (L.36). A.S.160 and A.S.163 . . . . Factor by 0·965
Light Alloy (D.T.D.303). A.S.162 and A.S.165 . . . . Factor by 0·934
Mild Steel 20/32 Tons. A.S.460 and A.S.463 . . . . Factor by 2·748
45% Nickel Alloy (D.T.D.268). A.S.461 and A.S.464 . . . . Factor by 2·948
Monel (D.T.D.204a) and Copper. A.S.462, 465, and 467 . . . . Factor by 3·117
Tungum (D.T.D.367). As.466 and A.S.468 . . . . Factor by 2·980

RIVETS, WEIGHTS *

Copper Flat Head Rivets, A.S.469.

Weights per gross and per 1,000 pieces.

Diameters	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.
Lengths	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1/8 in. per gross	·027						
,, 1,000	·186						
3/16 in. per gross	·036	·089	·177				
,, 1,000	·248	·621	1·227				
1/4 in. per gross	·045	·109	·212	·360			
,, 1,000	·309	·759	1·474	2·502			
5/16 in. per gross	·053	·129	·248	·416	·639		
,, 1,000	·371	·898	1·720	2·89	4·44		
3/8 in. per gross	·062	·149	·283	·471	·719	1·03	1·42
,, 1,000	·432	1·036	1·97	3·27	4·99	7·18	9·88
7/16 in. per gross	·071	·169	·319	·527	·798	1·14	·56
,, 1,000	·494	1·175	2·21	3·66	5·54	7·94	10 87
1/2 in. per gross	·080	·189	·354	·582	·88	1·25	1·71
,, 1,000	·556	1·31	2·46	4 04	6·10	8·69	11·85
9/16 in. per gross	·089	·209	·390	·637	·96	1·36	1·85
,, 1,000	·617	1·45	2·70	4·43	6·65	9·45	12·84
5/8 in. per gross	·098	·230	·425	·69	1·04	1·47	1·99
,, 1,000	·68	1·59	2·95	4·81	7·21	10·20	13·82

* *By courtesy of the S.B.A.C..*

RIVETS, WEIGHTS—*continued*

Diameters	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	7/32 in.	1/4 in.
Lengths	lb.	lb.	lb.	lb.	lb.	lb.	lb.
11/16 in. per gross	107	·249	460	75	1·12	1·58	2·13
,, 1,000	·74	1·73	3·20	5·20	7·76	10·95	14·81
3/4 in. per gross	·116	269	496	·80	1·20	1·69	2·27
,, 1,000	·80	1·87	3 44	5 58	8·31	11·71	15·79
13/16 in. per gross	·124	289	53	86	1·28	1·79	2·42
,, 1,000	·86	2 00	3 69	5·96	8 87	12 46	16·78
7/8 in. per gross	·133	·309	·57	·91	1·36	1 90	·256
,, 1,000	·92	2 14	3 94	6·35	9 42	13·22	17·76
15/16 in. per gross	·142	·33	·60	·97	1 44	2·01	2·70
,, 1,000	·99	2·28	4·18	6 73	9 98	13·97	18·75
1 in. per gross	·151	·35	·64	1 03	1·52	2·12	2·84
,, 1,000	1·05	2 42	4·43	7·12	10 53	14·73	19·73
1 1/8 in. per gross		39	·71	1·14	1 68	2 34	3·12
,, 1,000		2 70	4 92	7 89	11 64	16·23	21·70
1 1/4 in. per gross		·43	·78	1 25	1 84	2·55	3·41
,, 1,000		2 98	5 41	8 66	12 75	17·74	23·67
1 3/8 in. per gross		·47	85	1 36	1·99	2·77	3·69
,, 1,000		3·25	5 91	9 43	13·86	19·25	25·64
1 1/2 in. per gross		·51	·92	1 47	2·15	2·99	3·98
,, 1,000		3 53	6·40	10 20	14 96	20·76	27·61
1 3/4 in. per gross						3·42	4·54
,, 1,000						23·78	31·55
2 in. per gross							5·11
,, 1,000							35·49

Weights given are for 1 bolt to Specifications A.1 and A.15

Weight in lb. ·238 lb./cu. in.

Plain length (in.)	A 6 B.A.	B 4 B.A.	C 2 B.A.	E ¼ in. B.S.F.	G 5/16 in. B.S.F.	J ⅜ in. B.S.F.	L 7/16 in. B.S.F.	N ½ in. B.S.F.
·1	·00160	·00279	·0062	·0125				
·2	·00185	·00324	·0069	·0139	·0257			
·3	·00210	00369	·0076	·0153	·0277	·0421		
·4	·00234	·00414	0083	·0167	·0297	0451	·0729	
·5	00259	·00459	·0090	·0181	·0318	·0481	·0772	·1083
·6	·00284	·00504	·0097	·0194	·0338	·0511	·0814	·1138
·7	·00308	00549	·0104	·0208	·0358	·0542	·0857	·1192
·8	·00333	·00594	·0111	·0222	·0378	·0572	·0899	·1247
·9	·00358	·00639	·0118	·0236	·0399	·0602	0942	·1301
1·0	·00382	·00684	·0125	·0250	0419	·0632	·0984	·1356
1·1	·00407	·00729	·0132	·0264	0439	0662	·1027	·1410
1·2	·00432	00774	0139	·0278	·0459	0693	·1070	1465
1·3	·00456	·00819	·0146	·0292	·0480	·0723	·1112	·1519
1·4	·00481	·00864	·0153	·0306	·0500	·0753	·1155	·1574
1·5	00506	00909	0160	·0319	·0520	·0783	1197	·1628
1·6	·00530	00954	0167	·0333	·0540	0813	·1240	·1682
1·7	00555	00999	0174	0347	·0561	0844	1282	·1737
1·8	00580	0104	0181	·0361	·0581	·0874	1325	·1791
1·9	00604	0109	0188	·0375	·0601	·0904	·1368	·1846
2·0	·00629	·0113	·0195	·0389	·0621	0934	1410	·1900
2·1	00654	0118	0201	·0403	0642	0964	1453	·1955
2·2	00678	0122	0208	0417	0662	0995	·1495	·2009
2·3	·00703	0127	0215	·0430	·0682	·1025	·1538	·2064
2·4	00728	0131	0222	·0444	·0702	·1055	·1580	2118
2·5	·00752	·0136	0229	·0458	·0723	·1085	·1623	·2173
2·6	00777	·0140	·0236	·0472	·0743	·1115	·1666	·2227
2·7	00802	·0145	·0243	·0486	·0763	·1146	·1708	·2282
2·8	·00826	·0149	·0250	·0500	0783	·1176	·1751	2336
2·9	·00851	·0154	·0257	·0514	·0804	·1206	·1793	·2390
3·0	·00876	0158	0264	0528	·0824	1236	·1836	·2445
3·1	·00900	0163	·0271	0542	·0844	·1266	·1878	·2499
3·2	00925	0167	·0278	·0556	·0864	·1297	·1921	·2554
3·3	·00950	·0172	·0285	·0569	·0885	·1327	1963	·2608
3·4	00974	0176	·0292	0583	·0905	·1357	·2006	·2663
3·5	00999	·0181	0299	·0597	·0925	·1387	·2049	·2717
3·6	·01024	·0185	·0306	·0611	·0945	·1417	·2091	·2772
3·7	·01048	·0190	·0313	·0625	·0966	·1448	·2134	·2826
3·8	·01073	·0194	·0320	·0639	·0986	·1478	·2176	·2881
3·9	·01097	0199	·0327	·0653	·1006	·1508	·2219	·2935
4·0	01122	·0203	·0333	·0667	·1026	·1538	·2261	·2990
4·1	·01147	·0208	0340	·0681	·1047	1568	·2304	·3044
4·2	·01171	·0212	·0347	·0694	·1067	·1599	·2347	·3099
4·3	·01196	·0217	·0354	·0708	·1087	·1629	·2389	·3153
4·4	·01221	·0221	·0361	·0722	·1107	·1659	·2432	·3208
4·5	·01245	·0226	·0368	·0736	·1128	·1689	·2474	·3262
4·6	·01270	·0230	·0375	·0750	·1148	·1719	·2517	·3317
4·7	·01295	0235	0382	·0764	·1168	·1750	·2559	·3371
4·8	·01319	·0239	·0389	·0778	·1188	·1780	·2602	·3426
4·9	·01344	·0244	·0396	·0792	·1209	·1810	·2645	·3480
5·0	·01369	·0248	·0403	·0806	·1229	·1840	·2687	·3534
Std. threaded length . .	·30 in.	·35 in.	·40 in.	·45 in.	·50 in.	·60 in.	·65 in.	·70 in.

For S.B.A.C. bolts subtract the following figures from weights given above :—

	4 B.A.	2 B.A.	¼ in. B.S.F.	5/16 in. B.S.F.	⅜ in. B.S.F.	7/16 in. B.S.F.	½ in. B.S.F.
Countersunk Head A.S. 1242, A.S. 1882 .	·001	·0023	·006	·0095	·0151	·027	·0392
Round Head A.S. 1246, A.S. 1884 .	·0006	·0014	·003	—	—	—	—
Mushroom Head A.S. 1248, A.S. 1885 .	·0003	·0007	·0014	—	—	—	—

* By courtesy of the S.B.A.C.

Weights given are for 1 bolt to Specifications A.1 and A.15

Weight in lb. 283 lb./cu. in

Plain length (in.)	P 9/16 in. B.S.F.	Q 5/8 in. B.S.F.	R 11/16 in. B.S.F.	S 3/4 in. B.S.F.	T 13/16 in. B.S.F.	U 7/8 in. B.S.F.	V 15/16 in. B.S.F.	W 1 in. B.S.F.
·1								
·2								
·3								
·4								
·5								
·6	·1708							
·7	·1777	2167						
·8	·1846	2253	3305					
·9	·1915	·2339	·3410	·4326				
1·0	·1984	·2425	·3515	·4451	5146	·6285	757	·89
1·1	·2052	·2511	3620	·4576	·5293	·6454	·776	·91
1·2	·2121	·2597	3725	4701	5441	·6623	·796	93
1·3	·2190	2683	·3830	·4826	·5588	·6792	·816	·95
1·4	·2259	·2769	3934	·4951	·5735	·6962	·835	·98
1·5	·2328	2855	·4039	·5075	·5883	·7131	·855	1·00
1·6	·2396	2941	·4144	·5200	6030	·7300	875	1 02
1·7	2465	·3027	4249	5325	6177	7469	894	1 04
1·8	·2534	·3113	4354	·5450	·6325	7639	914	1 07
1 9	·2603	·3199	4459	·5575	·6472	·7808	934	1·09
2·0	·2672	·3285	·4563	·5700	·6620	·7977	·953	1·11
2·1	2740	·3372	4668	·5824	·6767	8146	·973	1·13
2 2	·2809	·3458	·4773	5949	·6915	·8316	·992	1·15
2·3	·2878	3544	·4878	·6074	·7062	·8485	1 01	1·18
2·4	·2947	3630	·4983	·6199	·7209	·8654	1 03	1 20
2·5	·3016	·3716	·5088	·6324	·7357	·8824	1·05	1 22
2 6	·3085	·3802	·5192	·6449	·7504	8993	1 07	1 24
2·7	·3153	·3888	5297	6573	·7652	9162	1 09	1 27
2 8	·3222	·3974	5402	·6698	7799	·9331	1 11	1·29
2·9	·3291	·4060	·5507	·6823	·7946	9501	1 13	1 31
3·0	·3360	4146	·5612	6948	·8094	·9670	1·15	1·33
3·1	·3429	·4231	·5717	·7073	·8241	·9839	1 17	1·35
3 2	·3497	·4318	·5821	·7197	·8389	1·001	1 19	1·38
3·3	·3566	·4405	·5926	·7322	·8536	1·018	1·21	1·40
3·4	·3635	·4491	6031	·7447	·8683	1 035	1·23	1·42
3 5	·3704	·4577	6136	·7572	·8831	1·052	1·25	1·44
3·6	·3773	·4663	·6241	·7697	·8978	1 069	1 27	1·47
3·7	·3841	·4749	6346	·7822	·9126	1·085	1·29	1·49
3·8	·3910	·4835	·6450	7946	·9273	1 102	1·31	1·51
3·9	·3979	·4921	·6555	·8071	·9420	1·119	1·33	1·53
4·0	·4048	·5007	·6660	·8196	·9568	1·136	1·35	1·55
4·1	·4117	·5093	·6765	·8321	·9715	1·153	1·36	1·58
4 2	·4185	·5179	·6870	·8446	9863	1·170	1·38	1·60
4·3	·4254	·5265	·6975	·8571	1·001	1·187	1·40	1·62
4·4	·4323	·5351	·7079	·8695	1·016	1·204	1·42	1·64
4·5	·4392	·5437	·7184	·8820	1·030	1·221	1·44	1·67
4·6	·4461	·5524	·7289	·8945	1·045	1·238	1·46	1·69
4·7	·4530	·5610	·7394	·9070	1 060	1·255	1·48	1·71
4·8	·4598	·5696	·7499	·9195	1·075	1·272	1·50	1·73
4·9	·4667	·5782	·7604	·9320	1·089	1·289	1·52	1·75
5·0	·4736	·5868	·7780	·9444	1·104	1·306	1·54	1·78
Std. threaded length	·80 in.	·90 in.	1·1 in.	1·2 in.	1·3 in.	1·4 in.	1·5 in.	1·5 in.

CONVERSION FACTOR

To find weight of Duralumin Bolts multiply figures given by above table by ·3586 (Specific weight of Duralumin ··1015 lb./cu. in.).

WEIGHT OF NUTS *

Weight given in lb. for one nut in steel

CONVERSION FACTORS:—Duralumin . . . . 0·356
Brass . . . . 1·083

Size	Plain	Thin	Slotted
6 B.A.	·000746	·000473	Split pin weight
4 B.A.	·00152	·000997	to be neglected
2 B.A.	·00347	·00228	·00286
7/32 in. B.S.F.	·00549	·00360	·00484
1/4 in. B.S.F.	·00713	·00471	·00646
9/32 in. B.S.F.	·0115	·00758	·00913
5/16 in. B.S.F.	·0120	·00788	·0106
11/32 in. B.S.F.	—	·00985	—
3/8 in. B.S.F.	·0189	·0112	·0175
13/32 in. B.S.F.	—	·0165	—
7/16 in. B.S.F.	·0320	·0212	·0280
15/32 in. B.S.F.	—	·0267	—
1/2 in. B.S.F.	·0503	·0333	·0453
9/16 in. B.S.F.	·0723	·0479	·0624
5/8 in. B.S.F.	·0955	·0635	·0849
11/16 in. B.S.F.	·125	·0827	·114
3/4 in. B.S.F.	·154	·102	·135
13/16 in. B.S.F.	·159	·106	·142
7/8 in. B.S.F.	·195	·129	·177
15/16 in. B.S.F.	·236	·156	·215
1 in. B.S.F.	·295	·196	·265

* *By courtesy of the S.B.A.C.*

Weight of Simmonds' Elastic Stop Nuts

Weight in lb. of one nut

	Ordinary		Thin		Double	Anchor
	Steel	Duralumin	Steel	Duralumin	Steel	Duralumin
6 B.A.	·0012	·0005	·0006	·0003	·00219	·00075
4 B.A.	·00155	·0006	·0012	·00045	·00488	·00175
2 B.A.	·004	·0013	·0025	·001	·00675	·00238
$\frac{7}{32}$ in. B.S.F.	·007	·0025	·0051	·0019	·00925	—
$\frac{1}{4}$ in. B.S.F.	·0095	·0026	·006	·002	·01119	·00425
$\frac{9}{32}$ in. B.S.F.	·012	·003	·008	·0025	—	—
$\frac{5}{16}$ in. B.S.F.	·016	·0045	·010	·0035	·01725	·00619
$\frac{3}{8}$ in. B.S.F.	·026	·007	·0175	·006	·02344	·00825
$\frac{7}{16}$ in. B.S.F.	·030	·0135	·028	·0105	·03213	—
$\frac{1}{2}$ in. B.S.F.	·0595	·0205	·042	·0145	—	—

Weight of Spruce Sheet
(lb. per sq. ft.)

Thickness in inches	1/16	3/32	1/8	5/32	3/16	1/4	3/8	1/2	5/8	3/4	1
Spruce (28 lb./cu. ft.)	·146	·219	·292	·369	·438	·583	·875	1·167	1·458	1·75	2·333

Weights of Metal Sheet *

Density (lb./cu. in.)	Gauge	26	24	22	20	18	17	16	14	12	10	8	6
	Thickness in inches	·018	·022	·028	·036	·048	·056	·064	·080	·104	·128	·160	·192
·283	Steel	·734	·897	1·14	1·47	1·96	2·28	2·61	3·26	4·24	5·22	6·53	7·83
·103	Duralumin	·267	·326	·415	·535	·712	·831	·949	1·19	1·55	1·89	2·38	2·85
·0977	Aluminium	·254	·310	·395	·508	·677	·790	·902	1·13	1·47	1·80	2·26	2·71
·0656	Elektron	·170	·208	·265	·341	·455	·531	·606	·759	·987	1·21	1·52	1·82
·299	Brass	·777	·950	1·21	1·55	2·07	2·42	2·76	3·46	4·49	5·53	6·91	8·29

* *By courtesy of Hawker Aircraft, Ltd.*

WEIGHT FACTORS

Multipliers to convert weight of various components, sheet strip, etc., given for one metal into other metals.

Weight in	Mutliply by	To give weight in
Wrought iron . .	·92	Zinc.
,, .	·93	Cast iron.
,, . . .	·94	Tin.
,, . . .	1·02	Steel
,, . . .	1·09	Brass.
,, . . .	·33	Aluminium.
Steel (S.G. 7·84) . .	·3456	Aluminium.
,, . .	1 1339	Copper.
,, ...	3622	Duralumin.
,, ...	1 0727	Tungum
Duralumin . .	965	Aluminium.
,, . . .	·934	Light alloy D.T.D.303.
,, . . .	2·748	Mild Steel.
,, . . .	2 948	D T.D.237 or D.T.D.268.
,, . . .	3 117	Copper
,, . . .	2 980	Tungum D.T.D 367.

WEIGHTS OF PAINTS AND FINISHES *

Item	Specification	Weighed weights	Specification weights	Remarks
Filler titanine . . .	E.3	3·52 oz. per sq. yd.		
Universal primer . . .	UP.1 UP.4 UP.5	2·19–2·31 oz. per sq. yd. 1·274–2·037 oz. per sq. yd. 1·401–2·413 oz. per sq. yd.	·75–1·25 oz. per sq. yd.	
Clear varnish for water tanks.	D.T.D. 234		1·0 oz. per sq. yd.	
Aluminium pigmented oil varnish.	D.T.D. 260A	59 oz. per sq. yd.	Priming coat ·75–1·25 oz. per sq. yd. Finishing coat Al. and black ·5–1·0 oz. per sq. yd. Grey 1·0–1·5 oz. per sq. yd Blue and red 2·0–3·0 oz. per sq. yd. White and yellow 3·0–4·0 oz. per sq. yd.	
Matt pigmented oil varnish (cockpit green).	D.T.D. 314	2·37 oz. per sq. yd.	Priming coat ·75–1·25 oz. per sq. yd. Finishing coat 7·5–1·25 oz. per sq. yd.	
Seaplane varnish . . .	B.S.S. x 17	1·455 oz. per sq. yd.		
Stoving enamel . . .	D.T.D. 56		Type A. 1 coat not less than 9 oz. (black). Type B. 2 coats not more than 1·1 oz. (black). Type A. 1 coat not less than 1·3 oz. (grey). Type B. 2 coats not more than 1·8 oz. (grey).	
Aluminium pigmented cellulose enamel.	D.T.D. 63A	42 oz. per sq. yd.	Priming coat ·75–1·25 oz. per sq. yd. Finishing coat Al. and black ·5–1·0 oz. per sq. yd. White and grey 1·0–1·5 oz. per sq. yd.	

* *By courtesy of the S.B.A.C.*

WEIGHTS OF PAINTS AND FINISHES—*continued*

Item	Specification	Weighed weights	Specification weights	Remarks
Low-temperature stoving enamel—black.	D.T.D. 235	94 oz. per sq. yd.	9–1·4 oz. per sq. yd.	
Matt cellulose finish White	D.T.D. 308	1·57 oz. per sq. yd.	Priming coat 75–1·25 oz. per sq. yd. Finishing coat 75–1·25 oz. per sq. yd.	
Yellow		1·64 oz. per sq. yd.		
Black		71 oz. per sq. yd.		
Cockpit green . . .		81 oz. per sq. yd.		
Butuminous paint . .	B.S.S. · 9	682 – 906 oz per sq. yd.		
Acid-resisting paint . .	B.S.S. · 19	1·133 oz. per sq. yd.		
Madapolam	D.T.D. 343A	2·25 oz. per sq. yd.	2·25 oz. per sq. yd.	
SPECIMEN STANDARD DOPING SCHEME				
Aluminium pigmented .	D.T.D. 83A	32 oz. per sq. yd.	5–1·0 oz. per sq. yd.	
Taughtening dope . . Clear doping scheme .	D.T.D. 83A	6·0 oz. per sq. yd.		
1 red and 6 clear . . .	2D.101	[illegible] 5 oz. per sq. yd.		
1 red and 6 clear and 1 silver and 1 camouflage		7·5 oz. per sq. yd. [illegible] 5 oz. per sq. yd.	6·5–8·0 oz. per sq. yd.	
SPECIMEN BRITISH FINISH FOR METAL AIRCRAFT				
1st Primer	D.T.D. 517	2·701 oz. per sq. yd.	Priming coat 75–1·25 oz. per sq. yd. Finishing coat 75–1·25 oz. per sq. yd.	These weights are running totals.
2nd Plus filler . . .	,,	4·544 oz. per sq. yd.		
3rd (1st coat) . . .	,,			
4th (2nd coat) . . .	,,	8·696 oz. per sq. yd.		
5th Then flatten . .	,,	7·787 oz. per sq. yd.		
6th Plus camouflage				
7th (1st coat) . . .	,,	9·17 oz. per sq. yd.		
8th (2nd coat) . . .	,,			
9th Smooth and polish	,,	10·17 oz. per sq. yd.		

WEIGHTS OF PAINTS AND FINISHES—*continued*

SPECIMEN BRITISH FINISH FOR WOODEN AIRCRAFT

Item	Specification	Weighted weights	Specification weights	Remarks
Preliminary brown paint	342/202			2 coats, generally on edges, holes, etc.
1st Stopper . . .	E (White)			To fill screw and brad-holes.
2nd and 3rd Red dope	D.T.D. 83A			2 coats all woodwork.
4th Red dope . . .	D.T.D. 343A	10 8 oz. per sq. yd.		3rd coat red dope with madapolam.
Madapolam				To all woodwork.
5th Fabric tape . .	E.1 or D.T.D. 407			Edges and holes. All woodwork.
6th Filler titanine . .	E.3			2 coats to all woodwork.
7th Aluminium cellulose.	D.T.D. 63A			Whole aircraft.
8th Camouflage cellulose.	D.T.D. 83A			

SECTION V

MATERIALS

ATOMIC WEIGHTS, 1941

(*Chemical Society, London.*)

Name	Symbol	At. Wt.	Name	Symbol	At. Wt.
Aluminium	Al	26·97	Molybdenum	Mo	95·95
Antimony	Sb	121·76	Neodymium	Nd	144·27
Argon	A	39·44	Neon	Ne	20·18
Arsenic	As	74·91	Nickel	Ni	58·69
Barium	Ba	137·36	Niobium	No	92·91
Beryllium	Be	9·02	Nitrogen	N	14·00
Bismuth	Bi	209·00	Osmium	Os	190·2
Boron	B	10·82	Oxygen	O	16·00
Bromine	Br	79·91	Palladium	Pd	106·70
Cadmium	Cd	112·41	Phosphorus	P	30·98
Cæsium	Cs	132·91	Platinum	Pt	195·23
Calcium	Ca	40·08	Potassium	K	39·09
Carbon	C	12·01	Praseodymium	Pr	140·92
Cerium	Ce	140·13	Protoactinium	Pa	231·00
Chlorine	Cl	35·45	Radium	Ra	226·05
Chromium	Cr	52·01	Rhodium	Rh	102·91
Cobalt	Co	58·94	Rubidium	Rb	85·48
Copper	Cu	63·57	Ruthenium	Ru	101·7
Dyprosium	Dy	162·46	Samarium	Sa	150·43
Erbium	Er	167·64	Scandium	Sc	45·10
Europium	Eu	152·00	Selenium	Se	78·96
Fluorine	F	19·00	Silicon	Si	28·06
Gadolinium	Gd	156·90	Silver	Ag	107·88
Gallium	Ga	69·72	Sodium	Na	22·99
Germanium	Ge	72·60	Strontium	Sr	87·63
Gold	Au	197·20	Sulphur	S	32·06
Hafnium	Hf	178·6	Tantalum	Ta	180·88
Helium	He	4·00	Tellurium	Te	127·61
Holmium	Ho	164·95	Terbium	Tb	159·20
Hydrogen	H	1·008	Thallium	Tl	204·39
Indium	In	114·76	Thorium	Th	232·12
Iodine	I	126·92	Thulium	Tm	169·40
Iridium	Ir	193·1	Tin	Sn	118·70
Iron	Fe	55·85	Titanium	Ti	47·90
Krypton	Kr	83·7	Tungsten	W	183·92
Lanthanum	La	138·92	Uranium	U	238·07
Lead	Pb	207·21	Vanadium	V	50·95
Lithium	Li	6·94	Xenon	Xe	131·3
Lutecium	Lu	174·99	Ytterbium	Yb	173·04
Magnesium	Mg	24·32	Yttrium	Yt	88·92
Manganese	Mn	54·93	Zinc	Zn	65·38
Mercury	Hg	200·61	Zirconium	Zr	91·22

Heat Treatment of Steel

(Col. N. T. Belaiew, C.B.)

Carbon steel is an alloy of iron and carbon, the amount of carbon varying from ·25% to about 2·30%. Steels are generally graded according to the amount of carbon they contain. The following terms are commonly used:—

Medium high carbon steel	·26 to ·60% carbon.
High carbon steel	over ·60% carbon.
Very high carbon steel	over 1·25% carbon.

All such steels by rapid cooling from a red heat by quenching in water become extremely hard and more or less brittle. This hardness can, however, be modified and brittleness removed by "tempering" or reheating to temperatures between 200° and 450° C.

After the introduction of the Bessemer and open-hearth processes, alloys with less than ·25% carbon began to be considered as steels—as, for instance:—

Low carbon or mild steel, carbon not over ·25%.
Very low carbon steel—very mild steel, carbon not over ·10%.

Unlike high carbon steels, low carbon steels cannot be hardened, but, like the former, they can be manufactured from the molten state, and when ingot cast are capable of being forged or rolled, thus differing from cast iron.

Forging, rolling, stamping, or any other kind of work aims at reshaping the steel ingot to suit any particular requirement. Incidentally it alters the structure and results in straining the finished article. To bring back the steel to the best physical state to resist fracture under sudden stress these strains have to be removed, and for this purpose the method of "annealing" is adopted.

Annealing, hardening, and tempering are the main "heat treatments" of steel. All or any of them are used to give the steel the required degrée of elasticity, hardness, and ductility.

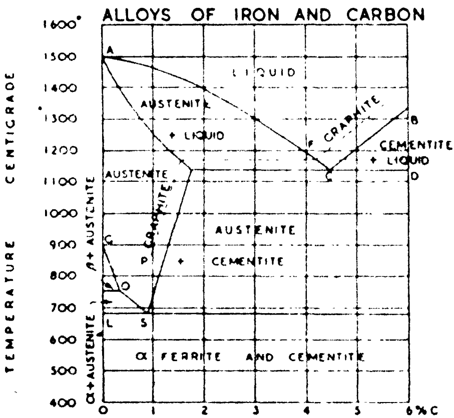
More than fifty years ago the shop practice of heat treatment showed that there were certain definite "critical temperatures" which had to be strictly complied with if any of the heat treatments were to be carried out successfully.

For instance, to be "hardened" the steel had to be heated just above red heat, or about 700° C. (point "a" of Tschernoff, "w" of Brinell) and then suddenly cooled to between 200° and 450° C. (Tschernoff's "d" and "e"). These temperatures being also the "tempering" temperatures.

"Annealing" temperature was given as being just above the hardening temperature, and the higher the less carbon content (Tschernoff's point "b"). This temperature was further linked up with the structure of steel, the understanding being that if heated below " b " the structure of steel remained unaltered, but if heated above, a nearly amorphous structure was obtained. This " amorphous " structure might be fixed by sudden cooling to temperatures below " a," such treatment resulting in toughening the article. One of the main applications of this rule was to consider for hot work the point " b " as the " finishing " temperature. It has been further pointed out that if a steel be heated above the necessary limits it might get " over-heated," with a resulting coarse and brittle structure. To remedy this, another careful heating to the correct temperature would be necessary.

If, however, the heating had reached a certain limit approaching its melting-point (" k " of Tschernoff), the steel would be " burnt " and become extremely red short, as well as cold short.

The importance of the " critical temperatures " as they come to us from the workshop is further accentuated by the fact that all find their appropriate place and explanation in the " equilibrium diagram " of the iron carbon alloys.



Woods used in Aircraft Design

	Weight, lb. per sq. ft. at 15% moisture	Compression parallel to grain, lb. per sq. in.	Compression perpendicular to grain, lb. per sq. in.	Shearing parallel to grain, lb. per sq. in.
Basewood . . .	26	4,500	620	720
Beech	44	6,500	1,670	1,300
Birch	44	7,300	1,590	1,300
Hickory	51	8,700	3,100	1,440
Black walnut . . .	39	7,600	1,730	1,000
Mahogany . . .	34	6,500	1,760	980
African mahogany .	32	5,700	1,400	860
Red cedar . . .	23	5,000	800	630
Norway pine . . .	34	6,600	1,080	870
* Spruce (Sitka) . .	27	5,000	840	750
White pine . . .	26	4,800	780	640
Ash	41	5,400	1,260	1,050

N.A.C.A. Technical Note, No. 296.

* Strength is reduced by 234 lb. per sq. in. for every 1% addition of moisture.

Identification of Rivets

Duralumin rivets must be softened by normalizing before using and must be used within two hours of normalizing. Normalized duralumin rivets may, however, be stored in an ice box of between 15° C. and 20° C., when age hardening is delayed up to 150 hours.

Duralumin rivets may be identified by the letter " D " stamped on the preformed head and on the shank.

Other light alloy rivets which do not require heat-treatment before use are dyed to assist in identification. The standard system adopted is:—

Aluminium rivets dyed	Black
Aluminium alloy D.T.D.327	Violet
Magnesium alloy MG5	Green
Magnesium alloy MG7	Red

Identification of Bolts

Bolts, of steel or duralumin, are usually supplied to B.S.I. Specifications or Aircraft General Standard (A.G.S.) parts, or S.B.A.C. standard.

B.S.I. bolts are identified by the code letters as below, followed by a number. This number is equal to ten times the length of the bolt. Thus a $\frac{1}{2}$ in. diameter B.S.I. bolt 2 in. long would be identified as N.20. On bolts of $\frac{1}{4}$ in. diameter and over the code letter is stamped on the head. Left-handed bolts are further designated by the letter " L " preceding the code letter. Duralumin bolts are marked with the letter " L ".

Code letters:—

B	4 B.A.	H	$\frac{11}{32}$ in.
C	2 B.A.	J	$\frac{3}{8}$ in.
D	$\frac{7}{32}$ in.	K	$\frac{13}{32}$ in.
E	$\frac{1}{4}$ in.	L	$\frac{7}{16}$ in.
F	$\frac{9}{32}$ in.	M	$\frac{15}{32}$ in.
G	$\frac{5}{16}$ in.	N	$\frac{1}{2}$ in.

Magnesium Alloy

Specification	Ult. tensile	Proof
D.T.D.88B Forgings, stampings . . .	15	8
D.T.D.259 Bars	14	9
D.T.D.142 Bars	15	8
D.T.D.118 Sheets	11	—
D.T.D.120A Sheets (Welding) . .	16	—
D.T.D.140A Castings . .	6	—

N.C. Sheet and Strips

Specification	Ult. tensile	Proof	Elongation, per cent.
B.S.S.85 Sheet	30	—	15
D.T.D.46A Strip	—	65	—
B.S.S.84 Sheet	20	—	25
D.T.D.166A CrNi Sheet and Strips	54	40	—
Steel Tubes			
2 T.1 ·35 Carbon.	35	—	—
2 T.2 NiCr	85	78	8
2 T.26 Mild Steel	20		11
T.50 50-ton Ni	50	45	—
N.C. Tubes			
D.T.D.97A	28	18	—
D.T.D.102A	35	30	—
D.T.D.203A	50	45	—

Steels

Specification	Ult. tensile	Elongation per cent.	Proof
S.76 40 Carbon	40	22	25
D.T.D.115 SiMn bars	90	10	—
3 S.1 Bright bar	35	15	—
2 S.2 55-ton Alloy	55	18	—
S.65 NiCr bars and forgings . .	65	17	—

N.C. Stainless Bars, etc.

Specification	Ult. tensile	Elongation, per cent.	Proof
S.61	35	25	—
S.62	46	20	—
S.80	55	15	—
D.T.D.161, 185, 189, Rivets	—	—	—
D.T.D.176A	35	30	15
Steel Sheet and Strips			
3 S.3 Hot rolled M.S. sheet	28	20	16
3 S.4 5% Ni	48	12	40
S.87 NiCr strip	65	7	55

Copper Alloys—Bars

	Specification	Maximum stress, tons per sq. in.	Elongation, per cent.
High Tensile Brass Bars	B.S.S.250		—
Naval Brass Bars	B.S.S 251	—	—
Brass Bars for Silver soldering or brazing	B.S.S.2 B.11	20	25
Hard rolled Bronze Bars	D.T.D.155	35	18
Phosphor Bronze Bars	B.S.S 369	—	—
Sheets			
Phosphor Bronze Strips	B.S.S.407	—	—
Brass Sheets (hard)	B.S.S.265	—	—
,, ,, (half hard)	B.S.S.266	—	—
,, ,, (annealed)	B.S.S 267	—	—
Copper Sheets (half hard)	B.S.S 899	—	—
Castings			
Gun Metal Castings	B.S.S.383	16	8
Phosphor Bronze Castings for Bearings	B.S.S 2 B.8	10	1 5
Tubes			
Copper Tubes	B.S.S.5 T 7	14–17	—
Cold-drawn Phosphor Bronze	B.S.S.2 T.52	25	—
Brass Tubes (annealed)	B.S.S.886	—	—
,, ,, (hard-drawn)	B.S.S.885	—	—

Aluminium Alloys

Sheet. Bars and Forgings, etc.

Specification	Ult. tensile	Proof
6 L.1 Duralumin	25	15
5 L.3 Duralumin Sheet	25	15
2 L.4 Hard Aluminium Sheet	9	—
B.S.S.2 L.38 Alclad	24	13 5
3 L.5 Castings	9	3·5
2 L.24 Y Alloy Castings	10	—
Aluminium Tubes		
5 T.4 Duralumin Tubes	26	19
4 T.9 Aluminium	7	—

MATERIAL SPECIFICATIONS—D.T.D. SERIES

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Classified List

METALLIC MATERIALS—LIGHT ALLOYS

Specification No. and Title
D.T.D.

Aluminium Alloys

Castings

131B Aluminium Alloy Sand or Die Castings (suitable for Pistons, etc.).
133B Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
165 Aluminium-Magnesium Alloy Castings.
231 10% Silicon-Aluminium Alloy Castings.
238 Aluminium Alloy Sand or Die Castings (as cast) (suitable for Pistons, etc.).
240 Silicon-Aluminium Alloy Castings (heat treated).
245 Silicon-Aluminium Alloy Castings (fully heat treated).
250 Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
255 Aluminium Alloy Die Castings (suitable for Pistons).
264 Aluminium Alloy Sand or Die Castings.
269 Aluminium Alloy Sand or Die Castings.
272 Aluminium-Silicon Alloy Sand or Die Castings (not suitable for Pistons).
276 Aluminium-Silicon Alloy Sand or Die Castings.
287 Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
294 Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
298 Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
300 Aluminium-Magnesium Alloy Sand or Die Castings (not suitable for Pistons).
304 Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
309 Aluminium Alloy Sand or Die Castings (heat treated) (not suitable for Pistons).
313 Aluminium Alloy Sand or Die Castings (as cast) (not suitable for Pistons).
361 Aluminium Alloy Sand Castings (not suitable for Pistons).

Specification No. and Title
D.T.D.

Aluminium Alloys—Castings—continued

424 Aluminium Alloy Castings for General Purposes.
428 Aluminium Alloy Castings for low Stressed Parts.
543 Aluminium Alloy Sand or Die Castings (heat treated) (suitable for Cylinder Heads).
598 Aluminium-Zinc Alloy Castings.

Bars, Extruded Sections and Forgings

128 Aluminium Alloy Forgings (for sealing rings for Cylinders).
130A Aluminium Alloy Bars, Extruded Sections and Forgings.
147 Light Alloy Airscrew Forgings (Fairey Reed type).
150A Light Alloy Airscrew Forgings (Detachable blades).
184 Light Alloy Airscrews Forgings and Stampings (detachable blades and complete air-screws).
246A Aluminium Alloy Crankcase Forgings (softened).
297 7% Magnesium-Aluminium Alloy Bars, Extruded Sections and Forgings (softened).
324 Silicon-Aluminium Alloy Forgings for Engine Cylinders and Pistons.
363 Aluminium Alloy Bars (Extruded and Rolled) and Extruded Sections.
364A Aluminium Alloy Bars, Extruded Sections and Forgings.
410 Aluminium Alloy Bars and Forgings.
423A Aluminium Alloy Bars, Extruded Sections and Forgings.
443 10/17 Aluminium Alloy Bars, Extruded Sections and Forgings.

Sheets and Coils

182A 7% Magnesium-Aluminium Alloy Sheets and Strips (annealed).
213A Aluminium-Manganese Alloy Sheets and Coils.
346 Soft Aluminium Alloy Sheets and Strips.
356 Wrought Light Aluminium Alloy Sheets and Strips.
390 Aluminium-Coated Aluminium Alloy Sheets and Coils.
546 Aluminium-Coated High Tensile Aluminium Alloy Sheets and Coils.
603 Aluminium Alloy Sheets and Coils (solution treated).
610 Aluminium-Coated Aluminium Alloy Sheets and Coils (solution treated).
696 High Tensile Aluminium Alloy Sheets and Coils (solution treated and artificially aged).

Specification No. and Title
D.T.D.

Tubes

186 7% Magnesium-Aluminium Tubes (hard).
190 7% Magnesium-Aluminium Alloy Tubes (annealed).
273 Aluminium Alloy Tubes.
310B Soft Aluminium Alloy Tubes (suitable for oil, petrol, gas starters and general purposes).
440 11/15 Aluminium Alloy Tubes.
450 10/17 Aluminium Alloy Tubes.
460 18/22 Aluminium Alloy Tubes.
464 Aluminium Alloy Tubes.
520 23/27 Aluminium Alloy Tubes.

Wires, Rivets, and Bolts

303 5% Magnesium-Aluminium Alloy Wire and Rivets.
327 Aluminium Alloy Wire and Rivets.
404 Hard Drawn High Tensile 7% Magnesium-Aluminium Alloy Wire and Rivets.
523 Cold Headed Aluminium Alloy Bolts.

Ingots

478 99% Secondary Aluminium Notched Bars and Ingots for Remelting.
479 Secondary Aluminium Alloy Notched Bars and Ingots for Remelting.

Magnesium Alloys

Castings

59A Magnesium Alloy Castings.
136A Magnesium Alloy Castings (suitable for Pressure Work).
140A Magnesium Alloy Castings (for lightly Stressed Parts).
281 Magnesium Alloy Castings (heat treated) (suitable for Pressure Work).
285 Magnesium Alloy Castings (fully heat treated).
289 Magnesium Alloy Castings (heated treated).
350 Magnesium Alloy Castings (as cast).

Bars, Forgings, and Stampings

88B Magnesium Alloy Forgings, including stampings and pressings.
142 Magnesium Alloy Bars (15 tons Tensile Strength).
259 Magnesium Alloy Bars.

Specification No. and Title
D.T.D.

Sheets and Strips

118 Magnesium Alloy Sheets (suitable for Welding).
120A Magnesium Alloy Sheets (suitable for Welding).

Tubes

348 Magnesium Alloy Tubes for Lightly Stressed Parts (suitable for Welding).

Ingots

325 Magnesium Alloy Ingots.

NON-FERROUS MATERIALS EXCLUDING LIGHT ALLOYS

Castings

174A Aluminium-Bronze Sand or Die Castings.
355 Silicon-Iron-Bronze Castings.
412 Aluminium-Bronze Sand or Die Castings.
459 Leaded-Bronze Seal Ring Pots.

Bars, Forgings, and Stampings

30A Bronze Bars for Carburettor Needle Seatings.
135 Aluminium-Nickel Bronze Forgings for Exhaust Valve Seats.
155 Hard Rolled Bronze (Gun Metal) Bars.
160 Aluminium-Bronze for Valve Seats.
164A Aluminium-Nickel-Iron Bronze Bars, Forgings and Stampings.
192 High Nickel-Copper Alloy Hot Rolled or Forged Bars, Stampings, and Forgings.
196 Cold Rolled or Cold Drawn and Annealed High Nickel-Copper Alloy Bars (suitable for cold bending).
197 Aluminium-Nickel-Iron Bronze Bars Stampings and Forgings.
200A Hard Drawn High Nickel Copper Alloy Bars.
204A High Nickel-Copper Alloy Rods.
265A Hard Drawn Phosphor Bronze Bars.
268 45% Nickel Alloy Rods.
319 Aluminium-Nickel-Silicon Brass Bars.
354 Chromium-Bronze Bars, Extruded Sections.
498 Silicon-Nickel-Copper Alloy Bars and Forgings.
504 Silicon-Nickel-Copper Alloy Bars.
529 Chromium-Nickel Heat-Resisting Steel Bars and Forgings.

Specification No. and Title
D.T.D.

Sheets and Coils

10B High Nickel-Copper Alloy Sheets (annealed).
200A Hard Nickel-Copper Alloy Sheets.
208 Cadmium-Copper Alloy Strips.
232 45% Nickel Alloy Sheets and Strips. 40–50 tons 0·1%. Proof Stress.
237 45% Nickel Alloy Sheets and Strips. 15 tons 0·1%. Proof Stress.
263 Silicon-Brass Sheets (annealed).
267 Silicon-Brass Sheets (half hard).
283A Aluminium-Nickel-Silicon Brass Sheets (annealed).
328 Nickel-Chromium-Iron Alloy Sheets and Strips (softened).

Tubes

204A High Nickel-Copper Alloy Tubes.
253A Aluminium-Nickel-Silicon Brass Tubes (Low Pressure).
265A Hard Drawn Phosphor Bronze Tubes (suitable for Bushes, etc.).
268 45% Nickel Alloy Tubes.
307 Silicon-Brass Tubes (annealed).
312 Hard Drawn Silicon Brass Tubes.
318A Tin-Iron Brass Tubes.
323 Aluminium-Nickel-Silicon Brass Tubes (Medium Pressure).
341 Nickel-Copper Alloy Tubes for Honeycomb Type Radiators.
354 Chromium-Bronze Tubes (suitable for Engine Valve Guides).
387 Copper or Copper Alloy Tubes for Honeycomb Type Radiators.
477 High Nickel-Copper Alloy Tubes.
604 Brass Tubes (suitable for Low Pressure and similar systems).

Wires, Rivets, and Bolts

204A High Nickel-Copper Alloy Wire and Rivets.
208 Cadmium-Copper Alloy Wires.
268 46% Nickel Alloy Wires, Rivets, Split Pins.
487 Aluminium-Copper-Nickel Alloy Cold Headed Bolts (not exceeding $\frac{1}{8}$ in. diameter).

Miscellaneous

214 White Metal Ingots (suitable for Bearings).
217 Cadmium Alloy Ingots (suitable for Bearings).
221A Cadmium-Zinc Solder.

Specification No. and Title
D.T.D.

Miscellaneous—continued

229A Lead Bronze Ingots and Bars (suitable for Bearings).
244 White Metal Bearings.
274 Lead Bronze Ingots and Bars (suitable for Bearings).
422 Lead Bronze Ingots and Bars (suitable for Bearings).

IRONS AND STEELS

Cast Irons

169 Iron Castings for Cylinders, Pistons, and Valve Guides.
233 Cast Iron Piston Ring Pots (chill cast).
277 Cast Iron Piston Ring Pots (chill cast).
334 Austenitic Cast Iron Pots (centrifugally cast) (suitable for Packing Rings for Valve Seats).
413 Cast Iron Piston Ring Pots (sand or chill cast).
485 Cast Iron Piston Ring Pots.

Steels

Castings

Non-Stainless
9B Manganese Steel Castings.
17A Steel Castings.

Bars and Forgings

Non-Stainless
87A 55–65-Ton Chromium-Aluminium-Molybdenum Steel (suitable for Nitrogen Hardening).
115 Silico-Manganese Steel Bars.
126A 40-Ton Carbon Steel Bars (suitable for Welding).
153 Bright Steel Bars for Pins and High Tensile Bolts.
188A 55–65-Ton Manganese-Molybdenum Steel.
228 55–65-Ton Nickel-Chromium-Molybdenum Steel (suitable for Nitrogen Hardening).
261 Alloy Steel Bars.
286A 55–65-Ton Chromium-Molybdenum Steel (suitable for Nitrogen Hardening).
299 Mild Steel Bars and Forgings.
306 60–70-Ton Chromium-Molybdenum Steel (suitable for Nitrogen Hardening).
317A 45–55-Ton Chromium-Molybdenum Steel (suitable for Nitrogen Hardening).
331 80–90-Ton Nickel-Chromium Steel.

Specification No. and Title
D.T.D.

Bars and Forgings—continued

Non-Stainless

461 55–65-Ton 1% Chromium Steel.
470 55–65-Ton Chromium-Molybdenum Steel.
473 75–85-Ton Nickel-Chromium-Molybdenum Steel.
480 55–65-Ton 1½% Nickel-Chromium-Molybdenum Steel.
490 55–65-Ton 2½% Nickel-Chromium-Molybdenum Steel (Medium Carbon).
500 80–90-Ton 2½% Nickel-Chromium-Molybdenum Steel (High Carbon).
510 40–50-Ton Manganese-Nickel-Molybdenum Steel.
519 3% Nickel-Chromium Case-hardening Steel.
529 Chromium-Nickel Heat Resisting Steel Bars and Forgings.
600 55–65-Ton Low Alloy Steel.

Stainless and Valve Steels

6A Cobalt-Chromium Valve Steel.
13B Silicon-Chromium Valve Steel Forgings or Stampings.
49B High Nickel High Chromium Steel Valve Forgings.
53 Non-corrodible Low Tensile Steel Bar.
176A Chromium-Nickel Non-corrodible Steel of 15 tons 0·1% Proof Stress.
247 High Thermal Expansion Steel (suitable for Valve Seats).
282 High Chromium Steel Valve Forgings.
311 Silicon-Chromium Valve Steel Forgings or Stampings.
463 55–70-Ton Non-corrodible Steel.
525 45–55-Ton Non-corrodible Steel (free machining).

Sheet and Strip

Non-Stainless

124A Hot Rolled or Cold Rolled Carbon Steel Sheets and Strips of 40 to 55 tons 0·1% Proof Stress.
137A Hot Rolled or Cold Rolled Carbon Steel Sheets and Strips of 50 to 65 tons 0·1% Proof Stress.
138A Hot Rolled or Cold Rolled Carbon Steel Sheets and Strips of 60 to 75 tons 0·1% Proof Stress.
187A Spring Steel Strips.
241 High Carbon Steel Strips.
330 Soft Iron Sheets and Strips (suitable for Electrical purposes).
488 Carbon Steel Strips (suitable for Magneto Contact Breaker Springs).

Specification No. and Title
D.T.D.

Sheet and Strip—continued

Stainless

60B High Chromium Non-corrodible Steel Sheets and Strips (40 to 55 tons 0·1% Proof Stress).
146A High Chromium Non-corrodible Steel Sheets and Strips of 30 Tons 0·1% Proof Stress.
158 Non-corrodible Steel Strips of 35 tons Proof Stress.
166B Chromium-Nickel Non-corrodible Steel Sheets and Coils of 40–50 tons 0·1% Proof Stress.
171B Chromium-Nickel Non-corrodible Steel Sheets and Coils of 15 tons 0·1% Proof Stress.
195 Non-corrodible Steel Strips of 55 tons 0·1% Proof Stress.
271 Non-corrodible Steel Strips (suitable for Magneto Contact Breaker Springs).
316 Chromium-Nickel Alloy Sheets and Strips of 10 tons 0·1% Proof Stress.
493 Chromium-Nickel Heat-Resisting Steel Sheets and Coils (suitable for Welding).
571 Chromium-Nickel Non-Corrodible Steel Sheets, Strips Tubes and Wire (suitable for Welding) (primarily for Exhaust Manifolds, etc.).

Tubes

Non-Stainless

41 Mild Steel Tubes (suitable for Welding).
167 45-Ton Steel Tubes.
178A Chrome-Molybdenum Steel Tubes (suitable for Welding).
254 75-Ton Nickel-Chromium Steel Tubes.
299 Mild Steel Tubes (suitable for Bearing Shells).
305 30-Ton Carbon Steel Tubes.
347 50-Ton Chrome-Molybdenum Steel Tubes (suitable for Welding).
359 45-Ton Manganese-Molybdenum or Chrome-Molybdenum Steel Tubes (suitable for Welding).
408 75-Ton Chrome-Molybdenum Steel Tubes (suitable for Welding).
432 Commercial Quality 20-Ton Steel Tubes.
501 Commercial Quality 35-Ton Steel Tubes.
503 Steel Tubes.
535 Commercial Quality 35-Ton Steel Tubes (suitable for Welding).
545 Commercial Quality 45-Ton Steel Tubes (suitable for Welding).
563 Commerical Quality 32-Ton Steel Tubes—Seamless or Welded.

Specification No. and Title
D.T.D.

Tubes—continued

Stainless

97A Low Tensile Non-corrodible Steel Tubes.
102A 35-Ton Non-corrodible Steel Tubes.
185A High Chromium Non-corrodible Steel Tubes.
199 50-Ton High Chromium Non-corrodible Steel Tubes.
203A 50-Ton Non-corrodible Steel Tubes.
207 35-Ton Chromium-Nickel Non-corrodible Steel Tubes (suitable for Pipe Lines).
211 50-Ton Chromium-Nickel Non-corrodible Steel Tubes.
491 Chromium-Nickel Heat-Resisting Steel Tubes (suitable for Welding).
507A Commercial Quality 35-Ton Non-corrodible Steel Tubes (suitable for Welding).

Miscellaneous

Wires, Cables, Springs, and Bolts

Non-Stainless

4A Chromium-Vanadium Steel for Valve Springs.
5A Hard Drawn Carbon Steel for Valve Springs.
82A Iron or Mild Steel Wire for Welding purposes.
215 High Tensile Steel Wire.
239 Steel Wire for Springs (not suitable for Engine Valve Springs).
394 Flexible Steel Wire Rope for Kite Balloon Cables.
398 Low Tensile Cold Headed Bolts.
401 High Tensile Cold Headed Bolts.

Stainless

61 Chromium-Nickel Non-corrodible Welding Rod.
161 Non-corrodible Steel Rods, Wire, Rivets and Split Pins.
163A High Chromium Non-corrodible Steel Stream-line Wires.
181A Non-corrodible Steel Flexible Wire Rope.
185A High Chromium Non-corrodible Steel Rods, Wires, Tubes, Rivets, and Split Pins.
189 Chromium Nickel Non-corrodible Steel Rods, Wire, Rivets, and Split Pins.
236 Non-corrodible Steel Aerial Wire.
301 High Chromium Non-corrodible Steel Tie Rods (Swaged).
326 Non-corrodible Steel Wire and Springs.
401 High Tensile Cold Headed Bolts.
489 Chromium-Nickel Heat-Resisting Steel Rods and Wire (suitable for Welding and for Split Pins).
549 Chromium-Nickel Non-Corrodible Steel Welding Rods and Wire.

Specification No. and Title
D.T.D.

Wires, Cables, Springs and Bolts—continued

Stainless

551 3% Chromium-Molybdenum Steel Thrust Rings (Nitrogen hardened).
569 55–65-Ton Manganese Molybdenum Steel Pressings.

NON-METALLIC MATERIALS

Dopes and Ingredients

83A Aeroplane Doping Schemes.
103 Cellulose Lacquers for Wooden Airscrews.
112 Toluol.
114 Dibutyl Phthalate.
426 Ethyl-Cellulose.

Fabrics, etc.

65A Silk Tape for Parachutes.
66 Silk Thread.
67A Silk Cordage for Parachute Shroud Lines.
69A Silk Fabric for Parachutes.
73 Jute Webbing.
86A Airship Linen Fabric.
256C Plaited Cordage.
258 Italian Hemp Ropes (Plaited).
295 Rubber Proofed Fabric for Riveted Tanks.
336B Waterproofed and Dyed Cotton Fabric.
343 Light Cotton Fabric (for covering plywood).
376 Soft Cotton Cord for Kite Balloons.
379 Heavy Cotton Tapes.
382 Silk Fabric for Parachutes (to be used for " D " Panels only).
385 Artificial Silk Fabric for Parachutes.
403 Silk Fabric for Kite Balloons.
407 4 oz.-Cotton Fabric and Tape.
418 1·5 oz.-Scoured Cotton Fabric.
431 Parachute Harness Webbing.
436A Proofed Cotton Fabric.
448B Waterproofed and Dyed Cotton Duck.
481 Nylon Cordage.
483 Rubber Proofed Silk Fabric.
486 Light Weight Silk Fabric.
492 Cotton Webbing.
494 Rubber Proofed Cotton Fabric.
499 Scoured Cotton Fabric.

Specification No. and Title
D.T.D.

Fabrics, etc.—continued

514 Nylon Yarn.
524 2¼-oz. Scoured Cotton Fabric.
526A Artificial Silk Fabric (Dyed or Printed).
528 Rubber Proofed Cotton Fabric.
531 Rubber Proofed Cotton Fabric (single ply).
532 Rubber Proofed Silk Fabric (single ply).
534 Jute Webbing.
537 Rubber Proofed Cotton (Fabric (three ply).
540 Linen Fabric and Tape.
567 Lightweight Fabric with Flexible Proofing.
572 Flexible Oil and Petrol Proof Cotton Duck.
575 Scoured Cotton Fabric.
576 Spun Silk Thread.
594 1·6 oz.-Cotton Fabric, Navy Blue.
595 1·65 oz.-Cotton Fabric (Dyed).
596 2 oz.-Cotton Fabric.

Instruments

Inst. 1. Issue 7. Drive, flexible, for Engine Speed Indicator.
Inst. 2. Gear Box, Dual Drive, Mark II, for Engine Speed Indicator.

Miscellaneous

37A Vulcanized Fibre for Jointing Purposes.
77 Powdered Graphite.
81 Tinning and Soldering Solution.
112 Toluol.
119 Aluminium Welding Flux.
121C Temporary Rust Preventive.
122B Lanolin.
139 Plastic Wood.
154A Sulphuric Acid for Accumulators.
218 Safety Glass for Windscreens.
219A Cork Jointing Material.
222A Safety Glass for Plane Goggle and Spectacle Glass.
223 Glycerin.
230 87 Octane Standard Fuel for Aero-engines.
279B Pigmented Lanolin Resin Solution.
335A Synthetic Resin Cement (Non Gap-Filling).
338 Anti-misting Compound.
344A Treated Ethylene Glycol.
357 Radiator Leak Compound.

Specification No. and Title
D.T.D.

Miscellaneous—continued

369A Pigmented Varnish Jointing Compound.
374 Kaolin.
375C Resin.
377 Zinc Chrome.
378 Compressed Asbestos Fibre Jointing.
389 Iso-Propyl Alcohol (2-Propanol).
395 Ethylene Glycol Mono-Ethyl Ether.
402A Bullet Proof Safety Glass for Windscreen Panels.
406A De-icing Fluid.
416 Compressed Asbestos Fibre Jointing with Wire Mesh Inserts.
458 Rubber Mouldings and Extensions for use in contact with Anti-Freezing Oil.
471 Silica Gel.
484 Synthetic Resin Cement (Gap-Filling).
527 French Chalk or French Chalk Substitute.
533 French Chalk or French Chalk Substitute and Red Oxide of Iron Mixture.
557 Low Temperature Grease.
587 Engine Corrosive Preventive.
623 Pigmented Shellac Solution.
637 Hard Vulcanized Fibre Sheets for Jointing Purposes.
663 Lanolin Resin Protective.

Lubricants and Hydraulic Fluids

44D Anti-Freezing Oil, Type 4DD.
55 Mineral Jelly.
71A Castor Oil for Lubrication.
72 Treated Castor Oil.
74 Sewing Machine Oil.
143C Anti-Freezing Grease.
388 Fluid for Oleo Shock Absorber Struts.
391 Fluid for Hydraulic Mechanisms.
392 Anti-Seize Grease for Threaded Fittings.
417A Anti-Freezing Oil, Type 417A.
419 High Melting Point Grease.
438 Graphited Wax.
472 Aero Engine Lubricating Oils.
539 High Altitude Controls Lubricant.
561 Corrosion Resisting Instrument Oil.
577 Low Temperature Grease.

Specification No. and Title
D.T.D.

Paints and Dopes

56B Stoving Enamel.
62B Pigmented Oil Varnish.
63A Cellulose Enamels and Primer (for Metals and Timber).
83A Aeroplane Doping Schemes.
226 Paint Remover.
234 Clear Varnish for Internal Protection of Drinking Water Tanks.
235 Low Temperature Stoving Enamel (priming and finishing coat).
260A Pigmented Oil Varnish and Undercoating.
308 Matt Cellulose Finishes and Primer.
314 Matt Pigmented Oil Varnishes and Primer.
399 Enamels resistant to hydraulic fluids.
400 Petrol-Resisting Paint.
420B Matt Pigmented Lanolin-Resin Finishes.
441 Distemper—Matt Finish.
449 Silicate Paint for Timber.
517 Matt Pigmented Synthetic Resin Primer and Finish (quick drying).
557 Flexible Paint.
623 Pigmented Shellac Solution.
663 Lanoline Resin Protective.

Plastics

216A Synthetic Resin Bonded Fabric Mouldings for Magneto Gear Wheels.
315 Pigmented Cellulose Acetate Sheets.
320 L.T. Varnished Insulating Tubing.
339A Transparent Synthetic Resin Sheets and Mouldings.
383 Cellulose Sheet for use as a protective wrapping.
442 Laminated Synthetic Resin Bonded Mouldings.
451 Synthetic Resin (Phenolic) Moulding Materials and Mouldings (Poor Shock Resistance).
452 Synthetic Resin (Phenolic) Moulding Materials and Mouldings (Low Shock Resistance).
453 Synthetic Resin (Phenolic) Moulding Materials and Mouldings (Medium Shock Resistance).
454 Synthetic Resin (Phenolic) Moulding Materials and Mouldings (High Shock Resistance).
496 Insulating Material Grade " A " for Mouldings in Aircraft Electrical Accessories.
497 Insulating Material Grade " B " for Impact Resisting Mouldings in Aircraft Electrical Accessories.

Specification No. and Title
D.T.D.

Plastics—continued

513 Insulating Material Grade "K" for Medium Impact Resisting Mouldings in Aircraft Electrical Accessories and Instruments.
522 Insulating Material Grade "E" for Impact and Acid Resisting Mouldings for Aircraft Accumulator Covers.
602 Poly-Vinyl Chloride Tubing.

Rubber

104 Rubber Solvent.
107A Rubber Tubing for Suspended Static Heads.
162A Shock Absorber Cord Rings for Gun Mountings.
205 Rubber Watch Holders.
227A Rubber Gaskets for Magneto Terminals, etc.
251B Rubber Tubing for Oxygen Breathing Masks.
329B Rubber Tubing for Automatic Controls.
337A Rubber Pads for Bomb Sight Brackets.
373 Rubber Tubing for Instrument Panels.
411 Rubber Hose for use with Ethylene Glycol.
421 Vulcanized Expanded Rubber.
439 Expanded Rubber Sheet.
458 Rubber Mouldings and Extrusions for use in contact with Anti-Freezing Oil.
474 Soft Rubber Sheet.
515B Cellular Rubber Sheet.

Timber

28B Sitka (Silver) Spruce as Rough Timber.
31 Ash.
32A Walnut as Rough Timber.
33A Mahogany as Rough Timber.
34A Rock Elm.
36B Sitka Spruce or Approved Substitutes.
302 Mahogany Substitutes (for use in Airscrews).
370 Laminated Compressed Wood.
427 Plywood for Lightly Stressed Parts of Aircraft.
469 Douglas Fir (as used in Aircraft parts).

PROCESS SPECIFICATIONS

901 Processes for cleaning Metal Parts in preparation for Protection against Corrosion.
902A Protection of Metal Parts against Corrosion by means of Organic Protectives.

Specification No. and Title
D.T.D.

PROCESS SPECIFICATIONS—*continued*

903 Zinc Plating.
904 Cadmium Plating.
905 Nickel Plating.
906 Metallizing.
907 Aluminizing.
908 Sherardizing.
909 Protection of the interior of Drinking Water Tanks against Corrosion.
910A Anodic Oxidation of Aluminium and Aluminium Alloy Parts.
911 Protection of Magnesium-Rich Alloy Parts against Corrosion.
912 Protection of Wooden Parts (except Windmills and Airscrews).
913 Identification Colouring of Aluminium and Aluminium Alloy Rivets.
914A Rot-Proofing of Canvas, Rope, and Cordage.
915A Process for Cleaning Aluminium and Aluminium Alloy Plating prior to Painting.

MATERIAL SPECIFICATIONS—D.T.D. SERIES

Numerical List

Spec. No. *D.T.D.* — *Description or Replacement Specification*

1 *Cancelled.* B.S., S.82.
2 *Cancelled.* B.S., S.67.
3 *Cancelled.* B.S., S.83 (B.S., S.90).
4A Chromium-Vanadium Steel for Valve Springs.
5A Hard Drawn Carbon Steel for Valve Springs.
6A Cobalt-Chromium Valve Steel.
7 *Cancelled.* Obsolete.
8 *Cancelled.* B.S., S.65.
9B Manganese Steel Castings.
10B High Nickel Copper Alloy Sheets.
11 *Cancelled.* B.S.384/1930, 407/1931.
12A *Cancelled.* B.S., S.84.
13B Silicon-Chromium Valve Steel Forgings or Stampings.
14A *Cancelled.* B.S. B.21.
15A *Cancelled.* B.S. B.22.
16 *Cancelled.* D.T.D.99 and 100.

Spec. No. D.T.D.	*Description or Replacement Specification*
17A	Mild Steel Castings.
18C	*Cancelled.* B.S. 6 L.1.
19	*Cancelled.* B.S. 2 S.28.
20	*Cancelled.* B.S.219/1925.
21	*Cancelled.* B.S., S.61.
22A	*Cancelled.* B.S., S.62.
23B	*Cancelled.* B.S., S.85.
24A	*Cancelled.* D.T.D.161, 185, and 189.
25	*Cancelled.* B.S. L.33.
26	*Cancelled.* Obsolete.
27	*Cancelled.* Obsolete.
28B	Sitka (Silver) Spruce as Rough Timber.
29A	*Cancelled.* Obsolete.
30A	Bronze Bars for Carburettor Needle Seatings.
31	Ash.
32A	Walnut as Rough Timber.
33A	Mahogany as Rough Timber.
34A	Rock Elm as Rough Timber.
36B	Sitka Spruce or Approved Substitutes.
37A	Vulcanized Fibre for Jointing Purposes.
39	*Cancelled.* Obsolete.
40	*Cancelled.* D.T.D.59A.
41	Mild Steel Tubes suitable for Welding.
42	*Cancelled.* D.T.D.144.
43	*Cancelled.* D.T.D.156.
44D	Anti-Freezing Oil, Type 44D.
46A	*Cancelled.* Obsolete.
48	*Cancelled.* B.S. F.51.
49B	High Nickel High Chromium Steel Valve Forgings.
50	*Cancelled.* Obsolete.
52A	*Cancelled.* B.S. F.56.
53	Non-corrodible Low Tensile Steel Bars.
54A	*Cancelled.* B.S. S.88.
55	Mineral Jelly.
56B	Stoving Enamel.
57B	*Cancelled.* D.T.D.166.
58A	*Cancelled.* B.S.S. 4 L.25.
59A	Magnesium Alloy Castings.
60B	High Chromium Non-corrodible Steel Sheets and Strips (40-55 tons 0·1% Proof Stress).
61	Chromium-Nickel Non-corrodible Welding Rod.
62B	Pigmented Oil Varnish.
63A	Cellulose Enamels and Primer (for Metals and Timber).
64A	*Cancelled.* B.S. F.55.

Spec. No. D.T.D.	*Description or Replacement Specification*
65A	Silk Tape for Parachutes.
66	Silk Thread.
67A	Silk Cordage for Parachute Shroud Lines.
68	*Cancelled.* B.S. F.53.
69A	Silk Fabric for Parachutes.
70	*Cancelled.* Obsolete.
71A	Castor Oil for Lubrication.
72	Treated Castor Oil.
73	Jute Webbing.
74	Sewing Machine Oil.
75	*Cancelled.* B.S. 6 F.1.
76	*Cancelled.* B.S. S.80.
77	Powdered Graphite.
78A	*Cancelled.* B.S.369–1940.
79A	*Cancelled.* B.S. T.52.
80	*Cancelled.* B.S. F.54.
81	Tinning and Soldering Solution.
82A	Iron or Mild Steel Wire for Welding purposes.
83A	Aeroplane Doping Schemes.
84	*Cancelled.* Obsolete.
86A	Airship Linen Fabric.
87A	55–65-Ton Chromium-Aluminium-Molybdenum Steel (suitable for Nitrogen Hardening).
88B	Magnesium Alloy Forgings, Stampings or Pressings (not suitable for Pistons).
89A	*Cancelled.* B.S. T.45.
90	*Cancelled.* Obsolete.
91A	*Cancelled.* B.S. T.50.
93	*Cancelled.* B.S. F.52.
94A	*Cancelled.* B.S. F.57.
97A	Low Tensile Non-corrodible Steel Tubes.
98A	*Cancelled.* B.S., S.86.
99	*Cancelled.* B.S., S.87.
100	*Cancelled.* B.S., S.86.
102A	35-Ton Non-corrodible Steel Tubes.
103	Cellulose Lacquers for Wooden Airscrews.
104	Rubber Solvent.
105	*Cancelled.* D.T.D.203A.
106	*Cancelled.* Obsolete.
107B	Rubber Tubing for Suspended Static Heads.
108A	*Cancelled.* B.S. 5 T.7.
109	*Cancelled.* D.T.D.472.
110	*Cancelled.* B.S. 2 L.37.
111	*Cancelled.* B.S. 2 L.38.

Spec. No. D.T.D. — *Description or Replacement Specification*

112 Toluol.
113 *Cancelled.* B.S. T.35.
114 Dibutyl Phthalate.
115 Silico Manganese Steel Bars.
116A *Cancelled.* B.S. D.34.
117 *Cancelled.* D.T.D.155.
118 Magnesium Alloy Sheets (suitable for Welding).
119 Aluminium Welding Flux.
120A Magnesium Alloy Sheets (suitable for Welding).
121D Temporary Rust Preventive.
122B Lanolin.
123A *Cancelled.* B.S.479A/1933, Type A.
124A Hot Rolled or Cold Rolled Carbon Steel Sheets and Strips 40 to 55 tons, 0·1% Proof Stress.
125 *Cancelled.* Obsolete.
126A 40-Ton Carbon Steel (suitable for Welding).
127 *Cancelled.* D.T.D.259.
128 Aluminium Alloy Forgings (for Sealing Rings for Cylinders).
129 *Cancelled.* Obsolete.
130A Aluminium Alloy Bars, Extruded Sections and Forgings.
131B Aluminium Alloy Sand or Die Castings (suitable for Pistons, etc.).
132 *Cancelled.* B.S. 2 L.42.
133B Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
134 *Cancelled.* D.T.D.224 and 230.
135 Aluminium-Nickel Bronze Forgings for Exhaust Valve Seats.
136A Magnesium Alloy Castings (suitable for Pressure Work).
137A Hot Rolled or Cold Rolled Carbon Steel Sheets and Strips of 50 to 65 tons, 0·1% Proof Stress.
138A Hot Rolled or Cold Rolled Carbon Steel Strips of 65 to 75 tons, 0·1% Proof Stress.
139 Plastic Wood.
140A Magnesium Alloy Castings (for lightly Stressed Parts).
141 *Cancelled.* B.S., S.84.
142 Magnesium Alloy Bars (15 tons Tensile Strength).
143C Anti-Freezing Grease.
144 *Cancelled.* D.T.D.171A.
145 *Cancelled.* Obsolete.
146A High Chromium Non-corrodible Steel Sheets and Strips of 30 tons 0·1% Proof Stress.
147 Light Alloy Airscrew Forgings (Fairey Reed type).

Spec. No. D.T.D.	*Description or Replacement Specification*
148	*Cancelled.* B.S. L.36.
149	*Cancelled.* D.T.D.167.
150A	Light Alloy Airscrew Forgings (detachable blades).
153	Bright Steel Bars for Pins and High Tensile Bolts.
154A	Sulphuric Acid for Accumulators.
155	Hard Rolled Bronze (Gun Metal) Bars.
156	*Cancelled.* D.T.D.176.
157	*Cancelled.* Obsolete.
158	Non-corrodible Steel Strip of 35 tons Proof Stress.
160	Aluminium-Bronze for Valve Seats.
161	Non-corrodible Steel Rods, Wire, Rivets, and Split Pins.
162A	Shock Absorber Cord Rings for Gun Mountings.
163A	High Chromium Non-corrodible Steel Stream-line Wires.
164A	Aluminium-Nickel-Iron Bronze Bars, Forgings and Stampings.
165	Aluminium-Magnesium Alloy Castings.
166B	Chromium-Nickel Non-corrodible Steel Sheets and Coils of 40–50 tons 0·1% Proof Stress.
167	45-Ton Steel Tubes.
168	*Cancelled.* Obsolete.
169	Iron Castings for Cylinders, Pistons, and Valve Guides.
170A	*Cancelled.* Obsolete.
171B	Chromium-Nickel Non-corrodible Steel Sheets and Coils of 15 tons 0·1% Proof Stress.
172B	*Cancelled.* Obsolete.
174A	Aluminium Bronze Die Castings.
175A	*Cancelled.* Obsolete.
176A	Chromium-Nickel Non-corrodible Steel of 15 tons 0·1% Proof Stress.
177A	*Cancelled.* Obsolete.
178A	Chrome-Molybdenum Steel Tubes (suitable for Welding).
179	*Cancelled.* Obsolete.
180A	*Cancelled.* B.S. L.46.
181A	Non-corrodible Steel Flexible Wire Rope.
182A	7% Magnesium-Aluminium Alloy Sheets and Strips (Annealed).
184	Light Alloy Airscrew Forgings and Stampings.
185A	High Chromium Non-corrodible Steel Rods, Wires, Tubes, Rivets, and Split Pins.
186A	7% Magnesium-Aluminium Alloy Tubes (hard).
187A	Spring Steel Strips.
188A	55–65-Ton Manganese-Molybdenum Steel.
189	Chromium-Nickel Non-corrodible Steel Rods, Wire, Rivets, and Split Pins.

Spec. No. D.T.D.	*Description or Replacement Specification*
190	7% Magnesium-Aluminium Alloy Tubes (annealed).
191	*Cancelled.* B.S. 4 L.25.
192	High Nickel-Copper Alloy Hot Rolled or Forged Bars, Stampings and Forgings.
194	*Cancelled.* Obsolete.
195	Non-corrodible Steel Strip of 55 tons 0·1% Proof Stress.
196	Cold Rolled or Cold Drawn and Annealed High Nickel-Copper Alloy Bars (suitable for Cold Bending).
197	Aluminium-Nickel-Iron Bronze Bars, Stampings and Forgings.
198A	*Cancelled.* Obsolete.
199	50-Ton High Chromium Non-corrodible Steel Tubes.
200A	Hard Drawn High Nickel-Copper Alloy Bars and Strips.
201	*Cancelled.* D.T.D.417A.
202	*Cancelled.* D.T.D.303.
203A	50-Ton Non-corrodible Steel Tubes.
204A	High Nickel-Copper Alloy Rods, Wire Tubes and Rivets.
205	*Cancelled.* Obsolete.
206	*Cancelled.* Obsolete.
207	35-Ton Chromium-Nickel Non-corrodible Steel Tubes.
208	Cadmium-Copper Alloy Wires and Strips.
209A	*Cancelled.* B.S. L.46.
211	50-Ton Chromium-Nickel Non-corrodible Steel Tubes.
212	*Cancelled.* Obsolete.
213A	Aluminium-Manganese Alloy Sheets and Coils.
214	White Metal Ingots.
215	High Tensile Steel Wire.
216A	Synthetic Resin Bonded Fabric Mouldings for Magneto Gear Wheels.
217	Cadmium Alloy Ingots.
218	Safety Glass for Windscreens.
219A	Cork Jointing Material.
220A	*Cancelled.* Obsolete.
221A	Cadmium-Zinc Solder.
222A	Safety Glass for Plane Goggle and Spectacle Glass.
223	Glycerin.
224	*Cancelled.* Obsolete.
225	*Cancelled.* Obsolete.
226	Paint Remover.
227A	Rubber Gaskets for Magneto Terminals, etc.
228	55–65-Ton Nickel-Chromium Molybdenum Steel.
229A	Lead Bronze Ingots and Bars.
230	87 Octane Standard Fuel for Aero-engines.
231	10% Silicon-Aluminium Alloy Castings.

Spec. No. D.T.D.	Description or Replacement Specification
232	45% Nickel Alloy Sheets and Strips of 40–50 tons 0·1% Proof Stress.
233	Cast Iron Piston Ring Pots (chill cast).
234	Clear Varnish for internal protection of drinking water tanks.
235	Low Temperature Stoving Enamel (priming and finishing coat).
236	Non-corrodible Steel Aerial Wire.
237	45% Nickel Alloy Sheets and Strips of 15 tons 0·1% Proof Stress.
238	Aluminium Alloy Sand or Die Castings (as cast) (suitable Pistons, etc.).
239	Steel Wire for Springs (not suitable for Engine Valve Springs).
240	Silicon-Aluminium Alloy Castings (heat treated).
241	High Carbon Steel Strips.
243	*Cancelled.* D.T.D.309.
244	White Metal Bearings.
245	Silicon-Aluminium Alloy Castings (fully heat treated).
246A	Aluminium Alloy Crankcase forgings (softened).
247	High Thermal Expansion Steel (suitable for Valve Seats).
248	*Cancelled.* D.T.D.313.
249	*Cancelled.* Obsolete.
250	Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
251B	Rubber Tubing for Oxygen Breathing Masks.
252	*Cancelled.* B.S. 2 L.40.
253A	Aluminium-Nickel-Silicon Brass Tubes.
254	75-Ton Nickel-Chromium Steel Tubes.
255	Aluminium Alloy Die Castings (suitable for Pistons).
256C	Plaited Cordage.
258	Italian Hemp Ropes (Plaited).
259	Magnesium Alloy Bars.
260A	Pigmented Oil Varnish and Undercoating.
261	Alloy Steel Bars.
263	Silicon-Brass Sheets (annealed).
264	Aluminium Alloy Sand or Die Castings.
265A	Hard Drawn Phosphor-bronze Bars and Tubes (suitable for Bushes, etc.).
266	*Cancelled.* Obsolete.
267	Silicon-Brass Sheets (half-hard).
268	45% Nickel Alloy Rods, Wires, Tubes, Rivets, and Split Pins.
269	Aluminium Alloy Sand or Die Castings.

Spec. No. D.T.D.	*Description or Replacement Specification*
270	*Cancelled.* Obsolete.
271	Non-corrodible Steel Strips (suitable for Magneto Contact-Breaker Springs).
272	Aluminium-Silicon Alloy Sand or Die Castings (not suitable for Pistons).
273	Aluminium Alloy Tubes.
274	Lead Bronze Ingots and Bars.
275	*Cancelled.* Obsolete.
276	Aluminium-Silicon Alloy Sand or Die Castings.
277	Cast Iron Piston Ring Pots (chill cast).
278	*Cancelled.* B.S. L.46.
279B	Pigmented Lanolin Resin Solution.
280	*Cancelled.* Obsolete.
281	Magnesium Alloy Castings (Heat Treated) (suitable for pressure work).
282	High Chromium Steel Valve Forgings.
283A	Aluminium-Nickel-Silicon Brass Sheets (annealed).
285	Magnesium Alloy Castings (fully heat treated).
286A	55–65-Ton Chromium-Molybdenum Steel (suitable for Nitrogen Hardening).
287	Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
289	Magnesium Alloy Castings (heat treated).
290	*Cancelled.* Obsolete.
292	*Cancelled.* B.S. L.46.
293	*Cancelled.* B.S. 2 L.40.
294	Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
295	Rubber Proofed Fabric for Riveted Tanks.
296	*Cancelled.* Obsolete.
•297	7% Magnesium-Aluminium Alloy Bars, Extruded Sections and Forgings (softened).
298	Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
299	Mild Steel Bars, Forgings, and Tubes (suitable for Bearing Shells).
300	Aluminium-Magnesium Alloy Sand or Die Castings (not suitable for Pistons).
301	High Chromium Non-corrodible Steel Tie Rods (Swaged).
302	Mahogany Substitutes (for use in Airscrews).
303	5% Magnesium-Aluminium Alloy Wire and Rivets.
304	Aluminium Alloy Sand or Die Castings (not suitable for Pistons).
305	30-Ton Carbon Steel Tubes.

Spec. No. D.T.D.	*Description or Replacement Specification*
306	60–70-Ton Chromium-Molybdenum Steel (suitable for Nitrogen Hardening).
307	Silicon Brass Tubes (annealed).
308	Matt Cellulose Finishes and Primer.
309	Aluminium Alloy Sand or Die Castings (heat treated) (not suitable for Pistons).
310B	Soft Aluminium Alloy Tubes (suitable for Oil, Petrol, Gas Starters and general purposes).
311	Silicon-Chromium Valve Steel Forgings or Stampings.
312	Hard Drawn Silicon Brass Tubes.
313	Aluminium Alloy Sand or Die Castings (as cast) (not suitable for Pistons).
314	Matt Pigmented Oil Varnishes and Primer.
315	Pigmented Cellulose Acetate Sheets.
316	Chromium-Nickel Alloy Sheets and Strips of 10 tons 0·1% Proof Stress.
317A	44–55-Ton Chromium-Molybdenum Steel (suitable for Nitrogen Hardening) (primarily intended for cylinders).
318A	Tin-Iron Brass Tubes.
319	Aluminium-Nickel-Silicon Brass Bars.
320	L.T. Varnished Insulating Tubing.
323	Aluminium-Nickel-Silicon Brass Tubes (Medium Pressure).
324	Silicon-Aluminium Alloy Forgings for Engine Cylinders and Pistons.
325	Magnesium Alloy Ingots.
326	Non-corrodible Steel Wire and Springs.
327	Aluminium Alloy Wire and Rivets.
328	Nickel-Chromium-Iron Alloy Sheets and Strips.
329B	Rubber Tubing for Automatic Controls.
330	Soft Iron Sheets and Strips (suitable for Electrical purposes).
331	80–90-Ton Nickel Chromium Steel.
334	Austenitic Cast Iron Pots (centrifugally cast) suitable for Packing Rings for Valve Seats).
335A	Synthetic Resin Cement (non gap-filling).
336B	Waterproofed and Dyed Cotton Fabric.
337A	Rubber Pads for Bomb Sight Brackets.
338	Anti-misting Compound.
339A	Transparent Synthetic Resin Sheets and Mouldings.
341	Nickel-Copper Alloy Tubes for Honeycomb Type Radiators.
342	*Cancelled.* B.S. L.47.
343	Light Cotton Fabric (for covering Plywood).
344A	Treated Ethylene Glycol.

Spec. No. D.T.D.	*Description or Replacement Specification*
346	Soft Aluminium Alloy Sheets and Strips.
347	50-Ton Chrome-Molybdenum Steel Tubes (Weldable).
348	Magnesium Alloy Tubes for lightly stressed parts (suitable for Welding).
350	Magnesium Alloy Castings (as cast).
351	*Cancelled.* B.S. L.47.
354	Chromium Bronze Bars, Extruded Sections and Tubes (suitable for Engine Valve Guides, etc.).
355	Silicon Iron Bronze Castings.
356	Wrought Light Aluminium Alloy Sheets and Strips.
357	Radiator Leak Compound.
359	45-Ton Manganese-Molybdenum or Chrome-Molybdenum Steel Tubes (Weldable).
361	Aluminium Alloy Sand Castings (heat treated) (not suitable for Pistons).
363	Aluminium Alloy Bars (Extruded or Rolled) and Extruded Sections.
364A	Aluminium Alloy Bars, Extruded Sections and Forgings.
367	Aluminium-Nickel-Silicon Brass Wire and Rivets.
369A	Pigmented Varnish Jointing Compound.
370	Laminated Compressed Wood.
373	Rubber Tubing for Instrument Panels.
374	Kaolin.
375C	Resin.
376	Soft Cotton Cord for Kite Balloons.
377	Zinc Chrome.
378	Compressed Asbestos Fibre Jointing.
379	Heavy Cotton Tapes.
382	Silk Silk Fabric for Parachutes (to be used for " D " Panels only).
383	Cellulose Sheet for use as a Protective Wrapping.
385	Artificial Silk Fabric for Parachutes.
386	*Cancelled.* Obsolete.
387	Copper or Copper Alloy Tubes for Honeycomb Type Radiators.
388	Fluid for Oleo Shock Absorber Struts.
389	Iso-Propyl Alcohol (2 Propanol).
390	Aluminium-Coated Aluminium Alloy Sheets and Coils.
391	Fluid for Hydraulic Mechanisms.
392	Anti-Seize Grease for Threaded Fittings.
394	Flexible Steel Wire Rope for Kite Balloon Cables.
395	Ethylene Glycol Mono-Ethyl Ether.
398	Low Tensile Cold-Headed Bolts.
399	Enamels Resistant to Hydraulic Fluids.

Spec. No. D.T.D.	*Description or Replacement Specification*
400	Petrol Resisting Paint.
401	High Tensile Cold-Headed Bolts.
402A	Bullet Proof Safety Glass for Windscreen Panels.
403	Silk Fabric for Kite Balloons.
404	Hard Drawn High Tensile 7% Magnesium Aluminium Alloy Wire and Rivets.
406A	De-icing Fluid.
407	4 oz. Cotton Fabric and Tape.
408	75 ton Chrome-Molybdenum Steel Tubes.
410	Aluminium Alloy Bars and Forgings.
411	Rubber Hose for use with Ethylene Glycol.
412	Aluminium-Bronze Sand or Die Castings.
413	Cast Iron Piston Ring Pots (sand or chill cast).
416	Compressed Asbestos Fibre Jointing with Wire Mesh Insertion.
417A	Anti-freezing Oil, Type 417A.
418	1·5 oz. Scoured Cotton Fabric.
419	High Melting Point Grease.
420B	Matt Pigmented Lanolin-resin Finishes.
421	Vulcanized Expanded Rubber.
422	Lead Bronze Ingots and Bars (suitable for Bearings).
423A	Aluminium Alloy Bars, Extruded Sections and Forgings.
424	Aluminium Alloy Castings for general purposes.
426	Ethyl Cellulose.
427	Plywood for Lightly Stressed Parts of Aircraft.
428	Aluminium Alloy Castings for Low Stressed Parts.
429	Cotton Canvas.
431	Parachute Harness Webbing.
432	Commercial Quality 20-ton Steel Tubes.
436A	Proofed Cotton Fabric.
437	*Cancelled.*
438	Graphited Wax.
439	Expanded Rubber Sheet.
440	11/15 Aluminium Alloy Tubes.
441	Distemper, Matt. Finish.
442	Laminated Synthetic Resin Bonded Mouldings.
443	10/17 Aluminium Alloy Bars, Extruded Sections and Forgings.
446	Vulcanized Rubber Sheet.
448B	Waterproofed and Dyed Cotton Duck.
449	Silicate Paint for Timber.
450	10/17 Aluminium Alloy Tubes.
451	Synthetic Resin (Phenolic) Moulding Materials and Mouldings (Poor Shock Resistance).

Spec. No. D.T.D.	*Description or Replacement Specification*
452	Synthetic Resin (Phenolic) Moulding Materials and Mouldings (Low Shock Resistance).
453	Synthetic Resin (Phenolic) Moulding Materials and Mouldings (Medium Shock Resistance).
454	Synthetic Resin (Phenolic) Moulding Materials and Mouldings (High Shock Resistance).
458	Rubber Mouldings and Extrusions for use in contact with Anti-freezing Oil.
459	Leaded Bronze Seal Ring Pots.
460	18/22 Aluminium Alloy Tubes.
461	55–65-Ton 1% Chromium Steel.
463	55–70-Ton Non-Corrodible Steel.
464	Aluminium Alloy Tubes.
469	Douglas Fir (as used in Aircraft Parts).
470	55–65-Ton Chromium-Molybdenum Steel.
471	Silica Gel.
*472	Aero Engine Lubricating Oils.
473	75–85-Ton Nickel-Chromium Molybdenum Steel.
474	Soft Rubber Sheet.
477	High Nickel-Copper Alloy Tubes.
478	99% Secondary Aluminium Notched Bars and Ingots for Remelting.
479	Secondary Aluminium Alloy Notched Bars and Ingots for Remelting.
480	55–65-Ton 1½% Nickel-Chromium-Molybdenum Steel.
481	Nylon Cordage.
483	Rubber Proofed Silk Fabric.
484	Synthetic Resin Cement (Gap-Filling).
485	Cast Iron Piston Ring Pots.
486	Light Weight Silk Fabric.
487	Aluminium-Copper-Nickel Alloy Cold-Headed Bolts (not exceeding ⅝ in. diameter).
488	Carbon Steel Strips (suitable for Magneto Contact Breaker Springs).
489	Chromium-Nickel Heat-Resisting Steel Rods and Wire (suitable for Welding and for Split Pins).
490	55–65-Ton 2½% Nickel-Chromium-Molybdenum Steel (Medium Carbon).
491	Chromium-Nickel Heat-Resisting Steel Tubes (suitable for Welding).
492	Cotton Webbing.

* D.T.D.472 is issued by The Secretary, Ministry of Supply.

Spec. No. D.T.D.	*Description or Replacement Specification*
493	Chromium-Nickel Heat-Resisting Steel Sheets and Coils (suitable for Welding).
494	Rubber-Proofed Cotton Fabric.
496	Insulating Material Grade "A" for Mouldings in Aircraft Electrical Accessories.
497	Insulating Material Grade "B" for Impact Resisting Mouldings in Aircraft Electrical Accessories.
498	Silicon-Nickel-Copper Alloy Bars and Forgings.
499	Scoured Cotton Fabric.
500	80–90-Ton 2½% Nickel-Chromium-Molybdenum Steel (High Carbon).
501	Commercial Quality 35-ton Steel Tubes.
503	Steel Tubes.
504	Silicon-Nickel-Copper Alloy Bars.
507A	Commercial Quality 35-ton Non-corrodible Steel Tubes.
510	40–50-Ton Manganese-Nickel-Molybdenum Steel.
513	Insulating Material Grade "K" for Medium Impact Resisting Mouldings in Aircraft Electrical Accessories and Instruments.
514	Nylon Yarn.
515A	Cellular Rubber Sheet.
517	Matt Pigmented Synthetic Resin Primer and Finish (Quick Drying).
519	3% Nickel-Chromium Case-hardening Steel.
520	23/27 Aluminium Alloy Tubes.
522	Insulating Material Grade "E" for Impact and Acid Resisting Mouldings for Aircraft Accumulator Covers.
523	Cold-Headed Aluminium Alloy Bolts.
524	2¼ oz. Scoured Cotton Fabric.
525	45–55-Ton Non-corrodible Steel (Free machining).
526A	Artificial Silk Fabric (Dyed or Printed).
527	French Chalk or French Chalk Substitute.
528	Rubber-Proofed Cotton Fabric.
529	Chromium-Nickel Heat-Resisting Steel Bars and Forgings.
531	Rubber-Proofed Cotton Fabric (single ply).
532	Rubber-Proofed Silk Fabric (single ply).
533	French Chalk or French Chalk Substitute and Red Oxide of Iron Mixture.
534	Jute Webbing.
535	Commercial Quality 35-ton Steel Tubes (suitable for Welding).
537	Rubber-Proofed Cotton Fabric (three ply).
539	High Altitude Controls Lubricant.
540	Linen Fabric and Tape.

Spec. No. D.T.D.	Description or Replacement Specification
543	Aluminium Alloy Sand or Die Castings (heat treated) (suitable for Cylinder Heads).
545	Commercial Quality 45-ton Steel Tubes (suitable for Welding).
546	Aluminium-Coated High Tensile Aluminium Alloy Sheets and Coils.
548	*Cancelled.*
549	Chromium-Nickel Non-Corrodible Steel Welding Rods and Wire.
551	3% Chromium-Molybdenum Steel Thrust Rings (Nitrogen hardened).
557	Flexible Paint.
561	Corrosion Resisting Instrument Oil.
563	Commercial Quality 32-Ton Steel Tubes—Seamless or Welded.
567	Lightweight Fabric with Flexible Proofing.
569	55–65-Ton Manganese Molybdenum Steel Pressings.
571	Chromium-Nickel Non-Corrodible Steel Sheets, Strips, Tubes, and Wire (suitable for Welding) (primarily for Exhaust Manifolds, etc.).
572	Flexible Oil and Petrol Proof Cotton Duck.
575	Scoured Cotton Fabric.
576	Spun Silk Thread.
577	Low Temperature Grease.
578	35-Ton Chrome Molybdenum Steel Tubes (suitable for Welding).
587	Engine Corrosion Preventive.
594	1·6 oz. Cotton Fabric Navy Blue.
595	1·65 oz. Cotton Fabric (Dyed).
596	2 oz. Cotton Fabric.
598	Aluminium-Zinc Alloy Castings.
600	55–65-Ton Low Alloy Steel.
602	Poly-Vinyl Chloride Tubing.
603	Aluminium Alloy Sheets and Coils (solution treated).
604	Brass Tubes (Suitable for Low Pressure and similar systems).
610	Aluminium-Coated Aluminium Alloy Sheets and Coils (solution treated).
623	Pigmented Shellac Solution.
637	Hard Vulcanized-Fibre Sheets for Jointing Purposes.
646	High Tensile Aluminium Alloy Sheets and Coils (solution treated and artificially aged).
663	Lanolin Resin Protective.

Spec. No. D.T.D	*Description or Replacement Specification*
901	Process for Cleaning Metal Parts in Preparation for Protection against Corrosion.
902A	Protection of Metal Parts against Corrosion by means of Organic Protectives.
903	Zinc Plating.
904	Cadmium Plating.
905	Nickel Plating.
906	Metallizing.
907	Aluminizing.
908	Sherardizing.
909	Protection of the Interior of Drinking Water Tanks against Corrosion.
910A	Anodic Oxidation of Aluminium and Aluminium Alloy Parts.
911	Protection of Magnesium-Rich Alloy Parts against Corrosion.
912	Protection of Wooden Parts (except Wind-mills and Air-screws).
913	Identification Colouring of Aluminium and Aluminium Alloy Rivets.
914A	Rot-Proofing of Canvas, Rope, and Cordage.
915A	Process for Cleaning Aluminium and Aluminium Alloy Plating prior to Painting.

ALPHABETICAL LIST OF A.M. A.G.S. PARTS

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Title	*A.M. A.G.S. No.*
Acorns, Universal (for Streamline Wires), 4 B.A. to 3/8 in. B.S.F.	663
Acorns, Universal (for Streamline Wires), [illegible] in. B.S.F. to 7/8 in. B.S.F.	664
Acorns, Universal (for Streamline Wires), 15/16 in. B.S.F. to 1 1/4 in. B.S.F.	665
Acorns (for Incidence Streamline Wires), 4 B.A. to 3/8 in. B.S.F.	669
Acorns (for Incidence, Streamline Wires), [illegible] in. B.S.F. to [illegible] in. B.S.F.	700
Acorns (for Incidence, Streamline Wires), 1/2 in. B.S.F. to 7/8 in. B.S.F.	701
Adaptor, Olive Joint	639
Adaptor, Internally Screwed	651
Adaptor, Terminal (For K.L.G. Sparking Plug	1535
Air Cock, 3 Way, 1/4 in. B.S.P.	290
Anchor Hook for Shock Absorber Elastic	1572
Ball Joint	385
Ballast Weights (Lead)	670
Beads, Insulating, Type " B " (Cup and Ball Ended)	1662
Bearing, Rod End, 5/16 in. B.S.F. External Thread	591
Bearing, Rod End, 3/8 in. B.S.F. Internal Thread (Short)	589
Bearing, Rod End, 3/8 in. B.S.F. Internal Thread (Long)	592
Bearing, Rod End, 7/16 in. B.S.F. Internal Thread (Short)	593

Title	*A.M. A.G.S. No.*
Bearing, Rod End—Plain Shank	590
Bearing, Self Aligning, 1898 in. Dia. Bore	631
Bearing, Self Aligning, ¼ in. Dia. Bore	632
Bearing, Self Aligning, 5/16 in. Dia. Bore	633
Bearing, Self Aligning, 7 mm. Dia Bore	634
Bearing, Self Aligning, 8 mm. Dia. Bore	635
Bearing, Self Aligning, ½ in. Dia. Bore	636
Bolts, B.S.F. (Stainless Steel), 3/16 in. to 2 in.	868
Bolts, B.A. (Stainless Steel), 2 B.A., 4 B.A., and 6 B.A.	869
Bolts, B.S.F. (H.T.S.), 3/16 in. to 2 in.	749
Bolts, B.A. (H.T.S.), 2 B.A., 4 B.A., and 6 B.A.	750
Bolts, B.S.F. (Light Alloy), 3/16 in., 1/4 in. to 2 in.	764
Bolts, 6 B.A. (Light Alloy)	765
Bolts, Repair (for De-Bergue Riveted Tanks)	159
Bolt, Slip, ½ in.-Aircraft Holding Down Gear	962
Bolts, Shear	571
Bonding Clamp	1500
Bonding Clamp	1501
Bonding Clamp	1502
Bonding Clamp	1503
Bonding Clamp	1504
Bonding Clamps (for Metal Braided Cables)	1558
Bonding Clamps, Cable	1564
Bonding Clamps (for Metal Braided Cables)	1560
Bonding Clips (for Sparking Plugs and Generators)	1534
Bonding Clips	1536
Bonding Clip (for H.T. Outer Sleeve)	T1537
Bonding Clip, Water Pipe (Brass)	1661
Bonding Lead (for Generators)	1612
Bonding Ring (for Generators)	1610
Bonding Strip Screw	1529
Bonding Strip (for Pipe Joints)	1533
Bonding Wire Socket	1599
Bow (Dee Shape), for Chain Shackle	912
Bow (Harp Shape), for Chain Shackle	914
Bracing Wires, Radiator	704
Bracing Wires, Radiator	705
Bracing Wires, Radiator	706
Bracing Wires, Radiator, Nipple for	707
Burrs, Copper	190
Burrs, Aluminium	191
Bush, Split (for L.T. Metal Braided Cable)	1561
Bushes, Insulating, Rubber	1696
Cable, Electric, Saddles	1542
Cable Ends, Claw Type, 6 B.A.	1593
Cable Ends, Claw Type, 4 B.A.	1594
Cable Ends, Claw Type, 2 B.A.	1595
Cable Ends, Claw Type, 0 B.A.	1596
Cable Ends, Crown Eye Type	1691
Cable Ends, Eye Type, Channel End	1681
Cable Ends, Fork Type, Channel End, Soldering	1678
Cable End, L.T.	1713
Cable Grip, Clutch—Aircraft Holding Down Gear	973
Cable Sleeve	1608
Cable Sleeve, Insulating, L.T.	1714
Cap, Filler	607
Cap, Protection, B.S.P. (Plastic)	504
Catch, Spring	787
Clamps, Bonding (for Metal Braided Cables)	1558
Clamps, Bonding (for Metal Braided Cables)	1560

Title	*A.M. A.G.S. No.*
Clamp, Cable Bonding	1500
Clamp, Cable Bonding	1501
Clamp, Cable Bonding	1502
Clamp, Cable Bonding	1503
Clamp, Cable Bonding	1504
Clamps, Cable Bonding	1564
Clamp (for Single Metal Braided H.T. and L.T. Cables)	1528
Clamp, Switch	1562
Cleats, Cable, Electric	1541
Cleats, Fibre, ⅛ in. Cable	1548
Cleats, Fibre, $\frac{3}{16}$ in. Cable	1547
Cleats, Fibre, ¼ in. Cable	1546
Cleats, Fibre, $\frac{5}{16}$ in. Cable	1563
Cleats, Panel Wiring (for Wireless Installations)	836
Cleats, Single Hole Attachment (Light Alloy)	1617
Cleat, Wiring, Aluminium	1690
Cleats, Wiring, Aluminium	1693
Cleat, Wiring, Aluminium, No. 1	1684
Cleat, Wiring, Aluminium, No. 9	1670
Cleat, Wiring, Aluminium, No. 10	1668
Cleats, Wiring, Aluminium, Nos. 12 and 13	1671
Cleats, Wiring, Aluminium, Nos. 14 and 15	1672
Cleat, Wiring, Brass, No. 1	1683
Cleats, Wiring, Brass, Nos. 2 to 8 (Inclusive)	1666
Cleat, Wiring, Brass, No. 9	1669
Cleat, Wiring, Brass, No. 10	1667
Cleat, Wiring, Fibre, No. 1	1673
Cleat, Wiring, Fibre, No. 2	1674
Cleat, Wiring, Fibre, No. 3	1675
Cleat, Wiring, Fibre, No. 4	1676
Cleats, Wiring, Fibre, Nos. 6 and 7	1677
Cleat, Wiring, Porcelain	1663
Cleat, Wiring, Porcelain, No. 3	1664
Clips, Bonding (for Sparking Plugs and Generators)	1534
Clips, Bonding	1536
Clip, Bonding (for H.T. Outer Sleeve)	T1537
Clip, Bonding, Water Pipe (Brass)	1661
Clip, Bonding, Water Pipe (with Boss)	1540
Clip (for Detachable Pipe Line)	584
Clip, Hose (for Flexible Pipe Connections)	606
Clip, Hose Pipe (Type "J")	605
Clip (for Speaking Tubes)	895
Cock, Air, 3 Way, ¼ in. B.S.P.	290
Cock, Drain	888
Cock, Drain, No. 1 Size	676
Cock, Drain, No. 2 Size	677
Cock (No. 2 Size), with Diffuser	966
Collars (Mild Steel)	899
Collet	1657
Collet	1736
Connections, Petrol, Oil and Water, Locking of	769
Couplings, Metal, Arrangement (Brass)	708
Couplings, Metal, Pipe Collar (Brass)	709
Couplings, Metal, Nipple (Brass)	710
Couplings, Metal, Outer Sleeve (Brass)	711
Couplings, Metal, Inner Sleeve (Brass)	712
Couplings, Metal, Adaptor Nipple (Brass)	713
Couplings, Metal (Flanged), Arrangement	751
Couplings, Metal (Flanged), Flange (Spigoted)	752

Title	*A.M. A.G.S. No.*
Couplings, Metal (Flanged), Flange (Plain)	753
Couplings, Metal (Flanged), Lock Washer	754
Coupling, Metal ($\frac{3}{16}$ in. Light Type), for Automatic Controls only	891
Couplings, Metal—Light Alloy ($\frac{3}{16}$ in. Light Type), for Automatic Controls only	900
Couplings, Metal (Light Alloy), Arrangement	901
Couplings, Metal (Light Alloy), Pipe Collar	902
Couplings, Metal (Light Alloy), Nipple	903
Couplings, Pipe (Light Alloy), Outer Sleeve	904
Couplings, Pipe (Light Alloy), Inner Sleeve	905
Couplings, Metal (Light Alloy), Adaptor Nipple	906
Couplings, Metal (Steel), Arrangement	951
Couplings, Pipe (Steel), Pipe Collar	952
Couplings, Metal (Steel), Nipple	953
Couplings, Metal (Steel), Outer Sleeve	954
Couplings, Metal (Steel), Inner Sleeve	955
Couplings, Metal (Steel), Adaptor Nipple	956
Couplings, Pipe—Pipe Joint, Arrangement of	1101
Couplings, Pipe (Light Alloy), Cone Union Body, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1102
Couplings, Pipe (Light Alloy), Cone Adaptor, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1104
Couplings, Pipe (Light Alloy), Reducing Cone Union	1107
Couplings, Pipe (Light Alloy), Union Body, $\frac{3}{16}$ in. to $1\frac{1}{2}$ in.	1103
Couplings, Pipe (Light Alloy), Union Adaptor, $\frac{3}{16}$ in. to $1\frac{1}{2}$ in.	1105
Couplings, Pipe (Light Alloy), Reducing Union	1109
Couplings, Pipe (Light Alloy), Union Body (Cone to Nipple Type)	1106
Couplings, Pipe (Light Alloy), Reducing Union (Cone to Nipple Type)	1108
Couplings, Pipe—Flanged Bulkhead Union Bodies, Arrangement of	1110
Couplings, Pipe (Light Alloy), Flanged Bulkhead Cone Union Body, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1111
Couplings, Pipe (Light Alloy), Flanged Bulkhead Union Body, $\frac{3}{16}$ in. to $1\frac{1}{2}$ in.	1112
Couplings, Pipe (Light Alloy), Flanged Bulkhead Union Body (Cone to Nipple Type)	1113
Couplings, Pipe (Light Alloy), Flanged Bulkhead Screwed Sleeve	1114
Couplings, Pipe (Light Alloy), Washer Plates for Flanged Bulkhead Fittings	1115
Couplings, Pipe (Light Alloy), Cone Elbow, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1116
Couplings, Pipe (Light Alloy), Union Elbow, $\frac{3}{8}$ in. to $1\frac{1}{2}$ in.	1117
Couplings, Pipe (Light Alloy), Cone Tees, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1118
Couplings, Pipe (Light Alloy), Cone Tees Unequal	1120
Couplings, Pipe (Light Alloy), Union Tees, $\frac{3}{8}$ in. to $1\frac{1}{2}$ in.	1119
Couplings, Pipe (Light Alloy), Union Tees, Unequal	1121
Couplings, Pipe (Light Alloy), Cone and Nipple Tees, Unequal	1122
Couplings, Pipe (Light Alloy), Cone, 4 Way Piece, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1123
Couplings, Pipe (Light Alloy), Cone, 4 Way Piece, Unequal	1125
Couplings, Pipe (Light Alloy), Union, 4 Way Piece, $\frac{3}{8}$ in. to $1\frac{1}{2}$ in.	1124
Couplings, Pipe (Light Alloy), Union, 4 Way Piece, Unequal	1126
Couplings, Pipe (Light Alloy), Cone and Nipple, 4 Way Piece, Unequal	1127
Couplings, Pipe—Banjo's, Arrangement of	1128
Couplings, Pipe (Light Alloy), Single End Cone Banjo Body, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1129
Couplings, Pipe (Light Alloy), Double End Cone Banjo Body, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1130
Couplings, Pipe (Light Alloy), Double R.A. Cone Banjo Body, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1131
Couplings, Pipe (Light Alloy), Single End Union Banjo Body, $\frac{3}{16}$ in. to 1 in.	1132

Title	*A.M. A.G.S. No.*
Couplings, Pipe (Light Alloy), Double End, Union Banjo Body, $\frac{3}{16}$ in. to 1 in.	1133
Couplings, Pipe (Light Alloy), Double R.A. Union Banjo Body, $\frac{3}{16}$ in. to 1 in.	1134
Couplings, Pipe, Banjo Bolt, $\frac{3}{16}$ in. to 1 in.	1135
Couplings, Pipe, Banjo Bolt with Cone Head Connection	1136
Couplings, Pipe, Banjo Bolt with Union Head Connection	1137
Couplings, Pipe, Jointing Washers (Aluminium)	1138
Couplings, Pipe, Jointing Washers (Copper)	1139
Couplings, Pipe, Nipple Plugs, $\frac{3}{16}$ in. to $1\frac{1}{4}$ in.	1140
Couplings, Pipe, Cone Plugs, $\frac{3}{16}$ in. to $1\frac{1}{2}$ in.	1143
Couplings, Pipe, Nipple, $\frac{3}{16}$ to $1\frac{1}{4}$	1141
Couplings, Pipe, Adaptor Nipple, $\frac{3}{16}$ in. to $1\frac{1}{4}$ in.	1142
Couplings, Pipe, Hexagon Bulkhead Union Bodies, Arrangement of	1144
Couplings, Pipe (Light Alloy), Hexagon Bulkhead Cone Union Body $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1145
Couplings, Pipe (Light Alloy), Hexagon Bulkhead Union Body, $\frac{3}{16}$ in. to $1\frac{1}{4}$ in.	1146
Couplings, Pipe (Light Alloy), Hexagon Bulkhead Union Body (Cone to Nipple Type), $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1147
Couplings, Pipe (Light Alloy), Thin Nuts, $\frac{3}{16}$ in. to $1\frac{1}{2}$ in.	1148
Couplings, Pipe, Washer Plates for Hexagon Bulkhead Fittings	1149
Couplings, Pipe (Light Alloy), 45° Cone Elbow, $\frac{3}{16}$ in. to $\frac{1}{2}$ in.	1154
Couplings, Pipe (Light Alloy), 45° Union Elbow, $\frac{3}{4}$ in. to $1\frac{1}{2}$ in.	1155
Couplings, Pipe (Light Alloy), Cone Caps, $\frac{3}{16}$ in. to $1\frac{1}{4}$ in.	1159
Couplings, Pipe (Light Alloy Range), Banjo Bolt, $\frac{3}{16}$ in. to 1 in., with Hole for Bleeder Screw	1173
Couplings, Pipe—Bleeder Screw	1174
Couplings, Pipe, 90° Union Elbow	1167
Couplings, Pipe, 45° Union Elbow	1168
Couplings, Pipe, Union Elbow—Union Sleeve	1169
Couplings, Pipe, 90° Elbow Tube	1177
Couplings, Pipe, 45° Elbow Tube	1178
Cross Bracing, Insulator for	1553
Disconnector (for Operating Head, Type "F" for Emergency Dinghies)	560
Discs, Blanking (for Use under Gland Nuts where Cable Sleeves are not Fitted)	1725
Drain Cock, No. 1 Size	676
Drain Cock, No. 2 Size	677
Drain Cock	888
Drainage Hole Eyelets (Marine Type)	889
Drainage Hole Eyelets	840
Elbow Assembly (for H.T. Cables)	1625
Electric Cable Cleats	1941
Electric Cable Saddles	1542
Eyebolt, 4 B.A.	796
Eyebolt, 2 B.A.	797
Eyebolt, $\frac{1}{4}$ in. B.S.F.	798
Eyebolt, $\frac{5}{16}$ in. B.S.F.	799
Eyebolt, $\frac{3}{8}$ in. B.S.F.	771
Eyebolt, $\frac{7}{16}$ in. B.S.F.	800
Eyebolt, $\frac{1}{2}$ in. B.S.F.	801
Eyebolt, $\frac{9}{16}$ in. B.S.F.	802
Eyebolt, $\frac{5}{8}$ in. B.S.F.	803
Eyebolt, $\frac{11}{16}$ in. B.S.F.	804
Eyebolt, $\frac{3}{4}$ in. B.S.F.	805
Eyebolt, $\frac{13}{16}$ in. B.S.F.	606
Eyebolts, Cheese Head	971
Eyelets (Aluminium and Brass)	232

Title		*A.M. A.G.S. No.*
Eyelets, Drainage Hole		840
Eyelets, Drainage Hole (Marine Type)		889
Eyelet, Terminal		1745
Ferrule, Cable End		1712
Ferrules, Standard Wire		156
Ferrules, Steel Wire (for Elastic Cord)		897
Ferrules (Non-Corrodible), for Screwed Rod		920
Ferrules (Coated), for Screwed Rod		934
Fibre, Cleats, ⅛ in. Cable		1548
Fibre, Cleats, 3/16 in. Cable		1547
Fibre, Cleats, ¼ in. Cable		1546
Fibre, Cleats, 5/16 in. Cable		1563
Filler Cap (Brass)		647
Filler Cap		607
Filler Seating (Flange Type)		608
Filler Seating, Alternative (Ring Type for Necks)		609
Filler, Standard, Petrol and Water Strainers		610
Filler, Standard, Details and Assembly of Strainers	3 Sheets	610
Filler, Standard, Details and Assembly of Strainers		610
Filler, Standard, Filler Neck		611
Filler, Standard, for Petrol Tanks (not Self Sealing Type)—also Oil and Water Tanks		612
Filler Extension Pipe, Screwed Ring and Locking Plates		714
Filter, Fuel, 300 G.P.H.—General Arrangement		1008
Filter, Fuel, 300 G.P.H.—Details		1009
Filter, Petrol, R.A.E. 100 G.P.H., Shallow Sump Type		937
Filters, Petrol, R.A.E., Details		939
Filter, Petrol, Standard, No. 1 Size		600
Filter, Petrol, Standard, No. 2 Size		601
Filter, Petrol, Standard, No. 3 Size		602
Filter, Petrol, Standard, Details		604
Filter, Petrol, R.A.E. 200 G.P.H., Shallow Sump Type		1001
Filter, Petrol, R.A.E., Details		1002
Flanges, Female (Brass)		629
Flanges, Female, Special (Brass)		630
Flanges, Female (Light Alloy)		958
Flanges, Female, Special (Light Alloy)		959
Fork Joints, Universal, 4 B.A.		451
Fork Joints, Universal, ¼ in. B.S.F.		453
Fork Joints, Universal, 5/16 in. B.S.F.		455
Fork Joint, 5/16 in. B.S.F.		640
Fork Joint, ⅜ in. B.S.F.		641
Fork Joint, 7/16 in. B.S.F.		660
Fork Joint, ½ in. B.S.F.		642
Fork Joint, ¾ in. B.S.F.		643
Fork Joint, 1 in. B.S.F.		644
Fork Joint, 1⅛ in. B.S.F.		645
Fork Joint, 1¼ in. B.S.F.		646
Frames, Inspection (Woods Type), 4 in. × 4 in.		583
Frames, Inspection (Woods Type), 6·625 in. × 6·625 in.		582
Hook, Anchor (for Shock Absorber Elastic)		1572
Hook, Drogue (Boat)		587
Hook, Drogue (Float)		588
Hose, Fuel, Flexatex—End Connection, Flared (Straight), for.—General Arrangement		1182
Hose, Fuel, Flexatex—End Connection (90° Elbow), for.—General Arrangement		1183
Hose, Fuel, Flexatex—End Connection (45° Elbow), for General Arrangement		1184

Title	*A.M. A.G.S. No.*
Hose, Fuel, Self Sealing—End Connection, Flared (Straight), for.—General Arrangement	1179
Hose, Fuel, Self Sealing—End Connection (90° Elbow), for.—General Arrangement	1180
Hose, Fuel, Self Sealing—End Connection (45° Elbow), for.—General Arrangement	1181
Hose, Fuel, Self Sealing and Flexatex—End Connection, 90° Nipple Elbow Assembly	1165
Hose, Fuel, Self Sealing and Flexatex—End Connection, 45° Nipple Elbow Assembly	1166
Hose, Fuel, Self Sealing and Flexatex—End Connection, Flared End Connecting Tube	1172
Hose, Fuel, Self Sealing and Flexatex—End Connection, 90° Elbow Tube	1175
Hose, Fuel, Self Sealing and Flexatex—End Connection, 45° Elbow Tube	1176
Hose, Fuel, Self Sealing—End Connection (Straight), for.—General Arrangement	1150
Hose, Fuel, Self Sealing and Flexatex—End Connection for.—Cone End Union Piece	1151
Hose, Fuel, Self Sealing—End Connection for.—End Cap	1153
Hose, Fuel, Flexatex—End Connection (Straight), for. General Arrangement	1160
Identification Label	1637
Identification Tabs for Streamline Wires	841
Identification Tabs for Tie Rods (Swaged)	842
Insulator (for ¼ in. Shock Absorber Cord)	1543
Insulator (for 5/16 in. Shock Absorber Cord)	1544
Insulator (for Cross Bracing)	1553
Insulator, Screw Eye	1665
Joint, Ball	385
Joint, Fork, Universal, 4 B.A.	451
Joint, Fork, Universal, ¼ in. B.S.F.	453
Joint, Fork, Universal, 5/16 in. B.S.F.	455
Joint, Fork, 5/16 in. B.S.F.	640
Joint, Fork, ⅜ in. B.S.F.	641
Joint, Fork, 7/16 in. B.S.F.	660
Joint, Fork, ½ in. B.S.F.	642
Joint, Fork, ⅞ in. B.S.F.	643
Joint, Fork, 1 in. B.S.F.	644
Joint, Fork, 1⅛ in. B.S.F.	645
Joint, Fork, 1¼ in. B.S.F.	646
Label Attachment—Engine Data	1007
Lead, Bonding (for Generators)	1612
Link, End (for Chain Shackle)	918
Locking Pin	1551
Locking Rings, Wire	154
Locking Rings, Wire	165
Locking of Petrol, Oil and Water Connections	769
Locknuts, Brass, B.A. (0–10 B.A. Even Sizes)	1584
Locknuts, Steel, B.S.F. (1⅜ in. to 2 in. R.H. and L.H.)	117
Locknuts, Union (Brass)	224
Locknuts, Union (Light Alloy)	957
Locknuts, Union (Steel)	207
Lockplate (Used with Lock Nut on Type "O," E.D. Generator)	1742
Lockwashers, Straight Tab (Brass Sheet)	659
Lockwashers, Angle Tab (Brass Sheet)	570
Lockwashers, Straight Tab (Steel)	194
Lockwashers, Angle Tab (Steel)	195

Title	*A.M. A.G.S. No.*
Lubrication, End Piece for Enot's " Autolub " Grease Gun	909
Lubrication Nipple	910
Lugs, Connecting (for Cable), Uniplug	1591
Lugs, Connecting (for Cable), Unisheath 4	1592
Lug, Connecting (for Cable), Unispark	1619
Lug, Connecting (for Cable), Uniflex 4	1620
Lug, Terminal (for Spark Plug Cable)	T1516
Lug, Terminal, L.T. Cable, 5 mm.	T1538
Lug, Terminal, L.T. Cable, 7 mm.	1524
Lug, Terminal, No. 1	1703
Lug, Terminal, No. 2	1704
Lug, Terminal, No. 3	1705
Lug, Terminal, No. 7	1715
Lug, Terminal, No. 8	1706
Lug, Terminal, Nos. 10 and 11	1737
Lug, Terminal, Nos. 12 and 13	1738
Lug, Terminal, No. 14	1739
Lug, Terminal, No. 15	1740
Lug, Terminal, No. 16 (for Use with Fuse Box, " B," when Using 64 Amp. Cable)	1741
Lug, Terminal, No. 17	1744
Lug, Terminal, No. 18	1746
Lug, Terminal, No. 22 (D.C. Output on " U.K.X." Generator)	1748
Lugs, Terminal, Nos. 19, 23, and 24	1747
Nipples, Standard, Conical	209
Nipple (for Radiator Bracing Wires)	707
Nuts, Castle, B.S.F. 1¼ in. to 2 in., R.H. and L.H. (Steel)	119
Nuts, Castle, B.S.F., 1¼ in. to 2 in. (Stainless Steel)	865
Nipple, Lubrication, Miniature Hook-on Type (Light Alloy)	554
Nuts, Castle, B.S.F., [illegible] in. to 2 in. (Light Alloy)	761
Nuts, Lock, B.A. 0 to 10 B.A. Even Sizes (Brass)	1584
Nuts, Lock, B.S.F., 1¼ in. to 2 in. R.H. and L.H. (Steel)	117
Nuts, Lock, Union (Steel)	207
Nuts, Locks, Union (Brass)	224
Nuts, Ordinary, 6 B.A. (Light Alloy)	762
Nuts, Ordinary, B.S.F., 1¼ in. to 2 in. R.H. and L.H. (Steel)	116
Nuts, Ordinary, B.S.F., 1¼ in. to 2 in. (Stainless Steel)	863
Nuts, Ordinary, B.S.F., [illegible] in., [illegible] in., [illegible] in., to 2 in. (Light Alloy)	759
Nuts, Ordinary, B.S.F., 1¼ in. to 2 in. R.H. and L.H. (Steel)	118
Nuts, Ordinary, B.S.F., 1¼ in. to 2 in. (Stainless Steel)	864
Nuts, Ordinary, B.S.F., [illegible] in., [illegible] in., [illegible] in., to 2 in. (Light Alloy)	760
Nuts, Union, Standard (Steel)	1188
Nuts, Union (Light Alloy)	1187
Nuts, Union (Brass)	807
Nuts, Union (for H.T. Cables)	T.1517
Nuts, Union (for L.T. Cables)	T.1519
Nuts, Wing, B.A.	113
Nuts, Wing, B.S.F.	120
Nuts, Lock, Union (Light Alloy)	957
Nuts, Thin Slotted	572
Nut, 9 mm. H.T. Cable, clamping	1506
Nut, 9 mm. H.T. Cable, Union	1507
Nut, Union (for H.T. Cable)	1634
Nut, Union (for L.T. Cable)	1635
Nut, Union	1709
Nut, Gland	1658
Nut, Lock, L.T. Union	1710
Olive Joint Adaptor	639
Olives for Copper Pipe Connections	581

Title	*A.M. A.G.S. No.*
Petroflex End Connection (Brass), for 3/16 in. Class I Tubing	616
Petroflex End Connection (Brass), for 1/4 in. Class I Tubing	617
Petroflex End Connection (Brass), for 5/16 in. Class I Tubing	875
Petroflex End Connection (Brass), for 3/8 in. Class I Tubing	618
Petroflex End Connection (Brass), for 1/2 in. Class I Tubing	619
Petroflex End Connection (Brass), for 5/8 in. Class I Tubing	620
Petroflex End Connection (Brass), for 3/4 in. Class I Tubing	621
Petroflex End Connection (Brass), for 7/8 in. Class I Tubing	622
Petroflex End Connection (Brass), for 1 in. Class I Tubing	767
Petroflex End Connection (Dural), for 5/16 in. Class I Tubing	879
Petroflex End Connection (Dural), for 3/8 in. Class I Tubing	826
Petroflex End Connection (Dural), for 1/2 in. Class I Tubing	827
Petroflex End Connection (Dural), for 5/8 in. Class I Tubing	828
Petroflex End Connection (Dural), for 3/4 in. Class I Tubing	829
Petroflex End Connection (Dural), for 7/8 in. Class I Tubing	830
Petroflex End Connection (Dural), for 1 in. Class I Tubing	831
Petrol Filter. (See Filter.)	
Petrol Tank, Filler for. (See Filler.)	
Pin for Chain Shackle	916
Pin, Locking	1155
Pins, Split (Non-Corrodible)	784
Pins, Split Taper	213
Pins, Split Taper (Light Alloy)	503
Pins, Standard, Split	166
Pins, Standard, Taper	167
Pins, Steel	384
Pins, Taper (Light Alloy)	502
Pins, Taper (Stainless Steel)	859
Plates, Link	206
Plugs (Brass)	565
Plugs, Flanged (Brass)	216
Plugs (Light Alloy)	566
Plugs, Flanged (Light Alloy)	948
Plug Protection, B.S.P. (Plastic)	505
Plug, Reducing	628
Plug, Sparking, Dummy, 12 mm.	1628
Plug, Sparking, Dummy, 14 mm.	1622
Plugs, Sparking, Dummy, 14 mm., with 2 Way Valve	1632
Plug, Sparking, Dummy, 18 mm.	1623
Plugs, Sparking, Dummy, 18 mm., with 2 Way Valve	1633
Plugs, Sparking, Dummy, 12, 14, and 18 mm.	1695
Pulleys, Single (Ball Bearing Type)	375
Pulleys, Double (Ball Bearing Type)	376
Pulleys, Single (Plain Bearing)	377
Pulleys, Double (Plain Bearing)	378
Pulleys, Double, Jockey (Ball Bearing Type)	379
Pulleys, Single, Jockey	380
Pulleys (for Main and Engine Controls)	666
Pulley, Plastic (1/4 in. Bore, Plain Bearing)	975
Pulley, Plastic (3/8 in. Bore, Plain Bearing)	976
Radiators, Honeycomb, R.T.1, Brass Tubes (Circular), for	837
Reducing Plug	628
Reducing Union Body	626
Release, Quick—Aircraft Holding Down Gear (9 Sheets)	960
Ring, Bonding (for Generators)	1610
Rings, Locking (for Fillers)	608
Rings, Locking (for Fillers)	609
Ring, Terminal	T.1527
Rings, Wire Locking	154

Title	*A.M. A.G.S. No.*
Rings, Wire Locking	165
Rings, Seaplane Lifting	890
Rivets, Flat Head, Light Alloy	785
Rivets, Solid	500
Rivets, Tubular	501
Rod, Screwed, S.1 (Coated)	575
Rod, Screwed (Light Alloy)	576
Rod, Screwed (Non-Corrodible)	921
Rod, Screwed, S.2, S.11, or D.T.D.153 (Coated)	935
Rods-Tie (Swaged), $\frac{3}{16}$ in. to $1\frac{1}{4}$ in. B.S.F. H.T.S.	579
Rods-Tie (Swaged), $\frac{5}{16}$ in. to $1\frac{1}{4}$ in. B.S.F. Steel, Non-Corroding	580
Saddlers, Electric Cable	1542
Screw, Bonding Strip	1529
Screw, Cups (Brass)	856
Screws, Standard Cheese Head, B.A. (Brass)	246
Screws, Standard Cheese Head B.A. (M.S.)	247
Screws, Cheese Head, B.A. (Steel, Non-Corroding)	896
Screws, Standard Countersunk, B.A. (Brass)	248
Screws, Standard Countersunk, B.A. (M.S.)	249
Screws, Countersunk, B.A. (Steel, Non-Corroding)	968
Screws, Standard Round Head, B.A. (Brass)	244
Screws, Standard Round Head, B.A. (M.S.)	245
Screws, Round Head, B.A. (Light Alloy)	564
Screws, Round Head, B.A. (Steel, Non-Corroding)	967
Screws, Wood, Countersunk Head (for Securing Metal Sheaths to Airscrews	858
Screws, Wood, Standard Countersunk (Brass)	250
Screws, Wood, Standard Countersunk (Steel)	251
Screws, Wood, Standard Countersunk Head (Non-Corrodible Steel)	893
Screws, Wood, Standard Round Head (Brass)	252
Screws, Wood, Standard Round Head (Steel)	253
Screws, Wood, Standard Round Head (Non-Corrodible Steel)	894
Seaplane Lifting Rings	890
Seating, Filler (Flange Type)	608
Seating, Filler, Alternative (Ring Type for Necks)	609
Shackes, Chain, for Anchor Cables (Assembly)	911
Shock Absorber Cord, $\frac{1}{4}$ in., Insulator for	1543
Shock Absorber Cord, $\frac{5}{16}$ in., Insulator for	1544
Sleeve, Cable	1606
Sleeve, Cable End	1711
Sleeve, Type 1, Circular (for Cables, Electric, L.T.)	1651
Sleeve, Type 1, Oval (for Cables, Electric, L.T.)	1652
Sleeve, Type 2, Inner, Circular (for Cables, Electric, L.T., Metal Braided)	1653
Sleeve, Type 2, Outer, Circular (for Cables, Electric, L.T., Metal Braided)	1654
Sleeve, Type 2, Inner, Oval (for Cables, Electric, L.T., Metal Braided)	1655
Sleeve, Type 2, Outer, Oval (for Cables, Electric, L.T., Metal Braided)	1656
Sleeves, Type 3 (for Trigenmet and Quadragenmet Cables)	1660
Sleeve, Identification	T.1514
Sleeve, L.T., Identification	T.1523
Sleeves, Identification (for Cable), Unisheath 4	1601
Sleeve, Identification (for Cable), Uniplug	1602
Sleeve, Identification (for Cable), Uniflex 4	1603
Sleeve, Identification (for Cable), Unispark 7	1621
Sleeve, L.T., Insulating	T.1522
Sleeve, Insulating, H.T. Plug End	T.1515
Sleeve, Insulating (for H.T. Ignition Cable Sparking Plug Terminal)	1716
Sleeve, Type 1, Circular (for Cables, Electric, L.T.	1688

Title	*A.M. A.G.S. No.*
Sleeve, Type 1, Oval (for Cable), Electric, L.T.	1689
Sleeves, Type 1, Circular (for Cable, Electric, L.T.)	1733
Sleeves, Type 3, Circular (for Cable, Electric, L.T., Metal Braided)	1726
Sleeves, Type 3, Inner, Circular (for Cable, Electric, L.T. Metal Braided)	1727
Sleeve, Type 3, Outer, Circular (for Cable, Electric, L.T., Metal Braided)	1728
Sleeve, Type 3, Outer, Circular (for Cable, Electric, L.T., Metal Braided)	1729
Sleeves, Type 3, Circular (for Cable, Electric, L.T., Metal Braided)	1732
Sleeve, Type 4, Inner, Circular (for Cables, Electric, L.T., Metal Braided)	1686
Sleeve, Type 4, Outer, Circular (for Cables, Electric, L.T., Metal Braided)	1687
Sleeves, Type 4, Inner, Circular (for Cable, Electric, L.T., Metal Braided)	1734
Sleeves, Type 4, Outer, Circular (for Cable, Electric, L.T., Metal Braided)	1735
Sleeve, Outer (for L.T. Metal Braided Cable), Unisheathmet 7	1638
Sleeve, Inner (for L.T. Metal Braided Cable), Unisheathmet 7	1639
Sleeve, Outer (for L.T. Metal Braided Cable), 7 mm. Dia.	T.1521
Sleeve, Inner (for L.T. Metal Braided Cable), 7 mm. Dia.	T.1520
Sleeve, Inner, Medium (for 8·5 mm. Dia. (Bristol) Metal Braided Cable	1629
Sleeve, Inner, Short (for 8·5 mm. Dia. (Bristol) Metal Braided Cable	1630
Sleeve, Outer (for 9 mm. H.T. Braided Cable)	1508
Sleeve, Inner (for 9 mm. H.T. Metal Braided Cable	1509
Sleeve, Inner (for H.T. Metal Braided Cable), 9 mm. Dia.	1616
Sleeve, Long (for H.T. Metal Braided Cable), 9·5 mm. Dia.	T.1511
Sleeve, Outer (for H.T. Metal Braided Cable), 9·5 mm. Dia.	T.1512
Sleeve, Inner (for H.T. Metal Braided Cable), 9·5 mm. Dia	T.1513
Sleeve, Inner (for L.T. Cable).	1636
Sleeves (for Cable), Trigenmet	1722
Sleeves, Inner (for Cable), Trigenmet	1723
Sleeves, Outer (for Cable), Trigenmet	1724
Sleeve, Outer, Circular (for Cable, Electric, L.T., Metal Braided)	1731
Sling, Cable, Torpedo, Thimbles for	898
Spherical Nipple, Standard	209
Split Pins, Standard	166
Split Pins (Non-Corrodible)	784
Split Taper Pins	213
Spring Catch	787
Staples, Insulating	1685
Strainers, General Arrangement and Details of Petrol and Water	610
Strip, Bonding (for Pipe Joints)	1533
Studs, No. 4 B.A.	883
Studs, No. 2 B.A.	884
Studs, $\frac{1}{4}$ in. B.S.F.	885
Studs, $\frac{5}{16}$ in. B.S.F.	886
Studs, $\frac{3}{8}$ in. B.S.F.	887
Switch Clamp	1562
Tabs, Identification (for Streamline Wires)	841
Tabs, Identification (for Tie Rods), Swaged	842
Tags, Nos. 29, 30, 31, and 32 (Post Office Type)	1615
Tanks, Petrol, Oil, and Water, Standard Filler for. (See Filler.)	
Tank Rivets, Snap Head (Copper)	397
Taper Pins, Standard	167
Taper Pins, Split	213
Taper Pins (Stainless Steel)	859
Terminal, Adaptor (for K.L.G. Sparking Plugs)	1535

Title	*A.M. A.G.S. No.*
Terminal, Ring	1600
Terminal, H.T.	1697
Terminals, Instrument (Single)	1707
Terminals, Instrument (Double)	1708
Terminal, Flag (Reference No. 5K/194	1743
Terminal Lug for Spark Plug Cable	T.1516
Terminal Lug, L.T. Cable, 5 mm.	T.1538
Terminal Lug, L.T. Cable, 7 mm.	1524
Terminal (Spring Loaded Type) for Magneto 7 mm. H.T. Cables	1624
Thermometer Pocket, Oil, ¼ in. B.S. Pipe	940
Thermometer Pocket, Oil, ⅜ in. B.S. Pipe	941
Thermometer Pocket, Oil, ½ in. B.S. Pipe	942
Thermometer Pocket, Oil, ¾ in. B.S. Pipe	963
Thermometer Pocket, Oil, 1 in. B.S. Pipe	943
Thermometer Pocket, Oil, 1¼ in. B.S. Pipe	964
Thermometer Pocket, Oil, 1½ in. B.S. Pipe	965
Thermometer Pocket, Oil, ⅛ in. B.S. Pipe	974
Thermometer Pocket, Oil, ¼ in. B.S. Pipe	940/M
Thermometer Pocket, Oil, ⅜ in. B.S. Pipe	941/M
Thermometer Pocket, Oil, ½ in. B.S. Pipe	942/M
Thermometer Pocket, Oil, ¾ in. B.S. Pipe	963/M
Thermometer Pocket, Oil, 1 in. B.S. Pipe	943/M
Thermometer Pocket, Oil, 1¼ in. B.S. Pipe	964/M
Thermometer Pocket, Oil, 1½ in. B.S. Pipe	965/M
Thermometer Pocket, Oil, ⅛ in. B.S. Pipe	974/M
Thermometer Washer (Copper)	839
Thimbles (Brass)	136
Thimble (for H.T. Cables), Flat End	T.1518
Thimble (for H.T. Cables), Conical End	T.1531
Thimbles (for Torpedo Cable Sling)	898
Thimbles (Non-Corrodible Steel)	969
Tools, Assembling (for Braided Cable Fittings)	1530
Tools, Pipe Expanding, Mk. I, Arrangement	772
Tools, Pipe Expanding, Mk. II, Arrangement	773
Tools, Pipe Expanding, Mk. I, Top Block	774
Tools, Pipe Expanding, Mk. I, Bottom Block	775
Tools, Pipe Expanding, Mks. I and II, Half Bush	776
Tools, Pipe Expanding, Mks. I and II, Pipe Expander	777
Tools, Pipe Expanding, Mks. I and II, Handle Bar, Collar and Washer	778
Tools, Pipe Expanding, Mks. I and II, Expander Screw and Clamping Nut	779
Tools, Pipe Expanding, Mks. I and II, Hinge Pin and Bush Locating Screw	780
Tools, Pipe Expanding, Mks. I and II, Tommy Bar and Eyebolt	781
Tools, Pipe Expanding, Mk. II, Top Block	782
Tools, Pipe Expanding, Mk. II, Bottom Block	783
Tools for Solid Rivets	880
Tools for Tubular Rivets, Snap, Spreader and Dolly	849
Tools for Tubular and Solid Rivets, Dolly Holder	850
Turnbuckles, 5 cwt.	490
Turnbuckles, 10 cwt.	491
Turnbuckles, 15 and 20 cwt.	492
Turnbuckles, 25 and 35 cwt.	493
Turnbuckles, 45 cwt.	494
Turnbuckles, 60 cwt.	495
Turnbuckles, 70 cwt.	496
Turnbuckles, 80 cwt.	497
Turnbuckles, 90 cwt.	498
Turnbuckles, 15 and 20 cwt. (Short)	506
Turnbuckles, 25 and 35 cwt. (Short)	507
Turnbuckles, 45 cwt. (Short)	508

(Turnbuckles 494–508 bracketed:) Not to be used in new construction after October, 1935.

Title	*A.M. A.G.S. No.*
Turnbuckle, $\frac{1}{2}$ in., Aircraft Holding Down Gear	961
Union Body, Double Ended (Brass)	627
Union Body, Reducing (Brass)	626
Union Body, Double Ended (Light Alloy)	907
Union Body, Reducing (Light Alloy)	908
Union Body, Double Ended (Steel)	949
Union Body, Reducing (Steel)	950
Union Locknuts (Brass)	224
Union Locknuts (Steel)	207
Union Locknuts (Light Alloy)	957
Unions, Low Pressure, Mark I (Dural) for $\frac{3}{16}$ in. Tubing	838
Unions, Low Pressure, Mark I (Brass) for $\frac{3}{16}$ in. Tubing	876
Union Nuts (Brass)	808
Union Nuts (Light Alloy)	770
Union Nuts for H.T. Cables	T.1517
Union Nuts for L.T. Cables	T.1519
Universal Acorns for Streamline Wires, 4 B.A. to $\frac{3}{8}$ in. B.S.F.	663
Universal Acorns for Streamline Wires, $\frac{7}{16}$ in. B.S.F. to $\frac{7}{8}$ in. B.S.F.	664
Universal Acorns for Streamline Wires, $\frac{15}{16}$ in. B.S.F. to $1\frac{1}{4}$ in. B.S.F.	665
Universal Fork Joints, 4 B.A.	451
Universal Fork Joints, $\frac{1}{4}$ in. B.S.F.	453
Universal Fork Joints, $\frac{5}{16}$ in. B.S.F.	455
Washers (Aluminium Alloy)	970
Washers, Bright (Steel)	160
Washers, Bright (Steel, Non-Corrodible)	946
Washers, Special Bright (Steel, Non-Corrodible)	947
Washers, Special Bright (Steel)	161
Washers, Double Spring (0–10 B.A. Even Sizes)	1583
Washers, Double Spring	163
Washer, Double Spring (·44 in. I/Dia.)	1607
Washers, Double Spring (Thin Type)	586
Washers, Jointing (Aluminium)	568
Washers, Round Jointing (Fibre)	164
Washers, Thin Jointing (Fibre)	567
Washers, Lock, Straight Tab (Steel)	194
Washers, Lock, Angle Tab (Steel)	195
Washers, Plain (0–10 B.A. Even Sizes)	1582
Washers, Single Spring	162
Washers, Single Spring (Thin Type)	585
Washers, Special (Aluminium Alloy)	157
Washer, Thermometer (Copper)	839
Water Tanks, Filler and Strainer for. (See Filler.)	
Weights, Ballast (Grey Cast Iron)	511
Weights, Ballast (Lead)	670
Wing Nuts, B.A.	113
Wing Nuts, B.S.F.	120
Wires, Bracing, Radiator	704
Wires, Bracing, Radiator	705
Wires, Bracing, Radiator	706
Wires, Bracing, Radiator, Nipple for	707
Wire Locking Rings	154
Wire Locking Rings	165
Wires, Streamline, $\frac{3}{16}$ in. to $1\frac{1}{4}$ in. B.S.F. (H.T.S.)	577
Wires, Streamline, $\frac{3}{16}$ in. to $1\frac{1}{4}$ in. B.S.F. (Steel, Non-Corroding)	578
Wiring Cleats, Panel (for Wireless Installations)	836
Woodscrews, Standard Countersunk (Brass)	250
Woodscrews, Standard Countersunk (Steel)	251
Woodscrews, Countersunk (for Securing Metal Sheaths to Airscrews)	858
Woodscrews, Standard Countersunk Head (Non-Corrodible Steel)	893

Title	*A.M. A.G.S. No.*
Woodscrews, Standard Round Head (Brass)	252
Woodscrews, Standard Round Head (Steel)	253
Woodscrews, Standard Round Head (Non-Corrodible Steel)	894

B.S. SPECIFICATIONS RELEVANT TO ABOVE

British Standard Specification	*No.*
Bolts, B.A. and B.S.F.	A.1 (Latest Issue)
Bolts, B.A. and B.S.F. (H.T.S. and Stainless Steel)	A.15 (Latest Issue)
Bolts, 4 and 2 B.A., ¼ in., 5/16 in., and ⅜ in., B.S.F. up to 1 in. Dia. (Light Alloy)	A.18 (Latest Issue)
Cable, Flexible	W.2 (Latest Issue)
Eyelets	S.P.2 (Latest Issue)
Fork Joints (4 B.A. to ½ in. B.S.F.), Mild Steel and Stainless Steel	S.P.3 (Latest Issue)
Fork Joints (4 B.A. to ½ in. B.S.F.), H.T.S.	S.P.7 (Latest Issue)
Hose Connections (Rubber)	F.7 (Latest Issue)
Joints, Fork (4 B.A. to ½ in. B.S.F.), Mild Steel and Stainless Steel	S.P.3 (Latest Issue)
Joints, Fork (4 B.A. to ½ in. B.S.F.), H.T.S.	S.P.7 (Latest Issue)
Locknuts, Steel (B.A. and B.S.F., up to 1 in.)	A.16 (Latest Issue)
Nuts, Brass (B.A. and B.S.F.)	A.14 (Latest Issue)
Nuts (B.A. and B.S.F., up to 1 in.), Steel	A.16 (Latest Issue)
Nuts (B.A. and B.S.F.), Brass	A.14 (Latest Issue)
Nuts (4 and 2 B.A. ¼in., 5/16 in., and ⅜ in. B.S.F.), Light Alloy	A.18 (Latest Issue)
Pins (Steel)	S.P.4 (Latest Issue)
Pipe Connections (Rubber)	F.7 (Latest Issue)
Rods, Tie (Swaged), 4 B.A. to ½ in. B.S.F.	W.8 (Latest Issue)
Shackles	S.P.1 (Latest Issue)
Streamline Wires (4 B.A. to ½ in. B.S.F.)	W.3 (Latest Issue)
Swaged Wires (Circular Section, 4 B.A. to ½ in. B.S.F.)	W.8 (Latest Issue)
Tie Rods (Swaged), 4 B.A. to ½ in. B.S.F.	W.8 (Latest Issue)
Wire, High Tensile Steel	W.1 (Latest Issue)
Wires, Streamline (4 B.A. to ½ in. B.S.F.)	W.3 (Latest Issue)
Wires, Swaged (Circular Section, 4 B.A. to ½ in. B.S.F.)	W.8 (Latest Issue)

BRITISH STANDARDS INSTITUTION

SECTIONAL LIST OF BRITISH STANDARDS

AIRCRAFT MATERIALS AND COMPONENTS

A. BOLTS, ETC.

6 A.1	Hexagonal Headed Bolts (Low Tensile Steel)	*Add.**
2 A.4	Test Pieces (Tensile, Bend, and Notched Bar).	
A.9	Magneto Couplings and Engine Mountings.	
A.14	Hexagonal Brass Nuts.	*Add.**
2 A.15	Hexagonal Headed Bolts (High Tensile Steel)	*Add.**

* NOTE.—" *Add.*" signifies that an Amendment slip is issued with this Standard.

A. BOLTS, ETC.—*continued*

A.16	Hexagonal Steel Nuts (Ordinary, Thin, Slotted, and Castle)	*Add.**
A.17	Machined Hexagonal Headed Bolts (Aluminium Alloy).	
A.18	Machined Hexagonal Nuts (Aluminium Alloy).	
A.19	Serrations and Gauges for Serrations.	*Add.**
A.20	Spline Shafts and Holes.	*Add.**

B. BRASS, COPPER, ETC.

2 B.8	Phosphor Bronze Castings for Bearings. (Includes Solid and Cored Sticks)	*Add.**
3 B.11	Brass Bars suitable to be Brazed or Silver Soldered.	*Add.**
2 B.21	White Metal (88/8/4) Ingots (suitable for Bearings).	
2 B.22	White Metal (92/4/4) Ingots (suitable for Bearings).	

D. DOPE AND INGREDIENTS

3 D.1	Methyl Ethyl Ketone.	
3 D.3	Amyl Acetate.	
3 D.4	Butyl Acetate.	
3 D.5	Castor Oil (for Nitro Dope Coverings).	
3 D.7	Benzyl Alcohol.	
2 D.8	Nitro-cellulose Syrup	*Add.**
3 D.9	Alcohol.	
3 D.10	Benzol.	
2 D.11	Triacetin.	
3 D.12	Triphenyl Phosphate.	
3 D.15	Distillation Apparatus.	
2 D.17	Butyl Alcohol.	
3 D.22	Acetone.	
D.26	Yellow Ochre.	
2 D.27	Zinc Oxide	*Add.**
2 D.28	Red Oxide of Iron	*Add.**
2 D.29	Identification Red	*Add.**
2 D.30	Carbon Black	*Add.**
2 D.31	Ultramarine Blue	*Add.**
2 D.32	Aluminium Powder.	
D.34	Ethylene Glycol.	
2 D.50	Cellulose Acetate	*Add.**
2 D.101	Properties of Aeroplane Doping Scheme.	

* **NOTE.—"** ***Add.*****" signifies that an Amendment slip is issued with this standard.**

E. Electrical

4 E.3 Low Tension Flexible Electric Cords and Cables . *Add.**
2 E.9 Sparking Plugs and Sparking Plug Holes, Taps, and Washers.
3 E.12 Electric Incandescent Lamps for Aircraft, other than Landing Lamps . . . . *Add.**
E.18 Electric Incandescent Lamps for Aircraft, Landing Lamps *Add.**

F. Fabric, etc.

6 F.1 4-oz. Linen Fabric and Tape (includes sample) . *Add.**
6 F.7 Rubber Hose for use with Aviation Fuel . . . *Add.**
4 F.8 Mercerised Cotton Aeroplane Fabric (Grade I).
4 F.15 Hemp Lines and Ropes for Kite Balloons.
5 F.16 Rubber Shock Absorber Cord.
2 F.30 Cotton Breaking Cord for Supplies Droppers.
3 F.31 Hemp Cordage for Supplies Droppers . . . . *Add.**
4 F.32 Hemp Cordage.
3 F.33 Flexible Cotton Ropes.
3 F.34 Linen Sewing Thread.
4 F.35 Flax Cordage.
2 F.37 18-oz. Cotton Canvas.
2 F.38 18-oz. Flax Canvas.
2 F.41 Rubber-Proofed Fabric.
3 F.45 Rubber Hose for use with Hot Water. . . . . *Add.**
3 F.47 Cotton Tapes.
F.49 Cotton Webbing.
3 F.50 Eyeleted Fuselage Webbing.
3 F.51 Light Elastic Cord for Parachutes, W/T Instruments and Aerial Suspensions.
F.52 Linen Reinforcement Webbing.
F.53 Parachute Main Harness Webbing.
F.54 Flax Sewing Cord for Parachute Harness.
2 F.55 Cotton Duck (Dyed) for Cases and Travelling Bags for Parachutes.
F.56 Transparent Sheets for Observation Panels.
F.57 Scoured Cotton Fabrics.

K. Cast Iron

4 K.6 Cast Iron Piston Ring Pots . . . . *Add.**
2 K.11 Iron Castings for Cylinders (Water-Cooled and Air-Cooled), Pistons and Valve Guides.

* Note.—"*Add.*" signifies that an Amendment slip is issued with this Standard.

L. Aluminium and Light Alloys

6 L.1 Aluminium Alloy Bars, Extruded Sections and Forgings (not greater than 3 in. diameter or minor sectional dimensions) . . . . *Add.**

5 L.3 Aluminium Alloy Sheets and Coils . . . . . . *Add.**

2 L.4 Aluminium Sheets (Hard) . . . . *Add.**

3 L.5 Aluminium-Zinc-Copper Alloy Castings.

3 L.8 12% Copper-Aluminium Alloy Castings.

4 L.11 7/1 Aluminium Alloy Castings.

2 L.16 Aluminium Sheets (Half hard) . . . . *Add.**

2 L.17 Aluminium Sheets (Soft) . . . . *Add.**

2 L.24 " Y " Aluminium Alloy Castings.

4 L.25 Aluminium Alloy Forgings (including Pistons and Cylinder Heads).

2 L.30 98% Aluminium Notched Bars and Ingots.

3 L.31 99% Aluminium Notched Bars and Ingots for Remelting.

2 L.33 Silicon Aluminium Alloy Castings . . . . . . *Add.**

L.34 99% Aluminium Bars and Sections.

L.35 " Y " Aluminium Alloy Castings (Heat Treated).

L.36 Aluminium Rivets.

2 L.37 Aluminium Alloy Rivets . . . . *Add.**

2 L.38 Aluminium Coated Aluminium Alloy Sheets and Coils. *Add.**

2 L.39 Aluminium Alloy Bars and Forgings (greater than 3 in. diameter or width across flats or minor sectional dimension) . . . . *Add.**

2 L.40 Aluminium Alloy Bars, Extruded Sections and Forgings (not greater than 3 in. diameter or minor sectional dimension) . . . . *Add.**

2 L.42 Aluminium Alloy Forgings (including Pistons and Cylinder Heads).

L.44 Soft Aluminium Alloy Extruded Bars and Sections (not greater than 3 in. diameter or minor sectional dimension) . . . . *Add.**

L.45 Aluminium Alloy Bars and Forgings (greater than 3 in. diameter across flats or minor sectional dimension). *Add.**

S. Steels

4 S.1 35–45-ton Carbon Steel Bars for machining for aircraft purposes.

2 S.2 55-ton Alloy Steel Bars . . . . *Add.**

3 S.3 Mild Steel Sheets and Strips (suitable for Welding) . *Add.**

3 S.6 " 40 " Carbon Steel (Normalized).

4 S.11 55–65-ton Nickel Chromium Steel.

* Note.—" *Add.*" signifies that an Amendment slip is issued with this Standard.

S. Steels—*continued*

2 S.14	Carbon Case-hardening Steel.	
3 S.15	3% Nickel Case-hardening Steel	*Add.**
3 S.20	Tinned Steel Sheets.	
2 S.21	" 20 " Carbon Steel.	*Add.**
3 S.24	Bright Steel Bars for Keys.	
2 S.28	Air-hardening Nickel-Chrome Steel.	
S.61	High Chromium Steel (Non-corroding)—35 Tons.	
S.62	High Chromium Steel (Non-corroding)—46 Tons.	
S.65	65-ton Nickel-Chrome Steel.	
S.67	5% Nickel Case-hardening Steel	*Add.**
S.68	16% Tungsten Steel.	
S.69	3½% Nickel Steel.	
S.70	" 55 " Carbon Steel (Normalized).	
S.71	" 30 " Carbon Steel (Normalized).	
2 S.76	" 40 " Carbon Steel (Hardened and Tempered).	
S.77	" 30 " Carbon Steel (Hardened and Tempered).	
S.79	" 55 " Carbon Steel (Hardened and Tempered).	
S.80	High Chromium Steel (Non-corroding)—55 Tons.	
2 S.81	65 to 75 Ton Nickel Chromium Steel	*Add.**
S.82	Nickel Chromium Case-hardening Steel.	
S.84	Low Carbon Steel Sheets and Strips (suitable for Welding).	
S.85	Non-corrodible Steel Sheets.	
S.90	High Tensile 5% Nickel Case-hardening Steel.	
S.100	Testing Procedure applicable to Aircraft Steels.	

S.P. Standard Details

2 S.P.1	Shackles	*Add.**
2 S.P.3	Fork Joints (Low Tensile Type).	
4 S.P.4	Steel Pins	*Add.**
S.P.6	Turnbuckles.	
2 S.P.7	Fork Joints (High Tensile Type).	
S.P.8	Turnbuckles (Tension Rod Type)	*Add.**

T. Tubes

2 T.1	35-ton Steel Tubes	*Add.**
3 T.2	85-ton Nickel-Chromium Steel Tubes (primarily for use as Axle Tubes)	*Add.**
5 T.4	Aluminium Alloy Tubes	*Add.**
5 T.7	Seamless Copper Tubes for Oil, Petrol, Gas Starters and General Purposes.	
4 T.9	Aluminium Tubes.	
3 T.26	20-ton Steel Tubes (suitable for Welding).	
2 T.35	35-ton Steel Tubes (suitable for Welding)	*Add.**

* Note.—" *Add.*" signifies that an Amendment slip is issued with this Standard.

T. Tubes—*continued*

2 T.45	45-ton Steel Tubes (suitable for Welding)	*Add.**
4 T.47	Brass Tubes for Honeycomb Type Radiators.	
2 T.50	50-ton Steel Tubes	*Add.**
2 T.51	High Pressure Seamless Copper Tubes.	
2 T.52	Hard Drawn Phosphor-Bronze and Phosphorus De-oxidized Bronze Tubes.	

V. Timber, Glues, etc.

4 V.2	Casein Cement.	
6 V.3	High Strength Plywood for Aircraft	*Add.**
3 V.4	Ash	*Add.**
3 V.5	Walnut (for use in Airscrews)	*Add.**
4 V.7	Mahogany (for use in Airscrews)	*Add.**
V.8	Rock Elm	*Add.**
6 V.10	Liquid and Gelatine Glues.	
5 V.11	Dry Gelatine Glue.	

W. Wires, Wire Ropes, etc.

3 W.1	High Tensile Steel Wire.	
5 W.2	Flexible Steel Wire Rope	*Add.**
6 W.3	Streamline Wires.	
3 W.6	Flexible Steel Wire Rope for Kite Balloon Cables	*Add.**
6 W.8	Tie Rods (Swaged).	

X. Paints and Varnishes

4 X.2	Oil and Petrol Resisting Battleship Grey Paint.	
3 X.4	White Dope Resisting Paint.	
3 X.6	Varnish for External Woodwork.	
3 X.7	Varnish for Internal Woodwork.	
2 X.8	Undercoating Propeller Varnish.	
3 X.9	Bituminous Paint.	
2 X.11	Transparent Woodfiller for Propellers.	
2 X.12	Finishing Propeller Varnish.	
2 X.14	Priming Varnish.	
2 X.17	Seaplane Varnish	*Add.**
X.18	Shellac Varnish.	
X.19	Acid Resisting Paint.	

* **Note.—"*Add.*" signifies that an Amendment slip is issued with this Standard.**

The following British Standards relating to Aircraft Materials and Components may also be obtained from the Institution:—

B.S. No.

83-1922. Standard of Reference for Dope and Protective Covering.

87-1931. Airscrew Hubs and their Fixings—

87 (Part 1) 1931. Airscrew Hubs.

87 (Part 2) 1931. Engine Flange Fixings.

135-1939. Benzoles (Pure Benzole, Pure Benzole for Nitration, Motor Benzole, 90's Benzole, Industrial Benzole).

185-1940. Glossary of Aeronautical Terms. [*Add*, November, 1940 and November 1943.]

491-1933. Nomenclature of Timber for Aircraft Purposes. (Including Sources of Supply and Application to Aircraft.)

563-1937. Land Aerodrome and Airway Lighting.

720-1937. Calibration of Carburettor Jets for Petrol Engines (all Types) (for flows not exceeding 2,000 ml. per min.).

TIMBERS

	Spec.	Moisture, max.	End grain, compression	Straightness, grain	Lb. per sq. ft., density
Ash . . .	B.S S.3 V 4	16%	5,500 at 16% moisture	1-10	40
Black Walnut	B.S.S.3 V.5	13%	7,500 at 13% moisture	1-12	35
Mahogany .	B.S.S.4 V.7	14%	6,250 at 14% moisture	—	32
Spruce (Silver)	D.T.D.36A	14-17%	*5,200 at 16% moisture	1-15	24

* 5,000 at 15% moisture is equivalent in Combined Bending and Compression to 5,500 lb. per sq. in.

The compressive strength varies inversely with the moisture content 200 lb. per sq. in. for each 1% moisture.

Notes

Copies of the above British Standards may be purchased from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1. Tel.: Abbey 3333. Telegrams: Standards, Sowest, London.

D.T.D. (Directorate of Technical Development) Specifications may be obtained from the Director of Publications, H.M. Stationery Office, York House, Kingsway, London, W.C.2.

A.G.S. (Aircraft General) Stores may be obtained from the Ministry of Supply, R.T.P., London, S.W.

Relevant B.S. Specifications Cancelled since April, 1930

Spec. number B.S.	Title	Date of cancellation	Replacement
3 B.1 .	High Tensile Brass Bars	May, 1940	B.S. Spec. 250—1940.
2 B.2 .	Bronze (Gun Metal) Castings)	June, 1940	B.S. Spec. 383—1940.
2 B.4 .	Copper Sheets—Annealed	Oct., 1930	Obsolete.
3 B.5 .	Brass Sheets (Hard Rolled)	July, 1937	B.S. Spec. 265—1936.
3 B.6 .	Naval Brass Bars	May, 1940	B.S. Spec. 251—1940.
3 B.12 .	Brass Sheets (Annealed)	July, 1937	B.S. Spec. 265—1936.
3 B.13 .	Brass Bars (High Speed Screwing and Turning)	May, 1940	B.S. Spec. 249—1940.
B.14 .	Brass Castings—Common	Oct. 1930	Obsolete.
2 B.15 .	Copper Sheets (Half Hard)	May, 1940	B.S. Spec. 899—1940.
2 B.16 .	Brass Sheets (Half Hard)	July, 1937	B.S. Spec. 265—1936.
B.19 .	65/35 Annealed Brass Sheets	July, 1937	B.S. Spec. 266—1936.
B.20 .	Brass Bars for Hot Stamping and Forgings	May, 1940	B.S. Spec. 218—1940.
4 D.100	Air Ministry Cellulose Acetate Dopes	Mar., 1936	Obsolete.
D.102 .	Nitro-Cellulose Dope	Mar., 1936	Obsolete.
2 D.103	Nitro Dope Coverings and Identification Colours	Mar., 1936	Obsolete.
D.105 .	Pigmented Nitro - Cellulose Dope	Mar., 1936	Obsolete.
3 E.1 .	High Tension Ignition Cables	April, 1932	Obsolete.
E.13 .	Sparking Plug Holes in Engine Cylinders	April, 1930	B.S. Spec.2.E.9.
E.16 .	Copper Asbestos Washers for Sparking Plugs	April, 1930	B.S. Spec. 2 E.9
2 F.29 .	Italian Hemp Ropes (Plaited)	Nov., 1934	Spec. D.T.D.258.
2 F.39 .	Flax Tent Duck	April, 1932	Obsolete.
F.40 .	Aircraft Cotton Fabric (Scoured)	April, 1929	B.S. Spec. F.57.
F.42 .	Skins for Rigid Airships	April, 1929	Obsolete.
F.43 .	Parachute Silk	April, 1932	Spec. D.T.D.69A.
F.44 .	Skin Lining of Gas Bag Fabric	April, 1929	Obsolete.
K.12 .	Iron Castings for Valve Guides and Air Cooled Engines	Oct., 1930	Obsolete.
2 L.32 .	Aluminium Bars	Oct., 1935	B.S.918—1940.

Relevant B.S. Specifications Cancelled since April, 1930—*continued*

Spec. number B.S.	Title	Date of cancel-lation	Replacement
L.48 .	Aluminium Alloy Drop Forgings for Pistons and Cylinder Heads (" Y " alloy)	Jan., 1940	B.S. Spec. 4 L.25.
S.83 .	High Tensile 5% Nickel Case Hardening Steel	Aug., 1936	B.S. Spec. S.90.
T.5. .	50-Ton Carbon Steel Tubes	Jan., 1933	B.S. Spec. T.50.
3 T.7 .	Seamless Copper Tubes	July, 1933	5 T.7.—Seamless Copper Tubes for Oil, Petrol, Gas Starters and General Purposes. 2 T.51.—High Pressure Seamless Copper Tubes.
5 T.8 .	Annealed Seamless Brass Tubes	Jan., 1940	B.S. Spec. 886—1940.
T.14 .	Tempered Carbon Steel Axle Tubes	July, 1933	Obsolete.
2 T.18 .	Hard Drawn Seamless Brass Tubes	Jan., 1940	B.S. Spec. 885—1940.
T.21 .	Annealed Carbon Steel Tubes	July, 1933	Obsolete.
T.48 .	10 mm. diameter Brass Tubes for Honeycomb type Radiators	July, 1930	B.S. Spec. 2 T.47.
2 X.1 .	Pigmented Oil Varnish for covering doped fabric.	May, 1934	D.T.D.62A.
2 X.5 .	Paints for Motor Transport Vehicles	May, 1934	Obsolete.
2 X.10	Air Drying Black Enamel	May, 1934	D.T.D.62A.
X.13 .	Protective Covering for Propellers	May, 1934	Obsolete.
2 X.15	Radiator Paint	May, 1934	D.T.D.62A.
X.20 .	White Spirit	May, 1934	B.S. Spec. 245/1926.
X.21 .	Turpentine	May, 1934	B.Sc. Spec. 244/1926.
X.22 .	Aluminium Paint	May, 1934	D.T.D.62A.
X.25 .	Paint for Pipe Lines	May, 1934	D.T.D.62A.

SECTION VI

STRENGTH OF MATERIALS

ABBREVIATIONS

Unless otherwise stated, the meanings of the abbreviations used in this section are as follows:—

A . . . Area.
D . . . External diameter.
d . . . Internal diameter.
E . . Modulus of elasticity.
f_s . . . Allowable shear stress.
f_{so} . . . Basic shear stress.
f_t . . . Ultimate tensile stress.
G . . . Modulus of rigidity.
I . . . Moment of inertia.
IZOD VALUE Factor of brittleness.
k . . . Radius of gyration.
L . . . Length.
P . . . Load.
P 2 . . . Load halved.
P_1 . . . 0·1% proof stress.
P_2 . . . 0·2% proof stress.
P_5 . . . 0·5% proof stress.
t . . . . Thickness.
U.T.S. . . Ultimate tensile stress.
W . . . Weight.
Z . . . Section modulus.
λ . . . (Lambda). Ratio of tube constants.
$>$ . . . Greater than.
$\geqslant$ . . . Equal to or greater than.
$\ngtr$ . . . Not greater than.
$<$ . . . Less than.
$\leqslant$ . . . Equal to or less than.
$\nless$ . . . Not less than.

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Tension

The ultimate factor is to be based on the ultimate stress, the proof factor on the 0·1% proof stress. Since, for British military aircraft, the proof factor is ·75 × the ultimate factor, the working direct stress may be taken as 1·1/3 × the 0·1% proof stress, or the ultimate tensile stress, whichever is less.

Torsion

The shear stress induced in tubes of circular cross-section should be calculated from the formula:—

$$\text{Shear stress } f_s = \frac{16D}{\pi(D^4 - d^4)} \times \text{Torque} = \frac{T}{Z_{\text{Polar}}}$$

where "D" and "d" are the external and internal diameters respectively.

Shear

1. *Single Shear*

(i) For values of $\frac{d}{t} < 1{\cdot}326$, the allowable shear stress, f_s, for bolts, pins and rivets in single shear in hard plates may be taken as $0{\cdot}6\ f_t$, where f_t is the ultimate tensile stress of the bolt material.

(ii) Between values of $\frac{d}{t} = 1{\cdot}326$ and $8{\cdot}22$, the strength of bolts, pins and rivets in single shear in hard plates may be expressed by the formula:—

$$f_s = 0{\cdot}696 f_t\left(1 - {\cdot}1106\left(\frac{d}{t}\right) + {\cdot}00525\left(\frac{d}{t}\right)^2\right).$$

(iii) For values of $\frac{d}{t} > 8{\cdot}22$, the allowable shear stress in single shear in hard plates may be taken as

$$f_s = \frac{2{\cdot}546}{(d/t)} f_t.$$

(iv) The absolute strengths of pins in single shear in hard plates have been tabulated on page 200.

2. *Double Shear*

(i) For values of $\frac{d}{t} < \cdot 663$, the allowable shear stress, f_s, for bolts, pins and rivets in double shear in hard plates may be taken as $0{\cdot}6\ f_t$, where f_t is the ultimate tensile stress of the bolt material, d is the bolt diameter and t is the thickness of the central plate.

(ii) Between values of $\frac{d}{t} = \cdot 663$ and $\frac{d}{t} = 4{\cdot}11$, the strength of bolts, pins and rivets in double shear in hard plates may be expressed by the formula:—

$$f_s = 0{\cdot}696 f_t \left(1 - \cdot 2212\left(\frac{d}{t}\right) + \cdot 021\left(\frac{d}{t}\right)^2\right).$$

(iii) For values of $\frac{d}{t} > 4{\cdot}11$, the allowable shear stress in double shear in hard plates is to be taken as

$$f_s = \frac{1{\cdot}273}{(d/t)} f_t.$$

(iv) The absolute strengths of pins in double shear in hard plates have been tabulated on page 200.

3. *General*

Data for the estimation of the strength of bolts, pins, and rivets in single or double shear in hard plates is to be found on page 200.

The bearing strength of the plate or tube in which the bolt, pin or rivet is bearing must always be checked (see BEARING). Information covering bolts in plates in various materials is provided on pages 203–210.

Standard values for the ultimate tensile stress, f_t, of materials are included in the tables of materials. The shear stress calculated from the formulæ given in paras. 1 and 2 is then to be associated with the specified ultimate factor; compliance with the proof factor requirement may then be assumed.

BEARING

Strength in bearing in tubes and plates should be estimated from pages 200 or 202 for steel tubes and plates, and pages 199 or 202 for light alloy tubes and plates.

Bursting

Bursting strength through the end of an eye cannot be based on shear. Eye design should therefore be determined on:—

$1{\cdot}5 \times$ area of section beyond hole on load line $\times$ working direct stress.

Compressive

Working direct stress should be used. This does not apply to design of struts. For this, strut curves or L/K curves should be used.

Bending

For solid fittings, bolts, etc., working direct stress should be used. For tubes:—

$$f_b = \frac{0{\cdot}1\% \text{ Proof Stress} + \text{Ultimate Tensile Stress}}{2}$$

providing f_b does not exceed working direct stress.

Steel Bars, Forgings, etc.

Material	Specification	En. Specification	Tension: U.T.S. f_t(T. in.$^{-2}$)	Proof stress P_1(T. in.$^{-2}$)	Proof stress P_2(T. in.$^{-2}$)	Proof stress P_5(T. in.$^{-2}$)	Working direct stress (T. in.$^{-2}$)	Elongation, %	E × 10^{-6} lb. in.$^{-2}$	Izod value (ft. lb.)	Remarks
Bright M.S. bar	3 S.1	En.6	35	27	15	19	22.7	15	28.5	20	Up to ¾ in. dia.
	3 S.1	En.6	35	21	15	19	22.7	15	28.5	20	Over ¾ in. up to 1½ in. dia.
	3 S.1	En.6	35	17	15	19	22.7	15	25.5	20	Over 1½ in. dia.
H.T.S. bar	2 S.2	En.16C	55	43	44	45	55	18	28.5	40	Up to 2½ in. dia.
	2 S.2	En.17C	55	43	44	45	55	18	28.5	40	2½ to 4 in. dia.
	2 S.2	En.24B	55	43	44	45	55	18	28.5	40	4 to 6 in. dia.
40-carbon steel	3 S.6	En.8	35	20	20.5	20.5	26.7	20	28.5	20	Normalised.
H.T.S. bar, forgings	4 S.11	En.16C	55	43	44	45	55	18	28.5	40	Up to 2½ in. dia.
	4 S.11	En.17C	55	43	44	45	55	18	28.5	40	2½ to 4 in. dia.
	4 S.11	En.24B	55	43	44	45	55	18	28.5	40	4 to 6 in. dia.
20-carbon steel	3 S.21	En.3	25					17	27.5		
Ni-Cr-Mo steel (100-ton)	2 S.28	En.30	100	64			85.3	10		10	Up to 2½ in. dia. (A.H. and T.)
	2 S.28	En.24G	100	64			85.3	8		8	Up to 1½ in. dia. (O.H. and T.)
	2 S.28	En.26D	100	64			85.3	10		10	1½ to 4 in. dia. (O.H. and T.)
	2 S.28	En.30	100	64			85.3	8		10	4 to 6 in. dia. (O.H. and T.)
Cr stainless steel	S.62	En.56H	46	30	32	35	40	20	29	20	
65-ton Ni-Cr steel	S.65	En.17E	65	54	54.5	55.5	65	16	29	35	Up to ¾ in. dia.
	S.65	En.24D	65	54	54.5	55.5	65	16	29	35	¾ to 2½ in. dia.
	S.65	En.25C	65	54	54.5	55.5	65	14	29	35	2½ to 6 in. dia.
16% Cr stainless steel	S.80	En.57	55	40	42	43.5	53.3	15	28	20	

STEEL BARS, FORGINGS, ETC.—*continued*

Material	Specification	En. specification	Tension							Izod value (ft. lb.)	Remarks
			U.T.S.	Proof stress			Working direct stress	Elongation, %	E 10^{-6} lb. in.$^{-2}$		
			f_t(T. in.$^{-2}$)	P_1(T. in.$^{-2}$)	P_2(T. in.$^{-2}$)	P_3(T. in.$^{-2}$)	(T. in.$^{-2}$)				
65-ton Ni-Cr steel .	2 S.81 2 S.81 2 S.81	En.17E En.24D En.25C	65 65 65	54 54 54			65 65 65	16 16 14		35 35 35	Up to ¾ in. dia. ¾ to 2½ in. dia. 2½ to 6 in. dia.
85-ton C.H. steel . .	S.82	En.39	85					12		25	
40-ton steel (for welding)	D.T.D.126A	En.14	40	31	34	37	40	20	28	35	Up to 4 in. dia.
Austenitic steel . .	D.T.D.176	En.58	35	15	16	18	20	50	28	50	
55-ton H.T. steel . .	D.T.D.188A D.T.D.188A	En.16C En.17C	55 55	43 43			55 55	18 18		40 40	Up to 2½ in. dia. 2½ to 4 in. dia.
60-ton nitriding steel .	D.T.D.306	En.40D	60	49			60	17		35	Up to 4 in. dia.
45-ton nitriding steel	D.T.D.317A	En.40A	45	34			45	20		45	Up to 6 in. dia.
80-ton alloy steel . .	D.T.D.331 D.T.D.331 D.T.D.331	En.24E En.25E En.26C	80 80 80	70 70 70			80 80 80	14 14 12		25 25 25	Up to 1½ in. dia. 1½ to 2½ in. dia. 2½ to 6 in. dia.
55-ton alloy steel . .	D.T.D.470	En.19C	55	43			55	18		35	Up to 2½ in. dia.
55-ton alloy steel . .	D.T.D.480	En.24B	55	43			55	18		40	2½ to 4 in. dia.
55-ton alloy steel . .	D.T.D.490	En.25A	55	43			55	18		40	4 to 6 in. dia.
80-ton alloy steel . .	D.T.D.500	En.26C	80	70			80	14-12		25	2½ to 6 in. dia.
65-ton alloy steel . .	D.T.D.519	En.36B	65					13		30	

STEEL TUBES

Material	Specification	Tension: U.T.S. f_t (T./in.^{2})	Tension: Proof stress P_1 (T./in.^{2})	Tension: Proof stress P_3 (T./in.^{2})	Tension: Proof stress P_5 (T./in.^{2})	Tension: Working direct stress (T./in.^{2})	Tension: Elongation, %	Tension: $E \times 10^{-6}$ (lb./in.^{2})	Izod value (ft. lb.)	Remarks
35-ton steel tube .	3 T.1	35	29	30	30·5	35		28		
85-ton steel tube .	3 T.2	85	73	78	83	85	8	29		Axle tube.
20-ton steel tube .	3 T.26 3 T.26	20 28	10·8 24	11·0 24	11·2 24	14·4 28		29 28		Softened (for welding). Half-hard.
35-ton steel tube .	2 T.35 2 T.35	35 30	30 25	30	30	35 30		28		Before welding. After welding.
45-ton steel tube .	2 T.45 2 T.45	45 30	40 25	40	40	45 30		28		Before welding. After welding.
50-ton steel tube .	2 T.50	50	44·5	45	45·5	50		28		
Mild steel tube .	D.T.D.41 D.T.D.41	30 24	26·5	27	27·5	30		28		Before welding. Annealed.
35-ton steel tube .	D.T.D.102A	35	28	29	30·5	35		29		
50-ton steel tube .	D.T.D.199	50	40	45	46·5	50		30·5		
50-ton steel tube .	D.T.D.203A	50		45		50				
35-ton chromium-nickel steel tube	D.T.D.207	35	15	18	20	20		27		Non-corrodible.
50-ton chromium-nickel steel tube	D.T.D.211	50	37	45	46	49·3		25·5		Non-corrodible.

STEEL TUBES—*continued*

Material	Specification	Tension							Izod value (ft. lb.)	Remarks
		U.T.S.	Proof stress			Working direct stress (T./in.^{2})	Elongation, %	E × 10^{-6} (lb./in.^{2})		
		f_t(T./in.^{2})	P_1(T./in.^{2})	P_2(T./in.^{2})	P_5(T./in.^{2})					
75-ton nickel chromium steel tube	D.T.D.254	75	65	68	70	75	10	28·5		
30-ton carbon steel tube	D.T.D.305	30		18						
50-ton manganese-molybdenum steel tube	D.T.D.347	50		45						Before welding (≯ 14 G.).
	D.T.D.347	45								After welding.
45-ton manganese-molybdenum steel tube	D.T.D.359	45		40						Before welding (> 14 G.).
	D.T.D.359	45		35						After welding.
75-ton steel tube .	D.T.D.408	75	67	68	71	75		29·5		Before welding (H. and T.).
	D.T.D.408									After welding.
20-ton steel tube .	D.T.D.432	28	24	24	24	28		28		Equivalent to T.26.
35-ton steel tube .	D.T.D.501	35		30						To be heat-treated if welded.
40-ton steel tube .	D.T.D.507	35	15	18		20				Before welding (stainless).
35-ton steel tube .	D.T.D.535	35		30						Before welding.
	D.T.D.535	30								After welding.
45-ton steel tube .	D.T.D.545	45		40						Before welding.
	D.T.D.545	30								After welding.

Steel Sheet and Strip, and Steel Castings

Material	Specification	Tension: U.T.S. f(T./in.²)	Tension: Proof stress P_1(T./in.²)	Tension: Proof stress P_2(T./in.²)	Tension: Proof stress P_3(T./in.²)	Tension: Working direct stress (T./in.²)	Tension: Elongation, %	$E \times 10^{-6}$ (lb./in.²)	Izod value (ft lb.)	Remarks
Sheet and Strip Mild steel sheet	3 S.3	28	16	16·5	17	21·3	20	30		Before welding.
Tinned steel sheet	3 S.20									For fuel tanks.
Low carbon steel sheet	S.84	20					25			Suitable for welding.
H.T. Ni-Cr steel strip	S.88C	75	65			75	5	29		Hardened and tempered.
Carbon steel sheet and strip	D.T.D.124A	45	40			45	12			Hardened and tempered.
Carbon steel sheet and strip	D.T.D.138A		65				5			Hardened and tempered.
Ni-Cr steel sheet and strip	D.T.D.166B	52	40	42	45	52		28·5		Stainless and non-magnetic.
Ni-Cr steel sheet and strip	D.T.D.171B	35	15	16·5	18·5	20		28		
Castings 40-ton steel casting		40				40	15			
60-ton steel casting		60								

Light Alloy Tubes, Sheet, and Strip

Material	Specification	Tension: U.T.S. f_t (T./in.^{2})	Proof stress P_1 (T./in.^{2})	Proof stress P_2 (T./in.^{2})	Proof stress P_5 (T./in.^{2})	Working direct stress (T./in.^{2})	Elongation, %	$E \cdot 10^{-6}$ (lb./in.^{2})	Remarks
Tubes Aluminium alloy tube .	5 T.4	26	18	19	20·5	24	8	10·5	Heat treated and drawn. D/t = 12·30.
	5 T.4	26	18	19	20·5	24	10	10·5	Heat treated and drawn. D/t = 30·67.
	5 T.4	25	15	16	17	20	12	10·5	Subsequently heat treated.
Aluminium tube . .	4 T.9	8							≯ 3 in. dia.
Aluminium alloy tube .	D.T.D.186A D.T.D.186A	26 25	18 17	19 18	20 19	24 22·7		10 10	≯ 12 G. > 12 G.
Wrought light-alloy tube .	D.T.D.220A D.T.D.220A D.T.D.220A	27 27 27	22 22 22	23 23 23		27 27 27	6 8 10		≯ 16 G. 16 G. to 12 G. > 12 G.
Aluminium alloy tube	D.T.D.273	29	22			29	10		
Aluminium tube (for pipe lines)	D.T.D.310B D.T.D.310B D.T.D.310B	9 10 11							[illegible] in. to ¼ in. dia. > ¼ in. and ≯ ⅜ in. dia. > ⅜ in. dia.
Aluminium alloy tube .	D.T.D.440	15	11	11·5	12	14·7		10	
Aluminium alloy tube .	D.T.D.450	17	10	10·5	11	13·3		10	
Aluminium alloy tube .	D.T.D.460	22	18	18·5	19	22		10	
Aluminium alloy tube .	D.T.D.464	28	23	24	25	28		10·5	
Aluminium alloy tube .	D.T.D.520	27	22	23	24	27		10·5	

LIGHT ALLOY TUBES, SHEET, AND STRIP—*continued*

Material	Specification	Tension							Remarks
		U.T.S.	Proof Stress			Working direct stress (T./in.^{2})	Elongation, %	$E \times 10^{-6}$ (lb./in.^{2})	
		f_t(T./in.^{2})	P_1(T./in.^{2})	P_2(T./in.^{2})	P_5(T./in.^{2})				
Sheet and Strip									
Aluminium alloy sheets and coils	5 L.3	25	15*	15·5	16	20	15†	10·5	* 14·5 for transverse loading.
Aluminium sheet (hard)	2 L.4	9	7·5	8	8·5	9		10	
Aluminium sheet (half-hard)	2 L.16	7	5·8	6·2	6·5	7		9	
Aluminium sheet (soft).	2 L.17	5							
Aluminium-coated sheet and strip	2 L.38	24	13·5			18	15†		
Soft aluminium alloy sheet	L.46	11					18†		
Aluminium-coated sheet and coil	L.47C	25	19			25	8†		Quenched and aged.
Magnesium alloy sheet.	D.T.D.118	11							Suitable for welding.
Magnesium alloy sheet.	D.T.D.120A	16	7			9·3	10†		Suitable for welding.
7% magnesium-aluminium alloy sheet and strip	D.T.D.182A	20							
Aluminium-manganese alloy sheets and strip	D.T.D.213A	11							
Wrought light alloy sheet and strip	D.T.D.356	27	21			27	8†		Solution heat treated and aged.
Aluminium-coated sheets and coils	D.T.D.390	25	15	15·5	16	20	15†		

* On thicknesses

LIGHT ALLOY BARS, FORGINGS, RODS, EXTRUSIONS

Material	Specification	Tension: U.T.S. f_t(T./in.^{2})	Proof stress T_1(P./in.^{2})	Proof stress P_2(T./in.^{2})	Proof stress P_5(T./in.^{2})	Working direct stress (T./in.^{2})	Elongation, %	E × 10^{-6} (lb./in.^{2})	Remarks
Dural bar and extrusion	6 L.1 6 L.1	25 24	15 14	15·5 14·5	16 15	20 18·7	15 15	10·5 10·5	Extrusions > 3/8 in. thick. Extrusions ≯ 3/8 in. thick.
99% aluminium bars and sections	L.34	5							
Aluminium rivets . .	L.36	7							
Aluminium alloy rivets.	2 L.37	25							After normalising.
Aluminium alloy bars and forgings	2 L.39	22	12			16	12		Bars for machining 3 in. to 6 in. dia.
	2 L.39 2 L.39	25 20	15 10·5			20 14	15 8		Forgings > 3 in. dia. Bars for machining 6 in. to 8 in. dia.
Aluminium alloy bars, extrusions and forgings	2 L.40	27	21			27	10		Bars and extrusions 3/8 in. to 3 in. dia.
	2 L.40	26	20			26	10		Extrusions ⩽ 3/8 in. thick.
Soft aluminium alloy bars and extrusions	L.44	11					18		≯ 3 in. dia.
Aluminium alloy bars and forgings	L.45	25	19			25	8		Bars for machining 3 in. to 6 in. dia.
	L.45 L.45	27 23	21 17			27 22·7	10 6		Forgings > 3 in. dia. Bars for machining 6 in. to 8 in. dia.
Magnesium alloy forgings	D.T.D.88B	15	8			10·7			

LIGHT ALLOY BARS, FORGINGS, RODS, EXTRUSIONS—*continued*

Material	Specification	Tension							Remarks
		U.T.S.	Proof stress			Working direct stress (T./in.²)	Elongation, %	$E \times 10^{-6}$ (lb./in.²)	
		f_t(T./in.²)	p_1(T./in.²)	p_2(T./in.²)	p(T./in.²)				
Aluminium alloy bars, forgings and extrusions	D.T.D.130A	27	21			27	10		Bars and extrusions > ¾ in. Forgings ≯ 3 in. dia.
	D.T.D.130A	26	20			26	10		Extrusions ≯ ¾ in. thick.
Magnesium-aluminium alloy bars, extrusions and forgings	D.T.D.297	20	8			10·7			
M.G.5 rivets . . .	D.T.D.303	16							Normalising not required.
Aluminium alloy rivets	D.T.D.327	17							Bif. rivets only.
Aluminium alloy bars and extrusions	D.T.D 363	33	27			33			≯ 3 in. dia.
Aluminium alloy bars, forgings, and extrusions	D.T.D.364A	30	26			30	8		Bars and extrusions > ¾ in. ≯ 3 in. dia.
	D.T.D.364A	28	24			28	8		Extrusions ≤ ¾ in. thick.
Aluminium alloy bars and forgings	D.T D.410	25	19			25	8		Bars for machining 3 in. to 6 in. dia.
	D.T.D.410	27	21			27	10		Forgings.
Aluminium alloy bars, forgings, and extrusions	D.T.D.423A D.T.D.423A	22 21	17 16			22 21	8 8		Up to 3 in. dia. Extrusions ≯ ¾ in. thick.
Aluminium alloy bars, forgings, and extrusions	D.T.D.443	17	10			13·3			

LIGHT ALLOY CASTINGS

Material	Maker's specification	Specification	Tension: U.T.S. f_t(T. in.^{2})	Proof stress P_1(T. in.^{2})	Proof stress P_2(T. in.^{2})	Proof stress P_3(T. in.^{2})	Elongation, %	$E \times 10^{-6}$ (lb. in.^{2})	Heat treatment	Remarks	
"Y" Al. alloy castings	"Y" alloy	L.35	14	12	13			9 5	Single		*Group I* High strength alloy for use where ductility is not important. U.T.S. ≮ 14 t./in.^{2}, 0 1% proof stress ≮ 10 5 T./in.^{2}
Al. alloy sand or die casting	R.R.53	D.T.D.131A	16	15 5					Double		
Si.-Al. alloy casting .	Alpax Gamma	D.T.D.245	15 5	13					Double		
Al. alloy sand or die casting	Ceralumin D	D.T.D.250	14	11 5					Single		
Al. alloy die casting .	Ceralumin C	D.T.D.255	18	17 5					Double		
Al. alloy sand or die casting .	N.A.222	D.T.D.269	15	13					Double		
Al. Si. alloy sand or die casting	N.A.125 T.67	D.T.D.276	15	11					Double		
Al. alloy sand or die casting	R.R.53C	D.T.D.309	19	18					Double		
Al alloy sand casting	N.A.226	D.T.D.361	21	20			1		Double		
Al. alloy sand or die casting	Aeral "A"	D.T.D.294	14	11			3		Single		*Group II* High strength alloys with high ductility. Elongation ≮ 3%.
Al. alloy sand or die casting	N.A.226 W.91	D.T.D.298	14	11			7		Single	Preferred material	
Al. alloy sand or die casting	N.A.350 and B.A.29	D.T.D.300	16	11			7		Single		
Al. alloy sand or die castings	N.A.226 T.92	D.T.D.304	18	14			4		Double	Preferred material	
Al. alloy sand or die castings	R.R.50	D.T.D.133B	11	7 5			2 5		Single	Preferred material	*Group III* Medium strength alloys with good ductility.
Al. Mg. alloy casting	—	D.T.D.165	9	5			3				
Si.-Al. alloy castings .	Alpax Beta	D.T.D.240	11	6			1 5		Single		
Al.-Si. alloy sand or die castings	N.A.125 W.60	D.T.D.272	11	8			2		Single		
Al. alloy sand or die castings	Ceralumin B	D.T.D.287	10	7 5			2		Single	Preferred material	
Al. alloy castings	—	D.T.D.424	9	5			2		None	Use whenever practical	
Al. Zn. Cu. alloy castings	—	L.5	9	3 5			2		None		*Group IV* Low grade (secondary) alloys.
Si.-Al. alloy castings	Alpax	L.33	10 5	3 5					None	Preferred material	
10% Si.-Al. alloy castings	M.V.C.	D.T.D.231	10	3			5		None	Preferred material	
Al. alloy sand or die castings	Birmasil N.A.158	D.T.D.264	12	4 5			2		None		
Al. alloy castings .	—	D.T.D.428	8						None	Use whenever practical	

Non-Ferrous Materials (Excluding Light Alloys)

Material	Specification	Tension: U.T.S. f_t(T./in.^{2})	Proof stress P_1(T./in.^{2})	Proof stress P_2(T./in.^{2})	Proof stress P_5(T./in.^{2})	Working direct stress (T./in.^{2})	Elongation, %	E × 10^{-6} (lb./in.^{2})	Remarks
Sheets Hard drawn high nickel-copper alloy	D.T.D.200A	45	30			40			Sheets thicker than 25 G and all bars.
Aluminium - nickel - silicon brass (tungum)	D.T.D.283A	22	6·5			8 7			0·2 in. and thicker (annealed).
Cold-rolled brass sheets, strip and foil (copper content 61·5% min., 64% max.)	B.S.S.265	18 25							Annealed, all widths up to 36 in. Half-hard, widths 18 ⩽ in. Half-hard, widths > 18 in. ⩽ 36 in.
Cold-rolled brass sheets, strip and foil (copper content 64% min., 67% max.)	B.S.S.266	18 25 23							Annealed, all widths up to 36 in. Half-hard, widths ⩽ 18 in. Half-hard, widths > 18 in. ⩽ 36 in.
Tubes 45% nickel alloy	D.T.D.268	35							
Tin-iron brass tubes . . .	D.T.D.318A	24							
Aluminium - nickel - silicon brass tubes (medium pressure)	D.T.D.323	27 27							
Hot-drawn seamless brass tubes	B.S.S.885 B.S.S.886	25 18							
Bars, Forgings, and Rods Aluminium - nickel - iron bronze bars, forgings, and stampings	D.T.D.164A D.T.D.197	38 35 45	20 17 25			26 7 22 7 33·3			⩽ 3 in. dia. > 3 in. dia.
Hard drawn high nickel-copper alloy	D.T.D.200A	45	30			40			Bars and strips.

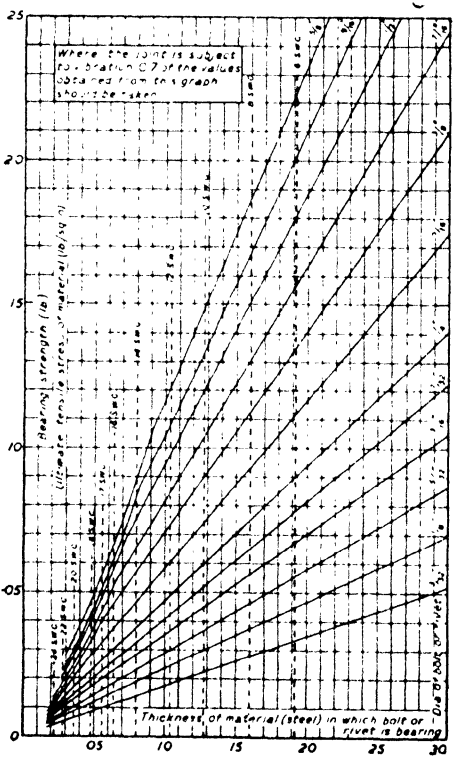
NON-FERROUS MATERIALS (EXCLUDING LIGHT ALLOYS)—*continued*

Material	Specification	Tension							Remarks
		U.T.S.	Proof stress			Working direct stress (T in.^{2})	Elongation, %	$E \times 10^{-6}$ (lb./in.^{2})	
		f(T./in.^{2})	P_1(T./in.^{2})	P_2(T. in.^{2})	P_3(T./in.^{2})				
Bars, Forgings, and Rods—continued High nickel-copper alloy rods, wire and rivets	D.T.D.204A	35							
45% nickel-alloy	D.T.D.268	35							
Aluminium - nickel - silicon brass bars	D.T.D.319	35 30	18 15			24 20			≤ 1 in. dia. > 1 in. dia.
Silicon - nickel - copper alloy bars and forgings	D.T.D.498	36	27			36			
Silicon - nickel - copper alloy bars	D.T.D.504	42	37			42			
Brass bars and sections . .	B.S.S.215	20							Bars, sections, and forgings.
Brass bars (high speed) . .	B.S.S.249	25	14*			21			* For rods ≯ ½ in. dia. and flats, squares, and hexagons of same cross-sectional area.
High-tensile brass bars . .	B.S.S.250	30 35	15 18			20 24			Grade A (up to 4 in. dia.). Brade B (up to 1½ in. dia.).
Naval brass (Admiralty mixture)	B.S.S.251	26 22 22							Bars and sections ≤ ¾ in. Bars and sections > ¾ in. ≯ 5 in. dia. Forgings.
Phosphor-bronze bar and rods	B.S.S.369	30 25 20 17·5	23 20 15 5			30 25 20 6·7			≤ 2 in. dia. > 2 in. dia. ≤ 3½ in. dia. > 3½ in. dia. ≤ 4½ in dia. > 4½ in. dia. ≤ 5½ in. dia.

Bearing Strength in Steel Plates

For the thickness of steel plate and size of holes, find from the graph the factor on the ultimate tensile stress of the material of the plate, to give the failing load in bearing.

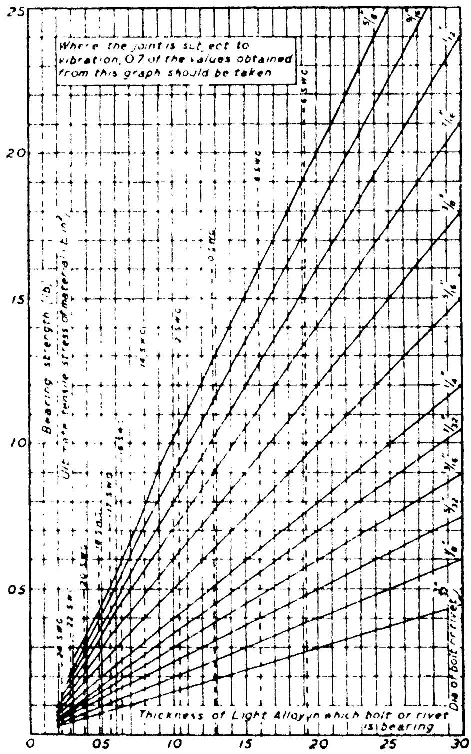
Example.—½ in. dia. bolt in 14 S.W.G. steel plate, D.T.D.166A (U.T.S. 52 tons/sq. in.). Bearing strength in plate = ·0752 × 52 × 2,240 = 8,759 lb.



(By courtesy of Hawker Aircraft)

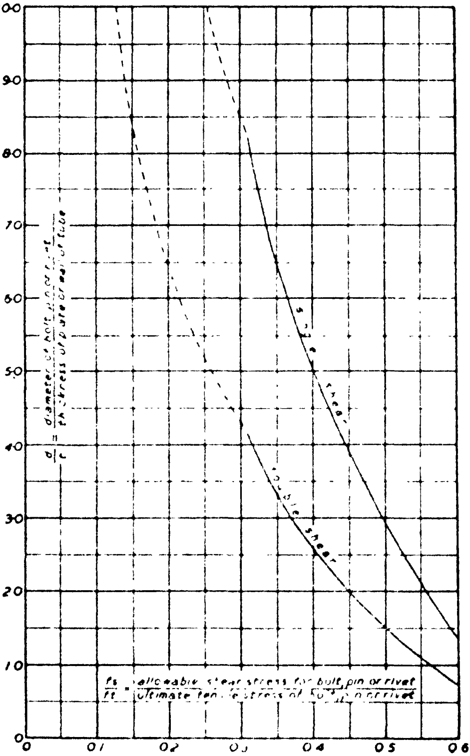
BEARING STRENGTH IN LIGHT ALLOY PLATES

For the thickness of light alloy plate and size of hole, find from the graph the factor on the ultimate tensile stress of the material of the plate to give the failing load in bearing.



(*By courtesy of Hawker Aircraft*)

Shear Strength of Bolts, Pins, and Rivets



(By courtesy of Hawker Aircraft)

SHEAR STRENGTH OF BOLTS, PINS, AND RIVETS

Example.—(i) $\frac{5}{16}$ in. dia. S.2 bolt in 16 S.W.G. D.T.D.166A, in single shear

$$\frac{d}{t}=\frac{\cdot 3125}{\cdot 064}=4\cdot 88 \qquad \frac{f_s}{f_t}=\cdot 408.$$

Permissible load $=\cdot 408\times A\times f_t.$
$=\cdot 408\times\cdot 0767\times 123{,}200.$
$=3{,}850$ lb.

(ii) $\frac{5}{16}$ in. dia. S.2 Bolt in 16 S.W.G. D.T.D.166A, in double shear

$$\frac{d}{t}=4\cdot 88. \qquad \frac{f_s}{f_t}=\cdot 261.$$

Permissible load $=\cdot 261\times 2A\times f_t.$
$=\cdot 261\times\cdot 1{,}534\times 123{,}200$
$=4{,}930$ lb.

Bearing Stress for Tubes and Plates

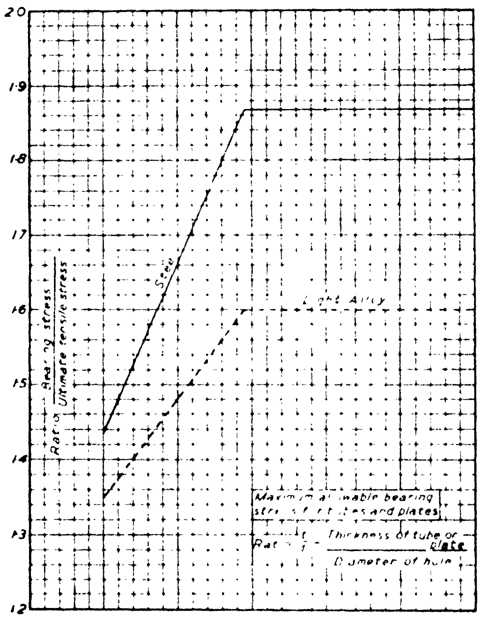
Example of Method of Use.—$\frac{5}{16}$ in. dia bolt bearing in ·2 in. thick L.40.

$$\text{Ratio } \frac{t}{d} = \frac{\cdot 2}{\cdot 31} = \cdot 64.$$

$$\text{Then, bearing ratio} = \frac{\text{Permissible load}}{\text{Bearing area} \times \text{U.T.S. of material}} = 1\cdot 6.$$

∴ Permissible load in bearing $= 1\cdot 6 \times \cdot 31 \times \cdot 2 \times 25 \times 2{,}240$
$= 5{,}600$ lb.

If subject to vibration, strength $= \cdot 7 \times 5{,}600 = 3{,}920$ lb.



Note.—Normal use as above.
·70 of above values to be used for joints subject to severe vibration.

(By courtesy of Hawker Aircraft)

† Strength of S.1 Bolts

(These are conservative figures as used by Hawker Aircraft.)

Ult. Stress 35 tons/in.^{2}

In S.3, T.26 (Ult. Stress 62,720 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,130	1,065	1,015	955	780*	625*	1,760*	1,410*	1,230*	1,050*	780*	625*
¼ in.	1,890	1,735	1,635	1,410*	1,055*	752*	2,345*	1,875*	1,645*	1,410*	1,055*	752*
$\frac{5}{16}$ in.	2,710	2,340*	2,040*	1,760*	1,220*	880*	2,930*	2,340*	2,040*	1,760*	1,220*	885*
⅜ in.	3,525*	2,810*	2,460*	2,020*	1,390*	1,020*	3,525*	2,810*	2,460*	2,020*	1,390*	1,020*

In T.1, T.35, D.T.D.535 (Ult. Stress 78,400 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,130	1,065	1,015	955	835	730	1,765	1,570	1,470	1,300*	975*	780*
¼ in.	1,890	1,735	1,635	1,515	1,300	940*	2,760	2,340*	2,050*	1,760*	1,320*	940*
$\frac{5}{16}$ in.	2,710	2,460	2,290	2,100	1,530*	1,110*	3,665*	2,930*	2,560*	2,200*	1,530*	1,100*
⅜ in.	3,595	3,200	2,980	2,530*	1,740*	1,280*	4,390*	3,520*	3,080*	2,530*	1,740*	1,280*

In T.45, D.T.D.545 (Ult. Stress 100,800. lb/in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,130	1,065	1,015	955	835	730	1,765	1,570	1,470	1,345	1,010	785
¼ in.	1,890	1,735	1,635	1,515	1,300	1,100	2,760	2,445	2,205	1,890	1,415	1,100
$\frac{5}{16}$ in.	2,710	2,460	2,290	2,100	1,765	1,370	3,810	3,135	2,745	2,350	1,765	1,370
⅜ in.	3,595	3,200	2,980	2,745	2,120	1,640*	4,695	3,760	3 290	2,830	2,120	1,640*

* Signifies that bearing in the tube or plate is the strength criterion.

† *By courtesy of Hawker Aircraft.*

Strength of S.1 Bolts—*continued*

In T.50, D.T.D.199, D.T.D.166, T.2, etc. (Ult. Stress>101,400 lb./in.²)

Da.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,130	1,065	1,015	955	835	730	1,765	1,570	1,470	1,345	1,010	785
¼ in.	1,890	1,735	1,635	1,515	1,300	1,100	2,760	2,445	2,205	1,890	1,415	1,100
$\frac{5}{16}$ in.	2,710	2,460	2,290	2,100	1,765	1,370	3,810	3,135	2,745	2,350	1,765	1,370
⅜ in.	3,595	3,200	2,980	2,745	2,120	1,650	4,695	3,760	3,290	2,820	2,120	1,650

In L.3, D.T.D.390 (Ult. Stress 56,000 lb./in.²)

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,130	1,060*	930*	795*	596*	465*	1,330*	1,060*	930*	795*	596*	465*
¼ in.	1,790*	1,430*	1,255*	1,075*	805*	590*	1,790*	1,430*	1,255*	1,075*	805*	590*
$\frac{5}{16}$ in.	2,240*	1,790*	1,570*	1,340*	955*	710*	2,240*	1,790*	1,570*	1,340*	955*	710*
⅜ in.	2,690*	2,150*	1,880*	1,560*	1,110*	830*	2,690*	2,150*	1,880*	1,560*	1,110*	830*

In T.4 (Ult. Stress 58,240 lb./in.²)

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G	14 G	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,130	1,065	975*	835*	620*	495*	1,395*	1,115*	975*	835*	620*	495*
¼ in.	1,860*	1,490*	1,305*	1,120*	838*	600*	1,860*	1,490*	1,305*	1,120*	838*	600*
$\frac{5}{16}$ in.	2,325*	1,855*	1,620*	1,395*	990*	740*	2,325*	1,855*	1,620*	1,395*	990*	740*
⅜ in.	2,800*	2,240*	1,950*	1,630*	1,150*	865*	2,800*	2,240*	1,950*	1,630*	1,150*	865*

* Signifies that bearing in the tube or plate is the strength criterion.

† STRENGTH OF S.2 BOLTS

Ult. Stress 55 tons/in.^{2}

In S.3, T.26 (Ult. Stress 62,720 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,760*	1,405*	1,230*	1,050*	780*	625*	1,760*	1,405*	1,230*	1,050*	780*	625*
$\frac{1}{4}$ in.	2,340*	1,875*	1,645*	1,400*	1,050*	753*	2,340*	1,875*	1,645*	1,400*	1,050*	753*
$\frac{5}{16}$ in.	2,930*	2,340*	2,050*	1,760*	1,220*	885*	2,930*	2,340*	2,050*	1,760*	1,220*	885*
$\frac{3}{8}$ in.	3,510*	2,810*	2,460*	2,020*	1,390*	1,020*	3,510*	2,810*	2,460*	2,020*	1,390*	1,020*

In T.1, T.35, D.T.D.535 (Ult. Stress 78,400 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,775	1,675	1,530*	1,310*	970*	770*	2,190*	1,750*	1,530*	1,310*	970*	770*
$\frac{1}{4}$ in.	2,930*	2,340*	2,050*	1,760*	1,315*	940*	2,930*	2,340*	2,050*	1,760*	1,315*	940*
$\frac{5}{16}$ in.	3,660*	2,930*	2,560*	2,200*	1,530*	1,110*	3,660*	2,930*	2,560*	2,200*	1,530*	1,100*
$\frac{3}{8}$ in.	4,390*	3,520*	3,080*	2,520*	1,740*	1,280*	4,390*	3,520*	3,080*	2,520*	1,740*	1,280*

In T.45, D.T.D.545 (Ult. Stress 100,800 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,775	1,675	1,595	1,500	1,250*	1,005*	2,775	2,260*	1,975*	1,685*	1,250*	1,005*
$\frac{1}{4}$ in.	2,970*	2,725	2,570	2,260*	1,695*	1,205*	3,780*	3,010*	2,640*	2,260*	1,695*	1,205*
$\frac{5}{16}$ in.	4,260	3,760*	3,280*	2,830*	1,960*	1,420*	4,710*	3,670*	3,280*	2,830*	1,960*	1,420*
$\frac{3}{8}$ in.	5,650*	4,500*	3,960*	3,250*	2,230*	1,640*	5,660*	4,500*	3,960*	3,250*	2,230*	1,640*

* Signifies that bearing in the tube or plate is the strength criterion.
† *By courtesy of Hawker Aircraft.*

STRENGTH OF S.2 BOLTS—*continued*

In T.50 (Ult. Stress 112,000 lb./in.^{2})

Dia.	14 G.	16 G.	17 G	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,775	1,675	1,595	1,500	1,315	1,085*	2,775*	2,465	2,170*	1,860*	1,395*	1,085*
¼ in.	2,970	2,725	2,570	2,380	1,880*	1,340*	4,190*	3,350*	2,930*	2,510*	1,880*	1,340*
$\frac{5}{16}$ in.	4,260	3,865	3,600	3,150*	2,180*	1,580*	5,230*	4,190*	3,660*	3,150*	2,180*	1,580*
⅜ in.	5,650	5,030	4,400*	3,600*	2,480*	1,825*	6,270*	5,030*	4,400*	3,600*	2,480*	1,825*

In D.T.D.166B (Ult. Stress 116,480 lb./in.^{2})

Dia.	14 G.	16 G	17 G	18 G.	20 G.	22 G.	14 G.	16 G	17 G	18 G	20 G.	22 G.
2 B.A.	1,775	1,675	1,595	1,500	1,315	1,130*	2,775	2,465	2,260*	1,940*	1,450*	1,130*
¼ in.	2,970	2,725	2,570	2,380	1,960*	1,400*	4,335	3,480*	3,060*	2,610*	1,960*	1,400*
$\frac{5}{16}$ in.	4,260	3,865	3,600	3,280*	2,270*	1,640*	5,450*	4,360*	3,810*	3,280*	2,270*	1,640*
⅜ in.	5,650	5,030	4,580*	3,740*	2,580*	1,900*	6,530*	5,240*	4,580*	3,740*	2,580*	1,900*

In L.3, D.T.D.390 (Ult. Stress 56,000 lb. in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G	20 G.	22 G.
2 B.A.	1,320*	1,060*	930*	795*	596*	465*	1,320*	1,060*	930*	795*	596*	465*
¼ in.	1,790*	1,430*	1,255*	1,075*	805*	594*	1,790*	1,430*	1,255*	1,075*	805*	594*
$\frac{5}{16}$ in.	2,240*	1,790*	1,570*	1,340*	955*	710*	2,240*	1,790*	1,570*	1,340*	955*	710*
⅜ in.	2,690*	2,150*	1,880*	1,560*	1,110*	830*	2,690*	2,150*	1,880*	1,560*	1,101*	830*

In T.4 (Ult Stress 58,240 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
2 B.A.	1,375*	1,100*	965*	820*	620*	483*	1,375*	1,100*	965*	820*	620*	483*
¼ in.	1,860*	1,490*	1,300*	1,120*	840*	616*	1,860*	1,490*	1,300*	1,120*	840*	616*
$\frac{5}{16}$ in.	2,330*	1,860*	1,630*	1,400*	995*	740*	2,330*	1,860*	1,630*	1,400*	995*	740*
⅜ in.	2,800*	2,240*	1,955*	1,630*	1,150*	865*	2,800*	2,240*	1,955*	1,630*	1,150*	865*

* Signifies that bearing in the tube or plate is the strength criterion.

† Strength of S.1 Bolts in S.80 or S.2 Ferrules

In T.1 (Ult. Stress 78,400 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G	16 G	17 G.	18 G.	20 G.	22 G.
$\frac{1}{4}$ in.	2,160	2,040	1,960	1,760*	1,315*	940*						
$\frac{5}{16}$ in.	3,200	2,930*	2,560*	2,200*	1,530*	1,100*						
$\frac{3}{8}$ in.	4,300	3,520*	3,080*	2,520*	1,740*	1,280*						

In T.45, D.T.D.545 (Ult. Stress 100,800 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
$\frac{1}{4}$ in.	2,160	2,040	1,960	1,850	1,660	1,210*						
$\frac{5}{16}$ in.	3,200	2,950	2,830	2,650	1,960*	1,420*						
$\frac{3}{8}$ in.	4,300	4,000	3,730	3,240*	2,240*	1,460*						

In T.50, D.T.D.199 (Ult. Stress 112,000 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
$\frac{1}{4}$ in.	2,160	2,040	1,960	1,850	1,660	1,340*						
$\frac{5}{16}$ in.	3,200	2,950	2,830	2,650	2,180*	1,580*						
$\frac{3}{8}$ in.	4,300	4,000	3,730	3,450	2,480*	1,825*						

* Indicates that bearing in the tube or plate is the strength criterion.

† *By courtesy of Hawker Aircraft.*

Strength of S.1 Bolts in S.80 or S.2 Ferrules—*continued*

In D.T.D.166B (Ult. Stress 116,480 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
¼ in.	2,160	2,040	1,960	1,850	1,660	1,400*						
5/16 in.	3,200	2,950	2,830	2,650	2,270*	1,640*						
⅜ in.	4,300	4,000	3,730	3,450	2,580*	1,900*						

In T.4 (Ult. Stress 58,240 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
¼ in.	1,860*	1,490*	1,300*	1,120*	840*	616*						
5/16 in.	2,330*	1,860*	1,630*	1,400*	995*	740*						
⅜ in.	2,800*	2,240*	1,955*	1,630*	1,150*	865*						

In L.3, D.T.D.390 (Ult. Stress 56,000 lb./in.^{2})

Dia.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.	14 G.	16 G.	17 G.	18 G.	20 G.	22 G.
¼ in.	1,790*	1,430*	1,255*	1,075*	806*	594*						
5/16 in.	2,240*	1,790*	1,570*	1,340*	956*	710*						
⅜ in.	2,690*	2,150*	1,880*	1,560*	1,110*	835*						

S.2 Bolts in S.80 or S.2 Ferrules

The strength of an S.2 bolt in an S.80 or S.2 ferrule is the same as that of a plain S.2 bolt of the same diameter as the *o/d* of the ferrule.

* Indicates that bearing in the tube or plate is the strength criterion.

† STRENGTH OF L.1 BOLTS

Ult. Stress 25 Tons/in.^{2}

In T.4 (Ult. Stress 58, 240 lb./in.^{2})

Dia.	14 G	16 G	17 G	18 G	20 G	22 G	14 G	16 G	17 G	18 G	20 G	22 G
2 B.A.	807	760	725	682	597	483*	1,260	1,100*	965*	820*	620*	483*
$\frac{1}{4}$ in.	1,350	1,240	1,168	1,072	840*	616*	1,860*	1,490*	1,300*	1,120*	840*	616*
$\frac{5}{16}$ in.	1,940	1,760	1,630*	1,400*	995*	740*	2,330*	1,860*	1,630*	1,400*	995*	740*
$\frac{3}{8}$ in.	2,565	2,240*	1,955*	1,630*	1,150*	865*	2,800*	2,240*	1,955*	1,630*	1,150*	865*

In L.3, D.T.D.390 (Ult. Stress 56,000 lb./in.^{2})

Dia.	14 G	16 G	17 G	18 G	20 G	22 G	14 G	16 G	17 G	18 G	20 G	22 G
2 B.A.	807	760	725	682	596*	465*	1,260	1,060*	930*	795*	596*	465*
$\frac{1}{4}$ in.	1,350	1,240	1,168	1,072	805*	594*	1,790*	1,430*	1,255*	1,075*	805*	594*
$\frac{5}{16}$ in.	1,940	1,760	1,570*	1,340*	955*	710*	2,240*	1,790*	1,570*	1,340*	955*	710*
$\frac{3}{8}$ in.	2,565	2,240*	1,880*	1,560*	1,110*	830*	2,690*	2,150*	1,880*	1,560*	1,110*	830*

* Signifies that bearing in the tube or plate is the strength criterion.

† *By courtesy of Hawker Aircraft.*

STRENGTH OF L.1 BOLTS—*continued*

In D.T.D.460 (Ult. Stress 49,280 lb./in.^{2})

Dia.	14 G	16 G	17 G	18 G	20 G	22 G	14 G	16 G	17 G	18 G	20 G	22 G
2 B.A.	807	760	725	682	525*	409*	1,160*	932*	820*	700*	525*	409*
$\frac{1}{4}$ in.	1,350	1,240	1,105*	946*	709*	522*	1,575*	1,260*	1,105*	946*	709*	522*
$\frac{5}{16}$ in.	1,940	1,575*	1,380*	1,180*	840*	625*	1,970*	1,575*	1,380*	1,180*	840*	625*
$\frac{3}{8}$ in.	2,365*	1,890*	1,650*	1,370*	977*	730*	2,365*	1,890*	1,650*	1,370*	977*	730*

In D.T.D.464 (Ult. Stress 62,720 lb./in.^{2})

Dia.	14 G	16 G	17 G	18 G	20 G	22 G	14 G	16 G	17 G	18 G	20 G	22 G
2 B.A.	807	760	725	682	597	520*	1,260	1,120	1,010	890*	667*	520*
$\frac{1}{4}$ in.	1,350	1,240	1,168	1,072	901*	665*	1,970	1,600*	1,405*	1,205*	901*	665*
$\frac{5}{16}$ in.	1,940	1,760	1,640	1,500*	1,070*	795*	2,505*	2005*,	1,760*	1,500*	1,070*	795*
$\frac{3}{8}$ in.	2,565	2,285	2,100*	1,750*	1,240*	930*	3,010*	2,410*	2,100*	1,750*	1,240*	930*

* Signifies that bearing in the tube or plate is the strength criterion.

TABLES SHOWING WEIGHT, AREA, MOMENTS OF INERTIA, SECTION MODULI AND RADII OF GYRATION OF ROUND TUBE SECTIONS

$A=\pi t(D-t)$ $\qquad I=\frac{\pi}{64}(D^4-d^4)$ $\qquad k=\sqrt{\frac{I}{A}}=\sqrt{\frac{D^2-d^2}{4}}$

$Z=\frac{\pi}{32}\left(\frac{D^4-d^4}{D}\right)$ $\qquad$ W = lb. per foot (steel tubes).

Outside dia.		⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.	1⅜ in.	1½ in.	1⅝ in.
24 Gauge ·022 in.	W	0·0840	0·1133	0·1426	0·1719	0·2002	0·2295	0·2588	0·2881	0·3172	0·3465	0·3768
	A	0·0244	0·0339	0·0417	0·0503	0·0590	0·0676	0·0762	0·0849	0·0935	0·1024	0·1108
	I	0·00038	0·0010	0·0019	0·0033	0·0054	0·0081	0·0116	0·0161	0·0215	0·0279	0·0356
	Z	0·0020	0·0039	0·0061	0·0089	0·0123	0·0162	0·0207	0·0257	0·0313	0·0373	0·0438
	k	0·1250	0·1691	0·2133	0·2575	0·3017	0·3458	0·3900	0·4342	0·4784	0·5226	0·5668
22 Gauge ·028 in.	W	0·1037	0·1410	0·1785	0·2157	0·2533	0·2907	0·3281	0·3655	0·4029	0·4403	0·4777
	A	0·0305	0·0415	0·0525	0·0635	0·0745	0·0855	0·0965	0·1075	0·1185	0·1295	0·1405
	I	0·00046	0·00116	0·0023	0·0042	0·0067	0·0101	0·0415	0·0201	0·0269	0·0351	0·0448
	Z	0·0025	0·0045	0·0075	0·0112	0·0153	0·0202	0·0258	0·0321	0·0391	0·0468	0·0552
	k	0·1230	0·1672	0·2113	0·2555	0·2998	0·3437	0·3880	0·4322	0·4762	0·5205	0·5647
20 Gauge ·036 in.	W	0·1301	0·1782	0·2264	0·2744	0·3223	0·3706	0·4185	0·4555	0·5148	0·5627	0·6110
	A	0·0383	0·0524	0·0666	0·0807	0·0948	0·1090	0·1231	0·1372	0·1514	0·1655	0·1797
	I	0·00056	0·0014	0·0029	0·0050	0·0083	0·0127	0·0183	0·0254	0·0340	0·0442	0·0567
	Z	0·0030	0·0058	0·0093	0·0135	0·0190	0·0254	0·0326	0·0407	0·0495	0·0592	0·0698
	k	0·1205	0·1645	0·2086	0·2528	0·2969	0·3410	0·3852	0·4925	0·4736	0·5176	0·5621
18 Gauge ·048 in.	W	0·1676	0·2319	0·2968	0·3601	0·4240	0·4882	0·5522	0·6164	0·6803	0·7446	0·8085
	A	0·0943	0·0682	0·0870	0·1059	0·1247	0·1436	0·1624	0·1813	0·2001	0·2190	0·2378
	I	0·00067	0·0018	0·0037	0·0065	0·0107	0·0163	0·0236	0·0328	0·0440	0·0577	0·0740
	Z	0·0036	0·0072	0·0117	0·0175	0·0245	0·0326	0·0419	0·0524	0·0641	0·0770	0·0911
	k	0·1167	0·1606	0·2048	0·2486	0·2928	0·3370	0·3812	0·4253	0·4694	0·5135	0·5580

TABLES SHOWING WEIGHT, AREA, MOMENTS OF INERTIA, SECTION MODULI AND RADII OF GYRATION OF ROUND TUBE SECTIONS—*continued*

Outside dia.		3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.	1 in.	1 1/8 in.	1 1/4 in.	1 3/8 in.	1 1/2 in.	1 5/8 in.
17 Gauge ·056 in.	W	0·1907	0·2655	0·3403	0·4150	0·4897	0·5644	0·6392	0·7140	0·7888	0·8636	0·9384
	A	0·0561	0·0781	0·1001	0·1221	0·1441	0·1660	0·1880	0·2100	0·2320	0·2540	0·2760
	I	0·00076	0·0019	0·0041	0·0074	0·0121	0·0185	0·0269	0·0376	0·0506	0·0663	0·0851
	Z	0·0039	0·0078	0·0131	0·0197	0·0277	0·0371	0·0479	0·0601	0·0736	0·0884	0·1047
	k	0·1140	0·1582	0·2022	0·2460	0·2900	0·3342	0·3784	0·4226	0·4666	0·5109	0·5551
16 Gauge ·064 in.	W	0·2125	0·2980	0·3834	0·4689	0·5544	0·6399	0·7253	0·8108	0·8962	0·9817	1·0672
	A	0·0625	0·0876	0·1128	0·1379	0·1630	0·1882	0·2133	0·2385	0·2636	0·2887	0·3139
	I	0·00082	0·0021	0·0045	0·0082	0·0135	0·0207	0·0301	0·0421	0·0567	0·0746	0·0958
	Z	0·0042	0·0085	0·0144	0·0218	0·0308	0·0414	0·0536	0·0673	0·0826	0·0995	0·1179
	k	0·1122	0·1558	0·1996	0·2436	0·2873	0·3317	0·3758	0·4199	0·4640	0·5080	0·5528
14 Gauge ·08 in.	W			0·4658	0·5726	0·6794	0·7862	0·8930	0·9998	1·1066	1·2134	1·3202
	A			0·1370	0·1684	0·1998	0·2321	0·2626	0·2941	0·3255	0·3569	0·3883
	I			0·0052	0·0096	0·0160	0·0246	0·0361	0·0506	0·0685	0·0903	0·1162
	Z			0·0166	0·0256	0·0365	0·0493	0·0641	0·0809	0·0997	0·1204	0·1430
	k			0·1947	0·2385	0·2821	0·3265	0·3706	0·4146	0·4587	0·5026	0·5472
12 Gauge ·104 in.	W					0·8565	0·9953	1·1341	1·2730	1·4118	1·5506	1·6895
	A					0·2519	0·2927	0·3336	0·3744	0·4152	0·4561	0·4969
	I					0·0191	0·0298	0·0440	0·0620	0·0844	0·1117	0·1445
	Z					0·0436	0·0597	0·0783	0·0994	0·1228	0·1490	0·1778
	k					0·2750	0·3190	0·3630	0·4069	0·4509	0·4950	0·5395
10 Gauge ·128 in.	W							1·3631	1·5339	1·7048	1·8757	2·0466
	A							0·4009	0·4512	0·5014	0·5517	0·6019
	I							0·0506	0·0718	0·0984	0·1308	0·1697
	Z							0·0900	0·1149	0·1431	0·1743	0·2089
	k							0·3554	0·3992	0·4432	0·4872	0·5318

Tables showing Weight, Area, Moments of Inertia, Section Moduli, and Radii of Gyration of Round Tube Sections

$A=\pi t(D-t)$ $\qquad I=\frac{\pi}{64}(D^4-d^4)$ $\qquad k=\sqrt{\frac{I}{A}}=\sqrt{\frac{D^2-d^2}{4}}$

$Z=\frac{\pi}{32}\left(\frac{D^4-d^4}{D}\right)$ $\qquad W$=lb. per foot (steel tubes).

Outside dia.		1¾ in.	1⅞ in.	2 in.	2⅛ in.	2¼ in.	2⅜ in.	2½ in.	2⅝ in.	2¾ in.	2⅞ in.	3 in.
24 Gauge ·022 in.	W	0·4160	0·4353	0·4646	0·4939	0·5232						
	A	0·1194	0·1281	0·1367	0·1455	0·1540						
	I	0·0445	0·0548	0·0667	0·0802	0·0955						
	Z	0·0509	0·0585	0·0667	0·0755	0·0849						
	k	0·6109	0·6552	0·6994	0·7435	0·7877						
22 Gauge ·028 in.	W	0·5157	0·5525	0·5899	0·6273	0·6647	0·7021	0·7395				
	A	0·1515	0·1625	0·1735	0·1845	0·1955	0 2065	0·2175				
	I	0·0562	0·0693	0·0844	0·1015	0·1207	0 1423	0·1661				
	Z	0·0642	0·0740	0·0844	0·0955	0·1073	0·1198	0·1329				
	k	0·6089	0·6531	0 6974	0·7414	0·7856	0·8296	0·8740				
20 Gauge ·036 in.	W	0·6589	0·7069	0·7551	0·8031	0·8510	0·8993	0·9476	0·9955	1·0438		
	A	0·1938	0·2079	0·2221	0·2362	0·2503	0·2645	0·2787	0·2928	0·3070		
	I	0·0711	0·0879	0·1071	0·1289	0·1533	0·1807	0·2115	0·2456	0·2827		
	Z	0·0813	0·0938	0·1071	0·1213	0·1363	0·1522	0·1692	0·1871	0·2056		
	k	0·6060	0·6502	0·6946	0·7384	0·7828	0·8270	0·8711	0·9151	0·9596		
18 Gauge ·048 in.	W	0·8728	0·9367	1·0001	1·0649	1·1291	1·1931	1·2573	1·3212	1·3855	1·4494	1·5137
	A	0·2567	0·2755	0·2944	0·3132	0·3321	0·3509	0·3698	0·3886	0·4075	0·4263	0·4452
	I	0·0931	0·1150	0·1404	0·1690	0·2014	0·2376	0·2780	0·3227	0·3721	0·4261	0·4851
	Z	0·1064	0·1228	0·1404	0·1591	0·1790	0·2001	0·2224	0·2459	0·2706	0·2964	0·3234
	k	0·6020	0·6460	0·6905	0·7343	0·7785	0·8230	0·8670	0·9109	0·9553	0·9994	1·0438

TABLES SHOWING WEIGHT, AREA, MOMENTS OF INERTIA, SECTION MODULI, AND RADII OF GYRATION OF ROUND TUBE SECTIONS—*continued*

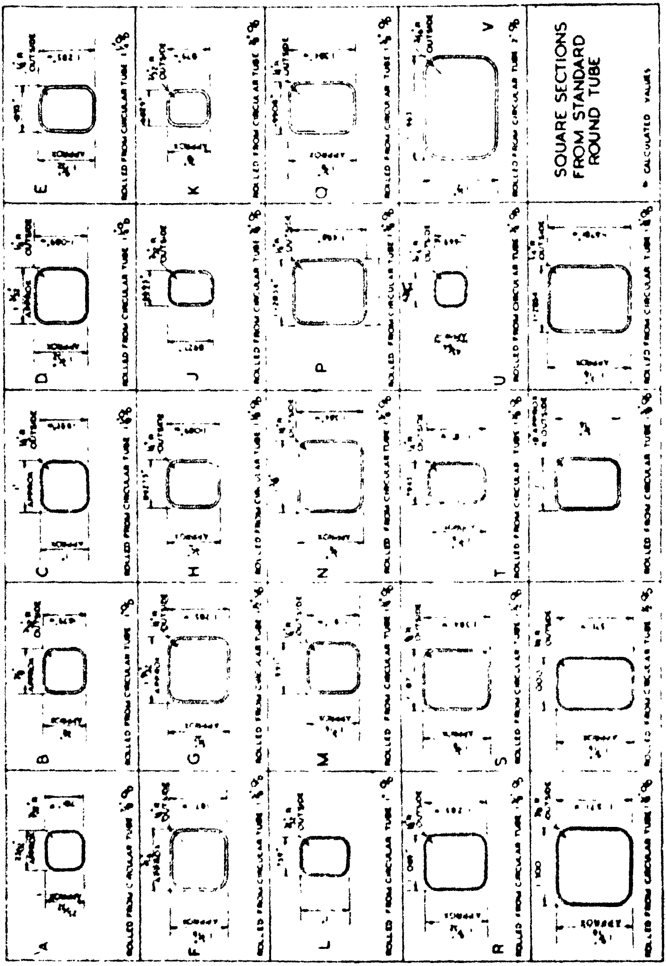
Outside dia.		1¾ in.	1⅞ in.	2 in.	2⅛ in.	2¼ in.	2⅜ in.	2½ in.	2⅝ in.	2¾ in.	2⅞ in.	3 in.
17 Gauge ·056 in.	W	1·0132	1·0878	1·1624	1·2373	1·3121	1·3869	1·4617	1·5365	1·6113	1·6860	1·7605
	A	0·2980	0·3200	0·3419	0·3639	0·3859	0·4079	0·4299	0·4510	0·4739	0·4959	0·5178
	I	0·1070	0·1324	0·1616	0·1949	0·2324	0·2743	0·3212	0·3730	0·4301	0·4927	0·5611
	Z	0·1223	0·1412	0·1616	0·1834	0·2066	0·2310	0·2570	0·2842	0·3128	0·3428	0·3741
	k	0·5992	0·6434	0·6876	0·7317	0·7759	0·8201	0·8643	0·9081	0·5926	0·9967	1·0410
16 Gauge ·064 in.	W	1·1526	1·2381	1·3236	1·4090	1·4945	1·5800	1·6654	1·7509	1·8364	1·9218	2·0073
	A	0·3390	0·3641	0·3893	0·4144	0·4396	0·4647	0·4898	0·5150	0·5401	0·5653	0·5904
	I	0·1208	0·1495	0·1826	0·2203	0·2628	0·3104	0·3635	0·4224	0·4873	0·5585	0·6364
	Z	0·1379	0·1595	0·1826	0·2073	0·2336	0·2614	0·2908	0·3218	0·3544	0·3886	0·4243
	k	0·5964	0·6406	0·6849	0·7288	0·7731	0·8172	0·8613	0·9057	0·9499	0·9939	1·0382
14 Gauge ·08 in.	W	1·4270	1·5337	1·6405	1·7473	1·8541	1·9609	2·0677	2·1745	2·2813	2·3881	2·4949
	A	0·4197	0·4511	0·4825	0·5139	0·5454	0·5768	0·6082	0·6396	0·6710	0·7024	0·7338
	I	0·1466	0·1821	0·2227	0·2691	0·3215	0·3802	0·4456	0·5180	0·5983	0·6863	0·7825
	Z	0·1676	0·1942	0·2227	0·2533	0·2858	0·3202	0·3565	0·3948	0·4351	0·4774	0·5217
	k	0·5910	0·6352	0·6792	0·7235	0·7675	0·8120	0·8558	0·9003	0·9441	0·9885	1·0327
12 Gauge ·104 in.	W	1·8283	1·9672	2·1060	2·2448	2·3837	2·5225	2·6613	2·8002	2·9390	3·0779	3·2167
	A	0·5377	0·5780	0·1694	0·6603	0·7011	0·7419	0·7828	0·8236	0·8644	0·9053	0·9461
	I	0·1830	0·2277	0·2792	0·3380	0·4047	0·4794	0·5627	0·6555	0·7577	0·8701	0·9931
	Z	0·2091	0·2429	0·2792	0·3182	0·3597	0·4037	0·4502	0·4994	0·5511	0·6053	0·6621
	k	0·5830	0·6273	0·6715	0·7155	0·7596	0·8040	0·8477	0·8921	0·9362	0·9804	1·0245
10 Gauge ·128 in.	W	2·2175	2·3884	2·5592	2·7301	2·9100	3·0719	3·2428	3·4137	3·5846	3·7554	3·9263
	A	0·6522	0·7025	0·7527	0·8030	0·8533	0·9035	0·9538	1·0040	1·0543	1·1046	1·1548
	I	0·2158	0·2694	0·3313	0·4019	0·4821	0·5720	0·6726	0·7843	0·9079	1·0439	1·1929
	Z	0·2466	0·2874	0·3313	0·3783	0·4285	0·4817	0·5381	0·5976	0·6603	0·7262	0·7953
	k	0·5752	0·6193	0·6634	0·7075	0·7516	0·7961	0·8398	0·8840	0·9281	0·9722	1·0164

PROPERTIES OF SQUARE SECTIONS

Side of square		Area	k	I
in.	in.			
$1\frac{1}{2}$	1·5	2·250	·434	·423
$1\frac{7}{16}$	1·4375	2·066	·416	·355
$1\frac{3}{8}$	1·375	1·891	·398	·300
$1\frac{5}{16}$	1·3125	1·723	·380	·248
$1\frac{1}{4}$	1·25	1·563	·362	·204
$1\frac{3}{16}$	1·1875	1·410	·343	·166
$1\frac{1}{8}$	1·125	1·266	·325	·1335
$1\frac{1}{16}$	1·0625	1·129	·307	·1060
1	1·00	1·000	·289	·0833
$\frac{15}{16}$	·9375	·879	·271	·0643
$\frac{7}{8}$	·875	·766	·253	·0488
$\frac{13}{16}$	·8125	·660	·235	·0363
$\frac{3}{4}$	·75	·562	·217	·0264
$\frac{11}{16}$	·6875	·473	·199	·0186
$\frac{5}{8}$	·625	·391	·1805	·0127
$\frac{9}{16}$	·5625	·316	·1625	·00835
$\frac{1}{2}$	·500	·250	·1445	·00521
$\frac{7}{16}$	·4375	·1914	·1265	·00305
$\frac{3}{8}$	·375	·1406	·1085	·00165
$\frac{5}{16}$	·3125	·0977	·0903	·00079
$\frac{1}{4}$	·250	·0625	·0723	·00033

k = radius of gyration. I = moment of inertia.

Note. All above values are given in inch units.


SQUARE SECTIONS
FROM STANDARD
ROUND TUBE
* CALCULATED VALUES

PROPERTIES OF RECTANGULAR TUBE SECTIONS (A. STANDARD 183)

Section		22 Gauge		20 Gauge		18 Gauge		17 Gauge		16 Gauge		14 Gauge		12 Gauge	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A	A	0·0745		0·0945		0·1247		0·1441		0·1630		0·1998		0·2519	
	I	0·0065		0·0081		0·0104		0·0115		0·0131		0·0154		0·0183	
	Z	0·0167		0·0208		0·0267		0·0320		0·0335		0·0395		0·0463	
	k	0·2955		0·2920		0·2890		0·2865		0·2835		0·2780		0·2700	
B	A	0·0855		0·1090		0·1436		0·1660		0·1862		0·2312		0·2927	
	I	0·0097		0·0121		0·0157		0·0177		0·0197		0·0234		0·0281	
	Z	0·0221		0·0275		0·0357		0·0402		0·0458		0·0532		0·0638	
	k	0·3370		0·3330		0·3300		0·3265		0·3230		0·3180		0·3100	
C	A	0·0965		0·1231		0·1624		0·1850		0·2133		0·2626		0·3336	
	I	0·0140		0·0176		0·0227		0·0258		0·0288		0·0345		0·0418	
	Z	0·0283		0·0355		0·0458		0·0521		0·0582		0·0698		0·0843	
	k	0·3805		0·3750		0·3735		0·3700		0·3675		0·3625		0·3540	
D	A	0·1075		0·1372		0·1813		0·2100		0·2385		0·2941		0·3744	
	I	0·0192		0·0240		0·0311		0·0355		0·0397		0·0477		0·0582	
	Z	0·0353		0·0442		0·0572		0·0652		0·0729		0·0877		0·1070	
	k	0·4225		0·4150		0·4140		0·4110		0·4080		0·4020		0·3945	
E	A	0·1075	0·1075	0·1372	0·1372	0·1813	0·1813	0·2100	0·2100	0·2385	0·2385	0·2941	0·2941	0·3744	0·3744
	I	0·0240	0·0140	0·0302	0·0176	0·0391	0·0226	0·0449	0·0258	0·0502	0·0288	0·0605	0·0343	0·0742	0·0415
	Z	0·0374	0·0314	0·0470	0·0395	0·0609	0·0505	0·0699	0·0578	0·0752	0·0645	0·0943	0·0770	0·1156	0·0929
	k	0·4720	0·3615	0·4690	0·3585	0·4640	0·3530	0·4625	0·3505	0·4585	0·3475	0·4530	0·3420	0·4450	0·3330
F	A	0·1185		0·1514		0·2001		0·2320		0·2636		0·3255		0·4152	
	I	0·0252		0·0318		0·0414		0·0473		0·0531		0·0639		0·0784	
	Z	0·0425		0·0536		0·0698		0·0798		0·0895		0·1078		0·1323	
	k	0·4610		0·4580		0·4550		0·4515		0·4490		0·4430		0·4340	
G	A	0·1295		0·1655		0·2190		0·2540		0·2887		0·3569		0·4561	
	I	0·0327		0·0412		0·0535		0·0614		0·0689		0·0834		0·1027	
	Z	0·0509		0·0641		0·0834		0·0956		0·1072		0·1298		0·1595	
	k	0·5025		0·4990		0·4950		0·4915		0·4890		0·4830		0·4740	
H	A	0·0965	0·0965	0·1231	0·1231	0·1624	0·1624	0·1880	0·1880	0·2133	0·2133	0·2626	0·2626	0·3336	0·3336
	I	0·0160	0·0120	0·0201	0·0149	0·0260	0·0193	0·0297	0·0220	0·0332	0·0245	0·0397	0·0292	0·0483	0·0352
	Z	0·0294	0·0269	0·0369	0·0334	0·0478	0·0432	0·0546	0·0492	0·0610	0·0546	0·0729	0·0654	0·0887	0·0788
	k	0·4070	0·3525	0·4040	0·3480	0·4000	0·3445	0·3975	0·3420	0·3945	0·3380	0·3890	0·3335	0·3815	0·3245

A = Area. I = Moment of inertia. Z = Section modulus. k = Radius of gyration.

Note.—The letters at the left-hand side of the Table are stroke items of " A " Standard 183.

(By courtesy of Hawker Aircraft)

PROPERTIES OF RECTANGULAR TUBE SECTIONS (A. STANDARD 183)—*continued*

Section		22 Gauge		20 Gauge		18 Gauge		17 Gauge		16 Gauge		14 Gauge		12 Gauge	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
J	A	0·0745	0·0745	0·0948	0·0948	0·1247	0·1247	0·1441	0·1441	0·1630	0·1630	0·1998	0·1998	0·2519	0·2519
	I	0·0079	0·0051	0·0098	0·0064	0·0127	0·0081	0·0143	0·0091	0·0159	0·0102	0·0188	0·0119	0·0224	0·0140
	Z	0·0177	0·0152	0·0220	0·0191	0·0285	0·0242	0·0320	0·0275	0·0357	0·0305	0·0421	0·0355	0·0502	0·0418
	k	0·3255	0·2615	0·3215	0·2595	0·3165	0·2550	0·3150	0·2525	0·3120	0·2500	0·3070	0·2440	0·2985	0·2355
K	A	0·0745	0·0745	0·0948	0·0948	0·1247	0·1247	0·1441	0·1441	0·1630	0·1630	0·1998	0·1998	0·2519	0·2519
	I	0·0077	0·0053	0·0096	0·0066	0·0124	0·0084	0·0140	0·0095	0·0156	0·0105	0·0184	0·0123	0·0220	0·0145
	Z	0·0176	0·0156	0·0219	0·0194	0·0282	0·0247	0·0319	0·0279	0·0355	0·0308	0·0418	0·0361	0·0500	0·0425
	k	0·3215	0·2670	0·3180	0·2640	0·3140	0·2595	0·3115	0·2565	0·3095	0·2540	0·3035	0·2450	0·2955	0·2400
L	A	0·0855	0·0855	0·1090	0·1090	0·1436	0·1436	0·1660	0·1660	0·1882	0·1882	0·2312	0·2312	0·2927	0·2927
	I	0·0116	0·0077	0·0146	0·0096	0·0189	0·0124	0·0213	0·0140	0·0238	0·0156	0·0284	0·0184	0·0342	0·0219
	Z	0·0232	0·0203	0·0292	0·0253	0·0378	0·0327	0·0426	0·0369	0·0476	0·0411	0·0568	0·0484	0·0684	0·0577
	k	0·3680	0·3000	0·3655	0·2970	0·3625	0·2940	0·3580	0·2905	0·3555	0·2880	0·3505	0·2820	0·3420	0·2735
M	A	0·1075	0·1075	0·1372	0·1372	0·1813	0·1813	0·2100	0·2100	0·2385	0·2385	0·2941	0·2941	0·3744	0·3744
	I	0·0216	0·0165	0·0272	0·0208	0·0352	0·0269	0·0403	0·0305	0·0451	0·0343	0·0542	0·0411	0·0664	0·0498
	Z	0·0364	0·0333	0·0458	0·042	0·0593	0·0544	0·0680	0·0616	0·0761	0·0693	0·0914	0·0830	0·1120	0·1006
	k	0·4480	0·3915	0·4450	0·3890	0·4405	0·3850	0·4350	0·3810	0·4345	0·3755	0·4300	0·3730	0·4210	0·3645
N	A	0·1405		0·1797		0·2378		0·2760		0·3139		0·3883		0·4969	
	I	0·0414		0·0523		0·0681		0·0782		0·0880		0·1066		0·1319	
	Z	0·0598		0·0756		0·0935		0·1130		0·1273		0·1540		0·1907	
	k	0·5430		0·5390		0·5350		0·5320		0·5290		0·5240		0·5160	
P	A	0·1405	0·1405	0·1797	0·1797	0·2378	0·2378	0·2760	0·2760	0·3139	0·3139	0·3883	0·3883	0·4969	0·4969
	I	0·0457	0·0370	0·0577	0·0468	0·0753	0·0609	0·0863	0·0698	0·0971	0·0784	0·1178	0·0946	0·1463	0·1171
	Z	0·0616	0·0575	0·0780	0·0728	0·1018	0·0946	0·1165	0·1085	0·1310	0·1220	0·1590	0·1472	0·1975	0·1820
	k	0·5710	0·5130	0·5665	0·5100	0·5630	0·5060	0·5590	0·5035	0·5560	0·5000	0·5500	0·4930	0·5420	0·4850
Q	A	0·1185	0·1185	0·1514	0·1514	0·2001	0·2001	0·2320	0·2320	0·2636	0·2636	0·3255	0·3255	0·4152	0·4152
	I	0·0313	0·0191	0·0395	0·0240	0·0513	0·0311	0·0588	0·0355	0·0659	0·0396	0·0799	0·0475	0·0983	0·0577
	Z	0·0453	0·0386	0·0571	0·0484	0·0743	0·0625	0·0850	0·0716	0·0954	0·0799	0·1156	0·0904	0·1422	0·1166
	k	0·5140	0·4010	0·5100	0·3980	0·5060	0·3940	0·5030	0·3910	0·5000	0·3880	0·4590	0·3830	0·4865	0·3725
R	A	0·1185	0·1185	0·1514	0·1514	0·2001	0·2001	0·2320	0·2320	0·2636	0·2636	0·3255	0·3255	0·4152	0·4152
	I	0·0283	0·0222	0·0357	0·0279	0·0463	0·0362	0·0531	0·0414	0·0596	0·0463	0·0719	0·0556	0·0885	0·0681
	Z	0·0441	0·0408	0·0556	0·0512	0·0721	0·0665	0·0827	0·0760	0·0929	0·0850	0·1120	0·1022	0·1379	0·1250
	k	0·4890	0·4330	0·4855	0·4290	0·4800	0·4250	0·4785	0·4220	0·4760	0·4190	0·4700	0·4120	0·4610	0·4040

A = Area. I = Moment of inertia. Z = Section modulus. k = Radius of gyration.

Note.—The letters at the left-hand side of the table are stroke items of "A" Standard 183.

Properties of Rectangular Tube Sections (A. Standard 183)—*continued*

Section		22 Gauge		20 Gauge		18 Gauge		17 Gauge		16 Gauge		14 Gauge		12 Gauge	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
S	A	0·1295	0·1295	0·1655	0·1655	0·2190	0·2190	0·2540	0·2540	0·2887	0·2887	0·3569	0·3569	0·4561	0·4561
	I	0·0363	0·0290	0·0459	0·0366	0·0598	0·0475	0·0654	0·0544	0·0768	0·0610	0·0930	0·0735	0·1150	0·0904
	Z	0·0524	0·0489	0·0665	0·0618	0·0864	0·0801	0·0985	0·0916	0·1110	0·1029	0·1342	0·1240	0·1662	0·1524
	k	0·5300	0·4735	0·5260	0·4700	0·5230	0·4660	0·5190	0·4635	0·5150	0·4590	0·5100	0·4540	0·5020	0·4450
T	A	0·0965	0·0965	0·1231	0·1231	0·1624	0·1624	0·1880	0·1880	0·2133	0·2133	0·2626	0·2626	0·3336	0·3336
	I	0·0179	0·0100	0·0225	0·0124	0·0290	0·0159	0·0332	0·0180	0·0372	0·0201	0·0446	0·0239	0·0544	0·0285
	Z	0·0302	0·0252	0·0379	0·0312	0·0489	0·0400	0·0559	0·0453	0·0672	0·0505	0·0752	0·0600	0·0918	0·0716
	k	0·4310	0·3215	0·4280	0·3170	0·4230	0·3130	0·4210	0·3096	0·4180	0·3075	0·4120	0·3020	0·4040	0·2925
U	A	0·0635		0·0807		0·1059		0·1221		0·1379		0·1684			
	I	0·0038		0·0048		0·0060		0·0065		0·0075		0·0088			
	Z	0·0114		0·0144		0·0180		0·0203		0·0224		0·0264			
	k	0·2450		0·2438		0·2375		0·2355		0·2330		0·2290			
V	A	0·1735	0·1735	0·2221	0·2221	0·2944	0·2944	0·3419	0·3419	0·3893	0·3893	0·4825	0·4825	0·6194	0·6194
	I	0·0947	0·0638	0·1203	0·0810	0·1576	0·1059	0·1819	0·1215	0·2049	0·1374	0·2506	0·1663	0·3120	0·2070
	Z	0·0962	0·0850	0·1225	0·1080	0·1607	0·1410	0·1852	0·1624	0·2090	0·1835	0·2555	0·2215	0·3180	0·2755
	k	0·7380	0·6060	0·7360	0·6040	0·7310	0·5995	0·7300	0·5975	0·7250	0·5940	0·7210	0·5880	0·7100	0·5765
W	A	0·1515	0·1515	0·1938	0·1938	0·2567	0·2567	0·2980	0·2980	0·3390	0·3390	0·4197	0·4197	0·5377	0·5377
	I	0·0558	0·0521	0·0706	0·0660	0·0922	0·0861	0·1061	0·0989	0·1194	0·1115	0·1450	0·1350	0·1804	0·1678
	Z	0·0711	0·0695	0·0900	0·0880	0·1175	0·1149	0·1351	0·1319	0·1521	0·1487	0·1847	0·1800	0·2295	0·2235
	k	0·6060	0·5860	0·6030	0·5840	0·5990	0·5785	0·5960	0·5760	0·5935	0·5740	0·5880	0·5680	0·5780	0·5585
X	A	0·1295	0·1295	0·1655	0·1655	0·2190	0·2190	0·2540	0·2540	0·2887	0·2887	0·3569	0·3569	0·4561	0·4561
	I	0·0429	0·0220	0·0543	0·0277	0·0708	0·0359	0·0811	0·0409	0·0915	0·0459	0·1105	0·0550	0·1371	0·0671
	Z	0·0546	0·0440	0·0691	0·0554	0·0902	0·0718	0·1034	0·0818	0·1166	0·0918	0·1407	0·1100	0·1747	0·1342
	k	0·5760	0·4125	0·5720	0·4090	0·5690	0·4045	0·5650	0·4015	0·5630	0·3985	0·5560	0·3920	0·5480	0·3830
Y	A	0·1185	0·1185	0·1514	0·1514	0·2001	0·2001	0·2320	0·2320	0·2636	0·2636	0·3255	0·3255	0·4152	0·4152
	I	0·0291	0·0194	0·0367	0·0244	0·0477	0·0315	0·0544	0·0360	0·0613	0·0404	0·0735	0·0483	0·091	0·0589
	Z	0·0444	0·0388	0·0559	0·0488	0·0728	0·0630	0·0830	0·0720	0·0935	0·0808	0·1125	0·0966	0·1388	0·1178
	k	0·4950	0·4040	0·4920	0·4000	0·4880	0·3965	0·4840	0·3940	0·4825	0·3910	0·4765	0·3850	0·4685	0·3760
Z	A	0·1515	0·1515	0·1938	0·1938	0·2567	0·2567	0·2980	0·2980	0·3390	0·3390	0·4197	0·4197	0·5377	0·5377
	I	0·0614	0·0413	0·0777	0·0523	0·1014	0·0679	0·1168	0·0781	0·1313	0·0877	0·1061	0·1062	0·1990	0·1312
	Z	0·0732	0·0643	0·0926	0·0812	0·1209	0·1058	0·1390	0·1217	0·1565	0·1366	0·1909	0·1652	0·2370	0·2040
	k	0·6360	0·5230	0·6335	0·5190	0·6285	0·5145	0·6255	0·5115	0·6230	0·5090	0·6160	0·5030	0·6080	0·4940

A – Area. *I* – Moment of inertia. Z – Section modulus. k – Radius of gyration.

Note.—The letters at the left-hand side of the table are stroke items of "A" Standard 183.

STRENGTH OF T.50 TUBES IN TENSION

(Bolt holes through both sides of tube)

Gauge	Dia. of hole (in.)	3/4 in. Area	3/4 in. Load	7/8 in. Area	7/8 in. Load	1 in. Area	1 in. Load	1.1/8 in. Area	1.1/8 in. Load	1.1/4 in. Area	1.1/4 in. Load	1.3/8 in. Area	1.3/8 in. Load
14 G. ·080 in.	3/16	·1384	15500	1698	19000	2012	22500	2326	26050	2641	29600	2955	33100
	1/4	·1284	14400	1598	17900	1912	21400	2226	24950	2541	28500	2855	32000
	5/16	·1184	13250	·1498	16800	1812	20300	2126	23800	2441	27400	2755	30850
	3/8												
16 G. ·064 in.	3/16	·1139	12750	1390	15600	1642	18400	1893	21200	2145	24050	2396	26800
	1/4	·1059	11850	·1310	14700	1562	17500	1813	20300	2065	23150	2316	25950
	5/16	·0979	10950	1230	13800	1482	16600	·1733	19400	1985	22250	2236	25000
	3/8												
17 G. ·056 in.	3/16	·1011	11300	1231	13800	145	16250	167	18700	189	21200	211	23600
	1/4	094	10500	1161	13000	135	15450	160	17900	·182	20400	204	22850
	5/16	0871	9750	1091	12200	131	14700	153	17100	175	19600	197	22050
	3/8												
20 G. ·036 in.	3/16	0672	7530	0813	9110	0955	10700	1096	12300	1237	13850	1379	15450
	1/4	0627	7020	0768	8600	0910	10200	105	11750	1192	13350	1334	14950
	5/16	0582	6520	0723	8100	0865	9700	1006	11250	1147	12850	1289	14450
	3/8												
22 G. ·028 in.	3/16	·0530	5950	0640	7150	0750	8400	0860	9650	0970	10850	1080	12100
	1/4	·0495	5550	0605	6800	0715	8000	0825	9250	0935	10500	1045	11700
	5/16	·046	5150	0570	6400	0680	7600	0790	8850	0900	10100	1010	11300
	3/8												

Gauge	Dia. of hole (in.)	1.1/2 in. Area	1.1/2 in. Load	1.5/8 in. Area	1.5/8 in. Load	1.3/4 in. Area	1.3/4 in. Load	1.7/8 in. Area	1.7/8 in. Load	2 in. Area	2 in. Load
14 G. ·080 in.	3/16										
	1/4	3169	35500	3483	39000	3797	42500	4111	46000	·4425	49600
	5/16	3069	34400	3383	37900	3697	41400	4011	44900	·4325	48400
	3/8	2969	33250	3283	36800	3597	40250	3911	43800	4225	47300
16 G. ·064 in.	3/16										
	1/4	2567	28750	2819	31550	3070	34400	3321	37200	·3573	40000
	5/16	2487	27850	2739	30650	2990	33500	·3241	36300	3493	39100
	3/8	2407	27000	2659	29800	2910	32600	·3161	35400	3413	38200
17 G. ·056 in.	3/16										
	1/4	226	25300	248	27800	270	30250	292	32700	314	35200
	5/16	219	24550	241	27000	263	29450	285	31900	307	34400
	3/8	212	23750	·234	26200	256	28650	278	31100	300	33600
20 G. ·036 in.	3/16										
	1/4	1475	16500	1617	18100	1758	19700	1899	21250	·2041	22850
	5/16	1430	16000	1572	17600	1713	19200	1854	20750	1996	22350
	3/8	1385	15500	1527	17100	1668	18650	1809	20250	1951	21850
22 G. ·028 in.	3/16	1190	13300	1300	14550	1410	15800	1520	17000	1630	18250
	1/4	1155	12950	1265	14150	·1375	15400	1485	16650	1595	17850
	5/16	·1120	12550	1230	13800	1340	15000	1450	16250	1560	17500
	3/8										

(By courtesy of Hawker Aircraft)

Streamline and Swaged Wires

(*Note.*—Ultimate strength the same for each, size for size.)

Size	Area of oval, sq. in.		Area of swaged portion, sq. in.	Ultimate strength, lb.
	Minimum	Maximum		
4 B.A.	·0071	·0065	·0085	1,050
2 B.A.	·0126	·0142	·0129	1,900
7/32 in.	0174	·0191	·0174	2,600
1/4 in.	·0233	·0250	0230	3,450
9/32 in.	·0314	·0338	·0337	4,650
5/16 in.	·0372	·0400	·0391	5,700
11/32 in.	·0473	·0508	·0495	7,150
3/8 in.	0561	·0603	·0590	8,500
13/32 in.	0683	0734	·0721	10,250
7/16 in.	0778	0836	·0835	11,800
15/32 in.	·0921	0990	0990	13,800
1/2 in.	103	·1107	·1116	15,500
9/16 in.	·139	—	·1400	20,200
5/8 in.	·168	—	·1713	24,700

Strength of Bullivant Standard Cable

Ref.	Construction		Size				Approx. breaking load, lb.
			Inches		Millimetres		
	No. of strands	Wires per strand	Diameter	Circle	Diameter	Circle	
				in.			
A	7	7	·068	3/16	1·7	5	500
B	7	7	·075	1/4	1·9	6	650
C	7	7	088	9/32	2·2	7	1,120
D	7	7	·099	5/16	2·5	8	1,500
E	7	7	·110	12/32	2·8	9	1,680
F	7	7	·115	23/64	2·9	9	1,750
G	7	7	·130	25/64	3·3	10	2,300
H	7	7	·138	27/64	3·5	11	2,450
I	7	7	·140	7/16	3·6	11	2,600
J	7	7	·164	33/64	4·1	13	3,600
K	7	7	·180	37/64	4·6	15	4,500
L	7	7	·210	21/32	5·3	17	6,300
M	7	12	093	19/64	2·4	7	850*
N	7	12	105	5/16	2·7	8	1,200*
O	7	14	·115	11/32	2·9	9	1,500*
P	7	19	·126	13/32	3·2	10	2,000*
Q	7	19	·137	7/16	3·5	11	2,450*
R	7	19	·150	1/2	3·8	12	2,900*
S	7	19	·168	9/16	4·3	14	3,400*
T	7	19	·182	19/32	4·6	15	4,200*
U	7	19	·195	5/8	5·0	16	5,000*
V	7	19	·218	11/16	5·5	17	5,500*
W	7	19	·228	23/32	5·8	18	6,250*
X	7	19	·239	3/4	6·1	19	7,250*
Y	7	19	·262	13/16	6·7	21	8,500*
Z	7	19	·270	27/32	6·9	22	9,600*
Z1	7	19	·305		7·7	25	11,000*

* Extra flexible.

Steel Wire Straining Cords

Specification item No.	Minimum breaking load, lb.	No. of strands	Maximum diameter of cord	Maximum Weight, lb. per 100 ft.
41	1,120	1	0·09	1·7
42	1,680	1	0·11	2·5
43	2,240	1	0·13	3·3
44	2,800	1	0·14	4·1
45	3,920	1	0·17	5·8
46	5,040	1	0·20	7·5
47	6,720	1	0·22	9·9
48	8,400	1	0·25	12·7
49	10,080	1	0·27	15·0
71	11,760	1	0·30	18·5
72	13,440	1	0·32	21·8
73	15,120	1	0·35	24·3
74	16,800	7	0·40	26·6
75	18,480	7	0·41	29·2
76	20,160	7	0·44	33·4
77	16,800	1	0·36	27·0
78	18,480	1	0·38	30·0
79	20,160	1	0·40	32·0

British Standards Specification 5.W.2

Flexible Steel Wire Rope

Specification Item No.	Minimum breaking load, lb.	No. of strands	Maximum diameter of rope	Maximum weight, lb. per 100 ft.
1	336	4	0·06	0·63
2	560	4	0·08	1·00
4	560	7	0·08	1·11
5	1,120	7	0·12	2·22
6	1,680	7	0·15	3·75
3	2,240	7	0·16	4·50
51	2,800	7	0·18	5·4
52	3,920	7	0·21	7·0
53	5,040	7	0·24	9·0
54	6,720	7	0·27	11·9
55	7,840	7	0·28	13·2
56	8,960	7	0·31	16·4
57	11,200	7	0·34	19·8
58	13,440	7	0·40	26·2
59	15,680	7	0·42	29·2
60	17,920	7	0·44	32·5

British Standard Specifications 5.W.2.

SPRINGS *

Round Wire Springs.—

Deflection of spring under load $= \dfrac{64Pr^3n}{Gd^4}$.

Maximum shearing stress $= \dfrac{16Prk}{\pi d^3}$.

Load on spring, P $= \dfrac{\pi d^3S}{16rK}$.

Square Wire Springs.—

Deflection of spring under load $= \dfrac{44 \cdot 5Pr^3n}{Gb}$.

Maximum shearing stress $= \dfrac{4 \cdot 8PrK}{b^3}$.

Load on spring, P $= \dfrac{Sb^3}{4 \cdot 8rK}$.

where b = length of side of square spring wire.
d = diameter of round spring wire.
r = mean radius of spring.
n = number of active turns.
G = torsional modulus of elasticity in lb./sq. in.
K = $\dfrac{4C-1}{4C-4} + \dfrac{\cdot 615}{C}$.
C = $2r/d$ for round wire.
= $2r/b$ for square wire.

* Handbook of Aeronautics, Vol. III.

BRINELL HARDNESS NUMBERS * (3,000 Kg. load.)

Diameter of impression in mm.	Brinell hardness number	Approx. tensile stress of steel, tons per sq. in.	Diameter of impression in mm.	Brinell hardness number	Approx. tensile stress of steel, tons per sq. in.
2·00	946	206·0	4·85	152	34·2
2·05	899	196·0	4·90	149	33·8
2·10	857	187·0	4·95	146	33·3
2·15	816	178·0	5·00	142	32·7
2·20	779	171·0	5·05	139	32·0
2·25	745	162·0	5·10	136	31·3
2·30	712	155·0	5·15	134	30·9
2·35	681	149·0	5·20	131	30·2
2·40	654	142·0	5·25	128	29·5
2·45	626	136·0	5·30	126	29·0
2·50	601	131·0	5·35	123	28·4
2·55	577	126·0	5·40	121	27·9
2·60	555	121·0	5·45	118	27·5
2·65	534	116·1	5·50	116	26·5
2·70	514	112·0	5·55	113	26·0
2·75	495	107·9	5·60	111	25·5
2·80	477	104·8	5·65	109	25·0
2·85	460	100·2	5·70	107	24·5
2·90	444	96·8	5·75	105	24·0
2·95	429	94·0	5·80	103	23·5
3·00	415	91·0	5·85	101	23·0
3·05	401	88·0	5·90	99·2	22·75
3·10	388	85·2	5·95	97·3	22·5
3·15	375	82·3	6·00	95·5	22·0
3·20	363	79·1	6·05	93·7	21·5
3·25	352	76·8	6·10	92·0	21·0
3·30	341	74·4	6·15	90·3	20·75
3·35	331	72·2	6·20	88·7	20·5
3·40	321	70·0	6·25	87·1	20·0
3·45	311	67·8	6·30	85·5	19·75
3·50	302	65·8	6·35	84·0	19·25
3·55	293	63·0	6·40	82·9	19·0
3·60	285	61·3	6·45	81·0	18·75
3·65	277	59·6	6·50	79·6	18·25
3·70	269	57·8	6·55	78·2	17·75
3·75	262	56·4	6·60	76·8	17·5
3·80	255	54·8	6·65	75·4	17·25
3·85	248	53·4	6·70	74·1	17·0
3·90	241	51·8	6·75	72·8	16·75
3·95	235	51·0	6·80	71·6	16·5
4·00	229	50·8	6·85	70·4	16·25
4·05	223	50·2	6·90	69·0	16·0
4·10	217	48·8	6·95	68·0	15·75
4·15	212	47·7			
4·20	206	46·4			
4·25	201	45·3			
4·30	197	44·2			
4·35	192	43·2			
4·40	187	42·2			
4·45	183	41·2			
4·50	178	40·3			
4·55	174	39·2			
4·60	170	38·3			
4·65	166	37·4			
4·70	163	36·6			
4·75	159	35·8			
4·80	156	35·1			

Material	Specification	Brinell hardness number
Low tensile steel	B.S.S. S.1	155
Med. tensile steel	B.S.S. S.65	300
High tensile steel	D.T.D.115	410
Aluminium	—	—
R. R. alloy	D.T.D.184	120
Duralumin	B.S.S. L.1	80
—	D.T.D.194	75
—	D.T.D.259	60
—	D.T.D.155	140

* John Brown & Co., Ltd.

SECTION VII

STRUCTURES

UNITS

From the Fundamental C.G.S. (*Centimetre-Gramme-Second*) Units of length, mass and time, are derived the other units in the table. The British Practical System and its relation to the C.G.S. system is given in the last column.

Unit of	C.G.S. system	British practical system
Length	1 centimetre (cm.)	1 foot (ft.) = 30·47997 cms.
Mass . . .	1 gramme (grm.)	1 pound (lb.) = 453·5924 grms.
Time	1 second (sec.)	1 second (sec.).
Force . .	1 dyne	1 poundal = 13,825·483 dynes.
Work or energy .	1 erg	1 ft. lb. = 13,565,149 15 Ergs (for $g = 981·17$).
Power or activity .	1 erg per sec.	1 ft. lb. per sec.
Velocity . . .	1 cm. per sec.	1 ft. per sec.
Acceleration	1 cm. per sec. per sec.	1 ft. per sec. per sec.
g *at London . .	981·17 cms. per sec. per sec.	32·1912 ft. per sec. per sec.

The C.G.S. Units are frequently termed " absolute " units.

One pound $= g \times$ poundals.

The *Dyne* is the force which, acting upon a gramme for 1 second gives it a velocity of 1 centimetre per second.

The *Erg* is the work done by a dyne working through a distance of 1 centimetre.

Acceleration is the time rate of increase of velocity Unit acceleration is the acceleration of a body whose velocity or speed increases in each second by 1 centimetre per second.

* g = Acceleration of gravity.

The following values of g are calculated from Helmert's formula for results at sea level. Here L = Latitude.

$$g = 980·617(1 - ·002644 \cos 2L + ·000007 \cos^2 2L)$$

Approximate Rule.—Subtract ·01 from g for every 33 metres of height above sea level, but add same if below sea level.

VALUES OF g AT SEA LEVEL AND GIVEN LATITUDES

System	L = 0°	L = 10°	L = 20°	L = 30°	L = 40°	L = 50°	L = 60°
British .	32·088	32·095	32·108	32·130	32·159	32·187	32·215
C.G.S. .	978·03	978·24	978·63	979·32	980·18	981·06	981·91

NEWTON'S LAWS OF MOTION (abbreviated)

(1) The state of rest or of uniform, straight-line motion in bodies remains unchanged unless impressed by force.

(2) Change of motion is proportional to, and in the direction of, the impressed force.

(3) To every action there is an equal reaction, *e.g.* a moving body resists the impressed force causing its motion.

t = Units of time (seconds); u = Initial velocity; v = Final velocity; s = Space traversed; f = Rate of acceleration or retardation.

Uniform motion	Accelerated motion	Retarded motion	Falling bodies
$t = \frac{s}{u}$	$t = \frac{v-u}{f} = \frac{2s}{u+v}$	$t = \frac{u-v}{f} = \frac{2s}{u+v}$	$t = \frac{v}{g} = \frac{2s}{v} = \sqrt{\frac{2s}{g}}$
$u = \frac{s}{t}$	$u = v - ft = \frac{2s}{t} - v$	$u = v + ft = \frac{2s}{t} - v$	$u = 0$
$v = u$	$v = u + ft = \frac{2s}{t} - u$	$v = u - ft = \frac{2s}{t} - u$	$v = gt = \frac{2s}{t} = \sqrt{2gs}$
$s = ut$	$s = ut + \frac{1}{2}ft^2 = \frac{1}{2}t(u+v)$	$s = ut - \frac{1}{2}ft^2 = \frac{1}{2}t(u+v)$	$s = \frac{1}{2}gt^2 = \frac{1}{2}tv = \frac{v^2}{2g}$
$f = 0$	$f = \frac{v-u}{t}$	$f = \frac{u-v}{t}$	$f = \frac{v}{t} = g$

g = Acceleration of gravity = 32·2 feet or 981 centimetres, or 9·81 metres per sec. per. sec. For closer definition of the value of g see "Pendulum."

Average velocity $= \frac{1}{2}(u+v)$.

Space traversed during the nth second $= u + f(n - \frac{1}{2})$.

Force, Acceleration, and Mass

In the fundamental formulæ connecting force, mass, acceleration, and energy the unit of force $\times g$ is equal to the unit of mass ; thus g dynes equal one gramme and g poundals equal one pound in the C.G.S. system and the F.P.S. system respectively (p. 19). However, engineers usually prefer to express both force and mass in pound units, which involves including the value of g in the formulæ (usually taken as 32·2, F.P.S. system).

Symbols Used –

F = Force in lb.	W = Mass in lb.
f = Acceleration, ft./sec./sec.	D = Distance in feet.

v, u, and t are as defined above.

By the second law of motion, $F = Wf \div g$
and $f = Fg \div W$.

The formulæ on the preceding page express the fact that the acceleration produced is proportional to the applied force and inversely proportional to the mass accelerated.

Work, Energy, and Momentum

The work done by a force is the product of the force and the distance through which it acts measured in the direction of action of the force. Thus absolute units of work are the foot-poundal (F.P.S. system) and the dyne-cm. or erg (C.G.S. system). The engineer's unit is the foot-pound, = F $\times s = g$ foot-poundals.

Kinetic Energy is the energy possessed by a body in virtue of its motion. For uniformly accelerated motion the change of kinetic energy is equal to the work done by impressed force.

$$\text{Kinetic energy} = \frac{Wv^2}{2g} \text{ (ft.-lb.).}$$

$$\text{Hence } Fs = \frac{Wv^2}{2g} - \frac{Wu^2}{2g} = \frac{W}{2g}(v^2 - u^2).$$

Potential Energy is the energy possessed by a body in virtue of its position. In falling through a height s a body of mass W will lose Ws foot-lb. of potential energy, but will gain an equal amount of kinetic energy.

Momentum is the product of mass and velocity = Wv.

$$\therefore Ft = \frac{Wv}{g} - \frac{Wu}{g} = \frac{W}{g}(v - u) = \text{change of momentum.}$$

Rotary Motion

Similar laws apply to the rotation and angular acceleration of a body acted upon by a couple. The moment of the couple, *i.e.* its turning effort, is often called the applied *Torque*. If the moment, or applied torque is T lb.-feet and the moment of inertia of the mass with respect to the axis of rotation is I (lb.-feet units), then the angular acceleration produced by the torque (a radians per sec. per sec.) is given by the relationship :—

$$T = Ia \div g.$$

Note.—The angular velocity in radians per sec. corresponding to a speed of N revolutions per min. is equal to $2\pi N \div 60$.

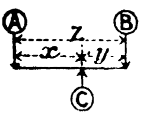
Kinetic energy of a rotating mass at velocity of ω radians per sec. $= \dfrac{I\omega^2}{2g} = \dfrac{\pi^2 N^2 I}{1{,}800g}$.

Power

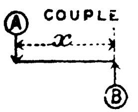
Power is the rate of doing work and can be measured in units such as foot-lb. per sec. or watts ; one watt $= 10^7$ ergs. per second.

1 *Horse-Power* $= 33{,}000$ foot-lb. per min., $= 746$ watts.

Equilibrium of Three Parallel Forces



$Ax = By$; $C = A + B$. $= Bz \div x = Az \div y$.
$B = C - A$. $= Ax \div y = Cx \div z$.
$A = C - B$. $= By \div x = Cy \div z$.
$x = Bz \div C$. $= By \div A$.
$y = Ax \div B$ $= Az \div C$.
$z = Cy \div A$. $= Cx \div B$.



Couple.—Two force of equal magnitude applied to the same body in parallel but opposite directions, but not in the same line of action, tending to twist the body. $A = B$.

Moment of a couple $= Ax$ or Bx.

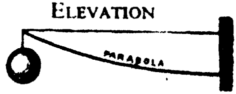
Beams of Equal Strength throughout their Length

The section is supposed in all cases to be rectangular throughout. The beams shown in plan are of uniform depth throughout. Those shown in elevation are of uniform breadth throughout.

B = Breadth of beam. D = Depth of beam.

Fixed at one end, loaded at the other ; curve parabola, vertex at loaded end ; BD^2 proportional to distance from loaded end.

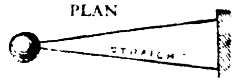
Elevation



Beams of Equal Strength throughout their Length—*continued*

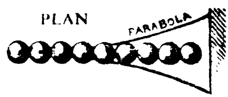
B = Breadth of beam. D = Depth of beam.

Fixed at one end; loaded at the other; triangle, apex at loaded end; BD^2 proportional to the distance from the loaded end.

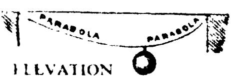


Fixed at one end; load distributed; triangle, apex at unsupported end; BD^2 proportional to square of distance from unsupported end.

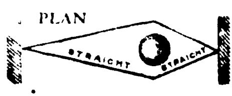
Fixed at one end; load distributed; curves two parabolas, vertices touching each other at unsupported end; BD^2 proportional to distance from unsupported end.



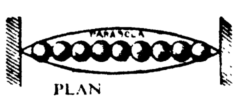
Supported at both ends; load at any one point; two parabolas, vertices at the points of support, bases at point loaded; BD^2 proportional to distance from nearest point of support.



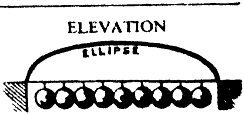
Supported at both ends; load at any one point; two triangles, apices at points of support, bases at point loaded; BD^2 proportional to distance from the nearest point of support.



Supported at both ends; load distributed; curves two parabolas, vertices at the middle of the beam; bases centre line of beam; BD^2 proportional to product of distances from points of support.



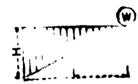
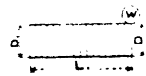
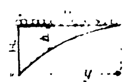
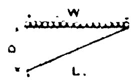
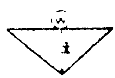
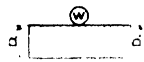
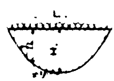
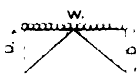
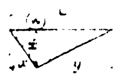
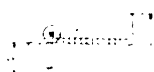
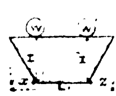
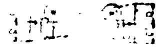
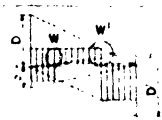
Supported at both ends; load distributed; curve semi-ellipse; BD^2 protional to the product of the distance from the points of support.



Bending Moments and Shearing Forces in Beams

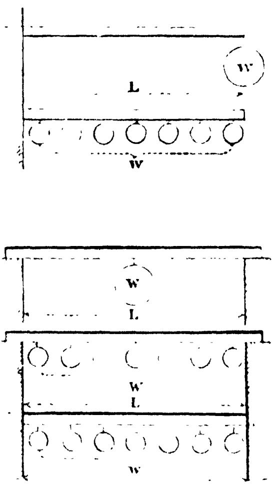
(Graphic Construction)

With any convenient scale lay off the distances H, D, or h, as shown in the diagrams, then the moments or forces may be measured off at any part of the span L.

	Bending moments	Shearing forces
1. One end fixed; the other loaded. $H = WL$; $D = W$.		
2. One end fixed; the load distributed. $H = \frac{WL}{2}$; $D = W$; $h = \frac{Hy^2}{L^2}$.		
3. Ends supported; load at centre. $H = \frac{WL}{4}$; $D = \frac{W}{2}$.		
4. Ends supported; load distributed. $H = \frac{WL}{8}$; $D = \frac{W}{2}$; $h = H - \frac{Hy^2}{(\frac{1}{2}L)^2}$.		
5. Ends supported; load not at centre. $H = \frac{Wxy}{L}$; $D = W$.		
6. Two equal loads equidistant from centre. $H = Wx$; $H' = W'z$; $D = W$; $D' = W'$.		 Shearing forces between W and W' neutralise each other
7. Unequal loading. Find the moment of each load as in Case 5. Then $H = a + b$ and $H' = c + d$; $D = W$, and $D' = W'$.		 Shearing forces between W and W' partly neutralised.

Strength of Rectangular Beams

L – Length of beam or span. } in inches.
B – Breadth of beam. } in inches.
D – Depth of beam.
W – Breaking weight in cwts.
K – Coefficient of rupture (for values of K, see below).
M – Multiplier for deflection.



	W	K	M
One end fixed. The other loaded.	$\frac{KBD^2}{L}$	$\frac{LW}{BD^2}$	·33
One end fixed Weight distributed	$\frac{2KBD^2}{L}$	$\frac{LW}{2BD^2}$	125
Ends supported. Weight in centre	$\frac{4KBD^2}{L}$	$\frac{LW}{4BD^2}$	·02
Ends supported. Weight distributed	$\frac{8KBD^2}{L}$	$\frac{LW}{8BD^2}$	·013
Ends fixed. Weight distributed.	$\frac{12KBD^2}{L}$	$\frac{LW}{12BD^2}$	·003

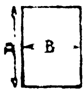
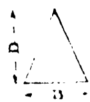
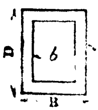
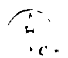
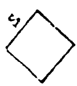
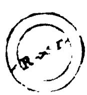
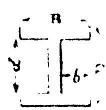
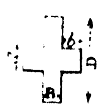
Values of K for Different Materials

Material	K cwt.	Material	K cwt.	Material	K cwt.
Wrought iron	68	Cedar, Lebanon	12	Oak, African	23
Cast iron	46	Cedar, West Indies	13	Oak, English	14
Cast brass	24	Chestnut	16	Pine, red	12
Ash, English	19	Deal	14	Pine, yellow	11
Ash, American	16	Elm	7	Pine, Memel	12
Birch	17	Fir (spruce)	13	Pitch	16
Beech	15	Mahogany	17	Teak	22

BEAMS OF VARIOUS SECTIONS

To find the breaking weight of beams of the following sections, use the formula for W in the preceding page, but substituting for BD^2 the values of V for the sectional required.

I = Moment of inertia (see " Moment of Inertia ").

	RECTANGLE $I=\frac{BD^3}{12}$ $V=BD^2$		TRIANGLE $I=\frac{BD^3}{36}$ $V=\frac{BD^2}{4}$
	HOLLOW RECTANGLE $I=\frac{BD^3-bd^3}{12}$ $V=\frac{BD^3-bd^3}{D}$		ELLIPSE $I=\cdot 7854CT^3$ $V=4\cdot 7CT^2$
	CIRCLE $I=\cdot 7854R^4$ $V=4\cdot 7R^3$		SQUARE $I=\frac{S^4}{12}$ $V=S^3$
	HOLLOW CIRCLE $I=\cdot 7854(R^4-r^4)$ $V=4\cdot 7\left(\frac{R^4-r^4}{R}\right)$		$I=\frac{BD^3-2bd^3}{12}$ $V=\frac{BD^3-2bd^3}{D}$
	SEMICIRCLE $I=\cdot 11R^4$ $V=1\cdot 16R^3$		$I=\frac{BD^3+2bd^3}{1}$ $V=\frac{BD^3+2bd^3}{D}$

Centre of Percussion and Oscillation

I = Moment of inertia.
d = Distance of the centre of gravity from the axis of motion.
M = Volume of body.
x = Distance of centre of oscillation or percussion from the axis.

$$x = \frac{I}{Md}.$$

Distance from centre of motion in a straight bar suspended at extremity, $\frac{2}{3}$ length.

Very slender cones suspended at apex, $\frac{4}{5}$ height.

Pendulum

l = Length of pendulum in feet.
L = ,, ,, inches.
T = Time of one oscillation in seconds.
N = Number of oscillations per minute.
g = Gravity. (Approximately = 32·2 if feet, or 386·4 if inches be required.)

$$T = \cdot 16\sqrt{L} = \pi\sqrt{\frac{l}{g}}.$$

$$T = \cdot 554\sqrt{l}.$$

$$l = g\left(\frac{T}{\pi}\right)^2; \quad L = \left(\frac{375{\cdot}36}{N}\right)^2.$$

$$N = \frac{375{\cdot}36}{\sqrt{L}}.$$

$L = 39{\cdot}1383$ inches in the latitude of London, if $T = 1$.

$$g = 32{\cdot}088\,(1 + \cdot 005133\sin^2\lambda)\left(1 - \frac{2h}{R}\right).$$

λ = Latitude; h = Height above the Sea in feet.
R = Radius of Earth = 20,900,000 feet.

To Find the Centre of Gravity of a Series of Lines

$$X = \frac{L_1x_1 + L_2x_2 + L_3x_3}{L_1 + L_2 + L_3}.$$

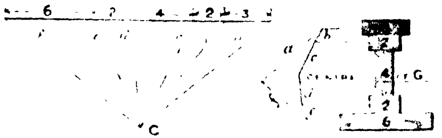
$$Y = \frac{L_1y_1 + L_2y_2 + L_3y_3}{L_1 + L_2 + L_3}.$$

Centre of Gravity

(By Graphic Construction)

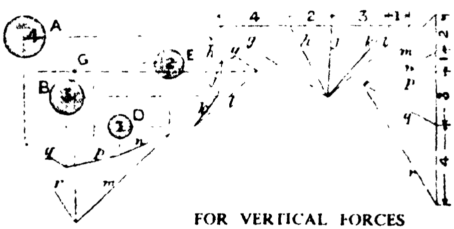
Divide the section into any convenient layers and construct a polygon of forces as follows:—

With any convenient scale set out on a horizontal line lengths corresponding with the area of each layer; assume any convenient point C, and draw lines from the lengths thus set out radiating to C. Then lines drawn parallel to these radiating lines, as shown in the diagram, intersecting the horizontal lines that pass through the centre of gravity of each layer respectively form the polygon of forces, and the intersection of the lines *af* gives the horizontal line of the centre of gravity of the layers.



The centre of gravity of any number of bodies ABDE may be found by constructing a polygon of forces in a similar manner for horizontal as well as for vertical forces, the intersection of the two lines of polygons giving the centre of gravity at G.

FOR HORIZONTAL FORCES

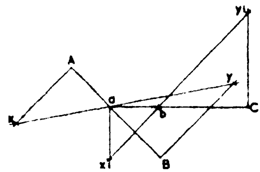


FOR VERTICAL FORCES

A simpler and more rapid graphical method of determining the common centre of gravity of any number of bodies lying in the same plane is as follows:—

Let the weights, or the volumes and areas, if the bodies are of the same density or of the same thickness, be represented in position by the points A, B, and C (their individual centres of gravity). Suppose the magnitude of A = 4, that of B = 3, and that of C = 5.

Join A and B, and erect perpendiculars Ax and By, making Ax=3 units and By=4 units. Join x and y. Where the line xy cuts the line AB, at a, is the common centre of gravity of the bodies A and B. Join a and C. Erect perpendiculars as before. Set off $ax_1=5$ units and C$y_1=7$ units (*i.e.* 4+3). Join x_1 and y_1. The intersection of x_1y_1 with aC at b determines the common centre of gravity of all three bodies.



The order in which the bodies are dealt with is immaterial, as are also the scales used, provided the same scale is employed for each ordinate of a pair of perpendiculars. When a large number of bodies is involved, the scales may conveniently be progressively reduced, since the magnitude of one perpendicular of the pairs is cumulative and the diagram might, therefore, become unwieldy.

Position of Centre of Gravity in Various Forms

Height from base in parabola $\frac{2}{5}$; in pyramid or cone $\frac{1}{4}$; in paraboloid $\frac{1}{3}$; in hemisphere $\frac{3}{8}$.

Segment of circle from centre $=\dfrac{\text{chord}^3}{12\ \text{area}}$.

Sector " " " $=\dfrac{2\ \text{chord}\times\text{radius}}{3\ \text{arc}}$.

Quad. sector = ·6002 rad.; 60° sector = ·6366R.

Semicircle = ·4244 rad. from centre of circle.

Semicircle of disc ring from centre

$$=\cdot 4244\left(\frac{R^3-r^3}{R^2-r^2}\right).$$

Sector of disc ring from centre

$$=\frac{2}{3}\,\frac{\text{chord}}{\text{arc}}\left(\frac{R^3-r^3}{R^2-r^2}\right).$$

When R and r = the outer and inner radii.

Squares, rectangles, cubes, equilateral triangles, rings, regular polygons, circles, cylinders, have their centre of gravity in their geometrical centres.

The Centre of Gravity of a Truncated Cone

A practical example of a truncated cone is a tapered spar, of which it is desirable to know the centre of gravity for slinging, etc. This can be determined from the formula:—

$$x = h\frac{(6g^2-8g+3)}{4(3g^2-3g+1)}.$$

Where h = length on axis.

x = height of centre of gravity from base.

$$g = \frac{\text{Diameter of base}}{\text{Diam. of base} - \text{Diam. of tip}}.$$

To Find the Centre of Gravity by Experiment

Suspend the body successively in two or more positions; then the intersection of the vertical lines from each point of suspension will pass through the centre of gravity. This method is only applicable to bodies of uniform thickness, *e.g.* plates.

Centre of Gravity (Homogeneous Substances)

P = The volume of any particle.

d = The distance of P from any given plane.

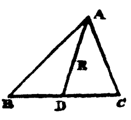
Σ = Sum.

x = The distance of the centre of gravity of the whole mass from a given plane.

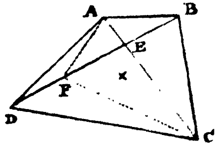
$$x = \frac{\Sigma(\text{P}d)}{\Sigma\text{P}} = \frac{\text{P}d+\text{P}_1d_1+\text{P}_2d_2+\text{etc}}{\text{P}+\text{P}_1+\text{P}_2+\text{etc.}}.$$

To Find the Centre of Gravity in a Triangle

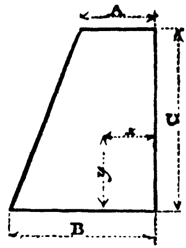
Bisect the base BC at D, and join AD. The centre of gravity lies in the line AD at E, DE being one-third of AD; or bisect each side and join each apex with the centre of the opposite side. The intersection of these lines will give the centre of gravity.



In a Parallelogram, or Any Four-sided Figure



In a parallelogram the intersection of the diagonals gives the centre of gravity. In any four-sided figure ABCD draw the diagonals intersecting at E. Lay off DF = BE, and join FA, FC; then the centre of gravity of the triangle FAC is also the centre of gravity of the figure ABCD.



Co-ordinates of the Centre of Gravity

$$x=\frac{1}{3}\left(A+B-\frac{AB}{A+B}\right).$$

$$y=\frac{C}{3}\left(\frac{2A+B}{A+B}\right).$$

Moment of Inertia and Radius of Gyration

The sum of the products of the mass of each elementary part of a body and the square of its distance from a given axis is called the Moment of Inertia of the body about that axis. Thus, if the masses of the parts are m_1, m_2, m_3, etc., and are at distances of d_1, d_2, d_3 respectively from the axis, then

$$\text{Moment of Inertia}=I=m_1d_1^2+m_2d_2^2+m_3d_3^2 \ . \ . \ . \text{ etc.}$$

The relationship between the moment of inertia and angular acceleration of a rotating body corresponds to that obtained between the mass and linear acceleration of a body moving in a straight line.

Similarly the moment of inertia of a surface can be ascertained from a consideration of elementary areas and the squares of their distances from the axis. This conception is of especial value in calculating the strength of beams, the moment of inertia of the cross-sectional area being required.

The radius of gyration (R) is such that:

for a body of mass M, $I=MR^2$;
or for an area A, $I=AR^2$.

In other words, the whole mass (or area) may be considered to be concentrated at the radius R from the axis without affecting the moment of inertia. It follows, by transposition, that:

$$\text{for a mass, } R=\sqrt{\frac{I}{M}};\ \text{ for an area, } R=\sqrt{\frac{I}{A}}.$$

Changes of Axis

If I is the moment of inertia of a mass M about an axis which passes through the centre of gravity then the moment of inertia (I_y) about a parallel axis distant y from the centre of gravity can readily be found, for $I_y=I+My^2$.

Similarly, for an area A, $I_y=I+Ay^2$.

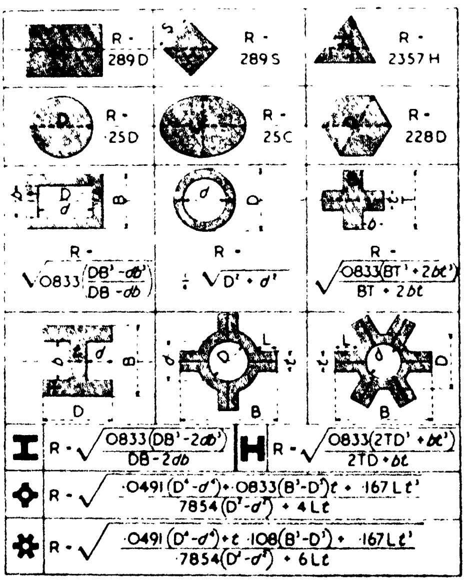
Radius of Gyration—Various Cases

In a bar revolving about one end	= ·577 length.
,, ,, centre	= ·289 length.
Circular plate revolving about centre	= ·707 radius.
,, ,, its diameter	= ·5 radius.
Sphere about its diameter	= ·6324 radius.
Hollow sphere (insensibly thick)	·816 radius.
Cylinder revolving about its axis	= ·707 radius.
Cone ,, ,,	·548 radius of base.
Cone (right angled) revolving about its apex	·866 height.
Rectangular plate, height h, revolving about base-line	= ·577 height.

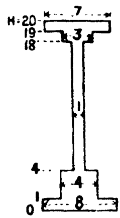
Radius of Gyration (R) of Various Plane Figures

(From these values I, the moment of inertia, is obtainable since $I = \text{area} \times R^2$.)

The horizontal dotted lines through the figures denote the axis of rotation, and in each case pass through the centre of gravity.



Moment of Inertia (Heppel)



N = Distance of neutral axis from *lower* edge of section.

H = Height of any particles from *lower* edge of section.

d = Distance of any particles from the neutral axis.

B = Breadth of section at any height.

Σ and Δ = The sum and difference respectively.

I = Moment of inertia $= \frac{2}{3}\Sigma B\Delta(d^3)$ if the neutral axis be central and the section symmetrical.

$\frac{1}{2}\Sigma B\Delta(H^3) - AN^2$ if the section be not symmetrical.

$$A = \Sigma B\Delta H. \quad N = \frac{\Sigma B\Delta(H^2)}{2A}.$$

Example Illustrating the Practical Application of the Preceding Formulæ

The more closely the section is divided into minute rectangles, the more accurate will be the result.

H	H^2	H^3	ΔH	ΔH^2	ΔH^3	B	$B\Delta H$	$B\Delta(H^2)$	$B\Delta(H^3)$
0	0	0	} 1	1	1	8	8	8	8
1	1	1							
4	16	64	3	15	63	4	12	60	252
18	324	5,832	14	308	5,768	1	14	308	5,768
19	361	6,859	1	37	1,027	3	3	111	3,081
20	400	8,000	1	39	1,141	7	7	273	7,987
Sum of columns, $\Sigma B\Delta H$, etc.							44	760	17,096

$$A = \Sigma B\Delta H = 44; \quad N = \frac{\Sigma B\Delta(H^2)}{2A} = \frac{760}{88} = 8{\cdot}63.$$

$$I = \frac{\Sigma B\Delta(H^3)}{3} - AN^2 = \frac{17{,}096}{3} - 44(8{\cdot}63)^2 = 2421.$$

Moment of Resistance

In a beam subjected to bending the stress is zero at the neutral axis which passes through the centre of gravity of the cross-sectional area. If y is the distance of the furthest edge of the section from the neutral axis, f the maximum skin stress, and I the moment of inertia of the sectional area, then:

$$\text{Moment of Resistance} = M = \frac{If}{y} = Zf.$$

Z is called the modulus of the section and is equal to $I \div y$. Clearly, if f is taken as the maximum safe stress for the material, then the value of M = maximum safe bending moment.

Moment of Inertia and Radius of Gyration in Angle-Bars

A = sectional area of the angle bar.

B and D = breadth of each side respectively.

T and t = thickness of each side.

$d = D - T$.

$y = \frac{d}{2} + \frac{\frac{1}{2}BDT}{BT + dt}$; $x = D - y$; $z = x - T$ { The axis passes through the centre of gravity.

I = moment of inertia.

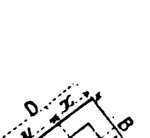
γ = radius of gyration.

Axis Parallel to B

(Equal sides)

$I = \frac{1}{3}\{B(x^3 - z^3) + t(y^3 + z^3)\}$

$= \cdot 09\ AB^2$ approximately; or more nearly $= KAB^2$.



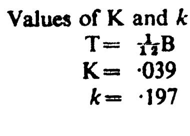
$\gamma = \sqrt{I \div A} = \cdot 3B$ approximately; or nearly $= kB$.

Values of K and k:

If T =	$\frac{1}{12}$B	$\frac{1}{10}$B	$\frac{1}{8}$B	$\frac{1}{6}$B	$\frac{1}{5}$B	$\frac{1}{4}$B
K =	·096	0·95	·093	·088	·084	·08
k =	·308	·305	·30	·297	·287	·283

Axis Diagonal

(Equal sides)



$I = \frac{1}{3}\{2x^4 + t\{B - (2x - \frac{1}{2}T)^3 - 2z^4)\}$

$= \cdot 038\ AB^2$ approximately; or more nearly $= KAB^2$.

$\gamma = \sqrt{I \div A}$; $= \cdot 195B$ approximately; or more nearly $= kB$.

Values of K and k:

T =	$\frac{1}{12}$B	$\frac{1}{10}$B	$\frac{1}{8}$B	$\frac{1}{6}$B	$\frac{1}{4}$B
K =	·039	·038	·038	·038	·037
k =	·197	·196	·195	·194	·192

Values of I and γ in angle bars of different dimensions; axis diagonal, sides equal:

Bars	$1\times1\times\frac{1}{8}$	$1\times1\times\frac{1}{4}$	$2\times2\times\frac{1}{4}$	$2\times2\times\frac{3}{8}$	$3\times3\times\frac{3}{8}$	$3\times3\times\frac{1}{2}$	$4\times4\times\frac{1}{2}$	$4\times4\times\frac{3}{4}$	$6\times6\times\frac{1}{2}$	$6\times6\times\frac{3}{4}$	$8\times8\times1$
I=	·009	·016	·142	·203	·719	·933	2·28	3·23	8·04	11·5	36·4
γ=	·195	·192	·389	·387	·584	·582	·779	·771	1·18	1·17	1·56
y=	·704	·661	1·41	1·36	2·11	2·07	2·81	2·73	4·32	4·22	5·63

Axis Diagonal

(Unequal sides)

$I=KABD$; $\gamma=k(B+D)$.

If B÷D=	·6	·65	·7	·75	·8	
K=	·033	·035	·036	·037	·038	in thin bars, $t=\frac{1}{16}D$.
=	·032	·033	·034	·035	·036	in thick bars, $t=\frac{1}{8}D$.

$k=\frac{1}{2}\sqrt{K}$, or from ·091 to ·097 in thin, and ·089 to ·09 in thick.

Moment of Inertia

(Graphic Construction)

D = Distance of edge of section from neutral axis.

g = Distance of centre of gravity of each section of the " inertia area " from the neutral axis.

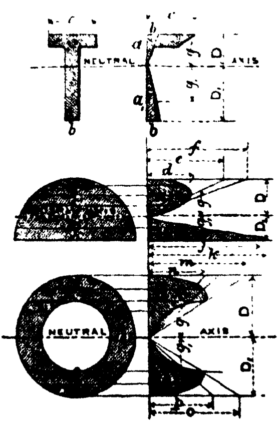
a = Section of " inertia area " above or below neutral axis.

I = Moment of inertia = $2Dag$ in symmetrical figures.

$I=Dag+D_1a_1g_1$, where Dag and $D_1a_1g_1$ are dimensions respectively above and below the neutral axis in unsymmetrical figures.

To form the " *inertia area* " divide the section into any convenient layers, drawing horizontal lines to represent the layers and neutral axis. On a horizontal line distant D from the neutral axis set off from any vertical line representing the widths of each layer respectively, and from the widths thus set off draw lines radiating to the point of intersection of the vertical line with the neutral axis, then the intersection of these radiating lines with the respective horizontal lines of each layer will give points in the line which limits the " inertia area."

SECTIONS INERTIA AREAS



Divide the section into convenient layers; then with any scale set out successively on a horizontal line lengths proportional to the area of each layer respectively; making the total length DB = the area of the section; also draw the perpendicular DC = ½DB; join BC, and from the points set out as above draw vector lines radiating to C. Then from the horizontal lines which pass through the centres of gravity of each layer respectively draw lines parallel to each vector respectively as shown in the diagram, forming a polygon. The intersection of the lines *hj* in the polygon determines the position of the neutral axis.

The lines of the polygon are denoted by the same letters as the vector lines to which they have been drawn parallel.

Then if I = Moment of inertia,

A = Area of the section,

a = Area of the polygon as formed above,

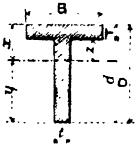
$$I = Aa.$$

The thinner the layers taken, the more accurate will be the result.

Moment of Inertia and Position of Neutral Axis

I = Moment of inertia.
y = Distance of neutral axis from bottom of section.

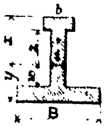
T Section



$$y = \frac{d}{2} + \frac{\frac{1}{2}BDT}{BT + dt}$$

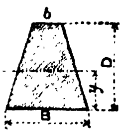
$$I = \frac{B(x^3 - z^3) + t(y^3 - z^3)}{3}.$$

Double Flange Section



$$I = \frac{B(y^3 - w^3) + b(x^3 - z^3) + t(w^3 + z^3)}{3}.$$

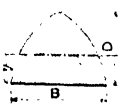
Trapezoid



$$y = \frac{D}{3} \cdot \frac{B + 2b}{B + b}.$$

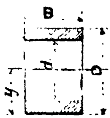
$$I = D^3 \frac{B^2 + 4Bb + b^2}{36(B + b)}.$$

Parabolic Segment



$$y = \frac{2D}{5}.$$

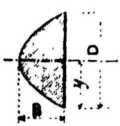
$$I = \frac{D^3B}{21 \cdot 875}$$



$$y = \frac{D}{2}.$$

$$I = B\frac{D^3 - d^3}{12}.$$

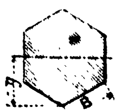
Parabolic Segment



$$y = \frac{D}{2}.$$

$$I = \frac{D^3B}{30}$$

Hexagon



$y = B$

$I = \frac{5}{16}B^4\sqrt{3}.$

$= \cdot 541266B^4$

For *Similar Sections*, D and d = the depths of the given and required sections respectively, and I and i be the moments of inertia, then $i = \frac{d^4}{D^4}$.

MODULUS OF ELASTICITY

The modulus of elasticity of any material is the force that would lengthen a bar of that material of 1 sq. in. section to double its length, or would compress it till its length became zero; supposing it possible to stretch or compress the bar to this extreme extent without breaking it, and that the following relation between stress and strain held good:—

a = Alteration in length due to any force F less than the modulus.

A = Alteration due to the modulus E. $\frac{a}{A}=\frac{F}{E}$.

TO FIND THE COMPRESSION OR EXTENSION OF ANY BODY UNDER A GIVEN STRAIN WITHIN ITS LIMITS OF ELASTICITY

(See next page.)

L = Length in feet of body before stress was applied.

l = Increase or decrease of length in feet caused by a stress f.

f = Stress applied in lb. per square inch.

E = Modulus of elasticity (for values of E see next page).

Strain = deformation per unit of length = $l \div L$.

$$E=(\text{stress} \div \text{strain})=f \div (l \div L).$$

Hence, by transposing terms:

$$l=\frac{Lf}{E}; \qquad E=\frac{Lf}{l}; \qquad f=\frac{lE}{L}.$$

DETERMINATION OF E FROM THE DEFLECTION OF A BEAM FREELY SUPPORTED AT ENDS AND LOADED AT CENTRE

l = Clear distance between supports in inches.

b = Breadth of beam in inches.

d = Depth of beam in inches.

W = Weight in lb.

x = Deflection in inches produced by W.

$$E=\frac{Wl^3}{4bd^3x}.$$

Modulus of Elasticity

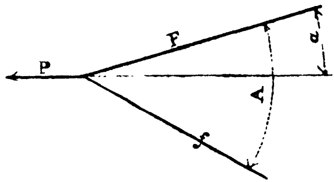
λ = Increase or decrease in inches per foot of length with a stress of one ton per square inch.

E = Modulus of Elasticity; 1 in.^{2} being the unit of area.

f = Maximum stress per square inch material will carry without permanent deformation, *i.e.* the elastic limit, usually from 50 to 70% of ultimate strength.

Material	λ in.	Modulus E		Stress f	
		lb.	tons	lb.	tons
Aluminium	·0022	12,500,000	5,580	13,000	5·80
,, bronze 10%	·0016	17,000,000	7,589	21,000	9·37
,, wire	·0015	18,500,000	8,259	—	—
Brass, cast	·0030	8,930,000	3,987	6,600	2·95
,, rolled	·0023	11,500,000	5,134	7,100	3·17
Copper, cast	·0030	9,000,000	4,018	7,000	3·12
,, rolled	·0022	12,000,000	5,357	8,300	3·71
,, wire	·0017	16,000,000	7,143	10,000	4·46
Gun-metal	·0027	9,900,000	4,420	10,000	4·46
Iron, cast, from	·0019	14,000,000	6,250	4,500	2·01
,, ,, to	·0012	23,000,000	10,268	9,000	4·02
,, wrought bars	·0009	29,000,000	12,946	17,800	7·95
,, ,, plate	·0010	27,000,000	12,054	16,500	7·37
,, ,, wire	·0011	25,000,000	11,161	25,000	11·16
Lead	·0374	720,000	321	1,500	·67
Phosphor-bronze	·0019	14,000,000	6,250	—	—
Steel, mild	·0009	30,000,000	13,393	31,000	13·84
,, cast	·0008	36,000,000	16,071	37,000	16·52
,, tool	·0007	40,000,000	17,857	60,000	26·79
Tin	·0058	4,600,000	2,054	2,880	1·29
Zinc	·0020	13,680,000	6,107	5,700	2·54
Timber					
Ash	·0164	1,640,000	732	3,796	1·69
Beech	·0220	1,345,000	600	3,113	1·39
Chestnut	·0291	925,000	413	3,600	1·61
Deal, Memel	·0168	1,600,000	714	2,920	1·30
Elm	·0201	1,340,000	598	1,500	·67
Larch	·0251	1,074,000	479	2,480	1·11
Mahogany	·0169	1,596,000	712	3,690	1·65
Oak, Canadian	·0157	1,710,000	763	3,930	1·75
,, English	·0189	1,420,000	634	3,170	1·42
Pine, pitch	·0142	1,900,000	848	3,230	1·44
,, red	·0145	1,850,000	826	2,930	1·31
,, white	·0244	1,100,000	491	2,300	1·03
,, yellow	·0173	1,550,000	692	2,170	·97
Teak	·0112	2,400,000	1,071	3,940	1·76

Resolution of Forces



F = A force acting in one direction.

f = ,, ,, another direction.

P = Resultant force of F and f combined.

A = Angle of direction of F with f.

a = Angle of P with F.

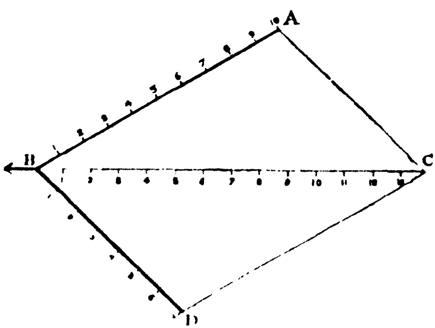
$P = \sqrt{F^2 + f^2 + (2Ff \cos A)}$.

$P = \sqrt{F^2 + f^2 - (2Ff \cos 180 - A)}$ when A exceeds 90°.

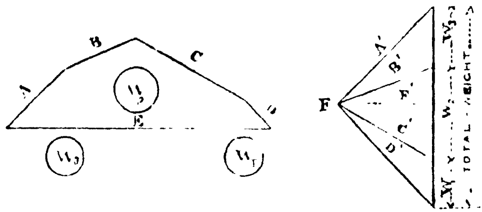
$\text{Sin } a = \dfrac{f \sin A}{P}$. $\qquad f = \dfrac{P \sin a}{\sin A}$.

By Parallelogram of Forces

Measure by any scale on each line their respective units of force, and complete the parallelogram; the diagonal represents the force and direction of the resultant. In the diagram two forces, AB = 10 tons and BD = 7 tons, give a resultant of BC = 13·8 tons.



Strains on a Polygonal Framing

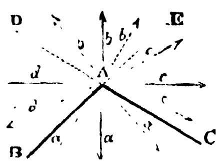


Set out on a perpendicular line with any scale a number of units total weight, and from the ends of this line lay off A′ parallel to A, and D′ parallel to D, and from their intersection F lay off B′ and C′ parallel to B and C. The portions cut off by the intersection of these lines with the vertical line represent the weights at each point, W_1, W_2, and W_3 required to keep the framing in equilibrium: and the lengths A′, B′, C′, etc., represent the strains on A, B, C, etc.

To Determine the Character of any Strain

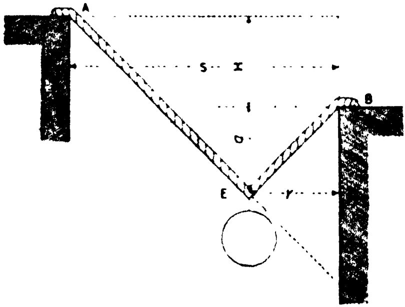
Let AB and AC be any two bars of a framing. Produce the lines AB, AC, to D and E. Let *a* represent the direction of the load if it passes in any direction between B and C, or *b* if it passes in any direction between D and E; *c* if between E and C; or *d* if between B and D.

Direction of load	Character of strain: On AB	Character of strain: On AC
a	Compression	Compression
b	Tension	Tension
c	Tension	Compression
d	Compression	Tension



Weighted Cord

To find the position a weight will take on a cord. Let A and B be the points of suspension. Lay off AC=length of cord; bisect BC in D; the intersection of the horizontal line DE with AC will give the required position.



L=Length of rope.

S=Span.

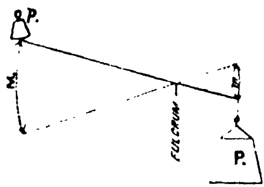
H=Height of one support above the other.

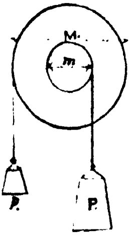
$$a=\frac{\sqrt{(L+S)(L-S)}-H}{2}.$$

$$y=\frac{aS}{\sqrt{(L+S)(L-S)}}.$$

Mechanical Advantage

The forces which are transmitted by either the lever, pulley, inclined plane, wedge, screw, or wheel, and axle, may be reduced in all cases to one rule, viz. the gain of force is directly proportioned to the loss of motion, and *vice versa.*





p = Force applied.

P = Force transmitted.

M = Motion of (p).

m = Motion of (P).

Then $$\frac{P}{p}=\frac{M}{m} \text{ and } P=\frac{Mp}{m}.$$

This of course does not include friction. The diagrams show the application in the case of the lever and the wheel and axle. The ratio (P/p) is called the Mechanical Advantage of the machine.

Millwork

NUMBER OF TEETH IN WHEELS

N = Number of teeth in driving wheel.

n = Number of teeth in driven wheel.

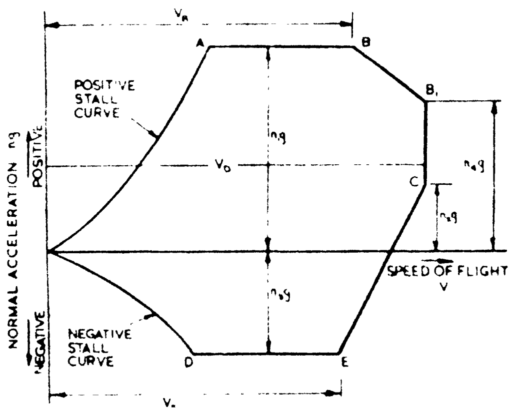
V = Revolutions of driving wheel.

v = Revolutions of driven wheel.

$$n=\frac{NV}{v}. \qquad v=\frac{NV}{n}.$$

Symmetric Flight Manœuvres

The basic flight requirements of all aircraft are now expressed in terms of a flight envelope, the co-ordinates of which are forward speed and normal acceleration of the aircraft. The aircraft structure must have an ultimate factor of not less than 1·5 under conditions of steady normal acceleration and forward speed as represented by all points falling within the boundary of the flight envelope, and under specified manœuvres involving pitching acceleration within that envelope.



V_D Design Diving Speed.
n_1 Maximum normal acceleration coefficient.
V_B 0·8V_D. V_E 0·7V_D.
n_3 1·0 if n_1 is less than 3·0, or zero if $n_1 > 3$.
n_2 0·5n_1, or 1·0, whichever is greater.
n_4 0·75n_1.

The general flight envelope is defined by the diagram above, and by the values of n and V_D which are given, with any necessary amplification for special types, in the particular Aircraft Specification.

It will be seen that point A replaces the old C.P. Forward case;

points B and B_1 the C.P. Back; point C the Nose Dive; and points D and E the Inverted Flight cases. The value of n varies with the classification of the aircraft.

The conditions represented by points A, B, B_1, C, D, and E have to be investigated in detail. Cases represented by intermediate points are examined, but not investigated in detail if it can be shown that none of them gives loads anywhere in the structure greater than the loads given by the terminal point case.

The particulars of the requirements for structural strength and design for flight may be found in Part 2 of A.P. 970 in the case of military aircraft, and in Air Registration Board Pamphlets D.3 and D.4 in the case of civil aircraft.

Air Loading on Wings

From the rationalized flight cases A, B, C, etc., the lift coefficient and the centre of pressure are deduced. The air loading on the wing may then be simply calculated by dividing the plan form into chordwise strips, when the resultant load on each strip may be assumed to be

$$\omega \cdot \delta s$$

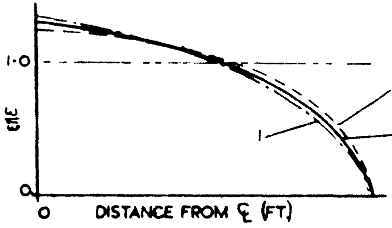
where ω is the spanwise wing loading per foot run, at the section considered

δs is the width of the strip.

The wing loading over each section is calculated in the following way: –

The total lift on the wing is divided by the span to obtain the mean spanwise loading per foot run. The loading is then plotted on a graph, so as to conform in shape with the plan form of the wing, and again to conform to a perfect elliptical shape of the same area. The mean between these two gives a very close approximation to the actual loading along the span.

(1) Spanwise loading according to plan form.
(2) Elliptical spanwise distribution.
(3) Mean between (1) and (2) Actual spanwise loading.



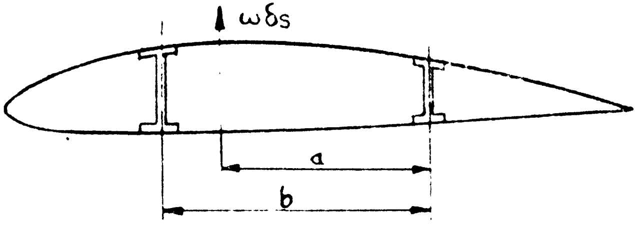
The resultant shear at each station immediately inboard of each strip may be calculated by integrating the wing loading

$$S = \int \omega \, . \, ds$$

and the bending moment by integrating the shear—

$$M = \iint \omega \, . \, ds \, . \, ds.$$

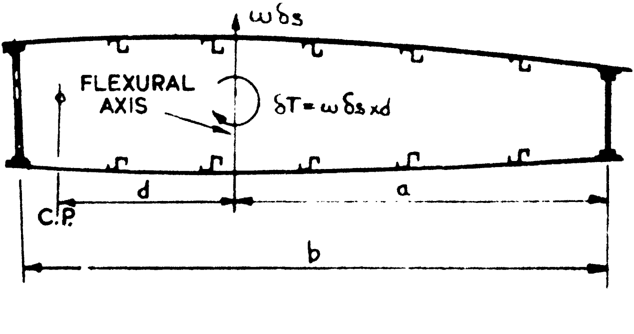
In the simple two-spar construction the loading on each spar is calculated by assuming the load on each strip concentrated at the centre of pressure and taking moments about one of the spars in order to find the load on the other, thus:—



Load on front spar $\frac{a}{b} \, . \, \omega \, . \, \delta s.$

Hence the shear and bending moment in each spar may be found by integration.

In the case of a simple stressed skin wing, where the main structure consists of a box formed by the two spars and the top and bottom skins of the wing between the spars, the load on each



strip is transferred from the centre of pressure to the flexural axis * of the section as a load at and a torque about the axis. The shear due to bending is distributed between the two spars according to their position in relation to the flexural axis, the direct compressive and tensile stresses due to bending are taken by the spar booms and the skin-stringer combination between the spars, and the torque is taken into the structure by torsional shear stresses round the box, which may be calculated after the formula of Batho.

* The flexural axis is determined by the ratio of the moments of inertia of the two spars.

Thus: $$a=\frac{I_B . b}{I_F+I_B}.$$

Load Factors. Gliders and Sailplanes

BRITISH GLIDING ASSOCIATION REQUIREMENTS

Stress corresponding to—	Component(s) affected	Load factor
Centre of pressure forward	Fuselage, wings, tailplane	6
Centre of pressure back	Wings	4
Vertical dive	Fuselage, wings, tailplane	1
Inverted flight	Wings	3
Launching	Fuselage	4
Landing	u c or landing gear	4
Rudder (maximum side load)	Rudder	2
		≏7.5 lb./sq. ft.

R.R.G. (RHÖN ROSSITTEN GESELLSCHAFT) REQUIREMENTS

Centre of pressure forward	Wings	6
Flight with maximum torsional load	Wings	1
Landing	Wings, fuselage	6.8
Breaking load on—	Elevators	31 lb. sq. ft.
	Rudder	31 " "
	Ailerons	16 " "
	Fuselage	34 " "
Wing tip landing at (speed applied at wing tip in direction of wing chord	Wing-fuselage junction	110 " "

AMERICAN

Centre of pressure forward	Wings	6
Centre of pressure back	Wings	4.25
Velocity at gliding angle of 1 in 6	Wings	1
Inverted flight		2.5
Breaking load on control surfaces	Tailplane and/or elevators	12 lb. sq. ft.
	Ailerons	9 " "
	Rudder	9 " "

Typical Constructional Methods used in British Aircraft

It is customary in the mass production of aircraft to fabricate the major components as separate units before bringing these units together to form the completed machine. Therefore it is advisable to consider the detail construction of these units separately under the headings of fuselage, engine mounting, tail unit and main planes. However, control surfaces also may be considered separately, because the characteristics of individual types of aircraft are reflected in the variety of methods used in the construction of these components.

Fuselage.—Generally this unit is the first one to appear on the assembly line, so it is logical to examine its construction primarily.

The modern tendency is to design a fuselage either wholly or in part on the monocoque principle, but the well-tried tubular structure is still well in evidence. Monocoque construction has one advantage over the tubular method in that it is lighter and thus of prime importance to the aircraft designer, but tubular construction is more accessible for the assembly of equipment and presents less difficulties in the attachment of the engine mounting and main planes. Thus aircraft are sometimes designed so that the centre fuselage, that is say, that portion which houses the crew and most of the equipment, is a tubular structure, while the rear fuselage, or that part behind the crew stations, is of pure monocoque structure.

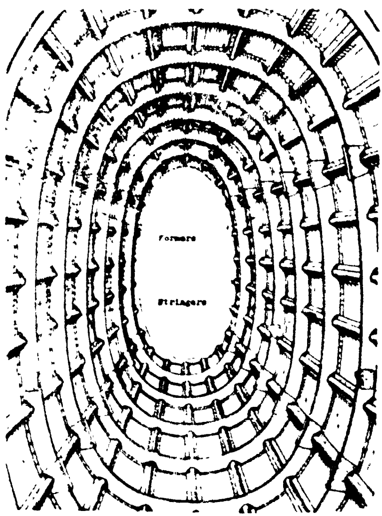
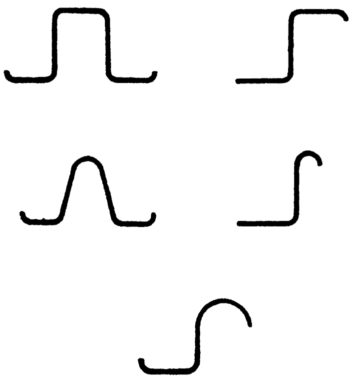


Fig. 1.

Monocoque Structure.—Fig. 1 illustrates a typical monocoque rear fuselage. Formers erected vertically at approximately 12-in. intervals with closely spaced continuous stringers, running fore and aft, form the structure for a skin plating which is riveted to both formers and stringers. This results in the surface of the fuselage being divided into a large number of small panels which are each bounded by a row of rivets.

This type of construction is also known as " stressed-skin " construction and, as its name implies, the stresses in the fuselage are transmitted through the skin covering. The efficiency of the structure relies on the skin being continuous, that is to say, unbroken by cut-outs for access doors, etc.

The formers are pressed from light alloy sheet, sometimes in one piece but it is more practicable to make them in four pieces, top, bottom and two sides, the joins being made with riveted fish-plates. This method facilitates production by making it possible to manufacture the parts on comparatively small presses. On the outer periphery of each former the edge is turned over at right angles to form a flange to which the skin is riveted. The inner edge of the former is also flanged in order to impart stiffness to the part.



Rolled Sections in common use.

Fig. 2

Stringers are made from light alloy rolled sections, these vary in shape and the most commonly used ones are shown in Fig. 2.

The skin is riveted to the flange of the stringer section.

The skin is made from alclad sheet shaped into panels each of which is usually made to cover as large an area as possible consistent with the width of standard size sheet and the compound curvature of the fuselage.

The construction of the rear fuselage is fairly consistent throughout and can be pure monocoque as it is seldom necessary to have access doors in this region, except on multi-engined types.

The structure of the centre portion of the fuselage, however, is much more complex as it houses the pilot and crew, most of the equipment, and probably has to cater for the installation of tanks as well as to make provision for attachment of the centre section or main planes. Thus the construction varies considerably with the design and type of aircraft.

However, the general principles of a monocoque structure are adhered to, but, because each former has an individual part to play, it is seldom that two formers look alike.

Fig. 3 shows a centre fuselage former. The contour is formed by two curved plates flanged to pick up the skin on the outside and cut away locally to allow the stringers to pass. These two plates

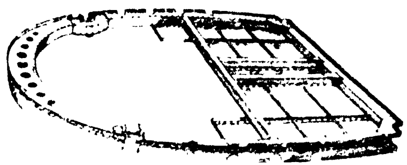


Fig. 3

are separated at their inside contours by a channel sectioned member to which they are riveted. Owing to the loads imposed nearly half of the former is covered with light alloy sheet which is stiffened along its edges and across its face by varying shaped rolled sections.

Fig. 4 shows a complete monocoque fuselage which illustrates clearly how the pure monocoque has been cut away to form the

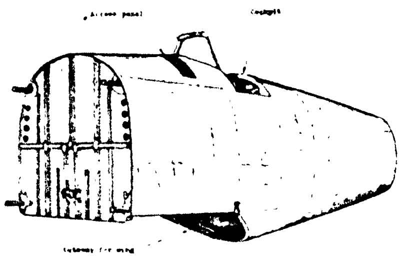


Fig. 4

cockpit and to provide accommodation for a one-piece wing, while on the top of the fuselage an access panel to the oil tank has been provided.

In the case of a single-engined aircraft the cockpit is covered by a perspex hood, while the fastest types have a pear drop blister. However, in multi-engined aeroplanes the pilot is accommodated in a nacelle which forms the forward part of the fuselage. This portion is usually of monocoque construction but, in order to give a good field of view, a large portion of the skin is replaced by Perspex panels.

Tubular Construction.—The use of tubular structure in the rear fuselage is rapidly dying out, but the composite construction is still in use. Fig. 5 shows a fuselage built on this principle.

As its name implies, a tubular structure is one in which the longerons and struts are made from tubes; these are usually of

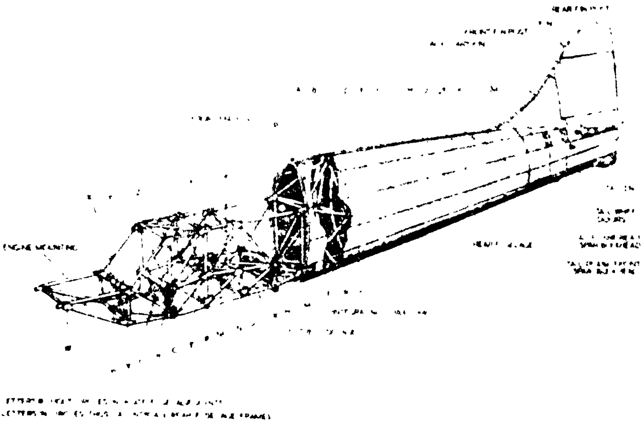


Fig. 5

steel although, in the more lightly loaded regions, light alloy tubes may be employed.

The essential differences in this method of construction lie in the formation of the joints between struts and longerons. Some designers favour butt-welding the joints while the tubes are held in a jig, while others complete the joint with side plates and channels. In this latter method the side plates and channels are made from stainless steel and side plates are bolted or tubular riveted to the ends of the side struts and to the longeron; distance tubes are placed over the bolt shank or rivet to prevent crushing of the tube. The top and bottom cross-struts are fitted into channels which in turn are bolted to the inside faces of the side strut joints. Although the general principle of plate joints is the same, different methods are employed, for instance, Hawker Air-Craft, Ltd., patented a method whereby the ends of the tubes and the local parts of the longerons were rolled to a square section, thus making a flat surface for the attachment of the side plates. Another method provides the struts with plug ends which are bolted between the side plates.

Wood Construction.—Although aeroplanes of wood construction are not common at the present time, there are notable exceptions and one of these should be mentioned to illustrate the modern trend.

The de Havilland Company has been faithful to all-wood construction for 23 years and an advanced form of this is developed in the " Mosquito."

The complete fuselage of this aeroplane is a monocoque structure consisting almost entirely of a wood shell. This is achieved by

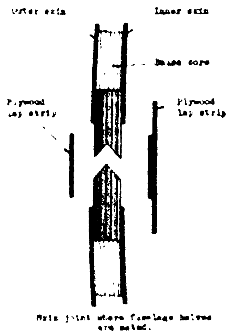


Fig. 6

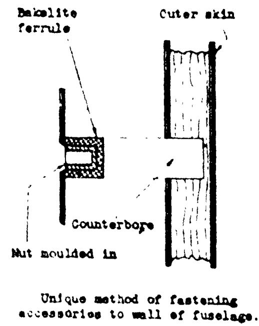


Fig. 7

sandwiching balsa wood $\frac{7}{16}$ in. thick between an outer and inner skin of spruce or birch plywood $\frac{1}{16}$ in. thick, the sandwich being glued and screwed. The selection of balsa wood requires special attention owing to the great variation in its density, but the " Mosquito " averages about 9 lb. per cu. ft.

The kind of plywood and direction of grain is changed to suit stress conditions. The forward portion is made of spruce while in the rear fuselage the birch plywood is laid with the grain running longitudinally, but at the tail end the grain is laid diagonally, the better to resist the torque of the tail unit.

The fuselage is fabricated in halves on left- and right-hand jigs; the wing section is glued in place with the rest and cut out after the half-fuselage is completed. All openings are reinforced around the edges with solid spruce or walnut. Top and bottom edges of each half are reinforced with laminated spruce members and, where these two multi-ply strips meet, vee-grooves accurately centre the edges but are not glued. Inner and outer plywood lap strips are glued and tacked in place (see Fig. 6).

There are seven bulkheads spaced at intervals throughout the fuselage, six of which are made in halves, but the seventh at the rear end is in one piece.

The finished fuselage is covered with fabric and painted with several coats of dope.

A novel method is employed for the attachment of equipment. Templates are provided for locating bracket holes into which bakelite moulded ferrules are glued (see Fig. 7).

MAIN PLANES.—The majority of modern aircraft are cantilever monoplanes, no bracing struts or wires being used to support the wings. However, when the wings are set in a very high position it is not always possible, for practical reasons, to make the structure a pure cantilever, so bracing struts are used.

The relative position of the planes to the fuselage, whether high wing, mid-wing, or low wing, depends to some extent on the purpose for which the aircraft is designed. A machine required for "spotting" or torpedo-bombing may well be designed with a high wing, and in a flying-boat the advantages of this position are obvious. More generally, however, aeroplanes are built with a low wing, this keeps down the length of the undercarriage legs to a minimum, saves weight, and simplifies the problem of retraction.

An example of the difficulties that may be encountered when designing a high-wing monoplane can be seen in the Fairey Barracuda. Owing to the comparatively long undercarriage it becomes necessary to carry the leg on a triangular-shaped torsion box which retracts into the side of the fuselage and lifts the wheel into the leading edge of the wing.

As most aircraft have cantilever wings and thus have a maximum bending moment on the centre line of the aeroplane, the structure at the fuselage is of primary importance.

Designs vary: sometimes a one-piece wing with continuous spars is used; in other aircraft a centre-section complete with engines, undercarriage, etc. is fitted, the outer portions of the planes being separate units attached outboard of the centre-section. In both cases the wings are fabricated as separate units and fitted to the fuselage at a late stage of assembly. By a third method a strong rigid structure is incorporated in the fuselage construction, the main planes being attached by pin joints at the fuselage sides.

In general all metal "stressed skin" construction is employed, but when a centre section is used it is sometimes found more convenient to use a tubular structure as this facilitates the accommodation of wheel housings, tanks, and engine mountings. Wheel housing, gun bays, etc. result in cut-outs being made in the skin surface, and, as the essence of " stressed skin " construction depends on the continuity of the skin, the use of tubular structure is justified otherwise the cut-aways have to be rigidly reinforced. This is especially so when the break takes place near the root of the plane where the loads are high. These stiff structures are termed torsion boxes.

The plan form of a cantilever wing invariably tapers towards the tip. This may be a straight taper or of elliptical shape, the latter being the most efficient aerodynamically, but, as the straight taper presents less difficulties in manufacture, it is more frequently used. The aerofoil is of a fairly constant section throughout, thus the wing tapers in thickness and chord.

Stressed skin Construction.—Typical wing construction is shown in Fig. 8 and consists of two main spars, nose, interspar, and trailing edge ribs with stringers running span-wise forming a

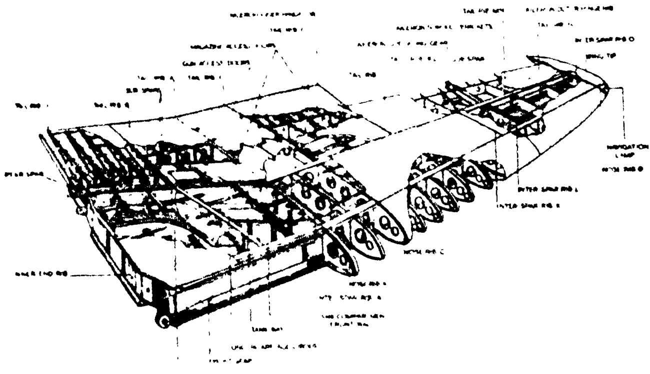


Fig. 8

structure to which the skin is riveted. In order to provide a clean wing entry, the rivets at the nosing and extending back to about 40% of the chord are countersunk flush with the skin surface, but aft of this point mushroom head rivets are in more general use.

Spars.—The basis of the wing is usually two main spars tapering from the root towards the tip. These are built up with light alloy extruded section booms at top and bottom joined by an alclad plate web. Typical boom sections are shown in Fig. 9. The webs are stiffened with rolled or extruded sections riveted vertically at intervals between the top and bottom booms.

Angles for attachment of the skin are provided at the spar booms and may be riveted on separately or incorporated in the shape of the boom section.

Although the spars may be jointed at the centre section or fuselage side for practical reasons, the wing bending moment is carried right through to the centre of the machine.

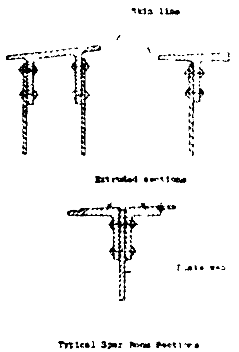


Fig. 9

Sometimes auxiliary spars are employed between the main spars and a subsidiary spar used where the wing is cut away for flap or aileron.

Auxiliary spars are formed in a similar manner to the main spars but are of lighter construction. The subsidiary spar, which is relatively lightly loaded, is made from light alloy plate, flanged top and bottom and stiffened by flanged lightening holes.

Nosing.—This part of the aerofoil forward of the front spar is built up of nose ribs to which the skin is attached. Ribs are made of light alloy sheet and, to impart stiffness to the webs, lightening holes are flanged or rolled section stiffeners are riveted on. Attachment of ribs to spar is facilitated by angle sections riveted to the nose ribs and riveted or bolted to the spar.

Interspar Ribs.—Between the main spars, ribs extending chordwise form the structure and are of two types.

Stiff ribs are used at the root of the plane and at either side of areas which are cut out for tank bays, gun bays, etc. These ribs are built up of extruded section booms curved to the aileron contour and joined by plate webs which are stiffened by light alloy sections riveted vertically. The torsion of the wing is taken mainly by these members and in conjunction with the skin form a torsion box. The remainder of the ribs are of lighter construction and often are fabricated from sheet, flanged top and bottom, with flanged lightening holes in the web.

In other designs, ribs have top and bottom booms of angle or channel section without web plate or bracing although tubes or other rolled sections sometimes interconnect the booms.

Trailing Edge Ribs.—Aft of the rear spar, subsidiary structure consists of trailing edge ribs which are built up in a similar manner to the other light ribs in the wing. At the aileron gap the ribs terminate at the subsidiary spar but the remaining ones extend back to the trailing edge. When split flaps are employed these conform to the bottom surface of the aerofoil section, therefore the trailing edge ribs are cut away to suit and are only about half the full depth of the section in this area.

The trailing edge is formed from a length of tapered extruded or rolled section which picks up with the aft end of the full-length ribs.

Skin.—Alclad sheet, usually about 20 s.w.g. in thickness, covers the whole of the structure, except where gun bays, etc. are provided, and is riveted to the flanges of the spars and ribs. The skin is divided into panels and the joins take place at the spars and stiff ribs, while the nosing, which has a sharp curvature, is formed in one piece so that its edges are riveted to the top and bottom booms of the front spar. Behind the rear spar, the skin has only a slight curvature and eleektron sheet is sometimes employed in this area.

Where torsion boxes are built into the structure it is often necessary to use locally a skin of 12 or 14 s.w.g.

Difficulty has been experienced in obtaining a smooth aerofoil shape as the use of many rows of rivets tends to give a quilted effect to the surface of the skin. Various methods are employed to overcome this difficulty such as pre-stretching or pre-tensioning the skins before riveting. Other methods include covering the skin with electrically heated blankets while the rivets are closed. On cooling, the skin pulls tight between the rivet runs.

Over gun-loading bays and at other places where large access panels are required, the panels are made to conform to the aerofoil contour and are usually well stiffened with top-hat sectioned stringers. The reason for this is two-fold: the panels must be capable of withstanding rough handling and must be stiff enough to withstand aerodynamic loads; they are secured in place with quickly detachable fasteners.

Stringers.—A lipped " L " section is commonly used for stringers. These run spanwise and are riveted to the interior surface of the skin, top and bottom, before assembly of the skin plating. Sometimes the stringers are intercostals but when they are continuous the ribs have to be notched to clear them.

Pin Joints.—The most common method of joining the wing to the centre section or fuselage is by means of pin joints. At the end of each main spar boom, top and bottom, a high tensile steel or steel bushed fitting is bolted. On one side of the joint this fitting consists of a fork end which mates with an eye end on the other side; the joint being completed by a large bolt. This bolt, sometimes tapered, is a tight fit in the fork and eye end, as there must be no risk of movement in these joints. As a further insurance, the front spar pin joints are often arranged so that the bolts are horizontal, while those at the rear spar are set vertically.

Pin joints are invariably used on Fleet Air Arm aircraft where it becomes necessary to fold the wings for stowage of the machine below deck. The rear pin joints are set at the angle required to allow the wing, after extraction of the front pins, to pivot round the rear bolt.

Wing Tip.—This is usually fabricated as a detachable part and is of similar construction to the main plane. The last rib of the plane and the first of the wing tip are stoutly made and the tip is secured by bolts passing through the two ribs. A detachable tip has the advantage that access to the interior of the wing and tip may be effected through the lightening holes in the end rib.

Wood Construction.—The all-wood cantilever wing of the "Mosquito" is built as a single unit with detachable tips. It carries the engines, undercarriages, and tanks. On assembly the fuselage is lowered on top of the centre portion of the wing and the two units are bolted together.

In general appearance the wing structure bears a resemblance to its metal counterpart and the methods used to obtain these conditions are noteworthy.

The basic structure of the plane is two main spars with nosing, interspar, and trailing edge ribs; spanwise stringers running from tip to tip form stiffeners for the skin and thus complete the now familiar "stressed-skin" construction.

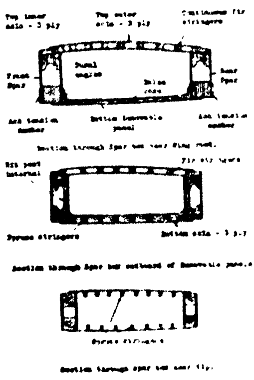


Fig. 10

Spars.—These are built in box fashion having ¼ in. thick birch plywood webs and laminated spruce booms. In plan view the spars taper from root to tip and, as the wings are tapered, the depth of the webs is greater at the root than at the tip. At the inboard portion of the wing, which carries the loads of the engines and undercarriage, the spars are reinforced at their bottom edges with longitudinal 4-ply ash tension strips (see Fig. 10). The booms are made from three laminations of 1¼ in. thick spruce, scarfed and spliced together in the thickest section, but these are lightened by spindled slots between the points of rib attachment. The bottom boom of the front spar is formed from horizontal laminations ⅜ in. thick, while in the rear spar the laminations are set vertically.

Outside the load-carrying area the bottom boom of each spar is changed to three horizontal laminations but, towards the tip, it is changed once again to a solid block, and the transition points are formed by means of long scarf joints.

On the face of the front spar, hardwood or Bakelite packings are used to distribute pressure of the metal brackets that support the engine and undercarriage. Similar packings are provided on the rear spar where the landing gear brackets are attached.

The space between the spar webs is filled in at each main rib and wherever a bracket is applied. One-inch square vertical spruce blocks are glued to the inside faces of the spars for rib attachment, screws passing through these and the ply web pick up similar blocks on the inside of the spar.

Leading Edge.—Forward of the front spar the structure consists of nose ribs which form the basis for the nosing skin; this is made in four sections.

The ribs are lightly constructed with spruce booms shaped to the nose contour and stiffeners of the same material. A 3-ply gusset is glued at the join of the stiffeners to the top boom and a longitudinal scalloped strip is set at an angle of 45 degrees into a spruce block at the front spar bottom boom attachment point. This structure is covered with a preformed plywood skin that overhangs the ribs so that the nosing can be glued and screwed in place to the top and bottom booms of the front spar where it becomes a fixed portion of the wing unit.

Interspar Ribs.—These conform to the aileron contour and are of three types; fuselage ribs, double-sided or box type ribs, and light ribs. Fuselage ribs come just inside the fuselage contour and carry shear bolts which support the fuselage panels below the wing. The webs are made of birch 3-ply $\frac{1}{4}$ in. thick reinforced with spruce flanges top and bottom also by rectangular vertical stiffeners.

Box-type ribs have two 3-ply sides $\frac{3}{16}$ in. thick between which are glued stiffeners made of walnut, birch, ash, or spruce, depending on their location and purpose. These ribs are the counterpart of the stiff ribs in metal construction and are used at places where the skin is cut away such as at wheel wells.

The light ribs have 3-ply birch webs which are located on the inboard side of solid spruce flanges. These ribs are used outboard of the load-carrying portion of the wing.

The ribs are glued and screwed to the blocks, already mentioned, on the faces of the front and rear spars.

Skin.—In the load-carrying area the top surface of the skin is of double thickness with fir stringers running spanwise sandwiched between the two layers of $\frac{1}{4}$ in. 5-ply birch. Outboard of this area the skin is a single thickness of plywood with longitudinal stringers.

The bottom skin is of composite construction and at the inboard end provides openings through which tanks may be introduced.

These openings are covered with stressed skin detachable panels, consisting of plywood-balsa sandwiches which are bolted to the spars and adjacent ribs.

Outboard of the tank bay, the plywood under-skin is permanently secured to the wing and is reinforced by stringers running lengthwise in similar manner to that of the top skin.

The complete wing, when screwed and bolted together, is fabric covered and given the normal protective treatment.

ENGINE MOUNTINGS.—Two types of engine are in general use, namely, in-line and radial engines; the mounting for each of these types has its own peculiarities.

Mountings for In-line Engines.—In the design of in-line engines,

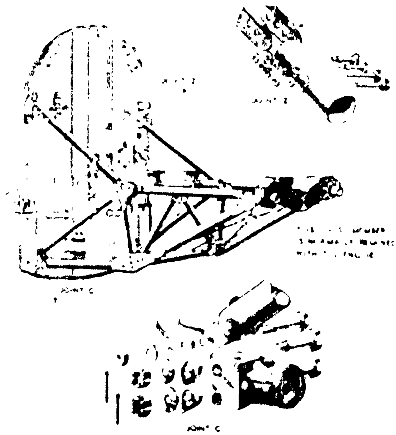


Fig. 11

four mounting feet are cast integrally with the crankcase to provide points for attachment to the airframe.

The majority of engine mountings consist of a tubular steel girder framework in which the joints are either welded or completed with stainless steel side plates in a similar manner to tubular fuselage construction; the engine being supported directly on four pick-up points corresponding to those on the engine crankcase.

The mounting may have cross-bracing and thus be a torsional rigid structure in itself, although it is sometimes found convenient to make use of the engine crankcase to obtain this result. Then the framework consists of right- and left-hand units bolted to the sides of the crankcase. The aft ends of the mounting are jointed either to the fuselage or wing structure according to the type of aircraft.

With modern high-powered engines, the attachment points are seldom of a completely rigid nature, thus the feet are not direct metal to metal connections but have hard rubber inserted between the feet on the engine and those on the mounting. Special flexible joints have been designed for different makes of engines which have a cushioning effect thus damping down the engine vibrations so that transmission to the airframe is minimized.

Increasing use is being made of castings in present-day aircraft. Fig. 11 shows the front feet cast integrally in a cradle which also acts as a cross-bracing member. Alternatively to tubular constructed side frameworks, right- and left-hand units are cast as one piece; these are fitted with anti-vibration mountings through which the engine feet pass in the form of spigots.

Mountings for Radial Engines.—In contrast to the in-line engine which has four horizontal feet, the radial engine has a vertical mounting ring cast integrally with the crankcase. The engine mounting follows suit with a ring corresponding to that of the engine to which it is bolted through flexible attachments. The ring is supported by a simple tubular steel structure usually consisting of four ties, tubular cross or vee-braced, which are attached at the aft ends to the main structure by pin joints. These latter are formed either by welding steel bushes to the split ends of the tubes or by steel fittings into which the tubes are socketed and bolted.

Engine Cowling.—In order that engine maintenance may be the more easily effected, engine and mounting are faired in with quickly detachable panels, thus the use of a tubular engine mounting facilitates access to engine and accessories.

The cowling for stationary engines usually consist of four panels, one top, two side and one beneath the engine. By arrangement with the engine manufacturers, lugs can be incorporated on the engine on which a framework can be erected and, together with a front ring and the fireproof bulkhead behind the engine, form a structure on which the cowling sits.

The framework is shaped to suit the cross-section of the fuselage or engine nacelle and fastener housings are riveted to it.

The panels are made from alclad sheet formed to the required contour and stiffened with light alloy rolled sections: the male portions of the fasteners are fitted at intervals of about 12 in. round the edge of each panel. When in position, the cowling is secured by the quickly detachable fasteners mating with the housings on the framework. Owing to the sharp curves found in the panels, the fasteners must have tolerance in all directions to enable them to pick up with their housings on the curve and yet, at the same time, they must hold the cowlings down tightly so that there is no tendency for the panels to lift under air loads.

Cowls for radial engines are circular in section over the cylinders which are almost completely enclosed; the remainder of the cowling fairs into the main structure. As these engines are air cooled it is necessary to incorporate air ducting into the cowling design. In general the portion in front consists of a double skin nose cowl giving a clean entry for the air while, behind the cylinders, cooling shutters or gills control the air flow. The cowling panels are held in position with quickly detachable fasteners but the modern tendency, especially where the cowl is completely circular, is to employ toggles. These latter are top dead centre strainers which pull the panels tightly on to the cowling framework. Thus only top and bottom panels become necessary and these can be held by three toggles at each side.

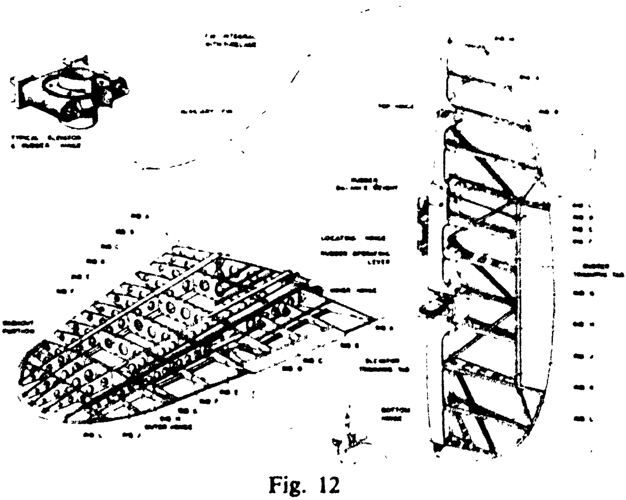


Fig. 12

TAIL UNIT.—This consists of tail plane and fin; elevators and rudder are considered under the heading of control surfaces.

Fins and rudders may be arranged in a number of different ways: (*a*) Fin built integrally with the fuselage as in Fig. 12. (*b*) Tail plane and fin built on to a detachable tail end which is bolted or riveted to the rear fuselage on assembly. (*c*) Twin fins mounted at the extremities of the tail plane. (*d*) Fin and tail plane separately assembled to the fuselage.

Fin.—This is symmetrical in section and the shape is maintained by a number of horizontal ribs supported by formers and a vertical sternpost; a capping forms the leading edge and the framework is covered by a skin which is sometimes stiffened with stringers riveted on.

Ribs and formers are made from alclad sheet flanged along the edges and stiffened by flanged lightening holes. The sternpost is made of heavier gauge plate and not lightened; it forms the support for the rudder hinges. The light alloy skin is riveted to the flanges of ribs, formers, and sternpost, thus completing a " stressed skin " unit.

The wood version of the fin is attached to the top of the fuselage by metal brackets bolted to the rear bulkheads.

It consists of heavy laminated formers and sternpost having 3-ply webs with horizontal ribs shaped to the fin contour and similarly constructed; the leading edge is made of 3-ply formed spruce and the plywood skin is glued to the structure and feathered into the leading edge. The rudder hinges are mounted on the aft face of the sternpost and bakelite and compressed laminated wood is used as bearings for brackets and bolts.

Tail Plane.—The most common position for the tail plane to be mounted is on top of the rear fuselage, but occasionally it is at the bottom. When the main planes are mounted in a high wing position it is necessary to set the tail plane still higher to avoid the down-wash from the wings; thus, as with the " Barracuda," the tail plane is mounted high up on the fin.

Most tail planes are cantilever, but if they are mounted at the top of the fin bracing struts may be necessary.

The tail plane is often fabricated in one piece, but as with the Hawker " Tempest " it can be made in interchangeable halves which are attached at the sides of the fuselage.

Whatever its relative position to the fuselage, the tail plane follows " stressed-skin " practice, *i.e.* two main spars with nosing. interspar ribs and formers behind the rear spar for the elevator shrouding, form the basis to which a stringer stiffened skin is riveted.

Spars have extruded section booms, top and bottom, joined by a plate web which is stiffened with flanged lightening holes and extensions aft the rear spar carry the elevator hinges.

Ribs and formers are made from light alloy sheet shaped to the symmetrical contour of the aerofoil section, flanged along the edges and stiffened by flanged lightening holes.

The tip of the plane is formed by a semi-circular capping section and the alclad skin is riveted to the flanges of formers, ribs, and spars; the construction as a whole being a scaled down version of the main planes.

In wood construction the tail plane has two continuous wood box-type spars that run from tip to tip. They are made with spruce booms, top and bottom, with 3-ply webs on each side except at the centre portion which is filled in with laminated spruce.

Interspar ribs shaped to the aerofoil section have spruce booms and plywood webs and similarly constructed nosing formers are provided ahead of the front spar to form the leading edge. Small plywood brackets are glued on the back face of the rear spar to support the skin where it overhangs to form the elevator shrouding.

The skin consists of 3-ply birch and the leading edge is completed with a 3-ply spruce member into which the top and bottom skins are glued and feathered.

The tail plane is attached by metal brackets at the front spar which anchor it to the rear fuselage bulkhead. Brackets bolted to the front face of the rear spar are connected to the rear bulkhead by two diagonal tubes at each point; the tubes are adjustable and enable the tail plane incidence to be rigged as required.

CONTROL SURFACES.—Included under this heading are ailerons, flaps, elevators, rudders, and trimming tabs. A good proportion of aircraft still use fabric-covered rudders, elevators, and ailerons because, in the past, considerable difficulty has been experienced in obtaining a light metal skin on the finished "stressed-skin" component. However, schemes have been devised to overcome this trouble and a patented method is described at the end of this section.

Ailerons.—Fabric-covered ailerons have a tubular spar carrying ribs to which is attached a nosing and trailing edge; the fabric covers the whole of the structure and is given applications of dope to tighten it. Mass balance weights are fitted in front of the hinge line and the unit is also balanced aerodynamically.

The spar is made of steel or dural tube with collars for rib attachment sweated or bolted in position.

Ribs are fabricated from light alloy plate with lightening holes in the webs and flanges along the edges in which eyelets are fitted for attachment of the fabric. Usually the ribs are made in one piece to the contour of the aileron and an alclad sheet nosing is bent round and riveted to the rib flanges in front of the spar. Lead mass balance weights are riveted along the inside of the nosing for most of its length. The trailing edge either consists of sheet or is made from a rolled section and riveted to the ends of the ribs, except where these are shortened to accommodate the trimming tab.

Wing trailing edge ribs of rigid construction attached to the rear spar carry the aileron hinges.

"Stressed-skin" ailerons have a light alloy spar of channel section. Ribs are made in two pieces from alclad sheet, the nose and trailing portions being riveted together through the spar web; flanged lightening holes stiffen the rib webs. The skin is riveted to the flanges of the spar and ribs and is stiffened by longitudinal stringers of angle section. The trailing edge is formed from a length of rolled or extruded section and joined to the aft ends of the ribs, except where these are cut back locally for the trimming tab. Mass balance weights are secured inside the nose portion along its entire length.

Flaps.– These are hydraulically operated and form part of the inboard trailing edge of the wing. The most common form is the split flap which is about half the depth of the wing section locally. All metal construction consists of a tubular or rolled section spar to which are attached one-piece light alloy ribs, and the alclad skin is riveted to the rib flanges.

In order that the flaps on both the port and starboard wings shall operate together, a torque tube interconnects them. The flaps are attached to the wing structure by split bearings or piano hinges.

In wood construction the spar has a plywood web reinforced at the edges with spruce. The outermost ribs are made of plywood while the inner ribs are of skeleton formation and made of spruce with ply reinforcing. The structure is covered with a plywood skin and the port and starboard units are interconnected by a tubular torque tube having sleeves mounted on it which are bolted to the two inboard ribs of each flap.

Elevators.–These are often built as separate halves and interconnected by a torque tube, but the spar can extend right across and act in this capacity.

The fabric-covered type of elevator has a tubular steel spar on which collars are mounted to carry light alloy ribs. A small diameter tube extension is sleeved into the spar end to support the tip and a horn balance, which is sometimes employed to obtain aerodynamic stability.

When the ribs are load-carrying members they are generally formed from light alloy sheet flanged to a channel section along the edges but, if they act purely as formers, it is more usual to make them in skeleton form, the booms being shaped from channel section and fitted with eyelets to which the fabric is laced.

The trailing edge is formed from oval tube and riveted to the aft ends of the ribs; the nose, balance, and tip portions are covered with an alclad skin forward of the spar and riveted to the rib flanges. Mass balance weights are fitted in the nosing along almost the entire length of the leading edge.

The elevator hinges are attached to load-carrying formers on the rear spar.

In "stressed-skin" construction a built-up box or channel section spar is fabricated from light alloy sheet with flanged lightening holes in the web. Ribs, made from flanged alclad sheet, consist of nose and trailing portions joined at the spar. Trailing edge and tip are made from a length of extruded or rolled section and riveted to the aft end of the trailing ribs, except in way of the trimming tab, where they are completed with a plate sub-spar. Skin is riveted to the structure and stiffened by angle or Z section stringers.

Rudders.—Fabric-covered types follow the same practice as is employed in other control surfaces.

At the forward edge a tubular or box-type rudder post carries a number of horizontal trailing ribs which are mostly of skeleton form. An alclad nose fairing is attached to the rudder post and the trailing edge is completed by a flattened tube riveted to the aft ends of the full ribs. At the trimming tab the ribs are cut back and the gap is filled by a light alloy flanged plate member. Owing to the rather large cut-away for the tab, tubular vee-bracing is fitted between the rudder post and the tab cut-away to stiffen the rudder against the pull of fabric when doped.

The top of the rudder, where the section tapers, is supported by either a small diameter tube or a tapered channel nosing and, where applicable, a horn balance is fitted in front of the rudder hinge line for aerodynamic balance. The mass balance is usually a single mass of lead arranged in front of the hinge line and, when convenient, in the horn balance.

The "stressed-skin" component is built upon a box section post which, together with a semicircular nosing, form a D section spar. Trailing ribs of typical construction are riveted to the rear face of the spar and a trailing edge, formed from extruded or rolled section, is attached to the aft ends of the full ribs. At the tab cut-away the space is sealed by a channel plate member riveted to the ribs and this forms a shroud for the trimming tab.

Stretching Metal Skins.—As the performance of aircraft, particularly high-speed types, is adversely affected by irregularities of the contour of the skin surface, it has been found desirable to improve the surface finish and maintain accuracy of contour. This is particularly true with regard to control surfaces.

Hawker Aircraft Limited have recently completed a patent specification by which the skin is kept at a uniform tension during the riveting up process.

Previously pre-tensioning of skins had been carried out by heating up the metal skin to expand it while it was being riveted to the supporting structure by placing heating pads in contact with the skin, but these pads obstruct the operator and cannot maintain the whole areas at uniform temperature with the result that after cooling the skin is not in uniform tension. Therefore it is deemed advisable to rivet up while the skin is at room temperature.

When the chord is small, as in the case of elevator or aileron, tension may be applied to the skin in a spanwise direction only, but when the chord exceed ¼ span it is desirable to maintain tension both in a chordwise and spanwise direction.

Jigs for the purpose are designed so that the skin is tensioned by means of toggles, weights, or springs. These are hooked through holes in an overlapping margin on the skin. Riveting can be carried out while the skin is thus held, but when stretching is required in more than one direction, it is preferred to heat the skin. Blankets for this purpose are either heated by water, steam, or electricity, and while the skin is in the stretched condition it is riveted around its margins only.

The heat is then removed and the skin will be uniformly tensioned when allowed to return to room temperature.

With the aid of drilling jigs the rivet holes picking up the structure are drilled and the rivets closed, after which the mechanical tensioning is released.

The excess margins which were required for the tensioning devices are trimmed off as a final operation.

This method enables thinner skins to be used than hitherto and thereby saves weight.

Trimming Tabs.—On most ailerons, elevators, and rudders, trimming tabs are incorporated in the trailing edge. These are operable from the cockpit and can be pre-set by the pilot to trim the aeroplane in the air and lighten the controls.

Ailerons which do not incorporate a controllable tab usually have a small fixed tab consisting of a thin strip of light alloy or stainless steel sheet projecting aft of the trailing edge and riveted to it. This tab is sufficiently flexible to be bent by the rigger on the ground in accordance with the pilot's report and helps to balance up the ailerons in the air.

However, the construction of the controllable type consists of a tubular light alloy spar at the leading edge on which a number of small ribs are mounted and an oval trailing edge; these form the structure over which a skin is riveted. The tab is streamline in section and conforms to the rest of the aerofoil contour.

It is attached to its main component by hinges which consist of either spigots fitted into the end of the tubular spar of the tab or piano hinges.

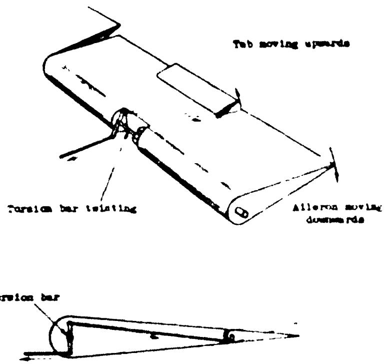
Spring Tab.—In order to ensure that control surfaces, especially ailerons, are light at high speed the surface must be very closely balanced aerodynamically. Its balance characteristics vary with altitude and it is also unduly sensitive to manufacturing errors.

Therefore a special form of trimming tab has been developed known as the spring tab.

With a spring tab fitted aerodynamic balance need not be nearly so critical, as the pilot's effort is transmitted to the control surface via a spring which deflects to operate a servo tab which assists the pilot.

For use with the same control forces applied by the pilot, aerodynamic balance of the spring-tab controlled surface is deliberately made less critical. Compensation for any heaviness of control thus introduced is catered for in the design by the size of the tab and the strength of the spring.

Fig. 13 illustrates the operation of the spring tab. It will be



Operation of Spring Tab Aileron.

Fig. 13

noticed that in this particular design a torsion bar has been substituted for the more conventional type of spring.

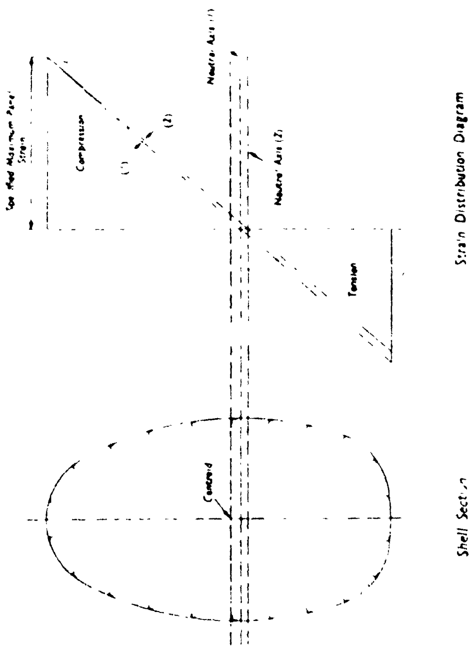
When the pilot operates the control with the aileron air-loaded the first movement causes the tab to move upwards, but a secondary movement through the torsion bar will move the aileron downwards aided by the tab, so lightening the controls.

Stressed-skin Structures

The following Data Sheets are reproduced by courtesy of the Royal Aeronautical Society. Complete sets can be obtained from the Society.

00.06.01

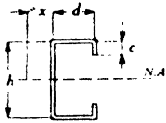
METHOD OF CALCULATING STRESS DISTRIBUTION IN A REINFORCED SHELL UNDER BENDING

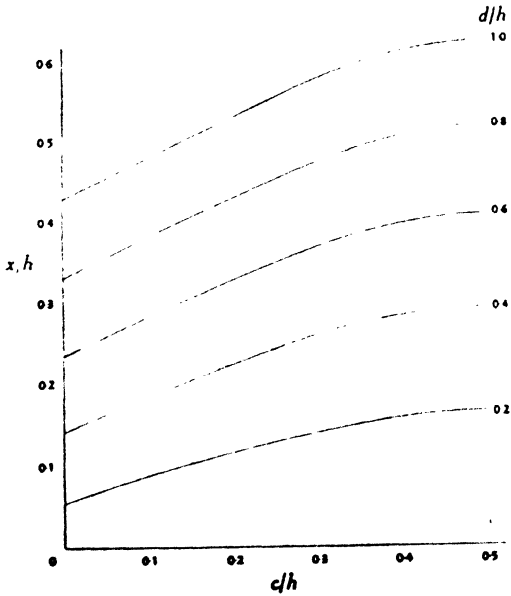


For a full description of this diagram, see Appendix, p. 491.

00.06.02

SHEAR CENTRE OF
LIPPED CHANNEL SECTION

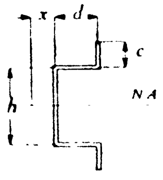


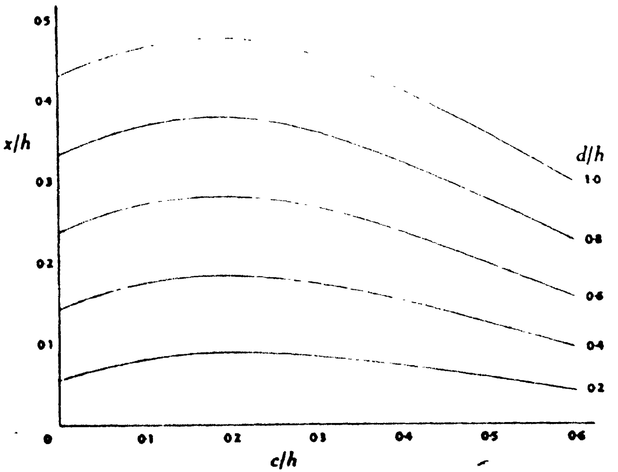


For a full description of this diagram, see Appendix, p. 493.

00.06.03

SHEAR CENTRE OF TOP HAT SECTION

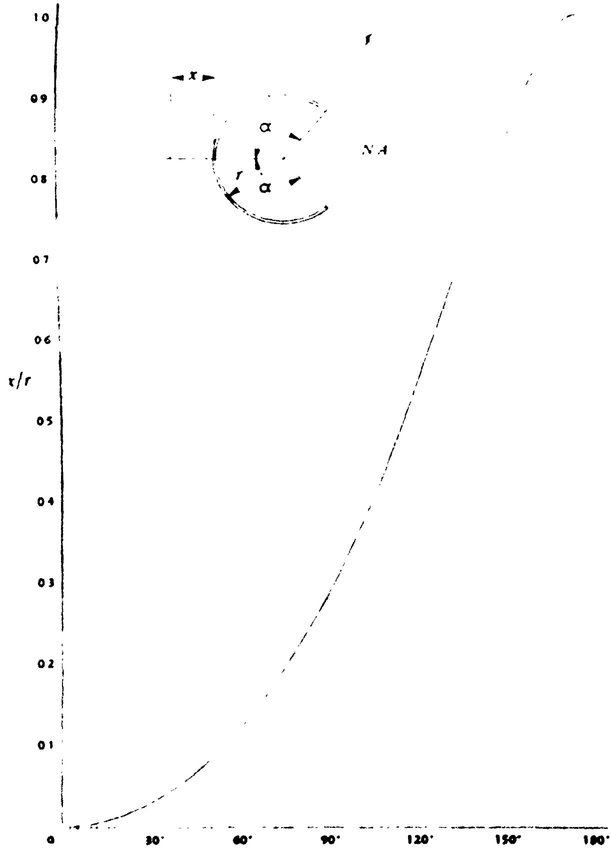




For a full description of this diagram, see Appendix, p. 494.

00.06.04

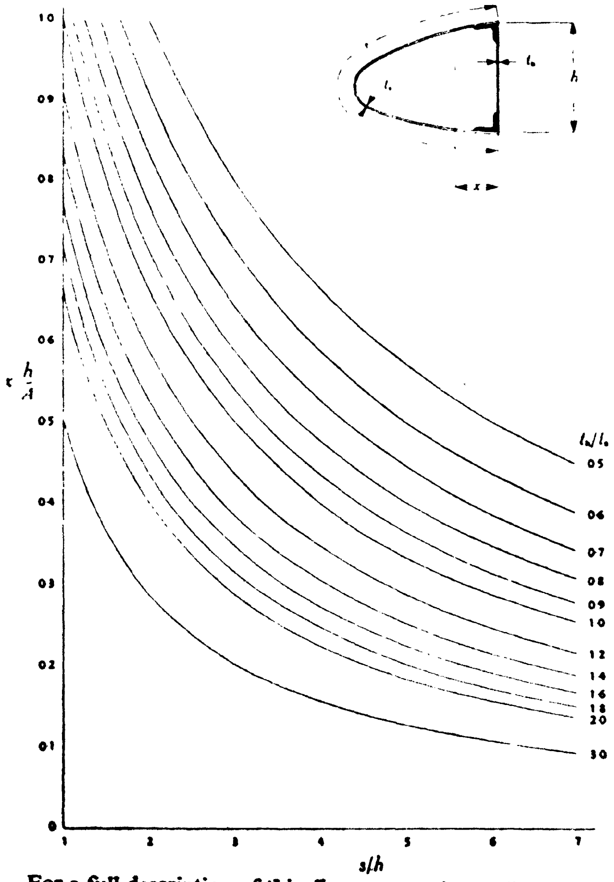
SHEAR CENTRE OF CIRCULAR ARC SECTION



For a full description of this diagram, see Appendix, p. 495.

00.06.05

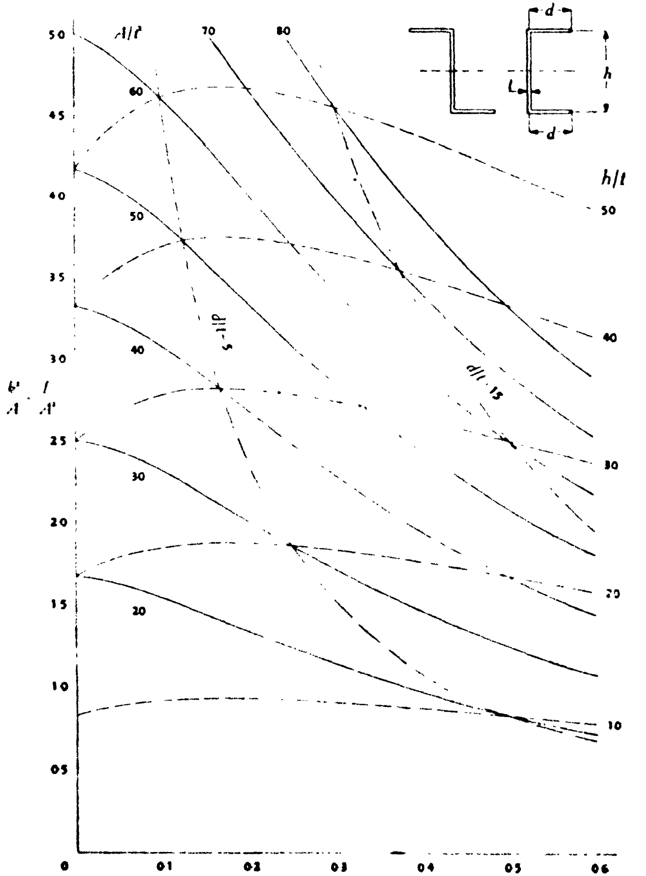
SHEAR CENTRE OF D SECTION



For a full description of this diagram, see Appendix, p. 496.

01.00.01

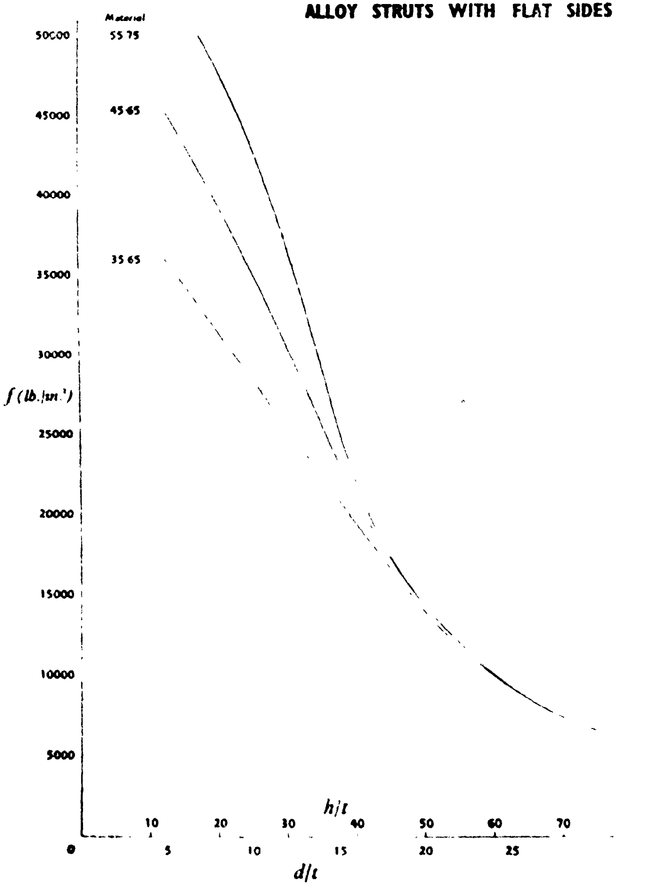
FLEXURAL PROPERTIES OF Z AND CHANNEL SECTION STRUTS



For a full description of this diagram, see Appendix, p. 497.

01.01.08

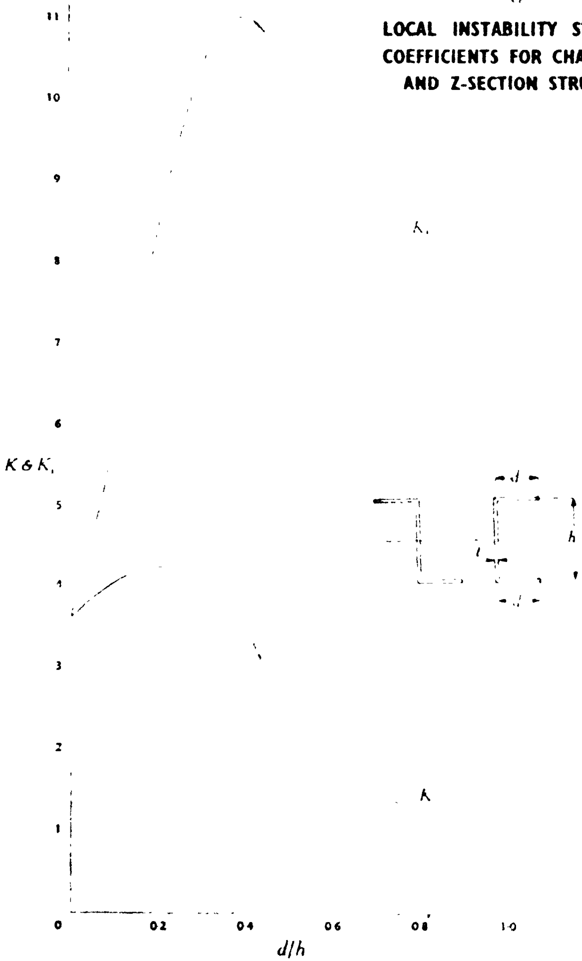
LOCAL INSTABILITY OF ALUMINIUM ALLOY STRUTS WITH FLAT SIDES



For a full description of this diagram, see Appendix, p. 498.

01.01.09

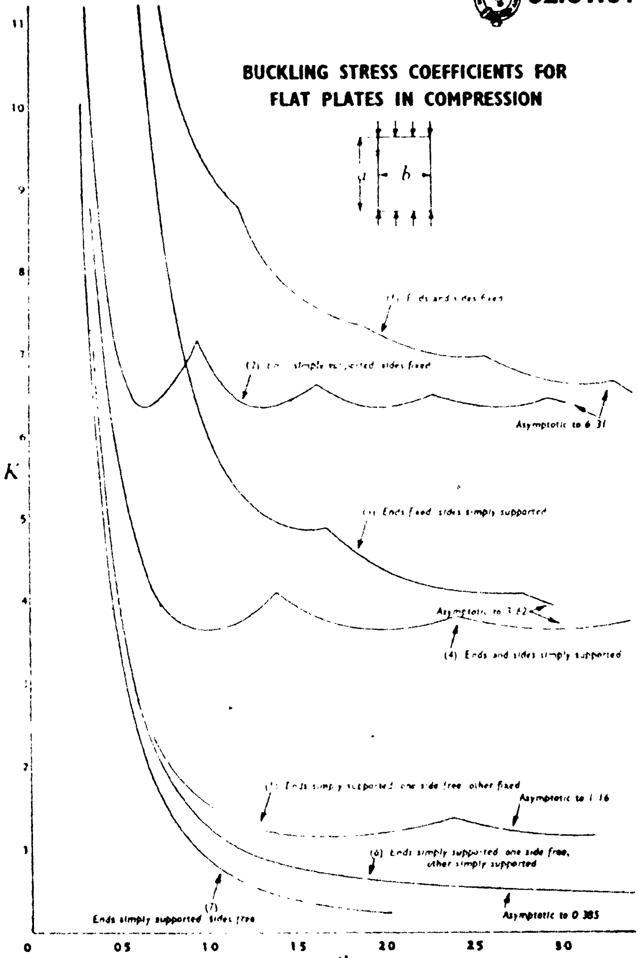
LOCAL INSTABILITY STRESS COEFFICIENTS FOR CHANNEL AND Z-SECTION STRUTS



For a full description of this diagram, see Appendix, p. 500.

02.01.01

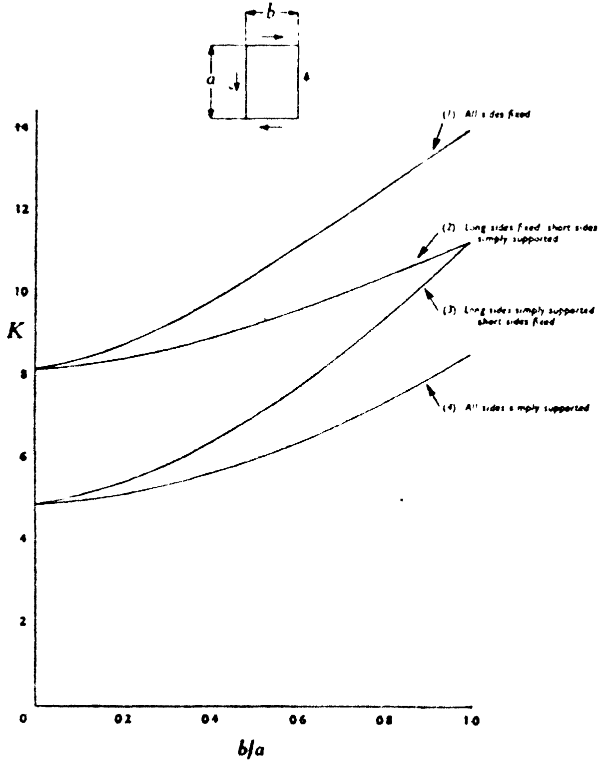
BUCKLING STRESS COEFFICIENTS FOR FLAT PLATES IN COMPRESSION



For a full description of this diagram, see Appendix, p. 501.

02.03.01

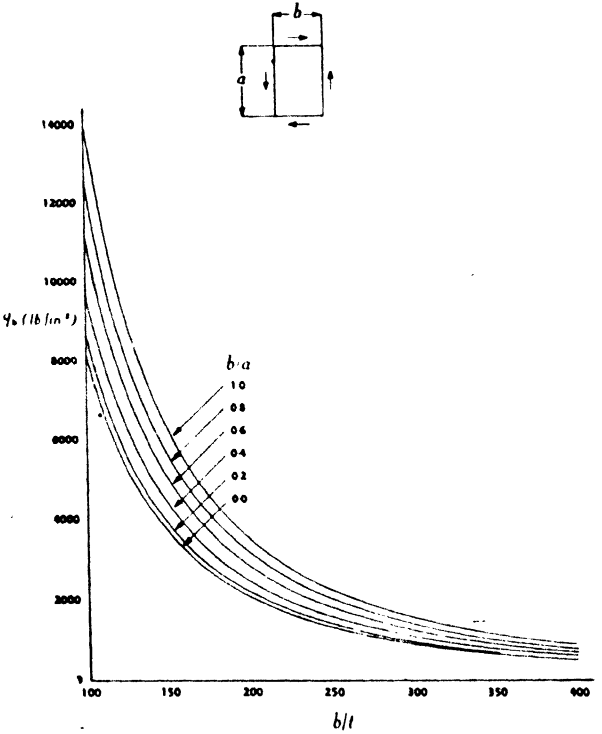
BUCKLING STRESS COEFFICIENTS FOR FLAT PLATES IN SHEAR



For a full description of this diagram, see Appendix, p. 503.

02.03.02

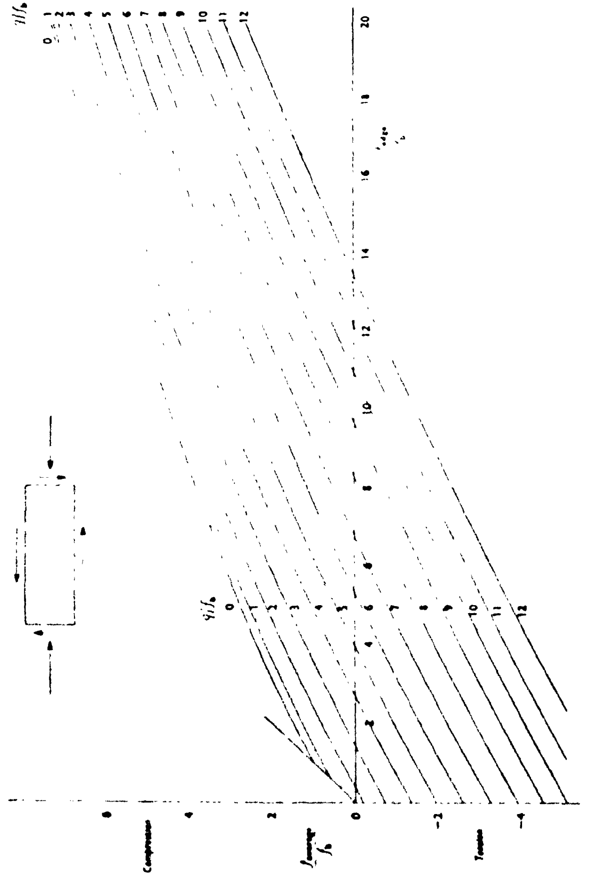
BUCKLING STRESS FOR FLAT ALUMINIUM ALLOY PLATES IN SHEAR
(ALL SIDES FIXED)



For a full description of this diagram, see Appendix, p. 504.

02.04.02

AVERAGE AND EDGE STRESSES FOR FLAT PLATES UNDER SHEAR AND COMPRESSION



For a full description of this diagram, see Appendix, p. 505.

SECTION VIII

THE POWER UNIT

Abbreviations

B.H.P.	Brake Horse Power.
B.M.E.P. . . .	Brake Mean Effective Pressure (lb. per sq. in.).
B.T.U. or B.Th.U..	British Thermal Unit.
C.H.U.	Centigrade Heat Unit.
I.H.P.	Indicated Horse Power
I.M.E.P. . . .	Indicated Mean Effective Pressure.
H.U.C.R. . . .	Highest Useful Compression Ratio.
J.	Joule's Mechanical Equivalent of Heat.
1 B.T.U. . . .	778 ft. lb.
1 C.H.U. . . .	1,400 ft. lb.

Octane Rating of Fuels

Iso-octane is the arbitrary standard test fuel for fuel comparisons. Thus iso-octane is rated at 100. Anti-knock characteristics of other fuels are then related to that of iso-octane and the *octane number* derived directly. Thus a fuel with the same anti-knock characteristics as iso-octane has an octane rating of 100; or a fuel having 60% of the anti-knock value of iso-octane would have an octane rating of 60, etc.

Certain leaded fuels may have an octane rating greater than 100, *i.e.* greater anti-knock properties than the standard test fuel, iso-octane.

Power and Work, Units and Relations

1 British Horse Power	= 33,000 ft. lb. per min. = 550 ft. lb. per sec.
	= 0·7461 Kilowatt = 42·44 B.Th.U. per min.
	1·014 French Horse Power (Force de Cheval).
1 British Horse-Power-Hr.	0·7461 Board of Trade Electrical Units.
1 French Horse Power	0·986 British Horse Power = 75 Kilogrammetres per sec.
1 Kilowatt	44,240 ft. lb. per min. = 737·3 ft. lb. per sec.
	1·341 British Horse Power = 56·91 B.Th.U. per min.
1 B.Th.U.	= 778 ft. lb. = 0·252 Kilogramme Calories.
	= 107·5 Kilogrammetres = 0·1055 Watt per sec.

NOTES ON HORSE POWER

(*Communicated by R. P. Gordon Jones.*)

The nature of the horse power of a prime mover should always be defined when stating its amount.

Brake Horse Power, B.H.P., is the horse-power output available at the propeller shaft. This power can be measured on the test bed by hydraulic or electric brakes; for certain engines torque meters are available which can measure the torque developed during flight. This device is usually incorporated in the engine's reduction gear. Wooden test fans are widely used for power absorption in production test departments. These are calibrated on a "known" engine at a given speed; the power at all other speeds can then be calculated from the propeller law.

Gross Brake Horse Power, or Crankshaft Horse Power, refers to the B.H.P. plus the supercharger horse power (see below).

Indicated Horse Power, I.H.P., is the work done on the pistons by the burning charge. This power can be measured by instruments such as the Farnbro' Recording Indicator or various applications of the Cathode Ray Tube. The I.H.P. takes no account of the internal friction losses such as are inevitable in the course of converting the reciprocating motion of the piston into the rotary motion of the final drive. Subtraction of the G.B.H.P. from the I.H.P. gives the *Friction Horse Power*. Expression of the G.B.H.P. as a percentage of the I.H.P. gives the *Mechanical Efficiency*. As the apparatus required to record the I.H.P. is delicate, it is usually only applied to single cylinder units. In the case of "main" engine tests, other means have been evolved for the estimation of the friction horse power. Chief amongst these are the Motoring Method and the Morse Test, of which the latter can only be applied to multi-cylinder engines.

Supercharger Horse Power, S.H.P., varies with the weight of air, pressure ratio and efficiency of the supercharger, and is usually ascertained on a special rig driven by an electric motor. An approximate estimation can however be made from the following general formula:—

$$\text{S.H.P.} = \text{B.H.P.} \times \left\{ \frac{\cdot 0017T(r^{\cdot 29} - 1)}{1 - [\cdot 0017T(r^{\cdot 29} - 1)]} \right\}.$$

Where T = The supercharger inlet temperature in degrees C. absolute.

r = The pressure ratio of the supercharger.

This formula assumes an adiabatic efficiency of 70%, a supercharger mechanical efficiency of 90% and an air consumption of ·11 lb./GBHP./min.

The power output of aircraft engines is usually quoted for the following conditions:—

International, Rated, or Maximum Climbing Power.—The maximum r.p.m. and boost pressure which can be maintained for a period of half an hour, with the aircraft in the climbing attitude, are known as the rated r.p.m. and rated boost pressure. The rated altitude is the greatest altitude at which the rated boost can be maintained at the rated r.p.m. and the power at this altitude is known as the *Rated, or International Power.*

Maximum All-Out-Level Power.—This is the power output at maximum all-out-level r.p.m. and boost, at the maximum all-out-level altitude. This condition applies to level flight only, for a duration of five minutes, and is that under which the maximum speed of the aircraft is measured. Both r.p.m. and boost pressure are generally higher than those stated for rated conditions.

Maximum Continuous Cruising Power (Rich Mixture).—This is the maximum power that may be used for level flight for periods in excess of five minutes, and up to half an hour. The r.p.m. must not be higher than 50 r.p.m. below all-out-level but must not be less than 85% of all-out-level. The B.H.P. may not be less than $\frac{8}{10}$ths of the power at sea-level at the all-out-level boost pressure and at the selected cruising r.p.m.

Maximum Economic Cruising Power (Weak Mixture).—This is the maximum power which may be used in conjunction with weak mixture, and has no limit other than the duration of the flight. Unlike the other conditions where boost is strictly scaled to complement r.p.m., the maximum boost may be used at r.p.m. lower than the maximum permissible. "Weak" mixture may be defined as the mixture strength resulting from a weakening off from normal rich that gives a 7–10% power decrease. (A 3% r.p.m. drop with fixed pitch propellor.)

Maximum Take-Off.—The maximum r.p.m. and boost pressure for take-off usually exceed those given for Rated. In the case of a power unit for a bomber the boost may exceed that given for All-Out-Level. This condition is limited to three minutes or a 1,000 ft.

Reference.—R.D.E.2 and *Handbook of Aeronautics*, Vol. 2, under "Testing of Engines," "Superchargers," by C. E. Jones.

The following is an example of the application of these rules:—

ENGINE: *Armstrong Siddeley "Tiger VIII."*—(Two-bank 14 cylinder radial with two-speed supercharger.)

International, Rated or Maximum Climbing Power.—

Moderate Supercharger: 2,375 r.p.m.$+\frac{1}{2}$ lb. boost. Rated altitude 6,250 ft.

Full Supercharger: 2,200 r.p.m.$\times\frac{1}{2}$ lb. boost. Rated altitude 12,750 ft.

Maximum All-Out-Level Power.—

Moderate Supercharger: 2,450 r.p.m. +½ lb. boost. All-Out-Level altitude 6,750 ft.

Full Supercharger: 2,450 r.p.m. ×½ lb. boost. All-Out-Level altitude 14,250 ft.

Maximum Continuous Cruise.—Both gears: 2,200 r.p.m. and −½ lb. boost.

Maximum Economic Cruise.—Both gears: 2,200 r.p.m. and −2 lb. boost (or r.p.m. obtained with V.P. Propeller).

Maximum Take-Off.—Moderate Supercharger: 2,375 r.p.m and +2½ lb. boost.

MISCELLANEOUS FORMULÆ

$$\text{Indicated Thermal Efficiency} = \frac{\text{I.H.P.} \times 33{,}000 \times 60}{C \times w \times 778}.$$

where C = calorific value of fuel (B.T.Us. per lb.).

w = lb. weight of fuel consumed per hour.

$$\text{Mechanical Efficiency} = \frac{\text{I.H.P.} - \text{engine losses}}{\text{I.H.P.}}.$$

$$= \frac{\text{B.H.P}}{\text{I.H.P.}}.$$

$$\text{Brake Thermal Efficiency} = \frac{2{,}545\ \text{B.H.P}}{wC}.$$

THERMAL EFFICIENCY AND COMPRESSION RATIO

$$\text{Theoretical Thermal Efficiency} = 1 - \left(\frac{1}{r}\right)^n.$$

where r = expansion ratio

n depends largely upon fuel properties, = ·258–·295.

$$\text{Thermal Efficiency (Practical)} = \frac{\text{I.H.P.}}{Ac}.^{*}$$

where A = lb. of air used per I.H.P. per hour.

c = fuel constant; typical values—rich petrol 1·96 } mixtures
rich hexane 1·94
rich heptane 1·995
rich ether 1·975
rich ethyl-alcohol 2·02.

$$\text{I.H.P.} = 9{\cdot}9165\ \text{I.M.E.P.} \times ld^2Nm \times 10^{-7}\ \dagger.$$

* H. R. Ricardo. † A. W. Judge, *Aircraft Engines*.

where l = piston stroke in inches.
d = bore in inches.
N = revolutions per minute.
m = number of cylinders.

$$\text{B.M.E.P.} = \frac{\text{B.H.P.}}{9{\cdot}9165 \times \text{B.H.P.} \times ld^2Nm \times 10^{-7}}$$

Cooling

Heat dissipated in unit time $= k_H C_P \rho V A (T_H - T_0)$ (Osborne Reynolds)

where k_H = coefficient, usually same as coefficient of skin friction.
C_P = specific heat at constant pressure.
V = velocity of airstream.
A = area of hotted surface.
T_H = temperature of hot surface.
T_0 = temperature of surrounding air.

Heat dissipated per unit surface area per unit time $= k \,.\, K C_P \rho V (T_H - T_0)$ (Lanchester)

where k = coefficient of skin friction.
K = coefficient or normal plane resistance.

Approximate equation, Cooling Area of radiator, in square feet $= {\cdot}1835 \times$ B.H.P.

Air-Cooled Engine

H.P. equivalent of heat dissipated per square foot of cooling surface $= \dfrac{V \,.\, d\theta}{15{,}000}$ (Lanchester)

Cooling Power, *i.e.* H.P. lost per square foot due to skin friction $= \dfrac{V}{10^8}$ (Lanchester)

Where $d\theta$ = temperature difference, in degrees Fahrenheit, between hot surface and cooling air.

Fluid-Cooled Petrol Engines

The cooling fluid used for these engines in modern practice is usually Ethylene Glycol. This fluid boils at 195° C. and its chemical formula is $C_2H_4(OH)_2$. Its specific heat is ·62 of that of water. In the case of water-cooled engines the water temperature cannot be allowed to exceed 95° C. at ground level in order to prevent boiling. This temperature becomes less at high altitudes as the boiling temperature of water diminishes with the pressure.

Ethylene Glycol enables a much higher temperature to be maintained in the radiator. The latter, therefore, is reduced in size, weight, and its drag is less. In certain cases it has been found that an Ethyl Glycol radiator one-third the size required for a water radiator has worked satisfactorily.

The heat dissipation of a modern aircraft radiator with tubes 360 mm. long may reach 64·4 H.P. per sq. ft. of frontal area at a speed of 88 F.P.S. and a temperature difference of 67° C. The drag of such a radiator will be 6·18 lb. per sq. ft. of frontal area at this speed and will vary as V^2 (Pye). The heat dissipation will vary as V^2, as temperature difference between the air and the radiator, and as density of the air.

Stored Energy

	Weight, lb. per kilowatt/hour	Total weight, lb. per kilowatt/hour
Petrol	0·18	0·20
Hydrogen gas in cylinder	0·06	3·03
Liquid hydrogen	0·06	0·18
Dry battery	46–65	46–65
Storage battery	108	108
Compressed air (100 lb./sq. in.)	281	881
Compressed air (1,000 lb./sq. in.)	128	401
Flywheel	302	302
Rubber	1,292	1,292
Steel spring	443,000	443,000

Supercharger Calculations

Formulæ for Air Ministry's official type tests. (From Aircraft Engines, by A. W. Judge.)

W = weight in lb. of air flowing per minute.
C_P = specific heat at constant pressure = ·238.
γ = ratio of specific heats = 1·41.
T_1 = absolute temperature of air intake.
T_2 = absolute temperature of air delivery.
P_1 = absolute pressure of air intake (lb./sq. in.).
P_2 = absolute pressure of air delivery (lb./sq. in.).

Horse Power for Adiabatic Compression

$$\text{Adiabatic H.P.} = \frac{WJC_PT_1}{33{,}000}\left\{\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right\}$$

Actual Compression H.P.

$$\text{Actual H.P. input to air} = \frac{WJC_P}{33{,}000}(T_2 - T_1)$$

Overall Adiabatic Efficiency

$$\text{Adiabatic efficiency} = \frac{WJC_P T_1\left\{\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right\}}{33{,}000 \times \text{observed H.P. input.}}$$

This is actually the theoretical power required to adiabatically compress the air from the lower to the higher pressure, assuming no mechanical losses.

Volumetric Effciency

$$\text{Volumetric efficiency } \frac{1{\cdot}355\ WT_1}{DNP_1}.$$

D = theoretical displacement (cu. ft. per rev.) of rotor.
N = R.P.M. of rotor.

Adiabatic Temperature Efficiency

(Ratio of adiabatic H.P. to the actual H.P. input to the air).

$$\text{Adiabatic temperature efficiency } \frac{T_1\left\{\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right\}}{T_2-T_1}$$

Power to Drive Blower

$$\text{H.P. absorbed by blower} = \text{engine B.H.P.}\left\{\frac{{\cdot}00208T_1(r^{\cdot 291}-1)}{1-{\cdot}00208T_1(r^{\cdot 291}-1)}\right\}$$

r = compression ratio of blower.

Corrected Compression Ratio

Corrected ratio $r = r_0(1 - {\cdot}00063 r_0^2(T_1 - T_0))$.

Corrections for Temperature and Pressure

Corrected B.H.P.

$$= \text{Test B.H.P.}\left\{1 + \frac{760 - \text{barometric press. at given height}}{3{,}500}\right\}$$

barometric pressure expressed in mm. of mercury.

Air Ministry Correction Factor (Combined Factor)

For variation of power at constant boost pressure with altitude—

$$\frac{B.H.P._1}{B.H.P._e} = \sqrt{\frac{288}{273+t_a}} \times \left[1 + \frac{29{\cdot}92 - P_a}{137{\cdot}8}\right]$$

where t_a = atmospheric temperature in °C. P_a = atmospheric pressure in inches of mercury.

COMBINED FACTORS

(*By courtesy of Rolls-Royce, Ltd.*)

Table showing values of combined factor at various altitudes; standard I.C.A.N. atmosphere.

Altitude, ft.	Pressure, in. Hg.	Combined factor	Altitude, ft.	Pressure, in. Hg.	Combined factor
0	29·92	1·000	11,500	19·41	1·121
250	29·65	1·002	11,750	19·22	1·123
500	29·38	1·005	12,000	19·03	1·126
750	29·12	1·008	12,250	18·84	1·128
1,000	28·86	1·011	12,500	18·65	1·131
1,250	28·59	1·013	12,750	18·46	1·133
1,500	28·33	1·016	13,000	18·28	1·136
1,750	28·07	1·019	13,250	18·10	1·138
2,000	27·82	1·022	13,500	17·93	1·441
2,250	27·51	1·024	13,750	17·75	1·143
2,500	27·31	1·027	14,000	17·57	1·146
2,750	27·06	1·030	14,250	17·40	1·148
3,000	26·81	1·033	14,500	17·22	1·151
3,250	26·57	1·035	14,750	17·05	1·153
3,500	26·32	1·038	15,000	16·88	1·156
3,750	26·08	1·041	15,250	16·71	1·158
4,000	25·84	1·044	15,500	16·54	1·161
4,250	25·60	1·046	15,750	16·38	1·163
4,500	25·36	1·049	16,000	16·21	1·166
4,750	25·12	1·052	16,250	16·05	1·168
5,000	24·89	1·055	16,500	15·89	1·171
5,250	24·66	1·057	16,750	15·73	1·173
5,500	24·43	1·060	17,000	15·57	1·176
5,750	24·21	1·063	17,250	15·41	1·178
6,000	23·98	1·066	17,500	19·25	1·181
6,250	23·75	1·068	17,750	15·10	1·183
6,500	23·53	1·071	18,000	14·94	1·185
6,750	23·31	1·073	18,250	14·78	1·187
7,000	23·09	1·076	18,500	14·63	1·190
7,250	22·87	1·078	18,750	14·48	1·192
7,500	22·65	1·081	19,000	14·33	1·194
7,750	22·43	1·083	19,250	14·18	1·196
8,000	22·22	1·086	19,500	14·03	1·199
8,250	22·01	1·088	19,750	13·89	1·201
8,500	21·80	1·091	20,000	13·74	1·203
8,756	21·59	1·093	20,250	13·60	1·205
9,000	21·39	1·096	20,500	13·47	1·208
9,250	21·18	1·098	20,750	13·33	1·210
9,500	20·98	1·101	21,000	13·18	1·212
9,750	20·78	1·103	21,250	13·04	1·214
10,000	20·58	1·106	21,500	12·91	1·217
10,250	20·38	1·108	21,750	12·77	1·219
10,500	20·18	1·111	22,000	12·63	1·221
10,750	19·09	1·113	22,250	12·50	1·223
11,000	19·79	1·116	22,500	12·36	1·226
11,250	19·60	1·118	22,750	12·23	1·228

COMBINED FACTORS—*continued*

Altitude, ft.	Pressure, in. Hg.	Combined factor	Altitude, ft.	Pressure, in. Hg.	Combined factor
23,000	12·10	1·230	36,750	6·471	1·349
23,250	11·97	1·232	37,000	6·394	1·350
23,500	11·84	1·235	37,250	6·318	1·391
23,750	11·71	1·237	37,500	6·243	1·351
24,000	11·59	1·239	37,750	6·169	1·352
24,250	11·46	1·241	38,000	6·096	1·352
24,500	11·34	1·244	38,250	6·024	1·353
24,750	11·22	1·246	38,500	5·953	1·354
25,000	11·10	1·249	38,750	5·882	1·354
25,250	10·98	1·251	39,000	5·812	1·355
25,500	10·86	1·254	39,250	5·743	1·355
25,750	10·74	1·256	39,500	5·675	1·356
26,000	10·62	1·258	39,750	5·608	1·356
26,250	10·50	1·260	40,000	5·541	1·357
26,500	10·39	1·263	40,250	5·475	1·357
26,750	10·27	1·265	40,500	5·410	1·358
27,000	10·16	1·267	40,750	5·345	1·359
27,250	10·05	1·269	41,000	5·283	1·359
27,500	9·940	1·272	41,250	5·221	1·360
27,750	9·831	1·274	41,500	5·162	1·360
28,000	9·720	1·276	41,750	5·100	1·361
28,250	9·612	1·278	42,000	5·036	1·361
28,500	9·504	1·281	42,250	4·978	1·362
28,750	9·398	1·283	42,500	4·920	1·362
29,000	9·293	1·285	42,750	4·861	1·363
29,250	9·188	1·287	43,000	4·802	1·363
29,500	9·085	1·289	43,250	4·743	1·364
29,750	8·982	1·291	43,500	4·689	1·364
30,000	8·880	1·293	43,750	4·633	1·364
30,250	8·750	1·295	44,000	4·578	1·365
30,500	8·680	1·298	44,250	4·526	1·365
30,750	8·582	1·300	44,500	4·469	1·366
31,000	8·483	1·302	44,750	4·416	1·366
31,250	8·386	1·305	45,000	4·365	1·367
31,500	8·291	1·307	45,250	4·311	1·367
31,750	8·195	1·309	45,500	4·250	1·368
32,000	8·101	1·311	45,750	4·207	1·368
32,250	8·007	1·313	46,000	4·160	1·368
32,500	7·915	1·316	47,750	4·105	1·369
32,750	7·823	1·318	46,500	4·058	1·369
33,000	7·732	1·320	46,750	4·010	1·370
33,250	7·642	1·323	47,000	3·966	1·370
33,500	7·553	1·325	47,250	3·917	1·371
33,750	7·465	1·327	47,500	3·871	1·371
34,000	7·377	1·329	47,750	3·824	1·371
34,250	7·291	1·332	48,000	3·781	1·372
34,500	7·205	1·334	48,250	3·734	1·372
34,750	7·120	1·336	48,500	3·691	1·373
35,000	7·036	1·338	48,750	4·648	1·373
35,250	6·951	1·340	49,000	3·604	1·373
35,500	6·868	1·343	49,250	3·560	1·374
35,750	6·787	1·345	49,500	3·518	1·374
36,000	6·708	1·347	49,750	3·474	1·374
36,250	6·628	1·348	50,000	3·436	1·375
36,500	6·549	1·349			

See also Tables of I.C.A.N., Altitude Data, pp. 21–29.

THRUS POI ND EQUIVA VARIOU HORSE POWI SPEED

Speed, miles per hour	Horse-power										
	1	10	20	30	40	50	60	70	80	90	100
1	375	3,750	7,500	11,250	15,000	18,750	22,500	26,250	30,000	33,750	37,500
5	75	750	1,500	2,250	3,000	3,750	4,500	5,250	6,000	6,750	7,500
10	37·5	375	750	1,125	1,500	1,875	2,250	2,625	3,000	3,375	3,750
15	25	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500
20	18·8	188	375	562·5	750	937·5	1,125	1,321·5	1,500	1,687·5	1,875
25	15	150	300	450	600	750	900	1,050	1,200	1,350	1,500
30	12·5	125	250	375	500	625	750	875	1,000	1,125	1,250
35	10·7	107·1	214·3	321·4	428·6	535·7	642·8	750	857·1	964·3	1,071·4
40	9·4	93·8	187·5	281·3	375	468·8	562·5	656·3	750	843·8	937·5
45	8·3	83·3	166·7	250	333·3	416·7	500	583·3	666·7	750	833·3
50	7·5	75	150	225	300	375	450	525	600	675	750
60	6·3	62·5	125	187·5	250	312·5	375	437·5	500	562·5	625
70	5·4	53·6	107·1	160·7	214·3	267·9	321·4	375	428·6	482·1	535·7
80	4·7	46·9	93·8	140·6	187·5	234·4	281·3	328·2	375	421·9	468·8
90	4·2	41·7	83·8	125	166·7	208·3	250	291·7	333·3	375	416·7
100	3·75	37·5	75	112·5	150	187·5	225	262·5	300	337·5	375

lso pp.

EFFECT OF HUMIDITY ON ENGINE POWER *

Corrector Factor for reducing engine performance data to standard conditions.

$$F = \frac{P_s}{B_0 - H_0}\sqrt{\frac{T_0}{T_s}}.$$

where F is the correction factor.

B_0=observed (total) barometric pressure in mm. Hg.

H_0=observed water vapour pressure in mm. Hg.

P_s=standard dry air pressure.

T_0=observed air temperature (° C. absolute).

T_s=standard dry air temperature (°C. absolute).

AIR MINISTRY FUEL SPECIFICATIONS *

Specification	D.T.D.224	D.T.D.230
Specific gravity	·79 (max.) at 15° C.	·79 (max.) at 15° C.
Boiling range:—		
10% recovery	Below 75° C.	Below 75° C.
20% ,,	,, 100° C.	,, 100° C.
90% ,,	,, 150° C.	,, 150° C.
Final boiling point	180° C.	180° C.
Reid vapour pressure at 100° F.	7 lb./sq. in (max.)	7 lb./sq. in (max.)
Total sulphur	·15% weight (max.)	·15% weight (max.)
Actual gum	10 mgm./100 c.c. (max.)	10 mgm./100 c.c. (max.)
Potential gum	+100 mgm. on above (max.)	×10 mgm. on above (max.)
Freezing point	Below −50° C.	Below −60° C.
Maximum lead concentration	Nil.	4 c.c. per gallon.
Minimum octane num-number	77	87

* A. W. Judge, *Aircraft Engines.*

SECTION IX

INSTRUMENTS, ARMAMENT, AND ACCESSORIES

PARACHUTES

Baling Out

(*Gwynne Johns*)

Drops of	500 ft.	will take	6	seconds.
,,	1,000 ft.	,,	11	,,
,,	2,000 ft.	,,	16	,,
,,	3,000 ft.	,,	21	,,
,,	4,000 ft.	,,	26	,,
,,	12,000 ft.	,,	60	,,
,,	15,000 ft.	,,	75	,,
,,	18,000 ft.	,,	90	,,

Uniform velocity is reached after 16 seconds of falling, so that every subsequent 1,000 ft. will take 5 seconds.

Travelling through thousands of feet with an unopened parachute a person has a terminal velocity of about 120 odd miles an hour.

On no account try to judge height by watching the ground. When falling free, the ground looks very much the same at 15,000 ft. as it does at 1,500 ft. Having decided how many seconds are to be counted, adhere to that figure and pull when the figure is reached. If the height is known on baling out, allow 5 seconds for every 1,000 ft. in heights from 24,000 ft. downwards, which will be on the safe side. At greater heights allow 4 seconds for every 1,000 ft., as the rate of descent will be higher in air of a lesser density.

The speed of descent can be greatly increased by collapsing the canopy of the parachute on one side. Do this by pulling one group of rigging lines by 5 ft. or 6 ft., which will result in the partial collapse of the canopy thus spilling the air from the other side.—*The Aeroplane.*

Limiting velocity of parachute

$$= \sqrt{\frac{2W}{1{\cdot}33\rho(0{\cdot}55S)}} \text{ ft. sec.}$$

or

$$= \sqrt{\frac{2W}{1{\cdot}33\rho D}} \text{ ft. sec.}$$

where W = wt. of parachute, equipment and man, in lb.

S = surface area of parachute.

D = projected area of parachute when open.

In Standard Air $V = 34\sqrt{\frac{W}{S}}$ ft./sec.

Rules for Safety

(i) It must be possible for the aircrew to leave an aircraft regardless of the position it might be in when disabled.

(ii) The parachute operating means must not depend upon the airman falling away from the aircraft.

(iii) The parachute equipment must be fastened to the body of the airman at all times whilst in the aircraft.

(iv) The operating mechanism must not be too complicated or liable to foul and must not be susceptible to damage through any ordinary service conditions.

(v) The parachute must be of such size and so disposed as to give maximum comfort to the wearer and permit him to leave the aircraft with the least difficulty or delay.

(vi) The parachute must open promptly and must be capable of withstanding the shock incurred by a 200 lb. load falling at a speed of 300 m.p.h.

(vii) The parachute must be steerable to a reasonable degree.

(viii) The harness must be comfortable and very strong and designed so as to transfer the shock of opening in such a manner as to prevent injury to the wearer. It must also be sufficiently adjustable to fit the largest and the smallest person.

(ix) The harness must be so designed that it will prevent the wearer falling out when the parachute opens, regardless of his position in the air, and at the same time it must be possible to remove the harness quickly when landing in the water or in a high wind.

(x) The strength "follow through" must be uniform from the harness to the top of the parachute.

(xi) The parachute must be so designed that it is easily repacked with little time and labour.

Armament

Muzzle Horse Power, M.H.P. $= \frac{mv^2r}{1{,}100g} = \frac{mv^2r}{32{,}400}$.

where m = mass of projectile in pounds.

v = muzzle velocity in feet per second.

r = rate of fire in rounds per second.

GUNS ARRANGED IN ASCENDING ORDER OF MUZZLE HORSE POWER

(By P. G. Masefield, from *The Aeroplane*, June 11th, 1943.)

Gun	Type of firing	Calibre		Rate of fire, rounds per min.	M.H.P.	K.E. per projectile, ft.-lb.	Weight of fire, lb. per min.	Strikes per second
		in.	mm.					
Vickers ·303 (1918) .	Synchronised	·303	7·676	400	32	2,740	10·0	6·7
Lewis ·303 (1918) .	Free	·303	7·676	550	37	2,240	13·7	9·1
R-M-B M.G.-17 * .	Synchronised	·3118	7·92	600	45	2,450	15·6	10
Browning 300 . .	Free	·300	7·62	1,100	75	2,240	26·5	18 4
Browning 303 . .	Free	·303	7·676	1,100	77	2,300	27·5	18·4
R-M-B M.G.-17 * .	Free	·3118	7·92	1,100	81	2,450	286·	18·4
R-M-B M.G.-131 * .	Free	·5118	13	900	194	7,200	67·5	15
Oerlikon * . . .	Free	·787	20	450	201	14,700	112·5	7·5
M.K. 101 * . . .	Free	1·181	30	100	208	68,000	70·0	1·7
Browning 50 cal. .	Synchronised	·50	12·7	600	237	13,000	77·5	10
Beresin †	Synchronised	·50	12·7	750	278	15,300	77·3	10
Browning 50 cal. .	Free	·50	12·7	750	296	13,000	96·7	12·5
AA Type F ‡ . .	Free	1·4566	37	85	329	127,000	93·5	1·4
Mauser M.G.151/15 *	Free	·5906	15	950	515	17,850	142·0	15·8
Shwak S.V. † . .	Free	·7874	20	750	610	26,850	200·0	12·5
Mauser M.G.151/20 *	Synchronised	·7874	20	700	630	29,700	175·0	11·7
British-Hispano . .	Free	·7874	20	650	632	32,200	162·5	10·8
Mauser M.G.151/20 *	Free	·7874	20	'800	716	29,700	200·0	13·3

* German. † Russian. ‡ American.

SECTION X

MATHEMATICS

ALGEBRAIC SIGNS IN ORDINARY USE

$+$	Plus, addition,
$+$	positive,
$+$	compression.
$\times$	Multiplication.
$-$	Minus, tension,
$-$	negative,
$-$	subtraction.
$=$	Equal to.
$\neq$	Unequal to.
$>$	Greater than.
$\ngtr$	Not greater than.
$<$	Less than.
$\nless$	Not less.
$\times$	Multiplied by.
$:$	Is to (ratio).
$::$	As; so is (ratio).
$\div$	Divided by.
$\perp$	Perpendicular to.
$\parallel$	Parallel to.
$\nparallel$	Not parallel.
$\because$	Because.
$\therefore$	Therefore.
$\angle$	Angle.
∟	Right angle.
$\triangle$	Triangle.
▭	Parallelogram.
□	Square.
○	Circumference.
⊙	Circle.
◓	Semicircle.
◔	Quadrant.
∞	Infinity.
⌒	Arc.
$\sim$	Difference.

( ) [ ] { } —— Vincula denoting that the numbers are to be taken together. *Example.*—
$5\,(a-b)$; or $5[a-b]$; or $5\overline{a-b}$; $=5a-5b$.

$a : b :: c : d = a$ is to b as c is to d.

$$\frac{a+b}{c-d}=(a+b)\div(c-d).$$

a', a'', a'''; or $b_{,}, b_{,,}, b_{,,,}$, accents denoting quantities of the same kind.

$45^\circ = 45$ degrees; $20' = 20$ minutes; $25'' = 25$ seconds; $12''' = 12$ thirds.

The first letters of the alphabet, a, b, c, etc., are often used to denote known quantities, whilst the last, x, y, z, to denote unknown quantities. The following letters are frequently used as follows:—

c Constant.	α An angle.
d Differential (see Calculus).	δ Variation.
E Modulus of elasticity.	Δ Finite difference.
$\int$ Integration (see Calculus).	ϵ Base of hyperbolic logarithms.
F or f Functions.	θ, ϕ Any angles.
g Gravity $=32{\cdot}2$.	λ Latitude.
k Coefficient.	π Ratio of circumference to diameter $=3{\cdot}14159$.
M Modulus.	ρ Radius.
n Any number.	Σ Sum of finite quantities.
R° Radius in degrees of arc $=57^\circ{\cdot}2958$.	$\propto$ Varies as.
R' Do. minutes $=3437'{\cdot}75$.	

$\sqrt{\ }$ Square root.	$a^2 = a$ squared.
$\sqrt[3]{\ }$ Cube root.	$a^3 = a$ cubed.
$\sqrt[n]{\ }$ n^{th} root.	$a^n = a$ raised to the power of a number equal n.
Sin a = the sine of a.	$a^{\frac{2}{3}} = \sqrt[3]{a^2}$.
$\text{Sin}^{-1}\,a$ = the arc whose sine is a.	
$(\text{Sin}\,a)^{-1} = \dfrac{1}{\sin a}$.	

Arithmetical and Geometrical Progression

A = First term.
x = Any term whose number is n from A.
n = Number of terms between A and x.
S = Sum of all the terms.
D = Difference between the terms.
R = Ratio by which the terms are to be multiplied or divided.

Arithmetical Progression

$$A = x - D(n-1) = \frac{2S}{n} - x.$$

$$x = A + D(n-1) = \frac{2S}{n} - A.$$

$$n = \frac{x-A}{D} + 1.$$

$$D = \frac{x-A}{n-1}.$$

$$S = \tfrac{1}{2}n(A+x).$$

Geometrical Progression

$$A = \frac{x}{R^{n-1}} = S - R(S-x).$$

$$x = AR^{n-1} = S - \frac{S-A}{R}.$$

$$R = \sqrt[n-1]{\frac{x}{A}}.$$

$$S = \frac{Rx - A}{R-1} = \frac{A}{1-R} \text{ when } n \text{ is infinite and } R < 1.$$

Algebraic Formulæ

Addition and Subtraction. $n+(-m) = n-m = -(m-n)$; $n-(+m) = n+(-m)$; $n-(-m) = n+(+m) = n+m$.

Multiplication. $a.b = a \times b = ab$; $n(m+p) = nm+np$; $(-n)\times(-m) = +mn$; $(+n)(-m) = -mn$.

DIVISION. $a \div b = \frac{a}{b} = a : b$; $(-a):(-b) = a:b = +\frac{a}{b}$;

$(-a):(+b) = (+a):(-b) = -\frac{a}{b}$; $\frac{m+n}{p} = \frac{m}{p} + \frac{n}{p}$;

$\frac{mn}{p} = \frac{m}{p} . n = m . \frac{n}{p}$; $\frac{p}{mn} = \frac{p}{m} : n = \frac{p}{n} : m$.

FRACTIONS. $\frac{a}{b} = \frac{an}{bn} = \frac{a:n}{b:n}$; $\frac{a}{b} \pm \frac{n}{b} = \frac{a \pm n}{b}$;

$\frac{a}{b} \cdot \frac{n}{p} = \frac{an}{bp}$; $\frac{a}{b} : \frac{n}{p} = \frac{a}{b} \cdot \frac{p}{n} = \frac{ap}{bn}$.

POWERS AND ROOTS. $a^m . b^m = (ab)^m$; $a^m : b^m = \left(\frac{a}{b}\right)^m$;

$a^m . a^n = a^{m+n}$; $a^m : a^n = a^{m-n}$; $(a^m)^n = a^{mn}$;
$(-a)^{2n} = a^{2n}$; $(-a)^{2n+1} = -a^{2n+1}$; $(a \pm b)^2 = a^2 \pm 2ab + b^2$;
$(a \pm b)^3 = a^3 \pm 3a^2b + 3ab^2 \pm b^3$; $a^0 = 1$; $a^{\pm\infty}$ = either 0 or ∞;

$x^{-m} = \frac{1}{x^m}$; $x^m = \frac{1}{x^{-m}}$; $a^{\frac{1}{m}} = \sqrt[m]{a}$; $a^m = \sqrt[\frac{1}{m}]{a}$;

$\sqrt[m]{a} . \sqrt[m]{b} = \sqrt[m]{ab}$; $\sqrt[m]{a} : \sqrt[m]{b} = \sqrt[m]{\frac{a}{b}}$; $\sqrt[m]{a^n} = (\sqrt[m]{a})^n$;

$\sqrt[n]{\sqrt[m]{a}} = \sqrt[m]{\sqrt[n]{a}}$; $\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a}$; $\sqrt[2m]{+a} = \pm b$;
$\sqrt[2m]{-a} = \pm b\sqrt{-1}$; $\sqrt[2m+1]{+a} = +c$; $\sqrt[2m+1]{-a} = -c$.

LOGARITHMS. $\log mn = \log m + \log n$; $\log \frac{m}{n} = \log m - \log n$;

$\log x^m = m \log x$; $\log \sqrt[m]{x} = \frac{\log x}{m}$.

EQUATIONS. Let $x + m = n$, then $x = n - m$. Let $nx = m$, then $x = \frac{m}{n}$.

Let $\frac{x}{n} = m$, then $x = mn$. Let $\frac{n}{x} = m$, then $x = \frac{n}{m}$.

Let $x^n = m$, then $x = \sqrt[n]{m}$. Let $\sqrt[n]{x} = m$, then $x = m^n$.

Let $a^x = b$, then $x \log a = \log b$, and $x = \frac{\log b}{\log a}$.

$x : n = m : p$; then $xp = mn$;
$x : n = m : x$, or $n : x = x : m$, then $x^2 = mn$, and $x = \sqrt{mn}$;
$x : n = m : p$, then $x : m = n : p$, and $(x \pm n) : n = (m \pm p) : p$.

QUADRATIC EQUATIONS. $x^2+ax=b$, then $x=-\frac{a}{2}\pm\sqrt{b+\left(\frac{a}{2}\right)^2}$;

$x^{2n}+ax^n=b$, then $x=\sqrt[n]{-\frac{a}{2}\pm\sqrt{b+\left(\frac{a}{2}\right)^2}}$;

$x+y=s$, and $xy=p$, then $x=\frac{s+\sqrt{s^2-4p}}{2}$, and $y=\frac{s-\sqrt{s^2-4p}}{2}$.

CUBIC EQUATION. $x^3+ax^2+bx+c=0$, becomes $x_1^3+b_1x_1+c_1=0$, if we put $x_1=x+\frac{a}{3}$; $b_1=b-\frac{a^2}{3}$; and $c_1=c-\frac{ab}{3}+\frac{2}{27}a^3$.

Cardan's solution of $x^3+bx+c=0$ is as follows:—

$$x=\sqrt[3]{-\frac{c}{2}+\sqrt{\left(\frac{b}{3}\right)^3+\left(\frac{c}{2}\right)^2}}+\sqrt[3]{-\frac{c}{2}-\sqrt{\left(\frac{b}{3}\right)^3+\left(\frac{c}{2}\right)^2}}.$$

This rule is correct if b is positive; or if b is negative and $\left(\frac{b}{3}\right)^3<\left(\frac{c}{2}\right)^2$.

If b is negative and $\left(\frac{b}{3}\right)^3=\left(\frac{c}{2}\right)^2$, the equation has three true roots —

$$x=-2\sqrt[3]{\frac{c}{2}},\quad x=\sqrt[3]{\frac{c}{2}},\quad x=\sqrt[3]{\frac{c}{2}}.$$

If b is negative and $\left(\frac{b}{3}\right)^3>\left(\frac{c}{2}\right)^2$, the roots are real, but Cardan's solution is impracticable.

APPROXIMATION FORMULÆ. If x_1 approximates to $x^2+ax+b=0$, then x (nearly) $=\frac{x_1^2-b}{2x_1+a}$.

If x_1 approximates to $x^3+ax^2+bx+c=0$, then

$$x=\frac{2x_1^3+ax_1^2-c}{3x_1^2+2ax_1+b}.$$

If x_1 approximates to $x^4+ax^3+bx^2+cx+d=0$, then

$$x=\frac{3x_1^4+2ax_1^3+bx_1^2-d}{4x_1^3+3ax_1^2+2bx_1+c}.$$

Binomial Theorem

$$(a+b)^n = a^n + na^{n-1}b + \frac{n(n-1)a^{n-2}b^2}{\underline{|2}} + \frac{n(n-1)(n-2)a^{n-3}b^3}{\underline{|3}} + \frac{n(n-1)(n-2)(n-3)a^{n-4}b^4}{\underline{|4}} +, \text{ etc.}$$

Newton's Theorem of Successive Approximations

This can be used for solving any equation with only one unknown, and is particularly useful for solving equations which would be difficult or impossible by other means.

Consider the equation $y=f(x)$, where y is known.

Assume x_1 as a first approximation to the value of x. Let this give y_1 as the value of $f(x_1)$.

Then a second approximation to x, much better than x_1, will be

$$x_2 \simeq x_1 - \frac{y_1-y}{dy_1/dx_1}.$$

Example.—Solve $x^5+x=33{\cdot}7$. Here $y=33{\cdot}7$.

Take $x_1=2$. $\therefore\ y_1=2^5+2=34;$

$\frac{dy}{dx}=5x^4+1.$ $\therefore\ \frac{dy_1}{dx_1}=5\times 2^4+1=81.$

$\therefore\ x_2=2-\frac{34-33{\cdot}7}{81}=1{\cdot}9963$, which is a much better approximation than x_1 to the true value of x.

By repeating the process with 1·9963 instead of 2, an even better third approximation x_3 can be obtained, viz.:

$$x_3=1{\cdot}9963-\frac{(1{\cdot}9963^5+1{\cdot}9963)-33{\cdot}7}{5(1{\cdot}9963)^4+1}.$$

This process can be continued indefinitely.

Interpolation (Sum and Difference), etc.

A = Any term of an equidistant series of terms.

a, b, c, etc. = The *first* term of the 1st, 2nd, 3rd, etc., orders of differences.

z = The term required.

x = The distance of z from A.

$$z=A+xa+x\frac{x-1}{2}b+x\frac{x-1}{2}\cdot\frac{x-2}{3}c, \text{ etc.}$$

Example.—Find the 30th term of a series of 1, 8, 27, 64, 125, etc.

1 = A				
	7 = a			
8		12 = b		
	19		6 = c	
27		18		0 = d
	37		6	
64		24		
	61			
125				

Then x being = 29; A = 1; a = 7; b = 12; and c = 6,

$$z = 1 + (29 \times 7) + \left(29 \times \frac{28}{2} \times 12\right) + \left(29 \times \frac{28}{2} \times \frac{27}{3} \times 6\right) = 27{,}000.$$

For Interpolating a Term in a Series

a, b, c, d, etc. = A series of equidistant terms.

n = The number of terms whose value is given. Then the required term will be found by reducing the equation that corresponds with n.

$a - b = 0$	equation	when	$n = 1$
$a - 2b + c = 0$	,,	,,	$= 2$
$a - 3b + 3c - d = 0$	,,	,,	$= 3$
$a - 4b + 6c - 4d + e = 0$	,,	,,	$= 4$
$a - 5b + 10c - 10d + 5e - f = 0$	,,	,,	$= 5$
$a - nb + n\dfrac{n-1}{2}c - n\dfrac{n-1}{2} \cdot \dfrac{n-2}{3}d$, etc.,		n	n

Example.—Given a, b, d, e, to find c; then as $n = 4$, by reducing the equation $n = 4$, $c = \dfrac{4(b+d)-(a+e)}{6}$.

Given log 2,523 = 4,019,173 = b }
,, log 2,525 = 4,022,614 = d } $4(b+d) = 32{,}167{,}148$
,, log 2,522 = 4,017,451 = a }
,, log 2,526 = 4,024,333 = e } $(a+e) = 8{,}041{,}784$

$4(b+d) - (a+e) = 24{,}125{,}364$

Required log 2,524 = 24,125,364 ÷ 6 = 4,020,894.

Conversion of Rates (Multiplier = x)

$x = m \div n = N \div M$; where M and N = the number of times the *given* rates are contained in the *required* rates; and m and n the times the *required* rates are contained in the *given* rates respectively; for M per N, or m per n.

Properties of the Circle

Diameter × 3·14159 = circumference.
Diameter × ·886227 = side of square of equal area.
Diameter × ·7071 = side of an inscribed square.
Diameter^2 × ·7854 = area of circle.
Circumference × ·31831 = diameter.
Circumference = 3·5449 $\sqrt{\text{area of circle}}$.
Diameter = 1·1283 $\sqrt{\text{area of circle}}$.
Length of arc = number of degrees × ·017453 × radius.

Arc of 1° to rad. 1 = 0·01745329.
Arc of 1′ to rad. 1 = 0·000290888.
Arc of 1″ to rad. 1 = 0·000004848.

Degrees in arc whose length = radius = 57°·2957795.
= one radian (circular measure).

Value of π (or Ratio of Diameter to Circumference)

$\pi = 3{\cdot}14159265358979323846264338327950$...

$\log \pi = 0{\cdot}4971499$	$\sqrt{\frac{2}{\pi}} = 0{\cdot}7978846$	$\frac{\sqrt{2}}{\pi} = 0{\cdot}4501582$
$\frac{360}{\pi} = 114{\cdot}59156$	$\frac{\pi}{\sqrt{2}} = 2{\cdot}2214415$	$\frac{1}{\pi^3} = 0{\cdot}032252$
$\frac{\pi}{360} = 0{\cdot}00872664$	$\sqrt{\frac{\pi}{2}} = 1{\cdot}2533$	$\pi^2 = 9{\cdot}869604$
$\frac{1}{\pi^2} = 0{\cdot}1013212$	$\sqrt{\pi} = 1{\cdot}772454$	$\pi^3 = 31{\cdot}006277$
$\frac{1}{\sqrt{\pi}} = 0{\cdot}5641896$	$\frac{4\pi}{3} = 4{\cdot}188790$	$\pi^4 = 97{\cdot}417$
$\pi\sqrt{2} = 4{\cdot}44288$	$\sqrt[3]{\pi} = 1{\cdot}464592$	$\sqrt{2\pi} = 2{\cdot}506628$
		$\sqrt[3]{6/\pi} = 1{\cdot}240701$

Approximation to π are 22/7 = $3{\cdot}\dot{1}4285\dot{7}$ and 355/113 = 3·141593.

VALUE OF π (OR RATIO OF DIAMETER TO CIRCUMFERENCE)—*continued*

n	$\pi^2 \times n$	$\frac{\pi^2}{n}$	$n\sqrt{\pi}$
1	·98696	9·8696	1·7725
2	19·7392	4·9348	3·5449
3	29·6088	3·2899	5·3174
4	39·4784	2·4674	7·0898
5	49·3480	1·9739	8·8623
6	59·2176	1·6449	10·6347
7	69·0872	1·4099	12·4072
8	78·9568	1·2337	14·1796
9	88·8264	1·0966	15·9521

MULTIPLES AND FRACTIONS OF π AND THEIR RECIPROCALS

(By courtesy of the Ford Motor Company, Ltd.)

$n \times \pi$	$\frac{1}{n \cdot \pi}$	$\frac{\pi}{n}$	$\frac{M}{\pi}$
π = 3·14159	$1/\pi$ = ·3183099	$\pi/2$ = 1 570796	$2/\pi$ = ·636620
2π = 6·28319	$\frac{1}{2}\pi$ = ·1591549	$\pi/3$ = 1 047198	$3/\pi$ = ·954930
3π = 9 43478	$\frac{1}{3}\pi$ = ·1061033	$\pi/4$ = ·785398	$4/\pi$ = 1·273240
4π = 12 56637	$\frac{1}{4}\pi$ = ·0795775	$\pi/5$ = ·628319	$5/\pi$ = 1 591549
5π = 15 70796	$\frac{1}{5}\pi$ = ·0636620	$\pi/6$ = ·523599	$6/\pi$ = 1·909859
6π = 18·84956	$\frac{1}{6}\pi$ = ·0530516	$\pi/7$ = ·448799	$7/\pi$ = 2 228169
7π = 21·99115	$\frac{1}{7}\pi$ = ·0454728	$\pi/8$ = ·392699	$8/\pi$ = 2·546479
8π = 25·13274	$\frac{1}{8}\pi$ = ·0397887	$\pi/9$ = ·349066	$9/\pi$ = 2·864789
9π = 28 27433	$\frac{1}{9}\pi$ = ·0353678	$\pi/10$ = ·314159	$10/\pi$ = 3·183099
10π = 31 41593	$\frac{1}{10}\pi$ = ·0318310	$\pi/11$ = ·289599	$11/\pi$ = 3 501409
11π = 34·55752	$\frac{1}{11}\pi$ = ·0289373	$\pi/12$ = ·261799	$12/\pi$ = 3 819719
12π = 37·69911	$\frac{1}{12}\pi$ = ·0265258	$\pi/13$ = ·241661	$13/\pi$ = 4·138029
13π = 40 84070	$\frac{1}{13}\pi$ = ·0244854	$\pi/14$ = ·224399	$14/\pi$ = 4 456338
14π = 43·98230	$\frac{1}{14}\pi$ = ·0227364	$\pi/15$ = ·209440	$15/\pi$ = 4 774648
15π = 47·12389	$\frac{1}{15}\pi$ = ·0212207	$\pi/16$ = ·196350	$16/\pi$ = 5 092958
16π = 50·26548	$\frac{1}{16}\pi$ = ·0198944	$\pi/17$ = ·184800	$17/\pi$ = 5·411268
17π = 53·40708	$\frac{1}{17}\pi$ = ·0187241	$\pi/18$ = ·174533	$18/\pi$ = 5·729578
18π = 56·54867	$\frac{1}{18}\pi$ = ·0176839	$\pi/19$ = ·165347	$19/\pi$ = 6·087888
19π = 59·69026	$\frac{1}{19}\pi$ = ·0167532	$\pi/20$ = ·157080	$20/\pi$ = 6·366198
20π = 62 83185	$\frac{1}{20}\pi$ = ·0159155	$\pi/180$ = ·0174533	$180/\pi$ = 57·295780

TRIGONOMETRY

Measurement of Angles

A *degree* is 1/360 of the plane angle about a point.

A *radian* is the angle subtended at the centre of a circle by an arc equal in length to the radius of that circle.

60 seconds (″) = 1 minute.
60 minutes (′) = 1 degree.
90 degrees (°) = 1 right angle.
1 radian = 57·2958 degrees = 57° 17′ 45″.
π radians = 180 degrees.

Trigonometrical Ratios

Sine (sin) A $= \dfrac{\text{opposite}}{\text{hypotenuse}} = \dfrac{a}{c}$

Cosine (cos) A $= \dfrac{\text{adjacent}}{\text{hypotenuse}} = \dfrac{b}{c}$

Tangent (tan) A $= \dfrac{\text{opposite}}{\text{adjacent}} = \dfrac{a}{b}$

Secant (sec) A $= \dfrac{1}{\cos A}$

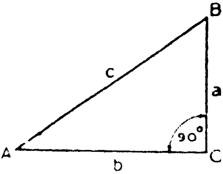
Cosecant (cosec) A $= \dfrac{1}{\sin A}$

Cotangent (cot) A $= \dfrac{1}{\tan A}$

Exsecant (exsec) A $= \sec A - 1$

Versine (vers) A $= 1 - \cos A$

Coversine (covers) A $= 1 - \sin A$.



Complementary Angles

Cos θ = sin $(90-\theta)$.
Tan θ = cot $(90-\theta)$
Cosec θ = sec $(90-\theta)$.
Sin θ = cos $(90-\theta)$.
Sec θ = cosec $(90-\theta)$.
Cot = tan $(90-\theta)$.

Signs of the Functions

Quadrant	Sin	Cos	Tan	Cot	Sec	Cosec
First	+ ve	+ ve	+ ve	+ ve	+ ve	+ ve
Second	+ ve	− ve	− ve	− ve	− ve	+ ve
Third	− ve	− ve	+ ve	+ ve	− ve	− ve
Fourth	− ve	+ ve	− ve	− ve	+ ve	− ve

Functions of Angles in any Quadrant (in Terms of Angles in First Quadrant)

Trigonometrical function	$-\theta$	$90° \pm \theta$	$180° \pm \theta$	$270° \pm \theta$	$n(360°) \pm \theta$
Sin . .	$-\sin\theta$	$+\cos\theta$	$\mp\sin\theta$	$-\cos\theta$	$\pm\sin\theta$
Cos . . .	$+\cos\theta$	$\mp\sin\theta$	$-\cos\theta$	$\pm\sin\theta$	$+\cos\theta$
Tan .	$-\tan\theta$	$\mp\cot\theta$	$\pm\tan\theta$	$\mp\cot\theta$	$\pm\tan\theta$
Cot . .	$-\cot\theta$	$\mp\tan\theta$	$\pm\cot\theta$	$\mp\tan\theta$	$\pm\cot\theta$
Sec . . .	$+\sec\theta$	$\mp\operatorname{cosec}\theta$	$-\sec\theta$	$\pm\operatorname{cosec}\theta$	$+\sec\theta$
Cosec . .	$-\operatorname{cosec}\theta$	$+\sec\theta$	$\mp\operatorname{cosec}\theta$	$-\sec\theta$	$\pm\operatorname{cosec}\theta$

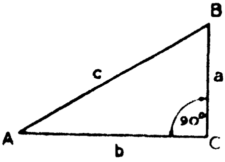
Functions of 0°, 30°, 45°, 60°, 90°, 120°, 135°, 150°, 180°, 270° and 360°

Angle	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	0
Cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	1
Tan	0	$\frac{\sqrt{3}}{3}$	1	$\sqrt{3}$	∞	$-\sqrt{3}$	-1	$-\frac{\sqrt{3}}{3}$	0	∞	0
Cot	∞	$\sqrt{3}$	1	$\frac{\sqrt{3}}{3}$	0	$-\frac{\sqrt{3}}{3}$	-1	$-\sqrt{3}$	∞	0	∞
Sec	1	$\frac{2\sqrt{3}}{3}$	$\sqrt{2}$	2	∞	-2	$-\sqrt{2}$	$-\frac{2\sqrt{3}}{3}$	-1	∞	1
Cosec	∞	2	$\sqrt{2}$	$\frac{2\sqrt{3}}{3}$	1	$\frac{2\sqrt{3}}{3}$	$\sqrt{2}$	2	∞	-1	∞
Vers	0	$\frac{2-\sqrt{3}}{2}$	$\frac{\sqrt{2}-1}{\sqrt{2}}$	$\frac{1}{2}$	1	[illegible]	$\frac{\sqrt{2}+1}{\sqrt{2}}$	$\frac{2+\sqrt{3}}{2}$	2	1	0

Solution of Right-Angled Triangles

(Following by courtesy of the Ford Motor Company, Ltd.)

$a = c \sin A.$
$\;\;= b \tan A.$
$b = c \cos A.$
$\;\;= a \cot A.$
$c = a \operatorname{cosec} A.$
$\;\;= b \sec A.$



Supplementary Angles

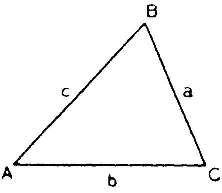
If θ lies between 90° and 180°,

$\text{Cos}\ \theta = -\cos(180° - \theta)$. $\text{Sec}\ \theta = -\sec(180° - \theta)$.
$\text{Sin}\ \theta = \sin(180° - \theta)$. $\text{Cosec}\ \theta = \text{cosec}(180° - \theta)$.
$\text{Tan}\ \theta = -\tan(180° - \theta)$. $\text{Cot}\ \theta = -\cot(180° - \theta)$.

The Sine Rule

In any triangle,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}.$$



The Cosine Rule

$a^2 = b^2 + c^2 - 2bc \cos A$. $\text{Cos}\ A = \dfrac{b^2 + c^2 - a^2}{2bc}$.

$b^2 = c^2 + a^2 - 2ca \cos B$. $\text{Cos}\ B = \dfrac{c^2 + a^2 - b^2}{2ca}$.

$c^2 = a^2 + b^2 - 2ab \cos C$. $\text{Cos}\ C = \dfrac{a^2 + b^2 - c^2}{2ab}$.

Solution of Triangles

1. Given two sides, b and c, and the included angle A.

$$a = \sqrt{(b^2 + c^2 - 2bc \cos A)}.$$

$$\text{Sin}\ B = \frac{b}{a} \sin A.$$

Note.—This equation gives two practical values for angle B since θ and $180° - \theta$ have the same sine. If correct angle is doubtful find angle B by the cosine rule.

$$C = 180° - (A + B).$$

2. Given two angles, A and B, and a side b.

$$C = 180° - (A + B).$$

$$a = b\frac{\sin A}{\sin B}. \qquad c = b\frac{\sin C}{\sin B}.$$

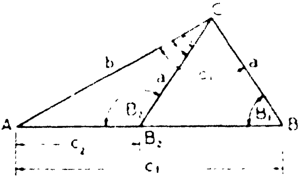
3. Given three sides, a, b, and c.

$$\text{Cos A}=\frac{b^2+c^2-a^2}{2bc}.$$

$$\text{Sin B}=\frac{b}{a}\sin \text{A (see note for case 1).}$$

$$\text{C}=180^\circ-(\text{A}+\text{B}).$$

4. Given two sides, a and b, and a non-included angle A.



(i) If b sin A$>a$ there are no solutions.

(ii) If b sin A$=a$ there is one solution, viz. B$=90^\circ$, C$=90^\circ-$A, $c=b$ cos A.

(iii) If b sin A$<a$ and $a<b$ there are two solutions, thus:—

(iiia)

$$\text{Sin B}_1=\frac{b}{a}\sin\text{A}.$$

$$\text{C}_1=180^\circ-(\text{A}+\text{B}_1).$$

$$c_1=\frac{a\sin \text{C}_1}{\sin \text{A}}.$$

(iiib)

$$\text{B}_2=180^\circ-\text{B}_1.$$

$$\text{C}_2=180^\circ-(\text{A}+\text{B}_2).$$

$$c_2=\frac{a\sin \text{C}_2}{\sin \text{A}}.$$

(iv) If b sin A$<a$ and $a\geqslant b$ there is one solution, viz. iiia above.

Note.—The above analysis assumes the given angle A is less than 90°. If A$\geqslant$90° there are no solutions, unless $b<a$ in which case there is one solution, viz. iiia above.

Area of a Triangle

Area$=\Delta=\frac{1}{2}\times$base$\times$perpendicular height.

$$=\tfrac{1}{2}ab\sin \text{C}=\tfrac{1}{2}bc\sin\text{A}=\tfrac{1}{2}ca\sin\text{B}.$$

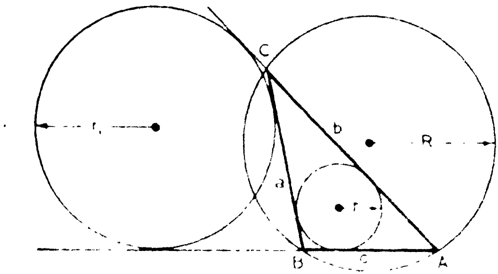
$$=\sqrt{s(s-a)(s-b)(s-c)}.$$

where $s=\frac{1}{2}(a+b+c)$.

Radius of Circumscribing Circle

$$R=\frac{abc}{4\Delta}.$$

$$2R=\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C}.$$



Radius of Inscribed Circle

$$r=\frac{\Delta}{s}=\sqrt{\frac{(s-a)(s-b)(s-c)}{s}}.$$

$$=(s-a)\tan\frac{A}{2}=(s-b)\tan\frac{B}{2}=(s-c)\tan\frac{C}{2}.$$

Radius of Escribed Circle

r_1=radius of circle touching side a and sides b and c produced.

$$=\frac{\Delta}{s-a}=\sqrt{\frac{s(s-b)(s-c)}{(s-a)}}=s\tan\frac{A}{2}.$$

Similar formulæ apply for the other two escribed circles.

Other Triangle Formulæ

$$a=b\cos C+c\cos B.$$

$$\text{Sin } A=\frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)}.$$

$$\text{Tan }\frac{B-C}{2}=\frac{b-c}{b+c}\cot\frac{A}{2}.$$

$$\text{Cos}\,\frac{A}{2}=\sqrt{\frac{s(s-a)}{bc}}.$$

$$\text{Sin}\,\frac{A}{2}=\sqrt{\frac{(s-b)(s-c)}{bc}}.$$

$$\text{Tan}\,\frac{A}{2}=\sqrt{\frac{(s-b)(s-c)}{s(s-a)}}.$$

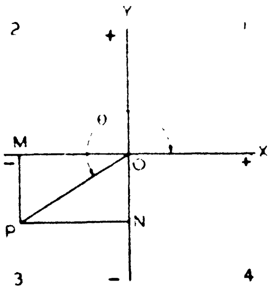
where $s=\frac{1}{2}(a+b+c)$.

Relations Between the Ratios

$$\text{Sin}^2\,\theta+\cos^2\theta=1$$
$$\text{Sec}^2\,\theta=1+\tan^2\theta$$
$$\text{Cosec}^2\,\theta=1+\cot^2\theta$$

$$\text{Tan}\,\theta=\frac{\sin\theta}{\cos\theta}\qquad \text{Cot}\,\theta=\frac{\cot\theta}{\sin\theta}$$

Angles of any Magnitude



Cos θ = projection of unit radius vector on the x-axis.

Sin θ = projection of unit radius vector on the y-axis.

Tan θ = sin θ/cos θ.

(For third quadrant illustrated, OP = 1, cos θ = OM negative, sin θ = ON negative.)

First Quadrant.—All ratios positive

Second Quadrant.—Sine, positive; cosine and tangent, negative.

Third Quadrant.—Tangent, positive; cosine and sine, negative.

Fourth Quadrant.—Cosine, positive; sine and tangent, negative.

Compound Angles

$$\text{Cos}\,(A+B)=\cos A\cos B-\sin A\sin B.$$
$$\text{Cos}\,(A-B)=\cos A\cos B+\sin A\sin B.$$
$$\text{Sin}\,(A+B)=\sin A\cos B+\cos A\sin B.$$
$$\text{Sin}\,(A-B)=\sin A\cos B-\cos A\sin B.$$

$$\text{Tan}\,(A+B)=\frac{\tan A+\tan B}{1-\tan A\tan B}.$$

$$\text{Tan}\,(A-B)=\frac{\tan A-\tan B}{1+\tan A\tan B}.$$

Multiple Angles

$\text{Cos } 2\theta = \cos^2\theta - \sin^2\theta = 2\cos^2\theta - 1.$

$= 1 - 2\sin^2\theta.$

$\text{Sin } 2\theta = 2\sin\theta\cos\theta.$

$\text{Tan } 2\theta = \dfrac{2\tan\theta}{1 - \tan^2\theta}.$

$\text{Cos } 3\theta = 4\cos^3\theta - 3\cos\theta.$

$\text{Sin } 3\theta = 3\sin\theta - 4\sin^3\theta.$

$\text{Cos}^2\theta = \tfrac{1}{2}(1 + \cos 2\theta).$

$\text{Sin}^2\theta = \tfrac{1}{2}(1 - \cos 2\theta).$

Sum and Difference Formulæ

$\text{Sin A} + \sin B = 2\sin\tfrac{1}{2}(A + B)\cos\tfrac{1}{2}(A - B).$

$\text{Sin A} - \sin B = 2\cos\tfrac{1}{2}(A + B)\sin\tfrac{1}{2}(A - B).$

$\text{Cos A} + \cos B = 2\cos\tfrac{1}{2}(A + B)\cos\tfrac{1}{2}(A - B).$

$\text{Cos A} - \cos B = 2\sin\tfrac{1}{2}(A + B)\sin\tfrac{1}{2}(B - A).$

Product Formulæ

$\text{Sin A} \cos B = \tfrac{1}{2}[\sin(A + B) + \sin(A - B)].$

$\text{Cos A} \sin B = \tfrac{1}{2}[\sin(A + B) - \sin(A - B)].$

$\text{Cos A} \cos B = \tfrac{1}{2}[\cos(A + B) + \cos(A - B)].$

$\text{Sin A} \sin B = \tfrac{1}{2}[\cos(A - B) - \cos(A + B)].$

Exponential Values of Sine and Cosine

$\text{Cos } \theta = \dfrac{1}{2}(e^{i\theta} + e^{-i\theta})$ $\qquad$ $\text{Sin } \theta = \dfrac{1}{2i}(e^{i\theta} - e^{-i\theta}).$

where θ is in radians and $i = \sqrt{-1}$.

De Moivre's Theorem

$(\text{Cos } \theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta$ for any value of n.

Inverse Circular Functions

$\text{Cos}^{-1} x$ = the angle whose cosine is x.
$\text{Sin}^{-1} x$ = the angle whose sine is x.
$\tan^{-1} x$ = the angle whose tangent is x.
The principal value of $\cos^{-1} x$ lies between 0 and π radians.

The principal values of $\sin^{-1} x$ and $\tan^{-1} x$ lie between $-\dfrac{\pi}{2}$ and $+\dfrac{\pi}{2}$ radians.

Complete Solution for Angles

If $\alpha=\cos^{-1} x$ then $\theta=2n\pi\pm\alpha$ gives all angles whose cosine is x where θ and α are in radians and n is any integer. Similarly,

$$\text{if } \alpha=\sin^{-1} x \text{ then } \theta=n\pi+(-1)^n\alpha.$$

$$\text{if } \alpha=\tan^{-1} x \text{ then } \theta=n\pi+\alpha.$$

Solution of Linear Equations

To solve the equation $a\cos\theta+b\sin\theta=c$

where $c^2<a^2+b^2$, let $\alpha=\tan^{-1} b/a$.

Then $\cos(\theta-\alpha)=c/\sqrt{a^2+b^2}$

from which $\theta-\alpha$ and hence θ may be determined.

Triogonometrical Series

If x is in radians,

$$\operatorname{Cos} x=1-\frac{x^2}{2!}+\frac{x^4}{4!}-\frac{x^6}{6!}+\ \ldots$$

$$\operatorname{Sin} x=x-\frac{x^3}{3!}+\frac{x^5}{5!}-\frac{x^7}{7!}+\ \ldots$$

$$\operatorname{Tan} x=x+\frac{x^3}{3}+\frac{2x^5}{15}+\frac{17x^7}{315}+\ \ldots$$

Table of Equivalent Inclination

Rise	Angle of inclination	Tangent	Sine	Radians
1 in 30	1°-55′	·0333	·0333	·0333
1 ,, 25	2° 17′	·04	·0400	·0400
1 ,, 20	2°-52′	·05	·0500	·0500
1 ,, 18	3°-11′	·0555	·0554	·0555
1 ,, 16	3°-35′	·0625	·0624	·0625
1 ,, 14	4°-5′	·0714	·0712	·0713
1 ,, 12	4° 46′	·0833	·0831	·0832
1 ,, 10	5°-43′	·1	·0996	·0997
1 ,, 9	6°-21′	·1111	·1103	·1105
1 ,, 8	7°-8′	·125	·1242	·1245
1 ,, 7	8°-8′	·1429	·1415	·1419
1 ,, 6	9°-28′	·1667	·1645	·1652
1 ,, 5	11°-19′	·2	·1962	·1975
1 ,, 4	14°-2′	·25	·2425	·2449
1 ,, 3	18°-26′	·3333	·3162	·3217

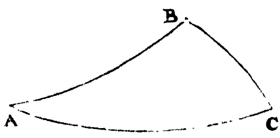
Spherical Right-angled Triangles

Right-angled Spherical Triangles

Let AB be the hypothenuse.
AC ,, base.
BC ,, perpendicular.
And A, B, and C the respective angles.

$\text{Sin } A = \sin BC \text{ cosect } AB.$
$= \sin BC \div \sin AB.$
$\text{Cosin } A = \sin B \text{ cosin } BC.$
$= \tan AC \text{ cotan } AB.$
$\text{Cotan } A = \sin AC \cot BC.$
$\text{Sin } B = \text{cosin } A \text{ secant } BC.$
$\text{Sin } AB = \sin BC \text{ cosect } A.$
$= \sin BC \div \sin A.$
$\text{Sin } AC = \text{cotan } A \tan BC.$
$\text{Sin } BC = \sin A \sin AB.$
$\text{Cosin } AB = \text{cosin } BC \text{ cosin } AC.$
$= \text{cotan } A \text{ cotan } B.$
$\text{Cosin } AC = \text{cosin } AB \text{ secant } BC.$
$= \text{cosin } AB \div \text{cosin } BC.$
$\text{Cosin } BC = \text{cosin } A \text{ cosect } B.$
$= \text{cosin } A \div \sin B.$
$\text{Cotan } AB = \text{cotan } AC \text{ cosin } A.$

Oblique-angled Spherical Triangles



$$\text{Sin } A = \frac{\sin BC \sin C}{\sin AB} = \frac{\sin BC \sin B}{\sin AC}.$$

$$\text{Sin B} = \frac{\sin AC \sin A}{\sin BC} = \frac{\sin AC \sin C}{\sin AB}.$$

$$\text{Sin C} = \frac{\sin AB \sin B}{\sin AC} = \frac{\sin AB \sin A}{\sin BC}.$$

$$\text{Sin AB} = \frac{\sin AC \sin C}{\sin B} = \frac{\sin BC \sin C}{\sin A}.$$

$$\text{Sin AC} = \frac{\sin AB \sin B}{\sin C} = \frac{\sin BC \sin B}{\sin A}.$$

$$\text{Sin BC} = \frac{\sin AB \sin A}{\sin C} = \frac{\sin AC \sin A}{\sin B}.$$

$$\text{Cosin A} = \frac{\cos BC - \cos AB \cos AC}{\sin AB \sin AC}.$$

$$= \cos BC \sin B \sin C - \cos B \cos C.$$

$$\text{Cosin AC} = \frac{\cos B + \cos A \cos C}{\sin A \sin C}.$$

$$= \cos B \sin BC \sin AB + \cos BC \cos AB.$$

$$\text{Tan A} = \frac{\sin B}{\sin AB \cot BC - \text{cosin } AB \text{ cosin } B}.$$

$$= \frac{\sin C}{\sin AC \cot BC - \cos AC \cos C}.$$

$$\text{Tan AC} = \frac{\sin BC}{\sin C \cot B + \cos C \cos BC}.$$

$$= \frac{\sin BC}{\sin C \cot B + \cos C \cos BC}.$$

Involution and Evolution of Fractions by Logarithms

In a logarithm the integer is called the *characteristic*, and the decimal portion the *mantissa*.

Involution.—The number carried from the *mantissa* to the *characteristic* being positive, must be deducted from the negative characteristic.

Example.—Find the 5th power of ·05, or the value of $\cdot05^5$.

$$\text{Log} \cdot 05 = \bar{2}\cdot69897$$

$$\text{then } \bar{2} \times 5 = \overline{10}$$

$$+$$

$$\text{and } \cdot69897 \times 5 = 3\cdot49485.$$

$$\text{Then log } \cdot05^5 = 7\cdot49485$$

$$\text{and } \cdot05^5 = \cdot0000003125.$$

Evolution.—If the *negative* characteristic be not divisible without a remainder by the index of the required root, the number of units sufficient to make it so divisible must be added to it, and the same number of units must also be added to the mantissa before division.

Example.—Find the value of $\sqrt[5]{\cdot0000003125}$.

$$\text{Log } \cdot0000003125 = \bar{7}\cdot49485$$

$$\text{then } \bar{7} + \bar{3} = \overline{10}, \text{ and } 10 \div 5 = \bar{2}$$

$$\text{and } 3\cdot49485 \div 5 = \cdot69897$$

Therefore $\log. \sqrt[5]{\cdot0000003125} = \bar{2}\cdot69897 = \log \text{ of } \cdot05$.

Proportion by Logarithms

Add together the logarithms of the 2nd and 3rd terms, and from their sum subtract the logarithm of the 1st term, then the number corresponding to the logarithm of the remainder gives the required answer.

Example.—68·30 : 13·70 : : 79·40.

Log 13·70	= 1·13672
Log 79·40	= 1·89982
Sum	3·03654
Log 68·30	= 1·83442
Diff.	1·20212 = log of 15·93.

DIFFERENTIAL AND INTEGRAL CALCULUS

Paragraphs which refer to the *Differential Calculus are in italics*, **those which refer to the Integral Calculus are in full-face type;** those which refer to both are in ordinary type.

The object of the Differential Calculus is to find how the indefinitely small changes in some VARIABLE *quantity alter at each instant the value of a quantity* DEPENDENT *upon it.*

The object of the Integral Calculus (the reverse of the Differential) is to ascertain from the ratio of indefinitely small changes in two or more magnitudes the function (f) which governs the changes.

Notation

Constant quantities, which retain the same value throughout the investigation, are usually represented by the early letters of the alphabet—a, b, c, e, etc.

Variables, to which different values may be assigned, by the later letters, u, v, w, x, y, z. The latter are frequently (but not invariably) used to denote the following:—

u=one or more functions; sometimes u=length; v=volume; x=abscissa; y=ordinate; z=surface, or area; d=differential, or the sign of differentiating; $\int$ is the sign of integration of the quantity that follows it: $\int\int\int$=successive integration; $\int_b^a$ denotes that the integration is to be within the limits of a and b.

Rules for Differentiation and Integration

Rule for Differentiation of any power of the variable x.—Deduct 1 from the index of the variable, and multiply by the original index, or $d(x^n)=nx^{n-1}\,.\,dx$. *For example,* $d(ax^3)=3ax^{3-1}=3ax^2\,.\,dx$.

Rule for Integration.—Add 1 to the index of the variable, and divide by the new index,* or $\int x^n dx=\frac{x^{n+1}}{n+1}$. **For example,**

$$\int 3ax^2dx=\frac{3ax^{2+1}}{3}=ax^3.$$

A constant coefficient is unchanged in differentiating; thus $d\,.\,ax^3=3ax^2\,.\,dx$.

If the constant be a term, it disappears; thus $d(a+x^3)=3x^2\,.\,dx$.

A constant factor may be removed from the process of integration, thus, $\int adx=a\,.\int.\,dx$.

A constant term must reappear in integration in the form of an arbitrary constant, thus, $\int 3x^2dx=x^3+C$.

$\int$ and d neutralise each other, thus, $\int.\,dx=x$.

Differential Coefficient

u, v, etc., are functions of the variable, x.

a, b, c, etc., are constants.

$$\frac{d(x)}{dx}=1. \quad \text{General formula: } \frac{dy}{dx}=nx^{-n1}$$

$$\frac{d(a)}{dx}=0. \qquad \frac{d^ny}{dx^n}=\frac{d(f^{(n-1)}(x))}{dx}=f^nx$$

$$\frac{d(u\pm v\pm w\pm\ \ldots}{dx}=\frac{du}{dx}\pm\frac{dv}{dx}\pm\frac{dw}{dx}\pm\ \ldots$$

$$\frac{d(au)}{dx}=a\frac{du}{dx}$$

$$\frac{d(vu)}{dx}=u\frac{dv}{dx}+v\frac{du}{dx}$$

* Except when $n=-1$ then $\int x^{-1}dx=\int\frac{dx}{x}=\log_e x$.

$$\frac{d\left(\frac{u}{v}\right)}{dx}=\frac{v\frac{du}{dx}-u\frac{dv}{dx}}{v^2}$$

$$\frac{du^n}{dx}=nu^{n-1}\frac{du}{dx}$$

$$\frac{du^v}{dx}=vu^{v-1}\frac{du}{dx}+u^v\log u\frac{dv}{dx}$$

$$\frac{de^u}{dx}=e^u\frac{du}{dx}\cdot\frac{d^ne^{ax}}{dx^n}=a^ne^{ax}$$

$$\frac{da^u}{dx}=a^u\log a\frac{du}{dx}$$

$$\frac{d\sin u}{dx}=\cos u\cdot\frac{du}{dx}$$

$$\frac{d\cos u}{dx}=-\sin u\cdot\frac{du}{dx}$$

$$\frac{d\tan u}{dx}=\sec^2 u\cdot\frac{du}{dx}$$

$$\frac{d\cot u}{dx}=-\operatorname{cosec}^2 u\frac{du}{dx}$$

$$\frac{d\sec u}{dx}=\sec u\tan u\cdot\frac{du}{dx}$$

$$\frac{d\operatorname{cosec} u}{dx}=-\operatorname{cosec} u\tan u\frac{du}{dx}$$

$$\frac{d\operatorname{vers} u}{dx}=-\sin u\frac{du}{dx}$$

$$\frac{d\sin^{-1}u}{dx}=\frac{1}{\sqrt{1-u^2}}\cdot\frac{du}{dx}\left(\text{where}-\frac{\pi}{2}<\sin^{-1}u<+\frac{\pi}{2}\right)$$

$$\frac{d\cos^{-1}u}{dx}=-\frac{1}{\sqrt{1-u^2}}\cdot\frac{du}{dx}\ (\text{where } 0<\cos^{-1}u<\pi)$$

$$\frac{d\tan^{-1}u}{dx}=\frac{1}{1+u^2}\cdot\frac{du}{dx}$$

$$\frac{d\cot^{-1}u}{dx}=-\frac{1}{1+u^2}\cdot\frac{du}{dx}$$

$$\frac{d\sec^{-1}u}{dx}=\frac{1}{u\sqrt{u^2-1}}\cdot\frac{du}{dx}\ (\text{where } 0<\sec^{-1}u<\pi)$$

$$\frac{d\operatorname{cosec}^{-1}u}{dx}=-\frac{1}{u\sqrt{u^2-1}}\cdot\frac{du}{dx}\left(\text{where } -\frac{\pi}{2}<\operatorname{cosec}^{-1}u<+\frac{\pi}{2}\right)$$

$$\frac{d\operatorname{vers}^{-1}u}{dx}=\frac{1}{\sqrt{2u-u^2}}\cdot\frac{du}{dx}\ (\text{where } 0<\operatorname{vers}^{-1}u<\pi)$$

$$\frac{d^n\sin ax}{dx}=a^n\sin\left(ax+\frac{n\pi}{2}\right)$$

$$\frac{d^n\cos ax}{dx}=a^n\cos\left(ax+\frac{n\pi}{2}\right).$$

Fundamental Integrals

$$\int df(x)=f(x)+c.$$

$$d\int f(x)dx=f(x)dx.$$

$$\int\{f_1(x)\pm f_2(x)\pm\ldots\}dx=\int f_1(x)dx\pm\int f_2(x)dx\pm\ldots$$

$$\int af(x)dx=a\int f(x)dx.$$

$$\int u^n du=\frac{u^{n+1}}{n+1}+c\ (n\neq-1)$$

$$\int\frac{du}{u}=\log_e u+c$$

$$\int u\,dv=uv-\int v\,.\,du.$$

Useful Integrals

$$\int n\,dx=nx+c$$

$$\int nx^{n-1}dx=x^n+c$$

$$\int(ax+b)^n dx=\frac{1}{a(n+1)}(ax+b)^{n+1}+c$$

$$\int\frac{dx}{ax+b}=\frac{1}{a}\log_e(ax+b)+c$$

$$\int\frac{xdx}{ax+b}=\frac{x}{a}-\frac{b}{a^2}\log_e(ax+b)+c$$

$$\int\frac{x^2dx}{ax+b}=\frac{1}{a^3}\left\{\frac{(ax+b)^2}{2}-2b(ax+b)+b^2\log_e(ax+b)\right\}+c$$

$$\int\frac{x^2dx}{(ax+b)^2}=\frac{1}{a^3}\{(ax+b)-2b\log_e(ax+b)+b^2\log_e(ax+b)\}+c$$

$$\int\frac{x^2dx}{(ax+b)^3}=\frac{1}{a^3}\left\{\log_e(ax+b)+\frac{2b}{ax+b}-\frac{b^2}{2(ax+b)^2}\right\}+c$$

$$\int\frac{dx}{x(ax+b)}=\frac{1}{b}\log_e\frac{x}{ax+b}+c$$

$$\int\frac{dx}{x^2(ax+b)}=-\frac{1}{bx}+\frac{a}{b^2}\log_e\frac{ax+b}{x}+c.$$

Differential Equations

A differential equation is simply an equation involving derivatives or differentials.

The *degree* of a differential equation is the same as the power to which the highest order derivative is raised.

The *solution* is the relation involving only the variables without their derivatives, and arbitrary constants. In general a solution of a differential equation of the *m*th order will contain *m* arbitrary constants. Where particular values are assigned to these constants the solution becomes a *particular solution.*

Examples of Differential Equations

Equation: $X_1Y_1dx + X_2Y_2dy = 0$ where X and Y are respectively functions of x and y above

Solution: $\int \frac{X_1}{X_2}dx + \int \frac{Y_2}{Y_1}dy = C$

Equation: $dy - f\left(\frac{y}{x}\right)dx = 0$

Solution: $x = Ce^{\int \frac{dv}{f(v)-v}}$, where $v = \frac{y}{x}$

Equation: $dy + (X_1y - X_2)dx = 0$

Solution: $y = e^{-\int X_1 dx}\left(\int X_2 e^{\int X_1 dx}dx + c\right)$

Equation: $\frac{d^2y}{dx^2} = X$

Solution: $y = x\int X dx - \int xX dx + Cx + D$. C and D are constants

Equation: $\frac{d^2y}{dx^2} = Y$

Solution: $x = \int \frac{dy}{\sqrt{2\int Y dy + c}} + D$

Equation: $\frac{d^2x}{dt^2} - k^2x = 0$

Solution: $x = Ce^{kt} + De^{-kt}$.

Equation of Simple Harmonic Motion

$$\frac{d^2x}{dt^2} + k^2x = 0.$$

Solutions: $x = Ce^{kt\sqrt{-1}} + De^{-kt\sqrt{-1}}$
$= C\sin(kt + D)$
$= C\cos(kt + D)$
$= C\cos kt + D\sin kt.$

Damped Vibration

$$\frac{d^2x}{dt^2}+2e\frac{dx}{dt}+k^2x=0.$$

Solutions: $x=e^{-lt}(C+Dt)$, if $e^2=k^2$

$x=e^{-lt}(Ce^{\sqrt{l^2-k^2}t}+De^{-\sqrt{l^2-k^2}t})$, if $l^2>k^2$

$x=Ce^{-lt}\sin(\sqrt{k^2-l^2}t+D)$, if $l^2<k^2$.

Taylor's and Maclaurin's Theorems

Let y be a function of x which it is possible to develop in a series of ascending powers of that variable; and suppose that h=any indeterminate quantity, $y=A+Bx+Cx^2+Dx^3+Ex^4+$ etc.; and when x becomes $x+h$, let $y=y'$,

$$y'=y+\frac{dy}{dx}h+\frac{d^2y}{dx^2}\cdot\frac{h^2}{1\times2}+\frac{d^3y}{dx^3}\cdot\frac{h^3}{1\times2\times3}+\frac{d^4y}{dx^4}\cdot\frac{h^4}{1\times2\times3\times4}+\text{, etc.,}$$

or " Taylor's Theorem ";

$$y^1=(y)_0+\left(\frac{dy}{dx}\right)_0x+\frac{1}{1\times2}\left(\frac{d^2y}{dx^2}\right)_0\cdot x^2+\frac{1}{1\times2\times3}\cdot\left(\frac{d^3y}{dx^3}\right)_0x^3+\text{ etc.,}$$

or " Maclaurin's Theorem."

Simpson's Formula of Quadratures

To find the approximate value of any definite integral of the form $\int z\,.\,dx$, where z is any function of x.

Find $n+1$ values of z, corresponding to $n+1$ equidistant values of x; such as $z_0, z_1, z_2, z_3 \ldots z_{n-2}, z_{n-1}, z_n$; then the value of the integral is the product of the third part of the equidistance, by a sum compounded of, (A) the extreme values of z; or (z_0+z_n); (B) the quadruple sum of the *odd* values of z; or $4(z_1+z_3+\ldots z_{n-1})$; (C) the double sum of the *even* values of z; or $2(z_2+z_4+\ldots z_{n-2})$; the greater the value of n, the nearer will be the approximation. n must be an *even* number.

Maxima and Minima

If a quantity increases continuously, and then decreases, its values, at the limits of increase or decrease, are the maxima or minima respectively. If it decreases (or increases) continually it has no maxima or minima.

The function u is a minimum or maximum when $\frac{du}{dx}=0$.

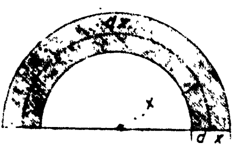
If the second differential coefficient $\frac{d^2u}{dx^2}$ be negative, the value of u is a maximum.

If $\frac{d^2u}{dx^2}$ be positive, u is a minimum.

The point of contrary flexure (in a curve whose equation is $f(xy)=0$) occurs when $\frac{d^2y}{dx^2}=0$ or $=\infty$.

Simple Example of the Application of the Principles of the Calculus to Increase in Area

$x=$ Radius $=12$.
$dx=$ Rate of increment of x.
$z=$ Area of figure.
$dz=$ Rate of increment of area.
$=$ Hatched portion in diagram.

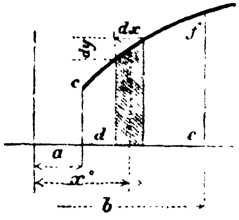


Differential Calculus.—A figure increases at the rate $dx=2$ when $x=12$; at what rate dz does the area increase when $z=ax^2$ and $a=\frac{1}{2}\pi=1\cdot5708$? $dz=2ax^{2-1}\,dx=2ax\,.\,dx=75\cdot4$.

Example in Integration.—A figure is found to increase in the ratio $\frac{dz}{dx}=2ax$. Find the f, or function; $\int dz=\int 2axdx=\frac{2ax^{1+1}}{2}=ax^2$.

Note.—In this and other diagrams given to exemplify the principles of the calculus the increments are shown as having considerable magnitude, otherwise they cannot be shown in diagram; but properly the increments should be indefinitely small.

$$d(x^n) = nx^{n-1}dx; \int x^n dx = \frac{x^{n+1}}{n+1}.$$



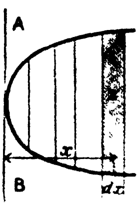
Simple Example of the Integration between Fixed Limits

Let x and y be any co-ordinates.

b and a = the greatest and least values of x.

$\int_a^b y\,dx$ = the area of the figure $cdef$.

Application of the Calculus to Areas and Centres of Gravity



z = Area of one of the layers parallel to plane AB.

x = Distance of centre of layer from the plane AB.

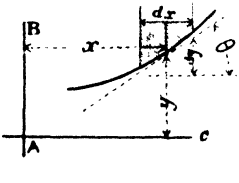
dx = Thickness of one layer.

V = Volume of the whole body = sum of volumes of the layers = $\int z\,dx$.

Distance of centre of gravity from plane

$$AB = \frac{\int xz\,dx}{V}.$$

Application of Calculus to Curves



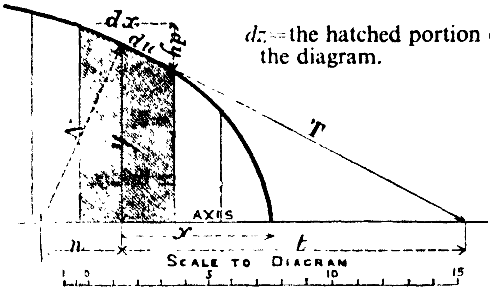
Let AB, Ac, be the axes of the co-ordinates of the curve,

x and y the co-ordinates.

$\phi(xy) = 0$ = the equation of the curve.

$$\text{Tan}\ \theta = \frac{dy}{dx}.$$

Example of the Application of the Calculus to Curves



dz = the hatched portion of the diagram.

Let A =	Major axis of an ellipse	say 40.
a	Minor axis of an ellipse	say 20.
y	Any ordinate	7·1414.
x	Any abscissa corresponding with y .	6.

Then the equation of an ellipse being $y^2 = \frac{a^2}{A^2}(Ax - x^2)$;

therefore $$\frac{a^2Ax}{A^2} - \frac{a^2x^2}{A^2} - y^2 = 0 = 10x - \frac{x^2}{4} - y^2,$$

the differential of which is $10 - \frac{x}{2} - 2y = \frac{20 - x - 4y}{2}$

and $\frac{dy}{dx} = \frac{20 - x}{4y} = \cdot491$; also $\frac{dx}{dy} = \frac{4y}{20 - x} = 2\cdot04$.

Length of tangent $T = y\sqrt{1 + \left(\frac{dx}{dy}\right)^2} = 16\cdot225$

,, subtangent $t = y\frac{dx}{dy} = 14\cdot568$

,, normal $N = y\sqrt{1 + \left(\frac{dy}{dx}\right)^2} = 7\cdot955$

,, subnormal $n = y\frac{dy}{dx} = 3\cdot506$

Tan of angle of T with $t = \frac{dy}{dx} = \cdot491 = \tan 26^\circ\ 10'$.

Note.—dx, dy, etc., in this and in the preceding diagrams are shown as having considerable magnitude, but properly they should be *indefinitely small.*

$$d(x^n)=nx^{n-1}dx;\ \int x^n dx=\frac{x^{n+1}}{n+1}.$$

SIMPLE EXAMPLE OF MAXIMA AND MINIMA

u is a minimum or maximum when $\frac{du}{dx}=0$.

In formula $S=\frac{W}{2DL}(Lx-x^2)$ (see lattice bridges); find the point at which the strain is a maximum.

$\frac{W}{2DL}$ is the same in all cases, and therefore a constant; substitute a for it; and u for S; or $u=aLx-ax^2$;

then $$\frac{du}{dx}=aLx^{1-1}-2ax^{2-1}=aL-2ax.$$

Make $\frac{du}{dx}$ (or $aL-2ax$)$=0$;

then $$2ax=aL;\quad \text{or}\quad 2x=L;\quad \text{or}\quad x=\frac{L}{2};$$

or the point of maximum or minimum value is at half the span.

When the second differential coefficient $\frac{d^2u}{dx^2}$ is negative, u is a maximum; but if positive, u is a minimum.

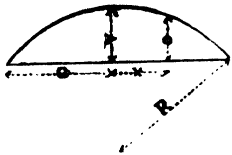
$\frac{d^2u}{dx^2}=-2a$; therefore u is a maximum.

EXAMPLE OF THE APPLICATION OF THE CALCULUS TO GIRDERS

In any girder (whether straight, curved, continuous, or discontinuous) if the bending moment at any point be expressed as a function of a variable x, the normal shearing force at that point will be expressed by the differential coefficient of the function.

Thus, if the bending moment at any point be expressed by $M=W(2ax-x^2)$; the normal shearing force at that point will be $\frac{dM}{dx}=W(2a-2x)=2W(a-x)$.

SEGMENT OF CIRCLES



V = Versed sine. C = Semichord.

R = Radius. O = Any ordinate.

X = Distance of Ordinate from centre.

$O = \sqrt{R^2 - X^2} - (R - V)$.

$R = \frac{V^2 + C^2}{2V}$ or diameter $\frac{V^2 + C^2}{V}$.

$V = R - \sqrt{R^2 - C^2}$.

$X = \sqrt{R^2 - (O + R - V)^2}$.

Area of segment $= \frac{4V}{3} \sqrt{(0{\cdot}625V)^2 + C^2}$.

CONIC SECTIONS

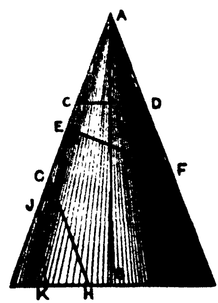
Section on plane AB, the line of axis forms a TRIANGLE.

Ditto on CD, parallel to the base forms a CIRCLE.

Ditto on EF at an angle to the base forms an ELLIPSE.

Ditto on GH, parallel to the slope of the cone forms a PARABOLA.

Ditto on JK, cutting the side at an angle less than parabola forms a HYPERBOLA.



Conic Sections

Diagrams and Formulæ corresponding with the Symbols are given in succeeding pages.

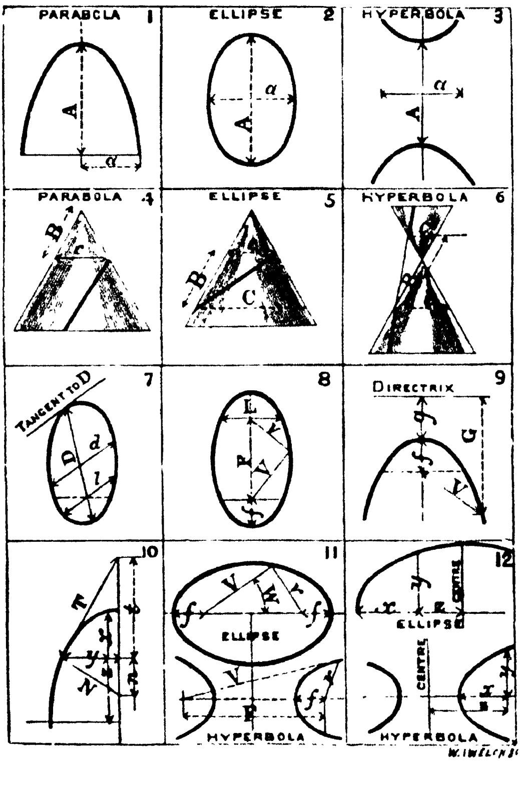
Symbol	Definition
A	Major Axis (or Transverse Axis) is the right line that passes through the vertices of a curve (Figs. 1, 2, 3).
a	Minor Axis (or Conjugate) is a right line passing through the centre of the major axis at right angles to it. In the parabola A and *a* are infinite; the symbols have therefore been adopted to express the height and ½ the base respectively in the case of the parabola.
B	Slant Height of the portion of the cone that affects the figure (see Diagrams 3, 4, and 5).
C and *c*	Diameters of the Cone at the respective vertices of the figure (Figs. 4, 5, and 6).
D	Diameter of Curve is any straight line that passes through the centre of the curve and is terminated at both ends by the circumference (Fig. 7).
d	Conjugate Diameter to D. A diameter is said to be conjugate to another when it is parallel to the tangent of that diameter.
F	Distance of Foci apart (Figs. 8 and 11).
f	Focal Distance, or distance of the focus from the nearest vertex (Figs. 8 and 11).
g	Distance of Vertex from Directrix.—The directrix is a line at right angles to the major axis, and is in such a position that $f : g :: V : G$ (Fig. 9).
G	Offset to Directrix from the end of any radius vector V (Fig. 9).
L	Latus Rectum (or Principal Parameter) passing through the focus, it is a double ordinate, which is a third proportion to the axis; or $A : a :: a : L$ (Fig. 8).

CONIC SECTIONS—*continued*

Symbol	Definition
l	PARAMETER.—A third proportion to any diameter and its conjugate; or D : d : : d : l (Fig. 7).
n	SUBNORMAL.—The portion of the transverse axis subtended by the normal (Fig. 10).
N	NORMAL.—A line drawn at right angles to a tangent from the tangent point to the transverse axis (Fig. 10).
t	SUBTANGENT.—That part of the transverse axis that is subtended by the tangent (Fig. 10).
T	TANGENT.—A right line which touches the curve, and, being produced, does not cut it. The length of the tangent is limited between the point of contact and the transverse axis.
R	RADIUS OF CURVATURE at any point of the curve.
V, v	RADII VECTORES.—The radius vector is a stright line drawn from the focus to any point in the curve (Fig. 11).
W	TRACED ANGLE.—The angle formed by the radius vector and the transverse axis (Fig. 11).
x	ABSCISSA.—The portion of the diameter which is between the ordinate and the curve.
y	ORDINATE.—Any line parallel to the tangent of a diameter, and drawn from that diameter to the curve (Fig. 12).
z	DISTANCE FROM CENTRE of curve to any ordinate (Fig. 12).

CONIC SECTIONS—*continued*

Diagrams illustrating the Symbols used in the Definitions and Formulæ.



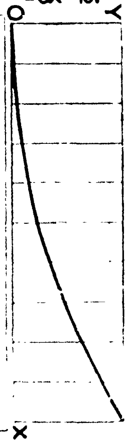
		Parabola	Ellipse	Hyperbola
A*	Major axis	$\frac{a^2B}{c^2}$	$\sqrt{B^2+Cc}$	$\sqrt{B^2-Cc}$
a*	Minor axis	$\sqrt{\frac{c^2A}{B}}$	$\sqrt{Cc}$	$\sqrt{Cc}$
B	Slant height . . .	$\frac{c^2A}{a^2}$	$\sqrt{A^2-a^2}$	$\sqrt{A^2+a^2}$
C	Diam. of cone at vertices	—	$\frac{a^2}{c}$	$a^2 \div c$
c		$\sqrt{\frac{a^2B}{A}}$	$\frac{a^2}{C}$	$a^2 \div C$
D	Conjugate diameters	—	$\sqrt{A^2+a^2-d^2}$	$\sqrt{A^2-a^2+d^2}$
d			$\sqrt{A^2+a^2-D^2}$	$\sqrt{A^2-a^2+D^2}$
F	Distance of foci . .	—	B	B
f	Focal distance . . .	$y^2 \div 4x$	$\frac{A-F}{2}$	$\frac{F-A}{2}$
g	Distance of directrix .	f	$f^2 \div \left(\frac{a^2}{2A}-f\right)$	$f^2 \div \left(\frac{a^2}{2A}-f\right)$
G	Offset to ditto . . .	V	$gV \div f$	$gV \div f$
L	Latus rectum . . .	$4f$	$a^2 \div A$	$a^2 \div A$
l	Parameter	—	$d^2 \div D$	
n	Subnormal	$y^2 \div t$	$y^2 \div t$	$y^2 \div t$
N	Normal	$\sqrt{y^2+n^2}$	$\sqrt{y^2+n^2}$	$\sqrt{y^2+n^2}$
t	Subtangent . . .	$2x$	$\frac{A^2}{4z}-z$	$z-\frac{A^2}{4z}$
T	Tangent	$\sqrt{y^2+t^2}$	$\sqrt{y^2+t^2}$	$\sqrt{y^2+t^2}$
V / v	Radius vector . . .	$x+f$	$\sqrt{(x-f)^2+y^2}$	$\sqrt{(x-f)^2+y^2}$
R	Radius of curvature .	—	$\frac{4\sqrt{(Vv)^3}}{Aa}$	$\frac{4\sqrt{(Vv)^3}}{Aa}$
W	Sine of traced angle .	$y \div V$	$y \div V$	$y \div V$
x	Abscissa from a vertex	$\frac{Ay^2}{a^2}$	$\frac{A(a \pm \sqrt{a^2-4y^2})}{2a}$	$\frac{A(a \pm \sqrt{a^2+4y^2})}{2a}$
y	Ordinate	$\frac{a\sqrt{x}}{\sqrt{A}}$	$\frac{a}{A}\sqrt{Ax-x^2}$	$\frac{a}{A}\sqrt{x(A+x)}$
z	Distance of y from centre	—	$\frac{A}{2}-x$	$\frac{A}{2}+x$

* In the parabola A = height; $a = \frac{1}{2}$ base.

Catenary Curves by Ordinates in Terms of Semi-span

The semi-span being divivded into 10ths.
For formulæ of the Catenary curve, see " Catenary."

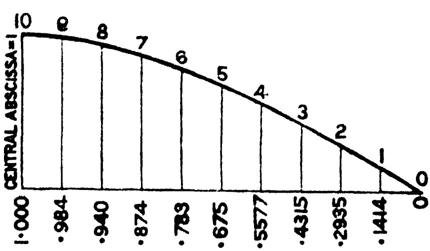
Parameter = P = 100	Parameter = P = 10	Parameter = P = 5	S = Semispan = OX = 10.	Parameter = P = 1000	Parameter = P = 1
·0000	·0000	·000		·0000	·0000
·0050	·0500	·0869		·0005	·543
·0200	·2007	·1737		·0020	2·762
·0450	·4534	·2606		·0045	9·068
·0800	·8107	·3474		·0080	26·31
·1251	1·2763	·4343		·0125	73·21
·1801	1·8547	·5212		·0180	200·72
·2451	2·5515	·6080		0·245	547·32
·3202	3·3744	·6949		·0320	1489·5
·4052	4·3309	·7817		·0405	4050·5
·5004	5·4308	·8686		·0500	11012



Construction of Hyperbola by Abscissæ

(W. H. Thomas)

Ordinate divided into 10ths. The figures under each abscissa, multiplied by the length of the central abscissa, give points in the curve.

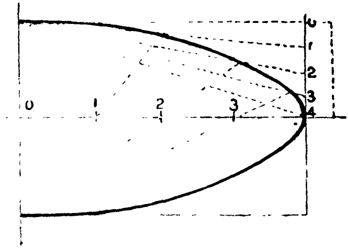


Construction of Ellipse, Hyperbola, and Parabola, by Intersecting Straight Lines

Any convenient number of equal divisions may be taken, and the intersections of straight lines as indicated in the diagrams will give points in the curve.

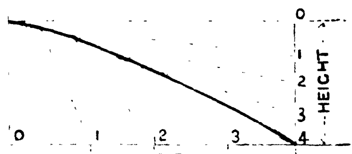
Ellipse

Divide half minor and half major axes. Intersecting lines radiate from end of minor axis.



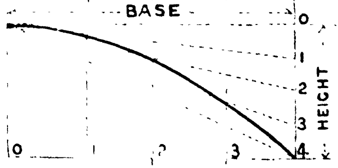
Hyperbola

Divide height and base. Intersecting lines radiate from end of major axis and vertex.



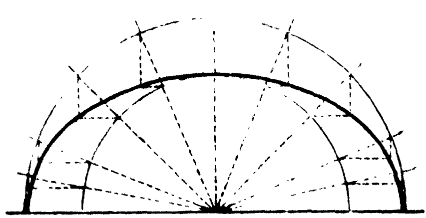
Parabola

Divide height and base. Intersecting lines vertical, and radiating from vertex.

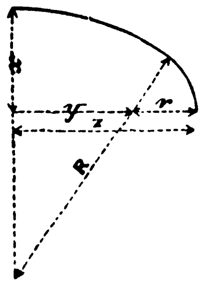


To Construct an Ellipse from Two Circles

Describe two semicircles whose diameters are respectively the length of the major and minor axes. The intersection of the horizontal and vertical lines drawn from any radial line will give a point in the curve.



To Calculate the Radius of a False Ellipse with 3 Centres



R = Large radius.
r = Small radius.
x = Semi-minor axis.
z = Semi-major axis.
y = Distances of centre or r from minor axis.

$$R = z + \frac{y^2 - (x-y)^2}{2(x-r)}.$$

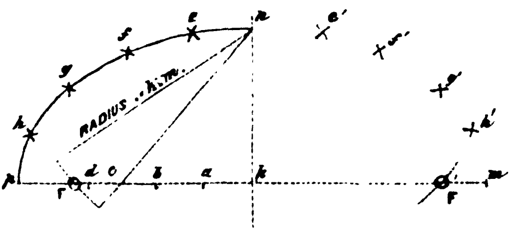
$$y = z - r.$$

To construct a false ellipse closely approximating to a true ellipse.

(R. Strachey.)

$$R = \frac{z(3z+x)}{4x}.$$

$$r = \frac{x(z+2x)}{3z}.$$



To draw an Ellipse:

From n, with radius nF = semi-transverse axis km, draw a circle, cutting the transverse axis at FF′. FF′ are the foci of the ellipse.

On the transverse axis lay off any points $abcd$, between the foci, and

From F with radius = pa describe a portion of a circle at e, also from F′ with radius = ma describe a portion of a circle at e; the curve will pass through the intersection of these circles at e.

In like manner f is described from the foci with the radii = pb and mb respectively.

g with the radii = pc and me respectively.
h „ „ = pd „ md „

To Calculate any Ordinate

(See diagram below.)

Let T = Semi-transverse axis.
C = Semi-conjugate axis.
K = The length of any ordinates.
X = Distance of the ordinate from the centre.

$$K=\sqrt{C^2-\left(\frac{CX}{T}\right)^2}.$$

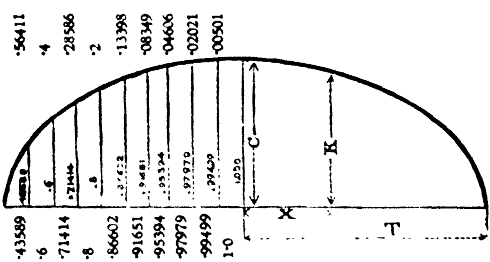
Area of an ellipse $=\pi TC$.

Periphery of an ellipse *approximately*

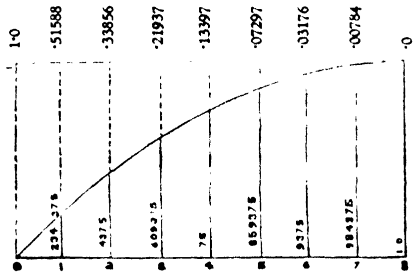
$$=\tfrac{1}{2}\pi[\sqrt{2(T^2+C^2)}+T+C].$$

To Construct an Ellipse by Ordinates

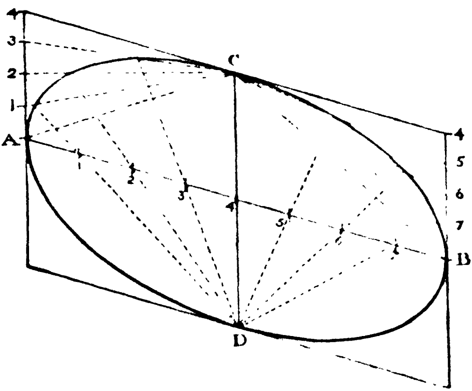
Divide the semi-transverse axis into 10 equal parts, and draw ordinates. The length of these ordinates = the semi-conjugate axis C, multiplied by the respective numbers on each ordinate in the diagram. The complement of each ordinate is shown above it.



Ordinates of the Semi-ellipse divided into 8ths.



To Construct an Ellipse when the Diameters do not Cross One Another at Right Angles



Let AB and CD be the given diameters.

Draw the bounding lines parallel to both diameters and divide the longest diameter into any number of equal parts, also divide the shorter bounding lines into the same number of equal parts. From one end of the shorter diameter D draw radial lines *through* the divisions of the longer diameter, and from the opposite end C draw radial lines to the divisions on the shorter bounding lines; the intersection of these lines will give points in the curve.

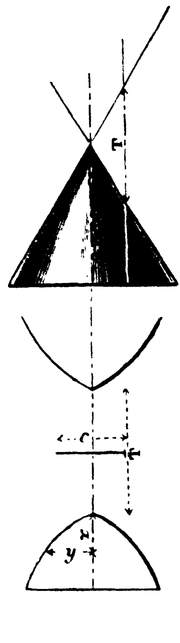
HYPERBOLA

The transverse axis of a hyperbola is that part of the axis which, if continued, would join an opposite cone.

The conjugate axis is a line drawn through the centre of the transverse axis at right angles to it.

The parameter is the chord of the curve drawn through the focus at right angles to the axis.

The focus is a point in the axis where the ordinate is $= \frac{1}{2}$ diameter.



T = Transverse axis.

C = Conjugate axis.

x = Abscissa.

= Ordinate.

$$y = \frac{C\sqrt{x(T+x)}}{T}.$$

$$x = \frac{T\sqrt{y^2 + \left(\frac{C}{2}\right)^2}}{C} - \frac{T}{2}.$$

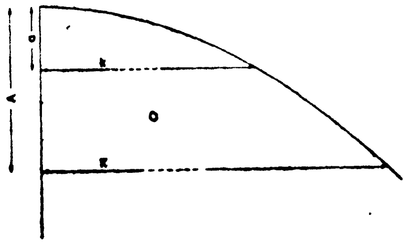
$$C = \frac{Ty}{\sqrt{x(T+x)}}.$$

$$T = \frac{Cx\left(\sqrt{y^2 + \left(\frac{C}{2}\right)^2} + \frac{C}{2}\right)}{y^2}.$$

$$\text{Parameter} = \frac{C^2}{T}.$$

PARABOLA.

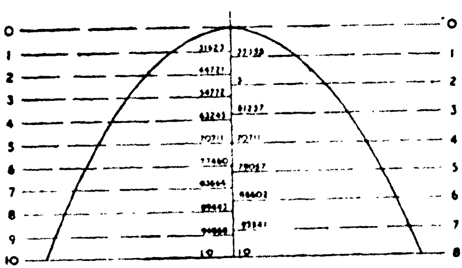
A and a = the abscissæ.
K and k = the ordinates.



$$k = \frac{K\sqrt{a}}{\sqrt{A}}. \qquad a = \frac{A \times k^2}{K^2}.$$

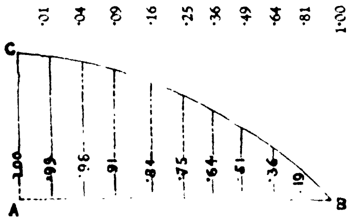
ORDINATES OF THE PARABOLA

ABSCISSA DIVIDED IN 10THS. ABSCISSA DIVIDED IN 8THS.

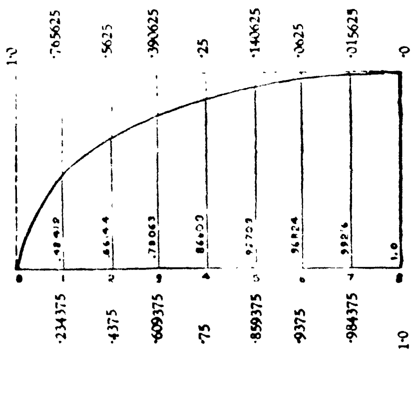


Construction of Parabolic Curve

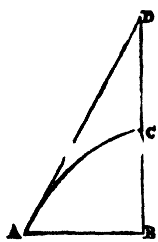
Divide the ordinate AB into 10 equal parts and raise perpendiculars, the length of which will be determined by multiplying the abscissa AC by the respective number on each perpendicular in the diagram. The complement of each ordinate is shown above it.



Ordinate of the Parabola, divided into 8ths.



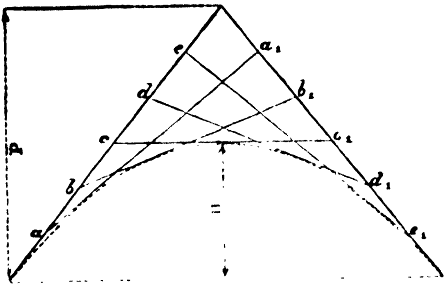
To Draw a Tangent to Any Part of a Parabola



Make CD=BC and join DA; DA is the tangent.

To Construct a Parabola

Make P=2H and divide the sides of the triangle into any even number of equal parts, join *aa*, *bb*, *cc*, etc., the lines will be tangents to the parabola.

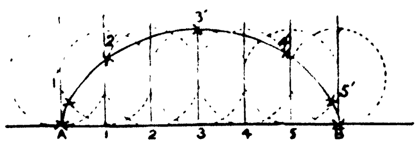


Construction of the Cycloidal Curve

On the line AB, lay off any point 1, 2, 3, 4, etc., draw perpendicular lines at each point, and on each describe circles equal to the generating circle.

On the circumference of the circle at 1 lay off 1·1′ = A.1.
„ „ „ 2 „ 2·2′ = A.2.
„ „ „ 3 „ 3·3′ = A.3.

and so on; the points 1′, 2′, 3′, 4′, 5′, are points of the curve.

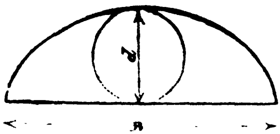


See also another method of forming a cycloid, "Wave lines."

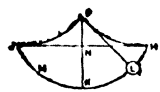
Calculation of the Cycloidal Curve

Length of base $B = \pi \times d$.
Diameter of generating circle $d = B \div \pi$.

Area of cycloid = area of generating circle × 3.
Length of curve = $4d$.



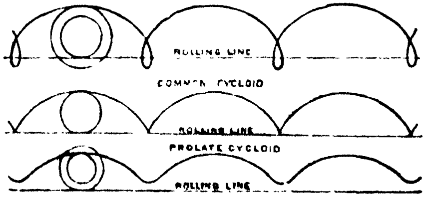
The area of AFDEBA is equal to that of the generating circle. The tangent FG is parallel to the chord DE. The arc DF is double the chord DE. The circular arc DE = FE parallel to the base AB.



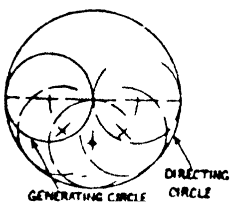
If the cycloid be turned upside down a body falls through any arc LK in the same time independently of the length of the arc; this time is to that of a body falling perpendicularly from N to K as 3·14159 to 2; and, if a pendulum be made to oscillate in the arc of a cycloid its vibrations will be isochronous. The evolute of a cycloid is another equal cycloid. The cycloid is the curve of quickest descent between any two points.

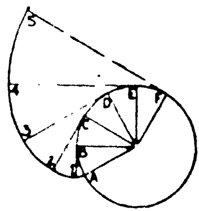
The cycloid is formed by a tracing point attached to a generating circle which rolls on a straight line. If the tracing point be beyond the circumference of the generating circle, a curtate cycloid will be produced terminating in nodes; if the tracing point be on the circumference a common cycloid will be formed terminating in cusps, if within the circumference a prolate cycloid will be formed.

CURTATE CYCLOID



The generating circle may roll around either the exterior or the interior of a second circle instead of a straight line. The types of curve then traced out are known as the epicycloid and hypocycloid respectively. There is a special case when the generating circle rolls within a directing circle of twice the diameter (see diagram at left, below). The locus or path traced out by any point on the circumference of the generating circle is then a straight line which passes through the centre of the directing circle; *i.e.* the locus of such a point lies along a diameter of the directing circle. This property has been used in the design of certain mechanisms.



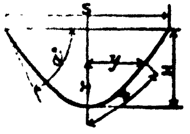


Involute Curves

The involute to a circle is of great importance owing to the use which is made of it in modern gearing. It can most simply be defined as the path traced out by the end of a thin inextensible cord when this is held taut and is unwrapped from a cylinder. Similarly, involute curves can be traced for figures other than a circle.

To construct the involute to a circle, as shown in the diagram, divide the circumference into a number of equal parts by points such as A, B, C, D, E. Draw a tangent at each point and measure off distances B1, C2, D3, etc., equal to the lengths of the arcs BA, CA, DA, etc., respectively. The involute is a smooth curve drawn to join the points 1, 2, 3, etc.

Catenary



S = Span.
H = Dip.
y = Abscissa.
x = Ordinate.
z = Length of chain between vertex and ordinate.

p = Parameter = horizontal tension at vertex (or lowest point in the chain).

t = Tension at point of suspension.

a° = Angle of suspension.

L = Length of the chain.

$$y = p\left(\text{hyp. log}\ \frac{p+x+\sqrt{2px+x^2}}{p}\right);$$

$$= p\left(\text{hyp. log}\ \frac{z+p+x}{p}\right).$$

$z = p \,.\, \tan a^\circ$; $t = p \,.\, \sec a^\circ$; $x = z \,.\, \operatorname{cosec} a^\circ \,.\, \operatorname{versin} a^\circ$.

If L = 2S, then H = ·7966S, and $a^\circ = 77^\circ\ 3'$.

The tension at the point of suspension with respect to y is at a minimum when $a^\circ = 56^\circ\ 28'$; then if p be assumed = 1, then $x = {\cdot}81$ $y = 1{\cdot}1996$, $z = 1{\cdot}5089$.

Distance of centre of gravity chain $2z$ above vertex

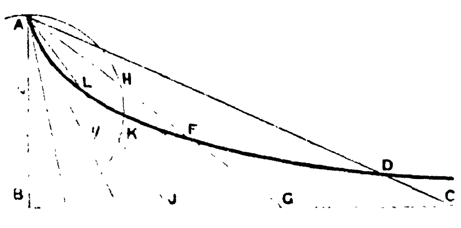
$$= \tfrac{1}{2}\left(x + \frac{py}{z} - p\right).$$

If p = H = 1, then S = 2·6339, L = 3·4641, t = 2, and $a^\circ = 60^\circ$.

Cissoid Curve

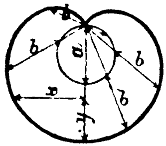
x = Abscissa. a = Axis = AB. y = Ordinate.

$$y = \sqrt{\frac{x^3}{a-x}}.$$



On AB describe a semicircle, and from A draw lines radiating to the asymptote BC, which is at right angles to AB; on these lines lay off JL = AK; GF = AH; CD = AE; etc.

CARDIOIDE



x = Abscissa.

a = Diameter of generating circle.

y = Ordinate.

To construct a cardioide curve describe the generating circle and through one end of its diameter draw radiating lines, always making $bbb = a$.

The equation to the curve is as follows:—

$$y^4 - 6ay^3 + 2x^2y^2 - 6ax^2y + x^4 + 12a^2y^2 - 8a^3y + 3a^2x^2 = 0.$$

ARCHIMEDES SPIRAL

(F. G. Royal-Dawson)

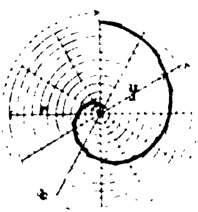
Equation $y = mx$,

where y is radius vector, x angle of revolution (in circular measure), and m a constant.

Open Form.—If $m = 1$, unit y occurs at $x = 1$, that is 57°·2957. If it is desired to make unit y correspond to 60°, the formula becomes

$$y = 0{\cdot}955x.$$

Construction (see Diagram).—From centre describe a circle, radius r, passing through point reached by spiral at end of one revolution. Divide this into a number of equal sectors, and divide radius into similar number of equal parts. Describe concentric circles through radial points thus formed. Then the intersection points taken progressively from sector to sector starting from originating tangent are points on the curve.

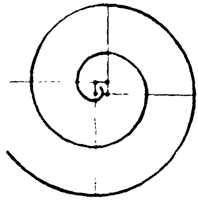


The process may be continued for succeeding revolutions.

Compact Form.—By decreasing m, convolutions become more compact. Thus if it is desired to make unit y correspond to a complete revolution (360°),

$$m = \frac{\cdot 955}{6} = \cdot 159.$$

In such cases, convolutions become more circular in form, and can be very approximately described by a series of quadrants from four centres, as in the diagram (sometimes called a " false " spiral).



Convolutions may be clockwise or anti-clockwise.

Radius of Curvature at any point,

$$R = \frac{(r^2 + m^2)^{\frac{3}{2}}}{r^2 + 2m^2}.$$

LOGARITHMIC OR EQUIANGULAR SPIRAL

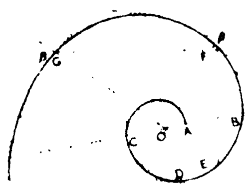
Radius vector increases in geometric ratio, angle of revolution in arithmetic ditto. Hence any radius vector is a mean proportional between the two at equal angular distances from it on opposite sides.

Equation $r = m^{\phi}$,

where r = radius vector, m a constant, and ϕ = angle of revolution (in circular measure).

$$\therefore \log r = \phi \log m.$$

When $r = 1$, $\log r = 0$, hence curve cuts initial line at unit distance OA from O (see diagram).



Also, tangent at any point makes constant angle β with radius vector. β is given by

$$\tan \beta = \frac{1}{\log_e m} = \frac{\log_{10} e}{\log_{10} m} = \frac{0{\cdot}43429448}{\log_{10} m}.$$

Example.—Let $m = 1{\cdot}25$, so that $r = (1{\cdot}25)^{\phi}$.

At one complete revolution (360°), $2\pi = 6{\cdot}28318$.

Hence $\log r = 6{\cdot}28318 \log (1{\cdot}25) = {\cdot}6089030$,

whence $r = 4{\cdot}0635 = OB$.

Also, $OC^2 = OA \cdot OB$, $OD^2 = OC \cdot OB$, $OE^2 = OD \cdot OB$, and so on. Chords between points 90° apart form successive right angles, as EFG.

For constant angle β

$$\tan\beta = \frac{\cdot 43429448}{\log(1\cdot 25)} = 4\cdot 48142,$$

whence $\beta = 77^\circ\ 25'$.

Radius of Curvature at any point, $R = r \operatorname{cosec}\beta$.

If another constant b is introduced, making the general equation

$$r = bm^{\phi},$$

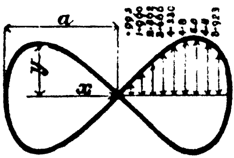
the initial distance OA becomes b.

The larger the value of m the greater the spread of the curve and the smaller the value of β. When $m=1$, $\beta=90^\circ$, and the curve becomes a simple circle.

Lemniscoid, or Vibratory Curve of Lissajous

(Acoustics)

Lemniscoid



x = abscissa,
y = ordinate,
a = axis,

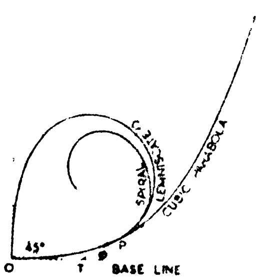
$$y = x\,\frac{\sqrt{a^2 - x^2}}{a}.$$

Note.—This curve, although sometimes called a lemniscate, has no transitional properties, and should not be confused with the true lemniscate (see under Transition Curves).

Transition Curves

(Highways)

A transition curve is one in which the radius of curvature decreases either (a) in exact inverse ratio to length of curve from origin, or (b) at a slightly slower rate.



The Transition Spiral conforms to (*a*), the Lemniscate to (*b*) for all polar deflections up to 45°, the Cubic Parabola to (*b*) up to a deflection of about 4°, then very slowly up to about 9°, after which it gradually increases (see diagram).

TRANSITION SPIRAL (Bernouilli), or CLOTHOID (also known as Cornu's spiral in Optics)

Basic Formula.— $L=m\sqrt{\phi}$,

where L is length of curve from origin, m a constant, and ϕ the angle (in circular measure) made by the tangent at any point P meeting the base line OT in T.

$m=\sqrt{2RL}$, where R is radius of curvature.

Thus RL is constant, R being inversely proportional to L.

If a is polar deflection TOP, of any point P,

$$\tan a=\frac{\phi}{3}+Q,$$

where Q is a small correction negligible for small angles.

Also $a=\frac{\phi}{3}-N$, where N is a small correction negligible for small angles.

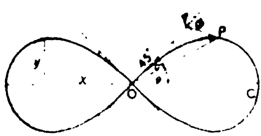
Back angle $TPO=b=\phi-a=3(a+N)-a=2a+3N$.

Also, for small angles $y=\frac{x^2}{6RL}$ approx., and a varies approx. as L^2.

LEMNISCATE (Bernouilli)

Co-ordinate Formula referred to Axis $OC=q$ (see diagram),

$$x^2+y^2=q\sqrt{x^2-y^2}.$$



Polar Equation.—Let OP be any radius vector, or polar ray r,

$$r=q\sqrt{\cos 2\theta}.$$

For purposes of transition curves, tangent at origin OT, 45° to OC, is used as base line, or polar axis, whence, if a be polar deflection, the equation becomes

$$r=q\sqrt{\sin 2a}.$$

Also $\phi = 3a$, and $\tan a = \tan\frac{\phi}{3}$ for all values of a.

Radius of Curvature $R = \frac{q}{3} \cdot \frac{1}{\sqrt{\sin 2a}}$.

Back angle $b = 2a$.

Also, for small angles $y = \frac{x^3}{6RL}$ approx., and a varies approx. as L^2.

Cubic Parabola

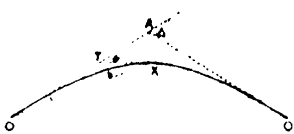
Basic Formula. $y = mx^3$

$$= \frac{x^3}{6RL} \text{ approx. for small angles.}$$

Also $\tan a = \frac{\tan\phi}{3}$ for all angles.

Radius of Curvature $R = \frac{r}{\sin 2\phi \cos\phi}$.

Wholly Transitional Highway Curve (see Diagram)



$\therefore$ Deviation Angle $= 2\phi$.

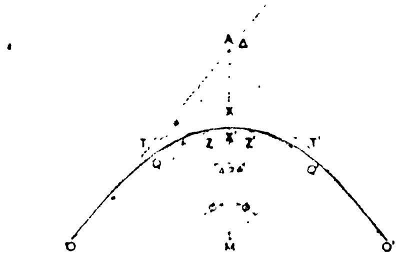
Lemniscate. $a = \frac{\Delta}{6}$, $\phi = 3a$, $b = 2a$,

$$AO = r\frac{\cos 2a}{\cos 3a}, \quad AX = r\frac{\sin a}{\cos 3a}.$$

Spiral. $a = \frac{\phi}{3} - N = \frac{\Delta}{6} - N$, $\phi = 3(a + N)$, $b = 2a + 3N$.

Owing to the corrections necessary the spiral is unsuited for wholly transitional curves, except for very small polar deflections, when it is virtually a lemniscate.

TRANSITION WITH CENTRAL CIRCULAR ARC (see Diagram)



Δ — Deviation Angle.

ZZ′ Central Circular Arc, of Radius R.

OZ, Z′O′ Transitions, of length L.

CQ Shift s, at mid-point of transition, which also bisects s.

C — Tangent-point of curve of radius $(R+s)$.

TZ Tangent at Z.

XX′ — Shift s, at mid-point of curve.

AO = AC + CO.

$AC = (R+s)\tan\frac{\Delta}{2}$, where $s = \frac{L^2}{24R}$.

$CO = \frac{1}{2}L - t$, where t is small correction, negligible for small deflections.

$AX = (R+s)\left(\sec\frac{\Delta}{2} - 1\right)$.

$AX' = AX + s$.

y ordinate at centre of transition $= \frac{1}{2}s$.

Y ,, end ,, $= 4s$ approx.

Unit-Chord System.—Unit of measurement a polar ray, whose polar deflection is 16 minutes, hence deflections in quarter-chords are the series 1′, 4′, 9′, 16′, 25′, 36′, etc., with slight modifications beyond 4°. Thus the series is constant for all transitions, whether lemniscate, spiral, or cubic parabola, whatever the length of the unit-chord may be. This simplifies theodolite operations.

Speed-Chord Formula.—$11{\cdot}4C^2 = V^3$, where C is the length of unit-chord in feet and V the speed in miles per hour.

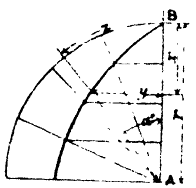
Metric Equivalent.—$510C_m{}^2 = V_{km}{}^3$, where C_m is in metres and V_{km} in kilometres per hour.

American Degree System, for Spirals only. The degree of a curve is $\frac{5{,}730}{R}$, where R is radius in feet. The unit degree of curve of a spiral is the degree of curve at a point 100 ft. from the origin or tangent-point. If D is the degree of curvature at a distance L_s, where L_s is the distance in stations (at 100-ft. intervals) and K the unit degree of the spiral, then $D = KL_s$.

To reduce this formula to terms of L and R in feet,

$$K = \frac{5{,}730 \times 100}{RL}.$$

QUADRATRIX

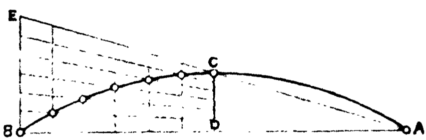


Divide the circumference of a quadrant and the radius AB into the same number of equal parts; then the intersection of the respective lines as drawn in the diagram gives points in the curve.

$$y = \frac{\sin a(r - x)}{\sqrt{r^2 - \sin a^2}}.$$

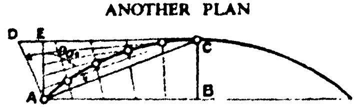
$$x = 0{\cdot}636\, rz.$$

PLAN OF SETTING OUT A CAMBER OR FLAT CURVE



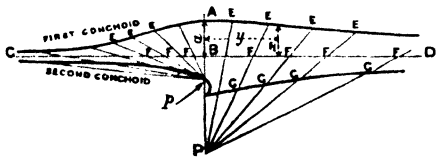
Joint AC and produce the line AC until it cuts the perpendicular line BE. Divide the half span BD into any convenient number of parts, and on each division erect a perpendicular. Also divide BE into the same number of parts. Then lines radiating from the divisions on EB to the point A will, at their intersection with the perpendiculars, give points in the curve.

ANOTHER PLAN



Join AC and draw the line AD at right angles to AC until it cuts the horizontal tangent line CD. Also draw AE perpendicular to the line AB. Divide the half chord AB into any convenient number of parts, also DC and AE into the same number of parts. Then lines radiating to C from the divisions on AE will, at their intersection with the lines which join the divisions on AB and DC, give points in the curve.

Conchoid Curve



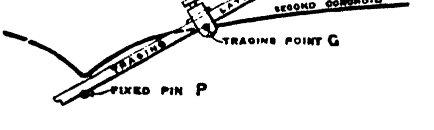
From the point P on the straight line PA lay off PB=b=the distance of the generating point from the asymptote CD which is at right angles to PA; also lay off BA=a=axis of the conchoid. Draw from P any radiating lines cutting the asymptote at FFF, and on these lines produced lay off FE, FE, etc.=a; these distances will give points in a "*first*" conchoid (or a conchoid on that side of the asymptote which is opposite to the generating point P).

For a second conchoid (or one formed on the same side as the generating point) the distances FG, FG, etc.=a are laid off towards P; if b is less than a the curve will have a node at the centre, if $b=a$ it will have a cusp at the centre. The left-hand curve is drawn with p as the generating point: b being less than a.

$bx=(a-x)\sqrt{x^2+y^2}$, for a first conchoid.

$bx=(x-a)\sqrt{x^2+y^2}$, for a second conchoid.

MODE OF TRACING A CONCHOID CURVE



For a first conchoid the tracing point must be in the prolongation of the lath above the straight-edge.

EQUATIONS OF CURVES

The formula $Ax^2+Bxy+Cy^2+Dx+F=0$, represents an ellipse, parabola, or hyperbola, according as B^2-4AC is *positive* in the ellipse; is 0 in the parabola; or negative in the hyperbola.

The following are the equations of the principal curve when x = the abscissa, y = the ordinate, a = the axis, p = the parameter.

CIRCLE, $y=\sqrt{ax-x^2}$.

ELLIPSE, $y=\sqrt{\frac{p}{a}(ax-x^2)}$.

HYPERBOLA, $y=\sqrt{\frac{p}{a}(ax+x^2)}$.

PARABOLA, $y=\sqrt{px}$.

PARABOLA, CUBIC, $y=mx^3$.

CATENARY, $y=\frac{p}{2}(\epsilon^{\frac{x}{p}}+\epsilon^{-\frac{x}{p}})$.

1ST CONCHOID, $bx=(a-x)\sqrt{x^2+y^2}$
2ND CONCHOID, $bx=(x-a)\sqrt{x^2+y^2}$ } when b = distance of the generating point from the asymptote (or PB, see diagram of Conchoid).

CISSOID, $y=\sqrt{\frac{x^3}{a-x}}$.

CARDIOIDE, $y^4-6ay^3+2x^2y^2-6ax^2y+x^4+12a^2y^2-8a^3y+3a^2x^2=0$.

LEMNISCOID, $y=x\frac{\sqrt{a^2-x^2}}{a}$.

LEMNISCATE, $x^2+y^2=q\sqrt{x^2-y^2}$
$r=q\sqrt{\cos 2\theta}$ } axis formulæ.

$r=q\sqrt{\sin 2a}$ base line formula.

QUADRATRIX, $y=\frac{\sin\theta(r-x)}{\sqrt{r^2-(\sin\theta)^2}}$; where θ = the angle subtended by y, and r = the radius of the generating circle.

SPIRAL, ARCHIMEDES, $y=mx$.

,, LOGARITHMIC OF EQUIANGULAR, $r=m\phi$.

,, TRANSITION, $L=m\sqrt{\phi}$.

Mensuration of Surfaces

Area of triangle . . . . = Base × ½ perpendicular.
,, circle . . . . . = Diameter² × ·7854.
,, sector of circle . Length of arc × ½ radius.
,, ,, ,, . =

$$\frac{\text{Number of degrees in arc} \times \text{area of the circle.}}{360}$$

Area of parabola . . . = Base × $\frac{2}{3}$ height.

Frustum of a parabola . = $\frac{2}{3}$ height $\frac{\text{base}^3 - \text{top}^3}{\text{base}^2 - \text{top}^2}$.

Area of ellipse . . . = Transverse axis × ·7854 conjugate axis.

,, cycloid . . . Area of generating circle × 3.

Surface of cylinder . . Area of both ends + length × circumference.

,, cone . . . Area of base + circumference of base × ½ slant height.

,, sphere . . Diameter² × 3·14159.

,, frustum . . Sum of girth at both ends × ½ slant height + area of both ends.

Segment Areas

The area of a segment = Area of a sector − ½ chord × (radius − versin).

Area of segment of circle = Diameter² × x (see Table).

$\frac{D}{V}$ = The versed sine divided by the diameter of the circle of which the segment is a part.

$\frac{V}{D}$	x	$\frac{V}{D}$	x	$\frac{V}{D}$	x	$\frac{V}{D}$	x	$\frac{V}{D}$	x
·01	·001329	·11	·047006	·21	·119898	·31	·207376	·41	·303187
·02	·003749	·12	·053385	·22	·128114	·32	·216666	·42	·313042
·03	·006866	·13	·059999	·23	·136465	·33	·226034	·43	·322928
·04	·010538	·14	·066833	·24	·144945	·34	·235473	·44	·332843
·05	·014681	·15	·073875	·25	·153546	·35	·244980	·45	·342783
·06	·019239	·16	·081112	·26	·162263	·36	·254551	·46	·352742
·07	·024168	·17	·088536	·27	·171090	·37	·264179	·47	·362717
·08	·029435	·18	·096135	·28	·180020	·38	·273861	·48	·372704
·09	·035012	·19	·103900	·29	·189048	·39	·283593	·49	·382700
·10	·040875	·20	·111824	·30	·198168	·40	·293370	·50	·392699

Mensuration of Solids

Cylinder = Area of one end × length.

Sphere = Diameter^3 × ·5236.

Segment of sphere = $\cdot 5236H(H^2+3R\cdot)$, where H = height of segment and R = radius of the base of the segment.

Cone or pyramid = Area of base × $\frac{1}{3}$ perpendicular height.

Frustum = $\frac{1}{3}H(A+a+\sqrt{A\times a})$. When A and a = Areas of the ends, H = Perpendicular height.

Frustum of cone = $\cdot 2618H(D^2+d^2+D\,.\,d)$. When D and d = the diameters of each end, H = Perpendicular height.

Wedge = Area of base × $\frac{1}{2}$ perpendicular height.

Frustum of wedge = $\frac{1}{2}H(A+a)$, when A and a = Area at each end, H = Perpendicular height.

Volume of frustum of wedge

$$=\frac{H}{6}\{l(2w+w_1)+l_1(w+2w_1)\}$$

when l = length at bottom, l_1 = length at top,
and w = width „ w_1 = width „

Length of Helices and Spirals

C = Circumference of a circle equal in diameter to diam. of helix or largest diam. of spiral.

c = Circumference of a circle equal the smallest diameter of the spiral.

n = Number of revolutions of helix or spiral.

p = Pitch of revolutions.

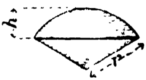
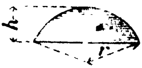
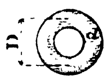
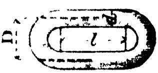
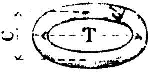
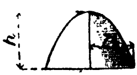
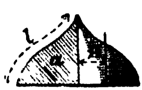
h = Height of the conical spiral.

$x=n\sqrt{C^2+p^2}$. = Length of helix.

$l=n\left(\frac{C+c}{2}\right)$. = Length of plain spiral.

$L=\sqrt{l^2+h^2}$. = Length of conical spiral.

SURFACE AND SOLIDITY OF BODIES

		Convex surface	Solidity
1		$\pi d^2 = 3{\cdot}14159d^2$	$\frac{\pi}{6}d^3 = {\cdot}5236d^3$
2		$6{\cdot}2832rh + 3{\cdot}14159r\sqrt{r^2-(r-h)^2}$	$2{\cdot}0944r^2h$
3		$2\pi rh = 6{\cdot}2832rh$	$\frac{1}{3}\pi h^2(3r-h)$
4		$3{\cdot}14159d\sqrt{\frac{D^2+d^2}{2}}$ D = Axis of rotation	${\cdot}5236Dd^2$ D = Axis of rotation
5		$\pi^2D \,.\, d = 9{\cdot}8696D \,.\, d$	$(2{\cdot}46741D)d^2$
6		$\pi^2D \,.\, d + 2\pi ld$ $= 9{\cdot}87D \,.\, d + 6{\cdot}28ld$	${\cdot}7854d^2(3{\cdot}14159D+2l)$
7		$\pi^2 d\sqrt{\frac{T^2+C^2}{2}}$ $= 9{\cdot}87d\sqrt{\frac{T^2+C^2}{2}}$	$2{\cdot}4674d^2\sqrt{\frac{T^2+C^2}{2}}$
8		${\cdot}5236\frac{r}{h^2}\{(4h^2+r^2)^{\frac{3}{2}}-r^3\}$	$1{\cdot}5708r^2h$
9		$6{\cdot}2832r \,.\, l$ l = Length of generating line r = Radius of centre of gravity of generating line $2\pi rl$	$6{\cdot}2832r \,.\, a$ a = Area of generating figure r = Radius of centre of gravity of area $2\pi ra$

1. Sphere. 2. Sector of sphere. 3. Segment of sphere. 4. Ellipsoid. 5. Ring. 6. Link. 7. Elliptic link. 8. Paraboloid. 9. Any figure of revolution on axis.

Table of Polygons

S = Side of polygon.
R = Radius of circumscribed circle.
r = Radius of inscribed circle.
A = Angle formed by the intersection of the sides.

Name	No. of sides	A	Area = S^2 ×	S = R ×	S = *r* ×
Triangle . .	3	60°	·4330	1 732	3·4641
Pentagon . .	5	108°	1·7205	1 1755	1·4536
Hexagon . .	6	120°	2·5980	1·0000	1·1547
Octagon . .	8	135°	4·8284	·7653	0 8284
Decagon . .	10	144°	7 6942	·6180	·6498

Area of any regular polygon = Radius of inscribed circle × ½ number of sides × length of one side.

Table of Polyhedrons

Name	No. of faces	R = S ×	*r* = S ×	A = S^2 ×	C = S^3 ×
Tetrahedron .	4	·6124	·2041	1·7320	0·1178
Cube . . .	6	·8660	5 000	6 0000	1·0000
Octahedron .	8	·7071	·4082	3 4641	·4714
Dodecahedron .	12	1·4012	1 1135	20 6458	7·6631
Icosahedron .	20	9510	·7558	8 6602	2·1817

S = Length of linear edge of a side.
R = Radius of circumscribed circle.
r = Radius of inscribed circle.
A = Area of polyhedron.
C = Cube contents of polyhedron.

SECTION XI

GENERAL DATA

GREEK ALPHABET

	Small	Capital
Alpha	α	A
Beta	β	B
Gamma	γ	Γ
Delta	δ	Δ
Epsilon	ϵ	E
Zeta	ζ	Z
Eta	η	H
Theta	θ	Θ
Iota	ι	I
Kappa	κ	K
Lamda	λ	Λ
Mu	μ	M
Nu	ν	N
Xi	ξ	Ξ
Omicron	o	O
Pi	π	Π
Rho	ρ	P
Sigma	σ or s	Σ
Tau	τ	T
Upsilon	υ	Υ
Phi	ϕ	Φ
Chi	χ	X
Psi	ψ	Ψ
Omega	ω	Ω

Conversion Factors

To convert	*Into*	*Multiply by*
Atmospheres	Ft. of water at 4° C.	33·90
,,	Inches of Hg at 0° C.	29·9212
,,	Cms. of Hg at 0° C.	76·0
,,	Kg. per sq. cm.	1·033
,,	Kg. per sq. metre	1,033·276
,,	Lb. per sq. in.	14·696
,,	Lb. per sq. ft.	2,116·225
,,	Millibars	1·013
,,	Bars	1,013,250·0
Bars	Dynes per sq. cm.	1·0
B.T.U.	Calories	0·2520
,,	C.H.U.	5/9
,,	Ft.-pounds	778·3
,,	Gramme-calories	252·0
,,	Kg.-calories	·25198
,,	Pound-Centigrade units	·5556
,,	H.P. hours	$3{\cdot}929 \times 10^{-4}$
,,	Therms	10^{-5}
Calories	B.T.U.	3·969
,,	C.H.U.	2·205
Centigrade (degrees)	Fahrenheit (degrees)	$(°C \times 9/5) + 32$
Centimetres	Inches	·393700
,,	Feet	·0328083
Cheval-Vapeur	Horse Power	·9863
,,	Kilowatt	·7355
C.H.U.	B.T.U.	9/5
,,	Ft.-lb.	1,401
,,	Calories	·4536
,,	Gramme-calories	453·6
,,	H.P. hours	$7{\cdot}072 \times 10^{-4}$
Common logs	Naperian logs	2·3026
Cms. per sec.	Ft. per sec.	·0328083
Cms. of Hg.	Inches of water	5·352391
,,	Ft. of water	·0328083
,,	Lb. per sq. in.	·193368
,,	Lb. per sq. ft.	27·84507
,,	Kg. per sq. mtr.	135·951
Cubic centimetres	Cubic inches	·06102338
,,	Litres	·000999973
,,	Pints (Imperial)	·001760
,,	Pints (U.S.)	·002113
Cubic feet	Cubic inches	1,728

CONVERSION FACTORS—*continued*

To convert	*Into*	*Multiply by*
Cubic feet	Cubic yards	1/9
,,	Cubic metres	·028317017
,,	Cubic centimetres	28,317·017
,,	Gallons (Imperial)	6·229
,,	Gallons (U.S.)	7·481
,,	Litres	28·31625
Cubic inches	Cubic cms.	16·3871624
,,	Gallons (Imperial)	·003604
,,	Gallons (U.S.)	·004329
,,	Litres	·0163876
Cubic metres	Cubic feet	35·3144548
,,	Cubic inches	61,023·3753
,,	Cubic yards	1·307943
,,	Gallons (Imperial)	220·24
,,	Gallons (U.S.)	264·17
Cubic yards	Cubic feet	27
,,	Cubic metres	·76455945
Cwt.	Kilograms	50·803
,,	Pounds	112
Degrees (arc)	Radians	$\pi/180 = \cdot017453292$
Dynes	Grams	·00101972
,,	Poundals	$7{\cdot}233 \times 10^{-5}$
°Fahrenheit	°Centigrade	$(°F. - 32) \times 5/9$
Fathoms	Feet	6
,,	Metres	1·8288
Feet	Centimetres	30·48006
,,	Metres	·3048006
Feet per minute	Miles per hr.	·0113636
,,	Cms. per sec.	·508001
,,	Metres per sec.	·00508001
,,	Km. per hr.	·018288
Feet per second	Miles per hr.	·681818
,,	Cms. per sec.	30·48006
,,	Metres per sec.	·3048006
,,	Km. per hr.	1·09728220
,,	Knots	·5920858
Feet of water	Atmospheres	·02950
,,	Lb. per sq. in.	·433530
,,	Lb. per sq. ft.	62·428327
,,	Kg. per sq. m.	304·8006
,,	Inches Hg	·882671
,,	Cm. Hg	·224199
,,	Mm. Hg	22·4199

CONVERSION FACTORS—*continued*

To convert	*Into*	*Multiply by*
Foot-pounds . . .	B.T.U.	·001285
,, . . .	C.H.U.	·000714
,, . . .	Gram-calories	·324
,, . . .	Joules	1·356
,, . . .	Kg.-metres	·1384
Foot-pounds per sec. .	Horse Power	1/550 = ·001818
Foot-pounds per min. .	Horse Power	1/33,000
Force de Cheval (C.V.)	Horse Power	·9863
Gallons (Imperial). .	Cubic inches	2277·4
,, . .	Cubic feet	·1606
,, . .	Litres	4·546
,, . .	Gallons (U.S.)	1·201
Gallons (U.S.) . . .	Cubic inches	231·0
,, . . .	Cubic feet	·133680
,, . . .	Litres	3·785332
,, . . .	Gallons (Imperial)	·832680
Gallons (IMP.) water .	Lb.	10
,, .	Cubic feet	·1606
Grains	Grammes	·0647988
Grammes	Grains	15·43236
,, ...	Ounces	·0352739
,, ...	Pounds	·0022046223
,, ...	Dynes	980·665
Grammes per c.c. . .	Lb. per cu. ft.	62·42833
,, . .	Lb. per cu. in.	·03613
Grammes per cm. . .	Lb. per ft.	·06719702
,, . .	Lb. per inch	·0055914
Horse-power . . .	B.T.U. per min.	42·41
,, . . .	C.H.U. per min.	23·56
,, . . .	Ft.-lb. per min.	33,000
,, . . .	Ft.-lb. per sec.	550
,, . . .	Force de Cheval	1·013872
,, . . .	Kgm.-metres per sec.	76·04039
,, . . .	Gm.-metres per sec.	76,040·39
,, . . .	Kilowatts	·7457
Horse-power hours .	Ft.-pounds	1,980,000
,, .	B.T.U.	2,545·06
,, .	Kgm.-metres	273,745·4
Imperial gallons . .	U.S. Gallons	1·205
Inches	Centimetres	2·54000508
,, ...	Feet	·0833
,, ...	Metres	·0254000508
,, ...	Millimetres	25·4000508

CONVERSION FACTORS—*continued*

To convert	*Into*	*Multiply by*
Inches	Mils	1,000
Inches of Mercury . .	Atmospheres	·0334211
,, . .	Inches of water	13·5951
,, . .	Feet of water	1·132925
,, . .	Lb. per sq. in.	·4911570
,, . .	Lb. per sq. ft.	70·72661
,, . .	Kg. per sq. metre	345·3162
Inches of water . .	Inches of mercury	·0735559
,, . .	Cms. of mercury	·1868324
,, . .	Lb. per sq. in.	·0361275
,, . .	Lb. per sq. ft.	5·202360
,, . .	Kg. per sq. metre	25·400051
Joules	Ergs	10^7
,, ...	Foot-pounds	·7375606
,, ...	Kgm.-metres	·1019716
Kgm.-calories . . .	B.T.U.	3·9685
,, ...	Ft.-pounds	3·087·4
,, ...	Kgm.-metres	426·85
Kilograms	Pounds	2·20462234
,, ...	Ounces	35·273957
Kilogramme-metres .	Ft.-lb.	7·2329983
,, .	Calories	·00234
,, .	Ergs	9·80665 · 10^7
Kgm. per metre . .	Lb. per ft.	·6719702
Kgm. per sq. cm. . .	Lb. per sq. in.	14·2234
Kgm. per sq. metre .	Lb. per sq. in.	·00142234
,, .	Lb. per sq. ft.	·2048169
,, .	Inches of Hg	·00289590
,, .	Feet of water	·003280833
Kgm. per cu. metre .	Lb. per cu. ft.	·06242833
Kilometres	Feet	3,280·833
,, ...	Miles	·6213700
,, ...	Knots (measurement)	·539593
,, ...	Yards	1,093·611
Kilometres per hr. .	Feet per sec.	·9113426
,, .	Miles per hour	·62137
,, .	Metres per sec.	·2777
,, .	Knots	·539593
Knots	Feet per sec.	1·688944
,, ...	Miles per hr.	1·151553
,, ...	Km. per hr.	1·853249
,, ...	Metres per sec.	·514791
Lb.	Grammes	453·5924277

CONVERSION FACTORS—*continued*

To convert	*Into*	*Multiply by*
Lb.	Kilogrammes	·45359243
,,	Poundals	32·174
Lb. per sq. in.	Atmospheres	·0680457
,,	Feet of water	2·306645
,,	Inches of Hg	2·036009
,,	Mm. of Hg	51·71
,,	Kg. per sq. m.	703·06687
,,	Kg. per sq. cm.	·07030669
Lb. per sq. ft.	Inches of water	·1992220
,,	Feet of water	·0
,,	Kgm. per sq. m.	4·8824088
Lb. per cu. in.	Grammes per cu. m.	27·6797424
Lb. per cu. ft.	Kgm. per cu. m.	16·018369
Lb. per cu. yd.	Kgm. per cu. m.	·5933
Litres	Cubic inches	61·02503
,,	Cubic feet	·035315411
,,	Pints (Imperial)	1·764
,,	Gallons (Imperial)	·219975
,,	Gallons (U.S.)	·264178
Litres per Km.	Gallons (IMP.) per mile	·3544
Metres	Inches	39·37
,,	Feet	3·280833
,,	Yards	1·093611
Metres per sec.	Feet per sec.	3·280833
,,	Miles per hour	2·2369317
,,	Knots	1·9433
,,	Km. per hr.	3·6
Metres per minute	Feet per sec.	·0547
Metric H.P.	Ft.-lb. per sec.	542·5
,,	Horse-power	·9863
,,	Kilowatts	·7355
Metric tonnes	Pounds	2204·6
Miles	Knots (measurement)	·86839
,,	Kilometres	1·609347
Miles per hour	Feet per sec.	1·46666 or 22/15
,,	Feet per min.	88
,,	Knots	·8683925
,,	Metres per sec.	·4470409
,,	Km. per hour	1·609347
Millimetres	Inches	·03937
Mils	Inches	·001
,,	Millimetres	·0254

CONVERSION FACTORS—*continued*

To convert	*Into*	*Multiply by*
Mils (circular)	Sq. mils	·7854
,,	Sq. mm.	$5{\cdot}067 \times 10^{-4}$
Ounces	Grammes	28·349527
,,	Kilogrammes	·0283495
Ounces per sq. yd.	Gms. per sq. m.	33·906
Pints	Cubic inches	34·67
,,	Litres	·568
Pints of liquids	Weight in lb.	1·25 × S.G. of liquid
Pounds (see Lbs.).		
Poundals	Pounds	·0310810
,,	Dynes	13·825·561
Radians	Degrees	57·29578
Radians per sec.	Degrees per sec.	57·29578
,,	Revs. per sec.	·159155
,,	Revs. per min.	9·5493
Revs. per min.	Radians per sec.	·10472
Slugs	Pounds	32·174
Sq. centimetres	Sq. inches	·1549997
,,	Sq. feet	·00107639
,,	Circular mils	197352·0
Sq. feet	Sq. centimetres	929·03412
,,	Sq. metres	·0929034
Sq. inches	Square millimetres	645·162581
,,	Square centimetres	6·45162581
,,	Square mils	10^6
,,	Circular mils	1·273,240
Sq. Kilometres	Square miles	·3862
Sq. metres	Square feet	10·763867
,,	Square yards	1·1959853
Sq. miles	Acres	640
,,	Sq. kilometres	2·589
Sq. millimetres	Sq. inches	·00115
,,	Circular mils	1973·5
Sq. mils	Sq. millimetres	·00064516
,,	Circular mils	1·2732
Sq. yards	Sq. metres	·8361307
Tons	Pounds	2,240
,,	Kilograms	101·05
,,	Short tons	1·12
,,	Tonnes (Metric)	1·016
Tons per sq. in.	Kgm. per sq. m.	1·575
Tonnes (metric)	Tons	·9842

CONVERSION FACTORS—*continued*

To convert	*Into*	*Multiply by*
U.S. Gallons . . .	Imperial Gallons	·830
,, . . .	Litres	3·7854
	(See also under " gallons ")	
Watts	Ft.-lb. per min.	44·26
Yards	Centimetres	91·44018
,, ...	Metres	·9144018

WEIGHTS AND MEASURES

AVOIRDUPOIS WEIGHT

drachms	oz.	lb.	qr.	cwt.	tons	French grammes
1	·0625	0039	000139	·000035	·00000174	1 771846
16	1	·0625	00223	·000558	·000028	28·34954
256	16	1	0357	00893	000447	453·59
7,168	448	28	1	25	0125	12,700
28,672	1,792	112	4	1	05	50,802
573,440	35,840	2,240	80	20	1	1,016,048

TROY WEIGHT

grains	dwt.	oz.	lb.	French grammes	avoirdupois pound
1	·04167	·00208	·0001736	·0648	0 0001428
24	1	·05	004167	1·555	0 0034285
480	20	1	·0833	31 1035	0 068571
5,760	240	12	1	373 242	0 822857

Troy weight is partly obsolete, the only recognised pound being the avoirdupois pound. The dwt. is no longer used. The ounce and grain are legal for use in trade.

APOTHECARY'S WEIGHT

grain or minim.	scruple	drachm	ounce	pound
1	·05	·01667	00208	0001736
20	1	·3333	04167	·00347
60	3	1	·125	01042
480	24	8	1	·0833
5,760	288	96	12	1

LONG MEASURE

in.	ft.	yd.	fath.	poles	furl.	mile	French metres
1	·083	·02778	0139	·005	·000126	0000158	·0254
12	1	·333	·1667	0606	·00151	·0001894	·3048
36	3	1	·5	182	00454	·000568	·9144
72	6	2	1	364	0091	·001136	1·8267
198	16½	5½	2¾	1	·025	·003125	5·0291
7,920	660	220	110	40	1	·125	201·16
63,360	5,280	1,760	880	320	8	1	1609·315

SURVEYING MEASURE (Lineal)

in.	link	ft.	yd.	chain	mile	French metres
1	·126	·0833	·0278	·00126	·0000158	·0254
7·92	1	·66	·22	·01	·000125	·2012
12	1·515	1	·333	·01515	·000189	·3048
36	4·545	3	1	·04545	·000568	·9144
792	100	66	22	1	·0125	20·116
63,360	8,000	5,280	1,760	80	1	1,609·315

The statute mile is 5,280 ft, as given above, but the British nautical mile is 6,080 ft. = 5,280 × 1·515. The Admiralty knot is a rate, and not a distance, *i.e.* 1 knot = 1 nautical mile per hour = 1·853 kilometres per hour. The International nautical mile of 6,076·12 ft. = 1,852 metres, is not accepted by the British Admiralty. One degree of a great circle of the earth at the equator = 60·064 nautical miles = 69·164 statute miles, the circumference of the earth being thus 131,468,083 ft.

SQUARE MEASURE

in.	ft.	yd	perches	rood	acre	square metres
1	·00694	·000772	·0000255	·00000064	·000000159	·000641
144	1	·111	·00367	·0000918	·000023	·0929
1,296	9	1	·0331	·000826	·0002062	·8361
39,204	272¼	30¼	1	·025	·00625	25·292
1,568,160	10,890	1,210	40	1	·25	1011·72
6,272,640	43,560	4,840	160	4	1	4046·87

1 chain wide . . . = 8 acres per mile.
10 square chains . . = 1 acre.
1 hectare . . . . = 2·471143 acres.
1 square mile . . = 27,878,400 sq. ft. = 3,097,600 sq. yd. = 640 acres.
Acres = ·0015625 sq. miles.
Sq. yd. = ·000000323 sq. miles.

CUBIC MEASURE

in.	ft.	yd.	cubic metre, or stere
1	·0005787	·00002143	·000016386
1,728	1	·03704	·028315
46,656	27	1	·764513

Dry Measure

Cub. in.	Gallons	Pecks	Cub. ft.	Bushels	Cub. yd.
46,656	168·179	84·089	27	21·0223	1
2,219·35	8	4	1·28435	1	·047568
1,728	6·22884	3·1144	1	·7786	0·037037
554·838	2	1	·32109	·25	0·011892
277·42	1	·5	·16054	·125	
1	·003604	·001802	·000579		

Liquid Measure

Cub. in.	Gills	Pints	Quarts	Gallon
277·420	32	8	4	1
69·355	8	2	1	0·25
34·677	4	1	0 5	0·125
8·6693	1	0·25	0·125	0·03125
1	0·11535	0·28837	0·014419	0·003604

The standard Imperial gallon contains 10 lb., avoirdupois, of distilled water at 62° F., with the barometric height of 30 in. One Imperial gallon=277·420 cub. in. One United States gallon =231·00 cu. in.

All the old measures of capacity are now obsolete and illegal, only Imperial avoirdupois and gallon being used. These old measures were wine, ale and beer, wool, bread and flour, cheese and butter, hay and straw, coal and coke, glass.

Useful Data for Rapid Approximation

WATER

1 cub. ft. of water=62·288 lb.=·557 cwt.=·028 tons=6¼ galls.

Sea water, sp. g. 1·026; 1 cub. ft.=·0285 tons.

Head in ft. × ·4325=lb. per sq. in. (fresh water). R=2·3122.

Depth in fathoms × 2·6624=lb. per sq. in. (sea water).

Tons water × 224=gallons; 1 gallon=10 lb.

Cubic feet per min. × 9,000=gallons per 24 hours.

(Inches diam. of pipe)^2=lb. of water contained per yard.

P=Pressure in lb. per square inch.

H = Head of water in feet.

V = Theoretical velocity in feet per second

g = Force of gravity.

P = H × ·4335. H = P × 2·307.

Pressure per square foot = H 62·4.

$g = 32{\cdot}2$. $2g = 64{\cdot}4$. $\sqrt{2g} = 8{\cdot}025$.

$V = \sqrt{2gH} = 8{\cdot}025\sqrt{H}$.

$H = \frac{V^2}{2g} = {\cdot}0155V^2$. $\frac{1}{2g} = {\cdot}0155$.

1 in. water gauge = ·03604 lb. = ·57644 oz. per sq. in.

1 in. mercurial gauge = ·49116 lb. per sq. in., or approx. ½ lb.

1 atmosphere = 14·7 lb. per sq. in. = 33·99 ft. water = 29·93 in. mercury. 1 atmosphere is usually taken = 15 lb.

1 in. barom. press. = 70·727 lb. per sq. ft. = 13,325 tons per acre.

RAINFALL AND SNOW

Inches of rainfall × 100·925 = tons per acre.

,, ,, × 14·4686 = millions of galls. per sq. mile.

,, ,, × 2,323,200 = cub. ft. per sq. mile.

Weight of snow = ·433 lb. per sq. foot for each inch of depth.

SPEED

Feet per min.	× ·01136	= miles per hour.	R = 88.
,, ,,	× ·009868	= knots.	R = 101·2683.
Feet per sec.	× ·68182	= miles per hour.	R = 1·4667.
,, ,,	× ·5921	= knots.	R = 1·687805.

Note.—R = Reciprocal.

SPEED CONVERSION TABLE

Miles per hour	Knots	Feet per minute	v = ft. per second	Metres per second	Kilometre per hour	v^2
1	·869	88	1·5	·447	1·609	2·25
2	1·738	176	2·9	·894	3·219	8·41
3	2·607	264	4·4	1·341	4·828	19·36
4	3·476	352	5·9	1·788	6·437	34·81
5	4·345	440	7·3	2·235	8·047	53·29
6	5·214	528	8·8	2·682	9·656	77·44
7	6·083	616	10·3	3·129	11·26	106
8	6·952	704	11·7	3·576	12·87	137
9	7·821	792	13·2	4·023	14·48	174
10	8·690	880	14·7	4·470	16·09	216
11	9·559	968	16·1	4·917	17·70	259
12	10·428	1,056	17·6	5·364	19·31	310
13	11·297	1,144	19·1	5·812	20·92	365
14	12·166	1,232	20·5	6·258	22·53	420
15	13·035	1,320	22·0	6·706	24·14	484
16	13·904	1,408	23·5	7·153	25·75	552
17	14·773	1,496	24·9	7·600	27·36	620
18	15·642	1,584	26·4	8·047	28·97	697
19	16·511	1,672	27·9	8·494	30·58	773
20	17·380	1,760	29·3	8·941	32·19	858
21	18·249	1,848	30·8	9·388	33·80	949
22	19·118	1,936	32·3	9·835	35·40	1,043
23	19·986	2,024	33·7	10·282	37·01	1,136
24	20·855	2,112	35·2	10·729	38·62	1,239
25	21·724	2,200	36·7	11·176	40·23	1,397
26	22·593	2,288	38·1	11·623	41·84	1,452
27	23·462	2,376	39·6	12·070	43·45	1,568
28	24·331	2,464	41·1	12·517	45·06	1,689
29	25·200	2,552	42·5	12·964	46·67	1,806
30	26·069	2,640	44·0	13·411	48·28	1,936
31	26·938	2,728	45·5	13·858	49·89	2,070
32	27·807	2,816	46·9	14·305	51·50	2,200
33	28·676	2,904	48·4	14·752	53·11	2,343
34	29·545	2,992	49·9	15·199	54·72	2,490
35	30·414	3,080	51·3	15·646	56·33	2,632
36	31·283	3,168	52·8	16·093	57·94	2,788
37	32·152	3,256	54·3	16·540	59·54	2,948
38	33·021	3,344	55·7	16·987	61·15	3,102
39	33·890	3,432	57·2	17·435	62·76	3,272
40	34·759	3,520	58·7	17·882	64·37	3,446
41	35·628	3,608	60·1	18·329	65·98	3,612
42	36·497	3,696	61·6	18·776	67·59	3,795
43	37·366	3,784	63·1	19·223	69·20	3,982
44	38·235	3,872	64·5	19·670	70·81	4,160
45	39·104	3,960	66·0	20·117	72·42	4,356
46	39·973	4,048	67·5	20·564	74·03	4,556
47	40·842	4,136	68·9	21·011	75·64	4,747
48	41·711	4,224	70·4	21·458	77·25	4,956
49	42·580	4,312	71·9	21·905	78·86	5,170
50	43·449	4,400	73·3	22·352	80·47	5,373

SPEED CONVERSION TABLE—*continued*

Miles per hour	Knots	Feet per minute	V ft. per second	Metres per second	Kilometre per hour	V^2
51	44·318	4,488	74·8	22·799	82·07	5,595
52	45·187	4,576	76·3	23·246	83·68	5,821
53	46·056	4,664	77·7	23·693	85·29	6,037
54	46·925	4,752	79·2	24·140	86·90	6,273
55	47·794	4,840	80·7	24·587	88·51	6,512
56	48·663	4,928	82·1	25·034	90·12	6,740
57	49·532	5,016	83·6	25·481	91·73	6,989
58	50·401	5,104	85·1	25·928	93·33	7,242
59	51·270	5,192	86·5	26·375	94·95	7,484
60	52·139	5,280	88·0	26·822	96·56	7,744
61	53·008	5,368	89·5	27·269	98·17	8,010
62	53·877	5,456	90·9	27·716	99·78	8,263
63	54·746	5,544	92·4	28·163	101·39	8,537
64	55·615	5,632	93·9	28·610	103·00	8,817
65	56·484	5,720	95·3	29·057	104·61	9,082
66	57·353	5,808	96·8	29·504	106·22	9,370
67	58·222	5,896	98·3	29·951	107·82	9,662
68	59·091	5,984	99·7	30·398	109·43	9,940
69	59·959	6,072	101·2	30·845	111·04	10,241
70	60·828	6,160	102·7	31·292	112·65	10,547
71	61·697	6,248	104·1	31·739	114·26	10,836
72	62·566	6,336	105·6	32·186	115·87	11,151
73	63·435	6,424	107·1	32·633	117·48	11,470
74	64·304	6,512	108·5	33·080	119·09	11,772
75	65·173	6,600	110·0	33·527	120·70	12,100
76	66·042	6,688	111·5	33·974	122·31	12,432
77	66·911	6,776	112·9	34·421	123·92	12,746
78	67·780	6,864	114·4	34·868	125·53	13,087
79	68·649	6,952	115·9	35·315	127·14	13,433
80	69·518	7,040	117·3	35·762	128·75	13,759
81	70·387	7,128	118·8	36·209	130·35	14,113
82	71·256	7,216	120·3	36·656	131·96	14,472
83	72·125	7,304	121·7	37·103	133·57	14,811
84	72·994	7,392	123·2	37·550	135·18	15,178
85	73·863	7,480	124·7	37·997	136·79	15,550
86	74·732	7,568	126·1	38·444	138·40	15,901
87	75·601	7,656	127·6	38·891	140·01	16,282
88	76·470	7,744	129·1	39·340	141·62	16,667
89	77·339	7,832	130·5	39·785	143·23	17,030
90	78·208	7,920	132·0	40·232	144·84	17,424
91	79·077	8,008	133·5	40·679	146·45	17,822
92	79·946	8,096	134·9	41·126	148·06	18,198
93	80·815	8,184	136·4	41·573	149·67	18,604
94	81·684	8,272	137·9	42·020	151·28	19,016
95	82·553	8,360	139·3	42·467	152·88	19,404
96	83·422	8,448	140·8	42·914	154·49	19,824
97	84·291	8,536	142·3	43·361	156·10	20,249
98	85·160	8,624	143·7	43·808	157·71	20,649
99	86·029	8,712	145·2	44·255	159·32	21,083
100	86·898	8,800	146·7	44·702	160·93	21,520

SPEED CONVERSION TABLE (METRICAL)

V = kilometres per hour	Miles per hour	Metres per second	V^2	V = kilometres per hour	Miles per hour	Metres per second	V^2
1	·621	·278	1	41	25·476	11·389	1,681
2	1·242	·556	4	42	26·097	11·667	1,764
3	1·864	·833	9	43	26·719	11·944	1,849
4	2·485	1·111	16	44	27·340	12·222	1,936
5	3·107	1·389	25	45	27·962	12·500	2,025
6	3·728	1·667	36	46	28·583	12·778	2,116
7	4·350	1·944	49	47	29·204	13·056	2,209
8	4·970	2·222	64	48	29·826	13·333	2,304
9	5·592	2·500	81	49	30·45	13·611	2,401
10	6·214	2·778	100	50	31·07	13·889	2,500
11	6·835	3·056	121	51	31·69	14·17	2,601
12	7·456	3·333	144	52	32·31	14·44	2,704
13	8·077	3·611	169	53	32·93	14·72	2,809
14	8·699	3·889	196	54	33·55	15·00	2,916
15	9·320	4·167	225	55	34·17	15·28	3,025
16	9·942	4·444	256	56	34·80	15·55	3,136
17	10·563	4·722	289	57	35·42	15·83	3,249
18	11·185	5·000	324	58	36·04	16·11	3,364
19	11·806	5·278	361	59	36·66	16·39	3,481
20	12·427	5·556	400	60	37·28	16·67	3,600
21	13·049	5·833	441	61	37·90	16·94	3,721
22	13·670	6·111	484	62	38·52	17·22	3,844
23	14·291	6·389	529	63	39·15	17·50	3,969
24	14·913	6·667	576	64	39·77	17·78	4,096
25	15·534	6·944	625	65	40·39	18·05	4,225
26	16·156	7·222	676	66	41·01	18·33	4,356
27	16·777	7·500	729	67	41·63	18·61	4,489
28	17·398	7·778	784	68	42·25	18·89	4,624
29	18·020	8·056	841	69	42·87	19·16	4,761
30	18·641	8·333	900	70	43·49	19·44	4,900
31	19·262	8·611	961	71	44·12	19·72	5,041
32	19·884	8·889	1,024	72	44·74	20·00	5,184
33	20·505	9·167	1,089	73	45·36	20·28	5,329
34	21·127	9·444	1,156	74	45·98	20·56	5,476
35	21·748	9·722	1,225	75	46·60	20·83	5,625
36	22·369	10·000	1,296	76	47·22	21·11	5,776
37	22·991	10·278	1,369	77	47·84	21·39	5,929
38	23·612	10·556	1,444	78	48·47	21·66	6,084
39	24·233	10·834	1,521	79	49·09	21·94	6,241
40	24·855	11·111	1,600	80	49·71	22·22	6,400

SPEED CONVERSION TABLES (METRICAL)—*continued*

V = kilometres per hour	Miles per hour	Metres per second	V^2	V = kilometres per hour	Miles per hour	Metres per second	V^2
81	50·33	22·50	6,561	116	72·08	32·22	13,456
82	50·95	22·78	6,724	117	72·70	32·50	13,689
83	51·57	23·05	6,889	118	73·32	32·78	13,924
84	52·19	23·33	7,056	119	73·94	33·05	14,161
85	52·81	23·61	7,225	120	74·56	33·33	14,400
86	53·43	23·89	7,396	121	75·18	33·61	14,641
87	54·06	24·17	7,569	122	75·81	33·89	14,884
88	54·68	24·44	7,744	123	76·43	34·17	15,129
89	55·30	24·72	7,921	124	77·05	34·44	15,376
90	55·92	25·00	8,100	125	77·67	34·72	15,625
91	56·54	25·27	8,281	126	78·29	35·00	15,876
92	57·17	25·56	8,464	127	78·91	35·28	16,129
93	57·79	25·83	8,649	128	79·54	35·56	16,384
94	58·41	26·11	8,836	129	80·16	35·83	16,641
95	59·03	26·39	9,025	130	80·78	36·11	16,900
96	59·65	26·67	9,216	131	81·40	36·39	17,161
97	60·27	26·94	9,409	132	82·02	36·67	17,424
98	60·89	27·22	9,604	133	82·64	36·94	17,689
99	61·52	27·50	9,801	134	83·26	37·22	17,956
100	62·14	27·78	10,000	135	83·88	37·50	18,225
101	62·76	28·05	10,201	136	84·51	37·78	18,406
102	63·38	28·33	10,404	137	85·13	38·06	18,769
103	64·00	28·61	10,609	138	85·75	38·33	19,044
104	64·62	28·88	10,816	139	86·37	38·61	19,321
105	65·24	29·17	11,025	140	86·99	38·89	19,600
106	65·87	29·44	11,236	141	87·61	39·17	19,881
107	66·49	29·72	11,449	142	88·23	39·44	20,164
108	67·11	30·00	11,664	143	88·86	39·72	20,449
109	67·72	30·28	11,881	144	89·48	40·00	20,736
110	68·35	30·56	12,100	145	90·10	40·28	21,025
111	68·97	30·83	12,321	146	90·72	40·55	21,316
112	69·59	31·11	12,544	147	91·34	40·83	21,609
113	70·21	31·39	12,769	148	91·96	41·11	21,904
114	70·84	31·67	12,996	149	92·58	41·39	22,201
115	71·46	31·94	13,225	150	93·21	41·67	22,500

Inches and 16ths converted into Millimetres

In.	0	1	2	3	4	5	6	7	8	9	10	11	In.
	—	25·400	50·799	76·199	101·60	127·00	152·40	177·80	203·20	228·60	254·00	279·39	
$\frac{1}{16}$	1·5875	26·987	52·387	77·786	103·19	128·59	153·98	179·38	204·78	230·18	255·58	280·98	$\frac{1}{16}$
$\frac{1}{8}$	3·1749	28·574	53·974	79·374	104·77	130·17	155·57	180·97	206·37	231·77	257·17	282·57	$\frac{1}{8}$
$\frac{3}{16}$	4·7624	30·162	55·561	80·961	106·36	131·76	157·16	182·56	207·96	233·36	258·76	284·16	$\frac{3}{16}$
$\frac{1}{4}$	6·3499	31·749	57·149	82·549	107·95	133·35	158·75	184·15	209·55	234·95	260·35	285·74	$\frac{1}{4}$
$\frac{5}{16}$	7·9374	33·337	58·736	84·136	109·54	134·94	160·33	185·73	211·13	236·53	261·93	287·33	$\frac{5}{16}$
$\frac{3}{8}$	9·5248	34·924	60·324	85·723	111·12	136·52	161·92	187·32	212·72	238·12	263·52	288·92	$\frac{3}{8}$
$\frac{7}{16}$	11·112	36·512	61·911	87·311	112·71	138·11	163·51	188·91	214·31	239·71	265·11	290·51	$\frac{7}{16}$
$\frac{1}{2}$	12·700	38·099	63·499	88·898	114·30	139·70	165·10	190·50	215·90	241·30	266·70	292·09	$\frac{1}{2}$
$\frac{9}{16}$	14·287	39·687	65·086	90·486	115·89	141·28	166·68	192·08	217·48	242·88	268·28	293·68	$\frac{9}{16}$
$\frac{5}{8}$	15·875	41·274	66·674	92·073	117·47	142·87	168·27	193·67	219·07	244·47	269·87	295·27	$\frac{5}{8}$
$\frac{11}{16}$	17·462	42·862	68·261	93·661	119·06	144·46	169·86	195·26	220·66	246·06	271·46	296·86	$\frac{11}{16}$
$\frac{3}{4}$	19·050	44·449	69·849	95·248	120·65	146·05	171·45	196·85	222·25	247·65	273·05	298·44	$\frac{3}{4}$
$\frac{13}{16}$	20·637	46·037	71·436	96·836	122·24	147·63	173·03	198·43	223·83	249·23	274·63	300·03	$\frac{13}{16}$
$\frac{7}{8}$	22·225	47·624	73·024	98·423	123·82	149·22	174·62	200·02	225·42	250·82	276·22	301·62	$\frac{7}{8}$
$\frac{15}{16}$	23·812	49·212	74·611	100·01	125·41	150·81	176·21	201·61	227·01	252·41	277·81	303·21	$\frac{15}{16}$
	0	1	2	3	4	5	6	7	8	9	10	11	

For metres move the decimal point *three* figures forward.

Example.—$8\frac{3}{16}$ = 207·96 millimetres, = 20·796 centimetres, = 2·0796 decimetres, = ·20796 metre.

SQUARE INCHES EQUIVALENT TO SQUARE FEET

Square feet	0	1	2	3	4	5	6	7	8	9	Square feet
0	—	144	288	432	576	720	864	1,008	1,152	1,296	0
10	1,440	1,584	1,728	1,872	2,016	2,160	2,304	2,448	2,592	2,736	10
20	2,880	3,024	3,168	3,312	3,456	3,600	3,744	3,888	4,032	4,176	20
30	4,320	4,464	4,608	4,752	4,896	5,040	5,184	5,328	5,472	5,616	30
40	5,760	5,904	6,048	6,192	6,336	6,480	6,624	6,768	6,912	7,056	40
50	7,200	7,344	7,488	7,632	7,776	7,920	8,064	8,208	8,352	8,496	50
60	8,640	8,784	8,928	9,072	9,216	9,360	9,504	9,648	9,792	9,936	60
70	10,080	10,224	10,368	10,512	10,656	10,800	10,944	11,088	11,232	11,376	70
80	11,520	11,664	11,808	11,952	12,096	12,240	12,384	12,528	12,672	12,816	80
90	12,960	13,104	13,248	13,392	13,536	13,680	13,824	13,968	14,112	14,256	90
	0	1	2	3	4	5	6	7	8	9	

SQUARE FEET EQUIVALENT TO SQUARE INCHES

Square inches	0	10	20	30	40	50	60	70	80	90	Square inches
0	—	·0694	·1389	·2083	·2778	·3472	·4167	·4861	·5556	·6250	0
100	·6944	·7639	·8333	·9028	·9722	1·042	1·111	1·181	1·250	1·319	100
200	1·389	1·458	1·528	1·597	1·667	1·736	1·806	1·875	1·944	2·014	200
300	2·083	2·153	2·222	2·292	2·361	2·431	2·500	2·569	2·639	2·708	300
400	2·778	2·847	2·917	2·986	3·056	3·125	3·194	3·264	3·333	3·403	400
500	3·472	3·542	3·611	3·681	3·750	3·819	3·889	3·958	4·028	4·097	500
600	4·167	4·236	4·306	4·375	4·444	4·514	4·583	4·653	4·722	4·792	600
700	4·861	4·931	5·000	5·069	5·139	5·208	5·278	5·347	5·417	5·486	700
800	5·556	5·625	5·694	5·764	5·833	5·903	5·972	6·042	6·111	6·181	800
900	6·250	6·319	6·389	6·458	6·528	6·597	6·667	6·736	6·806	6·875	900
	0	10	20	30	40	50	60	70	80	90	

Cubic Inches equivalent to Cubic Feet

Cubic feet	0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Cubic feet
0	—	172·8	345·6	518·4	691·2	864·0	1,307	1,210	1,382	1,555	0
1	1,728	1,901	2,074	2,246	2,419	2,592	2,765	2,938	3,110	3,283	1
2	3,456	3,629	3,802	3,974	4,147	4,320	4,493	4,666	4,838	5,011	2
3	5,184	5,357	5,530	5,702	5,875	6,048	6,221	6,394	6,566	6,739	3
4	6,912	7,085	7,258	7,430	7,603	7,776	7,949	8,122	8,294	8,467	4
5	8,640	8,813	8,986	9,158	9,331	9,504	9,677	9,850	10,022	10,195	5
6	10,368	10,541	10,714	10,886	11,059	11,232	11,405	11,578	11,750	11,923	6
7	12,096	12,269	12,442	12,614	12,787	12,960	13,133	13,306	13,478	13,651	7
8	13,824	13,997	14,170	14,342	14,515	14,688	14,861	15,034	15,206	15,379	8
9	15,552	15,725	15,898	16,070	16,243	16,416	16,589	16,762	16,934	17,107	9
	0	·1	·2	·3	·4	·5	·6	·7	·8	·9	

Cubic Feet equivalent to Cubic Inches

Cubic inches	0	100	200	300	400	500	600	700	800	900	Cubic inches
0	—	·0579	·1157	·1736	·2315	·2894	·3472	·4051	·4630	·5208	0
1,000	·5787	·6366	·6944	·7523	·8102	·8681	·9259	·9838	1·042	1·100	1,000
2,000	1·157	1·215	1·273	1·331	1·389	1·447	1·505	1·563	1·620	1·678	2,000
3,000	1·736	1·794	1·852	1·910	1·968	2·025	2·083	2·141	2·199	2·257	3,000
4,000	2·315	2·373	2·431	2·488	2·546	2·604	2·662	2·720	2·778	2·836	4,000
5,000	2·894	2·951	3·009	3·067	3·125	3·183	3·241	3·299	3·356	3·414	5,000
6,000	3·472	3·530	3·588	3·646	3·704	3·762	3·819	3·877	3·935	3·993	6,000
7,000	4·051	4·109	4·167	4·225	4·282	4·340	4·398	4·456	4·514	4·572	7,000
8,000	4·630	4·688	4·745	4·803	4·861	4·919	4·977	5·035	5·093	5·150	8,000
9,000	5·208	5·266	5·324	5·382	5·440	5·498	5·556	5·613	5·671	5·729	9,000
	0	100	200	300	400	500	600	700	800	900	

TABLE OF CUBIC FEET EQUIVALENT TO IMPERIAL GALLONS

Gallons	0	1	2	3	4	5	6	7	8	9	Gallons
0	—	·16046	·32092	·48138	·64184	·80230	·96276	1·12322	1·28368	1·44414	0
10	1·60460	1·76505	1·92551	2·08597	2·24643	2·40689	2·56735	2·72781	2·88827	3·04873	10
20	3·20919	3·36965	3·53011	3·69057	3·85103	4·01149	4·17195	4·33241	4·49287	4·65333	20
30	4·81379	4·97424	5·13470	5·29516	5·45562	5·61608	5·77654	5·93700	6·09746	6·25792	30
40	6·41838	6·57884	6·73930	6·89976	7·06022	7·22068	7·38114	7·54160	7·70206	7·86252	40
50	8·02298	8·18343	8·34389	8·50435	8·66481	8·82527	8·98573	9·14619	9·30665	9·46711	50
60	9·62757	9·78803	9·94849	10·10895	10·26941	10·42987	10·59033	10·75079	10·91125	11·07171	60
70	11·23216	11·39262	11·55308	11·71354	11·87400	12·03446	12·19492	12·35538	12·51584	12·67630	70
80	12·83676	12·90722	13·15768	13·31814	13·47860	13·63906	13·79952	13·95998	14·12044	14·28090	80
90	14·44136	14·60181	14·76227	14·92273	15·08319	15·24365	15·40411	15·56457	15·72503	15·88549	90
	0	1	2	3	4	5	6	7	8	9	

Note.—Calculated at 62·321 lb. per cubic foot (Sale of Gas Act, 1859).

TABLE OF TONS PER SQUARE INCH EQUIVALENT TO KILOG. PER SQUARE MM.

Kilog. per sq. mm.	0	1	2	3	4	5	6	7	8	9	Kilog. per sq. mm.
	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	
0	—	0·634	1·269	1·904	2·539	3·174	3·809	4·444	5·079	5·714	0
10	6·349	6·984	7·619	8·254	8·889	9·524	10·159	10·293	11·428	12·063	10
20	12·698	13·333	13·968	14·603	15·238	15·873	16·508	17·143	17·778	18·423	20
30	19·048	19·683	20·318	20·953	21·587	22·222	22·857	23·492	24·127	24·762	30
40	25·397	26·032	26·667	27·302	27·937	28·572	29·207	29·842	30·477	37·112	40
50	31·747	32·381	33·016	33·651	34·286	34·921	35·556	36·191	36·826	37·461	50
60	38·096	38·731	39·366	40·001	40·636	41·271	41·906	42·540	43·175	48·810	60
70	44·445	45·080	45·715	46·350	46·985	47·620	48·235	48·890	49·525	50·160	70
80	50·795	51·430	52·065	52·700	53·334	53·969	54·604	55·239	55·874	56·509	80
90	57·144	57·779	58·414	59·049	59·684	60·819	60·954	61·589	62·224	62·859	90
	0	1	2	3	4	5	6	7	8	9	

TABLE OF KILOGRAMS PER SQUARE MM. EQUIVALENT TO TONS PER SQUARE INCH

Tons per sq. in.	0	1	2	3	4	5	6	7	8	9	Tons per sq. in.
	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	Kilog. per sq. mm.	
0	—	1·574	3·149	4·724	6·299	7·874	9·449	11·024	12·599	14·174	0
10	15·749	17·324	18·899	20·474	22·049	23·623	25·198	26·773	28·348	29·923	10
20	31·498	33·073	34·648	36·223	37·798	39·373	40·948	42·523	44·098	45·672	20
30	47·247	48·822	50·397	51·972	53·547	55·122	56·697	58·272	59·847	61·422	30
40	62·997	64·572	66·147	67·721	69·296	70·871	72·446	74·021	75·596	77·171	40
50	78·746	80·321	81·896	83·471	85·046	86·621	88·196	89·771	91·345	92·920	50
60	94·495	96·070	97·645	99·220	100·795	102·370	103·945	105·520	107·095	108·670	60
70	110·245	111·820	113·394	114·969	116·544	118·119	119·694	121·269	122·844	124·419	70
80	125·994	127·569	129·144	130·719	132·294	133·869	135·443	137·018	138·593	140·168	80
90	141·473	143·318	144·893	146·468	148·043	149·618	151·193	152·768	154·343	155·918	90
	0	1	2	3	4	5	6	7	8	9	

Table of Tons Equivalent to lb. (Avoirdupois)

Lb.	0	1	2	3	4	5	6	7	8	9	Lb.
0	—	·000446	·000893	·001339	·001786	·002232	·002679	·003125	·003571	·004018	0
10	·004464	·004911	·005357	·005804	·006250	·006696	·007143	·007589	·008036	·008482	10
20	·008929	·009375	·009821	·010268	·010714	·011161	·011607	·012054	·012500	·012946	20
30	·013393	·013839	·014286	·014732	·015179	·015625	·016071	·016581	·016964	·017411	30
40	·017857	·018304	·018750	·109196	·019643	·020089	·020536	·020982	·021429	·021875	40
50	·022321	·022768	·023214	·023661	·024107	·024554	·025000	·025446	·025893	·026339	50
60	·026786	·027232	·027679	·028125	·028571	·029018	·029464	·029911	·030357	·030804	60
70	·031250	·031696	·032143	·032589	·033036	·033482	·033929	·034375	·034821	·035268	70
80	·035714	·036161	·036607	·037054	·037500	·037946	·038393	·038839	·039286	·039732	80
90	·040179	·040625	·041071	·041518	·041964	·042411	·042857	·043304	·043750	·044196	90

Table of Pounds (Avoirdupois) Equivalent to Tons

Tons	0	1	2	3	4	5	6	7	8	9	Tons
0	—	2,240	4,480	6,720	8,960	11,200	13,440	15,680	17,920	20,160	0
10	22,400	24,640	26,880	29,120	31,360	33,600	35,840	38,080	40,320	42,560	10
20	44,800	47,040	49,280	51,520	53,760	56,000	58,240	60,480	62,720	64,960	20
30	67,200	69,440	71,680	73,920	76,160	78,400	80,640	82,880	85,120	87,360	30
40	89,600	91,840	94,080	96,320	98,560	100,800	103,040	105,280	107,520	109,760	40
50	112,000	114,240	116,480	118,720	120,960	123,200	125,440	127,680	129,920	132,160	50
60	134,400	136,640	138,880	141,120	143,360	145,600	147,840	150,080	152,320	154,560	60
70	156,800	159,040	161,280	163,520	165,760	168,000	170,240	172,480	174,720	176,960	70
80	179,200	181,440	183,680	185,920	188,160	190,400	192,640	194,880	197,120	199,360	80
90	201,600	203,840	206,080	208,320	210,560	212,800	215,040	217,280	219,520	221,760	90

Decimal Equivalents of Inches, Feet and Yards

Fractions of an inch	Decimals of an inch	$\frac{1}{32}$nds		Decimals of an inch
	·0625	1	=	·03125
$\frac{1}{8}$	·125	3	=	·09375
	·1875	5	=	·15625
$\frac{1}{4}$	·25	7	=	·21875
	·3125	9	=	·28125
$\frac{3}{8}$	·375	11	=	·34375
	·4375	13	=	·40625
$\frac{1}{2}$	·5	15	=	·46875
	·5625	17	=	·53125
$\frac{5}{8}$	·625	19	=	·59375
	·6875	21	=	·65625
$\frac{3}{4}$	·75	23	=	·71875
	·8125	25	=	·71825
$\frac{7}{8}$	·875	27	=	·84375
	·9375	29	=	·90625
1 inch	1·00	31	=	·96875

Inches		Feet		Yards
1	=	·0833	=	·0278
2	=	·1667	=	·0556
3	=	·25	=	·0833
4	=	·3333	=	·1111
5	=	·4167	=	·1389
6	=	·5	=	·1667
7	=	·5833	=	·1944
8	=	·6667	=	·2222
9	=	·75	=	·25
10	=	·8333	=	·2778
11	=	·9167	=	·3056
12	=	1·000	=	·3333

Decimal Equivalents of the Divisions of a Foot

For divisions in 32nds, see next page.

	0	1	2	3	4	5	6	7	8	9	10	11	
		·08333	·16666	·25	·33333	·41666	·5	·58333	·66666	·75	·83333	·91666	
$\frac{1}{16}$	·00521	·08854	·17187	·25521	·33854	·42187	·50521	·58854	·67187	·75521	·83854	·92187	$\frac{1}{16}$
$\frac{1}{8}$	·01041	·09374	·17707	·26041	·34374	·42707	·51041	·59374	·67707	·76041	·84374	·92707	$\frac{1}{8}$
$\frac{3}{16}$	·01562	·09895	·18228	·26562	·34895	·43228	·51562	·59895	·68228	·76562	·84895	·93228	$\frac{3}{16}$
$\frac{1}{4}$	·02083	·10416	·18750	·27083	·35416	·43750	·52083	·60416	·68750	·77083	·84516	·93750	$\frac{1}{4}$
$\frac{5}{16}$	·02604	·10937	·19270	·27604	·35937	·44270	·52604	·60937	·69270	·77604	·85937	·94270	$\frac{5}{16}$
$\frac{3}{8}$	·03125	·11458	·19791	·28125	·36458	·44791	·53125	·61458	·69791	·78125	·86458	·94791	$\frac{3}{8}$
$\frac{7}{16}$	·03646	·11979	·20312	·28646	·36979	·45312	·53646	·61979	·70312	·78646	·86979	·95312	$\frac{7}{16}$
$\frac{1}{2}$	·04166	·12500	·20832	·29166	·37500	·45833	·54166	·62500	·70832	·79166	·87500	·95833	$\frac{1}{2}$
$\frac{9}{16}$	·04687	·13020	·21353	·29687	·38020	·46353	·54687	·63020	·71353	·79687	·88020	·96353	$\frac{9}{16}$
$\frac{5}{8}$	·05208	·13541	·21874	·30208	·38541	·46875	·55208	·63541	·71874	·80208	·88541	·96875	$\frac{5}{8}$
$\frac{11}{16}$	·05729	·14062	·22395	·30729	·39026	·47395	·55729	·64062	·72395	·80729	·89062	·97395	$\frac{11}{16}$
$\frac{3}{4}$	·06250	·14583	·22916	·31250	·39583	·47916	·56250	·64583	·72916	·81250	·89583	·97916	$\frac{3}{4}$
$\frac{13}{16}$	·06771	·15104	·23437	·31771	·40104	·48437	·56771	·65104	·73437	·81771	·90104	·98437	$\frac{13}{16}$
$\frac{7}{8}$	·07292	·15625	·23958	·32292	·40625	·48958	·57292	·65625	·73958	·82292	·90625	·98958	$\frac{7}{8}$
$\frac{15}{16}$	·07813	·16146	·24479	·32813	·41146	·49479	·57813	·66146	·74479	·82813	·91146	·99479	$\frac{15}{16}$
	0	1	2	3	4	5	6	7	8	9	10	11	

Decimal Equivalents of the Divisions of a Foot in 32nds of an Inch

(For the divisions in 16ths, see preceding page)

	Inches 0	Inches 1	Inches 2	Inches 3	Inches 4	Inches 5	Inches 6	Inches 7	Inches 8	Inches 9	Inches 10	Inches 11	
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	
1/32	·00260	·08594	·16927	·25260	·33594	·41927	50260	·58594	·66927	·75260	·83594	·91927	1/32
3/32	·00781	·09114	·17448	·25781	·34114	·42448	·50781	·59114	·67448	·75781	·84114	·92448	3/32
5/32	·01302	·09635	·17969	·26302	·34635	·42969	·51302	59635	·67969	·76302	·84635	·92969	5/32
7/32	·01823	·10156	·18489	·26823	·35156	·43489	·51823	·60156	·68489	·76823	·85156	·93489	7/32
9/32	·02344	·10677	·19010	·27344	·35677	·44010	·52344	·60677	·69010	·77344	·85677	·94010	9/32
11/32	·02864	·11198	·19531	·27864	·36198	·44531	·52864	·61198	·69531	·77864	·86198	·94531	11/32
13/32	·03385	·11719	·20052	·28385	·36719	·45052	·53385	·61719	·70052	·78385	·86719	·95052	13/32
15/32	·03906	·12239	·20573	·28906	·37239	·45573	·53906	·62239	·70573	·78906	·87239	·95573	15/32
17/32	·04427	·12760	·21094	·29427	·37760	·46094	·54427	62760	·71094	·79427	·87760	·96094	17/32
19/32	·04948	·13281	·21614	29948	·38281	·46614	·54948	·63281	·71614	·79948	·88281	·96614	19/32
21/32	·05469	·13802	·22135	·30469	·38802	·47135	·55469	·63802	·72135	·80469	·88802	·97135	21/32
23/32	·05989	·14323	·22656	·30989	·39323	·47656	·55989	·64323	·72656	·80989	·89323	·97656	23/32
25/32	·06510	·14844	·23177	·31510	·39844	·48177	·56510	·64844	·73177	·81510	·89844	·98177	25/32
27/32	·07031	·15364	·23698	·32031	·40364	·48698	·57031	·65364	·73698	·82031	·90364	·98698	27/32
29/32	·07552	·15885	·24219	·32552	·40885	·49219	·57552	·65885	·74219	·82552	·90885	·99219	29/32
31/32	·08073	·16406	·24739	·33073	·41406	·49739	·58073	·66406	·74739	·83073	·91406	·99739	31/32
	0	1	2	3	4	5	6	7	8	9	10	11	

Decimal Equivalents of a Degree

Min.	0″	10″	20″	30″	40″	50″	Min.
0	·00000	·00278	·00556	·00833	·01111	·01389	0
1	·01667	·01944	·02222	·025	·02778	·03055	1
2	·03333	·03611	·03888	·04166	·04444	·04722	2
3	·05	·05278	·05555	·05833	·06111	·06388	3
4	·06667	·06944	·07222	·075	·07777	·08055	4
5	·08333	·08611	·08888	·09166	·09444	·09722	5
6	·1	·10277	·10555	·10833	·11111	·11388	6
7	·11667	·11944	·12222	·125	·12777	·13055	7
8	·13333	·13611	·13888	·14166	·14444	·14722	8
9	·15	·15277	·15555	·15833	·16111	·16388	9
10	·16666	·16944	·17222	·175	·17777	·18055	10
11	·18333	·18611	·18888	·19166	·19444	·19722	11
12	·2	·20277	·20555	·20833	·21111	·21388	12
13	·21666	·21944	·22222	·225	·22777	·23055	13
14	·23333	·23611	·23888	·24166	·24444	·24722	14
15	·25	·25277	·25555	·25833	·26111	·26388	15
16	·26666	·26944	·27222	·275	·27777	·28055	16
17	·28333	·28611	·28888	·29166	·29444	·29722	17
18	·3	·30277	·30555	·30833	·31111	·31388	18
19	·31666	·31944	·32222	·325	·32777	·33055	19
20	·33333	·33611	·33888	·34166	·34444	·34722	20
21	·35	·35277	·35555	·35833	·36111	·36388	21
22	·36666	·36944	·37222	·375	·37777	·38055	22
23	·38333	·38611	·38888	·39166	·39444	·39722	23
24	·4	·40278	·40555	·40833	·41111	·41388	24
25	·41666	·41944	·42222	·425	·42777	·43055	25
26	·43333	·43611	·43888	·44166	·44444	·44722	26
27	·45	·45278	·45555	·45833	·46111	·46388	27
28	·46666	·46944	·47222	·475	·47777	·48055	28
29	·48333	·48611	·48888	·49166	·49444	·49722	29
30	·5	·50277	·50555	·50833	·51111	·51388	30
31	·51666	·51944	·52222	·525	·52777	·53055	31
32	·53333	·53611	·53888	·54166	·54444	·54722	32
33	·55	·55278	·55555	·55833	·56111	·56388	33
34	·56666	·56944	·57222	·575	·57777	·58055	34
35	·58333	·58611	·58888	·59166	·59444	·59722	35
Min.	0″	10″	20″	30″	40″	50″	Min.

DECIMAL EQUIVALENTS OF A DEGREE—*continued*

Min.	0″	10″	20″	30″	40″	50″	Min.
36	·6	·60277	·60555	·60833	·61111	·61388	36
37	·61666	·61944	·62222	·625	·62777	·63055	37
38	·63333	·63611	·63888	·64166	·64444	·64722	38
39	·65	·65277	·65555	·65833	·66111	·66388	39
40	·66666	·66944	·67222	·675	·67777	·68055	40
41	·68333	·68611	·68888	·69166	·69444	·69722	41
42	·7	·70277	·70555	·70833	·71111	·71388	42
43	·71666	·71944	·72222	·725	·72777	·73055	43
44	·73333	·73611	·73888	·74166	·74444	·74722	44
45	·75	·75277	·75555	·75833	·76111	·76388	45
46	·76666	·76944	·77222	·775	·77777	·78055	46
47	·78333	·78611	·78888	·79166	·79444	·79722	47
48	·8	·80277	·80555	·80333	·81111	·81388	48
49	·81666	·81944	·82222	·825	·82777	·83055	49
50	·83333	·83611	·83888	·84166	·84444	·84722	50
51	·85	·85277	·85555	·85833	·86111	·86388	51
52	·86666	·86944	·87222	·875	·87777	·88055	52
53	·88333	·88611	·88888	·89166	·89444	·89722	53
54	·9	·90277	·90555	·90833	·91111	·91388	54
55	·91666	·91944	·92222	·925	·92777	·93055	55
56	·93333	·93611	·93888	·94166	·94444	·94722	56
57	·95	·95277	·95555	·95833	·96111	·96388	57
58	·96666	·96944	·97222	·975	·97777	·98055	58
59	·98333	·98611	·98888	·99166	·99444	·99722	59
Min.	0″	10″	20″	30″	40″	50″	Min.

APPROXIMATION ("TRIAL AND ERROR") FOR ANY POWER ABOVE THE SQUARE

N = the number out of which the root is to be extracted.

n = the nearest root first taken.

r = Index of the root required.

R = Root required.

$$R = n\frac{N(r+1)+n^r(r-1)}{N(r-1)+n^r(r+1)}.$$

The process is to be repeated, taking the results of the first approximation for the second trial, etc.

Decimal Equivalents of Lb., Qr. and Cwt.

qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.
0	0½	·0045	1	0	·25	2	0	·5	3	0	·75
0	1	·0089	1	1	·2589	2	1	·5089	3	1	·7589
0	2	·0179	1	2	·2679	2	2	·5179	3	2	·7679
0	3	·0268	1	3	·2768	2	3	·5268	3	3	·7768
0	4	·0357	1	4	·2857	2	4	·5357	3	4	·7857
0	5	·0446	1	5	·2946	2	5	·5446	3	5	·7946
0	6	·0536	1	6	·3036	2	6	·5536	3	6	·8036
0	7	·0625	1	7	·3125	2	7	·5625	3	7	·8125
0	8	·0714	1	8	·3214	2	8	·5714	3	8	·8214
0	9	·0804	1	9	·3303	2	9	·5803	3	9	·8303
0	10	·0893	1	10	·3393	2	10	·5893	3	10	·8393
0	11	·0982	1	11	·3482	2	11	·5982	3	11	·8482
0	12	·1071	1	12	·3571	2	12	·6071	3	12	·8571
0	13	·1161	1	13	·3661	2	13	·6161	3	13	·8661
0	14	·125	1	14	·375	2	14	·625	3	14	·875
0	15	·1339	1	15	·3839	2	15	·6339	3	15	·8839
0	16	·1429	1	16	·3929	2	16	·6429	3	16	·8929
0	17	·1518	1	17	·4018	2	17	·6518	3	17	·9018
0	18	·1607	1	18	·4107	2	18	·6607	3	18	·9107
0	19	·1696	1	19	·4196	2	19	·6696	3	19	·9196
0	20	·1786	1	20	·4286	2	20	·6786	3	20	·9286
0	21	·1875	1	21	·4375	2	21	·6875	3	21	·9375
0	22	·1964	1	22	·4464	2	22	·6964	3	22	·9464
0	23	·2054	1	23	·4554	2	23	·7054	3	23	·9554
0	24	·2143	1	24	·4643	2	24	·7143	3	24	·9643
0	25	·2232	1	25	·4732	2	25	·7232	3	25	·9732
0	26	·2321	1	26	·4822	2	26	·7322	3	26	·9822
0	27	·2411	1	27	·4911	2	27	·7411	3	27	·9911

Decimal Equivalents of Pounds and Ounces

oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.
¼	·015625	3	·1875	6½	·40625	10	·625	13½	·84375
½	·03125	3½	·21875	7	·4375	10½	·65625	14	·875
¾	·046875	4	·25	7½	·46875	11	·6875	14½	·90625
1	·0625	4½	·28125	8	·5	11½	·71875	15	·9375
1½	·09375	5	·3125	8½	·53125	12	·75	15½	·96875
2	·125	5½	·34375	9	·5625	12½	·78125	16	1·0
2½	·15625	6	·375	9½	·59375	13	·8125		

SCREWS

Angle of thread = 55°.

$\frac{1}{6}$ of depth is rounded off at top and bottom.

Number of threads to the inch in square threads = $\frac{1}{2}$ number of those in angular threads.

Depth of threads = ·64 pitch for angular, = ·475 pitch for square threads.

WHITWORTH'S STANDARD NUTS AND BOLT-HEADS

Diam. of bolt, inches	Width across flats	Thickness of nuts	Thickness of bolt-heads	Diam. of bolt at bottom of thread	Diam. of bolt, inches	Width across flats	Thickness of nuts	Thickness of bolt-heads	Diam. of bolt at bottom of thread
$\frac{1}{8}$	338	$\frac{1}{8}$	·1093	·0929	$1\frac{1}{8}$	1·8605	$1\frac{1}{8}$	·9843	·942
$\frac{3}{16}$	·448	$\frac{3}{16}$	·1640	·1341	$1\frac{1}{4}$	2·0483	$1\frac{1}{4}$	1·0937	1·067
$\frac{1}{4}$	·525	$\frac{1}{4}$	·2187	·1859	$1\frac{3}{8}$	2·2146	$1\frac{3}{8}$	1·2031	1·1615
$\frac{5}{16}$	·6014	$\frac{5}{16}$	·2734	·2413	$1\frac{1}{2}$	2·4134	$1\frac{1}{2}$	1·3125	1·2865
$\frac{3}{8}$	7094	$\frac{3}{8}$	·3281	·2949	$1\frac{5}{8}$	2·5763	$1\frac{5}{8}$	1·4218	1·3688
$\frac{7}{16}$	·8204	$\frac{7}{16}$	·3828	·346	$1\frac{3}{4}$	2·7578	$1\frac{3}{4}$	1·5312	1·4938
$\frac{1}{2}$	·9191	$\frac{1}{2}$	·4375	·3932	$1\frac{7}{8}$	3·0183	$1\frac{7}{8}$	1·6406	1·5904
$\frac{9}{16}$	1·011	$\frac{9}{16}$	·4921	·4557	2	3·1491	2	1·75	1·7154
$\frac{5}{8}$	1·101	$\frac{5}{8}$	·5468	·5085	$2\frac{1}{8}$	3·337	$2\frac{1}{8}$	1·8593	1·8404
$\frac{11}{16}$	1·201	$\frac{11}{16}$	·6015	·571	$2\frac{1}{4}$	3·546	$2\frac{1}{4}$	1·9687	1·9298
$\frac{3}{4}$	1·3012	$\frac{3}{4}$	·6562	·6219	$2\frac{3}{8}$	3·75	$2\frac{3}{8}$	2·0781	2·0548
$\frac{13}{16}$	1·39	$\frac{13}{16}$	·7109	·6844	$2\frac{1}{2}$	3·894	$2\frac{1}{2}$	2·1875	2·1798
$\frac{7}{8}$	1·4788	$\frac{7}{8}$	·7656	·7327	$2\frac{5}{8}$	4·049	$2\frac{5}{8}$	2·2968	2·3048
$\frac{15}{16}$	1·5745	$\frac{15}{16}$	·8203	·7952	$2\frac{3}{4}$	4·181	$2\frac{3}{4}$	2·4062	2·384
1	1·6701	1	·875	·8399	3	4·531	3	2·625	2·634

The threads of the American Standard Screw are in the form of an equilateral triangle of which $\frac{1}{8}$th of the depth is wanting both at top and bottom.

The depth of the thread d 64,952 pitch.

Diam. of thread outside D

inside D 1·299 pitch.

British Standard Whitworth Screw Threads

Dimensions in inches

Full diam.		No. of threads per in.	Depth of thread	Effective diam.	Core diam.	Cross section area of core sq. in.
Frac.	Dec.					
1/4	·25	20	·03200	·2180	·1860	·0272
5/16	·3125	18	·03555	·2769	·2414	·0458
3/8	·375	16	·04000	·3350	·2950	·0683
7/16	·4375	14	·04575	·3918	·3460	·0940
1/2	·500	12	·05335	·4466	·3933	·1215
9/16	·5625	12	·05335	·5091	·4558	·1632
5/8	·625	11	·05820	·5668	·5086	·2032
11/16	·6875	11	·05820	·6293	·5711	·2562
3/4	·750	10	·06405	·6860	·6219	·3038
13/16	·8125	10	·06405	·7485	·6844	·3679
7/8	·875	9	·07115	·8039	·7327	·4216
15/16	·9375	9	·07115	·8664	·7952	·4966
1	1·000	8	·08005	·9200	·8399	·5540
1 1/8	1·125	7	·09150	1·0335	·9420	·6969
1 1/4	1·250	7	·09150	1·1585	1·0670	·8942
1 3/8	1·375	6	·10670	1·2683	1·1616	1·0597
1 1/2	1·500	6	·10670	1·3933	1·2866	1·3001
1 5/8	1·625	5	·12805	1·4969	1·3689	1·4718
1 3/4	1·750	5	·12805	1·6219	1·4939	1·7528
1 7/8	1·875	4·5	·14230	1·7327	1·5904	1·9866
2	2·000	4·5	·14230	1·8577	1·7154	2·3111
2 1/8	2·125	4·5	·14230	1·9827	1·8404	2·6602
2 1/4	2·250	4	·16010	2·0899	1·9298	2·9249
2 3/8	2·375	4	·16010	2·2149	2·0548	3·3161
2 1/2	2·500	4	·16010	2·3399	2·1798	3·7318
2 5/8	2·625	4	·16010	2·4649	2·3048	4·1721
2 3/4	2·75	3·5	·18295	2·5670	2·3841	4·4641
3	3·000	3·5	·18295	2·8170	2·6341	5·4496
3 1/4	3·25	3·25	·19700	3·0530	2·8560	6·4063
3 1/2	3·5	3·25	·19700	3·3030	3·1060	7·5769
3 3/4	3·75	3	·21345	3·5366	3·3231	8·6732
4	4·00	3	·21345	3·7866	3·5731	10·0272
4 1/2	4·50	2·875	·22270	4·2773	4·0546	12·9118
5	5·00	2·75	·23285	4·7672	4·5343	16·1477
5 1/2	5·50	2·625	·24395	5·2561	5·0121	19·7301
6	6·00	2·5	·25615	5·7439	5·4877	23·6521

British Association Screw Threads (B.A.)

No.	Diameter mm.	Diameter in.	Pitch mm.	Pitch in.	Depth thread mm.	Effect, diam. mm.	Core diam. mm.	Cross section at bottom of thread, sq. mm.
0	6·0	·236	1 0	·0394	·6	5 4	4·8	18·10
1	5·3	·209	·9	·0354	·54	4·76	4·22	13·99
2	4·7	·185	·81	·0319	·485	4·215	3·73	10·93
3	4·1	·161	·73	·0287	·44	3·66	3·22	8·14
4	3·6	·142	·66	·0260	·395	3·205	2·81	6·20
5	3·2	·126	·59	·0232	·355	2·845	2·49	4·87
6	2·8	·110	53	·0209	·32	2·48	2·16	3·66
7	2·5	·098	48	·0189	·29	2·21	1·92	2·89
8	2·2	·087	·43	·0169	·26	1·94	1·68	2·22
9	1·9	·075	·39	·0154	·235	1·665	1·43	1·61
10	1·7	·067	·35	·0138	·21	1 49	1·28	1·29
11	1·5	·059	·31	·0122	·185	1·315	1·13	1·00
12	1·3	·051	·28	·0110	·17	1·13	·96	·72
13	1·2	·047	·25	·0098	·15	1·05	·9	·64
14	1·0	·039	·23	·0091	·14	·86	·72	·41
15	·9	·035	·21	·0083	·125	·775	·65	·33
16	·79	·031	·19	·0075	·115	·675	·56	·25
17	·70	·028	·17	·0067	·10	·6	·50	·20
18	·62	·024	·15	·0059	·09	·53	·44	·15
19	·54	·021	·14	·0055	·085	·455	·37	·11
20	·48	·019	·12	·0047	·07	·41	·34	·091
21	·42	·017	·11	·0043	·065	·355	·29	·066
22	·37	·015	·10	·0039	06	·31	·25	·049
23	·33	·013	·09	·0035	·055	·275	·22	·038
24	·29	·011	·08	·0031	·05	·24	·19	·028
25	·25	·010	·07	·0028	·04	·21	·17	·023

British Standard Fine Screw Threads

Full diam. From	Full diam. To	Threads per in.	Pitch	Depth of thread	Full diam From	Full diam To	Threads per in.	Pitch	Depth of thread
1/4	9/32	26	·03846	·02465	1 1/8	1 1/4	9	·11111	·07115
5/16		22	·04545	·02910	1 3/8	1	8	·12500	·08005
3/8		20	·05000	·03200	1 3/4	2 1/8	7	·14286	·09150
7/16		18	·05556	·03555	2 1/4	2 7/8	6	·16667	·10670
1/2	9/16	16	·06250	·04000	3	3 3/8	5	·20000	·12805
5/8	11/16	14	·07143	·04575	3 1/2	4 3/8	4·5	·22222	·14230
3/4	13/16	12	·08333	·05335	4 1/2	5 3/8	4	·25000	·16010
7/8	15/16	11	·09091	·05820	5 1/2	6	3·5	·28571	·18295
1		10	·10000	·06405					

British Standard Pipe Threads

Dimensions in inches

Nominal bore of tube	App. outside dia. of tube	Outside dia. of thread	Depth of thread	Core diameter	No. of threads per inch
$\frac{1}{8}$	$\frac{13}{32}$	·383	·0230	·337	28
$\frac{1}{4}$	$\frac{17}{32}$	·518	·0335	·451	19
$\frac{3}{8}$	$\frac{11}{16}$	·656	·0335	·589	19
$\frac{1}{2}$	$\frac{27}{32}$	·825	·0455	·734	14
$\frac{5}{8}$	$\frac{15}{16}$	·902	·0455	·811	14
$\frac{3}{4}$	$1\frac{1}{16}$	1·041	·0455	·950	14
$\frac{7}{8}$	$1\frac{7}{32}$	1·189	·0455	1·098	14
1	$1\frac{11}{32}$	1·309	·0580	1·193	11
$1\frac{1}{4}$	$1\frac{11}{16}$	1·650	·0580	1·534	11
$1\frac{1}{2}$	$1\frac{29}{32}$	1·882	·0580	1·766	11
$1\frac{3}{4}$	$2\frac{5}{32}$	2·116	·0580	2·000	11
2	$2\frac{3}{8}$	2·347	·0580	2·231	11
$2\frac{1}{4}$	$2\frac{5}{8}$	2·587	·0580	2·471	11
$2\frac{1}{2}$	3	·2960	·0580	2·844	11
$2\frac{3}{4}$	$3\frac{1}{4}$	3·210	·0580	3·094	11
3	$3\frac{1}{2}$	3·460	·0580	3·344	11
$3\frac{1}{4}$	$3\frac{3}{4}$	3·700	·0580	3·584	11
$3\frac{1}{2}$	4	3·950	·0580	3·834	11
$3\frac{3}{4}$	$4\frac{1}{4}$	4·200	·0580	4·084	11
4	$4\frac{1}{2}$	4·450	·0580	4·334	11
$4\frac{1}{2}$	5	4·950	·0580	4·834	11
5	$5\frac{1}{2}$	5·450	·0580	5·334	11
$5\frac{1}{2}$	6	5·950	·0580	5·834	11
6	$6\frac{1}{2}$	6·450	·0580	6·334	11
7	$7\frac{1}{2}$	7·450	·0640	7·322	10
8	$8\frac{1}{2}$	8·450	·0640	8·322	10
9	$9\frac{1}{2}$	9·450	·0640	9·322	10
10	$10\frac{1}{2}$	10·450	·0640	10·322	10
11	$11\frac{1}{2}$	11·450	·0800	11·290	8
12	$12\frac{1}{2}$	12·450	·0800	12·290	8
13	$13\frac{3}{4}$	13·680	·0800	13·520	8
14	$14\frac{3}{4}$	14·680	·0800	14·520	8
15	$15\frac{3}{4}$	15·680	·0800	15·520	8
16	$16\frac{3}{4}$	16·680	·0800	16·520	8
17	$17\frac{3}{4}$	17·680	·0800	17·520	8
18	$18\frac{3}{4}$	18·680	·0800	18·520	8

Angle of thread 55°. Threads rounded at crests and roots leaving depth of thread 0·64 pitch app. Taper screws coned $\frac{1}{16}$ inch (measured on diameter) per inch length.

Wire and Plate Gauges

Equivalents in decimals of an inch

No.	Standard wire	Birmingham plate	Lancashire	Whitworth	French wire, ordinary		French wire, galvanized	
	in.	in	in		in	mm	in	mm.
7/0	0 500						-	-
6/0	0 464					-	—	-
5/0	0 432							—
4/0	0·400	-					—	-
3/0	0 372				-		-	—
2/0	0 348				—	—		- -
0	0 324	—			01535	·39	—	—
1	0·300	·004	227	001	01772	·45	02362	·6
2	0 276	·005	219	002	02205	56	02756	·7
3	0 252	008	209	·003	02638	67	·03150	8
4	0 232	010	204	004	03110	79	03543	·9
5	0 212	·012	·201	005	03543	·90	·03937	1·0
6	0 192	013	198	006	03976	1 01	·04331	1 1
7	0 176	015	195	007	04410	1·12	·04724	1·2
8	0 160	016	192	008	04882	1 24	·05118	1 3
9	0 144	·019	·191	·009	05315	1 35	·05512	1 4
10	0 128	·024	190	·010	·05748	1 46	·05906	1 5
11	0 116	029	189	011	06614	1 68	06299	1 6
12	0 104	034	·185	012	07087	1·80	·07037	1 8
13	0·092	·036	·180	·013	07520	1·91	·07874	2·0
14	0 080	·041	·177	014	07953	2 02	·08662	2·2
15	0 072	047	175	015	·08425	2 14	·09410	2 4
16	0 064	051	·174	016	08858	2·25	·10630	2 7
17	0 056	057	·169	·017	·11181	2·84	·11811	3 0
18	0 048	·061	·167	·018	·13386	3·40	·13386	3 4
19	0·040	·064	·164	019	15551	3·95	·15355	3 9
20	0 036	·067	160	·020	·17717	4 50	·17323	4·4
21	0 032	072	157	·021	20079	5 10	·19292	4·9
22	0 028	·074	152	022	22244	5 65	·21260	5·4
23	0·024	077	150	023	24410	6 20	·23229	5·9
24	0 022	082	148	024	26772	6 80	—	—
25	0 020	·095	146	025				
26	0 018	·103	·143	026				
27	0 0164	·113	141	027				
28	0·0148	120	138	028				
29	0 0136	·124	·134	029				
30	0 0124	·126	·125	·030				
31	0 0116	·133	·118	031				
32	0 0108	·143	115	032				
33	0 0100	·145	111	·033				
34	0 0092	·148	·109	034				
35	0 0084	158	·107	035				
36	0 0076	167	·105	036				

S. W. G.—*continued*

No.	S. W. G.	No.	S. W. G.
	in.		in.
37	0·0068	44	0·0032
38	0 0060	45	0 0028
39	0 0052	46	0·0024
40	0 0048	47	0·0020
41	0 0044	48	0 0016
42	0·0040	49	0·0012
43	0·0036	50	0 0010

Wood Screw Gauges Compared

(Guest, Keen, and Nettlefold)

Gauge No.	British		American		French		German	
	in.	mm.	in.	mm.	mm.	in.	mm.	in.
0000	0·054	1·37	—	—	1¼	0·049	1·3	0·051
000	·057	1·15	—	—	1½	·059	1·5	·059
00	·060	1·52	—	—	1¾	·069	1·8	·071
0	·063	1·60	0·060	1·52	2	·079	2·1	·083
1	·066	1·68	·073	1·85	2¼	·088		
2	·080	2·03	·086	2·18	2½	·098	2·4	·095
3	·094	2·39	·099	2·51	2¾	·108	2·7	·106
4	·108	2·74	·112	2·84	3	·118	3	·118
5	·122	3·10	·125	3·17	3½	·138	3·5	·138
6	·136	3·45	·138	3·50	4	·157	4	·157
7	·150	3·81	·151	3·83	4½	·177	4·5	·177
8	·164	4·16	·164	4·16	5	·197	5	·197
9	·178	4·52	·177	4·49	5½	·216	5·5	·216
10	·192	4·88	·190	4·83	6	·236	6	·236
11	·206	5·23	·203	5·16	6½	·256	6·5	·256
12	·220	5·59	·216	5·50	7	·276	7	·276
13	·234	5·94	—	—	8	·315	8	·315
14	·248	6·30	·242	6·15	9	·354	9	·354
15	·262	6·65	—		10	·394	10	·394
16	·276	7·00	·268	6·80	11	·433	—	—
17	·290	7·36	—	—	12	472	—	—
18	·304	7·72	·294	7·48				
20	·332	8·43	·320	8·13				
22	·360	9·14	—	—				
24	·388	9·85	·372	9·45				
26	·416	10·57						
28	·444	11·29						
30	·472	12·00						
32	·560	12·70						
34	·528	13·40						
36	·556	14·10						
38	·584	14·80						
40	·612	15·50						
50	·752	19·10						

Intermediate British sizes are not normally made and there is a tendency to restrict sizes generally. There was a tendency before the war to bring French sizes into line with the German. Switzerland adopts American sizes for export and German sizes for home consumption.

Birmingham Gauge (B.G.). For Sheets and Hoops

Legalised by Board of Trade, Nov. 1st, 1914

No.	Equivalent in inches	No.	Equivalent in inches	No.	Equivalent in inches	No.	Equivalent in inches
15/0	1·0000	3	0·2804	20	0·0392	37	0·0054
14/0	0·9583	4	0·250	21	0·0349	38	0·0048
13/0	0·9167	5	0·2225	22	0·03125	39	0·0043
12/0	0·8750	6	0·1981	23	0·02782	40	0·00386
11/0	0·8333	7	0·1764	24	0·02476	41	0·00343
10/0	0·7917	8	0·1570	25	0·02204	42	0·00306
9/0	0·750	9	0·1398	26	0·01961	43	0·00272
8/0	0·7083	10	0·1250	27	0·01745	44	0·00242
7/0	0·6666	11	0·1113	28	0·015625	45	0·00215
6/0	0·625	12	0·0991	29	0·0139	46	0·00192
5/0	0·5883	13	0·0882	30	0·0123	47	0·00170
4/0	0·5416	14	0·0785	31	0·0110	48	0·00152
3/0	0·500	15	0·0699	32	0·0098	49	0·00135
2/0	0·4452	16	0·0625	33	0·0087	50	0·00120
1/0	0·3964	17	0·0556	34	0·0077	51	0·00107
1	0·3532	18	0·0495	35	0·0069	52	0·00095
2	0·3147	19	0·0440	36	0·0061		

Notes on Wire and Plate Gauges

In the United Kingdom the only legal gauges in common use are the Standard Wire Gauge (S.W.G.) and the Birmingham Gauge for sheets and hoops (B.G.).

Imperial Standard Wire Gauge

Areas and circumferences of wire in inches

S.W.G.	Area	Circum-ference	S.W.G.	Area	Circum-ference
7/0	1963495	1 570796	23	0004524	·075398
6/0	1690931	1 457699	24	·0003801	·069115
5/0	1465741	1·357168	25	0003142	·062832
4/0	·1256637	1·256637	26	0002545	·056549
3/0	1086865	1 168672	27	·0002112	·051522
2/0	0951149	1 093274	28	·0001720	·046496
0	·0824479	1 017876	29	·0001453	·042726
1	·0706858	·942478	30	0001208	038956
2	·0598285	·867080	31	0001057	·036442
3	·0498759	·791681	32	00009161	033929
4	·0422733	728850	33	00007854	·031416
5	0352989	666018	34	00006648	·028903
6	·0289529	·603186	35	00005542	·026389
7	·0243285	·552920	36	·00004536	·023876
8	·0201062	·502655	37	·00003632	·021363
9	·0162860	·452389	38	00002827	·018850
10	0128680	·402124	39	·00002124	·016336
11	·0105683	·364425	40	·00001810	·015080
12	·0084949	·326726	41	·00001521	·013823
13	·0066476	289027	42	·00001257	·012566
14	0050265	·251327	43	00001018	·011310
15	0040715	·226195	44	·00000804	·010053
16	·0032170	·201062	45	00000616	·008796
17	·0024630	175929	46	·00000452	·007540
18	0018096	·150796	47	00000314	·006283
19	0012566	·125664	48	·00000201	·005027
20	·0010179	113097	49	·00000113	·003770
21	·0008042	·100531	50	00000079	·003142
22	·0006158	087965			

The Imperial Standard Wire Gauge came into operation March 1st, 1884, and is the only legal standard wire gauge for the United Kingdom.

American B. and S. and B.W.G. (Stubs)

Wire gauges in inches

No.	B and S.	B.W.G.	No.	B and S.	B.W.G.	No.	B. and S.	B.W.G.	No.	B. and S.	B.W.G.
4/0	4600	454	7	·1443	·180	17	·0453	·058	27	·0142	·016
3/0	·4096	·425	8	·1285	·165	18	·0403	·049	28	·0126	·014
2/0	·3648	·380	9	·1144	·148	19	·0359	·042	29	·0113	·013
0	·3249	·340	10	·1019	·134	20	·0320	·035	30	·0100	·012
1	·2893	·300	11	·0907	·120	21	·0285	·032	31	·0089	·010
2	·2576	·284	12	·0808	·109	22	·0253	·028	32	·0080	·009
3	·2294	·259	13	·0720	·095	23	·0226	·025	33	·0071	·008
4	·2043	·238	14	·0641	·083	24	·0201	·022	34	·0063	·007
5	·1819	·220	15	·0571	·072	25	·0179	·020	35	·0056	·005
6	·1620	·203	16	·0508	·065	26	·0159	·018	36	·0050	·004

LENGTH OF THE CIRCULAR ARC SUBTENDED BY ANY ANGLE.

I.e. Radians per degree of angle

Degrees					
°	Arc		Arc	°	Arc
1	0174533	31	·5410521	61	1·0646508
2	·0349066	32	·5585054	62	1·0821041
3	0523599	33	·5759587	63	1·0995574
4	0698132	34	·5934119	64	1·1170107
5	·0872665	35	·6108652	65	1·1344640
6	1047198	36	·6283185	66	1·1519173
7	·1221730	37	·6457718	67	1·1693706
8	·1396263	38	·6632251	68	1·1868239
9	·1570796	39	·6806784	69	1·2042772
10	·1745329	40	·6981317	70	1·2217305
11	·1919862	41	·7155850	71	1·2391828
12	2094395	42	·7330383	72	1·2566371
13	2268928	43	·7504916	73	1·2740904
14	2443461	44	·7679449	74	1·2915436
15	2617994	45	·7853982	75	1·3089969
16	2792527	46	·8028515	76	1·3264502
17	2967060	47	·8203047	77	1·3439035
18	·3141593	48	·8377580	78	1·3613568
19	·3316126	49	·8552113	79	1·3788101
20	·3490659	50	·8726646	80	1·3962634
21	·3665191	51	·8901179	81	1·4137167
22	·3839724	52	·9075712	82	1·4311700
23	·4014257	53	·9250245	83	1·4486233
24	·4188790	54	·9424778	84	1·4660766
25	·4363323	55	·9599311	85	1·4835299
26	·4537856	56	·9773844	86	1·5009832
27	·4712389	57	·9948377	87	1·5184364
28	·4886922	58	1·0122910	88	1·5358897
29	·5061455	59	1·0297443	89	1·5533430
30	·5235988	60	1·0471976	90	1·5707963

Length of the Circular Arc—*continued*

Minutes						Seconds					
′	·00	′	·0	′	·0	″	·000	″	·000	″	·000
1	02909	21	061087	41	119264	1	0048	21	1018	41	1988
2	05818	22	063955	42	122173	2	0097	22	1067	42	2036
3	08727	23	066904	43	125082	3	0145	23	1115	43	2085
4	11636	24	069813	44	127991	4	0194	24	1164	44	2133
5	14544	25	072722	45	130900	5	0242	25	1212	45	2182
6	17453	26	075631	46	133809	6	0291	26	1261	46	2230
7	20362	27	078540	47	136717	7	0339	27	1309	47	2279
8	23271	28	081449	48	139626	8	0388	28	1357	48	2327
9	26180	29	084358	49	142535	9	0436	29	1406	49	2376
10	29089	30	087266	50	145444	10	0485	30	1454	50	2424
11	31998	31	090175	51	148353	11	0533	31	1503	51	2473
12	34907	32	093084	52	151262	12	0582	32	1551	52	2521
13	37815	33	095993	53	154171	13	0630	33	1599	53	2570
14	40724	34	098902	54	157080	14	0679	34	1648	54	2618
15	43633	35	101811	55	159989	15	0727	35	1697	55	2666
16	46542	36	104720	56	162897	16	0776	36	1745	56	2715
17	49451	37	107629	57	165806	17	0824	37	1794	57	2763
18	52360	38	110538	58	168715	18	0873	38	1842	58	2812
19	55269	39	113446	59	171624	19	0921	39	1891	59	2860
20	58178	40	116355	60	174533	20	0970	40	1939	60	2909

Length of Circular Arcs

Versin./Chord	0	·01	·02	·03	·04	·05	·06	·07	·08	·09
	·000	·000	·00	·00	·00	·00	·0	·0	·0	0
0	0	267	11	24	43	67	096	130	170	215
·001	003	323	12	26	43	69	099	134	174	219
·002	011	384	13	27	47	72	102	138	178	224
·003	024	451	14	29	49	75	106	142	183	229
·004	043	523	15	31	52	78	109	145	187	234
·005	067	600	17	33	54	80	112	149	192	239
·006	096	683	18	35	56	83	116	153	196	244
·007	131	771	19	36	59	86	119	157	201	249
·008	171	864	21	38	61	89	123	161	205	254
·009	216	963	22	41	64	93	126	166	210	259

Approximate Rule for Length of Arc L

C = Chord of Arc; c = Chord of ½ Arc.

$L = \frac{1}{3}(8c - C)$.

LENGTH OF CIRCULAR ARCS

Table of difference between the chord and the arc: chord being =1·00. To find the length of any arc, divide the versed sine by the chord, and find the tabular No. (diff.) due to the result; then Length of arc = chord × (1 + diff.).

Vers./Chord	·001	·001	·002	·003	·004	·005	·006	·007	·008	·009
	diff.	diff.	diff.	diff.	diff.	diff.	diff.	diff.	diff.	diff.
·100	·0265	·0270	·0275	·0281	·0286	·0291	·0297	·0303	·0308	·0314
·110	·0320	·0325	·0331	·0337	·0343	·0349	·0355	·0361	·0367	·0373
·120	·0380	·0386	·0392	·0399	·0405	·0412	·0418	·0425	·0431	·0438
·130	·0445	·0451	·0458	·0465	·0472	·0479	·0486	·0493	·0500	·0507
·140	·0515	·0522	·0530	·0537	·0544	·0552	·0559	·0567	·0574	·0582
·150	·0590	·0597	·0605	·0613	·0621	·0629	·0637	·0645	·0653	·0661
·160	·0669	·0677	·0686	·0694	·0702	·0711	·0719	·0728	·0736	·0745
·170	·0754	·0762	·0771	·0780	·0789	·0798	·0807	·0816	·0825	·0834
·180	·0843	·0852	·0861	·0870	·0880	·0889	·0898	·0908	·0917	·0927
·190	·0936	·0946	·0956	·0965	·0975	·0985	·0995	·1005	·1015	·1025
·200	·1035	·1045	·1055	·1065	·1075	·1085	·1096	·1106	·1116	·1127
·210	·1137	·1148	·1158	·1169	·1180	·1190	·1201	·1212	·1222	·1233
·220	·1244	·1255	·1266	·1277	·1288	·1300	·1311	·1322	·1333	·1344
·230	·1356	·1367	·1379	·1390	·1402	·1414	·1425	·1436	·1448	·1460
·240	·1471	·1483	·1495	·1507	·1519	·1531	·1543	·1555	·1567	·1579
·250	·1591	·1603	·1616	·1628	·1640	·1653	·1665	·1677	·1690	·1702
·260	·1715	·1727	·1740	·1753	·1765	·1778	·1791	·1804	·1816	·1829
·270	·1843	·1856	·1869	·1882	·1895	·1908	·1921	·1934	·1948	·1961
·280	·1974	·1988	·2001	·2015	·2028	·2042	·2056	·2070	·2083	·2097
·290	·2111	·2124	·2138	·2152	·2166	·2179	·2193	·2206	·2220	·2235
·300	·2249	·2263	·2278	·2292	·2306	·2320	·2335	·2349	·2364	·2378
·310	·2392	·2407	·2422	·2436	·2451	·2465	·2480	·2495	·2509	·2524
·320	·2539	·2554	·2569	·2584	·2599	·2614	·2629	·2614	·2659	·2674
·330	·2689	·2704	·2720	·2735	·2750	·2766	·2781	·2796	·2812	·2827
·340	·2843	·2858	·2874	·2889	·2905	·2921	·2937	·2952	·2968	·2984
·350	·3000	·3016	·3031	·3047	·3063	·3079	·3095	·3111	·3128	·3144
·360	·3160	·3176	·3192	·3209	·3225	·3241	·3258	·3274	·3290	·3307
·370	·3323	·3340	·3356	·3373	·3390	·3406	·3423	·3440	·3456	·3473
·380	·3490	·3507	·3524	·3451	·3557	·3574	·3591	·3608	·3625	·3642
·390	·3660	·3677	·3694	·3711	·3728	·3745	·3763	·3780	·3797	·3815
·400	·3832	·3850	·3867	·3885	·3902	·3920	·3937	·3955	·3972	·3990
·410	·4008	·4025	·4043	·4061	·4079	·4097	·4114	·4132	·4510	·4168
·420	·4186	·4204	·4222	·4240	·4258	·4276	·4294	·4313	·4331	·4349
·430	·4367	·4386	·4404	·4422	·4440	·4459	·4477	·4496	·4514	·4533
·440	·4551	·4570	·4588	·4607	·4625	·4644	·4663	·4681	·4700	·4719
·450	·4738	·4756	·4775	·4794	·4813	·4832	·4851	·4870	·4889	·4908
·460	·4927	·4946	·4965	·4984	·5003	·5022	·5042	·5061	·5808	·5099
·470	·5118	·5138	·5157	·5176	·5916	·5215	·5235	·5254	·5274	·5293
·480	·5313	·5332	·5352	·5371	·5391	·5411	·5430	·5450	·5470	·5489
·490	·5509	·5529	·5548	·5568	·5588	·5608	·5628	·5648	·5668	·5688
·500	·5708	—	—	—	—	—	—	—	—	—

Areas of Small Circles

Advancing by decimals

Diam.	Areas				
	·000	·001	·002	003	·004
·000	0	·0000008	·0000031	·0000071	·0000126
·010	·0000785	·0000950	·0001131	·0001327	·0001539
·020	·0003142	·0003464	·0003801	·0004155	·0004524
·030	·0007069	·0007548	·0008043	·0008553	·0009079
·040	·0012566	·0013203	·0013854	·0014522	·0015205
·050	·0019635	·0020428	·0021237	·0022062	·0022902
·060	·0028274	·0029225	·0030191	·0031172	·0032170
·070	·0038485	·0039592	·0040715	0041854	·0043008
·080	·0050265	·0051530	·0052810	·0054106	·0055418
·090	·0063617	·0065039	·0066476	·0067929	·0069398
	005	·006	·007	·008	·009
·000	·0000196	·0000283	·0000385	0000503	·0000636
·010	·0001767	·0002016	·0002270	·0002545	·0002835
·020	·0004909	·0005309	·0005726	0006158	·0006605
·030	·0009621	·0010179	·0010752	0011341	·0011946
·040	·0015904	·0016619	·0017349	0018096	·0018857
·050	·0023758	0024630	·0025518	0026421	0027340
·060	·0033183	·0034212	·0035257	0036317	·0037393
·070	·0044179	·0045365	·0046566	·0047784	·0049017
·080	·0056745	·0058088	·0059447	·0060821	·0062211
·090	·0070882	·0072382	·0073898	·0075430	·0076977

AREAS OF SMALL CIRCLES

Diam.	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·0	·000078	·00031	·0007	·00126	·00196	·00283	00385	·00503	·00636
·1	·0079	0095	·0113	·0133	·0154	·0177	·0201	0227	·0255	·0284
·2	·0314	·03464	·038	·0415	·0452	·0491	0531	·0572	·0616	·066
·3	0707	·0755	·0804	·0855	0908	0962	·1018	·1075	·1134	·1195
·4	·1257	·132	·1385	·1452	·1521	·1590	·1662	·1735	·181	·1886
·5	·1963	·2043	·2124	·2206	·2290	·2376	2463	·2552	·2642	·2734
·6	·2827	·2922	·3019	·3117	·3217	·3318	·3421	·3526	·3632	·3739
·7	·3848	·3959	4072	4185	4301	4418	4536	4657	·4778	·4902
·8	5027	5153	·5281	5411	·5542	5674	·5809	·5945	·6082	·6221
·9	6362	6504	6648	6793	694	7088	·7238	·739	·7543	7698

AREAS OF SMALL CIRCLES

Advancing by 32nds

Diam.	Area	Diam.	Area	Diam.	Area	Diam.	Area
[illegible]	·00077	[illegible]	·0621	[illegible]	2217	[illegible]	·4794
[illegible]	·00307	[illegible]	0767	[illegible]	·2485	[illegible]	·5185
[illegible]	·00690	[illegible]	0928	[illegible]	·2769	[illegible]	·5591
[illegible]	·01227	[illegible]	·1104	[illegible]	·3068	[illegible]	·6013
[illegible]	01917	[illegible]	·1296	[illegible]	·3382	[illegible]	·6450
[illegible]	·02761	[illegible]	·1503	[illegible]	·3712	[illegible]	·6903
[illegible]	03760	[illegible]	1726	[illegible]	·4057	[illegible]	·7371
[illegible]	04909	[illegible]	1963	[illegible]	4418	1	·7854

Diameters of Circles, Circumference being Known

Diam.	Circumference ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diam.
0		·0318	·0637	·0955	·1273	·1592	·1910	·2228	·2546	·2865	0
1	·3183	·3501	·3820	·4138	·4456	·4775	·5093	·5111	·5730	·6048	1
2	·6366	·6684	·7003	·7321	·7639	·7958	·8276	·8594	·8913	·9231	2
3	·9549	·9868	1·019	1·050	1·082	1·114	1·146	1·178	1·210	1·241	3
4	1·273	1·305	1·337	1·369	1·401	1·432	1·464	1·496	1·528	1·560	4
5	1·592	1·623	1·655	1·687	1·719	1·751	1·783	1·814	1·846	1·878	5
6	1·910	1·942	1·974	2·005	2·037	2·069	2·101	2·133	2·165	2·196	6
7	2·228	2·260	2·292	2·324	2·355	2·387	2·419	2·451	2·483	2·515	7
8	2·546	2·578	2·610	2·642	2·674	2·706	2·737	2·769	2·801	2·833	8
9	2·865	2·897	2·928	2·960	2·992	3·024	3·056	3·088	3·119	3·151	9
Diam.	·0	1·	·2	·3	·4	·5	·6	·7	·8	·9	Diam.

CONTENTS OF SPHERES

Diam.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diam.
0		·0005	·0042	·0141	·0335	·0655	·1131	·1796	·2681	·3817	0
1	·5236	·6969	·9048	1·150	1·437	1·767	2·145	2·572	3·054	3·591	1
2	4·189	4·849	5·575	6·371	7·238	8·181	9·203	10·30	11·49	12·77	2
3	14·14	15·60	17·16	18·82	20·60	22·45	24·43	26·52	28·73	31·06	3
4	33·51	36·09	38·79	41·63	44·60	47·71	50·96	54·36	57·91	61·60	4
5	65·45	69·46	73·62	77·95	82·45	87·11	91·95	96·97	102·2	107·5	5
6	113·1	118·1	124·8	130·9	137·3	143·8	150·5	157·5	164·6	172·0	6
7	179·6	187·4	195·4	203·7	212·2	220·9	229·8	239·0	248·5	258·2	7
8	268·1	278·3	288·7	299·4	310·3	321·6	333·0	344·8	356·8	369·1	8
9	381·7	394·6	407·7	421·2	434·9	448·9	463·2	477·9	492·8	508·0	9
Diam.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diam.

For each decimal point added to or subtracted from the diameter, alter *three* decimal points in the tabular number.

Thus:—

	diameter	contents
	5·8	102·2
	58	102,200
	·58	·1022

COMBINED TABLE OF AREAS OF CIRCLES,

Diam.	Areas								Diam.
	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	
0	0	·0078	·0122	·0314	·0490	·0706	·1104	·1257	0
1	·7854	·9503	·9940	1·1309	1·227	1·3273	1·484	1·5393	1
2	3·142	3·4636	3·546	3·8013	3·976	4·1547	4·430	4·5239	2
3	7·069	7·5476	7·669	8·0424	8·295	8·5530	8·946	9·0792	3
4	12·57	13·2025	13·36	13·8544	14·18	14·5220	15·03	15·2053	4
5	19·64	20·4282	20·62	21·2372	21·64	22·0618	22·69	22·9022	5
6	28·27	29·2247	29·46	30·1907	30·67	31·1725	31·91	32·1699	6
7	38·48	39·5920	39·87	40·7151	41·28	41·8539	42·71	43·0085	7
8	50·27	51·5300	51·84	52·8102	53·45	54·1062	55·08	55·4178	8
9	63·62	65·0389	65·39	66·4762	67·20	67·9292	69·02	69·3979	9
10	78·539	80·1186	80·51	81·7130	82·51	83·3230	84·54	84·9488	10
11	95·03	96·7691	97·20	98·5205	99·40	100·287	101·6	102·070	11
12	113·1	114·990	115·4	116·898	117·8	118·823	120·2	120·763	12
13	132·7	134·782	135·3	136·848	137·8	138·929	140·5	141·026	13
14	153·9	156·145	156·6	158·368	159·4	160·606	162·2	162·860	14
15	176·7	179·079	179·6	181·458	182·6	183·854	185·6	186·265	15
16	201·1	203·583	204·2	206·120	207·3	208·672	210·5	211·241	16
17	227·0	229·658	230·3	232·352	233·7	235·062	237·1	237·787	17
18	254·4	257·304	258·0	260·155	261·5	263·022	265·1	265·905	18
19	283·5	286·521	287·2	289·529	291·0	292·553	294·8	295·593	19
20	314·159	317·309	318·1	320·474	322·0	323·655	326·0	326·852	20
21	346·4	349·667	350·4	352·990	354·6	356·328	358·8	359·681	21
22	380·1	383·597	384·4	387·076	388·8	390·571	393·2	394·082	22
23	415·5	419·097	420·0	422·733	424·5	426·385	429·1	430·053	23
24	452·4	456·168	457·1	459·961	461·8	463·770	466·6	467·595	24
25	490·874	494·809	495·7	498·760	500·7	502·726	505·7	506·708	25
Diam.	0	1	⅛ 125	2	¼ 25	3	⅜ 375	4	Diam.

ADVANCING BY 8THS AND 10THS

Diam.	Areas ½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.
0	·1963	·2827	·3068	·3848	·4417	·5026	·6013	·6361	0
1	1·767	2 0106	2 073	2 2698	2 405	2 5446	2·761	2 8352	1
2	4·908	5 3093	5·411	5·7255	5·939	6 1575	6·491	6·6052	2
3	9·621	10 1787	10·32	10·7521	11 04	11·3411	11·79	11·9459	3
4	15·90	16 6190	16·80	17·3494	17·72	18·0951	18·66	18·8574	4
5	23·75	24 6301	24·85	25·5176	25·96	26·4208	27·10	27·3397	5
6	33 18	34 2120	34·47	35 2566	35·78	36·3168	37·12	37 3928	6
7	44·17	45·3647	45·66	46·5663	47·17	47·7837	48·70	49·0168	7
8	56·74	58 0881	58·42	59·4469	60·13	60·8213	61·86	62·2115	8
9	70·88	72 3824	72 75	73·8982	74·66	75·4298	76 58	76·9770	9
10	86·59	88·2475	88 66	89 9204	90·76	91·6090	92·88	93·3133	10
11	103·8	105 683	106·1	107 513	108·4	109 359	110·7	111·220	11
12	122·7	124 690	125·1	126·677	127·6	128·679	130 1	130·698	12
13	143·1	145·267	145·8	147·411	148·4	149·571	151·2	151·747	13
14	165·1	167·415	167·9	169·717	170·8	172·034	173·7	174·366	14
15	188·6	191·134	191·7	193·593	194·8	196 067	197·9	198·556	15
16	213·8	216·424	217·0	219 040	220·3	221·671	223·6	224·318	16
17	240·5	243·285	243·9	246·057	247·4	248·846	250·9	251·650	17
18	268·8	271·716	272 4	274·646	276·1	277·591	279·8	280·552	18
19	298·6	301·719	302·4	304·805	306·3	307·908	310·2	311·026	19
20	330·0	333·292	334·1	336·536	338·1	339·795	342·2	343·070	20
21	363·0	366·436	367·2	369·837	371·5	373·253	375·8	376·685	21
22	397·6	401·150	402·0	404·708	406·4	408·282	410·9	411·871	22
23	433·7	437·436	438·3	441·151	443·0	444·881	447·6	448·628	23
24	471·4	475 292	476·2	479 164	481·1	483·052	485·9	486·955	24
25	510·7	514 719	515·7	518·748	520·7	522 793	525·8	526·854	25
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	9·	Diam.

COMBINED TABLE OF AREAS OF CIRCLES,

Diam.	Areas								Diam.
	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	
26	530·9	535·022	536·0	539·129	541·1	543·253	546·3	547·392	26
27	572·6	576·805	577·8	581·070	583·2	585·350	588·5	589·646	27
28	615·8	620·159	621·2	624·581	626·7	629·019	632·3	633·472	28
29	660·5	665·084	666·2	669 663	671·9	674·258	677·7	678·868	29
30	706·9	711·580	712·7	716·316	718·6	721·067	724·6	725·835	30
31	754·8	759·646	760·9	764·539	767·0	769·448	773·1	774·372	31
32	804·2	809·284	810·5	814·334	816·9	819·399	823·2	824·481	32
33	855·3	860·492	861·8	865·699	868·3	870·922	874·8	876·160	33
34	907·9	913·270	914·6	918·635	921·3	924·011	928·1	929·410	34
35	962·1	967·620	969·0	973·142	795·9	978·679	982·8	984·231	35
36	1,017·9	1,023·54	1,025·0	1,029·21	1,032·1	1,034 91	1,039·2	1,040·62	36
37	1,075·2	1,081·03	1,082·5	1,086·86	1,089·8	1,092·71	1,097·1	1,098·58	37
38	1,134·1	1,140·09	1,141·6	1,146·08	1,149·1	1,152·09	1,156·6	1,158·11	38
39	1,194·6	1,200·72	1,202·3	1,206·87	1,210·0	1,213·04	1,217·7	1,219·22	39
40	1,256·6	1,262·93	1,264·5	1,269·23	1,272·4	1,275·56	1,280·3	1,281·89	40
41	1,320·3	1,326·70	1,328·3	1,333·16	1,336·4	1,339·64	1,344·5	1,346·14	41
42	1,385·4	1,392·05	1,393·7	1,398·67	1,402·0	1,405·30	1,410·3	1,411·96	42
43	1,452·2	1,458·96	1,460·7	1,465·74	1,469·1	1,472·53	1,477·6	1,479·34	43
44	1,520·5	1,527·45	1,529·2	1,534·38	1,537·9	1,541·33	1,546·6	1,548·30	44
45	1,590·4	1,597·51	1,599·3	1,604·60	1,608·2	1,611·71	1,617·0	1,618·83	45
46	1,661·9	1,669·13	1,671·0	1,676·38	1,680·0	1,683·65	1,689·1	1,690·93	46
47	1,734·9	1,742·33	1,744·2	1,749·74	1,753·5	1,757·16	1,762·7	1,764·60	47
48	1,809·6	1,817·10	1,819·0	1,824·67	1,828·5	1,832·25	1,837·9	1,839·84	48
49	1,885·7	1,893·45	1,895·4	1,901·17	1,905·0	1,908·90	1,914·7	1,916·65	49
50	1,963·5	1,971·36	1,973·3	1,979·23	1,983·2	1,987·13	1,993·1	1,995·04	50
Diam.	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.

ADVANCING BY 8THS AND 10THS—*continued*

Diam.	Areas ½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.
26	551·5	555·717	556·7	559·903	562·0	564·105	567·2	568·323	26
27	593·9	598·286	599·3	602·629	604·8	606·988	610·8	611·363	27
28	637·9	642·425	643·5	646·926	649·1	651·442	654·8	655·973	28
29	683·4	688·136	689·2	692·793	695·1	697·466	709·9	702·155	29
30	730·6	735·417	736·6	740·231	742·6	745·061	748·6	749·907	30
31	779·3	784·268	785·5	789·240	791·7	794·227	798·0	799·230	31
32	829·6	834·691	836·0	839·820	842·4	844·964	848·8	850·124	32
33	881·4	886·685	888·0	891·970	894·6	897·272	901·3	902·589	33
34	934·8	940·249	941·6	945·692	948·4	951·150	955·3	956·625	34
35	989·8	995·384	996·8	1,000·098	1,003·8	1,006·60	1,010·8	1,012·23	35
36	1,046·4	1,052·09	1,053·5	1,057·84	1,060·7	1,063·62	1,068·0	1,069·40	36
37	1,104·5	1,110·36	1,111·8	1,116·28	1,119·2	1,122·21	1,126·7	1,128·15	37
38	1,164·2	1,170·21	1,171·7	1,176·28	1,179·3	1,182·37	1,186·9	1,188·47	38
39	1,225·4	1,231·63	1,233·2	1,237·86	1,241·0	1,244·10	1,248·8	1,250·36	39
40	1,288·3	1,294·62	1,296·2	1,301·00	1,304·2	1,307·40	1,312·2	1,313·82	40
41	1,352·7	1,359·18	1,360·8	1,365·72	1,369·0	1,372·28	1,377·2	1,378·85	41
42	1,418·6	1,425·31	1,427·0	1,432·01	1,435·4	1,438·72	1,443·8	1,445·45	42
43	1,486·2	1,493·01	1,494·7	1,499·87	1,503·3	1,506·74	1,511·9	1,513·62	43
44	1,555·3	1,562·28	1,564·0	1,569·29	1,572·8	1,576·32	1,581·6	1,583·37	44
45	1,626·0	1,633·12	1,634·9	1,640·30	1,643·9	1,647·48	1,652·9	1,654·68	45
46	1,698·2	1,705·54	1,707·4	1,712·87	1,716·5	1,720·21	1,725·7	1,727·57	46
47	1,772·1	1,779·52	1,781·4	1,787·01	1,790·8	1,794·51	1,800·1	1,802·02	47
48	1,847·5	1,855·08	1,857·0	1,862·72	1,866·6	1,870·38	1,876·1	1,878·05	48
49	1,924·4	1,932·20	1,934·2	1,940·00	1,943·9	1,947·82	1,953·7	1,955·65	49
50	2,003·0	2,010·90	2,012·9	2,018·86	2,022·8	2,026·83	2,032·8	2,034·82	50
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

COMBINED TABLE OF AREAS OF CIRCLES.

Diam.	Areas ·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.
51	2,042·8	2,050·84	2,052·9	2,058·87	2,062·9	2,066·92	2,073·0	2,074·99	51
52	2,123·7	2,131·89	2,133·9	2,140·08	2,144·2	2,148·29	2,154·5	2,156·51	52
53	2,206·2	2,214·52	2,216·6	2,222·87	2,227·1	2,231·23	2,237·5	2,239·61	53
54	2,290·2	2,298·71	2,300·8	2,307·22	2,311·5	2,315·74	2,322·1	2,324·28	54
55	2,375·8	2,384·48	2,386·0	2,393·14	2,397·5	2,401·82	2,408·3	2,410·51	55
56	2,463·0	2,471·81	2,474·0	2,480·63	2,485·1	2,489·47	2,496·1	2,498·32	56
57	2,551·8	2,560·72	2,563·0	2,569·70	2,574·2	2,578·69	2,585·5	2,587·70	57
58	2,642·1	2,651·20	2,653·5	2,660·33	2,664·9	2,669·48	2,676·4	2,678·65	58
59	2,734·0	2,743·25	2,745·6	2,752·54	2,757·2	2,761·85	2,768·8	2,771·17	59
60	2,827·4	2,836·87	2,839·2	2,846·32	2,851·1	2,855·78	2,862·9	2,865·26	60
61	2,922·5	2,932·06	2,934·5	2,941·66	2,946·5	2,951·28	2,958·5	2,960·92	61
62	3,019·1	3,028·82	3,031·3	3,038·58	3,043·5	3,048·36	3,055·7	3,058·15	62
63	3,117·3	3,127·15	3,129·6	3,137·07	3,140·2	3,147·01	3,154·5	3,156·96	63
64	3,217·0	3,227·05	3,229·6	3,237·13	3,242·2	3,247·22	3,254·8	3,257·33	64
65	3,318·3	3,328·53	3,331·1	3,338·76	3,343·9	3,349·01	3,356·7	3,359·28	65
66	3,421·2	3,431·57	3,434·2	3,441·96	3,447·2	3,452·37	3,460·2	3,462·79	66
67	3,525·7	3,536·19	3,538·8	3,546·74	3,552·0	3,557·30	3,565·2	3,567·88	67
68	3,631·7	3,642·37	3,645·1	3,653·08	3,658·4	3,663·80	3,671·9	3,674·54	68
69	3,739·3	3,750·13	3,752·8	3,760·99	3,766·4	3,771·87	3,780·0	3,782·76	69
70	3,848·5	3,859·46	3,862·2	3,870·48	3,876·0	3,881·51	3,889·8	3,892·56	70
71	3,959·2	3,970·36	3,973·2	3,981·53	3,981·1	3,992·73	4,001·1	4,003·93	71
72	4,071·5	4,082·83	4,085·7	4,094·16	4,099·8	4,105·51	4,114·0	4,116·87	72
73	4,185·4	4,196·87	4,199·7	4,208·36	4,214·1	4,219·86	4,228·5	4,231·38	73
74	4,300·9	4,312·48	4,315·4	4,324·12	4,330·0	4,335·79	4,344·6	4,347·47	74
75	4,417·9	4,429·66	4,432·6	4,441·46	4,447·4	4,453·28	4,462·2	4,465·12	75
Diam.	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.

ADVANCING BY 8THS AND 10THS – *continued*

Diam.	Areas ½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.
51	2,083·1	2,091·17	2,093·2	2,099·28	2,103·4	2,107·41	2,113·5	2,115·56	51
52	2,164·8	2,173·01	2,175·1	2,181·28	2,185·4	2,189·56	2,195·8	2,197·87	52
53	2,248·0	2,256·42	2,258·5	2,264·85	2,269·1	2,273·29	2,279·6	2,281·75	53
54	2,332·8	2,341·40	2,343·5	2,349·98	2,354·3	2,358·58	2,365·0	2,367·20	54
55	2,419·2	2,427·95	2,430·2	2,436·69	2,441·1	2,445·45	2,452·0	2,454·22	55
56	2,507·2	2,516·07	2,518·3	2,524·97	2,529·4	2,533·88	2,540·6	2,542·81	56
57	2,596·7	2,605·76	2,608·0	2,614·12	2,619·4	2,623·89	2,630·7	2,632·98	57
58	2,687·8	2,697·03	2,699·3	2,706·24	2,710·9	2,715·47	2,722·4	2,724·71	58
59	2,780·5	2,789·86	2,792·2	2,799·23	2,803·9	2,808·62	2,815·7	2,818·02	59
60	2,874·8	2,884·26	2,886·7	2,893·79	2,898·6	2,903·34	2,910·5	2,912·89	60
61	2,970·6	2,980·24	2,982·7	2,989·93	2,994·8	2,999·63	3,006·9	3,009·34	61
62	3,068·0	3,077·79	3,080·3	3,087·63	3,092·6	3,097·49	3,104·9	3,107·36	62
63	3,166·9	3,176·91	3,179·4	3,186·90	3,191·9	3,196·92	3,204·4	3,206·95	63
64	3,267·5	3,277·59	3,280·1	3,287·75	3,292·8	3,297·92	3,305·6	3,308·11	64
65	3,369·6	3,379·85	3,382·4	3,390·17	3,395·3	3,400·49	3,408·3	3,410·84	65
66	3,473·2	3,483·68	3,486·3	3,491·16	3,499·4	3,504·64	3,512·5	3,515·14	66
67	3,578·5	3,589·08	3,591·7	3,599·71	3,605·0	3,610·35	3,618·4	3,621·01	67
68	3,685·3	3,696·06	3,698·8	3,706·84	3,712·2	3,717·64	3,725·8	3,728·45	68
69	3,793·7	3,804·60	3,807·3	3,815·54	3,821·0	3,826·50	3,834·7	3,837·47	69
70	3,903·6	3,914·71	3,917·5	3,925·81	3,931·4	3,936·92	3,945·3	3,948·05	70
71	4,015·2	4,026·40	4,029·2	4,037·65	4,043·3	4,048·92	4,057·4	4,060·21	71
72	4,128·3	4,139·65	4,142·5	4,151·06	4,156·8	4,162·49	4,171·1	4,173·93	72
73	4,242·9	4,254·48	4,257·4	4,266·04	4,271·8	4,277·63	4,286·3	4,289·23	73
74	4,359·2	4,370·87	4,373·8	4,382·60	4,388·5	4,394·34	4,403·2	4,406·10	74
75	4,477·0	4,488·84	4,491·8	4,500·72	4,506·7	4,512·62	4,521·6	4,524·54	75
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

COMBINED TABLE OF AREAS OF CIRCLES,

Diam.	Areas								Diam.
	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	
76	4,536·5	4,548·41	4,551·4	4,560·37	4,566·4	4,572·35	4,581·3	4,584·35	76
77	4,656·6	4,668·73	4,671·8	4,680·85	4,686·9	4,692·99	4,702·1	4,705·14	77
78	4,778·4	4,790·63	4,793·7	4,802·90	4,809·1	4,815·20	4,824·4	4,827·50	78
79	4,901·7	4,914·09	4,917·2	4,926·53	4,932·8	4,938·98	4,948·3	4,951·44	79
80	5,026·6	5,039·13	5,042·3	5,051·72	5,058·0	5,064·32	5,073·8	5,076·95	80
81	5,153·0	5,165·74	5,168·9	5,178·48	5,184·9	5,191·25	5,200·8	5,204·02	81
82	5,281·0	5,293·91	5,297·1	5,306·82	5,313·3	5,319·74	5,329·4	5,332·67	82
83	5,410·6	5,423·66	5,426·9	5,436·72	5,443·3	5,449·80	5,459·6	5,462·89	83
84	5,541·8	5,554·98	5,558·3	5,568·20	5,574·8	5,581·43	5,591·4	5,594·68	84
85	5,674·5	5,687·87	5,691·2	5,701·25	5,707·9	5,714·64	5,724·7	5,728·04	85
86	5,808·8	5,822·33	5,825·7	5,835·86	5,842·6	5,840·91	5,859·6	5,862·97	86
87	5,944·7	5,958·36	5,961·8	5,972·05	5,978·9	5,985·76	5,996·1	5,999·48	87
88	6,082·1	6,095·96	6,099·4	6,109·81	6,116·7	6,123·67	6,134·1	6,137·55	88
89	6,221·2	6,235·14	6,238·6	6,249·14	6,256·2	6,263·16	6,273·7	6,277·19	89
90	6,361·7	6,375·88	6,379·4	6,390·04	6,397·1	6,404·22	6,414·9	6,418·41	90
91	6,503·9	6,518·19	6,521·8	6,532·51	6,539·7	6,546·85	6,557·6	6,561·20	91
92	6,647·6	6,662·08	6,665·7	6,676·55	6,683·8	6,691·05	6,701·9	6,705·55	92
93	6,792·9	6,807·54	6,811·2	6,822·17	6,829·5	6,836·82	6,847·8	6,851·48	93
94	6,939·8	6,954·56	6,958·3	6,969·35	6,976·8	6,984·16	6,995·3	6,998·98	94
95	7,088·2	7,103·16	7,106·9	7,118·11	7,125·6	7,133·07	7,144·3	7,148·05	95
96	7,238·2	7,253·33	7,257·1	7,268·43	7,276·0	7,283·55	7,294·9	7,298·69	96
97	7,389·8	7,405·07	7,408·9	7,420·33	7,428·0	7,435·60	7,447·1	7,450·90	97
98	7,543·0	7,558·38	7,562·2	7,573·80	7,581·5	7,589·23	7,600·8	7,604·68	98
99	7,697·7	7,713·26	7,717·2	7,728·38	7,736·6	7,744·42	7,756·1	7,760·03	99
100	7,853·98	7,869·71	—	7,885·44	—	7,901·19	—	7,916·95	100
Diam.	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.

ADVANCING BY 8THS AND 10THS—*continued*

Diam.	Areas								Diam.
	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	
76	4,596·4	4,608·38	4,611·4	4,620·42	4,626·4	4,632·47	4,641·5	4,644·54	76
77	4,717·3	4,729·49	4,732·5	4,741·68	4,747·8	4,753·96	4,763·1	4,766·12	77
78	4,839·8	4,852·16	4,855·3	4,864·52	4,870·7	4,876·89	4,886·2	4,889·27	78
79	4,963·9	4,976·42	4,979·5	4,988·93	4,995·2	5,001·45	5,010·9	5,014·00	79
80	5,089·6	5,102·24	5,105·4	5,114·90	5,121·2	5,127·59	5,137·1	5,140·29	80
81	5,216·8	5,229·63	5,232·8	5,242·45	5,248·9	5,255·29	5,264·9	5,268.15	81
82	5,345·6	5,358·59	5,361·8	5,371·57	5,378·1	5,384·57	5,394·3	5,397·59	82
83	5,476·0	5,489·12	5,492·4	5,502·26	5,508·8	5,515·42	5,525·3	5,528·59	83
84	5,608·0	5,621·23	5,624·6	5,634·53	5,641·2	5,647·84	5,657·8	5,661·17	84
85	5,741·5	5,754·90	5,758·3	5,768·36	5,775·1	5,781·83	5,791·9	5,795·31	85
86	5,876·6	5,890·15	5,893·6	5,903·76	5,910·6	5,917·39	5,927·6	5,931·03	86
87	6,013·2	6,026·97	6,030·4	6,040·73	6,047·6	6,054·52	6,064·9	6,068·32	87
88	6,151·4	6,165·35	6,169·8	6,179·28	6,186·3	6,193·22	6,203·7	6,207·18	88
89	6,291·3	6,305·31	6,308·8	6,319·39	6,326·4	6,333·49	6,344·1	6,347·61	89
90	6,432·6	6,446·84	6,450·4	6,461·08	6,468·2	6,475·34	6,486·0	6,489·61	90
91	6,575·6	6,589·94	6,593·5	6,604·34	6,611·5	6,618·75	6,629·6	6,633·18	91
93	6,720·1	6,734·61	6,738·3	6,749·16	6,756·5	6,763·73	6,774·7	6,778·32	92
93	6,866·2	6,880·85	6,884·5	6,895·56	6,902·9	6,910·29	6,921·3	6,925·03	93
94	7,013·8	7,028·67	7,032·4	7,043·53	7,051·0	7,058·42	7,069·6	7,073·32	94
95	7,163·0	7,178·05	7,181·8	7,193·07	7,200·6	7,208·11	7,219·4	7,223·17	95
96	7,313·8	7,329·00	7,332·8	7,344·18	7,351·8	7,359·38	7,370·8	7,374·59	96
97	7,466·2	7,481·53	7,485·4	7,496·87	7,504·5	7,512·22	7,523·8	7,257·59	97
98	7,620·1	7,635·62	7,639·5	7,651·19	7,658·9	7,666·63	7,678·3	7,682·16	98
99	7,775·7	7,791·29	7,795·2	7,806·94	7,814·8	7,822·61	7,834·4	7,838·29	99
100	—	7,948·53	—	7,964·34	—	7,980·16	—	7,996·00	100
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

Combined Table of Circumferences of Circles,

Diam.	Circumferences 0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.
0	0	·31	·3927	·62	·7854	·94	1·178	1·25	0
1	3·141	3·45	3·534	3·77	3·927	4·08	4·319	4·39	1
2	6·283	6·59	6·675	6·91	7·068	7·22	7·461	7·53	2
3	9·425	9·74	9·817	10·05	10·21	10·36	10·60	10·68	3
4	12·57	12·88	12·95	13·19	13·35	13·50	13·74	13·82	4
5	15·70	16·02	16·10	16·33	16·49	16·65	16·88	16·96	5
6	18·85	19·16	19·24	19·47	19·63	19·79	20·02	20·10	6
7	21·99	22·30	22·38	22·61	22·77	22·93	23·16	23·24	7
8	25·13	25·44	25·52	25·76	25·91	26·07	26·31	26·38	8
9	28·27	28·58	28·66	28·90	29·05	29·21	29·45	29·53	9
10	31·41	31·73	31·80	32·04	32·20	32·35	32·59	32·67	10
11	34·55	34·87	34·95	35·18	35·34	35·50	35·73	35·81	11
12	37·10	38·01	38·09	38·82	38·48	38·64	38·87	38·95	12
13	40·84	41·15	41·23	41·46	41·62	41·78	42·01	42·09	13
14	43·98	44·29	44·37	44·61	44·76	44·92	45·16	45·23	14
15	47·12	47·43	47·51	47·75	47·90	48·06	48·30	48·38	15
16	50·26	50·57	50·65	50·89	51·05	51·20	51·44	51·52	16
17	53·40	53·72	53·79	54·03	54·19	54·35	54·58	54·65	17
18	56·54	56·86	56·94	57·17	57·33	57·49	57·72	57·80	18
19	59·69	60·00	60·08	60·31	60·47	60·63	60·86	60·94	19
20	62·83	63·14	63·22	63·46	63·61	63·77	64·01	64·08	20
21	65·97	66·28	66·36	66·60	66·75	66·91	67·15	67·22	21
22	69·11	69·42	69·50	69·74	69·90	70·05	70·29	70·37	22
23	72·25	72·57	72·64	72·88	73·04	73·19	73·43	73·51	23
24	75·39	75·71	75·79	76·02	76·18	76·34	76·57	76·65	24
25	78·54	78·85	78·93	79·16	79·32	79·48	79·71	79·79	25
Diam.	0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.

Advancing by 8ths and 10ths

Diam.	Circumferences ½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.
0	1·570	1·88	1·963	2·19	2·356	2·51	2·748	2·82	0
1	4·712	5·02	5·105	5·34	5·497	5·65	5·820	5·96	1
2	7·854	8·16	8·246	8·48	8·639	8·79	9·032	9·11	2
3	10·99	11·30	11·38	11·62	11·78	11·93	12·17	12·25	3
4	14·13	14·45	14·52	14·76	14·92	15·08	15·31	15·39	4
5	17·27	17·59	17·67	17·90	18·06	18·22	18·45	18·53	5
6	20·42	20·73	20·81	21·04	21·20	21·36	21·59	21·67	6
7	23·56	23·87	23·95	24·19	24·34	24·50	24·74	24·81	7
8	26·70	27·01	27·09	27·33	27·48	27·64	27·88	27·96	8
9	29·84	30·15	30·23	30·47	30·63	30·78	31·02	31·10	9
10	39·98	33·30	33·37	33·61	33·77	33·92	34·16	34·24	10
11	36·12	36·44	36·52	36·75	38·91	37·07	37·30	37·38	11
12	39·27	39·58	39·66	39·89	40·05	40·21	40·44	40·52	12
13	42·41	42·72	42·80	43·03	43·19	43·35	43·58	43·66	13
14	45·55	45·86	45·94	46·18	46·33	46·49	46·73	46·80	14
15	48·69	49·00	49·08	49·32	48·48	49·63	49·87	49·95	15
16	51·83	52·15	52·22	52·46	52·62	52·78	53·01	53·09	16
17	54·97	55·29	55·37	55·60	55·76	55·92	56·15	56·23	17
18	58·11	58·43	58·51	58·74	58·90	59·06	59·29	59·37	18
19	61·26	61·57	61·65	61·88	62·04	62·20	62·43	62·51	19
20	64·40	64·71	64·79	65·03	65·18	65·34	65·58	65·65	20
21	67·54	67·85	67·93	68·17	68·32	68·48	68·72	68·80	21
22	70·68	71·00	71·07	71·31	71·47	71·62	71·86	71·94	22
23	73·82	74·14	74·22	74·45	74·61	74·76	75·00	75·08	23
24	76·96	77·28	77·36	77·59	77·75	77·91	78·14	78·22	24
25	80·10	80·42	80·50	80·73	80·89	81·05	81·28	81·36	25
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

Combined Table of Circumferences of Circles,

Diam.	Circumferences								Diam.
	·0	·1	1/8 ·125	·2	1/4 ·25	·3	3/8 ·375	·4	
26	81·68	81·99	82·07	82·30	82·46	82·62	82·85	82·93	26
27	84·82	85·13	85·21	85·45	85·60	85·76	86·00	86·07	27
28	87·96	88·27	88·35	88·59	88·75	88·90	89·14	89·22	28
29	91·10	91·42	91·49	91·73	91·89	92·04	92·28	92·36	29
30	94·25	94·56	94·64	94·87	95·03	95·19	95·42	95·50	30
31	97·4	97·70	97·8	98·01	98·2	98·33	98·6	98·64	31
32	100·5	100·8	100·9	101·1	101·3	101·4	101·7	101·7	32
33	103·7	103·9	104·1	104·3	104·5	104·6	104·9	104·9	33
34	106·8	107·1	107·2	107·4	107·6	107·7	108·0	108·0	34
35	110·0	110·2	110·3	110·5	110·7	110·8	111·1	111·2	35
36	113·1	113·4	113·5	113·7	113·9	114·0	114·3	114·3	36
37	116·2	116·5	116·6	116·8	117·0	117·1	117·4	117·4	37
38	119·4	119·6	119·8	120·0	120·2	120·3	120·6	120·6	38
39	122·5	122·8	122·9	123·1	123·3	123·4	123·7	123·7	39
40	125·7	125·9	126·1	126·2	126·4	126·6	126·8	126·9	40
41	128·8	129·1	129·9	129·4	129·6	129·7	130·0	130 0	41
42	131·9	132·2	132·3	132·5	132·7	132·8	133·1	133·2	42
43	135·1	135·4	135·5	135·7	135·9	136·0	136·3	136·3	43
44	138·2	138·5	138·6	138·8	139·0	139·1	139·4	139·4	44
45	141·4	141·6	141·8	142·0	142·2	142·3	142·6	142·6	45
46	144·5	144·8	144·9	145·1	145·3	145·4	145·7	145·7	46
47	147·7	147·9	148·0	148·2	148·4	148·5	148·8	148·9	47
48	150·8	151·1	151·2	151 4	151·6	151·7	152·0	152·0	48
49	153·9	154·2	154·3	154 5	154·7	154·8	155·1	155·1	49
50	157·1	157·3	157·5	157·7	157·9	158·0	158·3	158·3	50
Diam.	·0	·1	1/8 ·125	·2	1/4 ·25	·3	3/8 ·375	·4	Diam.

ADVANCING BY 8THS AND 10THS—*continued*

Diam.	Circumferences ½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.
26	83·25	83·56	83·64	83·88	84·03	84·19	84·43	84·50	26
27	86·39	86·70	86·78	87·02	87·17	87·33	87·57	87·65	27
28	89·53	89·84	89·92	90·16	90·32	90·47	90·71	90·79	28
29	92·67	92·99	93·06	93·30	93·46	93·61	93·85	93·93	29
30	95·81	96·13	96·21	96·44	96·60	96·76	96·99	97·07	30
31	99·0	99·27	99·4	99·58	99·7	99·90	100·1	100·2	31
32	102·1	102·4	102·5	102·7	102·9	103·0	103·3	103·3	32
33	105·2	105·5	105·6	105·8	106·0	106·1	106·4	106·5	33
34	108·4	108·6	108·8	109·0	109·2	109·3	109·6	109·6	34
35	111·5	111·8	111·9	112·1	112·3	112·4	112·7	112·7	35
36	114·7	114·9	115·1	115·2	115·5	115·6	115·8	115·9	36
37	117·8	118·1	118·2	118·4	118·6	118·7	119·0	119·0	37
38	121·0	121·2	121·3	121·5	121·7	121·8	122·1	122·2	38
39	124·1	124·4	124·5	124·7	124·9	125·0	125·3	125·3	39
40	127·2	127·5	127·6	127·8	128·0	128·1	128·4	128·4	40
41	130·4	130·6	130·8	131·0	131·2	131·3	131·6	131·6	41
42	133·5	133·8	133·9	134·1	134·3	134·4	134·7	134·7	42
43	136·7	136·9	137·1	137·2	137·4	137·6	137·8	137·9	43
44	139·8	140·1	140·2	140·4	140·6	140·7	141·0	141·0	44
45	142·9	143·2	143·3	143·5	143·7	143·9	144·1	144·2	45
46	146·1	146·3	146·5	146·7	146·9	147·0	147·3	147·3	46
47	149·2	149·5	149·6	149·8	150·0	150·1	150·4	150·4	47
48	152·4	152·6	152·8	152·9	153·2	153·3	153·5	153·6	48
49	155·5	155·8	155·9	156·1	156·3	156·4	156·7	156·7	49
50	158·7	158·9	159·0	159·2	159·4	159·5	159·8	159·9	50
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

COMBINED TABLE OF CIRCUMFERENCES OF CIRCLES.

Diam.	Circumferences								Diam.
	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	
51	160·2	160·5	160·6	160·8	161·0	161·1	161·4	161·4	51
52	163·4	163·6	163·8	163·9	164·1	164·3	164·5	164·6	52
53	166·5	166·8	166·9	167·1	167·3	167·4	167·7	167·7	53
54	169·6	169·9	170·0	170·2	170·4	170·5	170·8	170·9	54
55	172·8	173·1	173·2	174·3	173·6	173·7	174·0	174·0	55
56	175·9	176·2	176·3	176·6	176·7	176·9	177·1	177·2	56
57	179·1	179·3	179·5	179·7	179·9	180·0	180·2	180·3	57
58	182·2	182·5	182·6	182·8	183·0	183·1	183·4	183·4	58
59	185·4	185·6	185·7	185·9	186·1	186·2	186·5	186·6	59
60	188·5	188·8	188·9	189·1	189·3	189·4	189·7	189·7	60
61	191·6	191·9	192·0	192·2	192·4	192·5	192·8	192·8	61
62	194·8	195·0	195·2	195·4	195·6	195·7	196·0	196·0	62
63	197·9	198·2	198·3	198·5	198·7	198·8	199·1	199·1	63
64	201·1	201·3	201·5	201·6	201·8	202·0	202·0	202·3	64
65	204·2	204·5	204·6	204·8	205·0	205·1	205·4	205·4	65
66	207·3	207·6	207·7	207·9	208·1	208·2	208·5	208·6	66
67	210·5	210·8	210·9	211·1	211·3	211·4	211·7	211·7	67
68	213·6	213·9	214·0	214·2	214·4	214·5	214·8	214·8	68
69	216·8	217·0	217·2	217·3	217·6	217·7	217·9	218·0	69
70	219·9	220·2	220·3	220·5	220·7	220·8	221·1	221·1	70
71	223·1	223·3	223·4	223·6	223·8	223·9	223·2	224·3	71
72	226·2	226·5	226·6	226·8	227·0	227·1	227·4	227·4	72
73	229·3	229·6	229·7	229·9	230·1	230·2	230·5	230·5	73
74	232·5	232·7	232·9	233·1	233·3	233·4	233·7	233·7	74
75	235·6	235·9	236·0	236·2	236·4	236·5	236·8	236·8	75
Diam.	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.

ADVANCING BY 8THS AND 10THS—*continued*

Diam.	Circumference ½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.
51	161·8	162·1	162·2	162·4	162·6	162·7	163·0	163·0	51
52	164·9	165·2	165·3	165·5	165·7	165·8	166·1	166·1	52
53	168·1	168·3	168·5	168·7	168·9	169·0	169·3	169·3	53
54	171·2	171·5	171·6	171·8	172·0	172·1	172·4	172·4	54
55	174·4	174·6	174·8	174·9	175·1	175·3	175·5	175·6	55
56	177·5	177·8	177·9	178·1	178·3	178·4	178·7	178·7	56
57	180·6	180·9	181·0	181·2	181·4	181·5	181·8	181·9	57
58	183·8	184·0	184·2	184·4	184·6	184·7	185·0	185·0	58
59	186·9	187·2	187·3	187·5	187·7	187·8	188·1	188·1	59
60	190·1	190·3	190·5	190·6	190·9	190·9	191·2	191·3	60
61	193·2	193·5	193·6	193·8	194·0	194·1	194·4	194·4	61
52	196·4	196·6	196·7	196·9	197·1	197·2	197·5	197·6	62
63	199·5	199·8	199·9	200·1	200·3	200·4	200·7	200·7	63
64	202·6	202·9	203·0	203·2	203·4	205·5	203·8	203·8	64
65	205·8	206·0	206·2	206·4	206·6	206·7	207·0	207·0	65
66	208·9	209·2	209·3	209·5	209·7	209·8	210·1	210·1	66
67	212·1	212·3	212·5	212·6	212·8	213·0	212·2	212·3	67
68	215·2	215·5	215·6	215·8	216·0	216·1	216·4	216·4	68
69	218·3	218·6	218·7	218·9	219·1	219·2	219·5	219·5	69
70	221·5	221·7	221·9	222·1	222·3	222·4	222·7	222·7	70
71	224·6	224·9	225·0	225·2	225·4	225·5	225·8	225·8	71
72	227·8	228·0	228·2	228·3	228·6	228·7	228·9	229·0	72
73	230·9	231·2	231·3	231·5	231·7	231·8	232·1	232·1	73
74	234·0	234·3	234·4	234·6	234·8	234·9	235·2	235·3	74
75	237·2	237·5	237·6	237·8	238·0	238·1	238·4	238·4	75
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

COMBINED TABLE OF CIRCUMFERENCES OF CIRCLES,

Diam.	Circumferences								Diam.
	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	
76	238·8	239·0	239·2	239·3	239·5	239·7	239·9	240·0	76
77	241·9	242·2	242·3	242·5	242·7	242·8	243·1	243·1	77
78	245·0	245·3	245·4	245·6	245·8	245·9	246·2	246·3	78
79	248·2	248·5	248·6	248·8	249·0	249·1	249·4	249·4	79
80	251·3	251·6	251·7	251·9	252·1	252·2	252·5	252·5	80
81	254·5	254·7	254·9	255·0	255·3	255·4	255·6	255·7	81
82	257·6	257·9	258·0	258·2	258·4	258·5	258·8	258·8	82
83	260·8	261·0	261·1	261·3	261·5	261·6	261·9	262·0	83
84	263·9	264·2	264·3	264·5	264·7	264·8	265·1	265·1	84
85	267·0	267·3	267·4	267·6	267·8	267·9	268·2	268·2	85
86	270·2	270·4	270·6	270·8	271·0	271·1	271·4	271·4	86
87	273·3	273·6	273·7	273·9	274·1	274·2	274·5	274·5	87
88	276·5	276·7	276·9	277·0	277·2	277·4	277·6	277·7	88
89	279·6	279·9	280·0	280·2	280·4	280·5	280·8	280·8	89
90	282·7	283·0	283·1	283·3	283·5	283·6	283·9	284·0	90
91	285·9	286·1	286·3	286·5	286·7	286·8	287·1	287·1	91
92	289·0	289·3	289·4	289·6	289·8	289·9	290·2	290·2	92
93	292·2	292·4	292·6	292·7	293·0	293·1	293·3	293·4	93
94	295·3	295·6	295·7	295·9	296·1	296·2	296·5	296·5	94
95	298·5	298·7	298·8	299·0	299·2	299·3	299·6	299·7	95
96	301·6	301·9	302·0	302·2	302·4	302·5	302·8	302·8	96
97	304·7	305·0	305·1	305·3	305·3	305·6	305·9	305·9	97
98	307·9	308·1	303·3	308·5	308·7	308·8	309·1	309·1	98
99	311·0	311·3	311·4	311·6	311·8	311·9	312·2	312·2	99
100	314·2	314·5	—	314·7	—	315·1	—	315·4	100
Diam.	·0	·1	⅛ ·125	·2	¼ ·25	·3	⅜ ·375	·4	Diam.

ADVANCING BY 8THS AND 10THS—*continued*

Diam.	Circumferences								Diam.
	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	
76	240·3	240·6	240·7	240·9	241·1	241·2	241·5	241·5	76
77	243·5	243·7	243·9	244·1	244·3	244·4	244·7	244·7	77
78	246·6	246·9	247·0	247·2	247·4	247·5	247·8	247·8	78
79	249·8	250·0	205·1	250·3	250·5	250·6	250·9	251·0	79
80	252·9	253·2	253·3	253·5	253·7	253·8	254·1	254·1	80
81	256·0	256·3	256·4	256·6	256·8	256·9	257·2	257·2	81
82	259·3	259·4	259·6	259·8	260·0	260·1	260·4	260·4	82
83	262·3	262·6	262·7	262·9	263·1	263·2	263·5	263·5	83
84	265·5	265·7	265·9	266·0	266·3	266·4	266·6	266·7	84
85	268·6	268·9	269·0	269·2	269·4	269·5	268·8	269·8	85
86	271·7	272·0	272·1	272·3	272·5	272·6	272·9	273·0	86
87	274·9	275·2	275·3	275·5	275·7	275·8	276·1	276·1	87
88	278·0	278·3	278·4	278·6	278·8	278·9	279·2	279·2	88
89	281·2	281·4	281·8	281·8	282·0	282·1	282·4	282·4	89
90	282·3	284·6	284·7	284·9	285·1	285·2	285·5	285·5	90
91	287·5	287·7	287·8	288·0	288·2	288·3	288·6	288·7	91
92	290·6	290·9	291·0	291·2	291·4	291·5	291·8	291·8	92
93	293·7	294·0	294·1	294·3	294·5	294·6	294·9	294·9	93
94	296·9	297·1	297·3	297·5	297·7	297·8	298·1	298·1	94
95	300·0	300·3	300·4	300·6	300·8	300·9	301·2	301·2	95
96	303·2	303·4	303·6	303·7	303·9	304·1	304·3	304·4	96
97	306·3	306·6	306·7	306·9	307·1	307·2	307·5	307·5	97
98	309·4	309·7	309·8	310·0	310·2	310·3	310·6	310·7	98
99	312·6	312·9	313·0	313·2	313·4	313·5	313·8	313·8	99
100	—	316·0	—	316·3	—	316·6	—	316·9	100
Diam.	½ ·5	·6	⅝ ·625	·7	¾ ·75	·8	⅞ ·875	·9	Diam.

International Units

The International OHM is the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14·4521 grammes in mass of a constant cross-sectional area and of a length of 106·300 centimetres.

The International AMPERE is the unvarying electric current which when passed through a solution of nitrate of silver in water deposits silver at the rate of 0·00111800 of a gramme per second.

The International VOLT is the electrical pressure which when steadily applied to a conductor whose resistance is one international ohm will produce a current of one international ampere.

Other Electrical Units

Conductance (G) is the reciprocal of resistance (R).

The word "Mho" (ohm written backwards) is used as the unit of conductance, which in itself explains conductance as the inverse of resistance.

With three conductances or conductors in parallel, their conductance G in mhos $= g_1 + g_2 + g_3$.

The COULOMB is the unit of quantity; and is the quantity of electricity conveyed by 1 ampere in 1 second = 1 ampere second. 1 ampere hour = 3,600 coulombs.

The MICROFARAD is the unit of capacity or capacitance. Where a sushstance is charged with electricity it becomes a condenser, and the charge is measured in microfarads. The farad = 1,000,000 microfarads, is nominally the unit of capacity, but is far too large a unit to be of practical use.

The HENRY is the unit of self-induction or inductance, and has no application to continuous current circuits. The inductance of a circuit, machine, or apparatus is measured in henrys or millihenrys.

IMPEDANCE (Z) is the total resistance of an alternating current circuit, and is expressed in ohms.

In a continuous current circuit the ohmic resistance R = E÷I, in the alternating current the impedance Z = E÷I, and impedance includes ohmic resistance, capacity, and inductance, or any combination of the three.

ADMITTANCE is the reciprocal of impedance.

Practical Electrical Units

Electrical units used in practice are derived from the C.G.S. units. C.G.S. units multiplied by the C.G.S. value given in the fourth column gives the corresponding electrical unit.

Unit of	Symbol of the unit	Name	C.G.S. value
Current .	I	Ampere .	10^{-1}
Electro-motive force	E	Volt	10^{8}
Resistance . .	R	Ohm	10^{9}
Conductance .	G	Mho . . .	10^{-9}
Quantity . .	Q	Coulomb .	10^{-1}
Capacity . .	C	Microfarad . .	10^{-15}
Self-inductance .	L	Henry	10^{9}
Power	P	Watt	10^{7} ergs per sec.
Energy or work .	W	Joule	10^{7} ergs
Commerce . .	kWh	Kilowatt--hour or kelvin	$3{\cdot}6 \cdot 10^{13}$ ergs

Notation

The index to the base 10 is constantly used for brevity in electrical work. Instead of writing 100,000,000, the expression 10^{8} is employed, likewise 10^{-1} means 0·1 or one-tenth.

Thus the watt 10^{7} ergs per second 10,000,000 ergs per second.

The ampere a tenth of the C.G.S. unit, or 1 ampere 0·1 C.G.S. unit.

10 amperes 1 C.G.S. unit.

Prefixes

Meg(a) 1 million times; as megohm 1,000,000 ohms.

Micr(o) a millionth; as microvolts $\frac{1}{1000000}$ volt.

Kilo a thousand; as kilowatt 1,000 watts.

Milli- a thousandth; as milliampere $\frac{1}{1000}$ ampere.

Affixes

-ion quality; as conduction, the quality possessed by a conductor of conducting.

-ance quantity; as conductance, the quantity of conduction possessed by a conductor.

-ivity quantity per unit area; as conductivity, the conductance per sq. in. or $cm.^2$

Corrosion Due to Electrolytic Action

(By courtesy of Hawker Aircraft, Ltd.)

Serious defects due to corrosion will occur through electrolytic action between dissimilar metals in contact with each other in the presence of moisture.

The use of approved jointing compounds may not always prevent electrolytic corrosion, due to the difficulty of obtaining an adequate layer of jointing material between the contact faces. For example, difficulty in obtaining satisfactory insulation is to be expected in the case of a stainless steel plug end which is a push fit into an aluminium alloy tube, due to the removal of jointing compound on the insertion of the plug into the tube.

In such cases, it is essential that careful consideration be given to the selection of the materials in order to avoid a potential difference greater than 0·25 volt, wherever possible.

The following table shows values of the E.M.F. between various materials and a calomel electrode immersed in sea water. The E.M.F. between any pair of materials is equal to the difference of the value given for each. The material having the higher potential will tend to corrode in contact with the material of lower potential.

Stationary Values of Electrode Potentials with Respect to a Saturated Calomel Electrode

Material	*Potential (volts)*
Aluminium and Aluminium Alloys	
Duralumin, heat treated and aged	0·60
M.G.7, 7% Mg. Al. alloy	0·61
R.R.56	0·70
Aluminium alloy sand or die-casting, D.T.D.133 B.	0·73
Aluminium coated aluminium alloy, 2 L.38	0·73
Wrought aluminium alloy, R.R.77 extrusion	0·74
Aluminium alloy castings (10–13% Si.), L.33	0·75
Aluminium sheet, L.16	0·76
Wrought aluminium alloy, R.R.77	0·77
Aluminium alloy casting, D.T.D.424	0·80
M.G.5, 5% Mg.-Al. alloy	0·82
Aluminium alloy castings (14% Zn.), 3 L.5	0·91
Brass, Bronze, etc.	
Silver-plated copper	0·01
45% nickel alloy, D.T.D.237	0·13
Monel K	0·13
Monel	0·16
Al-Ni-Si brass (Tungum), D.T.D.283A	0·18
Cupro-nickel (70 : 30)	0·18

STATIONARY VALUES OF ELECTRODE POTENTIALS WITH RESPECT TO A SATURATED CALOMEL ELECTRODE—*continued*

Material	*Potential (volts)*
Brass, Bronze, etc.—continued	
Copper, 2 B.15	0·18
German silver	0·19
Aluminium brass	0·21
Phosphor bronze, 2 B.8	0·22
Aluminium bronze	0·23
Inconel	0·24
Gunmetal, 2 B.2	0·24
Brass, 3 B.5	0·30
Steels	
Stainless—	
Austenitic, *e.g.* D.T.D.166, D.T.D.171, D.T.D.176, D.T.D.207, D.T.D.211	0·20
High chromium, *e.g.* S.80	0·35
12% chromium, *e.g.* S.61, S.62, S.85	0·45
Non-stainless—	
S.88	0·62
S.3	0·70
S.65	0·71
S.4	0·72
D.T.D.138	0·72
S.2	0·73
S.6	0·76
S.21	0·76
S.84	0·79
Magnesium alloys (Elektron)	1·58
Miscellaneous	
Nickel	0·14
·0008 in. Cr. plated on ·0015 in. Ni. plated on steel	0·25
·000035 in. Cr. plated on ·0015 in. Ni. plated on steel	0·43
Tin	0·46
·0005 in. tin electroplated on mild steel	0·47
Tinman's solder Grade A	0·47
Tinman's solder Grade B	0·48
2·5% silver-lead solder	0·50
·0005 in. chromium electroplated on mild steel	0·53
Tin-dipped steel	0·66
Cast iron grey	0·70
·001 in. cadmium electroplated on mild steel	0·78
Zinc-cadmium solder, D.T.D.221	1·04
·001 in. zinc electroplated on mild steel	1·10

Examples of causes of past defects have been:—

(i) Stainless steel in contact with aluminium or aluminium alloy. Stainless steel should then be cadmium plated.

(ii) Copper, brass, or tungum pipes in contact with aluminium alloy spars either directly or through trapped water.

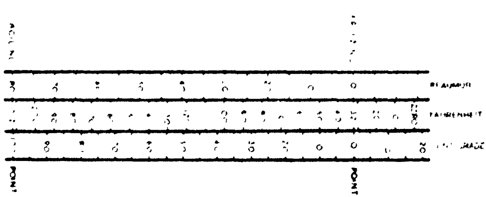
(iii) Brass, monel, tungum, 45% nickel alloy rivets in aluminium alloy structures. The rivets should be tinned and cadmium plated.

(iv) Duralumin rivets with Elektron. Only M.G.5 or D.T.D.303 rivets should be used or, where access to the interior of a unit cannot be obtained, T.A.P. "pop" rivets (L.46 or D.T.D.182A).

TABLE OF FAHR. DEG. EQUIVALENT TO CENTIGRADE (C.°)

C.	0	1	2°	3°	4	5	6°	7°	8°	9°
0	32	33·8	35·6	37·4	39·2	41	42·8	44·6	46·4	48·2
10	50	51·8	53·6	55·4	57·2	59	60·8	62·6	64·4	66·2
20	68	69·8	71·6	73·4	75·2	77	78·8	80·6	82·4	84·2
30	86	87·8	89·6	91·4	93·2	95	96·8	98·6	100·4	102·2
40	104	105·8	107·6	109·4	111·2	113	114·8	116·6	118·4	120·2
50	122	123·8	125·6	127·4	129·2	131	132·8	134·6	136·4	138·2
60	140	141·8	143·6	145·4	147·2	149	150·8	152·6	154·4	156·2
70	158	159·8	161·6	163·4	165·2	167	168·8	170·6	172·4	174·2
80	176	177·8	179·6	181·4	183·2	185	186·8	188·6	190·4	192·2
90	194	195·8	197·6	199·4	201·2	203	204·8	206·6	208·4	210·2
100	212	213·8	215·6	217·4	219·2	221	222·8	224·6	226·4	228·2

COMPARATIVE SCALE OF ENGLISH AND FRENCH THERMOMETERS



The boiling and freezing points are those of water at mean sea level, atmospheric pressure.

Freezing point, or 32° Fahr. Zero in Centigrade or Reaumur.

Boiling point, or 212° Fahr. 100° Cent. or 80° Reaumur.

To Convert Temperature Centigrade or Reaumur, into Temperature Fahrenheit

Let F = Temperature Fahrenheit. C = Temperature Centigrade. R = Temperature Reaumur.

$$F = \frac{9C}{5} + 32 = \frac{9R}{4} + 32 = C + R + 32.$$

$$C = \frac{5(F - 32)}{9} = \frac{5R}{4}; \quad R = \frac{4(F - 32)}{9} = \frac{4C}{5}.$$

Table of Centigrade Degrees Equivalent to Degrees Fahr.

The figures in *italics* are minus quantities; thus 14° Fahr. = −10° C.

Note.—The decimal in each set of figures is *recurring*.

Example.—57° Fahr. = 13·8888····C.

Fahr.	0	1	2	3	4	5	6	7	8	9
0	*17·7*	*17·2*	*16·6*	*16·1*	*15·5*	*15·0*	*14·4*	*13·8*	*13·3*	*12·7*
10	*12·2*	*11·6*	*11·1*	*10·5*	*10·0*	*9·4*	*8·8*	*8·3*	*7·7*	*7·2*
20	*6·6*	*6·1*	*5·5*	*5·0*	*4·4*	*3·8*	*3·3*	*2·7*	*2·2*	*1·6*
30	*1·1*	*·5*	0	·5	1·1	1·6	2·2	2·7	3·3	3·8
40	4·4	5·0	5·5	6·1	6·6	7·2	7·7	8·3	8·8	9·4
50	10·0	10·5	11·1	11·6	12·2	12·7	13·3	13·8	14·4	15·0
60	15·5	16·1	16·6	17·2	17·7	18·3	18·8	19·4	20·0	20·5
70	21·1	21·6	22·2	22·7	23·3	23·8	24·4	25·0	25·5	26·1
80	26·6	27·2	27·7	28·3	28·8	29·4	30·0	30·5	31·1	31·6
90	32·2	32·7	33·3	33·8	34·4	35·0	35·5	36·1	36·6	32·2
100	37·7	38·3	38·8	39·4	40·0	40·5	41·1	41·6	42·2	42·7
110	43·3	43·3	44·4	45·0	45·5	46·1	46·6	47·2	47·7	48·3
120	48·8	49·4	50·0	50·5	51·1	51·6	52·2	52·7	53·3	53·8
130	54·4	55·0	55·5	56·1	56·6	57·2	57·7	58·3	58·8	59·4
140	60·0	60·5	61·1	61·6	62·2	62·7	63·3	63·8	64·4	65·0
150	65·5	66·1	66·6	67·2	67·7	68·3	68·8	69·4	70·0	70·5
160	71·1	71·6	72·2	72·7	73·3	73·8	74·4	75·0	75·5	76·1
170	76·6	77·2	77·7	78·3	78·8	79·4	80·0	80·5	81·1	81·6
180	82·2	82·7	83·3	83·8	84·4	85·0	85·5	86·1	86·6	87·2
190	87·7	88·3	88·8	89·4	90·0	90·5	91·1	91·6	92·2	92·7
200	93·3	93·8	94·4	95·0	95·5	96·1	96·6	97·2	97·7	98·3
210	98·8	99·4	100·0	100·5	101·1	101·6	102·2	102·7	103·3	103·8
220	104·4	105·0	105·5	106·1	106·6	107·2	107·7	108·3	108·8	109·4
230	110·0	110·5	111·1	111·6	112·2	112·7	113·3	113·8	114·4	115·0
240	115·5	116·1	116·6	117·2	117·7	118·3	118·8	119·4	120·0	120·5
250	121·1	121·6	122·2	122·7	123·3	123·8	124·4	125·0	125·5	126·1
260	126·6	127·2	127·7	128·3	128·8	129·4	130·0	130·5	131·1	131·6
270	132·2	132·7	133·3	133·8	134·4	135·0	135·5	136·1	136·6	137·2
280	137·7	138·3	138·8	139·4	140·0	140·5	141·1	141·6	142·2	142·7
290	143·3	143·8	144·4	145·0	145·5	146·1	146·6	147·2	147·7	148·3
Fahr.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°

COEFFICIENT OF ROLLING FRICTION, μ

(N.A.C.A. Technical Report, No. 583)

Size	Pressure	Bearings	Load per wheel (lb.)	Inflation pressure (lb. per sq. in.)	Tyre deflection (static) (in.)	μ Concrete	μ Firm turf	μ Soft turf
22 × 10 – 4	Extra low	Plain	1,240	12·5	2·55	·029	·035	
..	..	..	940	12·5	2·05	·030	·041	
..	..	..	640	12·5	1·58	·025	·054	
..	..	..	940	10·0	2·50	·028	·047	
..	..	..	940	8·0	2·92	·033	·050	
30 × 13 – 6	Extra low	Plain	1,740	12·5	2·82	·027	·046	
..	..	..	1,340	12·5	2·29	·024	·046	
..	..	..	940	12·5	1·74	·023	·047	
..	..	..	940	10·0	1·96	·029	·049	
..	..	..	940	8·0	2·19	·035	·047	
7·50 – 10	Low	Roller	1,540	20	2·26	·013	·025	
..	..	..	1,240	20	1·90	·010	·023	
..	..	..	940	20	1·52	·009	·029	
..	..	..	940	16	1·78	·010	·026	
..	..	..	940	12	2·18	·012	·026	
8·50 – 10	Low	Roller	1,740	20	2·52	·013	·030	
..	..	..	1,340	20	1·93	·014	·031	
..	..	..	940	20	1·56	·010	·034	
..	..	..	940	16	1·83	·013	·029	
..	..	..	940	12	2·22	·015	·030	
8·50 – 10	Low	Plain	1,740	20	2·52	·020		
..	..	..	940	20	1·56	·018		
26 × 5	Standard	Plain	1,240	50	·94	·018		·070
..	..	..	940	50	76	·015		·071
..	..	..	640	50	58	·013		·066
26 × 5	Standard	Plain	1,740	60	·80	·017		·064
..	..	..	1,340	60	·67	·011		·072
..	..	..	940	60	·53	·015		·077
..	..	..	940	60	·53	—	·037	
..	..	..	940	50	·62	·020	·033	
..	..	..	940	40	·69	·025	·033	

Approximate general values of μ are :—

Hard surface (concrete, etc.)	·02	Short grass (average)	·05	Soft turf	·08–·15
Hard turf	·04	Long grass (average)	·10	Muddy turf, sand, etc.	·15–·30

SQUARES, CUBES, SQUARE ROOTS, AND CUBE ROOTS

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
1	1	1	1·0	1·0	51	2601	132651	7·14143	3·7084
2	4	8	1·41421	1·2599	52	2704	140608	7·21110	3·7325
3	9	27	1·73205	1·4422	53	2809	148877	7·28011	3·7563
4	16	64	2·0	1·5874	54	2916	157464	7·34847	3·7798
5	25	125	2·23607	1·7100	55	3025	166375	7·4162	3·8030
6	36	216	2·44949	1·8171	56	3136	175616	7·48331	3·8259
7	49	343	2·64575	1·9129	57	3249	185193	7·54983	3·8485
8	64	512	2·82843	2·0	58	3364	195112	7·61577	3·8709
9	81	729	3·0	2·0801	59	3481	205379	7·68115	3·8930
10	100	1000	3·16228	2·1544	60	3600	216000	7·74597	3·9149
11	121	1331	3·31662	2·2240	61	3721	226981	7·81025	3·9365
12	144	1728	3·46410	2·2894	62	3844	238328	7·87401	3·9579
13	169	2197	3·60555	2·3513	63	3969	250047	7·93725	3·9791
14	196	2744	3·74166	2·4101	64	4096	262144	8·0	4·0
15	225	3375	3·87298	2·4662	65	4225	274625	8·06226	4·0207
16	256	4096	4·0	2·5198	66	4356	287496	8·12404	4·0412
17	289	4913	4·12311	2·5713	67	4489	300763	8·18535	4·0615
18	324	5832	4·24264	2·6207	68	4624	314432	8·24621	4·0817
19	361	6859	4·35890	2·6684	69	4761	328509	8·30662	4·1016
20	400	8000	4·47214	2·7144	70	4900	343000	8·36660	4·1213
21	441	9261	4·58258	2·7589	71	5041	357911	8·42615	4·1408
22	484	10648	4·69042	2·8020	72	5184	373248	8·48528	4·1602
23	529	12167	4·79583	2·8439	73	5329	389017	8·54400	4·1793
24	576	13824	4·89898	2·8845	74	5476	405224	8·60233	4·1983
25	625	15625	5·0	2·9240	75	5625	428175	8·66025	4·2172
26	676	17576	5·09902	2·9625	76	5776	438976	8·71780	4·2358
27	729	19683	5·19615	3·0	77	5929	456533	8·77496	4·2543
28	784	21952	5·29150	3·0366	78	6084	474552	8·83176	4·2727
29	841	24389	5·38516	3·0723	79	6241	493039	8·88819	4·2308
30	900	27000	5·47723	3·1072	80	6400	512000	8·94427	4·3089
31	961	29791	5·56776	3·1414	81	6561	531441	9·0	4·3267
32	1024	32768	5·65685	3·1748	82	6724	551368	9·05539	4·3445
33	1089	35937	5·74456	3·2075	83	6889	571787	9·11043	4·3621
34	1156	39304	5·83095	3·2396	84	7056	592704	9·16515	4·3795
35	1225	42875	5·91608	3·2711	85	7225	614125	9·21954	4·3968
36	1296	46656	6·0	3·3019	86	7396	636056	9·27362	4·4140
37	1369	50653	6·08276	3·3322	87	7569	658503	9·32738	4·4310
38	1444	54872	6·16441	3·3620	88	7744	681472	9·38083	4·4480
39	1521	59319	6·245	3·3912	89	7921	704969	9·43398	4·4647
40	1600	64000	6·32456	3·4200	90	8100	729000	9·48683	4·4814
41	1681	68921	6·40312	3·4482	91	8281	753571	9·53939	4·4979
42	1764	74088	6·48074	3·4760	92	8464	778688	9·59166	4·5144
43	1849	79507	6·55744	3·5034	93	8469	804357	9·64365	4·5307
44	1936	85184	6·63325	3·5303	94	8836	830584	9·69536	4·5468
45	2025	91125	6·70820	3·5569	95	9025	857375	9·74679	4·5629
46	2116	97336	6·78233	3·5830	96	9216	884736	9·79796	4·5789
47	2209	103823	6·85565	3·6088	97	9409	912673	9·84886	4·5947
48	2304	110592	6·92820	3·6342	98	9604	941192	9·89949	4·6104
49	2401	117649	7·0	3·6593	99	9801	970299	9·94987	4·6261
50	2500	125000	7·07107	3·6840	100	10000	1000000	10·0	4·6416

SQUARES, CUBES, SQUARE ROOTS, AND CUBE ROOTS *continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
101	10201	1030301	10·04988	4·6570	151	22801	3442951	12·28821	5·3251
102	10404	1061208	10·09950	4·6723	152	23104	3511808	12·32883	5·3368
103	10609	1092727	10·14889	4·6875	153	23409	3581577	12·36932	5·3485
104	10816	1124864	10·19804	4·7027	154	23716	3652264	12·40967	5·3601
105	11025	1157625	10·24695	4·7177	155	24025	3723875	12·44990	5·3717
106	11236	1191016	10·29563	4·7326	156	24336	3796416	12·49000	5·3832
107	11449	1225043	10·34408	4·7475	157	24649	3869893	12·52996	5·3947
108	11664	1259712	10·39230	4·7622	158	24964	3944312	12·56981	5·4061
109	11881	1295029	10·44031	4·7769	159	25281	4019679	12·60952	5·4175
110	12100	1331000	10·48809	4·7914	160	25600	4096000	12·64911	5·4288
111	12321	1367631	10·53565	4·8059	161	25921	4713281	12·68858	5·4401
112	12544	1404928	10·58301	4·8203	162	26244	4251528	12·72792	5·4514
113	12769	1442897	10·63015	4·8346	163	26569	4330747	12·76715	5·4626
114	12996	1481544	10·67708	4·8488	164	26896	4410944	12·80625	5·4737
115	13225	1520875	10·72381	4·8629	165	27225	4492125	12·84523	5·4848
116	13456	1560896	10·77033	4·877	166	27556	4574296	12·88410	5·4959
117	13689	1601613	10·81665	4·8910	167	27889	4657463	12·92285	5·5069
118	13924	1643032	10·86278	4·9049	168	28224	4741632	12·96148	5·5178
119	14161	1685159	10·90871	4·9187	169	28561	4826809	13·00000	5·5288
120	14400	1728000	10·95445	4·9324	170	28900	4913000	13·03840	5·5397
121	14641	1771561	11·0	4·9461	171	29241	5000211	13·07670	5·5505
122	14884	1815848	11·04536	4·9597	172	29584	5088448	13·11488	5·5613
123	15129	1860867	11·09054	4·9732	173	29929	5177717	13·15295	5·5721
124	15376	1906624	11·13553	4·9866	174	30276	5268024	13·19091	5·5828
125	15625	1953125	11·18034	5·0	175	30625	5359375	13·22876	5·5934
126	15876	2000376	11·22497	5·0133	176	30976	5451776	13·26650	5·6041
127	16129	2048383	11·26943	5·0265	177	31329	5545233	13·30413	5·6147
128	16384	2097152	11·31371	5·0397	178	31684	5639752	13·34166	5·6252
129	16641	2146689	11·35782	5·0528	179	32041	5735339	13·37909	5·6357
130	16900	2197000	11·40188	5·0658	180	32400	5832000	13·41641	5·6462
131	17161	2248091	11·44552	5·0788	181	32761	5929741	13·45362	5·6567
132	17424	2299968	11·48913	5·0916	182	33124	6028568	13·49074	5·6671
133	17689	2352637	11·53256	5·1045	183	34389	6128487	13·52775	5·6774
134	17956	2406104	11·57584	5·1172	184	33856	6229504	13·56466	5·6877
135	18225	2460375	11·61895	5·1299	185	34225	6331625	13·60147	5·6980
136	18496	2515456	11·6619	5·1426	186	34596	6434856	13·63818	5·7083
137	18769	2571353	11·70470	5·1551	187	34969	6539203	13·67479	5·7185
138	19044	2628072	11·74734	5·1676	188	35344	6644672	13·71131	5·7287
139	19321	2685619	11·78983	5·1801	189	35721	6751269	13·74773	5·7388
140	19600	2744000	11·8322	5·1925	190	36100	6859000	13·78405	5·7489
141	19881	2803221	11·87434	5·2048	191	36481	6967871	13·82028	5·7590
142	20164	2863288	11·9164	5·2171	192	36864	7077888	13·85641	5·7689
143	20449	2924207	11·9583	5·2293	193	37249	7189057	13·89244	5·7790
144	20736	2985984	12·0	5·2415	194	37636	7301384	13·92839	5·7890
145	21025	3048625	12·0416	5·2536	195	38025	7414875	13·96424	5·7988
146	21316	3112136	12·08305	5·2656	196	38416	7529536	14·000	5·8088
147	21609	3176523	12·12436	5·2776	197	38809	7645373	14·03567	5·8186
148	21904	3241792	12·16553	5·2896	198	32904	7762392	14·07125	5·8285
149	22201	3307949	12·20656	5·3015	199	39601	7880599	14·10674	5·8383
150	22500	3375000	12·24745	5·3133	200	40000	8000000	14·14214	5·8480

SQUARE, CUBES, SQUARE ROOTS, AND CUBE ROOTS—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
201	40401	8120601	14·1774	5·8578	251	63001	15813251	15·8430	6·3080
202	40804	8242408	14·2127	5·8675	252	63504	16003008	15·8745	6·3164
203	41209	8365427	14·2478	5·8771	253	64009	16194277	15·9060	6·3247
204	41616	8489664	14·2829	5·8868	254	64516	16387064	15·9374	6·3330
205	42025	8615125	14·3178	5·8964	255	65025	16581375	15·9687	6·3413
206	42436	8741816	14·3527	5·9059	256	65536	16777216	16·0	6·3496
207	42849	8869743	14·3875	5·9155	257	66049	16974593	16·0312	6·3579
208	43264	8998912	14·4222	5·9250	258	66564	17173512	16·0624	6·3661
209	43681	9129329	14·4568	5·9345	259	67081	17373979	16·0935	6·3743
210	44100	9261000	14·4914	5·9439	260	67600	17576000	16·1245	6·3825
211	44521	9393931	14·5258	5·9533	261	68121	17779581	16·1555	6·3907
212	44944	9528128	14·5602	5·9627	262	68644	17984728	16·1864	6·3988
213	45369	9663597	14·5945	5·9721	263	69169	18191447	16·2173	6·4070
214	45796	9800344	14·6287	5·9814	264	69696	18399744	16·2481	6·4151
215	46225	9938375	14·6629	5·9907	265	70225	18609625	16·2788	6·4232
216	46656	10077696	14·6969	6·0	266	70756	18821096	16·3095	6·4312
217	47089	10218313	14·7309	6·0092	267	71289	19034163	16·3401	6·4393
218	47524	10360232	14·7648	6·0185	268	71824	19248832	16·3707	6·4473
219	47961	10503459	14·7986	6·0277	269	72361	19465109	16·4012	6·4553
220	48400	10648000	14·8324	6·0368	270	72900	19683000	16·4317	6·4633
221	48841	10793861	14·8661	6·0459	271	73441	19902511	16·4621	6·4713
222	49284	10941048	14·8997	6·0550	272	73984	20123648	16·4924	6·4792
223	49729	11089567	14·9332	6·0641	273	74529	20346417	16·5227	6·4872
224	50176	11239424	14·9666	6·0732	274	75076	20570824	16·5529	6·4951
225	50625	11390625	15·0	6·0822	275	75625	20796875	16·5831	6·5030
226	51076	11543176	15·0333	6·0912	276	76176	21024576	16·6132	6·5108
227	51529	11697083	15·0665	6·1002	277	76729	21253933	16·6433	6·5187
228	51984	11852352	15·0997	6·1091	278	77284	21484952	16·6733	6·5265
229	52441	12008989	15·1327	6·1180	279	77841	21717639	16·7033	6·5343
230	52900	12167000	15·1658	6·1269	280	78400	21952000	16·7332	6·5421
231	53361	12326391	15·1987	6·1358	281	78961	22188041	16·7631	6·550
232	53824	12487168	15·2315	6·1446	282	79524	22425768	16·7929	6·558
233	54289	12649337	15·2643	6·1534	283	80089	22665187	16·8226	6·565
234	54756	12812904	15·2971	6·1622	284	80656	22906304	16·8523	6·573
235	55225	12977875	15·3297	6·1710	285	81225	23149125	16·8819	6·581
236	55696	13144256	15·3623	6·1797	286	81796	23393656	16·9115	6·589
237	56169	13312053	15·3948	6·1885	287	82369	23639903	16·9411	6·596
238	56644	13481272	15·4272	6·1972	288	82944	23387872	16·9706	6·604
239	57121	13651919	15·4596	6·2058	289	83521	24137569	17·0	6·611
240	57600	13824000	15·4919	6·2145	290	84100	24389000	17·0294	6·619
241	58081	13997521	15·5242	6·2231	291	84681	24642171	17·0587	6·627
242	58564	14172488	15·5563	6·2317	292	85264	24897088	17·0880	6·634
243	59049	14348907	15·5885	6·2403	293	85849	25153757	17·1172	6·642
244	59536	14526784	15·6205	6·2488	294	86436	25412184	17·1464	6·649
245	60025	14706125	15·6525	6·2573	295	87025	25672375	17·1756	6·657
246	60516	14886936	15·6844	6·2658	296	87616	25934336	17·2047	6·664
247	61009	15069223	15·7162	6·2743	297	88209	26198073	17·2337	6·672
248	61504	15252992	15·7480	6·2828	298	88804	26463592	17·2627	6·679
249	62001	15438249	15·7797	6·2912	299	89401	26730899	17·2916	6·687
250	62500	15625000	15·8114	6·2996	300	90000	27000000	17·3205	6·694

SQUARE, CUBES, SQUARE ROOTS, AND CUBE ROOTS—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
301	90601	27270901	17·3494	6·702	351	123201	43243551	18·7350	7·054
302	91204	27543608	17·3781	6·709	352	123904	43614208	18·7617	7·061
303	91809	27818127	17·4069	6·717	353	124609	43986977	18·7883	7·067
304	92416	28094464	17·4356	6·724	354	125316	44361864	18·8149	7·074
305	93025	28372625	17·4642	6·731	355	126025	44738875	18·8414	7·081
306	93636	28652616	17·4929	6·739	356	126736	45118016	18·8680	7·087
307	94249	28934443	17·5214	6·746	357	127449	45499293	18·8944	7·094
308	94864	29218112	17·5499	6·753	358	128164	45882712	18·9209	7·101
309	95481	29503629	17·5784	6·761	359	128881	46268279	18·9473	7·107
310	96100	29791000	17·6068	6·768	360	129600	46656000	18·9737	7·114
311	96721	30080231	17·6352	6·775	361	130321	47045881	19·0	7·120
312	97344	30371328	17·6635	6·782	362	131044	47437928	19·0263	7·127
313	97969	30664297	17·6918	6·790	363	131769	47832147	19·0526	7·133
314	98596	30959144	17·7200	6·797	364	132496	48228544	19·0788	7·140
315	99225	31255875	17·7482	6·804	365	133225	48627125	19·1050	7·147
316	99856	31554496	17·7764	6·811	366	133956	49027896	19·1311	7·153
317	100489	31855013	17·8045	6·818	367	134689	49430863	19·1572	7·160
318	101124	32157432	17·8326	6·826	368	135424	49836032	19·1833	7·166
319	101761	32461759	17·8606	6·833	369	136161	50243409	19·2094	7·173
320	102400	32768000	17·8885	6·840	370	136900	50653000	19·2354	7·179
321	103041	33076161	17·9165	6·847	371	137641	51064811	19·2614	7·186
322	103684	33386248	17·9444	6·854	372	138384	51478848	19·2873	7·192
323	104329	33698267	17·9722	6·861	373	139129	51895117	19·3132	7·198
324	104976	34012224	18·0	6.868	374	139876	52313624	19·3391	7·205
325	105625	34328125	18·0278	6·875	375	140625	52734375	19·3649	7·211
326	106276	34645976	18·0555	6·882	376	141376	53157376	19·3907	7·218
327	106929	34965783	18·0831	6·889	377	142129	53582633	19·4165	7·224
328	107584	35287552	18·1108	6·896	378	142884	54010152	19·4422	7·230
329	108241	35611289	18·1384	6·903	379	143641	54439939	19·4679	7·237
330	108900	35937000	18·1659	6·910	380	144400	54872000	19·4936	7·243
331	109561	36264691	18·1934	6·917	381	145161	55306341	19·5192	7·249
332	110224	36594368	18·2209	6·924	382	145924	55742968	19·5448	7·256
333	110889	36926037	18·2483	6·931	383	146689	56181887	19·5704	7·262
334	111556	37259704	18·2757	6·938	384	147456	56623104	19·5959	7·268
335	112225	37595375	18·3030	6·945	385	148225	57066625	19·6214	7·275
336	112896	37933056	18·3303	6·952	386	148996	57512456	19·6469	7·281
337	113569	38272753	18·3576	6·959	387	149769	57960603	19·6723	7·287
338	114244	38614472	18·3848	6·966	388	150544	58411072	19·6977	7·294
339	114921	38958219	18·4120	6·973	389	151321	58863869	19 7231	7·300
340	115600	39304000	18·4391	6·980	390	152100	59319000	19·7484	7·306
341	116281	39651821	18·4662	6·986	391	152881	59776471	19·7737	7·312
342	116964	40001688	18·4932	6·993	392	153664	60236288	19·7990	7·319
343	117649	40353607	18·5203	7·0	393	154449	60698457	19·8242	7·325
344	118336	40707584	18·5472	7·007	394	155236	61162984	19·8494	7·331
345	119025	41063625	18·5742	7·014	395	156025	61629875	19·8746	7·337
346	119716	41421736	18·6011	7·020	396	156816	62099136	19·8997	7·343
347	120409	41781923	18·6279	7·027	397	157609	62570773	19·9249	7·350
348	121104	42144192	18·6548	7·034	398	158404	63044792	19·9499	7·356
349	121801	42508549	18·6815	7·041	399	159201	63521199	19·9750	7·362
350	122500	42875000	18·7083	7·047	400	160000	64000000	20·0	7·368

SQUARE, CUBES, SQUARE ROOTS, AND CUBE ROOTS—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
401	160801	64481201	20·0250	7·374	451	203401	91733851	21·237	7·669
402	161604	64964808	20·0499	7·380	452	204304	92345408	21·260	7·674
403	162409	65450827	20·0749	7·386	453	205209	92959677	21·284	7·680
404	163216	65939264	20·0998	7·393	454	206116	93576664	21·307	7·680
405	164025	66430125	20·1246	7·399	455	207025	94196375	21·331	7·691
406	164836	66923416	20·1494	7·405	456	207936	94818816	21·354	7·697
407	165649	67419143	20·1742	7·411	457	208849	95443993	21·378	7·703
408	166464	67917312	20·1990	7·417	458	209764	96071912	21·401	7·708
409	167281	68417929	20·2237	7·423	459	210681	96702579	21·424	7·714
410	168100	68921000	20·2485	7·429	460	211600	97336000	21·448	7·719
411	168921	69426531	20·2731	7·435	416	212521	97972181	21·471	7·725
412	169744	69934528	20·2978	7·441	462	213444	98611128	21·494	7·731
413	170569	70444997	20·3224	7·447	463	214369	99252847	21·517	7·736
414	171396	70957944	20·3470	7·453	464	215296	99897341	21·541	7·742
415	172225	71473375	20·3715	7·459	465	216225	100544625	21·564	7·747
416	173056	71991296	20·3961	7·465	466	217156	101194696	21·587	7·753
417	173889	72511713	20·4206	7·471	467	218089	101847563	21·610	7·758
418	174724	73034632	20·4450	7·477	468	219024	102503232	21·633	7·764
419	175561	73560059	20·4695	7·483	469	219961	103161709	21·656	7·769
420	176400	74088000	20·4939	7·489	470	220900	103823000	21·679	7·775
421	177241	74618461	20·5183	7·495	471	221841	104487111	21·703	7·780
422	178084	75151448	20·5426	7·501	472	222784	105154048	21·726	7·786
423	178929	75686967	20·5670	7·507	473	223729	105823817	21·749	7·791
424	179776	76225024	20·5913	7·513	474	224676	106496424	21·772	7·797
425	180625	76765625	20·6155	7·518	475	225625	107171875	21·794	7·802
426	181476	77308776	20·6398	7·524	476	226576	107850176	21·817	7·808
427	182329	77854483	20·6640	7·530	477	227529	108531333	21·840	7·813
428	183184	78402752	20·6882	7·536	478	228484	109215352	21·863	7·819
429	184041	78953589	20·7123	7·542	479	229441	109902239	21·886	7·824
430	184900	79507000	20·7364	7·548	480	230400	110592000	21·909	7·830
431	185761	80062991	20·7605	7·554	481	231361	111284641	21·932	7·835
432	186624	80621568	20·7846	7·560	482	232324	111980168	21·954	7·841
433	187489	81182737	20·8087	7·565	483	233289	112678587	21·977	7·846
434	188356	81746504	20·8327	7·571	484	234256	113379904	22·0	7·851
435	189225	82312875	20·8567	7·577	485	235225	114084125	22·023	7·857
436	190096	82881856	20·8806	7·583	486	236196	114791256	22·045	7·862
437	190969	83453453	20·9045	7·589	487	237169	115501303	22·068	7·868
438	191844	84027672	20·9284	7·594	488	238144	116214272	22·091	7·873
439	192721	84604519	20·9523	7·600	489	239121	116930169	22·113	7·878
440	193600	85184000	20·9762	7·606	490	240100	117649000	22·136	7·884
441	194481	85766121	21·0	7·612	491	241081	118370771	22·159	7·889
442	195364	86350888	21·024	7·617	492	242064	119095488	22·181	7·894
443	196249	86938307	21·048	7·623	493	243049	119823157	22·204	7·900
444	197136	87528384	21·071	7·629	494	244036	120553784	22·226	7·905
445	198205	88121125	21·095	7·635	495	245025	121287375	22·249	7·910
446	198916	88716536	21·119	7·640	496	246016	122023936	22·271	7·916
447	199809	89314623	21·142	7·646	497	247009	122763473	22·293	7·921
448	200704	89915392	21·166	7·652	498	248004	123505992	22·316	7·926
449	201601	90518849	21·190	7·657	499	249001	124251499	22·338	7·932
450	202500	91125000	21·213	7·663	500	250000	125000000	22·361	7·937

Squares, Cubes, Square Roots, and Cube Roots—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
501	251001	125751501	22·383	7·942	551	303601	167284151	23·473	8·198
502	252004	126506008	22·405	7·948	552	304704	168196608	23·495	8·203
503	253009	127263527	22·428	7·953	553	305809	169112377	23·516	8·208
504	254016	128024064	22·450	7·958	554	306916	170031464	23·537	8·213
505	255025	128787625	22·472	7·963	555	308025	170953875	23·558	8·218
506	256036	129554216	22·494	7·969	556	309136	171879616	23·580	8·223
507	257049	130323843	22·517	7·974	557	310249	172808693	23·601	8·228
508	258064	131096512	22·539	7·979	558	311364	173741112	23·622	8·233
509	259081	131872229	22·561	7·984	559	312481	174676879	23·643	8·238
510	260100	132651000	22·583	7·990	560	313600	175616000	23·664	8·243
511	261121	133432831	22·605	7·995	561	314721	176558481	23·685	8·247
512	262144	134217728	22·627	8·0	562	315844	177504328	23·707	8·252
513	263169	135005697	22·649	8·005	563	316969	178453547	23·728	8·257
514	264196	135796744	22·672	8·010	564	318096	179406144	23·749	8·262
515	265225	136590875	22·694	8·016	565	319225	180362125	23·770	8·267
516	266256	137388096	22·716	8·021	566	326356	181321496	23·791	8·272
517	267289	138188413	22·738	8·026	567	321489	182284263	23·812	8·277
518	268324	138991832	22·760	8·031	568	322624	183250432	23·833	8·282
519	269361	139798359	22·782	8·036	569	323761	184220009	23·854	8·286
520	270400	140608000	22·804	8·041	570	324900	185193000	23·875	8·291
521	271441	141420761	22·825	8·047	571	326041	186169411	23·896	8·296
522	272484	142236648	22·847	8·052	572	327184	187149248	23·917	8·301
523	273529	143055667	22·869	8·057	573	328329	188132517	23·937	8·306
524	274576	143877824	22·891	8·062	574	329476	189119224	23·958	8·311
525	275625	144703125	22·913	8·067	575	330625	190109375	23·979	8·316
526	276676	145531576	22·935	8·072	576	331776	191102976	24·0	8·320
527	277729	146363183	22·956	8·077	577	332929	192100033	24·031	8·325
528	278784	147197952	22·978	8·082	578	334084	193100552	24·042	8·330
529	279841	148035889	23·0	8·088	579	335241	194104539	24·062	8·335
530	280900	148877000	23·022	8·093	580	336400	195112000	24·083	8·340
531	281961	149721291	23·043	8·098	581	337561	196122941	24·104	8·344
532	283024	150568768	23·065	8·103	582	338724	197137368	24·125	8·349
533	284089	151419437	23·087	8·108	583	339889	198155287	24·145	8·354
534	285156	152273304	23·108	8·113	584	341056	199176704	24·166	8·359
535	286225	153130375	23·130	8·118	585	342225	200201625	24·187	8·363
536	287296	153990656	23·152	8·123	586	343396	201230056	24·207	8·368
537	288369	154854153	23·173	8·128	587	344569	202262003	24·228	8·373
538	289444	155720872	23·195	8·133	588	345744	203297472	24·249	8·378
539	290521	156590819	23·216	8·138	589	346921	204336469	24·269	8·382
540	291600	157464000	23·238	8·143	590	348100	205379000	24·290	8·387
541	292681	158340421	23·259	8·148	591	349281	206425071	24·310	8·392
542	293764	159220088	23·281	8·153	592	350464	207474688	24·331	8·397
543	294849	160103007	23·302	8·158	593	351649	208527857	24·352	8·401
544	295936	160989184	23·324	8·163	594	352836	209584584	24·372	8·406
545	297025	161878625	23·345	8·168	595	354025	210644875	24·393	8·411
546	298116	162771336	23·367	8·173	596	355216	211708736	24·413	8·416
547	299209	163667323	23·388	8·178	597	356409	212776173	24·434	8·420
548	300304	164566592	23·409	8·183	598	357604	213847192	24·454	8·425
549	301401	165469149	23·431	8·188	599	358801	214921799	24·474	8·430
550	302500	166375000	23·452	8·193	600	360000	216000000	24·495	8·434

SQUARES, CUBES, SQUARE ROOTS, AND CUBE ROOTS *continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
601	361201	217081801	24·515	8·439	651	423801	275894451	25·515	8·667
602	362404	218167208	24·536	8·444	652	425104	277167808	25·534	8·671
603	363609	219256227	24·556	8·448	653	426409	278445077	25·554	8·676
604	364816	220348864	24·576	8·453	654	427716	279726264	25·573	8·680
605	366025	221445125	24·597	8·458	655	429025	281011375	25·593	8·685
606	367236	222545016	24·617	8·462	656	430336	282300416	25·612	8·689
607	368449	223648543	24·637	8·467	657	431649	283593393	25·632	8·693
608	369664	224755712	24·658	8·472	658	432964	284890312	25·652	8·698
609	370881	225866529	24·678	8·476	659	434281	286191179	25·671	8·702
610	372100	226981000	24·698	8·481	660	435600	287496000	25·690	8·707
611	373321	228099131	24·718	8·486	661	436921	288804781	25·710	8·711
612	374544	229220928	24·739	8·490	662	438244	290117528	25·729	8·715
613	375769	230346397	24·759	8·495	663	439569	291434247	25·749	8·720
614	376996	231475544	24·779	8·499	664	440896	292754944	25·768	8·724
615	378225	232608375	24·799	8·504	665	442225	294079625	25·788	8·729
616	379456	233744896	24·819	8·509	666	443556	295408296	25·807	8·733
617	380639	234885113	24·839	8·513	667	444889	296740963	25·826	8·737
618	381924	236029032	24·860	8·518	668	446224	298077632	25·846	8·742
619	383161	237176659	24·880	8·522	669	447561	299418309	25·865	8·746
620	384400	238328000	24·900	8·527	670	448900	300763000	25·884	8·750
621	385641	239483061	24·920	8·532	671	450241	302111711	25·904	8·755
622	386884	240641848	24·940	8·536	672	451584	303464448	25·923	8·759
623	388129	241804367	24·960	8·541	673	452929	304821217	25·942	8·763
624	389376	242970624	24·980	8·545	674	452476	306182024	25·962	8·768
625	390625	244140625	25·0	8·550	675	455625	307546875	25·981	8·772
626	391876	245314376	25·020	8·554	676	456976	308915776	26·0	8·776
627	393129	246491883	25·040	8·559	677	458329	310288733	26·019	8·718
628	394384	247673152	25·060	8·564	678	459684	311665752	26·038	8·785
629	395641	248858189	25·080	8·568	679	461041	313046839	26·058	8·789
630	396900	250047000	25·100	8·573	680	462400	314432000	26·077	8·794
631	398161	251239591	25·120	8·577	681	463761	315821241	26·096	8·793
632	399424	252435968	25·140	8·582	682	465124	317214568	26·115	8·802
633	400689	253636137	25·159	8·586	683	466489	318611987	26·134	8·807
634	401956	254840104	25·179	8·591	684	467856	320013504	26·153	8·811
635	403225	256047875	25·199	8·595	685	469225	321419125	26·172	8·815
636	404496	257259456	25·219	8·600	686	470596	322828856	26·192	8·819
637	405769	258474853	25·239	8·604	687	471969	324242703	26·211	8·824
638	407044	259694072	25·259	8·609	688	473344	325660672	26·230	8·828
639	408321	260917119	25·278	8·613	689	474721	327082769	26·249	8·832
640	409600	262144000	25·298	8·618	690	476100	328509000	26·268	8·387
641	410881	263374721	25·318	8·622	691	477481	329939371	26·287	8·841
642	412164	264609288	25·338	8·627	692	478864	331373888	26·306	8·845
643	413449	265847707	25·357	8·631	693	480249	332812557	26·325	8·849
644	414736	267089984	25·377	8·636	694	481636	334255384	26·344	8·854
645	416025	268336125	25·397	8·640	695	483025	335702375	26·363	8·358
646	417316	269586136	25·417	8·645	696	484416	337153536	26·382	8·862
647	418609	270840023	25·436	8·649	697	485809	338608873	26·401	8·866
648	419904	272097792	25·456	8·653	698	487204	340068392	26·420	8·871
649	421201	273359449	25·475	8·658	699	488601	341532099	26·439	8·875
650	422500	274625000	25·495	8·662	700	490000	343000000	26·458	8·879

SQUARES, CUBES, SQUARE ROOTS, AND CUBE ROOTS—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
701	491401	344472101	26·476	8·883	751	564001	423564751	27·404	9·090
702	492804	345948408	26·495	8·887	752	565504	425259008	27·428	9·094
703	494209	347428927	26·514	8·892	753	567009	426957777	27·441	9·098
704	495616	348913664	26·533	8·896	754	568516	428661064	27·459	9·102
705	497025	350402625	26·552	8·900	755	570025	430368875	27·477	9·106
706	498436	351895816	26·571	8·904	756	571536	432081216	27·495	9·110
707	499849	353393243	26·589	8·909	575	573049	433798093	27·514	9·114
708	501264	354894912	26·608	8·913	758	574564	435519512	27·532	9·118
709	502681	356400829	26·267	8·917	759	576081	437245479	27·550	9·122
710	504100	357911000	26·646	8·921	760	577600	438976000	27·568	9·126
711	505521	359425431	26·665	8·925	761	579121	440711081	27·586	9·130
712	506944	360944128	26·683	8·929	762	580644	442450728	27·604	9·134
713	508369	362467097	26·702	8·934	763	582169	444194947	27·622	9·138
714	509796	363994344	26·721	8·938	764	583696	445943744	27·641	9·142
715	511225	365525875	26·739	8·942	765	585225	447697125	27·659	9·146
716	512656	367061696	26·758	8·946	766	586756	449455096	27·677	9·150
717	514089	368601813	26·777	8·950	767	588289	451217663	27·695	9·154
718	515524	370146232	26·796	8·955	768	589824	452984832	27·713	9·158
719	516961	371694959	26·814	8·959	769	591361	454756609	27·731	9·162
720	518400	373248000	26·833	8·963	770	592900	456533000	27·749	9·166
721	519841	374805361	26·851	8·967	771	594441	458314011	27·767	9·170
722	521284	376367048	26·870	8·971	772	525984	460099648	27·785	9·174
723	522729	377933067	26·889	8·975	773	597529	461889917	27·803	9·178
724	524176	379503424	26·907	8·979	774	599076	463684824	27·821	9·181
725	525625	381078125	26·926	8·893	775	600625	465484375	27·839	9·185
726	527076	382657176	26·944	8·988	776	602176	467288576	27·857	9·189
727	528529	384240583	26·963	8·992	777	603729	469097433	27·875	9·193
728	529984	385828352	26·981	8·996	778	605284	470910952	27·893	9·197
729	531441	387420489	27·0	9·0	779	606481	472729139	27·911	9·201
730	532900	389017000	27·019	9·004	780	608400	474552000	27·928	9·205
731	534361	390617891	27·037	9·008	781	609961	476379541	27·946	9·209
732	535824	392223168	27·055	9·012	782	611524	478211768	27·964	9·213
733	537289	393832837	27·074	9·016	783	613089	480048687	27·982	9·217
734	538756	395446904	27·092	9·021	784	614656	481890304	28·0	9·221
735	540225	397065375	27·111	9·025	785	616225	483736625	28·018	9·225
736	541696	398688256	27·129	9·029	786	617796	485587656	28·036	9·229
737	543169	400315553	27·148	9·033	787	619369	487443403	28·054	9·233
738	544644	401947272	27·166	9·037	788	620944	489303872	28·071	9·237
739	546121	403583419	27·185	9·041	789	622521	491169069	28·089	9·240
740	547600	405224000	27·203	9·045	790	624100	493039000	28·107	9·244
741	549081	406869021	27·221	9·049	791	625681	494913671	28·125	9·248
742	550564	408518488	27·240	9·053	792	627264	496793088	28·142	9·252
743	552049	410172407	27·258	9·057	793	628849	498677257	28·160	9·256
744	553536	411830784	27·276	9·061	794	630436	500566184	28·178	9·260
745	555025	413493625	27·295	9·065	795	632025	502459875	28·196	9·264
746	556516	415160936	27·313	9·069	796	633616	504358336	28·213	9·268
747	558009	416832723	27·331	9·073	797	635209	506261573	28·231	9·272
748	559504	418508992	27·350	9·078	798	636804	508169592	28·249	9·275
749	561001	420189749	27·368	9·082	799	638401	510082399	28·267	9·279
750	562500	421875000	27·386	9·086	800	640000	512000000	28·284	9·283

SQUARES, CUBES, SQUARE ROOTS, AND CUBE ROOTS—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
801	641601	513922401	28·302	9·287	851	724201	616295051	29·172	9·476
802	643204	515849608	28·320	9·291	852	725904	618470208	29·189	9·480
803	644809	517781627	28·337	9·295	853	727609	620650477	29·206	9·484
804	646416	519718464	28·355	9·299	854	729316	622835864	29·223	9·488
805	648025	521660125	28·373	9·302	855	731025	625026375	29·240	9·491
806	649636	523606616	28·390	9·306	856	732736	627222016	29·257	9·495
807	651249	525557943	28·408	9·310	857	734449	629422793	29·275	9·499
808	652864	527514112	28·425	9·314	858	736164	631628712	29·292	9·502
809	654481	529475129	28·443	9·318	859	737881	633839779	29·309	9·506
810	656100	531441000	28·460	9·322	860	739600	636056000	29·326	9·510
811	657721	533411731	28·478	9·326	861	741321	638277381	29·343	9·513
812	659344	535387328	28·496	9·329	862	743044	640503928	29·360	9·517
813	660969	537367797	28·513	9·333	863	744769	642735647	29·377	9·521
814	662596	539353144	28·531	9·337	864	746496	644972544	29·394	9·524
815	664225	541343375	28·548	9·341	865	748225	647214625	29·411	9·528
816	665856	543338496	28·566	9·345	866	749956	649461896	29·428	9·532
817	667489	545338513	28·583	9·348	867	751689	651714363	29·445	9·535
818	669124	547343432	28·601	9·352	868	753424	653972032	29·462	9·539
819	670761	549353259	28·618	9·356	869	755161	656234909	29·479	9·543
820	672400	551368000	28·636	9·360	870	756900	658503000	29·496	9·546
821	674041	553387661	28·653	9·364	871	758641	660776311	29·513	9·550
822	675684	555412248	28·671	9·367	872	760384	663054848	29·530	9·554
823	677329	557441767	28·688	9·371	873	762129	665338617	29·547	9·557
824	678976	559476224	28·705	9·375	874	763876	667627624	29·563	9·561
825	680625	561515625	28·723	9·379	875	765625	669921875	29·580	9·565
826	682276	563559976	28·740	9·383	876	767376	672221376	29·597	9·568
827	683929	565609283	28·758	9·386	877	769129	674526133	29·614	9·572
828	685584	567663552	28·775	9·390	878	770884	676836152	29·631	9·576
829	687241	569722789	28·792	9·394	879	772641	679151439	29·648	9·579
830	688900	571787000	28·810	9·398	880	774400	681472000	29·665	9·583
831	690561	573856191	28·827	9·402	881	776161	683797841	29·682	9·586
832	692224	575930368	28·844	9·405	882	777924	686128968	29·698	9·590
833	693889	578009537	28·862	9·409	883	779689	688465387	29·715	9·594
834	695556	580093704	28·879	9·413	884	781456	690807104	29·732	9·597
835	697225	582182875	28·896	9·417	885	783225	693154125	29·749	9·601
836	698896	584277056	28·914	9·420	886	784996	695506456	29·766	9·605
837	700569	586376253	28·931	9·424	887	786769	697864103	29·783	9·608
838	702244	588480472	28·948	9·428	888	788544	700227072	29·799	9·612
839	703921	590589719	28·965	9·432	889	790321	702595369	29·816	9·615
840	705600	592704000	28·983	9·435	890	792100	704969000	29·833	9·619
841	707281	594823321	29·0	9·439	891	793881	707347971	29·850	9·623
842	708964	596947688	29·017	9·443	892	795664	709732288	29·866	9·626
843	710649	599077107	29·034	9·447	893	797449	712121957	29·883	9·630
844	712336	601211584	29·052	9·450	894	799236	714516984	29·900	9·633
845	714025	603351125	29·069	9·454	895	801025	716917375	29·917	9·637
846	715716	605495736	29·086	9·458	896	802816	719323136	29·933	9·641
847	717409	607645423	29·103	9·462	897	804609	721734273	29·950	9·644
848	719104	609800192	29·120	9·465	898	806404	724150792	29·966	9·648
849	720801	611960049	29·138	9·469	899	808201	726572699	29·983	9·651
850	722500	614125000	29·155	9·473	900	810000	729000000	30·0	9·655

SQUARES, CUBES, SQUARE ROOTS, AND CUBE ROOTS—*continued*

No	Square	Cube	Square root	Cube root	No	Square	Cube	Square root	Cube root
901	811801	731432701	30·017	9·658	951	904401	860085351	30·838	9·834
902	813604	733870808	30·033	9·662	952	906304	862801408	30·854	9·837
903	815409	736314327	30·050	9·666	953	908209	865523177	30·871	9·841
904	817216	738763264	30·067	9·669	954	910116	868250664	30·887	9·844
905	819025	741217625	30·083	9·673	955	912025	870983875	30·903	9·848
906	820836	743677416	30·100	9·676	956	913936	873722816	30·919	9·851
907	822649	746142643	30·116	9·680	957	915849	876467493	30·935	9·855
908	824464	748613312	30·133	9·683	958	917764	879217912	30·952	9·858
909	826281	751089429	30·150	9·687	959	919681	881974079	30·968	9·861
910	828100	753571000	30·166	9·691	960	921600	884736000	30·984	9·865
911	829921	756058031	30·183	9·694	961	923521	887503681	31·0	9·868
912	831744	758550528	30·199	9·698	962	925444	890277128	31·016	9·872
913	833569	761048497	30·216	9·701	963	927369	893056347	31·032	9·875
914	835396	763551944	30·232	9·705	964	929296	895841344	31·048	9·879
915	837225	766060875	30·249	9·708	965	931225	898632125	31·064	9·882
916	839056	768575296	30·265	9·712	966	933156	901428696	31·081	9·885
917	840889	771095213	30·282	9·715	967	935089	904231063	31·097	9·889
918	842724	773620632	30·299	9·719	968	937024	907039232	31·113	9·892
919	844561	776151559	30·315	9·722	969	938961	909853209	31·129	9·896
920	846400	778688000	30·332	9·726	970	940900	912673000	31·145	9·899
921	848241	781229961	30·348	9·729	971	942841	915498611	31·161	9·902
922	850084	783777448	30·364	9·733	972	944784	918330048	31·177	9·906
923	851929	786330467	30·381	9·736	973	946729	921167317	31·193	9·909
924	853776	788889024	30·397	9·740	974	948676	924010424	31·209	9·913
925	855625	791453125	30·414	9·743	975	950625	926859375	31·225	9·916
926	857476	794022776	30·430	9·747	976	952576	929714176	31·241	9·919
927	859329	796597983	30·447	9·750	977	954529	932574833	31·257	9·923
928	861184	799178752	30·463	9·754	978	956484	935441352	31·273	9·926
929	863041	801765089	30·479	9·757	979	958441	938313739	31·289	9·929
930	864900	804357000	30·496	9·761	980	960400	941192000	31·305	9·933
931	866761	806954491	30·512	9·764	981	962361	944076141	31·321	9·936
932	868624	809557568	30·529	9·768	982	964324	946966168	31·337	9·940
933	870489	812166237	30·545	9·771	983	966289	949862087	31·353	9·943
934	872356	814780504	30·561	9·775	984	968256	952763904	31·369	9·946
935	874225	817400375	30·578	9·778	985	970225	955671625	31·385	9·950
936	876096	820025856	30·594	9·782	986	972196	958585256	31·401	9·953
937	877969	822656953	30·610	9·785	987	974169	961504803	31·417	9·956
938	879844	825293672	30·627	9·789	988	976144	964430272	31·432	9·960
939	881721	827936019	30·643	9·792	989	978121	967361669	31·448	9·963
940	883600	830584000	30·659	9·796	990	980100	970299000	31·464	9·967
941	885481	833237621	30·676	9·799	991	982081	973242271	31·480	9·970
942	887364	835896888	30·692	9·803	992	984064	976191488	31·496	9·973
943	889249	838561807	30·708	9·806	993	986049	979146657	31·512	9·977
944	891136	841232384	30·725	9·810	994	988036	982107784	31·528	9·980
945	893025	843908625	30·741	9·813	995	990025	985074875	31·544	9·983
946	894916	846590536	30·757	9·817	996	992016	988047936	31·559	9·987
947	896809	849278123	30·773	9·820	997	994009	991026973	31·575	9·990
948	898704	851971392	30·790	9·824	998	996004	994011992	31·591	9·993
949	900601	854670349	30·806	9·827	999	998001	997002999	31·607	9·997
950	902500	857375000	30·822	9·830	1000	1000000	1000000000	31·623	10·0

Table of $\frac{2}{3}$ Powers or $\sqrt[3]{N^2}$

N.	0	1	2	3	4	N.
0	0	1	1·5874	2·0801	2·5198	0
10	4·6416	4·9461	5·2415	5·5288	5·8088	10
20	7·3681	7·6117	7·8514	8·0876	8·3203	20
30	9·6549	9·8683	10·079	10·288	10·495	30
40	11·696	11·89	12·083	12·274	12·463	40
50	13·572	13·752	13·932	14·11	14·287	50
60	15·326	15·496	15·665	15·833	16	60
70	16·985	17·146	17·307	17·467	17·626	70
80	18·566	18·721	18·875	19·028	19·180	80
90	20·083	20·231	20·379	20·527	20·674	90
100	21·554	21·688	21·831	21·973	22·115	100

N.	5	6	7	8	9	N.
0	2·9240	3·3019	3·6593	4	4·3267	0
10	6·0822	6·3496	6·6115	6·8683	7·1204	10
20	8·5499	8·7764	9	9·2209	9·4391	20
30	10·700	10·903	11·104	11·303	11·5	30
40	12·651	12·828	13·024	13·208	13·391	40
50	14·462	14·637	14·811	14·984	15·155	50
60	16·166	16·332	16·496	16·66	16·823	60
70	17·784	17·942	18·099	18·256	18·411	70
80	19·33	19·483	19·634	19·784	19·934	80
90	20·82	20·966	21·111	21·256	21·40	90
100	22·257	22·397	22·538	22·678	22·818	100

Table of Fourth and Fifth Powers of Numbers

No.	4th Power	5th Power	No.	4th Power	5th Power	No.	4th Power	5th Power	No.	4th Power	5th Power
1	1	1	26	456,976	11,881,376	51	6,765,201	345,025,251	76	33,362,176	2,535,525,376
2	16	32	27	531,441	14,348,907	52	7,311,616	380,204,032	77	35,153,041	2,706,784,157
3	81	243	28	614,656	17,210,368	53	7,890,481	418,195,493	78	37,015,056	2,887,174,368
4	256	1,024	29	707,281	20,511,149	54	8,503,056	459,165,024	79	38,950,081	3,077,056,399
5	625	3,125	30	810,000	24,300,000	55	9,150,625	503,284,375	80	40,960,000	3,276,800,000
6	1,296	7,776	31	923,521	28,629,151	56	9,834,946	550,731,776	81	43,046,721	3,486,784,401
7	2,401	16,807	32	1,048,576	33,554,432	57	10,556,001	601,692,057	82	45,212,176	3,707,398,432
8	4,096	32,768	33	1,185,921	39,135,393	58	11,316,496	656,356,768	83	47,458,321	3,939,040,643
9	6,561	59,049	34	1,336,336	45,435,424	59	12,117,361	714,924,299	84	49,787,136	4,182,119,424
10	10,000	100,000	35	1,500,625	52,521,875	60	12,960,000	777,600,000	85	52,200,625	4,437,053,125
11	14,641	161,051	36	1,679,616	60,466,176	61	13,845,841	844,596,301	86	54,700,816	4,704,270,176
12	20,736	248,832	37	1,874,161	69,343,957	62	14,776,336	916,132,832	87	57,289,761	4,984,209,207
13	28,561	371,293	38	2,085,136	79,235,168	63	15,752,961	992,436,543	88	59,969,536	5,277,319,168
14	38,416	537,824	39	2,313,441	90,224,199	64	16,777,216	1,073,741,824	89	62,742,241	5,584,059,449
15	50,625	759,375	40	2,560,000	102,400,000	65	17,850,625	1,160,290,625	90	65,610,000	5,904,900,000
16	65,536	1,048,576	41	2,825,761	115,856,201	66	18,974,736	1,252,332,576	91	68,574,961	6,240,321,451
17	83,521	1,419,857	42	3,111,696	130,691,232	67	20,151,121	1,350,125,107	92	71,639,296	6,590,815,232
18	104,976	1,889,568	43	3,418,801	147,008,443	68	21,381,376	1,453,933,568	93	74,805,201	6,956,883,693
19	130,321	2,476,099	44	3,748,096	164,916,224	69	22,667,121	1,564,031,349	94	78,074,896	7,339,040,224
20	160,000	3,200,000	45	4,100,625	184,528,125	70	24,010,000	1,680,700,000	95	81,450,625	7,737,809,375
21	194,481	4,084,101	46	4,477,456	205,962,976	71	25,411,681	1,804,229,351	96	84,934,656	8,153,726,976
22	234,256	5,153,632	47	4,879,681	229,345,007	72	26,873,856	1,934,917,632	97	88,529,281	8,587,340,257
23	279,841	6,436,343	48	5,308,416	254,803,968	73	28,398,241	2,073,071,593	98	92,236,816	9,039,207,968
24	331,776	7,962,624	49	5,764,801	282,475,249	74	29,986,576	2,219,006,624	99	96,059,601	9,509,900,499
25	390,625	9,765,625	50	6,250,000	312,500,000	75	31,640,625	2,373,046,875	100	100,000,000	10,000,000,000

Squares, Cubes, etc., of Fractions

Fraction	Equivalent	Square	Cube	$\sqrt{\ }$	$\sqrt[3]{\ }$	Reciprocal
$\frac{1}{16}$	·0625	·0039	·00024	·2500	·3969	16·00
$\frac{1}{8}$	·125	·0156	·0020	·3536	·5	8·000
$\frac{3}{16}$	·1875	·0352	·0066	·4330	·5724	5·333
$\frac{1}{4}$	·25	·0625	·0156	·5000	·6300	4·000
$\frac{5}{16}$	·3125	·0977	·0305	·5590	·6786	3·200
$\frac{3}{8}$	·375	·1406	·0527	·6124	·7211	2·667
$\frac{7}{16}$	·4375	·1914	·0837	·6614	·7591	2·286
$\frac{1}{2}$	·5	·25	·125	·7071	·7937	2·000
$\frac{9}{16}$	·5625	·3164	·1780	·7500	·8255	1·778
$\frac{5}{8}$	·625	·3906	·2441	·7906	·8550	1·600
$\frac{11}{16}$	·6875	·4727	·3250	·8292	·8826	1·455
$\frac{3}{4}$	·75	·5625	·4219	·8660	·9086	1·333
$\frac{13}{16}$	·8125	·6602	·5364	·9014	·9331	1·231
$\frac{7}{8}$	·875	·7656	·6699	·9354	·9565	1·143
$\frac{15}{16}$	·9375	·8789	·8240	·9682	·9787	1·067
1	1·0	1·0	1·0	1·0	1·0	1·0

Roots and Powers

The square root of any number not in the tables, but containing similar figures, may be found by altering a decimal point for every *two* integers or decimals altered.

The cube root may be found in a similar manner by altering one decimal for every *three* numbers altered. Thus:—

$\sqrt{9}=3$; $\sqrt{\cdot 09}=\cdot 3$; $\sqrt{900}=30$; $\sqrt{90{\cdot}000}=300$; $\sqrt[3]{8}=2$; $\sqrt[3]{8{,}000}=20$; $\sqrt[3]{\cdot 008}=\cdot 2$; $\sqrt[3]{80}=4{\cdot}309$; $\sqrt[3]{80{,}000}=43{\cdot}09$; $\sqrt[3]{800}=9{\cdot}283$; $\sqrt[3]{800{,}000}=92{\cdot}83$; $\sqrt[3]{\cdot 8}=\cdot 9283$.

If n=any number: $n^4=n^2\times n^2$; $n^5=n^2\times n^3$; $n^6=(n^3)^2$; $\sqrt[4]{n}=\sqrt{\sqrt{n}}$; $\sqrt[6]{n}=\sqrt[3]{\sqrt{n}}$.

The fifth root of n is most readily obtained by logarithms, also fractional roots, such as $\sqrt[\cdot 36]{n}$ (see "Involution and Evolution of Fractions by Logarithms").

RECIPROCALS OF NUMBERS

No.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	No.
0	·0	10·000	5·00000	3·33333	2·5000	2·000	1·66667	1·42857	1·25000	1·11111	0
1	1·000	·909091	·833333	·769231	·714286	·666667	·625000	·588235	·555556	·526316	1
2	·50000	·476190	·454545	·434783	·416667	·40000	·384615	·370370	·357143	·344828	2
3	·333333	·322581	·312500	·303030	·294118	·285714	·277778	·270270	·263158	·256410	3
4	·25000	·243902	·238095	·232558	·227273	·222222	·217391	·212766	·208333	·204082	4
5	·20000	·196078	·192308	·188679	·185185	·181818	·178571	·175439	·172414	·169492	5
6	·166667	·163934	·161290	·158730	156250	·153846	·151515	149254	·147059	144928	6
7	·142857	·140845	·138889	136986	·135135	·133333	·131579	129870	128205	·126582	7
8	·125000	·123457	121951	·120482	·119048	·117647	116279	114943	·113636	·112360	8
9	·111111	·109890	·108696	·107527	106383	·105263	·104167	·103093	·102041	101010	9
10	·10000	·099010	098039	·097087	096154	095238	·094340	·093458	·092593	091743	10
11	·090909	·090090	·089286	·088496	·087719	086957	·086207	085470	·084746	084034	11
12	·083333	·082645	·081967	·081301	080645	·080000	·079365	078740	·078125	·077519	12
13	·076923	·076336	075758	·075188	·074627	074074	073529	·072993	·072464	·071942	13
14	·071429	·070922	·070423	·069930	·069444	·068966	068493	·068027	·067568	·067114	14
15	·066667	·066225	065789	·065359	064935	·064516	·064103	·063694	·063291	·062893	15
16	·062500	·062112	·061728	·061350	060976	·060606	·062041	·059880	059524	·059172	16
17	·058824	·058480	·058140	·057803	·057471	·057143	056818	·056497	056180	055866	17
18	·055556	·055249	·054945	·054645	054348	·054054	053763	053476	053191	·052910	18
19	·052632	·052356	·052083	·051813	·051546	051282	051020	·050761	050505	050251	19
20	·050000	·049751	·049505	·049261	049020	·048780	·048544	·048309	·048077	·047847	20
21	·047619	·047393	·047170	·046948	046729	046512	046296	·046083	·045872	0·45662	21
22	·045455	·045249	·045045	·044843	·044643	·044444	·044248	·044053	·043860	043668	22
23	·043478	·043290	·043103	·042918	042735	·042553	·042373	·042194	042017	·041841	23
24	·041667	·041494	·041322	·041152	0 40984	040816	040650	·040486	·040323	·040161	24
25	·040000	·039841	·039683	·039526	039370	039216	·039062	·038911	·038760	·038610	25
26	·038462	·038314	·038168	·038023	037879	·037736	·037594	·037453	037313	·037175	26
27	·037037	·036900	·036765	·036630	·036496	·036364	·036232	·036101	035971	·035842	27
28	·035714	·035587	·035461	·035336	·035211	·035088	·034965	·034843	·034722	·034602	28
29	·034483	·034364	034247	·034130	·034014	·033898	033784	·033670	·033557	·033445	29
30	·033333	·033223	033113	·033003	032895	·032787	032680	·032573	·032468	·032362	30
	·0	·1	·2	·3	·4	·5	6	7	8	·9	

RECIPROCALS OF NUMBERS—*continued*

No.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	No.
31	·032258	·032154	·032051	·031949	·031847	·031746	·031646	·031546	·031447	·031348	31
32	·031250	·031153	·031056	·030960	·030864	·030769	·030675	·030581	·030488	·030395	32
33	·030303	·030211	·030120	·030030	·029940	·029851	·029762	·029674	·029586	·029499	33
34	·029412	·029326	·029240	·029155	·029070	·028986	·028902	·028818	·028736	·028653	34
35	·028571	·028490	·028409	·028329	·028249	·028169	·028090	·028011	·027933	·027855	35
36	·027778	·027701	·027624	·027548	·027473	·027397	·027322	·027248	·027174	·027100	36
37	·027027	·026954	·026882	·026810	·026738	·026667	·026596	·026525	·026455	·026385	37
38	·026316	·026247	·026178	·026110	·026042	·025974	·025907	·025840	·025773	·025707	38
39	·025641	·025575	·025510	·025445	·025381	·025316	·025253	·025189	·025126	·025063	39
40	·025000	·024938	·024876	·024814	·024752	·024691	·024631	·024570	·024510	·024450	40
41	·024390	·024331	·024272	·024213	·024155	·024096	·024038	·023981	·023923	·023866	41
42	·023810	·023753	·023697	·023641	·023585	·023529	·023474	·023419	·023364	·023310	42
43	·023256	·023202	·023148	·023095	·023041	·022989	·022936	·022883	·022831	·022779	43
44	·022727	·022676	·022624	·022573	·022523	·022472	·022422	·022371	·022321	·022272	44
45	·022222	·022173	·022124	·022075	·022026	·021978	·021930	·021882	·021834	·021786	45
46	·021739	·021692	·021645	·021598	·021552	·021505	·021459	·021413	·021368	·021322	46
47	·021277	·021231	·021186	·021142	·021097	·021053	·021008	·020964	·020921	·020877	47
48	·020833	·020790	·020747	·020704	·020661	·020619	·020576	·020534	·020492	·020450	48
49	·020408	·020367	·020325	·020284	·020243	·020202	·020161	·020121	·020080	·020040	49
50	·020000	·019960	·019920	·019881	·019841	·019802	·019763	·019724	·019685	·019646	50
51	·019608	·019569	·019531	·019493	·019455	·019417	·019380	·019342	·019305	·019268	51
52	·019231	·019194	·019157	·019120	·019084	·019048	·019011	·018975	·018939	·018904	52
53	·018868	·018832	·018797	·018762	·018727	·018692	·018657	·018622	·018587	·018553	53
54	·018519	·018484	·018450	·018416	·018382	·018349	·018315	·018282	·018248	·018215	54
55	·018182	·018149	·018116	·018083	·018051	·018018	·017986	·017953	·017921	·017889	55
56	·017857	·017825	·017794	·017762	·017731	·017699	·017668	·017637	·017606	·017575	56
57	·017544	·017513	·017483	·017452	·017422	·017391	·017361	·017331	·017301	·017271	57
58	·017241	·017212	·017182	·017153	·017123	·017094	·017065	·017036	·017007	·016978	58
59	·016949	·016920	·016892	·016863	·016835	·016807	·016779	·016750	·016722	·016694	59
60	·016667	·016639	·016611	·016584	·016556	·016529	·016502	·016474	·016447	·016420	60
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	

RECIPROCALS OF NUMBERS—*continued*

No.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	No.
61	·016393	·016367	·016340	·016313	·016287	·016260	·016234	·016207	·016181	·016155	61
62	·016129	·016103	·016077	·016051	·016026	·016000	·015974	·015949	·015924	·015898	62
63	·015873	·015848	·015823	·015798	·015773	·015748	·015723	·015699	·015674	·015649	63
64	·015625	·015601	·015576	·015552	·015528	·015504	·015480	·015456	·015432	·015408	64
65	·015385	·015361	·015337	·015314	·015291	·015267	·015244	·015221	·015198	·015175	65
66	·015152	·015129	·015106	·015083	·015060	·015038	·015015	·014993	·014970	·014948	66
67	·014925	·014903	·014881	·014859	·014837	·014815	·014793	·014771	·014749	·014728	67
68	·014706	·014684	·014663	·014641	·014620	·014599	·014577	·014556	·014535	·014514	68
69	·014493	·014472	·014451	·014430	·014409	·014388	·014368	·014347	·014327	·014306	69
70	·014286	·014265	·014245	·014225	·014205	·014184	·014164	·014144	·014124	·014104	70
71	·014085	·014065	·014045	·014025	·014006	·013986	·013966	·013947	·013928	·013908	71
72	·013889	·013870	·013850	·013831	·013812	·013793	·013774	·013755	·013736	·013717	72
73	·013699	·013680	·013661	·013643	·013624	·013605	·103587	·013569	·013550	·013532	73
74	·013514	·013495	·013477	·013459	·013441	·013423	·013405	·013387	·013369	·013351	74
75	·013333	·013316	·013298	·013280	·013263	·013245	·013228	·013210	·013193	·013175	75
76	·013158	·013141	·013123	·013106	·013089	·013072	·013055	·013038	·013021	·013004	76
77	·012987	·012970	·012953	·012937	·012920	·012903	·012887	·012870	·012853	·012837	77
78	·012821	·012804	·012788	·012771	·012755	·012739	·012723	·012706	·012690	·012674	78
79	·012658	·012642	·012626	·012610	·012594	·012579	·012563	·012547	·012531	·012516	79
80	·012500	·012484	·012469	·012453	·012438	·012422	·012407	·012392	·012376	·012361	80
81	·012346	·012330	·012315	·012300	·012285	·012270	·012255	·012240	·012225	·012210	81
82	·012195	·012180	·012165	·012151	·012136	·012121	·012107	·012092	·012077	·012063	82
83	·012048	·012034	·012019	·012005	·011990	·011976	·011962	·011947	·011933	·011919	83
84	·011905	·011891	·011876	·011862	·011848	·011834	·011820	·011806	·011792	·011779	84
85	·011765	·011751	·011737	·011723	·011710	·011696	·011682	·011669	·011655	·011641	85
86	·011628	·011614	·011601	·011587	·011574	·011561	·011547	·011534	·011521	·011507	86
87	·011494	·011481	·011468	·011455	·011442	·011429	·011416	·011403	·011390	·011377	37
88	·011364	·011351	·011338	·011325	·011312	·011299	·011287	·011274	·011261	·011249	88
89	·011236	·011223	·011211	·011198	·011186	·011173	·011161	·011148	·011136	·011123	89
90	·011111	·011099	·011086	·011074	·011062	·011050	·011038	·011025	·011013	·011001	90
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	

RECIPROCALS OF NUMBERS—*continued*

No.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	No.
91	·010989	·010977	·010965	·010953	·010941	·010929	·010917	·010905	·010893	·010881	91
92	·010870	·010858	·010846	·010834	·010823	·010811	·010799	·010787	·010776	·010764	92
93	·010753	·010741	·010730	·010718	·010707	·010695	·010684	·010672	·010661	·010650	93
94	·010638	·010627	·010616	·010604	·010593	·010582	·010571	·010560	·010549	·010537	94
95	·010526	·010515	·010504	·010493	·010482	·010471	·010460	·010449	·010438	·010428	95
96	·010417	·010406	·010395	·010384	·010373	·010363	·010352	·010341	·010331	·010320	96
97	·010309	·010299	·010288	·010277	·010267	·010256	·010246	·010235	·010225	·010214	97
98	·010204	·010194	·010183	·010173	·010163	·010152	·010142	·010132	·010121	·010111	98
99	·010101	·010091	·010081	·010070	·010060	·010050	·010040	·010030	·010020	·010010	99
100	·010000	·009990	·009980	·009970	·009960	·009950	·009940	·009930	·009921	·009911	100
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	

Any sum multiplied by the reciprocal of a number is equal to the same sum divided by the number which the reciprocal represents. Reciprocals are frequently useful for facilitating hasty calculations; the reciprocal, used as a multiplier, being substituted for its number used as a divisor.—In the Table the reciprocals are those of integers and decimals mixed; but it is easy to extend their use to integers alone, or decimals alone, by adding to the reciprocal in the Table a decimal point for each integer added to its number, or deducting a decimal point for each integer subtracted from its number.

Thus, reciprocal of 20·9 = ·047847; of 209·0 = ·0047847; of 2090·0 = ·00047847.

" " 0·209 = 4·7847; ·0209 = 47·847; ·00209 = 478·47.

SIX-FIGURE TRIGONOMETRICAL TABLES

Prepared by the Ford Trade School

0°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	0000000	1.00000	0000000	Infinite	1.00000	Infinite	60
1	0002909	1.00000	0002909	3,437.75	1.00000	3,437.75	60
2	0005818	1.00000	0005818	1,718.87	1.00000	1,718.87	58
3	0008727	1.00000	0008727	1,145.92	1.00000	1,145.92	57
4	0011636	999999	0011636	859.436	1.00000	859.437	56
5	0014544	999999	0014544	687.549	1.00000	687.550	55
6	0017453	999998	0017453	572.957	1.00000	572.958	54
7	0020362	999998	0020362	491.106	1.00000	491.107	53
8	0023271	999997	0023271	429.718	1.00000	429.719	52
9	0026180	999997	0026180	381.971	1.00000	381.972	51
10	0029089	999996	0029089	343.774	1.00000	343.775	50
11	0031998	999995	0031998	312.521	1.00001	312.523	49
12	0034907	999994	0034907	286.478	1.00001	286.479	48
13	0037815	999993	0037816	264.441	1.00001	264.443	47
14	0040724	999992	0040725	245.552	1.00001	245.554	46
15	0043633	999990	0043634	229.182	1.00001	229.184	45
16	0046542	999989	0046542	214.858	1.00001	214.860	44
17	0049451	999988	0049451	202.219	1.00001	202.221	43
18	0052360	999986	0052360	190.984	1.00001	190.987	42
19	0055268	999985	0055269	180.932	1.00002	180.935	41
20	0058177	999983	0058178	171.885	1.00002	171.888	40
21	0061086	999981	0061087	163.700	1.00002	163.703	39
22	0063995	999980	0063996	156.259	1.00002	156.262	38
23	0066904	999978	0066905	149.465	1.00002	149.468	37
24	0069813	999976	0069814	143.237	1.00002	143.241	36
25	0072721	999974	0072723	137.507	1.00003	137.511	35
26	0075630	999971	0075632	132.219	1.00003	132.222	34
27	0078539	999969	0078541	127.321	1.00003	127.325	33
28	0081448	999967	0081450	122.774	1.00003	122.778	32
29	0084357	999964	0084360	118.541	1.00004	118.544	31
30	0087265	999962	0087269	114.589	1.00004	114.593	30
31	0090174	999959	0090178	110.892	1.00004	110.897	29
32	0093083	999957	0093087	107.426	1.00004	107.431	28
33	0095992	999954	0095996	104.171	1.00005	104.176	27
34	0098900	999951	0098905	101.107	1.00005	101.112	26
35	0101809	999948	0101814	98.2179	1.00005	98.2230	25
36	0104718	999945	0104724	95.4895	1.00005	95.4947	24
37	0107627	999942	0107633	92.9085	1.00006	92.9139	23
38	0110535	999939	0110542	90.4633	1.00006	90.4689	22
39	0113444	999936	0113451	88.1436	1.00006	88.1492	21
40	0116353	999932	0116361	85.9398	1.00007	85.9456	20
41	0119261	999929	0119270	83.8435	1.00007	83.8495	19
42	0122170	999925	0122179	81.8470	1.00007	81.8532	18
43	0125079	999922	0125088	79.9434	1.00008	79.9497	17
44	0127987	999918	0127998	78.1263	1.00008	78.1327	16
45	0130896	999914	0130907	76.3900	1.00009	76.3966	15
46	0133805	999910	0133817	74.7292	1.00009	74.7359	14
47	0136713	999907	0136726	73.1390	1.00009	73.1458	13
48	0139622	999903	0139635	71.6151	1.00010	71.6221	12
49	0142530	999899	0142545	70.1533	1.00010	70.1605	11
50	0145439	999894	0145454	68.7501	1.00011	68.7574	10
51	0148348	999890	0148364	67.4019	1.00011	67.4093	9
52	0151256	999886	0151273	66.1055	1.00011	66.1130	8
53	0154165	999881	0154183	64·8580	1.00012	64.8657	7
54	0157073	999877	0157093	63.6567	1.00012	63.6646	6
55	0159982	999872	0160002	62.4992	1.00013	62.5072	5
56	0162890	999867	0162912	61.3829	1.00013	61.3910	4
57	0165799	999863	·0165822	60.3058	1.00014	60.3141	3
58	·0168707	·999858	0168731	59.2659	1.00014	59·2743	2
59	0171717	999853	0171641	58.2612	1·00015	58.2698	1
60	0174524	·999848	·0174551	57.2900	1.00015	57.2987	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES *continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	017452	999848	017455	57 2900	1 00015	57 2987	60
1	017743	999843	017746	56 3506	1 00016	56 3595	59
2	018034	999837	018037	55 4415	1 00016	55 4505	58
3	018325	999832	018328	54 5613	1 00017	54 5705	57
4	018616	999827	018619	53 7086	1 00017	53 7179	56
5	018907	999821	018910	52 8821	1 00018	52 8916	55
6	019197	999816	019201	52 0807	1 00018	52 0903	54
7	019488	999810	019492	51 3032	1 00019	51 3129	53
8	019779	999804	019783	50 5485	1 00020	50 5584	52
9	020070	999799	020074	49 8157	1 00020	49 8258	51
10	020361	999793	020365	49 1039	1 00021	49 1141	50
11	020652	999787	020656	48 4121	1 00021	48 4224	49
12	020942	999781	020947	47 7395	1 00022	47 7500	48
13	021233	999775	021238	47 0853	1 00023	47 0960	47
14	021524	999768	021529	46 4489	1 00023	46 4596	46
15	021815	999762	021820	45 8294	1 00024	45 8403	45
16	022106	999756	022111	45 2261	1 00024	45 2372	44
17	022397	999749	022402	44 6386	1 00025	44 6498	43
18	022687	999743	022693	44 0661	1 00026	44 0775	42
19	022978	999736	022984	43 5081	1 00026	43 5196	41
20	023269	999729	023275	42 9641	1 00027	42 9757	40
21	023560	999722	023566	42 4335	1 00028	42 4452	39
22	023851	999716	023857	41 9158	1 00028	41 9277	38
23	024141	999709	024148	41 4106	1 00029	41 4227	37
24	024432	999701	024439	40 9174	1 00030	40 9296	36
25	024723	999694	024731	40 4358	1 00031	40 4482	35
26	025014	999687	025022	39 9655	1 00031	39 9780	34
27	025305	999680	025313	39 5059	1 00032	39 5185	33
28	025595	999672	025604	39 0568	1 00033	39 0696	32
29	025886	999665	025895	38 6177	1 00034	38 6307	31
30	026177	999657	026186	38 1885	1 00034	38 2016	30
31	026468	999650	026477	37 7686	1 00035	37 7818	29
32	026759	999642	026768	37 3579	1 00036	37 3713	28
33	027049	999634	027059	36 9560	1 00037	36 9695	27
34	027340	999626	027350	36 5627	1 00037	36 5763	26
35	027631	999618	027641	36 1776	1 00038	36 1914	25
36	027922	999610	027933	35 8006	1 00039	35 8145	24
37	028212	999602	028224	35 4313	1 00040	35 4454	23
38	028503	999594	028515	35 0695	1 00041	35 0838	22
39	028794	999585	028806	34 7151	1 00041	34 7295	21
40	029085	999577	029097	34 3678	1 00042	34 3823	20
41	029375	999568	029388	34 0273	1 00043	34 0420	19
42	029666	999560	029679	33 6935	1 00044	33 7083	18
43	029957	999551	029970	33 3662	1 00045	33 3812	17
44	030248	999542	030262	33 0452	1 00046	33 0603	16
45	030539	999534	030553	32 7303	1 00047	32 7455	15
46	030829	·999525	030844	32 4213	1 00048	32 4367	14
47	031120	999516	031135	32 1181	1 00048	32 1337	13
48	031411	999507	031426	31 8205	1 00049	31 8362	12
49	031702	999497	031717	31 5284	1 00050	31 5442	11
50	031992	999488	032009	31 2416	1 00051	31 2576	10
51	032283	999479	032300	30 9599	1 00052	30 9761	9
52	032574	999469	032591	30 6833	1 00053	30 6996	8
53	032864	999460	032882	30 4116	1 00054	30 4280	7
54	033155	999450	033173	30 1446	1 00055	30 1612	6
55	033446	·999441	033465	29 8823	1 00056	29 8990	5
56	033737	999431	033756	29 6245	1 00057	29 6414	4
57	034027	999421	034047	29 3711	1 00058	29·3881	3
58	·034318	999411	034338	29 1220	1 00059	29 1392	2
59	·034609	999401	034630	28 8771	1 00060	28·8944	1
60	034899	999391	034921	28 6363	1 00061	28 6537	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·034899	·999391	·034921	28·6363	1·00061	28·6537	60
1	·035190	·999381	·035212	28·3994	1·00062	28·4170	59
2	·035481	·999370	·035503	28·1664	1·00063	28·1842	58
3	·035772	·999360	·035795	27·9372	1·00064	27·9551	57
4	·036062	·999350	·036086	27·7117	1·00065	27·7298	56
5	·036353	·999339	·036377	27·4899	1·00066	27·5080	55
6	·036644	·999328	·036668	27·2715	1·00067	27·2898	54
7	·036934	·999318	·036960	27·0566	1·00068	27·0750	53
8	·037225	·999307	·037251	26·8450	1·00069	26·8636	52
9	·037516	·999296	·037542	26·6367	1·00070	26·6555	51
10	·037806	·999285	·037834	26·4316	1·00072	26·4505	50
11	·038097	·999274	·038125	26·2296	1·00073	26·2487	49
12	·038388	·999263	·038416	26·0307	1·00074	26·0499	48
13	·038678	·999252	·038707	25·8348	1·00075	25·8542	47
14	·038969	·999240	·038999	25·6418	1·00076	25·6613	46
15	·039260	·999229	·039290	25·4517	1·00077	25·4713	45
16	·039550	·999218	·039581	25·2644	1·00078	25·2841	44
17	·039841	·999206	·039873	25·0798	1·00079	25·0997	43
18	·040132	·999194	·040164	24·8978	1·00081	24·9179	42
19	·040422	·999183	·040456	24·7185	1·00082	24·7387	41
20	·040713	·999171	·040747	24·5418	1·00083	24·5621	40
21	·041004	·999159	·041038	24·3675	1·00084	24·3880	39
22	·041294	·999147	·041330	24·1957	1·00085	24·2164	38
23	·041585	·999135	·041621	24·0263	1·00087	24·0471	37
24	·041876	·999123	·041912	23·8593	1·00088	23·8802	36
25	·042166	·999111	·042204	23·6945	1·00089	23·7156	35
26	·042457	·999098	·042495	23·5321	1·00090	23·5533	34
27	·042748	·999086	·042787	23·3718	1·00091	23·3932	33
28	·043038	·999073	·043078	23·2137	1·00093	23·2352	32
29	·043329	·999061	·043370	23·0577	1·00094	23·0794	31
30	·043619	·999048	·043661	22·9038	1·00095	22·9256	30
31	·043910	·999035	·043952	22·7519	1·00097	22·7739	29
32	·044201	·999023	·044244	22·6020	1·00098	22·6241	28
33	·044491	·999010	·044535	22·4541	1·00099	22·4764	27
34	·044782	·998997	·044827	22·3081	1·00100	22·3305	26
35	·045072	·998984	·045118	22·1640	1·00102	22·1865	25
36	·045363	·998971	·045410	22·0217	1·00103	22·0444	24
37	·045654	·998957	·045701	21·8813	1·00104	21·9041	23
38	·045944	·998944	·045993	21·7426	1·00106	21·7656	22
39	·046235	·998931	·046284	21·6056	1·00107	21·6288	21
40	·046525	·998917	·046576	21·4704	1·00108	21·4937	20
41	·046816	·998904	·046867	21·3369	1·00110	21·3603	19
42	·047106	·998890	·047159	21·2049	1·00111	21·2285	18
43	·047397	·998876	·047450	21·0747	1·00113	21·0984	17
44	·047688	·998862	·047742	20·9460	1·00114	20·9698	16
45	·047978	·998848	·048033	20·8188	1·00115	20·8428	15
46	·048269	·998834	·048325	20·6932	1·00117	20·7174	14
47	·048559	·998820	·048617	20·5691	1·00118	20·5934	13
48	·048850	·998806	·048908	20·4465	1·00120	20·4709	12
49	·049140	·998792	·049200	20·3253	1·00121	20·3499	11
50	·049431	·998778	·049491	20·2056	1·00122	20·2303	10
51	·049721	·998763	·049783	20·0872	1·00124	20·1121	9
52	·050012	·998749	·050075	19·9702	1·00125	19·9952	8
53	·050302	·998734	·050366	19·8546	1·00127	19·8798	7
54	·050593	·998719	·050658	19·7403	1·00128	19·7656	6
55	·050883	·998705	·050949	19·6273	1·00130	19·6528	5
56	·051174	·998690	·051241	19·5156	1·00131	19·5412	4
57	·051464	·998675	·051533	19·4051	1·00133	19·4309	3
58	·051755	·998660	·051824	19·2959	1·00134	19·3218	2
59	·052045	·998645	·052116	19·1879	1·00136	19·2140	1
60	·052336	·998630	·052408	19·0811	1·00137	19·1073	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·052336	·998630	·052408	19·0811	1·00137	19·1073	60
1	·052626	·998614	·052700	18·9755	1·00139	19·0019	59
2	·052917	·998599	·052991	18·8711	1·00140	18·8975	58
3	·053207	·998584	·053283	18·7678	1·00142	18·7944	57
4	·053498	·998568	·053575	18·6656	1·00143	18·6923	56
5	·053788	·998552	·053866	18·5645	1·00145	18·5914	55
6	·054079	·998537	·054158	18·4645	1·00147	18·4915	54
7	·054369	·998521	·054450	18·3655	1·00148	18·3927	53
8	·054660	·998505	·054742	18·2677	1·00150	18·2950	52
9	·054950	·998489	·055033	18·1708	1·00151	18·1983	51
10	·055241	·998473	·055325	18·0750	1·00153	18·1026	50
11	·055531	·998457	·055617	17·9802	1·00155	18·0079	49
12	·055822	·998441	·055909	17·8863	1·00156	17·9142	48
13	·056112	·998424	·056200	17·7934	1·00158	17·8215	47
14	·056402	·998408	·056492	17·7015	1·00159	17·7298	46
15	·056693	·998392	·056784	17·6106	1·00161	17·6389	45
16	·056983	·998375	·057076	17·5205	1·00163	17·5490	44
17	·057274	·998359	·057368	17·4314	1·00164	17·4600	43
18	·057564	·998342	·057660	17·3432	1·00166	17·3720	42
19	·057854	·998325	·057952	17·2558	1·00168	17·2848	41
20	·058145	·998308	·058243	17·1693	1·00169	17·1984	40
21	·058435	·998291	·058535	17·0837	1·00171	17·1130	39
22	·058726	·998274	·058827	16·9990	1·00173	17·0283	38
23	·059016	·998257	·059119	16·9150	1·00175	16·9446	37
24	·059306	·998240	·059411	16·8319	1·00176	16·8616	36
25	·059597	·998223	·059703	16·7496	1·00178	16·7794	35
26	·059887	·998205	·059995	16·6681	1·00180	16·6981	34
27	·060177	·998188	·060287	16·5874	1·00182	16·6175	33
28	·060468	·998170	·060579	16·5075	1·00183	16·5377	32
29	·060758	·998153	·060871	16·4283	1·00185	16·4587	31
30	·061049	·998135	·061163	16·3499	1·00187	16·3804	30
31	·061339	·998117	·061455	16·2722	1·00189	16·3029	29
32	·061629	·998099	·061747	16·1952	1·00190	16·2261	28
33	·061920	·998081	·062039	16·1190	1·00192	16·1500	27
34	·062201	·998063	·062331	16·0435	1·00194	16·0746	26
35	·062500	·998045	·062623	15·9687	1·00196	15·9999	25
36	·062791	·998027	·062915	15·8945	1·00198	15·9260	24
37	·063081	·998008	·063207	15·8211	1·00200	15·8527	23
38	·063371	·997990	·063499	15·7483	1·00201	15·7801	22
39	·063661	·997972	·063791	15·6762	1·00203	15·7081	21
40	·063952	·997953	·064083	15·6048	1·00205	15·6368	20
41	·064242	·997934	·064375	15·5340	1·00207	15·5661	19
42	·064532	·997916	·064667	15·4638	1·00209	15·4961	18
43	·064823	·997897	·064959	15·3943	1·00211	15·4267	17
44	·065113	·997878	·065251	15·3254	1·02213	15·3579	16
45	·065403	·997859	·065543	15·2571	1·00215	15·2898	15
46	·065693	·997840	·065836	15·1893	1·00216	15·2222	14
47	·065984	·997821	·066128	15·1222	1·00218	15·1553	13
48	·066274	·997801	·066420	15·0557	1·00220	15·0889	12
49	·066564	·997782	·066712	14·9898	1·00222	15·0231	11
50	·066854	·997763	·067004	14·9244	1·00224	14·9579	10
51	·067145	·997743	·067296	14·8596	1·00226	14·8932	9
52	·067435	·997724	·067589	14·7954	1·00228	14·8291	8
53	·067725	·997704	·067881	14·7317	1·00230	14·7656	7
54	·068015	·997684	·068173	14·6685	1·00232	14·7026	6
55	·068306	·997664	·068465	14·6059	1·00234	14·6401	5
56	·068596	·997645	·068758	14·5438	1·00236	14·5782	4
57	·068886	·997625	·069050	14·4823	1·00238	14·5168	3
58	·069176	·997604	·069342	14·4212	1·00240	14·4559	2
59	·069466	·997584	·069635	14·3607	1·00242	14·3955	1
60	·069756	·997564	·069927	14·3007	1·00244	14·3356	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	069756	997564	069927	14·3007	1·00244	14·3356	60
1	070047	997544	·070219	14·2411	1·00246	14·2762	59
2	·070337	997523	070512	14·1821	1·00248	14·2173	58
3	070627	997503	070804	14·1235	1·00250	14·1589	57
4	070917	·997482	071096	14·0655	1·00252	14·1010	56
5	071207	997462	·071389	14·0079	1·00254	14·0435	55
6	071497	997441	·071681	13·9507	1·00257	13·9865	54
7	071788	997420	071973	13·8940	1·00259	13·9300	53
8	·072078	·997399	072266	13·8378	1·00261	13·8739	52
9	072368	997378	072558	13·7821	1·00263	13·8183	51
10	072658	997357	072851	13·7267	1·00265	13·7631	50
11	072948	997336	073143	13·6719	1·00267	13·7084	49
12	073238	997314	073435	13·6174	1·00269	13·6541	48
13	073528	997293	073728	13·5634	1·00271	13·6002	47
14	073818	997272	074020	13·5098	1·00274	13·5463	46
15	074108	997250	074313	13·4566	1·00276	13·4937	45
16	074399	997229	074605	13·4039	1·00278	13·4411	44
17	074689	·997207	074898	13·3515	1·00280	13·3889	43
18	074979	997185	075190	13·2996	1·00282	13·3371	42
19	075269	997163	075483	13·2480	1·00284	13·2857	41
20	075559	997141	075775	13·1969	1·00287	13·2347	40
21	075849	997119	076068	13·1461	1·00289	13·1841	39
22	076139	997097	076361	13·0958	1·00291	13·1339	38
23	076429	997075	076653	13·0458	1·00293	13·0840	37
24	076719	997053	076946	12·9962	1·00296	13·0346	36
25	077009	997030	077238	12·9469	1·00298	12·9855	35
26	077299	997008	077531	12·8981	1·00300	12·9368	34
27	077589	996985	077824	12·8496	1·00302	12·8884	33
28	077879	996963	078116	12·8014	1·00305	12·8404	32
29	078169	996940	078409	12·7536	1·00307	12·7928	31
30	078459	996917	078702	12·7062	1·00309	12·7455	30
31	078749	996894	078994	12·6591	1·00312	12·6986	29
32	079039	996872	·079287	12·6124	1·00314	12·6520	28
33	079329	996848	079580	12·5660	1·00316	12·6057	27
34	079619	996825	079873	12·5199	1·00318	12·5598	26
35	079909	996802	080165	12·4742	1·00321	12·5142	25
36	080199	996779	080458	12·4288	1·00323	12·4690	24
37	080489	996756	080751	12·3838	1·00326	12·4241	23
38	080779	996732	081044	12·3390	1·00328	12·3795	22
39	081069	996709	081336	12·2946	1·00330	12·3352	21
40	081359	996685	081629	12·2505	1·00333	12·2913	20
41	081649	996661	081922	12·2067	1·00335	12·2476	19
42	081939	996637	082215	12·1632	1·00337	12·2043	18
43	082228	996614	·082508	12·1201	1·00340	12·1612	17
44	082518	996590	082801	12·0772	1·00342	12·1185	16
45	082808	996566	083094	12·0346	1·00345	12·0761	15
46	083098	996541	083386	11·9923	1·00347	12·0340	14
47	083388	996517	083679	11·9504	1·00350	11·9921	13
48	083678	996493	083972	11·9087	1·00352	11·9506	12
49	083968	·996468	084265	11·8673	1·00354	11·9093	11
50	084258	996444	084558	11·8262	1·00357	11·8684	10
51	084547	996419	084851	11·7853	1·00359	11·8277	9
52	084837	996395	085144	11·7448	1·00362	11·7873	8
53	·085127	996370	085437	11·7045	1·00364	11·7471	7
54	·085417	996345	085730	11·6645	1·00367	11·7073	6
55	085707	·996320	086023	11·6248	1·00369	11·6677	5
56	·085997	996295	086316	11·5853	1·00372	11·6284	4
57	086286	996270	086609	11·5461	1·00374	11·5893	3
58	086576	·996245	086902	11·5072	1·00377	11·5505	2
59	·086866	·996220	087196	11·4685	1·00379	11·5120	1
60	·087156	996195	087489	11·4301	1·00382	11·4737	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

SIX-FIGURE TRIGONOMETRICAL TABLES *continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	087156	996195	087489	11 4301	1 00382	11 4737	60
1	087446	996169	087782	11 3919	1 00385	11 4357	59
2	087735	996144	088075	11 3540	1 00387	11 3979	58
3	088025	996118	088368	11 3163	1 00390	11 3604	57
4	088315	996093	088661	11 2789	1 00392	11 3231	56
5	088605	·996067	088954	11 2417	1 00395	11 2861	55
6	088894	·996041	089248	11 2048	1 00397	11 2493	54
7	089184	·996015	089541	11 1681	1 00400	11 2128	53
8	089474	995989	089834	11 1316	1 00403	11 1765	52
9	089763	995963	090127	11 0954	1 00405	11 1404	51
10	090053	995937	090421	11 0594	1 00408	11 1045	50
11	090343	995911	090714	11 0237	1 00411	11 0689	49
12	090633	995884	091007	10 9882	1 00413	11 0336	48
13	090922	995858	091300	10 9529	1 00416	10 9984	47
14	091212	995832	091594	10 9178	1 00419	10 9635	46
15	091502	995805	091887	10 8829	1 00421	10 9288	45
16	091791	995778	092180	10 8483	1 00424	10 8943	44
17	092081	995752	092474	10 8139	1 00427	10 8600	43
18	092371	995725	092767	10 7797	1 00429	10 8260	42
19	092660	995698	093061	10 7457	1 00432	10 7921	41
20	092950	995671	093354	10 7119	1 00435	10 7585	40
21	093240	995644	093647	10 6783	1 00438	10 7251	39
22	093529	995616	093941	10 6450	1 00440	10 6919	38
23	093819	995589	094234	10 6118	1 00443	10 6589	37
24	094108	995562	094528	10 5789	1 00446	10 6261	36
25	094398	995535	094821	10 5462	1 00449	10 5935	35
26	094687	995507	095115	10 5136	1 00451	10 5611	34
27	094977	995479	095408	10 4813	1 00454	10 5289	33
28	095267	995452	095702	10 4491	1 00457	10 4969	32
29	095556	995424	095995	10 4172	1 00460	10 4650	31
30	095846	995396	096289	10 3854	1 00463	10 4334	30
31	096135	995368	096583	10 3538	1 00465	10 4020	29
32	096425	995340	·096876	10 3224	1 00468	10 3708	28
33	096714	995312	097170	10 2913	1 00471	10 3397	27
34	097004	995284	·097464	10 2602	1 00474	10 3089	26
35	097293	995256	097757	10 2294	1 00477	10 2782	25
36	097583	995227	098051	10 1988	1 00480	10 2477	24
37	097872	995199	098345	10 1683	1 00482	10 2174	23
38	098162	995170	098638	10 1381	1 00485	10 1873	22
39	098451	995142	098932	10 1080	1 00488	10 1573	21
40	·098741	995113	099226	10 0780	1 00491	10 1275	20
41	099030	995084	099519	10 0483	1 00494	10 0979	19
42	099320	995056	099813	10·0187	1 00497	10 0685	18
43	099609	995027	100107	9 98931	1 00500	10 0392	17
44	099899	994998	100401	9 96007	1 00503	10 0101	16
45	100188	994969	100695	9 93101	1 00506	9 98123	15
46	·100477	994939	·100989	9 90211	1 00509	9 95248	14
47	100767	994910	101282	9 87338	1 00512	9 92389	13
48	101056	994881	101576	9·84482	1 00515	9 89547	12
49	101346	994851	101870	9 81641	1 00518	9 86722	11
50	101635	994822	102164	9 78817	1 00521	9 83912	10
51	101924	·994792	102458	9 76009	1 00524	9 81119	9
52	102214	994762	102752	9 73217	1·00527	9·78341	8
53	·102503	·994733	103046	9·70441	1 00530	9 75579	7
54	102793	994703	103340	9 67680	1 00533	9 72833	6
55	103082	994673	103634	9 64935	1 00536	9·70103	5
56	103371	·994643	103928	9 62205	1 00539	9 67387	4
57	·103661	·994613	104222	9 59490	1 00542	9 64687	3
58	·103950	994583	·104516	9 56791	1 00545	9 62002	2
59	104239	·994552	·104810	9 54106	1 00548	9·59332	1
60	·104528	·994522	·105104	9 51436	1 00551	9·56677	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·104528	·994522	·105104	9·51436	1·00551	9·56677	60
1	·104818	·994491	·105398	9·48781	1·00554	9·54307	59
2	·105107	·994461	·105692	9·46141	1·00557	9·51411	58
3	·105396	·994430	·105987	9·43515	1·00560	9·48800	57
4	·105686	·994400	·106281	9·40904	1·00563	9·46203	56
5	·105975	·994369	·106575	9·38307	1·00566	9·43620	55
6	·106264	·994338	·106869	9·35724	1·00569	9·41052	54
7	·106553	·994307	·107163	9·33155	1·00573	9·38497	53
8	·106843	·994276	·107458	9·30599	1·00576	9·35957	52
9	·107132	·994245	·107752	9·28058	1·00579	9·33430	51
10	·107421	·994214	·108046	9·25530	1·00582	9·30917	50
11	·107710	·994182	·108340	9·23016	1·00585	9·28417	49
12	·107999	·994151	·108635	9·20516	1·00588	9·25931	48
13	·108289	·994120	·108929	9·18028	1·00592	9·23459	47
14	·108578	·994088	·109223	9·15554	1·00595	9·20999	46
15	·108867	·994056	·109518	9·13093	1·00598	9·18553	45
16	·109156	·994025	·109812	9·10646	1·00601	9·16120	44
17	·109445	·993993	·110107	9·08211	1·00604	9·13699	43
18	·109734	·993961	·110401	9·05789	1·00608	9·11292	42
19	·110023	·993929	·110695	9·03379	1·00611	9·08897	41
20	·110313	·993897	·110990	9·00983	1·00614	9·06515	40
21	·110602	·993865	·111284	8·98598	1·00617	9·04146	39
22	·110891	·993833	·111579	8·96227	1·00621	9·01788	38
23	·111180	·993800	·111873	8·93867	1·00624	8·99444	37
24	·111469	·993768	·112168	8·91520	1·00627	8·97111	36
25	·111758	·993735	·112463	8·89185	1·00630	8·94791	35
26	·112047	·993703	·112757	8·86862	1·00634	8·92482	34
27	·112336	·993670	·113052	8·84551	1·00637	8·90186	33
28	·112625	·993638	·113346	8·82252	1·00640	8·87901	32
29	·112914	·993605	·113641	8·79964	1·00644	8·85628	31
30	·113203	·993572	·113936	8·77689	1·00647	8·83367	30
31	·113492	·993539	·114230	8·75425	1·00650	8·81118	29
32	·113781	·993506	·114525	8·73172	1·00654	8·78880	28
33	·114070	·993473	·114820	8·70931	1·00657	8·76653	27
34	·114359	·993439	·115114	8·68701	1·00660	8·74438	26
35	·114648	·993406	·115409	8·66482	1·00664	8·72234	25
36	·114937	·993373	·115704	8·64275	1·00667	8·70041	24
37	·115226	·993339	·115999	8·62078	1·00671	8·67859	23
38	·115515	·993306	·116294	8·59893	1·00674	8·65688	22
39	·115804	·993272	·116588	8·57718	1·00677	8·63528	21
40	·116093	·993238	·116883	8·55555	1·00681	8·61379	20
41	·116382	·993205	·117178	8·53402	1·00684	8·59241	19
42	·116671	·993171	·117473	8·51259	1·00688	8·57113	18
43	·116960	·993137	·117768	8·49128	1·00691	8·54996	17
44	·117249	·993103	·118063	8·47007	1·00695	8·52889	16
45	·117537	·993068	·118358	8·44896	1·00698	8·50793	15
46	·117826	·993034	·118653	8·42795	1·00701	8·48707	14
47	·118115	·993000	·118948	8·40705	1·00705	8·46632	13
48	·118404	·992966	·119243	8·38625	1·00708	8·44566	12
49	·118693	·992931	·119538	8·36555	1·00712	8·42511	11
50	·118982	·992896	·119833	8·34496	1·00715	8·40466	10
51	·119270	·992862	·120128	8·32446	1·00719	8·38431	9
52	·119559	·992827	·120423	8·30406	1·00722	8·36405	8
53	·119848	·992792	·120718	8·28376	1·00726	8·34390	7
54	·120137	·992757	·121013	8·26355	1·00730	8·32384	6
55	·120426	·992722	·121309	8·24345	1·00733	8·30388	5
56	·120714	·992687	·121604	8·22344	1·00737	8·28402	4
57	·121003	·992652	·121899	8·20352	1·00740	8·26425	3
58	·121292	·992617	·122194	8·18370	1·00744	8·24457	2
59	·121581	·992582	·122489	8·16398	1·00747	8·22500	1
60	·121869	·992546	·122785	8·14435	1·00751	8·20551	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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Six-Figure Trigonometrical Tables—*continued*

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·121869	992546	122785	8·14435	1 00751	8 20551	60
1	·122158	·992511	·123080	8·12481	1 00755	8 18612	59
2	·122447	992475	·123375	8 10536	1 00758	8·16681	58
3	·122735	·992439	123670	8 08600	1 00762	8 14760	57
4	·123024	·992404	·123966	8·06674	1 00765	8 12849	56
5	·123313	992368	·124261	8·04756	1 00769	8 10946	55
6	·123601	992332	·124557	8 02848	1 00773	8 09052	54
7	·123890	·992296	·124852	8 00948	1 00776	8 07167	53
8	·124179	992260	·125147	7 99058	1 00780	8 05291	52
9	·124467	992224	·125443	7 97176	1 00784	8 03423	51
10	·124756	992187	·125738	7 95302	1 00787	8 01564	50
11	·125045	992151	·126034	7·93438	1 00791	7 99714	49
12	·125333	·992115	·126329	7 91582	1 00795	7·97873	48
13	·125622	·992078	·126625	7 89734	1 00799	7·96040	47
14	·125910	·992042	126920	7·87895	1 00802	7·94216	46
15	·126199	·992005	·127216	7 86064	1·00806	7 92400	45
16	·126488	·991968	·127512	7 84242	1 00810	7 90592	44
17	·126776	991931	·127807	7 82428	1·00813	7 88792	43
18	·127065	·991894	·128103	7 80622	1·00817	7·87001	42
19	·127353	·991857	128399	7·78825	1 00821	7 85218	41
20	·127642	·991820	·128694	7 77035	1·00825	7 83443	40
21	·127930	991783	·128990	7 75254	1 00828	7 81677	39
22	·128219	991746	·129286	7 73480	1 00832	7·79918	38
23	·128507	·991709	·129582	7·71715	1 00836	7·78167	37
24	·128796	991671	·129877	7 69957	1 00840	7·76424	36
25	·129084	·991634	130173	7 68208	1 00844	7 74689	35
26	129373	·991596	130469	7·66466	1 00848	7·72962	34
27	·129661	·991558	130765	7 64732	1 00851	7 71242	33
28	·129949	·991521	·131061	7·63005	1 00855	7 69530	32
29	·130238	991483	·131357	7 61287	·00859	7·67826	31
30	130526	991445	·131652	7 59575	1 00863	7 66130	30
31	·130815	·991407	131948	7·57872	1 00867	7·64441	29
32	·131103	·991369	·132244	7·56176	1·00871	7·62759	28
33	·131391	·991331	·132540	7·54487	1·00875	7·61085	27
34	·131680	991292	·132836	7 52806	1 00878	7 59418	26
35	·131968	991254	·133132	7 51132	1 00882	7·57759	25
36	·132256	991216	·133428	7 49465	1 00886	7 56107	24
37	·132545	991177	·133725	7·47806	1 00890	7 54462	23
38	·132833	·991138	·134021	7 46154	1·00894	7 52825	22
39	·133121	991100	·134317	7 44509	1·00898	7 51194	21
40	·133410	991061	·134613	7·42871	1·00902	7·49571	20
41	·133698	991022	134909	7 41240	1·00906	7·47955	19
42	133986	·990983	·135205	7 39616	1·00910	7·46346	18
43	·134274	·990944	·135502	7 37999	1 00914	7·44743	17
44	·134563	·990905	135798	7 36389	1 00918	7·43148	16
45	·134851	990866	·136094	7·34786	1·00922	7·41560	15
46	·135139	990827	·136390	7·33190	1 00926	7·39978	14
47	·135427	·990787	·136687	7·31600	1 00930	7·38403	13
48	·135716	·990748	·136983	7·30018	1·00934	7·36835	12
49	·136004	·990708	137279	7 28442	1 00938	7·35274	11
50	·136292	·990669	·137576	7 26873	1·00942	7·33719	10
51	·136580	·990629	·137872	7 25310	1 00946	7·32171	9
52	·136868	·990589	·138169	7·23754	1·00950	7·30630	8
53	·137156	·990549	·138465	7 22204	1 00954	7 29095	7
54	·137445	990509	·138761	7·20661	1 00958	7·27566	6
55	·137733	·990469	·139058	7·19125	1·00962	7·26044	5
56	·138021	·990429	·139354	7·17594	1 00966	7·24529	4
57	·138309	·990389	·139651	7·16071	1·00970	7·23019	3
58	·138597	·990349	·139948	7·14553	1 00975	7·21517	2
59	·138885	·990309	·140244	7·13042	1·00979	7·20020	1
60	·139173	·990268	·140541	7·11537	1·00983	7 18530	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·139173	·990268	·140541	7·11537	1·00983	7·18530	60
1	·139461	·990228	·140838	7·10038	1·00987	7·17046	59
2	·139749	·990187	·141134	7·08546	1·00991	7·15568	58
3	·140037	·990146	·141431	7·07059	1·00995	7·14096	57
4	·140325	·990105	·141728	7·05579	1·00999	7·12630	56
5	·140613	·990065	·142024	7·04105	1·01004	7·11171	55
6	·140901	·990024	·142321	7·02637	1·01008	7·09717	54
7	·141189	·989983	·142618	7·01174	1·01012	7·08269	53
8	·141477	·989942	·142915	6·99718	1·01016	7·06828	52
9	·141765	·989900	·143212	6·98268	1·01020	7·05392	51
10	·142053	·989859	·143508	6·96823	1·01024	7·03962	50
11	·142341	·989818	·143805	6·95385	1·01029	7·02538	49
12	·142629	·989776	·144102	6·93952	1·01033	7·01120	48
13	·142917	·989735	·144399	6·92525	1·01037	6·99708	47
14	·143205	·989693	·144696	6·91104	1·01041	6·98301	46
15	·143493	·989651	·144993	6·89688	1·01046	6·96900	45
16	·143780	·989610	·145290	6·88278	1·01050	6·95505	44
17	·144068	·989568	·145587	6·86874	1·01054	6·94115	43
18	·144356	·989526	·145884	6·85475	1·01059	6·92731	42
19	·144644	·989484	·146181	6·84082	1·01063	6·91352	41
20	·144932	·989442	·146478	6·82694	1·01067	6·89979	40
21	·145220	·989399	·146776	6·81312	1·01071	6·88612	39
22	·145507	·989357	·147073	6·79936	1·01076	6·87250	38
23	·145795	·989315	·147370	6·78564	1·01080	6·85893	37
24	·146083	·989272	·147667	6·77199	1·01084	6·84542	36
25	·146371	·989230	·147964	6·75838	1·01089	6·83196	35
26	·146659	·989187	·148262	6·74483	1·01093	6·81856	34
27	·146946	·989144	·148559	6·73133	1·01097	6·80521	33
28	·147234	·989102	·148856	6·71789	1·01102	6·79191	32
29	·147522	·989059	·149154	6·70450	1·01106	6·77866	31
30	·147809	·989016	·149451	6·69116	1·01111	6·76547	30
31	·148097	·988973	·149748	6·67787	1·01115	6·75233	29
32	·148385	·988930	·150046	6·66463	1·01119	6·73924	28
33	·148672	·988886	·150343	6·65144	1·01124	6·72620	27
34	·148960	·988843	·150641	6·63831	1·01128	6·71321	26
35	·149248	·988800	·150938	6·62523	1·01133	6·70027	25
36	·149535	·988756	·151236	6·61219	1·01137	6·68738	24
37	·149823	·988713	·151533	6·59921	1·01142	6·67454	23
38	·150111	·988669	·151831	6·58627	1·01146	6·66176	22
39	·150398	·988626	·152129	6·57339	1·01151	6·64902	21
40	·150686	·988582	·152426	6·56055	1·01155	6·63633	20
41	·150973	·988538	·152724	6·54777	1·01160	6·62369	19
42	·151261	·988494	·153022	6·53503	1·01164	6·61110	18
43	·151548	·988450	·153319	6·52234	1·01169	6·59855	17
44	·151836	·988406	·153617	6·50970	1·01173	6·58606	16
45	·152123	·988362	·153915	6·49710	1·01178	6·57361	15
46	·152411	·988317	·154213	6·48456	1·01182	6·56121	14
47	·152698	·988273	·154510	6·47206	1·01187	6·54886	13
48	·152986	·988228	·154808	6·45961	1·01191	6·53655	12
49	·153273	·988184	·155106	6·44720	1·01196	6·52429	11
50	·153561	·988139	·155404	6·43484	1·01200	6·51208	10
51	·153848	·988094	·155702	6·42253	1·01205	6·49991	9
52	·154136	·988050	·156000	6·41026	1·01209	6·48779	8
53	·154423	·988005	·156298	6·39804	1·01214	6·47572	7
54	·154710	·987960	·156596	6·38587	1·01219	6·46369	6
55	·154998	·987915	·156894	6·37374	1·01223	6·45171	5
56	·155285	·987870	·157192	6·36165	1·01228	6·43977	4
57	·155572	·987824	·157490	6·34961	1·01233	6·42787	3
58	·155860	·987779	·157788	6·33761	1·01237	6·41602	2
59	·156147	·987734	·158086	6·32566	1·01242	6·40422	1
60	·156434	·987688	·158384	6·31375	1·01247	6·39245	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·156434	·987688	·158384	6·31375	1·01247	6·39245	60
1	·156722	·987643	·158683	6·30189	1·01251	6·38073	59
2	·157009	·987597	·158981	6·29007	1·01256	6·36906	58
3	·157296	·987551	·159279	6·27829	1·01261	6·35743	57
4	·157584	·987506	·159577	6·26655	1·01265	6·34584	56
5	·157871	·987460	·159876	6·25486	1·01270	6·33429	55
6	·158158	·987414	·160174	6·24321	1·01275	6·32279	54
7	·158445	·987368	·160472	6·23160	1·01279	6·31133	53
8	·158732	·987322	·160771	6·22003	1·01284	6·29991	52
9	·159020	·987275	·161069	6·20851	1·01289	6·28853	51
10	·159307	·987229	·161368	6·19703	1·01294	6·27719	50
11	·159594	·987183	·161666	6·18559	1·01298	6·26590	49
12	·159881	·987136	·161965	6·17419	1·01303	6·25464	48
13	·160168	·987090	·162263	6·16283	1·01308	6·24343	47
14	·160455	·987043	·162562	6·15151	1·01313	6·23226	46
15	·160743	·986996	·162860	6·14023	1·01317	6·22113	45
16	·161030	·986950	·163159	6·12899	1·01322	6·21004	44
17	·161317	·986903	·163458	6·11779	1·01327	6·19898	43
18	·161604	·986856	·163756	6·10664	1·01332	6·18797	42
19	·161891	·986809	·164055	6·09552	1·01337	6·17700	41
20	·162178	·986762	·164354	6·08444	1·01342	6·16607	40
21	·162465	·986714	·164652	6·07340	1·01346	6·15517	39
22	·162752	·986667	·164951	6·06240	1·01351	6·14432	38
23	·163039	·986620	·165250	6·05143	1·01356	6·13350	37
24	·163326	·986572	·165549	6·04051	1·01361	6·12273	36
25	·163613	·986525	·165848	6·02962	1·01366	6·11199	35
26	·163900	·986477	·166147	6·01878	1·01371	6·10128	34
27	·164187	·986429	·166446	6·00797	1·01376	6·09062	33
28	·164474	·986381	·166745	5·99720	1·01381	6·08000	32
29	·164761	·986334	·167044	5·98646	1·01386	6·06941	31
30	·165048	·986286	·167343	5·97576	1·01391	6·05886	30
31	·165334	·986238	·167642	5·96510	1·01395	6·04834	29
32	·165621	·986189	·167941	5·95448	1·01400	6·03787	28
33	·165908	·986141	·168240	5·94390	1·01405	6·02743	27
34	·166195	·986093	·168539	5·93335	1·01410	6·01702	26
35	·166482	·986045	·168838	5·92283	1·01415	6·00666	25
36	·166769	·985996	·169137	5·91236	1·01420	5·99633	24
37	·167056	·985947	·169437	5·90191	1·01425	5·98603	23
38	·167342	·985899	·169736	5·89151	1·01430	5·97577	22
39	·167629	·985850	·170035	5·88114	1·01435	5·96555	21
40	·167916	·985801	·170334	5·87080	1·01440	5·95536	20
41	·168203	·985752	·170634	5·86051	1·01445	5·94521	19
42	·168489	·985703	·170933	5·85024	1·01450	5·93509	18
43	·168776	·985654	·171232	5·84001	1·01455	5·92501	17
44	·169063	·985605	·171532	5·82982	1·01461	5·91496	16
45	·169350	·985556	·171831	5·81966	1·01466	5·90495	15
46	·169636	·985507	·172131	5·80953	1·01471	5·89497	14
47	·169923	·985457	·172430	5·79944	1·01476	5·88502	13
48	·170210	·985408	·172730	5·78938	1·01481	5·87511	12
49	·170496	·985358	·173030	5·77936	1·01486	5·86524	11
50	·170783	·985309	·173329	5·76937	1·01491	5·85539	10
51	·171069	·985259	·173629	5·75941	1·01496	5·84558	9
52	·171356	·985209	·173928	5·74949	1·01501	5·83581	8
53	·171643	·985159	·174228	5·73960	1·01506	5·82606	7
54	·171929	·985109	·174528	5·72974	1·01512	5·81635	6
55	·172216	·985059	·174828	5·71992	1·01517	5·80667	5
56	·172502	·985009	·175128	5·71013	1·01522	5·79703	4
57	·172789	·984959	·175427	5·70037	1·01527	5·78742	3
58	·173075	·984909	·175727	5·69064	1·01532	5·77784	2
59	·173362	·984858	·176027	5·68094	1·01537	5·76829	1
60	·173648	·984808	·176327	5·67128	1·01543	5·75877	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·173648	·984808	·176327	5·67128	1·01543	5·75877	60
1	·173935	·984757	·176627	5·66165	1·01548	5·74929	59
2	·174221	·984707	·176927	5·65205	1·01553	5·73983	58
3	·174508	·984656	·177227	5·64248	1·01558	5·73041	57
4	·174794	·984605	·177527	5·63295	1·01564	5·72102	56
5	·175080	·984554	·177827	5·62344	1·01569	5·71166	55
6	·175367	·984503	·178127	5·61397	1·01574	5·70234	54
7	·175653	·984452	·178427	5·60452	1·01579	5·69304	53
8	·175939	·984401	·178727	5·59511	1·01585	5·68377	52
9	·176226	·984350	·179028	5·58573	1·01590	5·67454	51
10	·176512	·984298	·179328	5·57638	1·01595	5·66533	50
11	·176798	·984247	·179628	5·56706	1·01601	5·65616	49
12	·177085	·984196	·179928	5·55777	1·01606	5·64701	48
13	·177371	·984144	·180229	5·54851	1·01611	5·63790	47
14	·177657	·984092	·180529	5·53927	1·01616	5·62881	46
15	·177944	·984041	·180829	5·53007	1·01622	5·61976	45
16	·178230	·983989	·181130	5·52090	1·01627	5·61073	44
17	·178516	·983937	·181430	5·51176	1·01633	5·60174	43
18	·178802	·983885	·181731	5·50264	1·01638	5·59277	42
19	·179088	·983833	·182031	5·49356	1·01643	5·58383	41
20	·179375	·983781	·182332	5·48451	1·01649	5·57493	40
21	·179661	·983729	·182632	5·47548	1·01654	5·56605	39
22	·179947	·983676	·182933	5·46648	1·01659	5·55720	38
23	·180233	·983624	·183234	5·45751	1·01665	5·54837	37
24	·180519	·983571	·183534	5·44857	1·01670	5·53958	36
25	·180805	·983519	·183835	5·43966	1·01676	5·53081	35
26	·181091	·983466	·184136	5·43077	1·01681	5·52208	34
27	·181377	·983414	·184437	5·42192	1·01687	5·51337	33
28	·181663	·983361	·184737	5·41309	1·01692	5·50468	32
29	·181950	·983308	·185038	5·40429	1·01698	5·49603	31
30	·182236	·983255	·185339	5·39552	1·01703	5·48740	30
31	·182522	·983202	·185640	5·38677	1·01709	5·47881	29
32	·182808	·983149	·185941	5·37805	1·01714	5·47023	28
33	·183094	·983096	·186242	5·36936	1·01720	5·46169	27
34	·183379	·983042	·186543	5·36070	1·01725	5·45317	26
35	·183665	·982989	·186844	5·35206	1·01731	5·44468	25
36	·183951	·982935	·187145	5·34345	1·01736	5·43622	24
37	·184237	·982882	·187446	5·33487	1·01742	5·42778	23
38	·184523	·982828	·187747	5·32631	1·01747	5·41937	22
39	·184809	·982774	·188048	5·31778	1·01753	5·41099	21
40	·185095	·982721	·188349	5·30928	1·01758	5·40263	20
41	·185381	·982667	·188651	5·30080	1·01764	5·39430	19
42	·185667	·982613	·188952	5·29235	1·01769	5·38600	18
43	·185952	·982559	·189253	5·28393	1·01775	5·37772	17
44	·186238	·982505	·189555	5·27553	1·01781	5·36947	16
45	·186524	·982450	·189856	5·26715	1·01786	5·36124	15
46	·186810	·982396	·190157	5·25880	1·01792	5·35304	14
47	·187096	·982342	·190459	5·25048	1·01798	5·34486	13
48	·187381	·982287	·190760	5·24218	1·01803	5·33671	12
49	·187667	·982233	·191062	5·23391	1·01809	5·01809	11
50	·187953	·982178	·191363	5·22566	1·01815	5·32049	10
51	·188238	·982123	·191665	5·21744	1·01820	5·31241	9
52	·188524	·982069	·191966	5·20925	1·01826	5·30436	8
53	·188810	·982014	·192268	5·20107	1·01832	5·29634	7
54	·189095	·981959	·192570	5·19293	1·01837	5·28833	6
55	·189381	·981904	·192871	5·18480	1·01843	5·28036	5
56	·189667	·981849	·193173	5·17671	1·01849	5·27241	4
57	·189952	·981793	·193475	5·16863	1·01854	5·26448	3
58	·190238	·981738	·193777	5·16058	1·01860	5·25658	2
59	·190523	·981683	·194078	5·15256	1·01866	5·24870	1
60	·190809	·981627	·194380	5·14455	1·01872	5·24084	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·190809	·981627	·194380	5·14455	1·01872	5·24084	60
1	191095	·981572	·194682	5·13658	1·01877	5·23301	59
2	·191380	·981516	·194984	5·12862	1·01883	5·22521	58
3	·191666	·981460	·195286	5·12069	1 01889	5·21742	57
4	·191951	·981404	·195588	5·11279	1·01895	5·20966	56
5	·192237	·981349	195890	5·10490	1 01901	5·20193	55
6	192522	·981293	·196192	5 09704	1·01906	5 19421	54
7	192807	·981237	·196494	5·08921	1 01912	5 18652	53
8	193093	·981180	·196796	5·08139	1·01918	5 17886	52
9	193378	·981124	·197099	5 07360	1 01924	5·17121	51
10	193664	·981068	·197401	5 06584	1 01930	5 16359	50
11	193949	·981012	·197703	5 05809	1 01936	5·15599	49
12	·194234	·980955	·198005	5 05037	1·01941	5·14842	48
13	194520	·980899	·198308	5 04267	1 01947	5·14087	47
14	·194805	·980842	·198610	5 03499	1 01953	5 13334	46
15	·195090	·980785	·198912	5 02734	1·01959	5·12583	45
16	·195376	·980728	·199215	5 01971	1 01965	5 11835	44
17	·195661	980672	199517	5 01210	1 01971	5 11088	43
18	195946	·980615	·199820	5 00451	1 01977	5 10344	42
19	·196231	980558	200122	4 99695	1 01983	5·09602	41
20	·196517	980550	200425	4 98940	1·01989	5 08863	40
21	·196802	·980443	·200727	4 98188	1 01995	5·08125	39
22	·197087	·980386	201030	4 97438	1 02001	5 07390	38
23	197372	·980329	201333	4·96690	1·02007	5·06657	37
24	·197657	980271	201635	4 95945	1 02013	5 05926	36
25	197942	980214	201938	4·95201	1 02019	5 05197	35
26	·198228	·980156	·202241	4 94460	1·02025	5 04471	34
27	·198513	·980098	202544	4·93721	1·02031	5 03746	33
28	·198798	·980041	·202847	4 92984	1 02037	5·03024	32
29	199083	979983	·203149	4 92249	1 02043	5·02303	31
30	199368	·979925	203452	4 91516	1 02049	5·01585	30
31	199653	979867	·203755	4 90785	1 02055	5·00869	29
32	199938	979809	204058	4·90056	1 02061	5 00155	28
33	·200223	·979750	·204361	4 89330	1·02067	4 99443	27
34	·200508	979692	204664	4·88605	1 02073	4 98733	26
35	·200793	·979634	204967	4 87882	1·02079	4·98025	25
36	·201078	979575	205271	4 87162	1 02085	4·97320	24
37	·201363	·979517	·205574	4 86444	1 02091	4 96616	23
38	·201648	979458	·205877	4 85727	1·02097	4 95914	22
39	·201933	·979399	·206180	4 85013	1·02103	4·95215	21
40	·202218	979341	·206483	4·84300	1 02110	4 94517	20
41	·202502	·979282	·206787	4 83590	1·02116	4 93821	19
42	·202787	·979223	·207090	4·82882	1 02122	4·93128	18
43	·203072	979164	·207393	4 82175	1·02128	4·92436	17
44	·203357	979105	·207697	4 81471	1·02134	4·91746	16
45	·203642	·979045	·208000	4 80769	1·02140	4·91058	15
46	·203927	·978986	·208304	4·80068	1·02146	4·90373	14
47	·204211	978927	·208607	4·79370	1·02153	4·89689	13
48	·204496	·978867	·208911	4·78673	1·02159	4·89007	12
49	204781	·978808	·209214	4·77978	1·02165	4 88327	11
50	·205065	978748	·209518	4·77286	1·02171	4·87649	10
51	·205350	·978689	·209822	4·76595	1·02178	4·86973	9
52	·205635	·978629	·210126	4 75906	1·02184	4·86299	8
53	·205920	·978569	·210429	4·75219	1·02190	4 85627	7
54	·206204	·978509	·210733	4·74534	1·02196	4·84956	6
55	·206489	·978449	·211037	4·73851	1·02203	4·84288	5
56	206773	·978389	·211341	4·73170	1·02209	4·83621	4
57	·207058	·978329	·211645	4·72490	1·02215	4·82956	3
58	·207343	·978268	·211949	4·71813	1·02221	4·82294	2
59	·207627	·978208	·212253	4·71137	1·02228	4·81633	1
60	·207912	·978148	·212557	4·70463	1·02234	4·80973	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·207912	·978148	·212557	4·70463	1·02234	4·80973	60
1	·208196	·978087	·212861	4·69791	1·02240	4·80316	59
2	·208481	·979026	·213165	4·69121	1·02247	4·79661	58
3	·208765	·977966	·213469	4·68452	1·02253	4·79007	57
4	·209050	·977905	·213773	4·67786	1·02259	4·78355	56
5	·209334	·977844	·214077	4·67121	1·02266	4·77705	55
6	·209619	·977783	·214381	4·66458	1·02272	4·77057	54
7	·209903	·977722	·214686	4·65797	1·02279	4·76411	53
8	·210187	·977661	·214990	4·65138	1·02285	4·75766	52
9	·210472	·977600	·215294	4·64480	1·02291	4·75123	51
10	·210756	·977539	·215599	4·63825	1·02298	4·74482	50
11	·211040	·977477	·215093	4·63171	1·02304	4·73843	49
12	·211325	·977416	·216208	4·62518	1·02311	4·73205	48
13	·211609	·997354	·216512	4·61868	1·02317	4·72569	47
14	·211893	·977293	·216817	4·61219	1·02323	4·71935	46
15	·212178	·977231	·217121	4·60572	1·02330	4·71303	45
16	·212462	·977169	·217426	4·59927	1·02336	4·70673	44
17	·212746	·977108	·217731	4·59283	1·02343	4·70044	43
18	·213030	·977046	·218035	4·58641	1·02349	4·69417	42
19	·213315	·976984	·218340	4·58001	1·02356	4·68791	41
20	·213599	·976921	·218645	4·57363	1·02363	4·68167	40
21	·213883	·976859	·218950	4·56726	1·02369	4·67545	39
22	·214167	·976797	·219254	4·56091	1·02375	4·66925	38
23	·214451	·976735	·219559	4·55458	1·02382	4·66307	37
24	·214735	·976672	·219864	4·54826	1·02388	4·65690	36
25	·215019	·976610	·220169	4·54196	1·02395	4·65074	35
26	·215304	·976547	·220474	4·53568	1·02402	4·64461	34
27	·215588	·976484	·220779	4·52941	1·02408	4·63849	33
28	·215872	·976422	·221084	4·52316	1·02415	4·63238	32
29	·216156	·976359	·221390	4·51693	1·02421	4·62630	31
30	·216440	·976296	·221695	4·51071	1·02428	4·62023	30
31	·216724	·976233	·222000	4·50451	1·02435	4·61417	29
32	·217008	·976170	·222305	4·49832	1·02441	4·60813	28
33	·217292	·976107	·222610	4·49215	1·02448	4·60211	27
34	·217575	·976044	·222916	4·48600	1·02454	4·59611	26
35	·217859	·975980	·223221	4·47986	1·02461	4·59012	25
36	·218143	·975917	·223526	4·47374	1·02468	4·58414	24
37	·218427	·975853	·223832	4·46764	1·02474	4·57819	23
38	·218711	·975790	·224137	4·46155	1·02481	4·57224	22
39	·218995	·975726	·224443	4·45548	1·02488	4·56632	21
40	·219279	·975662	·224749	4·44942	1·02494	4·56041	20
41	·219562	·975598	·225054	4·44338	1·02501	4·55451	19
42	·219846	·975535	·225360	4·43735	1·02508	4·54863	18
43	·220130	·975471	·225665	4·43134	1·02515	4·54277	17
44	·220414	·975406	·225971	4·42534	1·02521	4·53692	16
45	·220697	·975342	·226277	4·41936	1·02528	4·53109	15
46	·220981	·975278	·226583	4·41340	1·02535	4·52527	14
47	·221265	·975214	·226889	4·40745	1·02542	4·51947	13
48	·221548	·975149	·227194	4·40152	1·02548	4·51368	12
49	·221832	·975085	·227500	4·39560	1·02555	4·50791	11
50	·222116	·975020	·227806	4·38969	1·02562	4·50216	10
51	·222399	·974956	·228112	4·38381	1·02569	4·49642	9
52	·222683	·974891	·228418	4·37793	1·02576	4·49069	8
53	·222967	·974826	·228724	4·37207	1·02582	4·48498	7
54	·223250	·974761	·229031	4·36623	1·02589	4·47928	6
55	·223534	·974696	·229337	4·36040	1·02596	4·47360	5
56	·223817	·974631	·229643	4·35459	1·02603	4·46793	4
57	·224101	·974566	·229949	4·34879	1·02610	4·46228	3
58	·224384	·974501	·230255	4·34300	1·02617	4·45664	2
59	·224668	·974435	·230562	4·33723	1·02624	4·45102	1
60	·224951	·974370	·230868	4·33148	1·02630	4·44541	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·224951	·974370	·230868	4·33148	1·02630	4·44541	60
1	·225234	·974305	·231175	4 32573	1·02637	4·43982	59
2	·225518	·974239	·231481	4 32001	1·02644	4·43424	58
3	·225801	·974173	·231788	4·31430	1·02651	4·42867	57
4	·226085	·974108	·232094	4 30860	1 02658	4·42312	56
5	·226368	·974042	·232401	4·30291	1·02665	4·41759	55
6	226651	·973976	·232707	4 29724	1·02672	4·41206	54
7	·226935	·973910	233014	4 29159	1 02679	4 40656	53
8	·227218	·973844	233321	4 28595	1 02686	4·40106	52
9	·227501	·973778	233627	4 28032	1 02693	4·39558	51
10	·227784	·973712	233934	4 27471	1·02700	4·39012	50
11	·228068	·973645	·234241	4·26911	1 02707	4·38466	49
12	·228351	·973579	·234548	4·26352	1·02714	4·37923	48
13	·228634	·973512	234855	4 25795	1 02721	4·37380	47
14	·228917	·973446	·235162	4 25239	1 02728	4·36839	46
15	·229200	973379	·235469	4 24685	1 02735	4·36299	45
16	·229484	·973313	235776	4 24132	1 02742	4 35761	44
17	·229767	·973246	·236083	4·23580	1·02749	4·35224	43
18	·230050	·973179	·236390	4 23030	1·02756	4 34689	42
19	·230333	·973112	236697	4 22481	1 02763	4·34154	41
20	·230616	·973045	·237004	4 21933	1 02770	4·33622	40
21	·230899	972978	237312	4 21387	1 02777	4·33090	39
22	·231182	972911	237619	4 20842	1 02784	4·32560	38
23	·231465	972843	237926	4·20298	1·02791	4 32031	37
24	·231748	·972776	238234	4 19756	1·02799	4·31503	36
25	·232031	972708	·238541	4·19215	1·02806	4·30977	35
26	·232314	·972641	·238848	4 18675	1·02813	4·30452	34
27	·232597	·972573	·239156	4·18137	1·02820	4·29929	33
28	·232880	972506	·239464	4·17600	1·02827	4·29406	32
29	·233162	·972438	·239771	4·17064	1·02834	4 28885	31
30	·233445	·972370	·240079	4 16530	1·02842	4·28366	30
31	·233728	·972302	·240386	4·15997	1 02849	4 27847	29
32	·234011	·972234	·240694	4·15465	1·02856	4·27330	28
33	·234294	·972166	·241002	4·14934	1·02863	4 26814	27
34	·234577	·972098	·241310	4·14405	1 02870	4·26300	26
35	·234859	·972029	·241618	4·13877	1 02878	4 25787	25
36	·235142	·971961	241925	4·13350	1·02885	4 25275	24
37	·235425	·971893	242233	4 12825	1·02892	4 24764	23
38	·235708	·971824	242541	4 12301	1 02899	4 24255	22
39	·235990	·971755	·242849	4 11778	1 02907	4 23746	21
40	·236273	971687	·243157	4 11256	1·02914	4·23239	20
41	·236556	·971618	·243466	4 10736	1·02921	4·22734	19
42	·236838	·971549	·243774	4 10216	1·02928	4·22229	18
43	·237121	·971480	·244082	4 09699	1 02936	4·21726	17
44	·237403	·971411	·244390	4·09182	1·02943	4·21224	16
45	·237686	·971342	·244698	4·08666	1·02950	4·20723	15
46	·237968	·971273	·245007	4·08152	1 02958	4·20224	14
47	·238251	·971204	·245315	4·07639	1·02965	4·19725	13
48	·238533	·971134	·245624	4·07127	1·02972	4·19228	12
49	·238816	·971065	·245932	4 06616	1·02980	4·18733	11
50	·239098	·970995	·246241	4 06107	1·02987	4·18238	10
51	·239381	·970926	·246549	4·05599	1·02994	4·17744	9
52	·239663	·970856	·246858	4·05092	1·03002	4·17252	8
53	·239946	·970786	·247166	4 04586	1·03009	4·16761	7
54	·240228	·970176	·247475	4·04081	1·03017	4·16271	6
55	·240510	·970647	·247784	4·03578	1·03024	4 15782	5
56	·240793	·970577	·248092	4·03076	1·03032	4·15295	4
57	·241075	·970506	·248401	4·02574	1·03039	4·14809	3
58	·241357	·970436	·248710	4·02074	1·03046	4·14323	2
59	·241640	·970366	·249019	4·01576	1·03054	4·13839	1
60	·241922	970296	·249328	4 01078	1·03061	4·13357	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·241922	·970296	·249328	4·01078	1·03061	4·13357	60
1	·242204	·970225	·249637	4·00582	1·03069	4·12875	59
2	·242486	·970155	·249946	4·00086	1·03076	4·12394	58
3	·242769	·970084	·250255	3·99592	1·03084	4·11915	57
4	·243051	·970014	·250564	3·99099	1·03091	4·11437	56
5	·243333	·969943	·250873	3·98607	1·03099	4·10960	55
6	·243615	·969872	·251183	3·98117	1·03106	4·10484	54
7	·243897	·969801	·251492	3·97627	1·03114	4·10009	53
8	·244179	·969730	·251801	3·97139	1·03121	4·09535	52
9	·244461	·969659	·252111	3·96651	1·03129	4·09063	51
10	·244743	·969588	·252420	3·96165	1·03137	4·08591	50
11	·245025	·969517	·252729	3·95680	1·03144	4·08121	49
12	·245307	·969445	·253039	3·95196	1·03152	4·07652	48
13	·245589	·969374	·253348	3·94713	1·03159	4·07184	47
14	·245871	·969302	·253658	3·94232	1·03167	4·06717	46
15	·246153	·969231	·253968	3·93751	1·03175	4·06251	45
16	·246435	·969159	·254277	3·93271	1·03182	4·05786	44
17	·246717	·969088	·254587	3·92793	1·03190	4·05322	43
18	·246999	·969016	·254897	3·92316	1·03197	4·04860	42
19	·247281	·968944	·255207	3·91839	1·03205	4·04398	41
20	·247563	·968872	·255517	3·91364	1·03213	4·03938	40
21	·247845	·968800	·255826	3·90890	1·03220	4·03479	39
22	·248126	·968728	·256136	3·90417	1·03228	4·03020	38
23	·248408	·968655	·256446	3·89945	1·03236	4·02563	37
24	·248690	·968583	·256756	3·89474	1·03244	4·02107	36
25	·248972	·968511	·257066	3·89004	1·03251	4·01652	35
26	·249253	·968438	·257377	3·88536	1·03259	4·01198	34
27	·249535	·968366	·257687	3·88068	1·03267	4·00745	33
28	·249817	·968293	·257997	3·87601	1·03275	4·00293	32
29	·250098	·968220	·258307	3·87136	1·03282	3·99843	31
30	·250380	·968148	·258618	3·86671	1·03290	3·99393	30
31	·250662	·968075	·258928	3·86208	1·03298	3·98944	29
32	·250943	·968002	·259238	3·85745	1·03306	3·98497	28
33	·251225	·967929	·259549	3·85284	1·03313	3·98050	27
34	·251506	·967856	·259859	3·84824	1·03321	3·97604	26
35	·251788	·967782	·260170	3·84364	1·03329	3·97160	25
36	·252069	·967709	·260480	3·83906	1·03337	3·96716	24
37	·252351	·967636	·260791	3·83449	1·03345	3·96274	23
38	·252632	·967562	·261102	3·82992	1·03353	3·95832	22
39	·252914	·967489	·261413	3·82537	1·03360	3·95392	21
40	·253195	·967415	·261723	3·82083	1·03368	3·94952	20
41	·253477	·967342	·262034	3·81630	1·03376	3·94514	19
42	·253758	·967268	·262345	3·81177	1·03384	3·94076	18
43	·254039	·967194	·262656	3·80726	1·03392	3·93640	17
44	·254321	·967120	·262967	3·80276	1·03400	3·93204	16
45	·254602	·967046	·263278	3·79827	1·03408	3·92770	15
46	·254883	·966972	·263589	3·79378	1·03416	3·92337	14
47	·255165	·966898	·263900	3·78931	1·03424	3·91904	13
48	·255446	·966823	·264211	3·78485	1·03432	3·91473	12
49	·255727	·966749	·264523	3·78040	1·03439	3·91042	11
50	·256008	·966675	·264834	3·77595	1·03447	3·90613	10
51	·256289	·966600	·265145	3·77152	1·03455	3·90184	9
52	·256571	·966526	·265457	3·76709	1·03463	3·89756	8
53	·256852	·966451	·265768	3·76268	1·03471	3·89330	7
54	·257133	·966376	·266079	3·75828	1·03479	3·88904	6
55	·257414	·966301	·266391	3·75388	1·03487	3·88479	5
56	·257695	·966226	·266702	3·74950	1·03495	3·88056	4
57	·257976	·966151	·267014	3·74512	1·03503	3·87633	3
58	·258257	·966076	·267362	3·74075	1·03511	3·87211	2
59	·258538	·966001	·267637	3·73640	1·03520	3·86790	1
60	·258819	·965926	·267949	3·73205	1·03528	3·86370	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	258819	965926	·267949	3 73025	1 03528	3 86370	60
1	·259100	·965850	·268261	3 72771	1·03536	3·85951	59
2	·259381	·965775	268573	3 72338	1·03544	3·85533	58
3	·259662	·965700	268885	3·71907	1 03552	3·85116	57
4	259943	·965624	·269197	3·71476	1 03560	3 84700	56
5	260224	·965548	·269509	3 71046	1 03568	3·84285	55
6	·260505	965473	·269821	3·70616	1 03576	3·83871	54
7	·260785	·965397	·270133	3 70188	1·03584	3·83457	53
8	·261066	965321	·270445	3 69761	1 03592	3·83045	52
9	·261347	965245	·270757	3 69335	1 03601	3 82633	51
10	261628	965169	271069	3 68909	1 03609	3 82223	50
11	261908	965093	·271382	3·68485	1·03617	3·81813	49
12	262189	965016	271694	3 68061	1 03625	3 81404	48
13	·262470	·964940	·272006	3·67638	1·03633	3·80996	47
14	·262751	964864	·272319	3·67217	1 03642	3·80589	46
15	·263031	964787	272631	3 66796	1 03650	3·80183	45
16	263312	964711	·272944	3 66376	1·03658	3·79778	44
17	·263592	964634	273256	3 65957	1 03666	3·79374	43
18	·263873	·964557	·273569	3 65538	1 03674	3·78970	42
19	264154	·964481	273882	3 65121	1 03683	3·78568	41
20	264434	964404	·274194	3 64705	1 03691	3·78166	40
21	264715	964327	274507	3 64289	1 03699	3·77765	39
22	·264995	·964250	·274820	3 63874	1·03708	3·77365	38
23	·265276	964173	275133	3 63461	1 03716	3·76966	37
24	·256556	·964095	·275446	3 63048	1 03724	3·76568	36
25	·265837	·964018	275759	3 62636	1 03732	3 76171	35
26	266117	·963941	276072	3 62224	1 03741	3·75775	34
27	266397	·963863	276385	3 61814	1 03749	3 75379	33
28	·266678	·963786	276698	3 61405	1·03757	3 74984	32
29	·266958	963708	·277011	3·60996	1 03766	3 74591	31
30	·267238	·963630	277325	3 60588	1 03774	3 74198	30
31	·267519	963553	277638	3 60181	1 03783	3 73806	29
32	·267799	·963475	·277951	3·59775	1·03791	3·73414	28
33	268079	·963397	278265	3 59370	1 03799	3·73024	27
34	268359	·963319	·278578	3 58996	1·03808	3·72635	26
35	268640	963241	·278891	3 58562	1 03816	3·72246	25
36	·268920	·963163	·279205	3 58160	1 03825	3·71858	24
37	269200	·963084	279519	3 57758	1 03833	3·71471	23
38	269480	963006	·279832	3 57357	1 03842	3·71085	22
39	269760	962928	280146	3 56957	1·03850	3·70700	21
40	·270040	·962849	280460	3 56557	1 03858	3 70315	20
41	·270320	962770	280773	3 56159	1 03867	3·69931	19
42	·270600	·962692	·281087	3 55761	1 03875	3·69549	18
43	·270880	·962613	·281401	3·55364	1·03884	3·69167	17
44	·271160	·962534	·281715	3 54968	1·03892	3·68785	16
45	·271440	·962455	282029	3·54573	1·03901	3·64805	15
46	·271720	·962376	·282343	3·54179	1·03909	3 68025	14
47	·272000	·962297	·282657	3·53785	1·03918	3 67647	13
48	·272280	962218	282971	3·53393	1·03927	3·67269	12
49	·272560	·962139	·283286	3 53001	1·03935	3·66892	11
50	·272840	·962059	·283600	3 52609	1·03944	3·66515	10
51	·273120	·961980	·283914	3 52219	1·03952	3·66140	9
52	·273400	961901	·284229	3·51829	1 03961	3·65765	8
53	·273679	·961821	·284543	3·51441	1·03969	3 65391	7
54	·273959	·961741	·284857	3·51053	1·03978	3 65018	6
55	·274239	961662	·285172	3·50666	1 03987	3·64645	5
56	·274519	·961582	·285487	3·50279	1·03995	3·64274	4
57	·274798	·961502	·285801	3·49894	1·04004	3·63903	3
58	·275078	·961422	·286116	3·49509	1·04013	3·63533	2
59	·275358	·961342	·286431	3·49125	1·04021	3·63164	1
60	·275637	·961262	·286745	3·84741	1·04030	3·62796	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·275637	·961262	286745	3·48741	1·04030	3·62796	60
1	·275917	961181	287060	3·48359	1·04039	3·62428	59
2	·276197	961101	287375	3·47977	1·04047	3·62061	58
3	276476	961021	·287690	3·47596	1·04056	3·61695	57
4	·276756	960940	288005	3·47216	1·04065	3·61330	56
5	·277035	·960860	288320	3·46837	1·04073	3·60965	55
6	277315	960779	288635	3·46458	1·04082	3·60601	54
7	·277594	·960698	288950	3·46080	1·04091	3·60238	53
8	·277874	·960618	·289266	3·45703	1·04100	3·59876	52
9	·278153	960537	289581	3·45327	1·04108	3·59514	51
10	·278432	·960456	·289896	3·44951	1·04117	3·59154	50
11	278712	960375	290211	3·44576	1·04126	3·58794	49
12	278991	·960294	·290527	3·44202	1·04135	3·58434	48
13	·279270	960212	290842	3·43829	1·04144	3·58076	47
14	·279550	960131	291158	3·43456	1·04152	3·57718	46
15	279829	·960050	291473	3·43084	1·04161	3·57361	45
16	280108	959968	·291789	3·42713	1·04170	3·57005	44
17	280388	959887	292105	3·42343	1·04179	3·56649	43
18	280667	·959805	292420	3·41973	1·04188	3·56294	42
19	·280946	959724	292736	3·41604	1·04197	3·55940	41
20	281225	959642	293052	3·41236	1·04206	3·55587	40
21	281504	·959560	293368	3·40869	1·04214	3·55235	39
22	·281783	·959478	293684	3·40502	1·04223	3·54883	38
23	282062	959396	294000	3·40136	1·04232	3·54531	37
24	282341	·959314	294316	3·39771	1·04241	3·54181	36
25	282620	959232	·294632	3·39406	1·04250	3·53831	35
26	282900	959150	294948	3·39042	1·04259	3·53482	34
27	·283179	959067	·295265	3·38679	1·04268	3·53134	33
28	·283457	958985	295581	3·38317	1·04277	3·52787	32
29	·283736	958902	295897	3·37955	1·04286	3·52440	31
30	·284015	·958820	296213	3·37594	1·04295	3·52094	30
31	·284294	958737	296530	3·37234	1·04304	3·51748	29
32	·284573	958654	296846	3·36875	1·04313	3·51404	28
33	·284852	958572	297163	3·36516	1·04322	3·51060	27
34	·285131	958489	297480	3·36158	1·04331	3·50716	26
35	·285410	958406	·297796	3·35800	1·04340	3·50374	25
36	·285688	958323	298113	3·35443	1·04349	3·50032	24
37	·285967	·958239	298430	3·35087	1·04358	3·49691	23
38	·286246	·958156	298747	3·34732	1·04367	3·49350	22
39	·286525	·958073	299063	3·34377	1·04376	3·49010	21
40	·286803	·957990	·299380	3·34023	1·04385	3·48671	20
41	·287082	957906	299697	3·33670	1·04394	3·48333	19
42	·287361	957822	300014	3·33317	1·04403	3·47995	18
43	·287639	957739	·300331	3·32965	1·04413	3·47658	17
44	·287918	·957655	300649	3·32614	1·04422	3·47321	16
45	·288196	·957571	·300966	3·32264	1·04431	3·46986	15
46	288475	957487	·301283	3·31914	1·04440	3·46651	14
47	·288753	·957404	·301600	3·31565	1·04449	3·46316	13
48	·289032	·957320	·301918	3·31216	1·04458	3·45983	12
49	·289310	·957235	302235	3·30688	1·04468	3·45650	11
50	·289589	957151	·302553	3·30521	1·04477	3·45317	10
51	·289867	·957067	·302870	3·30174	1·04486	3·44986	9
52	·290145	·956983	·303188	3·29829	1·04495	3·44655	8
53	·290424	·956898	303506	3·29483	1·04504	3·44324	7
54	·290702	·956814	·303823	3·29139	1·04514	3·43995	6
55	·290981	·956729	·304141	3·28795	1·04523	3·43666	5
56	·291259	·956644	304459	3·28452	1·04532	3·43337	4
57	·291537	·956560	·304777	3·28109	1·04541	3·43010	3
58	·291815	·956475	·305095	3·27767	1·04551	3·42683	2
59	·292094	·956390	·305413	3·27426	1·04560	3·42356	1
60	·292372	·956305	·305731	3·27085	1·04569	3·42030	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

17°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·292372	956305	·305731	3 27085	1·04569	3·42030	60
1	·292650	956220	306049	3·26745	1·04578	3·41705	59
2	·292928	·956134	306367	3 26406	1 04588	3·41381	58
3	·293206	956049	306685	3 26067	1·04597	3 41057	57
4	·293484	·955964	·307003	3 25729	1·04606	3 40734	56
5	293762	955879	·307322	3 25392	1 04616	3·40411	55
6	·294040	955793	307640	3 25055	1 04625	3·40089	54
7	294318	·955707	·307959	3 24719	1 04635	3·39768	53
8	·294596	·955622	·308277	3 24383	1 04644	3·39448	52
9	·294874	·955536	·308596	3 24049	1·04653	3·39128	51
10	·295152	955450	·308914	3 23714	1·04663	3·38808	50
11	·295430	955364	309233	3 23381	1 04672	3·38489	49
12	·295708	955278	·309552	3 23048	1·04682	3 38171	48
13	·295986	·955192	·309870	3 22715	1 04691	3·37854	47
14	·296264	955106	·310189	3 22348	1 04700	3 37537	46
15	·296542	955020	310508	3 22053	1 04710	3 37221	45
16	·296819	954934	310827	3 21722	1·04719	3·36905	44
17	·297097	·954847	311146	3 21392	1 04729	3·36590	43
18	·297375	·954761	311465	3 21063	1 04738	3·36276	42
19	297653	954674	311784	3 20734	1·04748	3·35962	41
20	297930	954588	312104	3 20406	1 04757	3·35649	40
21	298208	954501	312423	3 20079	1·04767	3·35336	39
22	298486	954414	312742	3 19752	1 04776	3·35025	38
23	·298763	·954327	313062	3 19426	1 04786	3·34713	37
24	·299041	954240	313381	3 19100	1 04795	3·34403	36
25	·299318	954153	313701	3·18775	1 04805	3 34092	35
26	·299596	·954066	314020	3 18451	1 04815	3·33783	34
27	·299873	953979	314340	3 18127	1 04824	3·33474	33
28	·300151	·953892	314659	3·17804	1 04834	3·33166	32
29	·300428	953804	314979	3 17481	1 04843	3·32858	31
30	·300706	953717	·315299	3 17159	1 04853	3·32551	30
31	·300983	953629	315619	3·16838	1·04863	3·32244	29
32	301261	953542	315939	3 16517	1 04872	3 31939	28
33	·301538	953454	·316258	3 16197	1 04882	3 31633	27
34	301815	953366	316578	3 15877	1 04891	3 31328	26
35	302093	·953279	316899	3 15558	1·04901	3·31024	25
36	302370	953191	317219	3 15240	1 04911	3 30721	24
37	302647	953103	317539	3 14922	1·04920	3 30418	23
38	302924	953015	317859	3 14605	1 04930	3·30115	22
39	303202	·952926	318179	3 14288	1·04940	3·29814	21
40	303479	·952838	318500	3·13972	1 04950	3 29512	20
41	·303756	·952750	·318820	3 13656	1·04959	3·29212	19
42	·304033	952661	·319141	3 13341	1 04969	3 28912	18
43	304310	952573	319461	3·13027	1 04979	3·28612	17
44	·304587	·952484	·319782	3 12713	1 04989	3 28313	16
45	·304864	·952396	·320103	3·12400	1 04998	3 28015	15
46	·305141	952307	·320423	3 12087	1·05008	3·27717	14
47	·305418	·952218	·320744	3·11775	1·05018	3·27420	13
48	·305695	·952129	·321065	3 11464	1·05028	3·27123	12
49	·305972	·952040	·321386	3 11153	1 05038	3·26827	11
50	·306249	·951951	321707	3·10842	1 05047	3·26531	10
51	306526	·951862	·322028	3 10532	1·05057	3·26237	9
52	·306803	·951773	·322349	3 10223	1·05067	3·25942	8
53	·307080	·951684	·322670	3·09914	1·05077	3·25648	7
54	·307357	·951594	·322991	3·09606	1·05087	3·25355	6
55	·307633	·951505	·323313	3·09298	1·05097	3·25062	5
56	·307910	·951415	·323634	3·08991	1·05107	3·24770	4
57	·308187	·951326	·323955	3·08684	1 05116	3·24478	3
58	·308464	·951236	·324277	3·08379	1·05126	3·24187	2
59	·308740	·951146	·324598	3·08073	1·05136	3·23897	1
60	·309017	·951057	·324920	3·07768	1·05146	3·23607	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

18°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·309017	·951057	·324920	3·07768	1·05146	3·23607	60
1	·309294	·950967	·325241	3 07464	1 05156	3 23317	59
2	·309570	·950877	·325563	3·07160	1 05166	3·23028	58
3	·309847	950786	·325885	3·06857	1 05176	3 22740	57
4	·310123	950696	·326207	3·06554	1·05186	3 22452	56
5	·310400	·950606	·326528	3·06252	1 05196	3·22165	55
6	·310676	950516	·326850	3 05950	1·05206	3·21878	54
7	·310953	950425	·327172	3 05649	1 05216	3 21592	53
8	·311229	950335	327494	3·05349	1 05226	3 21306	52
9	·311506	·950244	·327816	3·05049	1 05236	3 21021	51
10	·311782	·950154	·328139	3 04749	1 05246	3 20737	50
11	·312059	·950063	·328461	3·04450	1 05256	3 20453	49
12	·312335	·949972	·328783	3·04152	1 05266	3 20169	48
13	·312611	949881	·329106	3 03854	1·05276	3 19886	47
14	·312888	·949790	·329428	3·03556	1 05286	3 19604	46
15	·313164	·949699	·329751	3·03260	1 05297	3 19322	45
16	·313440	·949608	·330073	3·02963	1 05307	3 19040	44
17	·313716	·949517	330396	3 02667	1·05317	3 18759	43
18	·313992	·949425	330718	3 02372	1 05327	3 18479	42
19	314269	·949334	331041	3 02077	1·05337	3 18199	41
20	314545	949243	·331364	3 01783	1 05347	3 17920	40
21	·314821	949151	·331687	3·01489	1 05357	3 17641	39
22	·315097	·949059	·332010	3 01196	1 05367	3·17363	38
23	·315373	·948968	·332333	3 00903	1 05378	3·17085	37
24	·315649	·948876	·332656	3 00611	1·05388	3 16808	36
25	·315925	·948784	·332979	3 00319	1 05398	3 16531	35
26	·316201	·948692	·333302	3 00028	1 05408	3·16255	34
27	·316477	·948600	·333625	2 99738	1 05418	3 15979	33
28	·316753	·948508	·333949	2 99447	1 05429	3 15704	32
29	317029	948416	334272	2 99158	1 05439	3 15429	31
30	·317305	948324	334595	2 98868	1 05449	3 15155	30
31	·317580	·948231	·334919	2 98580	1 05459	3 14881	29
32	·317856	·948139	335242	2 98292	1·05470	3·14608	28
33	·318132	·948046	·335566	2·98004	1 05480	3·14335	27
34	·318408	·947954	·335890	2 97717	1 05490	3 14063	26
35	·318684	·947861	·336213	2 97430	1 05501	3 13791	25
36	·318959	·947768	·336537	2·97144	1 05511	3 13520	24
37	·319235	·947676	·336861	2·96858	1 05521	3 13249	23
38	·319511	·947583	·337185	2 96573	1 05532	3 12979	22
39	·319786	·947490	·337509	2 96288	1 05542	3 12709	21
40	·320062	·947397	·337833	2 96004	1 05552	3 12440	20
41	·320337	·947304	·338157	2 95721	1·05563	3 12171	19
42	·320613	·947210	·338481	2·95437	1·05573	3 11903	18
43	·320889	·947117	·338806	2·95155	1 05584	3·11635	17
44	·321164	·947024	·339130	2 94872	1·05594	3·11367	16
45	·321439	·946930	·339454	2 94590	1·05604	3·11101	15
46	·321715	·946837	·339779	2 94309	1 05615	3 10834	14
47	·321990	·946743	·340103	2·94028	1·05625	3·10568	13
48	·322266	·946649	·340428	2·93748	1 05636	3·10303	12
49	·322541	·946555	·340752	2·93468	1 05646	3·10038	11
50	·322816	·946462	·341077	2·93189	1 05657	3 09774	10
51	·323092	·946368	·341402	2·92910	1·05667	3 09510	9
52	·323367	·946274	341727	2·92632	1·05678	3·09246	8
53	·323642	·946180	·342052	2·92354	1·05688	3·08983	7
54	·323917	·946085	·342377	2·92076	1 05699	3·08721	6
55	·324193	·945991	·342702	2·91799	1·05709	3 08459	5
56	·324468	·945897	·343027	2·91523	1 05720	3 08197	4
57	·324743	·945802	·343352	2·91246	1·05730	3·07936	3
58	·325018	·945708	·343677	2·90971	1·05741	3·07675	2
59	·325293	·945613	·344002	2·90696	1·05751	3·07415	1
60	·325568	·945519	·344328	2·90421	1·05762	3·07155	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

19°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·325568	·945519	344328	2·90421	1 05762	3·07155	60
1	325843	·945424	·344653	2 90147	1 05773	3·06896	59
2	·326118	·945329	344978	2·89873	1 05783	3·06637	58
3	·326393	945234	·345304	2 89600	1 05794	3·06379	57
4	326668	·945139	·345630	2 89327	1 05805	3·06121	56
5	·326943	945044	·345955	2 89055	1 05815	3·05864	55
6	327218	944949	·346281	2 88783	1 05826	3 05607	54
7	327493	·944854	·346607	2 88511	1 05836	3 05350	53
8	·327768	944758	·346933	2 88240	1 05847	3 05094	52
9	·328042	·944663	·347259	2·87970	1 05858	3 04839	51
10	·328317	944568	347585	2 87700	1 05869	3 04584	50
11	·328592	944472	347911	2 87430	1 05879	3 04329	49
12	328867	944376	348237	2 87161	1 05890	3 04075	48
13	329141	944281	·348563	2 86892	1 05901	3 03821	47
14	329416	944185	348889	2 86624	1 05911	3 03568	46
15	329691	944089	349216	2 86356	1 05922	3·03315	45
16	·329965	943993	·349542	2 86089	1 05933	3 03062	44
17	330240	943897	·349868	2·85822	1·05944	3 02810	43
18	·330514	943801	·350195	2 85555	1·05955	3·02559	42
19	330789	943705	·350522	2 85289	1 05965	3·02308	41
20	331063	943609	·350848	2 85023	1 05976	3·02057	40
21	331338	943512	·351175	2 84758	1·05987	3·01807	39
22	331612	943416	·351502	2 84494	1·05998	3 01557	38
23	331887	943319	351829	2 84229	1 06009	3·01308	37
24	332161	943223	·352156	2·83965	1·06020	3·01059	36
25	·332435	943126	352483	2 83702	1·06030	3·00810	35
26	332710	943029	352810	2 83439	1 06041	3 00562	34
27	332984	942932	353137	2 83176	1·06052	3·00315	33
28	333258	942836	·353464	2 82914	1 06063	3 00067	32
29	·333533	·942739	·353791	2 82653	1 06074	2·99821	31
30	·333807	942641	·354119	2 82391	1 06085	2 99574	30
31	334081	942544	·354446	2 82130	1 06096	2 99329	29
32	·334355	942447	·354773	2 81870	1 06107	2 99083	28
33	·334629	942350	355101	2 81610	1·06118	2 98838	27
34	·334903	942252	355429	2 81350	1·06129	2 98594	26
35	335178	942155	355756	2 81091	1·06140	2 98349	25
36	·335452	·942057	356084	2 80833	1·06151	2 98106	24
37	335726	941960	356412	2 80574	1·06162	2·97862	23
38	336000	·941862	356740	2 80316	1 06173	2 97619	22
39	·336274	·941764	·357068	2 80059	1·06184	2·97377	21
40	336547	941666	·357396	2 79802	1·06195	2·97135	20
41	·336821	941569	·357724	2 79545	1·06206	2 96893	19
42	·337095	941471	·358052	2 79289	1·06217	2·96652	18
43	·337369	941372	·358380	2 79033	1·06228	2·96411	17
44	·337643	·941274	·358708	2·78778	1·06239	2 96171	16
45	·337917	941176	·359037	2 78523	1·06250	2·95931	15
46	·338190	941078	·359365	2·78269	1·06261	2 95691	14
47	·338464	·940979	·359694	2 78014	1·06272	2 95452	13
48	·338738	·940881	360022	2 77761	1 06283	2·95213	12
49	·339012	·940782	·360351	2 77507	1·06295	2·94975	11
50	339285	·940684	·360679	2 77254	1·06306	2·94737	10
51	·339559	940585	·361008	2 77002	1·06317	2 94500	9
52	·339832	·940486	·361337	2 76750	1·06328	2 94263	8
53	·340106	·940387	·361666	2·76498	1 06339	2·94026	7
54	·340380	·940288	·361995	2·76247	1 06350	2·93790	6
55	·340653	·940189	·362324	2 75996	1·06362	2·93554	5
56	·340927	·940090	·362653	2·75746	1·06373	2·93318	4
57	·341200	·939991	·362982	2·75496	1·06384	2·93083	3
58	·341473	·939891	·363312	2·75246	1·06395	2·92849	2
59	·341747	·939792	·363641	2 74997	1 06407	2·92614	1
60	·342020	·939693	·363970	2 74748	1·06418	2·92380	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

20°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	342020	·939693	363970	2 74748	1 06418	2 92380	60
1	·342293	·939593	·364300	2 74499	1 06429	2·92147	59
2	·342567	·939494	·364629	2 74251	1 06440	2 91914	58
3	·342840	·939394	·364959	2 74004	1 06452	2 91681	57
4	343113	·939294	365288	2 73756	1 06463	2 91449	56
5	·343387	939194	365618	2 73509	1·06474	2·91217	55
6	·343660	939094	365948	2 73263	1 06486	2 90986	54
7	·343933	938994	366278	2 73017	1 06497	2 90754	53
8	·344206	938894	366608	2 72771	1 06508	2 90524	52
9	·344479	·938794	366938	2 75226	1 06520	2 90293	51
10	·344752	938694	367268	2 72281	1 06531	2 90063	50
11	·345025	·938593	367598	2 72036	1 06542	2 89834	49
12	·345298	·938493	367928	2 71792	1 06554	2 89605	48
13	345571	938393	368259	2 71548	1 06565	2 89376	47
14	·345844	·938292	368589	2 71305	1 06577	2·89148	46
15	·346117	938191	368919	2 71062	1 06588	2 88920	45
16	·346390	938091	369250	2 70819	1·06600	2 88692	44
17	·346663	937990	369581	2 70577	1 06611	2 88465	43
18	·346936	937889	·369911	2 70335	1 06622	2 88238	42
19	347208	·937788	370242	2 70094	1 06634	2 88011	41
20	347481	·937687	370573	2 69853	1 06645	2 87785	40
21	347754	937586	370904	2 69612	1 06657	2 87560	39
22	·348027	937485	371235	2 69371	1 06668	2 87334	38
23	·348299	·937383	·371566	2 69131	1 06680	2 87109	37
24	·348572	937282	371897	2 68892	1 06691	2 86885	36
25	·348845	937181	372228	2 68653	1 06703	2 86661	35
26	·349117	·937079	372559	2 68414	1 06715	2 86437	34
27	·349390	·936977	372890	2 68175	1 06726	2 86213	33
28	·349662	936876	373222	2 67937	1 06738	2 85990	32
29	·349935	936774	373553	2 67700	1 06749	2 85767	31
30	·350207	·936672	373885	2 67462	1 06761	2 85545	30
31	·350480	936570	374216	2 67225	1 06773	2 85323	29
32	·350752	936468	·374548	2 66989	1 06784	2 85102	28
33	·351025	936366	·374880	2 66752	1 06796	2·84880	27
34	·351297	·936264	·375211	2 66516	1 06807	2 84659	26
35	·351569	936162	·375543	2 66281	1 06819	2 84439	25
36	·351842	936060	375875	2 66046	1 06831	2·84219	24
37	·352114	935957	376207	2 65811	1 06842	2 83999	23
38	·352386	·935855	·376539	2 65576	1 06854	2 83780	22
39	·352658	·935752	·376872	2 65342	1 06866	2 83561	21
40	·352931	·935650	·377204	2 65109	1 06878	2 83342	20
41	·353203	·935547	·377536	2 64875	1 06889	2 83124	19
42	353475	·935444	·377869	2 64642	1 06901	2 82906	18
43	·353747	·935341	·378201	2 64410	1 06913	2 82688	17
44	·354019	·935238	·378534	2 64177	1 06925	2 82471	16
45	·354291	·935135	·378866	2 63945	1 06936	2 82254	15
46	·354563	935032	·379199	2 63714	1 06948	2 82037	14
47	·354835	·934929	·379532	2 63483	1 06960	2 81821	13
48	·355107	944826	379864	2 63252	1 06972	2 81605	12
49	·355379	·934722	·380197	2 63021	1·06984	2 81390	11
50	·355651	·934619	·380530	2 62791	1 06995	2 81175	10
51	·355923	·934515	·380863	2 62561	1 07007	2 80960	9
52	·356194	·934412	·381196	2 62332	1 07019	2 80746	8
53	·356466	·934308	381530	2 62103	1 07031	2 80531	7
54	·356738	·934204	381863	2 61874	1 07043	2 80318	6
55	·357010	·934101	·382196	2·61646	1 07055	2·80104	5
56	·357281	·933997	·382530	2·61418	1 07067	2·79891	4
57	·357553	·933893	·382863	2 61190	1 07079	2·79679	3
58	·357825	·933789	·383197	2 60963	1 07091	2·79466	2
59	·358096	·933685	·383530	2·60736	1·07103	2·79254	1
60	·358368	·933580	·383864	2 60509	1 07114	2·79043	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

Six-Figure Trigonometrical Tables—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·358368	·933580	·383864	2 60509	1 07114	2 79043	60
1	·358640	933476	·384198	2 60283	1 07126	2·78832	59
2	·358911	·933372	·384532	2 60057	1·07138	2 78621	58
3	·359183	933267	384866	2 59831	1 07150	2·78410	57
4	·359454	·933163	·385200	2 59606	1 07162	2 78200	56
5	359725	·933058	385534	2 59381	1 07174	2 77990	55
6	359997	932954	385868	2 59156	1 07186	2 77780	54
7	·360268	932849	386202	2 58932	1 07199	2 77571	53
8	360540	932744	386536	2 58708	1 07211	2 77362	52
9	360811	932639	386871	2 58484	1 07223	2 77154	51
10	361082	932534	387205	2 58261	1 07235	2 76945	50
11	361353	·932429	387540	2 58038	1 07247	2 76737	49
12	361625	932324	·387874	2·57815	1 07259	2 76530	48
13	361896	932219	·388209	2 57593	1 07271	2 76323	47
14	·362167	932113	·388544	2 57371	1·07283	2·76116	46
15	362438	932008	·388879	2 57150	1 07295	2·75909	45
16	362709	931902	389214	2 56928	1 07307	2·75703	44
17	·362980	931797	389549	2 56707	1 07320	2·75497	43
18	·363251	931691	389884	2 56487	1 07332	2 75292	42
19	363522	931586	390219	2 56266	1 07344	2 75086	41
20	·363793	931480	390554	2 56046	1·07356	2 74881	40
21	364064	931374	390889	2 55827	1 07368	2 74677	39
22	364335	931268	·391225	2 55608	1 07380	2 74473	38
23	364606	931162	391560	2 55389	1 07393	2 74269	37
24	364877	931056	391896	2 55170	1 07405	2 74065	36
25	·365148	·930950	392231	2 54952	1 07417	2·73862	35
26	·365418	930843	·392567	2 54734	1 07429	2 73659	34
27	·365689	930737	·392903	2 54516	1 07442	2 73456	33
28	·365960	·930631	393239	2 54299	1 07454	2·73254	32
29	·366231	930524	393574	2 54082	1 07466	2 73052	31
30	·366501	930418	·393910	2 53865	1·07479	2 72850	30
31	366772	930311	·394247	2 53648	1 07491	2 72649	29
32	367042	930204	·394583	2 53432	1 07503	2·72448	28
33	367313	930097	394919	2 53217	1 07516	2 72247	27
34	367584	929990	395255	2 53001	1 07528	2·72047	26
35	367854	929884	395592	2 52786	1 07540	2 71847	25
36	368125	929776	395928	2 52571	1 07553	2 71647	24
37	368395	929669	396265	2 52357	1 07565	2 71448	23
38	368665	·929562	396601	2 52142	1 07578	2 71249	22
39	368936	929455	396938	2 51929	1 07590	2 71050	21
40	·369206	929348	397275	2 51715	1 07602	2 70851	20
41	369476	929240	397611	2 51502	1 07615	2 70653	19
42	369747	929133	397948	2 51289	1 07627	2 70455	18
43	370017	929025	398285	2 51076	1 07640	2 70258	17
44	·370287	928917	·398622	2·50864	1·07652	2·70061	16
45	370557	928810	·398960	2·50652	1 07665	2·69864	15
46	370828	928702	399297	2 50440	1·07677	2·69667	14
47	371098	928594	·399634	2 50229	1 07690	2·69471	13
48	·371368	928486	·399971	2·50018	1·07702	2 69275	12
49	·371638	928378	400309	2 49807	1·07715	2 69079	11
50	371908	928270	400646	2·49597	1·07727	2 68884	10
51	·372178	928161	·400984	2·49386	1·07740	2·68689	9
52	·372448	928053	401322	2·49177	1 07752	2·68494	8
53	·372718	927945	401660	2·48967	1·07765	2 68299	7
54	372988	927836	·401997	2 48758	1 07778	2·68105	6
55	373258	927728	·402335	2 48549	1 07790	2·67911	5
56	·373528	927619	·402673	2·48340	1·07803	2·67718	4
57	373797	927510	403011	2·48132	1·07816	2·67525	3
58	·374067	·927402	·403350	2 47924	1 07828	2 67332	2
59	374337	927293	·403688	2 47716	1 07841	2 67139	1
60	·374607	927184	·404026	2·47509	1·07853	2·66947	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

22°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·374607	·927184	·404026	2·47509	1·07853	2·66947	60
1	·374876	·927075	·404365	2·47302	1·07866	2·66755	59
2	·375146	·926966	·404703	2·47095	1·07879	2·66563	58
3	·375416	·926857	·405042	2·46888	1·07892	2·66371	57
4	·375685	·926747	·405380	2·46682	1·07904	2·66180	56
5	·375955	·926638	·405719	2·46476	1·07917	2·65989	55
6	·376224	·926529	·406058	2·46270	1·07930	2·65799	54
7	·376494	·926419	·406397	2·46065	1·07943	2·65609	53
8	·376763	·926310	·406736	2·45860	1·07955	2·65419	52
9	·377033	·926200	·407075	2·45655	1·07968	2·65229	51
10	·377302	·926090	·407414	2·45451	1·07981	2·65040	50
11	·377571	·925980	·407753	2·45246	1·07995	2·64851	49
12	·377841	·925871	·408092	2·45043	1·08006	2·64662	48
13	·378110	·925761	·408432	2·44839	1·08019	2·64473	47
14	·378379	·925651	·408771	2·44636	1·08032	2·64285	46
15	·378649	·925541	·409111	2·44433	1·08045	2·64097	45
16	·378918	·925430	·409450	2·44230	1·08058	2·63909	44
17	·379187	·925320	·409790	2·44027	1·08071	2·63722	43
18	·379456	·925210	·410130	2·43825	1·08084	2·63535	42
19	·379725	·925099	·410470	2·43623	1·08097	2·63348	41
20	·379994	·924989	·410810	2·43422	1·08109	2·63162	40
21	·380263	·924878	·411150	2·43220	1·08122	2·62976	39
22	·380532	·924768	·411490	2·43019	1·08135	2·62790	38
23	·380801	·924657	·411830	2·42819	1·08148	2·62604	37
24	·381070	·924546	·412170	2·42618	1·08161	2·62419	36
25	·381339	·924435	·412511	2·42418	1·08174	2·62234	35
26	·381608	·924324	·412851	2·42218	1·08187	2·62049	34
27	·381877	·924213	·413192	2·42019	1·08200	2·61864	33
28	·382146	·924102	·413532	2·41819	1·08213	2·61680	32
29	·382415	·923991	·413873	2·41620	1·08226	2·61496	31
30	·382683	·923880	·414214	2·41421	1·08239	2·61313	30
31	·382952	·923768	·414554	2·41223	1·08252	2·61129	29
32	·383221	·923657	·414895	2·41025	1·08265	2·60946	28
33	·383490	·923545	·415236	2·40827	1·08278	2·60763	27
34	·383758	·923434	·415577	2·40629	1·08291	2·60581	26
35	·384027	·923322	·415919	2·40432	1·08305	2·60399	25
36	·384295	·923210	·416260	2·40235	1·08318	2·60217	24
37	·384564	·923098	·416601	2·40038	1·08331	2·60035	23
38	·384832	·922986	·416943	2·39841	1·08344	2·59853	22
39	·385101	·922874	·417284	2·39645	1·08357	2·59672	21
40	·385369	·922762	·417626	2·39449	1·08370	2·59491	20
41	·385638	·922650	·417967	2·39253	1·08383	2·59311	19
42	·385906	·922538	·418309	2·39058	1·08397	2·59130	18
43	·386174	·922426	·418651	2·38863	1·08410	2·58950	17
44	·386443	·922313	·418993	2·38668	1·08423	2·58771	16
45	·386711	·922201	·419335	2·38473	1·08436	2·58591	15
46	·386979	·922088	·419677	2·38279	1·08449	2·58412	14
47	·387247	·921976	·420019	2·38084	1·08463	2·58233	13
48	·387516	·921863	·420361	2·37891	1·08476	2·58054	12
49	·387784	·921750	·420704	2·37697	1·08489	2·57876	11
50	·388052	·921638	·421046	2·37504	1·08503	2·57698	10
51	·388320	·921525	·421389	2·37311	1·08516	2·57520	9
52	·388588	·921412	·421731	2·37118	1·08529	2·57342	8
53	·388856	·921299	·422074	2·36925	1·08542	2·57165	7
54	·389124	·921185	·422417	2·36733	1·08556	2·56988	6
55	·389392	·921072	·422759	2·36541	1·08569	2·56811	5
56	·389660	·920959	·423102	2·36349	1·08582	2·56634	4
57	·389928	·920845	·423445	2·36158	1·08596	2·56458	3
58	·390196	·920732	·423788	2·35967	1·08609	2·56282	2
59	·390463	·920618	·424132	2·35776	1·08623	2·56106	1
60	·390731	·920505	·424475	2·35585	1·08636	2·55930	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·390731	·920505	·424475	2 35585	1 08636	2 55930	60
1	·390999	920391	·424818	2 35395	1 08649	2 55755	59
2	·391267	920277	·425162	2 35205	1·08663	2·55580	58
3	·391534	·920164	425505	2 35015	1·08676	2·55405	57
4	·391802	·920050	425849	2 34825	1·08690	2 55231	56
5	392070	919936	426192	2 34636	1 08703	2 55057	55
6	·392337	919822	·426536	2 34447	1·08717	2 54883	54
7	392605	919707	·426880	2 34258	1·08730	2 54709	53
8	392872	919593	427224	2 34069	1 08744	2 54536	52
9	·393140	919479	·427568	2 33881	1 08757	2 54363	51
10	·393407	·919364	427912	2 33693	1 08771	2 54190	50
11	·393675	·919250	428256	2 33505	1 08784	2·54017	49
12	·393942	919135	·428601	2 33317	1·08798	2 53845	48
13	394209	·919021	428945	2 33130	1·08811	2 53672	47
14	394477	918906	·429289	2 32943	1·08825	2 53500	46
15	394744	·918791	429634	2 32756	1 08839	2 53329	45
16	·395011	918676	·429979	2 32570	1 08852	2 53157	44
17	395278	918561	·430323	2 32383	1 08866	2 52986	43
18	·395546	·918446	·430668	2 32197	1 08880	2 52815	42
19	·395813	·918331	431013	2 32012	1 08893	2 52645	41
20	·396080	·918216	431358	2 31826	1 08907	2 52474	40
21	·396347	·918101	431703	2 31641	1 08920	2 52304	39
22	396614	917986	432048	2 31456	1 08934	2·52134	38
23	396881	·917870	432393	2 31271	1 08948	2 51965	37
24	397148	·917755	432739	2 31086	1 08962	2 51795	36
25	397415	917639	433084	2·30902	1 08975	2 51626	35
26	397682	917523	433430	2 30718	1 08989	2 51457	34
27	397949	917408	433775	2 30534	1 09003	2 51289	33
28	398215	·917292	434121	2·30351	1 09017	2 51120	32
29	·398482	917176	434467	2 30167	1·09030	2 50952	31
30	·398749	917060	434812	2 29984	1 09044	2 50784	30
31	399016	916944	·435158	2 29801	1 09058	2 50617	29
32	399283	916828	435504	2 29619	1 09072	2 50449	28
33	·399549	916712	435850	2 29437	1·09086	2 50282	27
34	·399816	916595	436197	2·29254	1 09099	2 50115	26
35	400082	·916479	436543	2 29073	1 09113	2·49948	25
36	400349	916363	·436889	2·28891	1·09127	2 49782	24
37	·400616	916246	437236	2 28710	1 09141	2 49616	23
38	·400882	916130	437582	2 28528	1 09155	2 49450	22
39	·401149	916013	437929	2 28348	1·09169	2 49284	21
40	·401415	915896	·438276	2 28167	1 09183	2·49119	20
41	·401681	·915779	·438622	2 27987	1 09197	2 48954	19
42	·401948	·915663	·438969	2 27806	1·09211	2 48789	18
43	·402214	·915546	·439316	2·27626	1·09224	2 48624	17
44	·402480	·915429	·439663	2 27447	1 09238	2 48459	16
45	·402747	915311	·440011	2 27267	1 09252	2·48295	15
46	·403013	·915194	·440358	2 27088	1·09266	2·48131	14
47	·403279	915077	440705	2 26909	1 09280	2 47967	13
48	·403545	·914960	441053	2 26730	1 09294	2 47804	12
49	·403811	·914842	·441400	2 26552	1 09308	2 47640	11
50	404078	·914725	·441748	2 26374	1 09323	2·47477	10
51	404344	·914607	·442095	2·26196	1·09337	2·47314	9
52	·404610	·914490	·442443	2·26018	1·09351	2 47152	8
53	·404876	·914372	·442791	2·25840	1·09365	2 46989	7
54	·405142	·914254	·443139	2 25663	1·09379	2·46827	6
55	·405408	·914136	·443487	2·25486	1 09393	2 46665	5
56	·405673	·914018	·443835	2·25309	1·09407	2 46504	4
57	·405939	·913900	·444183	2·25132	1 09421	2·66342	3
58	·406205	·913782	·444532	2·24956	1·09435	2 46181	2
59	·406471	·913664	·444880	2·24780	1·09449	2·46020	1
60	·406737	·913545	·445229	2·24604	1·09464	2·45859	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·406737	·913545	·445229	2·24604	1·09464	2·45859	60
1	·407002	·913427	·445577	2·24428	1·09478	2·45699	59
2	·407268	·913309	·445926	2·24252	1·09492	2·45539	58
3	·407534	·913190	·446275	2·24077	1·09506	2·45378	57
4	·407799	·913072	·446624	2·23902	1·09520	2·45219	56
5	·408065	·912953	·446973	2·23727	1·09535	2·45059	55
6	·408330	·912834	·447322	2·23553	1·09549	2·44900	54
7	·408596	·912715	·447671	2·23378	1·09563	2·44741	53
8	·408861	·912596	·448020	2·23204	1·09577	2·44582	52
9	·409127	·912477	·448369	2·23030	1·09592	2·44423	51
10	·409392	·912358	·448719	2·22857	1·09606	2·44264	50
11	·409658	·912239	·449068	2·22683	1·09620	2·44106	49
12	·409923	·912120	·449418	2·22510	1·09635	2·43948	48
13	·410188	·912001	·449768	2·22337	1·09649	2·43790	47
14	·410454	·911881	·450117	2·22164	1·09663	2·43633	46
15	·410719	·911762	·450467	2·21992	1·09678	2·43476	45
16	·410984	·911643	·450817	2·21819	1·09692	2·43318	44
17	·411249	·911523	·451167	2·21647	1·09707	2·43162	43
18	·411514	·911403	·451517	2·21475	1·09721	2·43005	42
19	·411779	·911284	·451868	2·21304	1·09735	2·42848	41
20	·412045	·911164	·452218	2·21132	1·09750	2·42692	40
21	·412310	·911044	·452568	2·20961	1·09764	2·42536	39
22	·412575	·910924	·452919	2·20790	1·09779	2·42380	38
23	·412840	·910804	·453269	2·20619	1·09793	2·42225	37
24	·413014	·910684	·453620	2·20449	1·09808	2·42070	36
25	·413369	·910563	·453971	2·20278	1·09822	2·41914	35
26	·413634	·910443	·454322	2·20108	1·09837	2·41760	34
27	·413899	·910323	·454673	2·19938	1·09851	2·41605	33
28	·414164	·910202	·455024	2·19769	1·09866	2·41450	32
29	·414429	·910082	·455375	2·19599	1·09880	2·41296	31
30	·414693	·909961	·455726	2·19430	1·09895	2·41142	30
31	·414958	·909841	·456078	2·19261	1·09909	2·40988	29
32	·415223	·909720	·456429	2·19092	1·09924	2·40835	28
33	·415487	·909599	·456781	2·18923	1·09939	2·40681	27
34	·415752	·909478	·457132	2·18755	1·09953	2·40528	26
35	·416016	·909357	·457484	2·18587	1·09968	2·40375	25
36	·416281	·909236	·457836	2·18419	1·09982	2·40222	24
37	·416545	·909115	·458188	2·18251	1·09997	2·40070	23
38	·416810	·908994	·458540	2·18084	1·10012	2·39918	22
39	·417074	·908872	·458892	2·17916	1·10026	2·39766	21
40	·417338	·908751	·459244	2·17749	1·10041	2·39614	20
41	·417603	·908630	·459596	2·17582	1·10056	2·39462	19
42	·417867	·908508	·459949	2·17416	1·10071	2·39311	18
43	·418131	·908387	·460301	2·17249	1·10085	2·39159	17
44	·418396	·908265	·460654	2·17083	1·10100	2·39008	16
45	·418660	·908143	·461006	2·16917	1·10115	2·38857	15
46	·418924	·908021	·461359	2·16751	1·10130	2·38707	14
47	·419188	·907899	·461712	2·16585	1·10144	2·38556	13
48	·419452	·907777	·462065	2·16420	1·10159	2·38406	12
49	·419716	·907655	·462418	2·16255	1·10174	2·38256	11
50	·419980	·907533	·462771	2·16090	1·10189	2·38107	10
51	·420244	·907411	·463124	2·15925	1·10204	2·37957	9
52	·420508	·907289	·463478	2·15760	1·10218	2·37808	8
53	·420772	·907166	·463831	2·15596	1·10233	2·37658	7
54	·421036	·907044	·464185	2·15432	1·10248	2·37509	6
55	·421300	·906922	·464538	2·15268	1·10263	2·37361	5
56	·421563	·906799	·464892	2·15104	1·10278	2·37212	4
57	·421827	·906676	·465246	2·14940	1·10293	2·37064	3
58	·422091	·906554	·465600	2·14777	1·10308	2·36916	2
59	·422355	·906431	·465954	2·14614	1·10323	2·36768	1
60	·422618	·906308	·466308	2·14451	1·10338	2·36620	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·422618	·906308	·466308	2·14451	1·10338	2·36620	60
1	·422882	·906185	·466662	2·14288	1·10353	2·36473	59
2	·423145	·906062	·467016	2·14125	1·10368	2·36325	58
3	·423409	·905939	·467371	2·13963	1·10383	2·36178	57
4	·423673	·905815	·467725	2·13801	1·10398	2·36031	56
5	·423936	·905692	·468080	2·13639	1·10413	2·35885	55
6	·424199	·905569	·468434	2·13477	1·10428	2·35738	54
7	·424463	·905445	·468789	2·13316	1·10443	2·35592	53
8	·424726	·905322	·469144	2·13154	1·10458	2·35446	52
9	·424990	·905198	·469499	2·12993	1·10473	2·35300	51
10	·425253	·905075	·469854	2·12832	1·10488	2·35154	50
11	·425516	·904951	·470209	2·12671	1·10503	2·35009	49
12	·425779	·904827	·470564	2·12511	1·10518	2·34863	48
13	·426042	·904703	·470920	2·12350	1·10533	2·34718	47
14	·426306	·904579	·471275	2·12190	1·10549	2·34573	46
15	·426569	·904455	·471631	2·12030	1·10564	2·34429	45
16	·426832	·904331	·471986	2·11871	1·10579	2·34284	44
17	·427095	·904207	·472342	2·11711	1·10594	2·34140	43
18	·427358	·904083	·472698	2·11552	1·10609	2·33996	42
19	·427621	·903958	·473054	2·11392	1·10625	2·33852	41
20	·427884	·903834	·473410	2·11233	1·10640	2·33708	40
21	·428147	·903709	·473766	2·11075	1·10655	2·33565	39
22	·428410	·903585	·474122	2·10916	1·10670	2·33422	38
23	·428672	·903460	·474478	2·10758	1·10686	2·33278	37
24	·428935	·903335	·474835	2·10600	1·10701	2·33135	36
25	·429198	·903210	·475191	2·10442	1·10716	2·32993	35
26	·429461	·903086	·475548	2·10284	1·10731	2·32850	34
27	·429723	·902961	·475905	2·10126	1·10747	2·32708	33
28	·429986	·902836	·476262	2·09969	1·10762	2·32566	32
29	·430249	·902710	·476619	2·09811	1·10777	2·32424	31
30	·430511	·902585	·476976	2·09654	1·10793	2·32282	30
31	·430774	·902460	·477333	2·09498	1·10808	2·32140	29
32	·431036	·902335	·477690	2·09341	1·10824	2·31999	28
33	·431299	·902209	·478047	2·09184	1·10839	2·31858	27
34	·431561	·902084	·478405	2·09028	1·10854	2·31717	26
35	·431823	·901958	·478762	2·08872	1·10870	2·31576	25
36	·432086	·901833	·479120	2·08716	1·10885	2·31436	24
37	·432348	·901707	·479477	2·08560	1·10901	2·31295	23
38	·432610	·901581	·479835	2·08405	1·10916	2·31155	22
39	·432873	·901455	·480193	2·08250	1·10932	2·31015	21
40	·433135	·901329	·480551	2·08094	1·10947	2·30875	20
41	·433397	·901203	·480909	2·07939	1·10963	2·30735	19
42	·433659	·901077	·481268	2·07785	1·10978	2·30596	18
43	·433921	·900951	·481626	2·07630	1·10994	2·30457	17
44	·434183	·900825	·481984	2·07476	1·11009	2·30318	16
45	·434445	·900698	·482343	2·07321	1·11025	2·30179	15
46	·434707	·900572	·482701	2·07167	1·11041	2·30040	14
47	·434969	·900445	·483060	2·07014	1·11056	2·29901	13
48	·435231	·900319	·483419	2·06860	1·11072	2·29763	12
49	·435493	·900192	·483778	2·06706	1·11087	2·29625	11
50	·435755	·900065	·484137	2·06553	1·11103	2·29487	10
51	·436017	·899939	·484496	2·06400	1·11119	2·29349	9
52	·436278	·899812	·484855	2·06247	1·11134	2·29211	8
53	·436540	·899685	·485214	2·06094	1·11150	2·29074	7
54	·436802	·899558	·485574	2·05942	1·11166	2·28937	6
55	·437063	·899431	·485933	2·05790	1·11181	2·28800	5
56	·437325	·899304	·486293	2·05637	1·11197	2·28663	4
57	·437587	·899176	·486653	2·05485	1·11213	2·28526	3
58	·437848	·899049	·487013	2·05333	1·11229	2·28390	2
59	·438110	·898922	·487373	2·05182	1·11244	2·28253	1
60	·438371	·898794	·487733	2·05030	1·11260	2·28117	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

26°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·438371	·898794	·487733	2 05030	1 11260	2 28117	60
1	·438633	·898666	·488093	2 04879	1·11276	2 27981	59
2	·438894	898539	488453	2 04728	1 11292	2·27845	58
3	·439155	·898411	·488813	2 04577	1·11308	2 27710	57
4	·439417	898283	489174	2 04426	1 11323	2 27574	56
5	·439678	·898156	·489534	2 04276	1 11339	2·27439	55
6	·439939	898028	·489895	2 04125	1 11355	2 27304	54
7	·440200	·897900	·490256	2 03975	1 11371	2 27169	53
8	·440462	897771	·490617	2 03825	1 11387	2 27035	52
9	·440723	897643	·490978	2 03675	1 11403	2 26900	51
10	·440984	897515	·491339	2 03526	1 11419	2·26766	50
11	·441245	897387	·491700	2 03376	1 11435	2 26632	49
12	·441506	897258	492061	2 03227	1 11451	2 26498	48
13	·441767	897130	·492422	2 03078	1 11467	2 26364	47
14	·442028	897001	·492784	2 02929	1 11483	2 26230	46
15	·442289	896873	·493145	2 02780	1 11499	2 26097	45
16	·442550	896744	·493507	2 02631	1 11515	2 25963	44
17	·442810	896615	·493869	2 02483	1 11531	2 25830	43
18	443071	896486	494231	2 02335	1 11547	2 25697	42
19	·443332	896358	·494593	2 02187	1 11563	2 25565	41
20	·443593	·896229	·494955	2 02039	1 11579	2 25432	40
21	·443853	·896099	·495317	2·01891	1 11595	2 25300	39
22	·444114	·895970	·495679	2 01743	1 11611	2 25167	38
23	·444375	·895841	·496042	2 01596	1 11627	2 25035	37
24	·444635	·895712	·496404	2 01449	1 11643	2 24903	36
25	·444896	895582	·496767	2 01302	1·11659	2 24772	35
26	445156	·895453	·497130	2 01155	1 11675	2 24640	34
27	445417	895323	·497492	2 01008	1 11691	2 24509	33
28	·445677	·895194	497855	2·00862	1 11708	2 24378	32
29	445937	·895064	·498218	2 00715	1 11724	2 24247	31
30	446198	·894934	·498582	2 00569	1 11740	2 24116	30
31	·446458	·894805	·498945	2 00423	1 11756	2 23985	29
32	446718	·894675	·499308	2·00277	1 11722	2 23855	28
33	446979	·894545	·499672	2 00131	1 11789	2 23724	27
34	·447239	·894415	·500035	1 99986	1 11805	2 23594	26
35	·447499	·894284	·500399	1 99841	1·11821	2 23464	25
36	·447759	·894154	·500763	1 99695	1 11838	2 23334	24
37	·448019	·894024	·501127	1 99550	1 11854	2·23205	23
38	448279	·893894	·501491	1 99406	1 11870	2·23075	22
39	·448539	893763	·501855	1 99261	1 11886	2 22946	21
40	·448799	·893633	·502219	1 99116	1 11903	2 22817	20
41	449059	893502	·502583	1 98972	1 11919	2 22688	19
42	·449319	893371	·502948	1 98828	1 11936	2 22559	18
43	·449579	893241	·503312	1 98684	1 11952	2 22430	17
44	·449839	·893110	·503677	1 98540	1 11968	2 22302	16
45	·450098	·892979	·504041	1 98396	1 11985	2·22174	15
46	·450358	·892848	·504406	1 98253	1 12001	2·22045	14
47	·450618	·892717	·504771	1 98110	1 12018	2·21918	13
48	·450878	892586	505136	1 97966	1 12034	2 21790	12
49	·451137	892455	·505502	1 97823	1 12051	2·21662	11
50	·451397	·892323	·505867	1 97681	1 12067	2·21535	10
51	·451656	·892192	·506232	1 97538	1·12083	2·21407	9
52	·451916	·892061	·506598	1 97395	1 12100	2 21280	8
53	·452175	·891929	·506963	1 97253	1·12117	2 21153	7
54	·452435	·891798	·507329	1 97111	1 12133	2·21026	6
55	·452694	891666	·507695	1 96969	1 12150	2·20900	5
56	·452953	891534	·508061	1 96827	1·12166	2·20773	4
57	453213	·891402	·508427	1 96685	1·12183	2 20647	3
58	·453472	·891270	·508793	1·96544	1 12199	2·20521	2
59	·453731	·891139	·509159	1 96402	1 12216	2 20395	1
60	·453990	·891007	·509525	1 96261	1·12233	2·20269	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

27°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	453990	891007	509525	1·96261	1 12233	2 20269	60
1	454250	890874	509892	1 96120	1 12249	2 20143	59
2	·454509	890742	·510258	1 95979	1 12266	2 20018	58
3	454768	890610	·510625	1 95838	1 12283	2·19892	57
4	455027	890478	510992	1 95698	1 12299	2 19767	56
5	455286	890345	·511359	1 95557	1 12316	2·19642	55
6	455545	890213	·511726	1 95417	1 12333	2·19517	54
7	455804	890080	·512093	1 95277	1 12349	2 19393	53
8	456063	·889948	·512460	1 95137	1 12366	2 19268	52
9	456322	889815	·512828	1 94997	1 12383	2 19144	51
10	456580	·889682	513195	1 94858	1 12400	2·19109	50
11	·456839	889549	513563	1 94718	1 12416	2 18895	49
12	457098	889416	513930	1 94579	1 12433	2·18772	48
13	457357	889283	·514298	1 94440	1 12450	2 18648	47
14	457615	889150	514666	1 94301	1 12467	2 18524	46
15	457874	889017	·515034	1 94162	1 12484	2 18401	45
16	·458132	888884	·515402	1 94023	1 12501	2 18277	44
17	·458391	888751	·515770	1 93885	1 12518	2 18154	43
18	458650	888617	516138	1 93746	1 12534	2 18031	42
19	·458908	888484	516507	1 93608	1 12551	2 17909	41
20	459166	888350	516875	1 93470	1 12568	2·17786	40
21	459425	888217	517244	1 93332	1·12585	2·17663	39
22	459683	888083	517613	1 93195	1 12602	2 17541	38
23	459942	·887949	517982	1 93057	1 12619	2·17419	37
24	460200	·887815	518351	1 92920	1 12636	2 17297	36
25	·460458	887681	518720	1 92782	1 12653	2 17175	35
26	·460716	887548	519089	1 92645	1 12670	2 17053	34
27	·460974	·887413	·519458	1 92508	1 12687	2 16932	33
28	461232	887279	·519828	1 92371	1·12704	2 16810	32
29	461491	·887145	·520197	1 92235	1 12721	2 16689	31
30	461749	·887011	520567	1 92098	1·12738	2 16568	30
31	462007	886876	520937	1 91962	1 12755	2 16447	29
32	462265	886742	521307	1 91826	1 12772	2·16326	28
33	462522	886608	·521677	1·91690	1 12789	2 16206	27
34	·462780	886473	522047	1 91554	1 12807	2 16085	26
35	463038	·886338	522417	1 91418	1 12824	2 15965	25
36	463296	·886204	522787	1 91282	1 12841	2 15845	24
37	463554	·886069	523158	1 91147	1 12858	2 15725	23
38	463812	885934	523528	1 91012	1 12875	2 15605	22
39	464069	·885799	523899	1 90876	1 12892	2·15485	21
40	464327	·885664	·524270	1 90741	1·21910	2 15366	20
41	464584	885529	524641	1 90607	1 12927	2 15246	19
42	·464842	885394	525012	1 90472	1 12944	2 15127	18
43	·465100	885258	525383	1 90337	1 12961	2 15008	17
44	·465357	885123	525754	1 90203	1 12979	2 14889	16
45	·465615	884988	526125	1·90069	1 12996	2 14770	15
46	465872	884852	526497	1·89935	1·13013	2·14651	14
47	·466129	·884717	526868	1 89801	1 13031	2·14533	13
48	·466387	884581	·527240	1·89667	1·13048	2·14414	12
49	·466644	·884445	527612	1·89533	1 13065	2 14296	11
50	·466901	·884309	·527984	1·89400	1 13083	2·14178	10
51	467158	·884174	·528356	1·89266	1·13100	2·14060	9
52	·467416	·884038	·528728	1 89133	1·13117	2 13942	8
53	·467673	·883902	·529100	1 89000	1 13135	2 13825	7
54	467930	·883766	529473	1·88867	1·13152	2·13707	6
55	·468187	·883629	·529845	1·88734	1 13170	2·13590	5
56	·468444	883493	·530218	1·88602	1 13187	2 13473	4
57	·468701	·883357	·530591	1·88469	1·13205	2·13356	3
58	·468958	·883221	·530963	1·88337	1·13222	2·13239	2
59	·469215	883084	·531336	1·88205	1·13239	2·13122	1
60	·469472	·882948	·531709	1·88073	1·13257	2·13005	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

28°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·469472	882948	531709	1 88073	1 13257	2·13005	60
1	·469728	882811	532083	1·87941	1 13275	2·12889	59
2	·469985	882674	532456	1 87809	1 13292	2·12773	58
3	470242	882538	·532829	1 87677	1 13310	2 12657	57
4	·470499	882401	533203	1 87546	1 13327	2 12540	56
5	·470755	·882264	533577	1 87415	1 13345	2 12425	55
6	471012	·882127	·533950	1 87283	1 13362	2·12309	54
7	471268	·881990	534324	1 87152	1 13380	2 12193	53
8	471525	·881853	·534698	1 87021	1 13398	2 12078	52
9	·471782	881715	·535072	1 86891	1 13415	2 11963	51
10	472038	881578	·535447	1 86760	1 13433	2 11847	50
11	472294	881441	535821	1 86630	1 13451	2 11732	49
12	·472551	881303	·536195	1 86499	1 13468	2 11617	48
13	·472807	881166	536570	1 86369	1 13486	2 11503	47
14	·473063	881028	536945	1 86239	1 13504	2·11388	46
15	·473320	·880891	·537319	1 86109	1 13521	2 11274	45
16	·473576	880753	537694	1·85979	1 13539	2 11159	44
17	·473832	·880615	538069	1 85850	1 13557	2 11045	43
18	474088	·880477	·538445	1·85720	1 13575	2 10931	42
19	·474344	880339	538820	1 85591	1 13593	2 10817	41
20	·474600	880201	539195	1 85462	1 13610	2 10704	40
21	474856	880063	539571	1 85333	1 13628	2 10590	39
22	475112	·879925	539946	1 85204	1 13646	2·10477	38
23	475368	·879787	540322	1 85075	1 13664	2·10363	37
24	475624	879649	·540698	1 84946	1 13682	2 10250	36
25	475880	879510	·541074	1 84818	1 13700	2 10137	35
26	476136	879372	541450	1 84689	1 13718	2 10024	34
27	·476392	879233	541826	1 84561	1 13735	2 00911	33
28	·476647	·879095	542203	1·84433	1·13753	2 09799	32
29	·476903	·878566	542579	1 84305	1 13771	2 09686	31
30	477159	878817	·542956	1 84177	1 13789	2 09574	30
31	·477414	·878678	·543332	1 84049	1 13807	2 09462	29
32	477670	878539	·543709	1 83922	1 13825	2 09350	28
33	·477925	·878400	·544086	1 83794	1 13843	2 09238	27
34	·478181	·878261	·544463	1·83667	1 13861	2 09126	26
35	·478436	878122	·544840	1 83540	1 13879	2 09014	25
36	·478692	·877983	545218	1 83413	1 13897	2 08903	24
37	·478947	·877844	·545595	1 83286	1 13916	2 08791	23
38	·479203	·877704	·545973	1 83159	1 13934	2·08680	22
39	·479458	877565	·546350	1·83033	1 13952	2·08569	21
40	479713	·877425	·546728	1 82906	1 13970	2 08458	20
41	·479968	877286	547106	1 82780	1·13988	2 08347	19
42	·480224	·877146	·547484	1 82654	1 14006	2 08236	18
43	·480479	·877006	·547862	1 82528	1·14024	2 08126	17
44	·480734	876867	548240	1 82402	1·14042	2 08015	16
45	·480989	·876727	·548619	1 82276	1·14061	2 07905	15
46	·481244	876587	548997	1 82150	1·14079	2 07795	14
47	·481499	876447	·549376	1·82025	1 14097	2 07685	13
48	·481754	·876307	·549755	1·81899	1·14115	2 07575	12
49	482009	·876167	·550134	1 81774	1·14134	2 07465	11
50	·482263	·876026	·550513	1 81649	1 14152	2·07356	10
51	·482518	·875886	550892	1 81524	1 14170	2·07246	9
52	·482773	·875746	·551271	1 81399	1·14188	2·07137	8
53	·483028	·875605	·551650	1·81274	1·14207	2·07027	7
54	·483282	·875465	·552030	1 81150	1·14225	2·06918	6
55	·483537	·875324	·552409	1·81025	1 14243	2·06809	5
56	·483792	·875183	·552789	1·80901	1·14262	2 06701	4
57	·484046	·875042	·553169	1·80777	1·14280	2·06592	3
58	·484301	·874902	·553549	1·80653	1 14299	2·06483	2
59	·484555	·874761	·553929	1·80529	1 14317	2·06375	1
60	·484810	·874620	·554309	1·80405	1 14335	2·06267	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

29°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·484810	·874620	·554309	1·80405	1·14335	2·06267	60
1	·485064	·874479	·554689	1·80281	1·14354	2·06158	59
2	·485318	·874338	·555070	1·80158	1·14372	2·06050	58
3	·485573	·874196	·555450	1·80034	1·14391	2·05942	57
4	·485827	·874055	·555831	1·79911	1·14409	2·05835	56
5	·486081	·873914	·556212	1·79788	1·14428	2·05727	55
6	·486335	·873772	·556593	1·79665	1·14446	2·05619	54
7	·486590	·873631	·556974	1·79542	1·14465	2·05512	53
8	·486844	·873489	·557355	1·79419	1·14483	2·05405	52
9	·487098	·873347	·557736	1·79296	1·14502	2·05298	51
10	·487352	·873206	·558118	1·79174	1·14521	2·05191	50
11	·487606	·873064	·558499	1·79051	1·14539	2·05084	49
12	·487860	·872922	·558881	1·78929	1·14558	2·04977	48
13	·488114	·872780	·559263	1·78807	1·14576	2·04870	47
14	·488367	·872638	·559645	1·78665	1·14595	2·04764	46
15	·488621	·872496	·560027	1·78563	1·14614	2·04658	45
16	·488875	·872354	·560409	1·78441	1·14632	2·04551	44
17	·489129	·872212	·560791	1·78319	1·14651	2·04445	43
18	·489382	·872069	·561174	1·78198	1·14670	2·04339	42
19	·489636	·871927	·561556	1·78077	1·14689	2·04233	41
20	·489890	·871784	·561939	1·77955	1·14707	2·04128	40
21	·490143	·871642	·562322	1·77834	1·14726	2·04022	39
22	·490397	·871499	·562705	1·77713	1·14745	2·03916	38
23	·490650	·871357	·563088	1·77592	1·14764	2·03811	37
24	·490904	·871214	·563471	1·77471	1·14782	2·03706	36
25	·491157	·871071	·563854	1·77351	1·14801	2·03601	35
26	·491411	·870928	·564238	1·77230	1·14820	2·03496	34
27	·491664	·870785	·564621	1·77110	1·14839	2·03391	33
28	·491917	·870642	·565005	1·76990	1·14858	2·03286	32
29	·492170	·870499	·565389	1·76869	1·14877	2·03182	31
30	·492424	·870356	·565773	1·76749	1·14896	2·03077	30
31	·492677	·870212	·566157	1·76630	1·14914	2·02973	29
32	·492930	·870069	·566541	1·76510	1·14933	2·02869	28
33	·493183	·869926	·566925	1·76390	1·14952	2·02765	27
34	·493436	·869782	·567310	1·76271	1·14971	2·02661	26
35	·493689	·869639	·567694	1·76151	1·14990	2·02557	25
36	·493942	·869495	·568079	1·76032	1·15009	2·02453	24
37	·494195	·869351	·568464	1·75913	1·15028	2·02349	23
38	·494448	·869207	·568849	1·75794	1·15047	2·02246	22
39	·494700	·869064	·569234	1·75675	1·15066	2·02143	21
40	·494953	·868920	·569619	1·75556	1·15085	2·02039	20
41	·495206	·868776	·570004	1·75437	1·15105	2·01936	19
42	·495459	·868632	·570390	1·75319	1·15124	2·01833	18
43	·495711	·868487	·570776	1·75200	1·15143	2·01730	17
44	·495964	·868343	·571161	1·75082	1·15162	2·01628	16
45	·496217	·868199	·571547	1·74964	1·15181	2·01525	15
46	·496469	·868054	·571933	1·74846	1·15200	2·01422	14
47	·496722	·867910	·572319	1·74728	1·15219	2·01320	13
48	·496974	·867765	·572705	1·74610	1·15239	2·01218	12
49	·497226	·867621	·573092	1·74492	1·15258	2·01116	11
50	·497479	·867476	·573478	1·74375	1·15277	2·01014	10
51	·497731	·867331	·573865	1·74257	1·15296	2·00912	9
52	·497983	·867187	·574252	1·74140	1·15315	2·00810	8
53	·498236	·867042	·574638	1·74022	1·15335	2·00708	7
54	·498488	·866897	·575026	1·73905	1·15354	2·00607	6
55	·498740	·866752	·575413	1·73788	1·15373	2·00505	5
56	·498992	·866607	·575800	1·73671	1·15393	2·00404	4
57	·499244	·866461	·576187	1·73555	1·15412	2·00303	3
58	·499496	·866316	·576575	1·73438	1·15431	2·00202	2
59	·499748	·866171	·576962	1·73321	1·15451	2·00101	1
60	·500000	·866025	·577350	1·73205	1·15470	2·00000	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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Six-Figure Trigonometrical Tables—*continued*

30°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·500000	·866025	·577350	1·73205	1·15470	2·00000	60
1	·500252	·865880	·577738	1·73089	1·15489	1·99899	59
2	·500504	·865734	·578126	1·72973	1·15509	1·99799	58
3	·500756	·865589	·578514	1·72857	1·15528	1·99698	57
4	·501007	·865443	·578903	1·72741	1·15548	1·99598	56
5	·501259	·865297	·579291	1·72625	1·15567	1·99498	55
6	·501511	·865151	·579680	1·72509	1·15587	1·99398	54
7	·501762	·865006	·580068	1·72393	1·15606	1·99298	53
8	·502014	·864860	·580457	1·72278	1·15626	1·99198	52
9	·502266	·864713	·580846	1·72163	1·15645	1·99098	51
10	·502517	·864567	·581235	1·72047	1·15665	1·98998	50
11	·502768	·864421	·581625	1·71932	1·15684	1·98899	49
12	·503020	·864275	·582014	1·71817	1·15704	1·98799	48
13	·503271	·864128	·582403	1·71702	1·15724	1·98700	47
14	·503523	·863982	·582793	1·71588	1·15743	1·98601	46
15	·503774	·863836	·583183	1·71473	1·15763	1·98502	45
16	·504025	·863689	·583573	1·71358	1·15782	1·98403	44
17	·504276	·863542	·583963	1·71244	1·15802	1·98304	43
18	·504528	·863396	·584353	1·71129	1·15822	1·98205	42
19	·504779	·863249	·584743	1·71015	1·15841	1·98107	41
20	·505030	·863102	·585134	1·70901	1·15861	1·98008	40
21	·505281	·862955	·585524	1·70787	1·15881	1·97910	39
22	·505532	·862808	·585915	1·70673	1·15901	1·97811	38
23	·505783	·862661	·586306	1·70560	1·15920	1·97713	37
24	·506034	·862514	·586697	1·70446	1·15940	1·97615	36
25	·506285	·862366	·587088	1·70332	1·15960	1·97517	35
26	·506535	·862219	·587479	1·70219	1·15980	1·97420	34
27	·506786	·862072	·587870	1·70106	1·16000	1·97322	33
28	·507037	·861924	·588262	1·69992	1·16019	1·97224	32
29	·507288	·861777	·588653	1·69879	1·16039	1·97127	31
30	·507538	·861629	·589045	1·69766	1·16059	1·97029	30
31	·507789	·861481	·589437	1·69653	1·16079	1·96932	29
32	·508040	·861334	·589829	1·69541	1·16099	1·96835	28
33	·508290	·861186	·590221	1·69428	1·16119	1·96738	27
34	·508541	·861038	·590613	1·69316	1·16139	1·96641	26
35	·508791	·860890	·591006	1·69203	1·16159	1·96544	25
36	·509041	·860742	·591398	1·69091	1·16179	1·96448	24
37	·509292	·860594	·591791	1·68979	1·16199	1·96351	23
38	·509542	·860446	·592184	1·68866	1·16219	1·96255	22
39	·509792	·860297	·592577	1·68754	1·16239	1·96158	21
40	·510043	·860149	·592970	1·68643	1·16259	1·96062	20
41	·510293	·860001	·593363	1·68531	1·16279	1·95966	19
42	·510543	·859852	·593757	1·68419	1·16299	1·95870	18
43	·510793	·859704	·594150	1·68308	1·16319	1·95774	17
44	·511043	·859555	·594544	1·68196	1·16339	1·95678	16
45	·511293	·859406	·594937	1·68085	1·16359	1·95583	15
46	·511543	·859258	·595331	1·67974	1·16380	1·95487	14
47	·511793	·859109	·595725	1·67863	1·16400	1·95392	13
48	·512043	·858960	·596120	1·67752	1·16420	1·95296	12
49	·512293	·858811	·596541	1·67641	1·16440	1·95201	11
50	·512543	·858662	·596908	1·67530	1·16460	1·95106	10
51	·512792	·858513	·597303	1·67419	1·16481	1·95011	9
52	·513042	·858364	·597698	1·67309	1·16501	1·94916	8
53	·513292	·858214	·598093	1·67198	1·16521	1·94821	7
54	·513541	·858065	·598488	1·67088	1·16541	1·94726	6
55	·513791	·857915	·598883	1·66978	1·16562	1·94632	5
56	·514040	·857766	·599278	1·66867	1·16582	1·94537	4
57	·514290	·857616	·599674	1·66757	1·16602	1·94443	3
58	·514539	·857467	·600069	1·66647	1·16623	1·94349	2
59	·514789	·857317	·600465	1·66538	1·16643	1·94254	1
60	·515038	·857167	·600861	1·66428	1·16663	1·94160	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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Six-Figure Trigonometrical Tables—*continued*

31°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·515038	·857167	·600861	1 66428	1·16663	1 94160	60
1	·515287	·857017	·601257	1·66318	1 16684	1·94066	59
2	·515537	856868	·601653	1 66209	1 16704	1 93973	58
3	·515786	856718	602049	1 66099	1 16725	1 93879	57
4	516035	856567	·602445	1 65990	1 16745	1·93785	56
5	·516284	·856417	·602842	1 65881	1·16766	1 93692	55
6	516533	·856267	603239	1 65772	1 16786	1 93598	54
7	516782	·856117	603635	1 65663	1 16806	1 93505	53
8	·517031	855966	604032	1 65554	1 16827	1·93412	52
9	·517280	855816	·604429	1 65445	1 16848	1 93319	51
10	·517529	855665	604827	1 65337	1 16868	1·93226	50
11	·517778	855515	605224	1 65228	1 16889	1 93133	49
12	518027	855364	605622	1 65120	1 16909	1 93040	48
13	·518276	·855214	606019	1 65011	1·16930	1·92947	47
14	·518525	855063	606417	1 64903	1·16950	1 92855	46
15	518773	854912	·606815	1 64795	1 16971	1 92762	45
16	519022	·854761	607213	1 64687	1·16992	1 92670	44
17	·519271	·854610	607611	1 64579	1 17012	1 92578	43
18	519519	854459	608010	1 64471	1 17033	1 92486	42
19	·519768	854308	608408	1 64363	1 17054	1 92394	41
20	·520016	854156	608807	1 64256	1 17075	1 92302	40
21	520265	854005	·609205	1 64148	1 17095	1 92210	39
22	·520513	·853854	609604	1 64041	1·17116	1·92118	38
23	·520761	853702	610003	1·63934	1 17137	1 92027	37
24	·521010	853551	·610403	1 63826	1 17158	1 91935	36
25	·521258	·853399	·610802	1 63719	1 17178	1 91844	35
26	·521506	853248	611201	1 63612	1·17199	1·91752	34
27	·521754	·853096	611601	1 63505	1 17220	1·91661	33
28	·522002	·852944	·612001	1 63398	1 17241	1 91570	32
29	·522251	·852792	·612401	1 63292	1 17262	1 91479	31
30	522499	·852640	·612801	1 63185	1 17283	1 91388	30
31	·522747	·852488	·613201	1 63079	1·17304	1 91297	29
32	·522995	·852336	·613601	1·62972	1 17325	1 91207	28
33	·523242	·852184	614002	1·62866	1 17346	1 91116	27
34	·523490	·852032	·614402	1·62760	1 17367	1 91026	26
35	·523738	·851879	614803	1 62654	1 17388	1 90935	25
36	·523986	851727	615204	1 62548	1 17409	1 90845	24
37	·524234	·851574	·615605	1 62442	1 17430	1·90755	23
38	·524481	·851422	616006	1 62336	1·17451	1·90665	22
39	·524729	·851269	·616408	1 62230	1·17472	1·90575	21
40	·524977	·851117	616809	1·62125	1 17493	1 90485	20
41	·525224	850964	·617211	1 62019	1 17514	1 90395	19
42	525472	·850811	·617613	1 61914	1·17535	1 90305	18
43	·525719	·850658	·618015	1·61808	1·17556	1 90216	17
44	·525967	·850505	·618417	1 61703	1·17577	1 90126	16
45	·526214	·850352	·618819	1·61598	1 17598	1 90037	15
46	·526461	·850199	·619221	1 61493	1 17620	1·89948	14
47	·526709	·850046	·619624	1 61388	1·17641	1·89858	13
48	·526956	·849893	·620026	1 61283	1 17662	1·89769	12
49	·527203	·849739	·620429	1·61179	1·17683	1·89680	11
50	·527450	·849586	·620832	1·61074	1 17704	1 89591	10
51	·527697	·849433	·621235	1·60970	1·17726	1 89503	9
52	·527944	·849279	·621638	1·60865	1·17747	1·89414	8
53	·528191	·849125	·622042	1·60761	1·17768	1·89325	7
54	·528438	·848972	·622445	1·60657	1 17790	1 89237	6
55	·528685	·848818	·622849	1·60553	1·17811	1·89148	5
56	·528932	·848664	·623253	1·60449	1·17832	1·89060	4
57	·529179	·848510	·623657	1·60345	1·17854	1·88972	3
58	·529426	·848356	·624061	1·60241	1·17875	1 88884	2
59	·529673	·848202	·624465	1·60137	1·17896	1·88796	1
60	·529919	·848048	·624869	1 60033	1·17918	1 88708	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

32°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·529919	·848048	·624869	1 60033	1·17918	1·88708	60
1	·530166	847894	·625274	1 59930	1·17939	1 88620	59
2	530413	847740	·625679	1 59826	1·17961	1·88532	58
3	·530659	·847585	·626083	1 59723	1·17982	1 88445	57
4	·530906	·847431	·626488	1·59620	1·18004	1 18004	56
5	·531152	·847277	·626894	1 59517	1·18025	1 88270	55
6	·531399	847122	·627299	1·59414	1 18047	1 88183	54
7	·531645	·846967	627704	1·59311	1 18068	1 88095	53
8	531891	846813	·628110	1·59208	1 18090	1·88008	52
9	532138	846658	·628516	1 59105	1 18111	1·87921	51
10	·532384	·846503	628921	1 59002	1 18133	1 87834	50
11	·532630	·846348	·629327	1 58900	1·18155	1 87748	49
12	·532876	·846193	·629734	1 58797	1·18176	1·87661	48
13	·533122	·846038	630140	1 58695	1 18198	1·87574	47
14	·533368	·845883	630546	1 58593	1 18220	1 87488	46
15	·533615	·845728	630953	1 58490	1 18241	1 87401	45
16	·533861	845573	631360	1·58388	1·18263	1·87315	44
17	·534106	845417	631767	1 58286	1 18285	1 87229	43
18	·534352	·845262	632174	1 58184	1 18307	1 87142	42
19	·534598	·845106	·632581	1 58083	1 18328	1 87056	41
20	·534844	844951	·632988	1 57981	1·18350	1·86970	40
21	·535090	·844795	633396	1 57879	1·18372	1·86885	39
22	·535335	844640	·633804	1·57778	1 18394	1·86799	38
23	·535581	844484	634211	1·57676	1 18416	1 86713	37
24	535827	844328	634619	1 57575	1·18437	1 86627	36
25	·536072	844172	635027	1 57474	1 18459	1 86542	35
26	·536318	·844016	635436	1·57372	1 18481	1 86457	34
27	·536563	·843860	635844	1·57271	1 18503	1·86371	33
28	·536809	·843704	·636253	1·57170	1·18525	1·86286	32
29	·537054	·843548	·636661	1·57069	1·18547	1 86201	31
30	537300	·843391	637070	1 56969	1 18569	1 86116	30
31	·537545	·843235	637479	1·56868	1 18591	1·86031	29
32	537790	·843079	·637888	1 56767	1 18613	1 85946	28
33	·538035	·842922	638298	1 56667	1 18635	1 85861	27
34	·538281	·842766	·638707	1 56566	1·18657	1 85777	26
35	·538526	·842609	·639117	1·56466	1 18679	1·85692	25
36	·538771	·842452	639527	1 56366	1 18701	1 85608	24
37	·539016	·842296	639937	1·56265	1 18723	1·85523	23
38	·539261	842139	640347	1 56165	1·18745	1 85439	22
39	·539506	841982	640757	1 56065	1·18767	1 85355	21
40	·539751	841825	·641167	1 55966	1 18790	1·85271	20
41	·539996	·841668	·641578	1 55866	1 18812	1 85187	19
42	·540240	·841511	·641989	1·55766	1·18834	1·85103	18
43	·540485	·841354	·642399	1 55666	1·18856	1 85019	17
44	·540730	·841196	·642810	1·55567	1·18878	1·84935	16
45	·540974	·841039	·643222	1·55467	1·18901	1·84852	15
46	·541219	·840882	·643633	1·55368	1·18923	1·84768	14
47	·541464	·840724	·644044	1·55269	1·18945	1·84685	13
48	·541708	·840567	·644456	1·55170	1·18967	1·84601	12
49	·541953	·840409	·644868	1·55071	1·18990	1·84518	11
50	·542197	·840251	·645280	1·54972	1·19012	1·84435	10
51	·542442	·840094	·645692	1·54873	1·19034	1·84352	9
52	·542686	·839936	·646104	1 54774	1·19057	1·84269	8
53	·542930	·839778	·646516	1·54675	1·19079	1·84186	7
54	·543174	·839620	·646929	1·54576	1·19102	1·84103	6
55	·543419	·839462	·647342	1·54478	1·19124	1·84020	5
56	·543663	·839304	·647755	1·54379	1·19146	1 83938	4
57	·543907	·839146	·648168	1·54281	1·19169	1·83855	3
58	·544151	·838987	648581	1·54183	1·19191	1·83773	2
59	·544395	·838829	·648994	1·54085	1·19214	1·83690	1
60	·544639	·838671	·649408	1·53986	1·19236	1·83608	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

33°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·544639	·838671	·649408	1·53986	1 19236	1·83608	60
1	·544883	·838512	·649821	1 53888	1 19259	1·83526	59
2	·545127	·838354	·650235	1·53791	1 19281	1·83444	58
3	·545371	·838195	·650649	1·53693	1 19304	1·83362	57
4	·545614	·838036	·651063	1·53595	1 19327	1·83280	56
5	·545858	·837878	·651477	1·53497	1 19349	1·83198	55
6	·546102	·837719	·651892	1 53400	1 19372	1·83116	54
7	·546346	·837560	·652306	1·53302	1 19394	1 83034	53
8	·546589	·837401	·652721	1·53205	1 19417	1·82953	52
9	·546833	·837242	·653136	1·53107	1·19440	1 82871	51
10	·547076	·837083	·653551	1·53010	1 19463	1·82790	50
11	·547320	·836924	·653966	1·52913	1 19485	1·82709	49
12	·547563	·836764	654382	1·52816	1 19508	1·82627	48
13	·547807	836605	·654797	1·52719	1 19531	1·82546	47
14	·548050	·836446	·655213	1·52622	1·19553	1·82465	46
15	·548293	·836286	·655629	1·52525	1·19576	1·82384	45
16	·548536	·836127	·656045	1·52429	1·19599	1·82303	44
17	·548780	·835967	656461	1·52332	1 19622	1 82222	43
18	·549023	·835807	·656877	1·52235	1 19645	1 82142	42
19	·549266	·835648	·657294	1·52139	1 19668	1 82061	41
20	·549509	·835488	657710	1·52043	1 19691	1·81981	40
21	·549752	835328	·658127	1·51946	1 19713	1·81900	39
22	·549995	835168	·658544	1 51850	1 19736	1·81820	38
23	·550238	835008	·658961	1 51754	1 19759	1·81740	37
24	·550481	834848	·659379	1·51658	1 19782	1 81659	36
25	·550724	834688	·659796	1 51562	1 19805	1·81579	35
26	·550966	·834527	·660214	1·51466	1 19828	1·81499	34
27	·551209	·834367	·660631	1·51370	1 19851	1·81419	33
28	·551452	·834207	·661049	1·51275	1 19874	1·81340	32
29	·551694	·834046	·661467	1·51179	1 19897	1·81260	31
30	·551937	·833886	·661886	1·51084	1·19920	1 81180	30
31	·552180	833725	·662304	1·50988	1·19944	1 81101	29
32	·552422	·833565	·662723	1·50893	1·19967	1·81021	28
33	·552664	·833404	·663141	1·50797	1·19990	1 80942	27
34	·552907	·833243	·663560	1·50702	1 20013	1 80862	26
35	·553149	·833082	·663979	1·50607	1·20036	1 80783	25
36	·553392	·832921	·664398	1·50512	1·20059	1 80704	24
37	·553634	·832760	·664818	1 50417	1 20083	1·80625	23
38	·553876	·832599	·665237	1 50322	1 20106	1 80546	22
39	·554118	·832438	·665657	1·50228	1 20129	1·80467	21
40	·554360	·832277	·666077	1·50133	1 20152	1·80388	20
41	·554602	·832115	·666497	1·50038	1 20176	1·80309	19
42	·554844	·831954	·666917	1·49944	1 20199	1·80231	18
43	·555086	·831793	·667337	1·49849	1 20222	1·80152	17
44	·555328	·831631	·667758	1·49755	1 20246	1·80074	16
45	·555570	·831470	·668179	1·49661	1 20269	1·79995	15
46	·555812	·831308	·668599	1·49566	1 20292	1·79917	14
47	·556054	·831146	·669020	1·49472	1 20316	1·79839	13
48	·556296	·830984	·669442	1·49378	1 20339	1·79761	12
49	·556537	·830823	·669863	1·49284	1·20363	1·79682	11
50	·556779	·830661	·670285	1·49190	1·20386	1·79604	10
51	·557251	·830499	·670706	1·49097	1·20410	1·79527	9
52	·557262	·830337	·671128	1·49003	1·20433	1·79449	8
53	·557504	·830174	·671550	1·48909	1·20457	1·79371	7
54	·557745	·830012	·671972	1 48816	1 20480	1·79293	6
55	·557987	·829850	·672394	1·48722	1·20504	1·79216	5
56	·558228	·829688	·672817	1·48629	1·20527	1·79138	4
57	·558469	·829525	·673240	1·48536	1·20551	1·79061	3
58	·558710	·829363	·673662	1·48442	1·20575	1·78984	2
59	·558952	·829200	·674085	1·48349	1·20598	1·78906	1
60	·559193	·829038	·674509	1·48256	1·20622	1·78829	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·559193	·829038	674509	1·48256	1·20622	1·78829	60
1	·559434	828875	·674932	1·48163	1·20645	1·78752	59
2	·559675	·828712	675355	1·48070	1·20669	1·78675	58
3	·559916	828549	675779	1·47977	1·20693	1·78598	57
4	·560157	828386	676203	1·47885	1·20717	1·78521	56
5	·560398	·828223	676627	1·47792	1·20740	1·78445	55
6	560639	828060	·677051	1·47699	1·20764	1·78368	54
7	·560880	827897	677475	1·47607	1·20788	1·78291	53
8	561121	827734	677900	1·47514	1·20812	1·78215	52
9	561361	827571	678324	1·47422	1·20836	1·78138	51
10	561602	827407	678749	1·47330	1·20859	1·78062	50
11	561843	827244	679174	1·47238	1·20883	1·77986	49
12	562083	827081	679599	1·47146	1·20907	1·77910	48
13	562324	826917	680025	1·47054	1·20931	1·77833	47
14	562564	826753	680450	1·46962	1·20955	1·77757	46
15	·562805	826590	680876	1·46870	1·20979	1·77681	45
16	·563045	826426	·681302	1·46778	1·21003	1·77606	44
17	563286	·826262	681728	1·46686	1·21027	1·77530	43
18	563526	826098	·682154	1·46595	1·21051	1·77454	42
19	·563766	825934	682580	1·46503	1·21075	1·77378	41
20	·564007	825770	·683007	1·46411	1·21099	1·77303	40
21	·564247	825606	683433	1·46320	1·21123	1·77227	39
22	564487	825442	683860	1·46229	1·21147	1·77152	38
23	·564727	·825278	684287	1·46137	1·21171	1·77077	37
24	·564967	·825114	684714	1·46046	1·21195	1·77001	36
25	565207	824949	685142	1·45955	1·21220	1·76926	35
26	565447	824785	685569	1·45864	1·21244	1·76851	34
27	565687	824620	685997	1·45773	1·21268	1·76776	33
28	·565927	824456	·686425	1·45682	1·21292	1·76701	32
29	·566166	·824291	·686853	1·45592	1·21316	1·76626	31
30	·566406	·824126	687281	1·45501	1·21341	1·76552	30
31	566646	823961	687709	1·45410	1·21365	1·76477	29
32	566886	823797	688138	1·45320	1·21389	1·76402	28
33	567125	823632	688567	1·45229	1·21414	1·76328	27
34	567365	·823467	688995	1·45139	1·21438	1·76253	26
35	567604	·823302	689425	1·45049	1·21462	1·76179	25
36	567844	·823136	689854	1·44958	1·21487	1·76105	24
37	568083	822971	690283	1·44868	1·21511	1·76031	23
38	·568323	·822806	690713	1·44778	1·21535	1·75956	22
39	·568562	·822641	691143	1·44688	1·21560	1·75882	21
40	·568801	·822475	691572	1·44598	1·21584	1·75808	20
41	569040	·822310	692003	1·44508	1·21609	1·75734	19
42	·569280	822144	692433	1·44418	1·21633	1·75661	18
43	·569519	·821978	692863	1·44329	1·21658	1·75587	17
44	569758	·821813	·693294	1·44239	1·21682	1·75513	16
45	·569997	821647	·693725	1·44149	1·21707	1·75440	15
46	·570236	·821481	·694156	1·44060	1·21731	1·75366	14
47	·570475	·821315	·694587	1·43970	1·21756	1·75293	13
48	·570714	·821149	695018	1·43881	1·21781	1·75219	12
49	·570952	·820983	695450	1·43792	1·21805	1·75146	11
50	·571191	820817	695881	1·43703	1·21830	1·75073	10
51	·571430	·820651	·696313	1·43614	1·21855	1·75000	9
52	·571669	·820485	696745	1·43525	1·21879	1·74927	8
53	·571907	820318	697177	1·43436	1·21904	1·74854	7
54	·572146	·820152	·697610	1·43347	1·21929	1·74781	6
55	·572384	·819985	698042	1·43258	1·21953	1·74708	5
56	·572623	·819819	698475	1·43169	1·21978	1·74635	4
57	·572861	·819652	698908	1·43080	1·22003	1·74562	3
58	·573100	·819486	·699341	1·42992	1·22028	1·74490	2
59	·573338	·819319	·699774	1·42903	1·22053	1·74417	1
60	·573576	·819152	·700208	1·42815	1·22077	1·74345	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

35°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·573576	819152	700208	1 42815	1 22077	1 74345	60
1	·573815	·818985	700641	1 42726	1 22102	1 74272	59
2	·574053	·818818	·701075	1 42638	1 22127	1 74200	58
3	·574291	·818651	·701509	1 42550	1 22152	1 74128	57
4	·574529	818484	701943	1 42642	1·22177	1 74056	56
5	·574767	·818317	·702377	1 42374	1 22202	1·73983	55
6	·575005	·818150	·702812	1 42286	1·22227	1·73911	54
7	575243	·817982	703246	1·42198	1 22252	1 73840	53
8	575481	·817815	703681	1 42110	1·22277	1·73768	52
9	575719	·817648	·704116	1 42022	1·22302	1 73696	51
10	·575957	·817480	704551	1 41934	1 22327	1 73624	50
11	·576195	·817313	·704987	1 41847	1 22352	1 73552	49
12	·576432	·817145	·705422	1·41759	1 22377	1 73481	48
13	576670	·816977	·705858	1 41672	1 22402	1·73409	47
14	576908	·816809	·706294	1 41584	1 22428	1 73338	46
15	577145	·816642	·706730	1 41497	1 22453	1 73267	45
16	577383	·816474	707166	1 41409	1 22478	1 73195	44
17	577620	·816306	707603	1 41322	1 22503	1 73124	43
18	577858	816138	708039	1 41235	1 22528	1·73053	42
19	578095	815969	·708476	1·41148	1 22554	1 72982	41
20	578332	815801	708913	1 41061	1 22579	1 72911	40
21	·578570	·815633	·709350	1 40974	1 22604	1 72840	39
22	578807	815465	709788	1·40887	1 22629	1 72769	38
23	579044	·815296	·710225	1 40800	1 22655	1·72698	37
24	·579281	·815128	·710663	1 40714	1 22680	1 72628	36
25	·579518	·814959	711101	1 40627	1 22706	1 72557	35
26	·579755	814791	·711539	1 40540	1·22731	1 72487	34
27	·579992	·814622	·711977	1·40454	1 22756	1 72416	33
28	·580229	814453	712416	1 40367	1·22782	1·72346	32
29	·580466	814284	·712854	1 40281	1 22807	1 77275	31
30	·580703	814116	·713293	1 40195	1 22833	1·72205	30
31	·580940	813947	·713732	1 40109	1·22858	1 72135	29
32	·581176	813778	·714171	1·40022	1·22884	1 72065	28
33	581413	·813608	·714611	1 39936	1 22909	1 71995	27
34	·581650	·813439	·715050	1·39850	1·22935	1 71925	26
35	581886	813270	715490	1·39764	1 22960	1 71855	25
36	582123	813101	715930	1·39679	1 22986	1·71785	24
37	582359	812931	·716370	1 39593	1·23012	1 71715	23
38	·582596	812762	·716810	1·39507	1 23037	1 71646	22
39	·582832	812592	717250	1·39421	1 23063	1·71576	21
40	583069	·812423	717691	1 39336	1 23089	1 71506	20
41	·583305	·812253	718132	1·39250	1 23144	1 71437	19
42	·583541	812084	·718573	1·39165	1 23140	1·71368	18
43	·583777	·811914	·719014	1 39079	1·23166	1·71298	17
44	·584014	·811744	719455	1 38994	1 23192	1·71229	16
45	·584250	811574	·719897	1 38909	1·23217	1·71160	15
46	·584486	·811404	·720339	1·38824	1·23243	1·71091	14
47	·584722	·811234	·720781	1·38738	1·23269	1·71022	13
48	·584958	·811064	·721223	1·38653	1 23295	1·70953	12
49	·585194	·810894	·721665	1·38568	1·23321	1·70884	11
50	·585429	·810723	·722108	1·38484	1·23347	1·70815	10
51	·585665	·810553	·722550	1·38399	1·23373	1·70746	9
52	·585901	·810383	·722993	1 38314	1 23398	1·70677	8
53	586137	·810212	·723436	1·38229	1·23424	1·70609	7
54	586372	·810042	·723879	1·38145	1·23450	1·70540	6
55	·586608	·809871	·724323	1·38060	1 23476	1·70472	5
56	·586844	·809700	·724766	1·37976	1 23502	1 70403	4
57	·587079	·809530	·725210	1 37891	1·23529	1 70335	3
58	·587314	·809359	·725654	1·37807	1·23555	1 70267	2
59	·587550	·809188	·726098	1·37722	1·23581	1·70198	1
60	·587785	·809017	·726543	1·37638	1·23607	1·70130	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·587785	·809017	·726543	1·37638	1·23607	1·70130	60
1	·588021	·808846	·726987	1·37554	1·23633	1·70062	59
2	·588256	·808675	·727432	1·37470	1·23659	1·69994	58
3	·588491	·808504	·727877	1·37386	1·23685	1·69926	57
4	·588726	·808333	·728322	1·37302	1·23711	1·69858	56
5	·588961	·808161	·728767	1·37218	1·23738	1·69790	55
6	·589196	·807990	·729213	1·37134	1·23764	1·69723	54
7	·589431	·807818	·729658	1·37050	1·23790	1·69655	53
8	·589666	·807647	·730104	1·36967	1·23816	1·69587	52
9	·589901	·807475	·730550	1·36883	1·23843	1·69520	51
10	·590136	·807304	·730996	1·36800	1·23869	1·69452	50
11	·590371	·807132	·731443	1·36716	1·23895	1·69385	49
12	·590606	·806960	·731889	1·36633	1·23922	1·69318	48
13	·590840	·806788	·732336	1·36549	1·23948	1·69250	47
14	·591075	·806617	·732783	1·36466	1·23975	1·69183	46
15	·591310	·806445	·733230	1·36383	1·24001	1·69116	45
16	·591544	·806273	·733678	1·36300	1·24028	1·69049	44
17	·591779	·806100	·734125	1·36217	1·24054	1·68982	43
18	·592013	·805928	·734573	1·36134	1·24081	1·68915	42
19	·592248	·805756	·735021	1·36051	1·24107	1·68848	41
20	·592482	·805584	·735469	1·35968	1·26134	1·68782	40
21	·592716	·805411	·735917	1·35885	1·24160	1·68715	39
22	·592951	·805239	·736366	1·35802	1·24187	1·68648	38
23	·593185	·805066	·736815	1·35719	1·24213	1·68582	37
24	·593419	·804894	·737264	1·35637	1·24240	1·68515	36
25	·593653	·804721	·737713	1·35554	1·24267	1·68449	35
26	·593887	·804548	·738162	1·35472	1·24293	1·68382	34
27	·594121	·804376	·738611	1·35389	1·24320	1·68316	33
28	·594355	·804203	·739061	1·35307	1·24347	1·68250	32
29	·594589	·804030	·739511	1·35224	1·24373	1·68183	31
30	·594823	·803857	·739961	1·35142	1·24400	1·68117	30
31	·595057	·803684	·740411	1·35060	1·24427	1·68051	29
32	·595290	·803511	·740862	1·34978	1·24454	1·67985	28
33	·595524	·803337	·741312	1·34896	1·24481	1·67919	27
34	·595758	·803164	·741763	1·34814	1·24508	1·67853	26
35	·595991	·802991	·742214	1·34732	1·24534	1·67788	25
36	·596225	·802817	·742666	1·34650	1·24561	1·67722	24
37	·596458	·802644	·743117	1·34568	1·24588	1·67656	23
38	·596692	·802470	·743569	1·34487	1·24615	1·67591	22
39	·596925	·802297	·744020	1·34405	1·24642	1·67525	21
40	·597159	·802123	·744472	1·34323	1·24669	1·67460	20
41	·597392	·801949	·744925	1·34242	1·24696	1·67394	19
42	·597625	·801776	·745377	1·34160	1·24723	1·67329	18
43	·597858	·801602	·745830	1·34079	1·24750	1·67264	17
44	·598092	·801428	·746282	1·33998	1·24777	1·67199	16
45	·598325	·801254	·746735	1·33916	1·24804	1·67133	15
46	·598558	·801080	·747189	1·33835	1·24832	1·67068	14
47	·598791	·800906	·747642	1·33754	1·24859	1·67003	13
48	·599024	·800731	·748096	1·33673	1·24886	1·66938	12
49	·599256	·800557	·748549	1·33592	1·24913	1·66873	11
50	·599489	·800383	·749003	1·33511	1·24940	1·66809	10
51	·599722	·800208	·749458	1·33430	1·24967	1·66744	9
52	·599955	·800034	·749912	1·33349	1·24995	1·66679	8
53	·600188	·799859	·750366	1·33268	1·25022	1·66615	7
54	·600420	·799685	·750821	1·33187	1·25049	1·66550	6
55	·600653	·799510	·751276	1·33107	1·25077	1·66486	5
56	·600885	·799335	·751731	1·33026	1·25104	1·66421	4
57	·601118	·799160	·752187	1·32946	1·25131	1·66357	3
58	·601350	·798986	·752642	1·32865	1·25159	1·66292	2
59	·601583	·798811	·753098	1·32785	1·25186	1·66228	1
60	·601815	·798636	·753554	1·32704	1·25214	1·66164	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

37°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·601815	·798636	·753554	1 32704	1·25214	1 66164	60
1	·602047	·798460	·754010	1·32624	1 25241	1 66100	59
2	602280	798285	·754467	1·32544	1 25269	1 66036	58
3	·602512	·798110	754923	1·32464	1 25296	1 65972	57
4	·602744	797935	755380	1 32384	1 25324	1·65908	56
5	·602976	·797759	·755837	1 32304	1 25351	1·65844	55
6	·603208	·797584	·756294	1 32224	1 25379	1 65780	54
7	·603440	797408	·756751	1 32144	1·25406	1·65717	53
8	·603672	797233	·757209	1 32064	1 25434	1 65653	52
9	·603904	·797057	·757667	1 31984	1 25462	1 65589	51
10	·604136	·796882	·758125	1 31904	1 25489	1 65526	50
11	·604367	·796706	·758583	1 31825	1 25517	1 65462	49
12	·604599	·796530	·759041	1 31745	1 25545	1 65399	48
13	·604831	·796354	·759500	1 31666	1 25572	1 65336	47
14	·605062	796178	759959	1 31586	1 25600	1 65272	46
15	605294	796002	·760418	1·31507	1 25628	1 65209	45
16	605526	·795826	760877	1 31427	1 25656	1 65146	44
17	·605757	795650	761336	1 31348	1 25683	1·65083	43
18	605988	·795473	761796	1 31269	1 25711	1·65020	42
19	·606220	795297	·762256	1 31190	1 25739	1 64957	41
20	606451	795121	762716	1 31110	1 25767	1 64894	40
21	·606682	·794944	·763176	1 31031	1 25795	1 64831	39
22	·606914	·794768	763636	1 30952	1 25823	1 64768	38
23	·607145	·794591	·764097	1 30873	1 25851	1 64705	37
24	607376	794415	764558	1·30795	1 25879	1 64643	36
25	607607	·794238	765019	1 30716	1·25907	1 64580	35
26	607838	·794061	765480	1 30637	1 25935	1 64518	34
27	608069	·793884	765941	1 30558	1 25963	1 64455	33
28	608300	793707	·766403	1 30480	1 25991	1 64393	32
29	608531	·793530	·766865	1 30401	·26019	1 64330	31
30	608761	·793353	767327	1 30323	1·26047	1·64268	30
31	·608992	·793176	767789	1 30244	1 26075	1·64206	29
32	·609223	·792999	·768252	1 30166	1 26104	1 64144	28
33	·609454	·792822	·768714	1 30087	1 26132	1 64081	27
34	·609684	·792644	·769177	1 30009	1 26160	1·64019	26
35	·609915	·792467	·769640	1 29931	1 26188	1 63957	25
36	610145	·792290	·770104	1·29853	1 26216	1·63895	24
37	·610376	·792112	770567	1 29775	1 26245	1 63834	23
38	·610606	·791935	·771031	1 29696	1 26273	1·63772	22
39	610836	·791757	771495	1 29618	1 26301	1 63710	21
40	·611067	791579	·771959	1 29541	1 26330	1·63648	20
41	·611297	791401	·772423	1 29463	1·26358	1·63587	19
42	·611527	·791224	·772888	1 29385	1 26387	1·63525	18
43	·611757	·791046	·773353	1 29307	1 26415	1·63464	17
44	·611987	·790868	·773818	1·29229	1 26443	1·63402	16
45	·612217	·790690	·774283	1 29152	1·26472	1·63341	15
46	·612447	·790511	·774748	1 29074	1 26500	1·63279	14
47	·612677	·790333	·775214	1·28997	1 26529	1·63218	13
48	·612907	·790155	·775680	1 28919	1·26557	1·63157	12
49	·613137	789977	·776146	1 28842	1 26586	1·63096	11
50	·613367	·789798	776612	1·28764	1·26615	1·63035	10
51	·613596	·789620	·777078	1·28687	1·26643	1·62974	9
52	·613826	·789441	·777545	1·28610	1 26672	1·62913	8
53	·614056	·789263	·778012	1·28533	1·26701	1 62852	7
54	·614285	·789084	·778479	1·28456	1·26729	1·62791	6
55	·614515	·788905	778946	1·28379	1 26758	1·62730	5
56	·614744	·788727	·779414	1 28302	1·26787	1·62669	4
57	·614974	·788548	·779881	1 28225	1·26815	1·62609	3
58	·615203	·788369	·780349	1·28148	1·26844	1·62548	2
59	·615432	·788190	·780817	1·28071	1·26873	1·62487	1
60	·615661	·788011	·781286	1·27994	1·26902	1·62427	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

38°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·615661	788011	781286	1 27994	1 26902	1 62427	60
1	·615891	787832	781754	1 27917	1 26931	1 62366	59
2	·616120	787652	·782223	1 27841	1 26960	1 62306	58
3	·616349	787473	782692	1 27764	1 26988	1·62246	57
4	·616578	·787294	·783161	1 27688	1 27017	1·62185	56
5	·616807	·787114	783631	1 27611	1 27046	1 62125	55
6	·617036	786935	784100	1 27535	1·27075	1 62065	54
7	617265	786756	·784570	1 27458	1 27104	1 62005	53
8	·617494	786576	·785040	1 27382	1 27133	1 61945	52
9	·617722	·786396	·785510	1 27306	1 27162	1 61885	51
10	617951	786217	785981	1 27230	1 27191	1 61825	50
11	618180	·786037	786451	1 27153	1 27221	1 61765	49
12	·618408	785857	786922	1·27077	1·27250	1 61705	48
13	·618637	785677	787394	1 27001	1 27279	1 61646	47
14	618865	785497	787865	1 26925	1 27308	1 61586	46
15	619094	785317	788336	1 26849	1 27337	1 61526	45
16	619322	785137	788808	1 26774	1 27366	1 61467	44
17	619551	·784957	·789280	1 26698	1 27396	1 61407	43
18	·619779	784776	·789752	1 26622	1 27425	1 61348	42
19	620007	784596	·790225	1 26546	1 27454	1 61288	41
20	620235	784416	·790697	1 26471	1 27483	1 61229	40
21	620464	784235	791170	1 26395	1 27513	1 61170	39
22	·620692	·784055	·791643	1 26319	1 27542	1 61111	38
23	620920	·783874	·792117	1 26244	1 27572	1 61051	37
24	621148	·783693	792590	1 26169	1 27601	1 60992	36
25	·621376	·783513	·793064	1 26093	1 27630	1 60933	35
26	·621604	783332	793538	1 26018	1 27660	1·60874	34
27	·621831	783151	·794012	1 25943	1 27689	1 60815	33
28	·622059	782970	794486	1·25867	1 27719	1 60756	32
29	·622287	782789	·794961	1·25792	1 27748	1 60698	31
30	·622515	782608	·795436	1·25717	1 27778	1 60639	30
31	·622742	·782427	·795911	1 25642	1 27807	1·60580	29
32	·622970	·782246	·796386	1 25567	1 27837	1 60521	28
33	623197	·782065	·796862	1 25492	1 27867	1 60463	27
34	623425	781883	797337	1·25417	1 27896	1·60404	26
35	·623652	781702	·797813	1·25343	1 27926	1 60346	25
36	623880	·781520	·798290	1 25268	1 27956	1 60287	24
37	624107	·781339	798766	1 25193	1 27985	1 60229	23
38	·624334	·781157	799242	1·25118	1 28015	1 60171	22
39	·624561	·780976	·799719	1 25044	1·28045	1 60112	21
40	·624789	·780794	800196	1 24969	1 28075	1 60054	20
41	·625016	·780612	·800674	1 24895	1 28105	1·59996	19
42	·625243	·780430	·801151	1 24820	1·28134	1·59938	18
43	·625470	·780248	·801629	1 24746	1 28164	1·59880	17
44	·625697	·780066	802107	1 24672	1 28194	1·59822	16
45	·625923	·779884	802585	1 24597	1 28224	1·59764	15
46	·626150	·779702	803063	1 24523	1·28254	1·59706	14
47	·626377	·779520	·803542	1·24449	1 28284	1 59648	13
48	·626604	·779338	·804021	1·24375	1·28314	1·59590	12
49	·626830	·779156	·804500	1·24301	1 28344	1·59533	11
50	·627057	·778973	·804979	1 24227	1 28374	1 59475	10
51	·627284	·778791	·805458	1 24153	1 28404	1·59418	9
52	·627510	·778608	·805938	1·24079	1 28434	1·59360	8
53	627737	·778426	·806418	1 24005	1 28464	1·59302	7
54	·627963	·778243	·806898	1·23931	1 28495	1·59245	6
55	·628189	·778060	·807379	1 23858	1·28525	1·59188	5
56	·628416	·777878	·807859	1 23784	1 28555	1·59130	4
57	·628642	·777695	·808340	1·23710	1·28585	1·59073	3
58	·628868	·777512	·808821	1 23637	1·28615	1 59016	2
59	·629094	·777329	·809303	1 23563	1·28646	1·58959	1
60	·629320	·777146	·809784	1·23490	1·28676	1·58902	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

39°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·629320	·777146	·809784	1 23490	1 28676	1·58902	60
1	629546	776963	·810266	1·23416	1·28706	1 58845	59
2	·629772	·776780	·810748	1·23343	1·28737	1·58788	58
3	·629998	·776596	811230	1 23270	1 28767	1 58731	57
4	·630224	·776413	811712	1·23196	1 28797	1 58674	56
5	·630450	·776230	812195	1·23123	1 28828	1·58617	55
6	·630676	·776046	812678	1 23050	1 28858	1 58560	54
7	·630902	·775863	·813161	1 22977	1 28889	1 58503	53
8	·631127	·775679	813644	1 22904	1 28919	1 58447	52
9	·631353	·775496	814128	1 22831	1 28950	1 58390	51
10	·631578	·775312	·814613	1 22758	1 28980	1 58333	50
11	·631804	775128	·815096	1·22685	1·29011	1 58277	49
12	·632029	774944	·815580	1 22612	1 29042	1 58221	48
13	·632255	·774761	·816065	1 22539	1 29072	1 58164	47
14	632480	·774577	·816549	1 22467	1 29103	1 58108	46
15	·632705	·774393	·817034	1 22394	1 29133	1 58051	45
16	632931	774209	·817520	1·22321	1 29164	1 57995	44
17	·633156	774024	818005	1 22249	1 29195	1·57939	43
18	·633381	·773840	·818491	1 22176	1 29226	1 57883	42
19	633606	·773656	·818976	1 22104	1 29256	1·57827	41
20	·633831	773472	·819462	1 22031	1 29287	1·57771	40
21	·634056	·773287	·819949	1 21959	1 29318	1·57715	39
22	·634281	·773103	·820435	1 21886	1 29349	1 57659	38
23	·634506	·772918	820922	1 21814	1·29380	1 57603	37
24	·634731	·772734	821409	1·21742	1 29411	1 57547	36
25	634955	·772549	821897	1 21670	1·29442	1·57491	35
26	635180	·772364	822384	1 21598	1 29473	1·57436	34
27	·635405	·772179	822872	1 21526	1 29504	1 57380	33
28	635629	771995	·823360	1 21454	1 29535	1 57324	32
29	635854	·771810	·823848	1 21382	1 29566	1·57269	31
30	·636078	771625	824336	1·21310	1 29597	1·57213	30
31	·636303	771440	·824825	1 21238	1 29628	1 57158	29
32	636527	771254	825314	1 21166	1 29659	1·57103	28
33	·636751	·771069	·825803	1 21094	1 29690	1 57047	27
34	636976	·770884	·826292	1 21023	1 29721	1 56992	26
35	637200	770699	·826782	1 20951	1 29752	1 56937	25
36	·637424	·770513	827272	1 20879	1 29784	1·56881	24
37	·637648	·770328	827762	1 20808	1 29815	1 56826	23
38	637872	·770142	·828252	1 20736	1 29846	1 56771	22
39	·638096	·769957	·828743	1 20665	1 29877	1·56716	21
40	·638320	·769771	·829234	1 20593	1 29909	1 56661	20
41	·638544	·769585	·829725	1 20522	1 29940	1·56606	19
42	·638768	·769400	·830216	1·20451	1·29971	1 56551	18
43	·638992	·769214	·830708	1·20379	1·30003	1·56497	17
44	·639215	·769028	·831199	1·20308	1 30034	1·56442	16
45	·639439	·768842	·831691	1 20237	1 30066	1·56387	15
46	·639663	·768656	·832183	1·20166	1 30097	1 56332	14
47	·639886	·768470	·832676	1·20095	1·30129	1·56278	13
48	·640110	·768284	·833169	1 20024	1 30160	1 56223	12
49	·640333	·768097	·833662	1·19953	1 30192	1·56169	11
50	·640557	·767911	·834155	1·19882	1·30223	1·56114	10
51	·640780	·767725	·834648	1 19811	1 30255	1 56060	9
52	·641003	·767538	·835142	1 19740	1 30287	1·56005	8
53	·641226	·767352	·835636	1·19669	1·30318	1·55951	7
54	·641450	·767165	836130	1·19599	1 30350	1·55897	6
55	·641673	·766979	·836624	1·19528	1 30382	1·55843	5
56	·641896	·766792	·837119	1 19457	1·30413	1 55789	4
57	·642119	·766605	·837614	1·19387	1·30445	1 55734	3
58	·642342	·766418	·838109	1·19316	1·30477	1·55680	2
59	·642565	·766231	·838604	1·19246	1·30509	1·55626	1
60	·642788	·766044	·839100	1·19175	1·30541	1·55572	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·642788	·766044	·839100	1·19175	1·30541	1·55572	60
1	·643010	·765857	·839595	1·19105	1·30573	1·55518	59
2	·643233	·765670	·840092	1·19035	1·30605	1·55465	58
3	·643456	·765483	·840588	1·18964	1·30636	1·55411	57
4	·643679	·765296	·841084	1·18894	1·30668	1·55357	56
5	·643901	·765109	·841581	1·18824	1·30700	1·55303	55
6	·644124	·764921	·842078	1·18754	1·30732	1·55250	54
7	·644346	·764734	·842575	1·18684	1·30764	1·55196	53
8	·644569	·764547	·843073	1·18614	1·30796	1·55143	52
9	·644791	·764359	·843571	1·18544	1·30829	1·55089	51
10	·645013	·764171	·844069	1·18474	1·30861	1·55036	50
11	·645235	·763984	·844567	1·18404	1·30893	1·54982	49
12	·645458	·763796	·845066	1·18334	1·30925	1·54929	48
13	·645680	·763608	·845564	1·18264	1·30957	1·54876	47
14	·645902	·763420	·846063	1·18194	1·30989	1·54822	46
15	·646124	·763232	·846563	1·18125	1·31022	1·54769	45
16	·646346	·763044	·847062	1·18055	1·31054	1·54716	44
17	·646568	·762856	·847562	1·17986	1·31086	1·54663	43
18	·646790	·762668	·848062	1·17916	1·31119	1·54610	42
19	·647012	·762480	·848562	1·17846	1·31151	1·54557	41
20	·647233	·762292	·849062	1·17777	1·31183	1·54504	40
21	·647455	·762104	·849563	1·17708	1·31216	1·54451	39
22	·647677	·761915	·850064	1·17638	1·31248	1·54398	38
23	·647898	·761727	·850565	1·17569	1·31281	1·54345	37
24	·648120	·761538	·851067	1·17500	1·31313	1·54292	36
25	·648341	·761350	·851568	1·17430	1·31346	1·54240	35
26	·648563	·761161	·852070	1·17361	1·31378	1·54187	34
27	·648784	·760972	·852573	1·17292	1·31411	1·54134	33
28	·649006	·760784	·853075	1·17223	1·31443	1·54082	32
29	·649227	·760595	·853578	1·17154	1·31476	1·54029	31
30	·649448	·760406	·854081	1·17085	1·31509	1·53977	30
31	·649669	·760217	·854584	1·17016	1·31541	1·53924	29
32	·649890	·760028	·855087	1·16947	1·31574	1·53872	28
33	·650111	·759839	·855591	1·16878	1·31607	1·53820	27
34	·650332	·759650	·856095	1·16809	1·31640	1·53768	26
35	·650553	·759461	·856599	1·16741	1·31672	1·53715	25
36	·650774	·759271	·857104	1·16672	1·31705	1·53663	24
37	·650995	·759082	·857608	1·16603	1·31738	1·53611	23
38	·651216	·758893	·858113	1·16535	1·31771	1·53559	22
39	·651437	·758703	·858619	1·16466	1·31804	1·53507	21
40	·651657	·758514	·859124	1·16398	1·31837	1·53455	20
41	·651878	·758324	·859630	1·16329	1·31870	1·53403	19
42	·652098	·758134	·860136	1·16261	1·31903	1·53351	18
43	·652319	·757945	·860642	1·16192	1·31936	1·53299	17
44	·652539	·757755	·861148	1·16124	1·31969	1·53247	16
45	·652760	·757565	·861655	1·16056	1·32002	1·53196	15
46	·652980	·757375	·862162	1·15987	1·32035	1·53144	14
47	·653200	·757185	·862669	1·15919	1·32068	1·53092	13
48	·653421	·756995	·863177	1·15851	1·32101	1·53041	12
49	·653641	·756805	·863685	1·15783	1·32134	1·52989	11
50	·653861	·756615	·864193	1·15715	1·32168	1·52938	10
51	·654081	·756425	·864701	1·15647	1·32201	1·52886	9
52	·654301	·756234	·865209	1·15579	1·32234	1·52835	8
53	·654521	·756044	·865718	1·15511	1·32267	1·52784	7
54	·654741	·755853	·866227	1·15443	1·32301	1·52732	6
55	·654961	·755663	·866736	1·15375	1·32334	1·52681	5
56	·655180	·755472	·867246	1·15308	1·32368	1·52630	4
57	·655400	·755282	·867756	1·15240	1·32401	1·52579	3
58	·655620	·755091	·868266	1·15172	1·32434	1·52527	2
59	·655839	·754900	·868776	1·15104	1·32468	1·52476	1
60	·656059	·754710	·869287	1·15037	1·32501	1·52425	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·656059	·754710	·869287	1·15037	1·32501	1·52425	60
1	·656279	·754519	·869798	1·14969	1·32535	1·52374	59
2	·656498	·754328	·870309	1·14902	1·32568	1·52323	58
3	·656717	·754137	·870820	1·14834	1·32602	1·52273	57
4	·656937	·753946	·871332	1·14767	1·32636	1·52222	56
5	·657156	·753755	·871843	1·14699	1·32669	1·52171	55
6	·657375	·753563	·872356	1·14632	1·32703	1·52120	54
7	·657594	·753372	·872868	1·14565	1·32737	1·52069	53
8	·657814	·753181	·873381	1·14498	1·32770	1·52019	52
9	·658033	·752989	·873894	1·14430	1·32804	1·51968	51
10	·658252	·752798	·874407	1·14363	1·32838	1·51918	50
11	·658471	·752606	·874920	1·14296	1·32872	1·51867	49
12	·658689	·752415	·875434	1·14229	1·32905	1·51817	48
13	·658908	·752223	·875948	1·14162	1·32939	1·51766	47
14	·659127	·752032	·876462	1·14095	1·32973	1·51716	46
15	·659346	·751840	·876977	1·14028	1·33007	1·51665	45
16	·659564	·751648	·877491	1·13961	1·33041	1·51615	44
17	·659783	·751456	·878006	1·13894	1·33075	1·51565	43
18	·660002	·751264	·878521	1·13828	1·33109	1·51515	42
19	·660220	·751072	·879037	1·13761	1·33143	1·51465	41
20	·660439	·750880	·879553	1·13694	1·33177	1·51415	40
21	·660657	·750688	·880069	1·13627	1·33211	1·51364	39
22	·660875	·750496	·880585	1·13561	1·33245	1·51314	38
23	·661094	·750303	·881102	1·13494	1·33279	1·51265	37
24	·661312	·750111	·881619	1·13428	1·33314	1·51215	36
25	·661530	·749919	·882136	1·13361	1·33348	1·51165	35
26	·661748	·749726	·882653	1·13295	1·33382	1·51115	34
27	·661966	·749534	·883171	1·13228	1·33416	1·51065	33
28	·662184	·749341	·883689	1·13162	1·33451	1·51015	32
29	·662402	·749148	·884207	1·13096	1·33485	1·50966	31
30	·662620	·748956	·884725	1·13029	1·33519	1·50916	30
31	·662838	·748763	·885244	1·12963	1·33554	1·50866	29
32	·663056	·748570	·885763	1·12897	1·33588	1·50817	28
33	·663273	·748377	·886282	1·12831	1·33622	1·50767	27
34	·663491	·748184	·886802	1·12765	1·33657	1·50718	26
35	·663709	·747991	·887322	1·12699	1·33691	1·50669	25
36	·663926	·747798	·887842	1·12633	1·33726	1·50619	24
37	·664144	·747605	·888362	1·12567	1·33760	1·50570	23
38	·664361	·747412	·888882	1·12501	1·33795	1·50521	22
39	·664579	·747218	·889403	1·12435	1·33830	1·50471	21
40	·664796	·747025	·889924	1·12369	1·33864	1·50422	20
41	·665013	·746832	·890446	1·12303	1·33899	1·50373	19
42	·665230	·746638	·890968	1·12238	1·33934	1·50324	18
43	·665448	·746445	·891489	1·12172	1·33968	1·50275	17
44	·665665	·746251	·892012	1·12106	1·34003	1·50226	16
45	·665882	·746057	·892534	1·12041	1·34038	1·50177	15
46	·666099	·745864	·893057	1·11975	1·34073	1·50128	14
47	·666316	·745670	·893580	1·11909	1·34108	1·50079	13
48	·666532	·745476	·894103	1·11844	1·34142	1·50030	12
49	·666749	·745282	·894627	1·11778	1·34177	1·49981	11
50	·666966	·745088	·895151	1·11713	1·34212	1·49933	10
51	·667183	·744894	·895675	1·11648	1·34247	1·49884	9
52	·667399	·744700	·896199	1·11582	1·34282	1·49835	8
53	·667616	·744506	·896724	1·11517	1·34317	1·49787	7
54	·667833	·744312	·897249	1·11452	1·34352	1·49738	6
55	·668049	·744117	·897774	1·11387	1·34387	1·49690	5
56	·668265	·743923	·898299	1·11321	1·34423	1·49641	4
57	·668482	·743728	·898825	1·11256	1·34458	1·49593	3
58	·668698	·743534	·899351	1·11191	1·34493	1·49544	2
59	·668914	·743339	·899877	1·11126	1·34528	1·49496	1
60	·669131	·743145	·900404	1·11061	1·34563	1·49448	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

42°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·669131	·743145	900404	1 11061	1 34563	1 49448	60
1	·669347	742950	·900931	1 10996	1 34599	1 49399	59
2	·669563	·742755	·901458	1 10931	1 34634	1 49351	58
3	·669779	742561	·901985	1 10867	1 34669	1 49303	57
4	·669995	742366	·902513	1 10802	1 34704	1 49255	56
5	·670211	742171	·903041	1·10737	1 34740	1·49207	55
6	·670427	741976	·903569	1·10672	1 34775	1 49159	54
7	·670642	741781	·904098	1 10607	1 34811	1 49111	53
8	·670858	·741586	·904627	1 10543	1 34846	1 49063	52
9	·671074	·741390	905156	1 10478	1 34882	1 49015	51
10	671289	741195	905685	1 10414	1 34917	1 48967	50
11	671505	741000	·906215	1 10349	1 34953	1 48199	49
12	671721	740805	·906745	1 10285	1 34988	1 48871	48
13	671936	·740609	·907275	1·10220	1·35024	1 48824	47
14	·672151	·740414	907805	1·10156	1 35060	1 48776	46
15	·672367	·740218	·908336	1 10091	1 35095	1 48728	45
16	·672582	740023	908867	1 10027	1 35131	1 48681	44
17	·672797	739827	909398	1 09963	1 35167	1·48633	43
18	·673013	739631	909930	1 09899	1 35203	1 48586	42
19	·673228	739435	910462	1 09834	1 35238	1 48538	41
20	673443	739239	910994	1 09770	1 35274	1 48491	40
21	·673658	739044	·911526	1 09706	1 35310	1 48443	39
22	673873	·738848	·912059	1 09642	1 35346	1 48396	38
23	·674088	·738652	912592	1·09578	1·35382	1 48349	37
24	·674302	738455	913125	1 09514	1 35418	1 48301	36
25	·674517	·738259	·913659	1 09450	1 35454	1 48254	35
26	674732	·738063	·914193	1 09386	1 35490	1·48207	34
27	·674947	737867	914727	1 09322	1 35526	1 48160	33
28	·675161	·737670	·915261	1 09258	1 35562	1 48113	32
29	·675376	737474	·915796	1·09195	1 35598	1·48066	31
30	·675590	737277	916331	1 09317	1 35634	1 48019	30
31	675805	737081	·916866	1 09067	1 35670	1 47972	29
32	·676019	736884	917402	1 09003	1 35707	1 47925	28
33	676233	736687	·917938	1 08940	1 35743	1 47878	27
34	·676448	736491	·918474	1 08876	1·35779	1 47831	26
35	·676662	736294	·919010	1 08813	1 35815	1 47784	25
36	676876	736097	·919547	1 08749	1 35852	1 47738	24
37	·677090	·735900	920084	1 08686	1 35888	1 47691	23
38	·677304	735703	920621	1 08622	1 35924	1·47644	22
39	677518	·735506	·921159	1 08559	1 35961	1·47598	21
40	677732	735309	921697	1 08496	1 35997	1 47551	20
41	·677946	·735112	·922235	1 08432	1 36034	1 47504	19
42	·678160	·734915	·922773	1 08369	1 36070	1 47458	18
43	·678373	734717	·923312	1 08306	1 36107	1 47411	17
44	678587	734520	·923851	1 08243	1·36143	1 47365	16
45	·678801	734323	924390	1 08179	1 36180	1·47319	15
46	·679014	734125	924930	1·08116	1 36217	1·47272	14
47	·679228	·733927	·925470	1 08053	1 36253	1·47226	13
48	·679441	·733730	·926010	1·07990	1·36290	1·47180	12
49	·679655	·733532	·926551	1 07927	1·36327	1 47134	11
50	·679868	·733334	·927091	1 07864	1·36363	1 47087	10
51	·680081	·733137	·927632	1·07801	1·36400	1·47041	9
52	·680295	·732939	·928174	1 07738	1 36437	1·46995	8
53	·680508	·732741	·928715	1 07676	1·36474	1·46949	7
54	·680721	·732543	·929257	1 07613	1·36511	1·46903	6
55	·680934	·732345	·929800	1 07550	1·36548	1·46857	5
56	·681147	·732147	·930342	1 07487	1 36585	1·46811	4
57	·681360	·731949	930885	1·07425	1 36622	1·46765	3
58	·681573	·731750	·931428	1 07362	1·36659	1·46719	2
59	·681786	·731552	·931971	1 07299	1·36696	1·46674	1
60	·681998	731354	·932515	1·07237	1·36733	1·46628	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

47°

SIX-FIGURE TRIGONOMETRICAL TABLES—*continued*

43°

M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·681998	·731354	·932515	1·07237	1·36733	1·46628	60
1	·682211	·731155	·933059	1·07174	1·36770	1·46582	59
2	·682424	·730957	·933603	1·07112	1·36807	1·46537	58
3	·682636	·730758	·934148	1·07049	1·36844	1·46491	57
4	·682849	·730560	·934693	1·06987	1·36881	1·46445	56
5	·683061	·730361	·935238	1·06925	1·36919	1·46400	55
6	·683274	·730162	·935783	1·06862	1·36956	1·46354	54
7	·683486	·729963	·936329	1·06800	1·36993	1·46309	53
8	·683698	·729765	·936875	1·06738	1·37030	1·46263	52
9	·683911	·729566	·937422	1·06676	1·37068	1·46218	51
10	·684123	·729367	·937968	1·06613	1·37105	1·46173	50
11	·684335	·729168	·938515	1·06551	1·37143	1·46127	49
12	·684547	·728969	·939063	1·06489	1·37180	1·46082	48
13	·684759	·728769	·939610	1·06427	1·37218	1·46037	47
14	·684971	·728570	·940158	1·06365	1·37255	1·45992	46
15	·685183	·728371	·940706	1·06303	1·37293	1·45946	45
16	·685395	·728172	·941255	1·06241	1·37330	1·45901	44
17	·685607	·727972	·941803	1·06179	1·37368	1·45856	43
18	·685818	·727773	·942352	1·06117	1·37406	1·45811	42
19	·686030	·727573	·942902	1·06056	1·37443	1·45766	41
20	·686242	·727374	·943451	1·05994	1·37481	1·45721	40
21	·686453	·727174	·944001	1·05932	1·37519	1·45676	39
22	·686665	·726974	·944552	1·05870	1·37556	1·45631	38
23	·686876	·726775	·945102	1·05809	1·37594	1·45587	37
24	·687088	·726575	·945653	1·05747	1·37632	1·45542	36
25	·687299	·726375	·946204	1·05685	1·37670	1·45497	35
26	·687510	·726175	·946756	1·05624	1·37708	1·45452	34
27	·687721	·725975	·947307	1·05562	1·37746	1·45408	33
28	·687932	·725775	·947859	1·05501	1·37784	1·45363	32
29	·688144	·725575	·948412	1·05439	1·37822	1·45319	31
30	·688355	·725374	·948965	1·05378	1·37860	1·45274	30
31	·688566	·725174	·949518	1·05317	1·37898	1·45229	29
32	·688776	·724974	·950071	1·05255	1·37936	1·45185	28
33	·688987	·724773	·950624	1·05194	1·37974	1·45141	27
34	·689198	·724573	·951178	1·05133	1·38012	1·45096	26
35	·689409	·724372	·951733	1·05072	1·38051	1·45052	25
36	·689620	·724172	·952287	1·05010	1·38089	1·45007	24
37	·689830	·723971	·952842	1·04949	1·38127	1·44963	23
38	·690041	·723770	·953397	1·04888	1·38165	1·44919	22
39	·690251	·723570	·953953	1·04827	1·38204	1·44875	21
40	·690462	·723369	·954508	1·04766	1·38242	1·44831	20
41	·690672	·723168	·955064	1·04705	1·38280	1·44787	19
42	·690882	·722967	·955621	1·04644	1·38319	1·44742	18
43	·691093	·722766	·956177	1·04583	1·38357	1·44698	17
44	·691303	·722565	·956734	1·04522	1·38396	1·44654	16
45	·691513	·722364	·957292	1·04461	1·38434	1·44610	15
46	·691723	·722163	·957849	1·04401	1·38473	1·44567	14
47	·691933	·721962	·958407	1·04340	1·38512	1·44523	13
48	·692143	·721760	·958966	1·04279	1·38550	1·44479	12
49	·692353	·721559	·959524	1·04218	1·38589	1·44435	11
50	·692563	·721357	·960083	1·04158	1·38628	1·44391	10
51	·692773	·721156	·960642	1·04097	1·38666	1·44347	9
52	·692983	·720954	·961202	1·04036	1·38705	1·44304	8
53	·693192	·720753	·961761	1·03976	1·38744	1·44260	7
54	·693402	·720551	·962322	1·03915	1·38783	1·44217	6
55	·693611	·720349	·962882	1·03855	1·38822	1·44173	5
56	·693821	·720148	·963443	1·03794	1·38860	1·44129	4
57	·694030	·719946	·964004	1·03734	1·38899	1·44086	3
58	·694240	·719744	·964565	1·03674	1·38938	1·44042	2
59	·694449	·719542	·965127	1·03613	1·38977	1·43999	1
60	·694658	·719340	·965689	1·03553	1·39016	1·43956	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	M

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Six-Figure Trigonometric Tables—*continued*

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M	Sine	Cosine	Tangent	Cotangent	Secant	Cosecant	
0	·694658	·719340	·965689	1 03553	1·39016	1·43956	60
1	·694868	·719138	·966251	1 03493	1·39055	1·43912	59
2	·695077	·718936	·966814	1·03433	1·39095	1·43869	58
3	695286	·718733	·967377	1·03372	1·39134	1·43826	57
4	·695495	718531	967940	1 03312	1·39173	1·43783	56
5	·695704	·718329	·968504	1 03252	1·39212	1·43739	55
6	·695913	·718126	·969067	1 03192	1·39251	1·43696	54
7	696122	717924	969632	1 03132	1 39291	1 43653	53
8	696330	717721	970196	1 03072	1 39330	1 43610	52
9	·696539	·717519	·970761	1 03012	1 39369	1 43567	51
10	·696748	·717316	971326	1 02952	1·39409	1·43524	50
11	696957	717113	·971892	1 02892	1·39448	1 43481	49
12	697165	716911	972458	1 02832	1 39487	1 43438	48
13	·697374	716708	973024	1 02772	1 39527	1 43395	47
14	·697582	716505	·973590	1 02713	1 39566	1 43352	46
15	·697790	716302	974157	1 02653	1·39606	1 43310	45
16	·697999	·716099	·974724	1 02593	1·39646	1 43267	44
17	698207	715896	·975291	1 02533	1 39685	1·43224	43
18	·698415	·715693	·975859	1 02474	1 39725	1 43181	42
19	·698623	715490	·976427	1 02414	1 39764	1 43139	41
20	698832	·715286	·976996	1 02355	1 39804	1 43096	40
21	·699040	715083	977564	1 02295	1 39844	1 43053	39
22	·699248	·714880	·978133	1 02236	1·39884	1 43011	38
23	·699455	·714676	978703	1 02176	1 39924	1·42968	37
24	·699663	·714473	·979272	1 02117	1 39963	1 42926	36
25	·699871	·714269	979842	1·02057	1 40003	1·42883	35
26	·700079	·714066	980413	1 01998	1 40043	1·42841	34
27	·700287	·713862	980983	1 01939	1 40083	1 42799	33
28	·700494	·713658	·981554	1 01879	1 40123	1 42756	32
29	700702	·713454	·982126	1 01820	1 40163	1·42714	31
30	700909	·713250	·982697	1·01761	1 40203	1·42672	30
31	·701117	·713047	983269	1 01702	1 40243	1 42630	29
32	701324	·712843	983842	1·01642	1 40283	1 42587	28
33	·701531	712639	·984414	1 01583	1 40324	1·42545	27
34	·701739	·712434	·984987	1 01524	1 40364	1·42503	26
35	·701946	·712230	·985560	1·01465	1 40404	1·42461	25
36	·702153	·712026	·986134	1 01406	1 40444	1 42419	24
37	·702360	·711822	·986708	1·01347	1 40485	1·42377	23
38	·702567	·711617	987282	1·01288	1 40525	1·42335	22
39	·702774	·711413	·987857	1 01229	1·40565	1·42293	21
40	·702981	·711209	·988432	1 01170	1·40606	1·42251	20
41	·703188	·711004	·989007	1 01112	1·40646	1·42210	19
42	·703395	·710799	·989582	1 01053	1·40687	1·42168	18
43	·703601	·710595	·990158	1 00994	1·40727	1·42126	17
44	·703808	·710390	990735	1·00935	1·40768	1·42084	16
45	·704015	·710185	·991311	1 00876	1·40808	1·42042	15
46	·704221	·709981	·991888	1 00818	1·40849	1·42001	14
47	·704428	·709776	·992465	1 00759	1 40890	1·41959	13
48	·704634	·709571	993043	1·00701	1·40930	1·41918	12
49	·704841	·709366	·993621	1 00642	1 40971	1·41876	11
50	·705047	·709161	·994199	1 00583	1·41012	1·41835	10
51	·705253	·708956	·994778	1·00525	1·41053	1·41793	9
52	·705459	·708750	·995357	1 00467	1·41093	1 41752	8
53	·705665	·708545	·995936	1·00408	1·41134	1·41710	7
54	·705872	·708340	·996515	1·00350	1·41175	1·41669	6
55	·706078	·708134	997095	1 00291	1·41216	1·41627	5
56	·706284	·707929	·997676	1·00233	1·41257	1·41586	4
57	·706489	·707724	·998256	1·00175	1·41298	1·41545	3
58	·706695	·707518	·998837	1·00116	1·41339	1·41504	2
59	·706901	·707312	·999418	1·00058	1·41380	1·41463	1
60	·707107	·707107	1·000000	1·00000	1·41421	1·41421	0
	Cosine	Sine	Cotangent	Tangent	Cosecant	Secant	R

Degrees to Radians

Degrees	Radians	Degrees	Radians	Degrees	Radians
1	·017453	31	541052	61	1·064651
2	·034907	32	·558505	62	1·082104
3	·052360	33	575959	63	1 099557
4	·069813	34	593412	64	1·117011
5	·087266	35	·610865	65	1·134464
6	·104720	36	628319	66	1·151917
7	122173	37	645772	67	1·169371
8	139626	38	·663225	68	1·186824
9	157080	39	·680678	69	1 204277
10	·174533	40	·698132	70	1·221730
11	·191986	41	·715585	71	1 239184
12	·209440	42	·733038	72	1·256637
13	·226893	43	·750492	73	1 274090
14	·244346	44	767945	74	1·291544
15	·261799	45	·785398	75	1 308997
16	·279253	46	·802851	76	1·326450
17	·296706	47	·820305	77	1·343904
18	·314159	48	·837758	78	1·361357
19	·331613	49	·855211	79	1 378810
20	·349066	50	·872665	80	1 396263
21	·366519	51	·890118	81	1·413717
22	·383972	52	·907571	82	1·431170
23	·401426	53	·925025	83	1 448623
24	·418879	54	·942478	84	1·466077
25	·436332	55	·959931	85	1·483530
26	·453786	56	·977384	86	1 500983
27	·471239	57	994838	87	1·518436
28	·488692	58	1 012291	88	1·535890
29	·506145	59	1 029744	89	1 553343
30	·523599	60	1 047198	90	1 570796

Minutes to Radians

Minutes	Radians	Minutes	Radians	Minutes	Radians
1	·000291	21	006109	41	·011926
2	·000582	22	·006400	42	·012217
3	·000873	23	·006690	43	·012508
4	·001164	24	·006981	44	012799
5	·001454	25	·007272	45	·013090
6	·001745	26	·007563	46	·013381
7	·002036	27	·007854	47	·013672
8	·002327	28	·008145	48	·013963
9	·002618	29	·008436	49	·014254
10	·002909	30	·008727	50	·014544
11	·003200	31	·009018	51	·014835
12	·003491	32	·009308	52	·015126
13	·003782	33	·009599	53	·015417
14	·004072	34	·009890	54	·015708
15	·004363	35	·010181	55	·015999
16	·004654	36	·010472	56	·016290
17	·004945	37	·010763	57	·016581
18	·005236	38	·011054	58	·016872
19	·005527	39	·011345	59	·017162
20	·005818	40	·011636	60	·017453

Logarithm of Numbers from 0 to 1,000

No.	0	1	2	3	4	5	6	7	8	9	Prop.
0	0	00000	30103	47712	60206	69897	77815	84510	90309	95424	
10	00000	00432	00860	01284	01703	02119	02531	02938	03342	03743	415
11	04139	04532	04922	05308	05690	06070	06446	06819	07188	07555	379
12	07918	08279	08636	08991	09342	09691	01037	10380	10721	11059	344
13	11394	11727	12057	12385	12710	13033	13354	13672	13988	14301	323
14	14613	14922	15229	15534	15836	16137	16435	16732	17026	17319	298
15	17609	17898	18184	18469	18752	19033	19312	19590	19866	20140	281
16	20412	20683	20952	21219	21484	21748	22011	22272	22531	22789	264
17	23045	23300	23553	23805	24055	24304	24551	24797	25042	25285	249
18	25527	25768	26007	26245	26482	26717	26951	27184	27416	27646	234
19	27875	28103	28330	28556	28780	29003	29226	29447	29667	29885	222
20	30103	30320	30535	30750	30963	31175	31387	31597	31806	32015	212
21	32222	32428	32634	32838	33041	33244	33445	33646	33846	34044	202
22	34242	34439	34635	34830	35025	35218	35411	35603	35793	35984	193
23	36173	36361	36549	36736	36922	37107	37291	37475	37658	37840	185
24	38021	38202	38382	38561	38739	38917	39094	39270	39445	39620	177
25	39794	39967	40140	40312	40483	40654	40824	40993	41162	41330	170
26	41497	41664	41830	41996	42160	42325	42488	42651	42813	42975	164
27	43136	43297	43457	43616	43775	43933	44091	44248	44404	44560	158
28	44716	44871	45025	45179	45332	45484	45637	45788	45939	46090	153
29	46240	46389	46538	46687	46835	46982	47129	47276	47422	47567	148
30	47712	47857	48001	48144	48287	48430	48572	48714	48855	48996	143
31	49136	49276	49415	49554	49693	49831	49969	50106	50243	50379	138
32	50515	50651	50786	50920	51055	51189	51322	51455	51587	51720	134
33	51851	51983	52114	52244	52375	52504	52634	52763	52892	53020	130
34	53148	53275	53403	53529	53656	53782	53908	54033	54158	54283	126
35	54407	54531	54654	54777	54900	55023	55145	55267	55388	55509	122
36	55630	55751	55871	55991	56110	56229	56348	56467	56585	56703	119
37	56820	56937	57054	57171	57287	57403	57519	57634	57749	57864	116
38	57978	58093	58206	58320	58433	58546	58659	58771	58883	58995	113
39	59106	59218	59329	59439	59550	59660	59770	59879	59988	60097	110
40	60206	60314	60423	60531	60638	60746	60853	60959	61066	61172	107

Indices of Logarithms:—

Log. 4,030 = 3·60530

,, 403 = 2·60530

,, 40·3 = 1·60530

Log. 4·03 = ·60530

,, ·403 = $\bar{1}$·60530

,, ·0403 = $\bar{2}$·60530

,, ·00403 = $\bar{3}$·60530

LOGARITHM OF NUMBERS FROM 0 TO 1,000—*continued*

No.	0	1	2	3	4	5	6	7	8	9	Prop.
41	61278	61384	61490	61595	61700	61805	61909	62014	62118	62221	104
42	62325	62428	62531	62634	62737	62839	62941	63043	63144	63246	102
43	63347	63448	63548	63649	63749	63849	63949	64048	64147	64246	99
44	64345	64444	64542	64640	64738	64836	64933	65031	65128	65225	98
45	65321	65418	65514	65610	65706	65801	65896	65992	66087	66181	96
46	66276	66370	66464	66558	66652	66745	66839	66932	67025	67117	95
47	67210	67302	67394	67486	67578	67669	67761	67852	67943	68034	92
48	68124	68215	68305	68395	68485	68574	68664	68753	68842	68931	90
49	69020	69108	69197	69285	69373	69461	69548	69636	69723	69810	88
50	69897	69984	70070	70157	70243	70329	70415	70501	70586	70672	86
51	70757	70842	70927	71012	71096	71181	71265	71349	71433	71517	84
52	71600	71684	71767	71850	71933	72016	72099	72181	72263	72346	82
53	72428	72509	72591	72673	72754	72835	72916	72997	73078	73159	81
54	73239	73320	73400	73480	73560	73640	73719	73799	73878	73957	80
55	74036	74115	74192	74273	74351	74429	74507	74586	74663	74741	78
56	74819	74896	74974	75051	75128	75205	75282	75358	75435	75511	77
57	75587	75664	75740	75815	75891	75967	76042	76118	76193	76268	75
58	76343	76418	76492	76567	76641	76716	76790	76864	76938	77012	74
59	70085	77159	77232	77305	77379	77452	77525	77597	77670	77743	73
60	77815	77887	77960	78032	78104	78176	78247	78329	78390	78462	72
61	78533	78604	78675	78746	78817	78888	78958	79029	79099	79169	71
62	79239	79309	79379	74949	79518	79588	79657	79727	79796	79865	70
63	79934	80003	80072	80140	80209	80277	80346	80414	80482	80550	69
64	80618	80686	80754	80821	80889	89056	81023	81090	81158	81224	68
65	81291	81358	81425	81491	81558	81624	81690	81757	81823	81889	67
66	81954	82020	82086	82151	82217	82282	82347	82413	82478	82543	66
67	82607	82672	82737	82802	82866	82930	82995	83059	83123	83187	64
68	83251	83315	83378	83442	83506	83569	83632	83696	83759	83822	63
69	83885	83948	84011	84073	84136	84198	84261	84323	84386	84448	63
70	84510	84572	84634	84696	84757	84819	84880	84942	85003	85065	62

Find Log. of 5,065
Log. of 5,060 . = 3·70415
Prop. 86 × Diff. 5 . = 430

Log. required = 3·704580

Find number of Log. 3·771442
Log. of . . 5,900 = 3·770850

Diff. = 592
Diff. 592 ÷ Prop. 73 = 8.

No. required 5,908

LOGARITHM OF NUMBERS FROM 0 TO 1,000—*continued*

No.	0	1	2	3	4	5	6	7	8	9	Prop.
71	85126	85187	85248	85309	85370	85431	85491	85552	85612	85673	61
72	85733	85794	85854	85914	85974	86034	86094	86153	86213	86273	60
73	86332	86392	86451	86510	86570	86629	86688	86747	86806	86864	59
74	86923	86982	87040	87099	87157	87216	87274	87332	87390	87448	58
75	87506	87564	87622	87680	87737	87795	87852	87910	87967	88024	57
76	88081	88138	88196	88252	88309	88366	88423	88480	88536	88593	57
77	88649	88705	88762	88818	88874	88930	88986	89042	89098	89154	56
78	89209	89265	89321	89376	89432	89487	89542	89597	89653	89708	55
79	89763	89818	89873	89927	89982	90037	90091	90146	90200	90255	54
80	90309	90363	90417	90472	90526	90580	90634	90687	90741	90795	54
81	90849	90902	90596	91009	91062	91116	91169	91222	91275	91328	53
82	91381	91434	91487	91540	91593	91645	91698	91751	91803	91885	53
83	91908	91960	92012	92065	92117	92169	92221	92273	92324	92376	52
84	92428	92480	92531	92583	92634	92686	92737	92788	92840	92891	51
85	92942	92993	93044	93095	93146	93197	93247	92398	93349	93399	51
86	93450	93500	93551	93601	93651	93702	93752	93802	93852	93902	50
87	93952	94002	94052	94101	94151	94201	94250	94300	94349	94399	49
88	94448	94498	94547	94596	94645	94694	94743	94792	94841	94890	49
89	94939	94988	95036	95085	95134	95182	95231	95279	95328	95376	48
90	95424	95472	95521	95569	95617	95665	95713	95761	95809	95856	48
91	95904	95952	95999	96047	96095	96142	96190	96237	96284	96332	48
92	96379	96426	96473	96520	96567	96614	96661	96708	96755	96802	47
93	96848	96895	96942	96988	97035	97081	97128	97174	97220	97267	47
94	97313	97359	97405	97451	97497	97543	97589	97635	97681	97727	46
95	97772	97818	97864	97909	97955	98000	98046	98091	98137	98182	46
96	98227	98272	98318	98363	98408	98453	98498	98543	98588	98632	45
97	98677	98722	98767	98811	98856	98900	98945	98989	99034	99078	45
98	99123	99167	99211	99255	99300	99344	99388	99432	99476	99520	44
99	99564	99607	99651	99695	99739	99782	99286	99870	99913	99957	44

To multiply by logarithms add the logarithms together and find the corresponding number.

To divide by logarithms subtract one from the other.

To extract the root divide the logarithm by the index of the root and find the number corresponding to it.

To raise a number to any power multiply the logarithm by the index of the power and find the corresponding number.

APPENDIX

DATA RELATING TO THE ROYAL AERONAUTICAL SOCIETY'S STRESSED SKIN DIAGRAMS, pp. 275–286

00.06.01

(*Second Issue January*, 1944)

METHOD OF CALCULATING STRESS DISTRIBUTION IN A REINFORCED SHELL UNDER BENDING

The method described is based on the assumption that plane cross-sections of the shell remain plane after bending, so that strains are proportional to the distances from a neutral axis where the axial deflection and therefore the direct stress is zero. Cross-sections will not in general remain plane in the regions near concentrated loads, cut-outs and rapid changes of section. For equilibrium in pure bending the sum of compression loads must equal the sum of tension loads, and the sum of the individual panel loads multiplied by their distances from the neutral axis must equal the total bending moment. It is assumed that the applied bending loads are in the direction of one of the principal axes of the shell.

The method may be used to calculate either the bending moment for a specified maximum panel strain, or the stress distribution corresponding to a given bending moment.

The procedure recommended for calculating the bending moment corresponding to a specified maximum compression strain is:—

(*a*) Calculate compression load-deflection curves for typical panels comprising one stringer and one plate each. If the stringer pitch, stringer cross-section or plate curvature vary appreciably around the periphery of the shell, it will be necessary to calculate one such diagram for each typical panel. The method of obtaining these load-deflection curves is described in 02.01.15.

(*b*) Choose a neutral axis (1) near the centroid of the shell cross-section, bearing in mind that it will be towards the tension side. For this neutral axis and with the specified maximum strain draw a straight line (1) as shown; this gives a first approximation to the distribution of strain across the section.

(*c*) From this diagram read off the corresponding panel loads from the panel load-deflection diagrams. On the tension side treat the whole area of the panel as fully effective. Add up all the panel loads on the tension side and on the compression side.

(*d*) In general the total tension and compression loads so found will not balance. Consequently a new neutral axis (2) must be chosen and a new strain line (2) drawn through it. In this way, by repeated approximation, a neutral axis and strain line are found which give equilibrium of direct loads.

(*e*) From the sum of the products of the panel loads thus determined and their distances from the final neutral axis the bending moment corresponding to the specified maximum compression strain is found. It should be noted that this bending moment will not in general be directly proportional to the maximum specified panel strain.

When the bending moment is given and the maximum panel strains are required, the above method may be suitably varied.

00.06.02

(*Issued November*, 1943)

Shear Centre of Lipped Channel Section

Notation:—

h = depth of web (in.).

d = width of each flange (in.).

c = width of each lip (in.).

x = distance of shear centre from centre line of web, measured along the neutral axis (in.).

Notes:—

The ratio x/h is plotted against the ratio c/h for various values of d/h.

It is assumed that the thickness is uniform over the section and is not more than about $h/15$. No allowance has been made for variation of shear stress across the thickness.

Derivations:—

Timoshenko, *Strength of Materials*, Second Edition, Part II, Chapter I.

T. Haas, Some notes on the shear centre of thin-walled open sections, *Journal of the Royal Aeronautical Society*, November, 1943.

Example:—

To find the shear centre of a lipped section when

$$h = 1{\cdot}50 \text{ in.}, \; d = 1{\cdot}00 \text{ in.}, \; c = 0{\cdot}35 \text{ in.}$$

Then

$$c/h = 0{\cdot}233 \text{ and } d/h = 0{\cdot}667.$$

From diagram, by interpolation,

$$x/h = 0{\cdot}38.$$

Therefore

$$x = 0{\cdot}38 \times 1{\cdot}50 = 0{\cdot}570 \text{ in.}$$

00.06.03

(*Issued November*, 1943)

SHEAR CENTRE OF TOP HAT SECTION

Notation:—

h = depth of web (in.).

d = width of each flange (in.).

c = width of each lip (in.).

x = distance of shear centre from centre line of web, measured along the neutral axis (in.).

Notes:—

The ratio x/h is plotted against the ratio c/h for various values of d/h.

It is assumed that the thickness is uniform over the section and is not more than about $h/15$. No allowance has been made for variation of shear stress across the thickness.

Derivations:—

Timoshenko, *Strength of Materials*, Second Edition, Part II, Chapter I.

T. Haas, Some notes on the shear centre of thin-walled open sections, *Journal of the Royal Aeronautical Society*, November, 1943.

Example:—

To find the shear centre of a top hat section when

$$h = 1{\cdot}50 \text{ in.}, \; d = 1{\cdot}20 \text{ in.}, \; c = 0{\cdot}65 \text{ in.}$$

Then

$$c/h = 0{\cdot}433 \text{ and } d/h = 0{\cdot}8.$$

From diagram,

$$x/h = 0{\cdot}307.$$

Therefore

$$x = 0{\cdot}307 \times 1{\cdot}50 = 0{\cdot}46 \text{ in.}$$

00.06.04

(Issued November, 1943)

SHEAR CENTRE OF CIRCULAR ARC SECTION

Notation:—

r = radius of arc (in.).

x = distance of shear centre from centre line of wall, measured along the neutral axis (in.).

2α = angle subtended by arc (degrees).

Notes:—

The ratio x/r is plotted against α. It is assumed that the wall thickness is uniform over the section and is not more than about $r/10$. No allowance has been made for variation of shear stress across the thickness.

Derivation:—

D. Williams, Behaviour in bending of thin-walled tubes and channels, R. and M., No. 1,669, 1935.

Example:—

To find the shear centre of a circular arc section when

$$r = 2 \text{ in. and } \alpha = 120°.$$

From diagram,

$$x/r = 0{\cdot}515.$$

Therefore

$$x = 0{\cdot}515 \times 2 = 1{\cdot}03 \text{ in.}$$

00.06.05

(*Issued November*, 1943)

Shear Centre of D-Section

Notation:—

h = depth of web (in.).
t_b = thickness of web (in.).
s = developed length of curved wall (in.).
t_s = thickness of curved wall (in.).
A = area enclosed by the section (in.^{2}).
x = distance of shear centre from centre line of web (in.).

Notes:—

The ratio $x(h/A)$ is plotted against the ratio s/h for various values of t_b/t_s.

It is assumed that all direct loads due to bending in the plane of the web are taken by flanges concentrated at the intersections of the flat web and the curved wall; the shear flows in the web and in the curved wall are therefore constant.

Derivation:—

Billewiez and Grzedzielski, *Calcul d'une aile monolongeron, Institut des recherches de l'aeronautique*, Warsaw, No. 2, 1935.

Example:—

To find the shear centre of a D-section with two heavy flanges when

$h = 27{\cdot}5$ in., $t_b = 0{\cdot}036$ in., $s = 108$ in., $t_s = 0{\cdot}048$ in., $A = 950$ in.^{2}.

Then

$$s/h = 3{\cdot}9 \text{ and } t_b/t_s = 0{\cdot}75.$$

From diagram, by interpolation,

$$x(h/A) = 0{\cdot}51.$$

Therefore

$$x = 0{\cdot}51 \times 950/27{\cdot}5 = 17{\cdot}6 \text{ in.}$$

01.00.01

(*Issued November*, 1943)

FLEXURAL PROPERTIES OF Z AND CHANNEL SECTION STRUTS

Notation:—

d = width of each flange (in.).

h = depth of web (in.).

t = thickness of flanges and web (in.).

A = area of section = $t(h+2d)$ (in.^{2}).

I = moment of inertia of section about an axis through the centroid of the section parallel to the flanges (in.^{4}).

k = radius of gyration of section about the same axis (in.).

Notes:—

The ratio k^2/A, which equals I/A^2, is plotted against the ratio d/h for various values of the ratios h/t and A/t^2. The chain dotted lines represent the extreme practical range of values of d/t. At the lower end of this range premature lateral instability may supervene and at the higher end the outstanding flanges may become laterally unstable.

Of two struts of the same material and of the same area the one with the higher k^2/A ratio would fail in flexure at a higher load, so that this ratio is, on a weight basis, a criterion for the efficiency of the strut in flexure.

01.01.08

(*Issued March*, 1943)

Local Instability of Aluminium Alloy Struts with Flat Sides

Notation:—

t = thickness of sides (in.).

h = width of side supported at both edges (in.).

d = width of side with one free edge (in.).

f = average stress at which local instability occurs (lb./in.^{2}).

E_t = tangent modulus of material at stress f (lb./in.^{2}).

Notes:—

The stress f is plotted against the ratios d/t and h/t for open or closed flat-sided sections of materials 35·65, 45·65, and 55·75 of 00.02.01. These particular materials have been selected because the dominant factor is the proof stress and the effect of the ratio f_p/f_{ult} is small.

It is assumed that the length of the strut is at least four times h or d, whichever is the larger; h and d are measured as though the sections were sharp-cornered.

For an open section it is assumed that the lip provides sufficient support to prevent the webs buckling sideways; this will generally be so provided that d is greater than $5t$. Minimum radii at the corners and a degree of initial straightness consistent with current practice have also been assumed.

This sheet refers solely to local instability and the liability of the strut to flexural or torsional instability must also be examined. The onset of local instability will result in an appreciable loss of stiffness but not necessarily in complete failure which will depend upon the loading conditions and the surrounding structure.

Derivations:—

The curves are based upon the following formulæ:

For sides with both edges supported . . $f = 3{\cdot}62E_t(t/h)^2$

For sides with one free edge . . . . . $f = 0{\cdot}58E_t(t/d)^2$

which are derived from 02.01.01 and experimental results.

E_t taken from 00.02.01.

Example:—

To find the average stress at which local instability occurs in a strut of Z-section, when

$$t=0{\cdot}048 \text{ in.},\ h=1{\cdot}50 \text{ in.},\ d=0{\cdot}75 \text{ in.},$$

and the material is 45·65.

Then $h/t=31$ and $d/t=15{\cdot}6$.

From diagram, the critical stress corresponding to these two values are 30,000 lb./in.^{2} and 22,000 lb./in.^{2}. Thus local instability occurs in the lip at an average stress of 22,000 lb./in.^{2}.

01.01.09

(*Issued November*, 1943)

Local Instability Stress Coefficients for Channel and Z-Section Struts

Notation:—

t = thickness of wall of strut (in.).

d = flange width (in.).

h = web depth (in.).

A_s = area of section = $(h+2d)t$ (in.^{2}).

E_t = tangent modulus of elasticity of strut material (lb./in.^{2}).

f = compression stress at which local instability occurs (lb./in.^{2}).

Buckling stress coefficients K and K_1 defined by

$$f = KE_t(t/h)^2 = K_1E_t[t/(h+2d)]^2 \text{ (lb./in.}^2\text{)}.$$

Notes:—

The coefficients K and K_1 are plotted against the ratio d/h. For constant t the coefficient K indicates the variation in buckling stress with constant h and the coefficient K_1 the variation with constant A_s. For comparison, the dotted line gives the coefficient derived by applying the empirical formulæ of 01.01.08 to the sections of this data sheet.

It is assumed that the length of the strut is at least $3h$ and the loaded edges of the strut are taken as simply supported.

This sheet refers solely to local instability and the liability of the strut to flexural and torsional instability must also be examined. The onset of local instability will not always correspond to complete failure, which will depend upon loading conditions.

Derivation:—

Unpublished work.

Example:—

To find the local instability stress of a Z-section strut, when

$t=0{\cdot}036$ in., $h=1{\cdot}0$ in., $d=0{\cdot}4$ in., and the material is 45·75.

Then $d/h=0{\cdot}4$ and from diagram $K=3{\cdot}35$.

With this value the local instability stress is in the plastic range, and from 00.02.02, by iteration,

$$f=3{\cdot}35\times 7{\cdot}9\times 10^6\times(0{\cdot}036/1{\cdot}0)^2=34{,}000 \text{ lb./in.}^2.$$

02.01.01

(*Issued February*, 1941)

Buckling Stress Coefficients for Flat Plates in Compression

Notation:—

t = sheet thickness (in.).

a = sheet length (in.).

b = sheet width (in.).

E = Young's modulus (lb./in.^{2}).

σ = Poisson's ratio.

m = number of half waves in (4) below.

Buckling stress coefficient K defined by

$$f_b = \mathrm{KE}(t/b)^2 \text{ (lb./in.}^2\text{)}.$$

Notes:—

The curves are only applicable to plates of isotropic materials and are drawn for values of $\sigma = 0{\cdot}3$.

K is plotted against the ratio a/b for various conditions of edge restraint.

The loaded edges are called " ends," the edges parallel to direction of load " sides."

" Fixed " is used in the same sense as " built in " or " encastré " and " simply supported " is used in the same sense as " pinned " or " hinged."

For a given value of a/b the number of half waves in which a plate buckles along its length is given by the number of troughs to the left of the appropriate a/b ordinate. In counting the troughs part of a trough is counted as a complete one.

Derivations:—

(1) Ends and sides fixed. Averages from approximations by Taylor-Trefftz and energy methods. Maulbetsch, *Journal of Applied Mechanics*, 1937, A-59.

(2) Ends simply supported, sides fixed. H. L. Cox, R. and M., No. 1,554, p. 9. (The formula on p. 10, line 2, should read $n^4 = (16/3)(b/d)^4$).

(3) Ends fixed, sides simply supported. Timoshenko, *Theory of Elastic Stability*, First Edition (1936), p. 363.

(4) Ends and sides simply supported. Timoshenko, *Theory of Elastic Stability*, First Edition (1936), p. 327.

$$K = \frac{\pi^2}{12(1-\sigma^2)}\left(\frac{a}{bm}+\frac{bm}{a}\right)^2,$$

m being chosen to make K a minimum.

(5) Ends simply supported, one side free, one side fixed. Trayer and March, N.A.C.A. Report No. 382, Appendix (Values are recalculated for $\sigma = 0{\cdot}3$).

(6) Ends simply supported, one side free, one side simply supported. Trayer and March, N.A.C.A. Report No. 382, Appendix.

$$K = \frac{\pi^2}{12(1-\sigma^2)}\left(\frac{b}{a}\right)^2 + \frac{1}{2(1+\sigma)}.$$

(7) Ends simply supported, both sides free.

$$K = \frac{\pi^2}{12(1-\sigma^2)}\left(\frac{b}{a}\right)^2.$$

Shown as limiting case of curves (1) to (6). In practice failure would occur at a load corresponding to the Euler load $\frac{\pi^2}{12}E(t/a)^2$.

Example:—

To find buckling stress of flat aluminium alloy plate, ends fixed, sides simply supported, when

$$t = 0{\cdot}048 \text{ in.}, \; a = 8 \text{ in.}, \; b = 6 \text{ in.}$$

From diagram, curve (3) $K = 5{\cdot}00$ for $a/b = 8/6 = 1{\cdot}33$. Therefore

$$f_b = KE(t/b)^2 = 5{\cdot}00 \times 10 \times 10^6 (0{\cdot}048/6)^2 = 3{,}200 \text{ lb./in.}^2.$$

02.03.01

(*Issued May*, 1941)

Buckling Stress Coefficients for Flat Plates in Shear

Notation:—

t = sheet thickness (in.).
a = length of longer side of plate (in.).
b = length of shorter side of plate (in.).
E = Young's modulus (lb./in.^{2}).
σ = Poisson's ratio.
q_b = shear stress at which plate first buckles.
Buckling stress coefficient K defined by

$$q_b = KE(t/b)^2 \text{ (lb./in.}^2\text{)}.$$

Notes:—

The curves are only applicable to plates of isotropic materials and are drawn for $\sigma = 0{\cdot}3$.

K is plotted against the ratio b/a for various conditions of edge restraint.

" Fixed " is used in the same sense as " built in " or " encastré " and " simply supported " is used in the same sense as " pinned " or " hinged."

The values shown for $b/a = 1$ and $b/a = 0$ are theoretical results; between these limits curves (1) and (4) are based on experimental results, but curves (2) and (3) are interpolations.

Derivations:—

(1) and (4) H. L. Cox, R. and M., No. 1,553.
Timoshenko, *Theory of Elastic Stability*, First Edition, p. 357.

Examples:—

To find the buckling stress of a flat aluminium alloy plate with its short sides fixed, and long sides simply supported when

$$t = 0{\cdot}036 \text{ in.}, \; a = 8{\cdot}375 \text{ in.}, \; b = 6{\cdot}25 \text{ in.},$$
$$E = 10 \times 10^6 \text{ lb./in.}^2.$$

Then

$$b/a = 6{\cdot}25/8{\cdot}375 = 0{\cdot}747.$$

From diagram

$$K = 8{\cdot}9.$$

Therefore

$$q_b = 8{\cdot}9 \times 10 \times 10^6 \times (0{\cdot}036/6{\cdot}25)^2$$
$$= 2{,}950 \text{ lb./in.}^2.$$

02.03.02

(*Issued May*, 1941)

BUCKLING STRESS FOR FLAT ALUMINIUM ALLOY PLATES IN SHEAR (ALL SIDES FIXED)

Notation:—

t = sheet thickness (in.).
a = length of longer side of plate (in.).
b = width of shorter side of plate (in.).
q_b = shear stress at which plate first buckles (lb./in.^{2}).

Notes:—

The curves show the values of the shear stress at which aluminium alloy plates first buckle for various ratios of b/t and b/a.

Derivation:—

Data sheet 02.03.01, taking E as 10×10^6 lb./in.^{2}.

Example:—

To find the buckling stress in shear of a flat aluminium alloy plate with all sides fixed when

$$t = 0{\cdot}048 \text{ in.}, \; a = 15{\cdot}5 \text{ in.}, \; b = 6{\cdot}75 \text{ in.}$$

Then

$$b/t = 140 \text{ and } b/a = 0{\cdot}435.$$

From diagram

$$q_b = 5{,}100 \text{ lb./in.}^2.$$

02.04.02

(*Issued January*, 1944)

Average and Edge Stresses for Flat Plates under Shear and Compression

Notation:—

f_b = direct stress at which plate first buckles under compression alone (lb./in.^{2}).

q = applied shear stress (lb./in.^{2}.).

f_{edge} = direct stress at sides of plate parallel to direction of compression (lb./in.^{2}).

$f_{average}$ = average direct stress in plate in direction of compression (lb./in.^{2}.).

Notes:—

The ratio $f_{average}/f_b$ is plotted against the ratio f_{edge}/f_b for varius values of q/f_b.

The plate is compressed in the direction of its length, which is assumed to be three or more times its width. The edges are simply supported and remain straight. It is assumed that after buckling the longitudinal edges are held at a fixed distance apart.

The stresses $f_{average}$ and q correspond to the loads carried by the plate; in addition, load may be carried by the edge members, the direct load carried by the longitudinal edge members for example being proportional to f_{edge}.

All strains are assumed to be within the elastic range.

Derivation:—

Kromm and Marguerre, *Verhalten eines von Schub und Druckkräften beanspruchten Plattenstreifens oberhalb der Beulgrenze*, Luftfahrtforschung, Vol. XIV, p. 627.

Examples:—

(1) Find the direct load which a flat aluminium alloy plate 6 in. wide and 0·048 in. thick will carry when

$$f_{edge} = 30{,}000 \text{ lb./in.}^2 \text{ and } q = 12{,}000 \text{ lb./in.}^2.$$

From 02.01.01,

$$f_b = 3{\cdot}62 \times 10 \times 10^6\ (0{\cdot}048/6)^2 = 2{,}300 \text{ lb./in.}^2.$$

Therefore

$$f_{edge}/f_b = 13, \text{ and } q/f_b = 5{\cdot}2.$$

From diagram,

$$f_{average} = 3{\cdot}6 \times f_b = 8{,}300 \text{ lb./in.}^2.$$

Therefore the plate will carry $0{\cdot}048 \times 6 \times 8{,}300 = 2{,}400$ lb. compression.

The longitudinal edge members will carry compression appropriate to the strain corresponding to $f_{edge} = 30{,}000$ lb./in.^{2}.

(2) Find direct load carried by the plate of example (1) when

$$f_{edge} = 6{,}000 \text{ lb./in.}^2,\ q = 20{,}000 \text{ lb./in.}^2.$$

Then

$$f_{edge}/f_b = 2{\cdot}6 \text{ and } q/f_b = 8{\cdot}7.$$

From diagram,

$$f_{average} = -3 \times f_b = -6{,}900 \text{ lb./in.}^2.$$

Therefore the load in the plate is $0{\cdot}048 \times 6 \times 6{,}900 = 2{,}000$ lb. tension.

GENERAL INDEX

17

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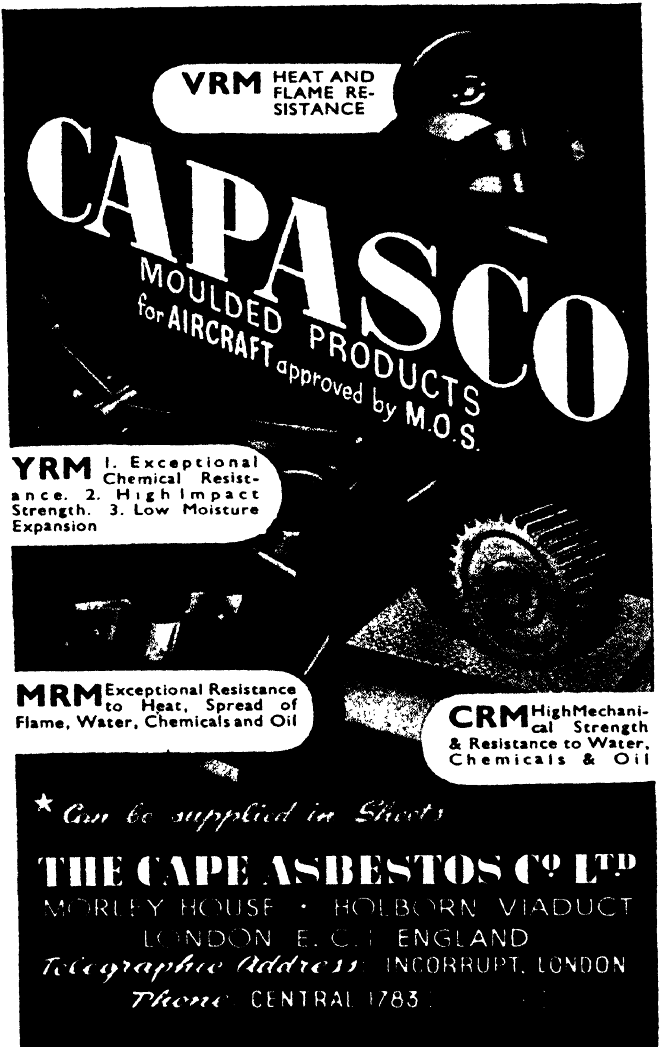
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CRM High Mechanical Strength & Resistance to Water, Chemicals & Oil
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THE CAPE ASBESTOS Cº LTD
MORLEY HOUSE · HOLBORN VIADUCT
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