CALCULATION OF COLUMNS

THEODOR NIELSEN

CALCULATION OF COLUMNS

CALCULATION OF COLUMNS

A PRACTICAL APPLICATION OF
THE THEORY

BY

THEODOR NIELSEN

M. DANISH AND RIVER PLATE INST. OF C.E.

London
E. & F. N. SPON, LTD., 57 HAYMARKET
New York
SPON & CHAMBERLAIN, 123 LIBERTY STREET
1911

PREFACE

THE object of this treatise is, to a great extent, to show the results of the researches of Professor A. OSTENFELD, of Copenhagen, the application of which affords rapid means of arriving at a reliable cross section of a mild steel column, and in general the strength of any column. It is supplemented with tables and with practical information dealing with the subject, which has been gathered by the author from time to time, and it is an extension of a paper (in the metric system only), read in Spanish before the Engineering Section of the Scientific Congress held in Buenos Aires in July 1910, to which the Author was the official representative of the Danish Government.

CONTENTS

NOTATIONS USED.

P = Force.

A = Sectional Area.

I = Moment of Inertia.

$r = \sqrt{\frac{I}{A}}$ = Radius of Gyration.

L = Actual Length.

l = "Free" Length (according to the method of fixing).

$x = \frac{l}{r}$ = Ratio of Free Length to Radius of Gyration.

e = Distance from Neutral Axis to extreme Fibre.

$R = \frac{I}{e}$ = Modulus of Section or Geometrical Moment of Resistance.

$k = \frac{r^2}{e} = \frac{R}{A}$ = Radius of Core (kernel).

E = Modulus of Elasticity.

S = Breaking Stress per unit area.

s = Stress per unit area.

B = Compressive Stress per unit area of a short bar.

C and c are constants depending upon the material.

CALCULATION OF COLUMNS

Free Length for Centrally Loaded Columns.

EXPERIMENTS and calculation show that the centre line of a column will, if deflected, assume a wave line, and the free length will be considered as the distance between two consecutive points of contraflexure, this being the length of a column with ideal pin ends. The first step in all column calculations is to deduce the free length from the actual length, and it is also the weak point of such calculations, as the free length depends upon the nature of the fixing of the ends (which may even cause some eccentricity of the loading). In case where any doubt exists it is better to assume a greater free length, say full length, of the column even if the ends are held.

As a guide the following will prove useful, but much depends upon individual judgment.

Both ends free: the free length $l = L$ is purely ideal, but very often allowed.

Pin ends: $l = 0{\cdot}8$ L deduced from U.S. tests by Prof. Ostenfeld.

Flat ends: $l = 0{\cdot}65$ L to $0{\cdot}75$ L in general, but for Phoenix, Z-bar and similar columns $l = 0{\cdot}6$ L deduced from U.S. tests by Prof. Ostenfeld. For wooden posts, $l = 0{\cdot}75$ L recommended by Prof. Tetmajer.

Both ends firmly held: $l = 0{\cdot}5$ L is a theoretical value; Prof. Claxton Fidler recommends for practice $l = 0{\cdot}6$ L.

Foot firmly held, top guided: $l = 0{\cdot}7$ L (theoretically $\frac{L}{\sqrt{2}}$).

Foot firmly held, top free: $l = 2$ L.

Lattice Girders.—Each compressive member will have a tendency (1) to deflect in the plane of the girder, and (2) normal to this plane. Generally the free length will be different in the two cases, and nearly always the moment of inertia is different, a greater moment corresponding to the greater l normal to the plane. It is not always possible to guess what is weakest, and calculation should then be made for the two planes normal to each other corresponding to the two principal axis of the section.

A compressive boom may in the plane of the girder have a tendency to form a wave line with points of reverse curvature in the apices, hence, say l = distance of apices. In the plane normal to the girder the same will be the case if there is a good cross and diagonal bracing, otherwise there will be a tendency to form a longer wave, say l = double the distance of the apices, an assumption allowed by Prof. Lütken of Copenhagen.

A strut of length L will get very little help from the booms against deflection normal to the plane of the girder, hence say $l = L$, only when there is a good cross bracing a shorter length might be allowed. In the plane of the girder the heavy booms will give a great support to the ends of the light strut. Prof. Lütken allows for riveted ends $l = 0{\cdot}6$ L, except for the end strut where $l = L$, as this strut behaves as a boom. If, as in a double Warren lattice, a tie of the same numerical stress is riveted to the centre of the strut he allows in the plane of the girder $l = 0{\cdot}4$ L.

In a multiple lattice Prof. Tetmajer allows $l = 1{\cdot}8$ times length of mesh. This figure is to the safe side of the results of calculations by Prof. Schüle in Zürich, concerning tests to destruction of an old 28 metres railway bridge that broke in the lattice bars of channel irons riveted to ties of flats. For flat lattice bars Messrs. Laissle and Schübeler, of Würtemberg (Bau der Brückenträger, 1871), assume that the ends may be considered theoretically held, and that, as the tension bar of the same section tends to stiffen the compression bar, this bar may be calculated as if it had double its actual moment of inertia. Based on these assumptions, the author has calculated the free length of a flat lattice bar to be 0·35, say $\frac{1}{3}$ of its length between nearest supports by booms or stiffeners.

Factors of Safety and Unit Stresses.

Prof. Ostenfeld recommends the following:

For **mild steel** and **wrought iron** a factor of safety from 3 to 5.

For buildings where the stresses have been very carefully taken out, considering the uneven distribution of the load, he allows a factor of safety of 3 for mild steel and a unit stress of 0·95 t/cm² = 6·0 tons/□″ = 13 500 lbs./□″ on short bars. (1 t = 1000 kg = 0·984 English tons = 2205 lbs., 1 t/cm² = 6·35 tons/□″ = 14 223 lbs./□″.)

For buildings where the stresses have been taken out in the ordinary way, allowing a super-load per unit area, he allows a factor of safety of 4, or a unit stress of 0·7 t/cm² = 4·4 tons/□″ = 10 000 lbs./□″ on short bars.

For **cast iron** he uses a factor of safety from 8 to 10, usually the latter.

For **wood** he allows a factor of safety from 5 to 8. For European pine, when using Tetmajer's straight line continued by Euler's formula, he uses a factor of safety of 6.

Columns with Free Ends and Centrally Loaded.

It is now universally recognised that **Euler's** formula gives good results in practice for long columns. This formula is

$$\mathbf{P} = \frac{\pi^2 \mathbf{E\,I}}{\mathbf{l}^2} \quad . \quad . \quad . \qquad (1)$$

A more modern and often more convenient form of it is as follows:

Introducing $$\mathbf{P} = \mathbf{A\,S} \quad . \quad . \quad . \qquad (2)$$

and $$\mathrm{I} = \mathrm{A}\,r^2 \text{ gives}$$

$$\mathbf{S} = \frac{\pi^2 \mathbf{E}}{\left(\frac{\mathbf{l}}{\mathbf{r}}\right)^2} \text{ or } \frac{\pi^2 \mathbf{E}}{\mathbf{x}^2} \quad . \quad . \qquad (3)$$

$\pi^2 = 9{\cdot}870$, often rounded off to 10.

Formulæ (2) and (3) are more convenient to use than (1), provided that tables are worked out for (3) and for r. The latter of course can be obtained from any English and American Standard Section Table, but r is not found in the German Standard Table, therefore it is given here, pages 34 and 35.

It must be remembered that for any column calculation I and r must be taken relative to the direction in which there is a curvature tendency (i.e. the neutral axis must be taken normal to this plane), hence in most cases the minimum values will be necessary in calculations: (note that for compound sections usually the min. r for the section equals the max. r for the single bar).

Plotting $x = \frac{l}{r}$ as abscissa and S as ordinate (see Figs. 1 to 3) we obtain the Euler Curve.

For **short columns** Euler's formula is dangerous as the results are far too high.

The late **Prof. J. B. Johnson**, of the U.S. (see Johnson, Bryan and Turneaure: Modern framed structures), proposes for short columns to use a Parabola which has the axis of ordinates for axis, and is tangent to the Euler curve, all plotted as mentioned above.

J. B. Johnson's formula is:

$$\mathbf{S = B - C\,x^2} \qquad (4)$$

At the tangent point (3) and (4) must give the same value of S hence

$$\frac{\pi^2 E}{x^2} = B - C x^2$$

or

$$B x^2 - C x^4 = \pi^2 E \qquad (5)$$

equally the same value of $\frac{dS}{dx}$,

hence

$$-\frac{2\pi^2 E}{x^3} = -2 C x$$

or

$$C x^4 = \pi^2 E \qquad (6)$$

The addition of (5) and (6) gives

$$B x^2 = 2 \pi^2 E$$

hence we obtain the junction of Johnson and Euler's formulæ at

$$\frac{l}{r} \text{ or } x = \sqrt{\frac{2 \pi^2 E}{B}} \quad . \quad . \quad (7)$$

$$2 \pi^2 = 19 \cdot 74$$

substituting x in (6) gives

$$C \frac{4 \pi^4 E^2}{B^2} = \pi^2 E$$

hence

$$C = \frac{B^2}{4 \pi^2 E} \quad . \quad . \quad . \quad (8)$$

$$4 \pi^2 = 39 \cdot 48.$$

As J. B. Johnson points out, B must be practically the yield point or, for material without it, the compressive stress.

Having B it is easy to find C by (8) and the limit x by (7); thus we can obtain reasonable column formulæ by (4) and by (3), as continuation, with very little work.

We can find B, even without a testing-machine, from the load that produces yielding (or first crack), and by noting deflections caused by certain loads on a small square beam, we can calculate E (to the safe side). This is particularly useful for timber, and an example shown later on for pitch pine will illustrate the formation of such formulæ.

Mild Steel and Wrought Iron. Central Load.

Exhaustive tests were made by the late Prof. L. v. Tetmajer of Vienna, when he was in Zürich, for columns with free ends (using steel points). Based on these tests, Prof. Ostenfeld calculated B and C in (4) by means of the method of the minor squares to be in kg/cm² (1 kg/cm² = 0·00635 tons/□″ = 14·22 lbs./□″) for

Mild steel . .	B = 2724	C = 0·086.
Wrought iron .	B = 2581	C = 0·087.

It may be added that for Prof. Tetmajer's tests the mean values of the yield points were for mild steel 2800, and for wrought iron 2450 kg/cm², hence very near the values of B given above, agreeing with J. B. Johnson's assumption.

These values did not exactly fit the Euler curves for **mild steel** with **E** = 2 150 000 kg/cm² = **2150 t/cm² = 13 600 tons/□"** = 30 600 000 lbs./□", and **wrought iron** with **E** = 2 000 000 kg/cm² = **2000 t/cm² = 12 700 tons/□"** = 28 400 000 lbs./□" as used by Prof. Tetmajer, therefore Prof. Ostenfeld assumed B as above, and calculated C by (8) obtaining for mild steel 0·0874, and for wrought iron 0·0844, or very little difference, which shows that Prof. J. B. Johnson's formula is most reasonable. Thus, to suit Euler with above values of E, the Johnson formula (4) $S = B - Cx^2$ gives the **Johnson-Ostenfeld** formula for

Mild Steel . . . $\mathbf{S = 2724 - 0{\cdot}0874\left(\frac{l}{r}\right)}$

kg/cm². . (9) limit $\frac{l}{r} = 125$

Wrought Iron . . $\mathbf{S = 2581 - 0{\cdot}0844\left(\frac{l}{r}\right)^2}$

kg/cm² . . . (10) limit $\frac{l}{r} = 124.$

These figures do not agree too well with Prof. Johnson's own figures, but are preferable, as they give the mean results of Prof. Tetmajer's excellent tests.

The author has worked out the accompanying table based on (9) and (10) as far as $\frac{l}{r} = 120$, from $\frac{l}{r} = 125$ to 200, the latter being beyond what is desirable in practice; the metric values have been copied from Prof. Tetmajer's book, "Angewandte Festigkeitslehre" of 1904.

Ex. 1.—A mild steel, B. S. H-beam 9" × 7" × 58 lb. of 20' 0" length with a substantial base carries a ceiling. Find safe load for a factor of safety 4.

L = 20' 0" = 240"; foot held and top guided; hence free length $l = 0{\cdot}7 \times 240 = 168''$.

then $r = 1''\cdot 64$; $\dfrac{l}{r} = \dfrac{168}{1\cdot 64} = 102$ gives by interpolation in Table I. (page 32) breaking load per unit area

$$S = 11\cdot 5 \text{ tons}/\square''.$$
$$A = 17\cdot 1 \ \square''.$$

Breaking load $A\,S = 17\cdot 1 \times 11\cdot 5 = 197$ tons.

Safe load $\dfrac{197}{4} = 49$ tons.

Ex. 2.—Two German standard channel bars N.P. No. 20 are laced together and form a $3\cdot 24$ m long strut in a bridge girder, and is stressed by $33\cdot 8$ t. Find the factor of safety.

$$L = 324 \text{ cm.}$$

Free length $l = 0\cdot 6 \times 324 = 194$ cm.

Min. r for the strut is max. r for the channel ; hence $r = 7\cdot 71$ cm. (see page 34).

$$\frac{l}{r} = \frac{194}{7\cdot 71} = 25.$$

By Table I. $S = 2.67$ t/cm^2.
$A = 2 \times 32\cdot 2 = 64\cdot 4$ cm^2.
Breaking load $A\,S = 64\cdot 4 \times 2\cdot 67 = 172$ t.

Factor of safety $\dfrac{172}{33\cdot 8} = 5\cdot 1$.

If the ends were not well stiffened or the booms not stiff, it would be wise to take

$$l = L = 324 \text{ cm.}$$

$$\frac{l}{r} = \frac{324}{7\cdot 71} = 42.$$

From Table I. $S = 2\cdot 57$ t/cm^2.
Breaking load $A\,S = 64\cdot 4 \times 2\cdot 57 = 165$ t.

Factor of safety $\dfrac{165}{33\cdot 8} = 4\cdot 9$.

It will be noted that from (9) $\dfrac{2724}{0\cdot 0874} = 31\,200$, and from

(10) $\frac{2581}{0 \cdot 0844} = 30\,600$ are both very nearly equal to 30 000, and **Prof. Ostenfeld** uses an approximation

$$\mathbf{S} = \left(\mathbf{1} + \frac{\mathbf{x}^2}{\mathbf{30\,000}}\right)\mathbf{B} \quad . \quad . \qquad (11)$$

where $x = \frac{l}{r}$ and B is the breaking load of a short bar. Formulæ (9) and (10) agree very favourably with (11) when using for the latter :

Mild Steel. B = 2·8 t/cm² = 17·8 tons/□″ = 40 000 lbs./□″

Wrought Iron. B = 2·6 t/cm² = 16·5 tons/□″ = 37 000 lbs./□″

As working stress equals S or B divided by a factor of safety it is seen that

$$\mathbf{F} = \mathbf{1} + \frac{\mathbf{x}^2}{\mathbf{30\,000}} \quad . \quad . \quad . \quad . \qquad (12)$$

is simply a **Stress Factor** giving the working stress of a column with $x = \frac{l}{r}$ from that of a short bar.

As a stress factor is very convenient in practice the following shows how the author has obtained a corresponding factor to suit Euler's formula.

On comparing (11) and (4) it is seen that $C = \frac{B}{30\,000}$ and substituting this in (8) we have

$$\frac{B}{30\,000} = \frac{B^2}{4\pi^2 E}$$

hence

$$B = \frac{4\pi^2 E}{30\,000}.$$

For mild steel with E = 2150 t/cm² this gives B = 2·83 t/cm² and for wrought iron with E = 2000 t/cm² we obtain B = 2·63 t/cm² (these values are very near the 2·8 and 2·6 given above, or 2·72 and 2·58 from (9) and (10)). By introducing the values thus found in formula (7) we obtain for both mild steel and wrought iron a transit from Johnson to Euler at $\frac{l}{r} = \mathbf{122\frac{1}{2}}$ (or very near the 125 and 124 given by (9) and (10), the exact formulæ).

Now using the factor F corresponding to Euler the breaking load FB is equal to S in formula (3) hence

$$FB = \frac{\pi^2 E}{x^2} \qquad Fx^2 = \frac{\pi^2 E}{B}$$

Substituting the corresponding values recently found gives for both mild steel and wrought iron $\frac{\pi^2 E}{B} = 7500$. Hence the stress factor for Euler becomes

$$\mathbf{F} = \frac{\mathbf{7500}}{\mathbf{x}^2} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Table I. gives the stress factors found from (12) and (13), and for working stress s of a short bar the column can be stressed to F s.

It should be carefully noted, when using a certain working stress, that it gives a suitable factor of safety on B as given above. Thus using the ordinary 5 tons/□″ the factor of safety $= \frac{17 \cdot 8}{5} = 3 \cdot 6$, or less than is generally thought, as we are accustomed to think of ultimate crushing strength instead of stress at the yield point.

The following table shows a series of values obtained by using F and B given in t/cm² compared with the exact values from (9), (10) and (3) partially copied from Table I. It will be seen that the approximation is satisfactory.

$\frac{l}{r}$	Mild Steel		Wrought Iron	
	F B = F × 2·8	Formulæ (9) and (3)	F B = F × 2·6	Formulæ (10) and (3)
0	2·80	2·72	2·60	2·58
50	2·57	2·51	2·38	2·37
100	1·87	1·85	1·73	1·74
150	0·932	0·943	0·865	0·877
200	0·524	0·531	0·486	0·494
300	0·233	0·236	0·217	0·219
400	0·131	0·133	0·122	0·123

Ex. 3.—A 15′ long strut formed of two braced B.S. channels 5″ × $2\frac{1}{2}$″ × 11 lb., and held by pins, is stressed to 4 tons/□″ for a short bar. Find the safe load.

L = 180″; $l = 0{\cdot}8 \times 180 = 144$″.

$r = 1{\cdot}94$″ (which equals max. r for a channel).

$$\frac{l}{r} = \frac{180}{1{\cdot}94} = 93.$$

From Table I., F = 0·711.

A = 2 × 3·23 = 6·46 □″.

Safe load F s A = 0·711 × 4 × 6·46 = 18·3 tons.

Ex. 4.—A 6 metres long stanchion formed of two German standard joists N.P. No. 20, with stiffened bedplate, is stressed in short bar to 0·7 t/cm². Find the safe load.

L = 600 cm, $l = 0{\cdot}7 \times 600 = 420$ cm.

$r = 8{\cdot}00$ cm (equal to max. r for joist).

$$\frac{l}{r} = \frac{420}{8{\cdot}00} = 52.$$

From Table I. F = 0·910.

A = 2 × 33·4 = 66·8 cm².

Safe load F s A = 0·910 × 0·7 × 66·8 = 42·5 t.

To design an economical column usually requires a good deal of trial and error; it can, however, by using Prof. Ostenfeld's deductions, be made an extremely easy work for mild steel and wrought iron. This method gives the satisfaction that any trial approaches the result, and the second trial usually gives a satisfactory result.

He obtains his formula in the following way.

The working stress s of a column, corresponding to $\mathbf{s_0}$ **in a short bar** is by formula (11)

$$s = \left(1 - \frac{\left(\frac{l}{r}\right)^2}{30\,000}\right) s_0$$

He then introduces the **area $\mathbf{A_0}$ of a short bar** corresponding to a load P.

$$\mathbf{A_0} = \frac{\mathbf{P}}{\mathbf{s_0}} \quad . \quad . \quad (14)$$

and Prof. Claxton Fidler's

$$\mathbf{Z} = \frac{\mathbf{A}}{\mathbf{r}^2} = \frac{\mathbf{A}^2}{\mathbf{I}} \quad . \quad . \quad (15)$$

The full area and the full moment of inertia must be used in (15); it would not be correct to work to one of the component members as used when determining the radius of gyration.

Substituting $r^2 = \frac{A}{z}$ from (15) and $s_0 = \frac{P}{A_0}$ from (14) into above expression for s gives

$$\frac{P}{A} = s = \left(1 - \frac{\left(\frac{z\,l^2}{A}\right)}{30\,000}\right) \frac{P}{A_0}$$

from which

$$A_0 = A - \frac{z\,l^2}{30\,000}$$

from this we obtain **Prof. Ostenfeld's formula**

$$\mathbf{A} = \mathbf{A}_0 + \frac{\mathbf{z}\,\mathbf{l}^2}{\mathbf{30\,000}} \quad . \quad . \quad (16)$$

If the length is l_1 metres and the areas are in square centimetres, the formula reduces itself to

$$\mathbf{A} = \mathbf{A}_0 + \tfrac{1}{3}\,\mathbf{z}\,\mathbf{l}_1^2 \quad . \quad . \quad (16)\text{A.}$$

Formula (16) gives the column area A_0 wanted for a short bar plus an increment $\frac{z\,l^2}{30\,000}$ to obtain stiffness, and he points out that z gives a measure for the economy of the section; the smaller z is, the less increment is wanted.

Formula (16) holds good up to $\frac{l}{r} = 122\tfrac{1}{2}$; at this limit we have

$$z\,l^2 = \frac{A\,l^2}{r^2} = A\left(\frac{l}{r}\right)^2 = A \times 122 \cdot 5^2 = 15\,000\ A.$$

Substituting this in (16) we have

$$A = A_0 + \frac{15\,000\ A}{30\,000} = A_0 + \tfrac{1}{2}\,A,$$

hence for the limit

$$\mathbf{A} = \mathbf{2}\,\mathbf{A}_0 \quad . \quad . \quad . \quad (17)$$

This limit is obtained when the stiffness increment is equal to what is required for a short bar.

Should the above ratio $\frac{l}{r}$ be exceeded, then Euler must be used, and the solution is quickly obtained. The formula (1) for the breaking load P gives

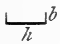
$$\mathbf{I} = \frac{\mathbf{P\,l^2}}{\pi^2\,\mathbf{E}} \quad . \quad . \quad . \qquad (18)$$

$$\pi^2 = 9 \cdot 870 \text{ or about } 10.$$

It must be remembered that P equals the safe load wanted, multiplied by the factor of safety.

In using Ostenfeld's formula (16) or (16)A, the first trial is made by using a tabular value of z, which keeps fairly constant for similar sections (and exactly so for geometrical similarity). The value of z can be worked out for any section, but for a great many that are most frequently required in practice the values are given in the following table which is extended from one given by Prof. Ostenfeld.

Section	Z	Remarks
O	12·6	Round bar (exactly: $z = 4\,\pi$).
◎ t	0·63	$t = 0{\cdot}05\ r$, where r is mean radius of tube and t the thickness of the metal.
„	1·25	$t = 0{\cdot}10\ r$.
„	2·50	$t = 0{\cdot}20\ r$.
„	3·66	$t = 0{\cdot}30\ r$.
□	12	Square bar.
b ▭ h	$\frac{12\,b}{h}$	Flat bar. b is greater than h.
h L t	8·4	Equal angle and $t = \frac{1}{6}\,h$.
„	7·2	„ „ „ $t = \frac{1}{7}\,h$.
„	6·3	„ „ „ $t = \frac{1}{8}\,h$.
„	5·7	„ „ „ $t = \frac{1}{9}\,h$.
„	5·0	„ „ „ $t = \frac{1}{10}\,h$.

Section	Z	Remarks
	7·1	4 equal angles riveted together, $t = \frac{1}{8} h$.
,,	5·8	,, ,, ,, ,, $t = \frac{1}{10} h$.
,,	5·0	,, ,, ,, ,, German standard.
,,	4·0	,, ,, ,, ,, ,, ,, 1 cm. clearance.
	3·3	2 equal angles with tie plates, $t = \frac{1}{8} h$.
	4·3	2 equal angles, $t = \frac{1}{8} h$.
	7·6	T bar with $b = 2 h = 12 t$.
,,	5·3	,, ,, $b = h = 8 t$.
	8·6	2 T bars riveted together, $b = 2 h = 12 t$.
,,	4·2	,, with distance pieces of sufficient thickness.
	6	Channel bar, British standard, $h = 2 b$.
,,	9	,, ,, but $h = 3 b$.
,,	7	German standard channel bar.
		Braced channel bars of sufficient distance to bring max. r into play :
] [	1·7	British standard with $h = 2 b$.
,,	1·0	,, ,, ,, $h = 3 b$.
,,	1·2	German standard in proper distance.
,,	6·0	,, having only 1 cm. clearance.
I	6	H beam, British standard, with h equal or less than 10″.
,,	10	,, ,, ,, ,, h greater than 10″.
,,	10	German standard.
,,	3	Differdange broad flange beam, h being 24 to 34 cm.
,,	4	,, ,, ,, ,, ,, 36 to 47½ cm.
I I	2	British standard H beams in sufficient distance, h equal or less than 12″.
,,	1	British standard H beams in sufficient distance, h greater than 12″.
,,	1 to 1·1	German standard H beams in sufficient distance.
	1·5	4 Phoenix bars, British standard.
,,	1·8	,, ,, German ,,

Ex. 5.—A strut of $l = 10' \, 0'' = 120''$ formed of one British standard H beam is required to carry 30 tons with a factor of safety 4. Find the section required.

As B = 17·8 tons/□″ the stress must be

$$s_0 = \frac{17 \cdot 8}{4} = 4 \cdot 45 \text{ tons}/\square''$$

and by Prof. Ostenfeld's formula (16)

$$A_0 = \frac{P}{s_0} = \frac{30}{4 \cdot 45} = 6 \cdot 74 \, \square''.$$

Try a section with $z = 6$.

$$\frac{z\, l^2}{30\,000} = \frac{6 \times 120^2}{30\,000} = 2 \cdot 88.$$

$$A = A_0 + \frac{z\, l^2}{30\,000} = 6 \cdot 74 + 2 \cdot 88 = 9 \cdot 62 \, \square''.$$

An 8″ × 6″ × 35 lb. H beam has 10·29 □″ area.

Prof. Ostenfeld's check:

By (15) $z = \frac{A^2}{I} = \frac{10 \cdot 29^2}{17 \cdot 95} = 5 \cdot 90.$

(This really settles the question, as $z = 6$ was assumed; but, to clearly show the method, the full check will be taken.)

$$\frac{z\, l^2}{30\,000} = \frac{5 \cdot 90 \times 120^2}{30\,000} = 2 \cdot 83.$$

$$A = A_0 + \frac{z\, l^2}{30\,000} = 6 \cdot 74 + 2 \cdot 83 = 9 \cdot 57 \, \square''$$

is wanted or less than there is in the joist, hence the column is safe, and no other commercial section suits the area required, therefore no further trial is wanted.

As a further check the actual factor of safety will now be found

$$r = 1 \cdot 32''; \qquad \frac{l}{r} = \frac{120}{1 \cdot 32} = 91.$$

From Table I., S = 12·7 tons/□″.

$$\text{Factor of safety} = \frac{\text{A S}}{\text{P}} = \frac{10{\cdot}29 \times 12{\cdot}7}{30} = 4{\cdot}36.$$

Ex. 6.—A 7·4 m long tubular column with ball bearings is required to carry 65 t and to be formed of 4 German standard Phœnix bars riveted together, and to be stressed to 0·7 t/cm². Find the section required.

$$A_0 = \frac{P}{s_0} = \frac{65}{0{\cdot}7} = 92{\cdot}9 \text{ cm}^2.$$

By (16)a $\frac{1}{3} z\, l_1^2 = \frac{1}{3} \times 1{\cdot}8 \times 7{\cdot}4^2 = 32{\cdot}9$ cm².
$A = A_0 + \frac{1}{3} z\, l_1^2 = 92{\cdot}9 + 32{\cdot}9 = 125$ cm².

4 Phœnix bars No. 12½ × 10 mm. body have area = 129 cm².

$$\text{Check}: z = \frac{A^2}{I} = \frac{129^2}{12\,200} = 1{\cdot}37.$$

$\frac{1}{3} z\, l_1^2 = \frac{1}{3} \times 1{\cdot}37 \times 7{\cdot}4^2 = 25{\cdot}0$ cm²
$A = A_0 + \frac{1}{3} z\, l_1^2 = 92{\cdot}9 + 25{\cdot}0 = 118$ cm², hence safe.

However 4 bars of No. 10 × 12 mm. having 120 cm² might be tried.

$$z = \frac{A^2}{I} = \frac{120^2}{7480} = 1{\cdot}92.$$

$\frac{1}{3} z\, l_1^2 = \frac{1}{3} \times 1{\cdot}92 \times 7{\cdot}4^2 = 35{\cdot}0.$
$A = 92{\cdot}9 + 35{\cdot}0 = 128$ cm², hence they are not strong enough.

Ex. 7.—A mild steel column with 6 m free length is required to carry 4·0 t and to be formed of one German standard channel. Factor of safety 4. Find the section required.

$B = 2{\cdot}8$ t/cm², hence $s_0 = \frac{2{\cdot}8}{4} = 0{\cdot}7$ t/cm².

$A_0 = \frac{P}{s_0} = \frac{4{\cdot}0}{0{\cdot}7} = 5{\cdot}7$ cm².
$\frac{1}{3} z\, l_1^2 = \frac{1}{3} \times 7 \times 6^2 = 84$ cm².

This increment is so much larger than A_0 that there is no doubt that Euler's formula must be used.

Breaking load P = 4 × 4·0 t = 16·0 t.

By formula (18) with $l = 600$ cm.

$$I = \frac{P\,l^2}{\pi^2\,E} = \frac{16 \cdot 0 \times 600^2}{9 \cdot 87 \times 2150} = 271.$$

Channel N.P. No. 26 with I = 317 must be used as the next lower channel, No. 24 only has I = 248.

Note.—Examples 6 and 7 have been taken from Prof. Ostenfeld's "Teknisk Elasticitetslære" of 1905.

Built Columns. Central Load.

When a column is built up of sectional members held together with lacing, it is very tempting to consider each sectional member separately as a column of a length equal to the distance between the points held, similar to the method used for calculating the boom of a girder. This is, however, a dangerous practice, as tests prove that nothing like the distance of the held points that appeared safe from such a calculation would be permissible in practice.

Prof. Tetmajer, who made numerous tests with columns formed of 2 or 4 mild steel angle bars (cross section ┐└ or ╡╞) held together with tie plates, found that no weakening was produced when the area of the rivet-holes did not exceed 12 per cent. of the cross sectional area, nor, when the tie plates were not spaced at a greater distance than 50 times the least radius of gyration of one of the angle bars.

Until further tests are made, Prof. Ostenfeld and L. Vianello, C.E., recommend that for built struts not more than 50 times the min. radius of gyration of the single bar should be allowed as the distance of side bracing for mild steel. Proportioning by the yield points gives the figure as 45 for wrought iron.

The late engineer, L. Vianello, in his book "Der Eisenbau" of 1905 works out in the following way a reasonable and plain method for calculating the bracing of a mild steel built column.

Generally, l is smaller than 105 r, hence Prof. Tetmajer's formula $3 \cdot 1 - \frac{1}{88} \frac{l}{r}$ t/cm² (see formula (21), page 20) can be used for breaking load. If the distance of the centres of gravity of the sectional bars, or sets of bars, is h, we have approximately $r = \frac{1}{2} h$. Allowing the $3 \cdot 1$ t/cm² as the yield point, then the $\frac{1}{88} \frac{l}{r} = \frac{1}{44} \frac{l}{h}$ must be due to the bending effect alone. The elastic line of a column coincides fairly with that of an evenly loaded beam; for the latter, the moment at the centre is $M = \frac{1}{8} p l^2$, and the corresponding stress in the sectional bars will consequently be $s = \frac{M}{h A} = \frac{p l^2}{8 h A}$, where A is the area of one of each of the two bars, or sets of bars. At the moment the column deflects we must have equality of the stresses found above, or

$$\frac{1}{44} \frac{l}{h} = \frac{p l^2}{8 h A} \qquad \text{hence } p = \frac{2 A}{11 l}$$

and the corresponding shear at the end must be $Q = \frac{1}{2} p l = \frac{A}{11}$ at the moment of yielding. This corresponds to breaking, but it is no use to design the bracing stronger than what corresponds to the safe load of the column.

Hence a smaller value of Q can be worked to, and allowing a working stress of 1 t/cm² against the $3 \cdot 1$ breaking load, the design of the bracing can be based on a value 3 times smaller than Q from above.

Therefore Vianello proportions the bracing to the crosswise end shear

$$Q = \frac{A}{33} \text{ metric tons} \qquad . \qquad . \qquad (19)$$

where A is the area of a sectional bar, or set of bars, in cm².

For the area A_1 square inches we get

$$Q = 0 \cdot 193 \, A_1 \text{ English tons} \qquad . \qquad (19)\text{A}$$

Vianello says that, working to the safe side, Q can be considered constant up to $\frac{1}{6}$ of the length from each end of the column and then decreasing evenly to zero at the centre.

For lattice bracing the stress in the braces can be found by revolving Q in the direction of the brace and the column axis.

Calling the distance from centre to centre of tie plates "*a*," then the corresponding moment is Qa, and, with "*h*" as before, the force on the end of the tie plate equals $\frac{Qa}{h}$, from which the riveting can be calculated. All tie plate connections to column members should have at least two rivets. Recent tests of Emperger with 4 angle bars (⌜⌝⌞⌟) united with tie plates with one rivet in each end showed no more resistance than 4 separate angle bars, a result that was to be expected.

Cast Iron. Central Load.

Based upon the numerous tests by Prof. Tetmajer the following formula has been deduced by Prof. Ostenfeld.

$$\mathbf{S} = \frac{7 \cdot 76}{1 + 0 \cdot 0007 \left(\frac{l}{r}\right)^2} \text{ t/cm}^2 \quad . \quad . \quad (20)$$

for which values are given in Table II., page 33.

Using z of formula (15) gives for determination of the dimension of a C.I. column to carry a given load based on above Rankine formula as developed by Prof. Claxton Fidler

$$A = A_0 \left(\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{0 \cdot 0007\, z\, l^2}{A_0}} \right)$$

where $A_0 = \frac{P}{s}$ might be calculated allowing a factor of safety 10 for $s = 0 \cdot 7$ t/cm² $= 4 \cdot 4$ tons/□″ $= 10\,000$ lbs./□″.

It will be seen that, even if Rankine's formula were as safe for mild steel and wrought iron as J. B. Johnson's, it would give much more work to find the dimensions of a column than by using Prof. Ostenfeld's formula (16) based on Johnson's formula.

The radius of gyration r of a hollow round column with outside diameter d and metal t can be quickly found by means of the following table, which goes beyond the limits used in practice.

$\frac{t}{d}$	$\frac{r}{d}$
0·000	0·353
0·020	0·346
0·040	0·339
0·060	0·333
0·080	0·326
0·100	0·320
0·120	0·314
0·140	0·308
0·160	0·302
0·180	0·297
0·200	0·292
0·220	0·286
0·240	0·281
0·260	0·277
0·280	0·273
0·300	0·269

Ex.—A 12″ column has $1\frac{1}{4}$″ metal, find radius of gyration:—

$$\frac{t}{d} = \frac{1\frac{1}{4}}{12} = 0\cdot104.$$

Interpolation:—

$$\frac{4}{20} = \frac{x}{6}$$

$$x = \frac{4 \times 6}{20} = 1$$

$$\frac{r}{d} = 0\cdot320 - 0\cdot001 = 0\cdot319$$

hence for $d = 12''$

$$r = 0\cdot319 \times 12 = 3\cdot83''.$$

Comparison of Formulæ for Mild Steel and Wrought Iron with Prof. Tetmajer's Tests.

The accompanying diagrams, Figs. 1 to 3, have been photographically reproduced, Fig. 1 from Prof. Ostenfeld's and Figs. 2 and 3 from Prof. Tetmajer's applied mechanics, and the author has added some curves (see page 21).

Figs. 1 and 2 show that the curve of Johnson-Ostenfeld and Euler agree well with the means of the tests. A heavy dot indicates the centre of a group of tests, and is usually close to the curve. The group centre for the shortest length in both cases was produced (exceptionally) by flat ended struts, taking $l = \frac{L}{2}$, hence they do not count much. The results of the mentioned formula can therefore be used with confidence for designing and checking.

For cast-iron, Fig. 3 shows good agreement with Rankine-Ostenfeld.

The illustrations also show Tetmajer's "straight lines" for

Mild steel . $\mathbf{S = 3 \cdot 10 - 0 \cdot 0114 \frac{l}{r}}$ t/cm² (21)

$$10 \angle \frac{l}{r} \angle 105$$

Wrought iron . $\mathbf{S = 3 \cdot 03 - 0 \cdot 0129 \frac{l}{r}}$ t/cm² (22)

$$10 \angle \frac{l}{r} \angle 112$$

and also his parabola for

Cast iron $\mathbf{S = 7 \cdot 76 - 0.120 \frac{l}{r} + 0 \cdot 00053 \left(\frac{l}{r}\right)^2}$ t/cm² (23)

$$5 \angle \frac{l}{r} \angle 80$$

continued by his Euler, for E = 1000 t/cm².

Further, the results of Prof. Claxton Fidler's formula, from his Theory and Practice of Bridge Construction, have been plotted on the diagrams; these were not intended for mean values but for safe values as the diagrams also show them to be, except for short columns of mild steel.

Plotting Johnson-Ostenfeld and Euler on Hodgkinson's tests in Prof. Fidler's book, shows good agreement for wrought iron, equally Rankine-Ostenfeld for cast iron.

Diagram Fig. 1 for mild steel shows the results of a Rankine formula

$$S = \frac{3 \cdot 27}{1 + 0 \cdot 000093 \left(\frac{l}{r}\right)^2} \text{ t/cm}^2 \quad . \quad . \qquad (24)$$

which is determined by the method of the minor squares from Prof. Tetmajer's tests by Prof. Ostenfeld, and, hence should be most reliable, but as Prof. Ostenfeld remarks, Rankine's formula does not agree well with the tests in general, and ought only to be used within certain limits for mild steel. It will be seen that for long columns it shows higher values than can be obtained by tests, and is therefore dangerous to use. Other versions of Rankine's formula that agree well for short lengths are still worse for long lengths of mild steel.

Fig. 4 gives an interesting comparison of generally used methods, showing the great variation of ordinary practice and the importance of using formulæ that are based upon tests.

Wood. Central Load.

Prof. Tetmajer has made numerous tests of **Pine** columns with steel pointed ends : from these he deduces the "straight line" formula

$$S = 0{\cdot}293 - 0{\cdot}0194 \frac{l}{r} \quad \text{t/cm}^2 \qquad . \quad (25)$$

$$5 < \frac{l}{r} < 100$$

continued by Euler with $E = 100$ t/cm^2.

Table II., page 33, shows the results of his formulæ, the metric values being taken from his book.

However, it often happens that other timbers than European pine are used for columns, and the engineer may then feel at a loss, but the difficulty can be got over as mentioned when dealing with J. B. Johnson's formula. As an example of making such formula shall be taken **Pitch Pine** using the mean values given by Rivington namely $B = 6400$ lbs./□″ and $E = 1\,500\,000$ lbs./□″.

Formula (8) gives

$$C = \frac{B^2}{4\pi^2 E} = \frac{6400^2}{39{\cdot}48 \times 1\,500\,000} = 0{\cdot}69$$

and (7) gives the limit

$$\frac{l}{r} = \sqrt{\frac{2\pi^2 E}{B}} = \sqrt{\frac{19{\cdot}74 \times 1\,500\,000}{6400}} = 68.$$

Hence by (4) breaking load by J. B. Johnson.

$$S = B - C\left(\frac{l}{r}\right)^2 = 6400 - 0{\cdot}69\left(\frac{l}{r}\right)^2 \text{ lbs./□″ up to } \frac{l}{r} = 68.$$

Above this ratio must be worked by Euler (3)

$$S = \frac{\pi^2 E}{\left(\frac{l}{r}\right)^2} = \frac{9 \cdot 87 \times 1\,500\,000}{\left(\frac{l}{r}\right)^2} = \frac{14\,800\,000}{\left(\frac{l}{r}\right)^2} \text{ lbs.}/\square''$$

as breaking load for pitch pine columns with free ends.

Eccentrically Loaded Columns.

The following formula of Prof. Ostenfeld gives reliable results for the breaking load of an eccentrically loaded column with free ends

$$\mathbf{S} = \frac{\mathbf{B}}{1 + \frac{\mathbf{f}}{\mathbf{k}} + \mathbf{c}\left(\frac{\mathbf{l}}{\mathbf{r}}\right)^2} \quad . \quad . \quad (26)$$

where f is the eccentricity, k the radius of core and B and c are constants given below. It will be noted that B which is the breaking load of a short bar, has somewhat different values than those given for central loads, thus however agreeing better with tests for eccentric loads.

Mild steel . B = 3·36 t/cm² = 21·3 tons/□″ = 47 800 lbs./□″, c = 0·00018.

Wrought iron. B = 3·03 t/cm² = 19·2 tons/□″ = 43 000 lbs./□″, c = 0·00018.

Cast iron . B = 7·00 t/cm² = 44·4 tons/□″ = 99 600 lbs./□″, c = 0·00085.

Pine or oak . B = 0·35 t/cm² = 2·2 tons/□″ = 5000 lbs./□″, c = 0·00035.

For use in designing he has developed

$$\mathbf{A} = \mathbf{A}_0 \left[\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{\mathbf{z}}{\mathbf{A}_0}(\mathbf{f\,e} + \mathbf{c l}^2)}\right] \quad . \quad (27)$$

A, A_0 and z have the same meaning as in formula (16) for central load, and e is the distance from neutral axis through centre of gravity to the extreme fibre. To determine A find A_0 and z, as shown previously, and assume e (by a guess). When A has been found by the first trial, and a section is selected, the corrected values of z and e are taken from this section and a fresh trial is made and then if necessary a further trial.

The development of the formula is worked out by Prof. Ostenfeld, but it is too long to reproduce here. He proves by Prof. Tetmajer's 9 tests for mild steel and 31 tests for wrought iron, that if the eccentricity is not too small the agreement with the tests, from which he deduced B and c, is good. Further, that the agreement is still good when $f = k$, while for smaller eccentricities the breaking weights obtained by (26) are somewhat too small, i.e. to the safe side anyhow.

He further mentions that for $f = 0$, the formula reduces itself to Rankine's formula, but that it will be seen that c has nearly double the value. For cast iron and wood no tests were made; he therefore prepared the values of B and c by analogies.

Prof. Ostenfeld mentions that a similar formula, published somewhat earlier by Dr. F. v. Emperger, was unknown to him when he developed his formula, and he calls attention to the fact that Emperger has not noticed that a greater value of c is necessary for the eccentric formula than for Rankine's to make agreement with the tests.

Ex. 8.—A column formed of two braced B.S. channel bars, $6'' \times 3\frac{1}{2}'' \times 17 \cdot 9$ lbs., is loaded with a 2″ eccentricity in the axial plane parallel to the webs. Free length $l = 153''$. Find safe load for a factor of safety 4.

$$B = 21 \cdot 3 \text{ tons}/\square''.$$

$k = \dfrac{R}{A} = \dfrac{9 \cdot 88}{5 \cdot 27} = 1'' \cdot 87.$ (R and A are taken for one channel only.)

$$\frac{f}{k} = \frac{2}{1 \cdot 87} = 1 \cdot 07.$$

$$r = 2 \cdot 36'' \text{ (max. } r \text{ for a channel).}$$

$$\frac{l}{r} = \frac{153}{2.36} = 65.$$

$$c\left(\frac{l}{r}\right)^2 = 0 \cdot 00018 \times 65^2 = 0.76.$$

By (26): $$S = \frac{B}{1 + \frac{f}{k} + c\left(\frac{l}{r}\right)^2} = \frac{21 \cdot 3}{1 + 1 \cdot 07 + 0 \cdot 76}$$

$$= \frac{21 \cdot 3}{2 \cdot 83} = 7 \cdot 53 \text{ tons}/\square''.$$

(If the load had been central, Table I. shows that the breaking load would have been $15 \cdot 0$ tons/□″ for $\frac{l}{r} = 65$.)

$A = 2 \times 2 \cdot 57 = 10 \cdot 5 \square''$.

As the breaking load = A S

the safe load $= \frac{10 \cdot 5 \times 7 \cdot 53}{4} = 19 \cdot 8$ tons.

Ex. 9.—Find the section to be used in a column, formed of two braced channels, that will carry a load of 24 tons 2″ out of centre in a plane parallel to the webs. The length is 18′ 3″, the base is well bedded, and the top carries a ceiling.

Allow a stress of $s_0 = 5$ tons/□″; then factor of safety $= \frac{21 . 3}{5} = 4 \cdot 26$.

$$A_0 = \frac{P}{s_0} = \frac{24}{5} = 4 \cdot 8 \square''.$$

Allow $z = 1 \cdot 0$ (see table of z values, page 13).

$$\frac{z}{A_0} = \frac{1 \cdot 0}{4 \cdot 8} = 0 \cdot 21.$$

Assume a 10″ channel with $e = 5''$.

$f e = 2 \times 5 = 10.$

$L = 18' \ 3'' = 219''.$

$l = 0 \cdot 7 \times 219 = 153''$; (foot held and top guided).

$c l^2 = 0 \cdot 00018 \times 153^2 = 4 \cdot 2.$

By (27): $$A = A_0 \left[\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{z}{A_0}(f e + c l^2)}\right]$$

$$= 4 \cdot 8 \left[0 \cdot 5 + \sqrt{0 \cdot 25 + 0 \cdot 21 \, (10 + 4 \cdot 2)}\right]$$

$$= 4 \cdot 8 \left[0 \cdot 5 + \sqrt{0 \cdot 25 + 2 \cdot 98}\right] = 4 \cdot 8 \, (0 \cdot 5 + 1 \cdot 80) = 11 \cdot 0 \square''.$$

For each channel is required $\frac{1}{2} \times 11{\cdot}0 = 5{\cdot}5\square''$. Try B.S. channel $7'' \times 3\frac{1}{2}'' \times 20{\cdot}2$ lb. with $5{\cdot}95\square''$. For this section we have

$$z = \frac{A^2}{I} = \frac{(2 \times 5{\cdot}95)^2}{2 \times 44{\cdot}5} = 1{\cdot}59$$

$$\frac{z}{A_0} = \frac{1{\cdot}59}{4{\cdot}8} = 0{\cdot}331.$$

$$e = \tfrac{1}{2} \times 7'' = 3{\cdot}5''.$$

$f\,e = 2 \times 3{\cdot}5 = 7.$
$c\,l^2 = 4{\cdot}2$ as before.

$$A = A_0 \left[\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{z}{A_0}(f\,e + c\,l^2)}\right]$$

$$= 4{\cdot}8\,[0{\cdot}5 + \sqrt{0{\cdot}25 + 0{\cdot}331\,(7 + 4{\cdot}2)}]$$

$$= 4{\cdot}8\,(0{\cdot}5 + \sqrt{3{\cdot}95}) = 4{\cdot}8 \times 2{\cdot}45 = 11{\cdot}7\square''$$

required, hence the column is safe as there are two channels with $2 \times 5{\cdot}95 = 11{\cdot}9\square''$.

Ex. 10.—A column formed of two German standard channels has a free length of 385 cm., and is required to carry 14·7 t. with an eccentricity of 10 cm. in axial plane parallel to webs. Factor of safety $4\frac{1}{2}$.

$B = 3{\cdot}36$ t/cm².

$$s_0 = \frac{3{\cdot}36}{4{\cdot}5} = 0{\cdot}75 \text{ t/cm}^2.$$

$$A_0 = \frac{P}{s_0} = \frac{14{\cdot}7}{0.75} = 19{\cdot}6 \text{ cm}^2.$$

Assume two channels N.P. No. 24; as the height is 24 cm. we have

$e = \frac{1}{2} \times 24 = 12$ cm.
$f\,e = 10 \times 12 = 120.$
$c\,l^2 = 0{\cdot}00018 \times 385^2 = 27.$

Assume $z = 1\cdot 2$, (see table of z values).

$$\tfrac{1}{4} + \frac{z}{A_0}(f\,e + c\,l^2) = \tfrac{1}{4} + \frac{1\cdot 2}{19\cdot 6}(120 + 27)$$

$$= 0\cdot 25 + 9\ 00 = 9\cdot 25.$$

$$A = A_0\left[\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{z}{A_0}(f\,e + c\,l^2)}\right]$$

$$= A_0\,(\tfrac{1}{2} + \sqrt{9\cdot 25}) = 19\cdot 6\,(0\cdot 5 + 3\cdot 04) = 69.4\text{ cm}^2.$$

the area of channels assumed $= 2 \times 42\cdot 3 = 84\cdot 6$ cm^2, therefore try a smaller channel, say No. 20; area $A = 2 \times 32\cdot 2 = 64\cdot 4$ cm^2.

$$z = \frac{A^2}{I} = \frac{64\cdot 4^2}{2 \times 1910} = 1\cdot 08.$$

$$e = \tfrac{1}{2} \times 20 = 10\text{ cm.}$$

$$f\,e = 10 \times 10 = 100.$$

$$\sqrt{\tfrac{1}{4} + \frac{z}{A_0}(f\,e + c\,l^2)} = \sqrt{\tfrac{1}{4} + \frac{1\cdot 08}{19\cdot 6}(100 + 27)}$$

$$= \sqrt{0\cdot 25 + 7\cdot 00} = \sqrt{7\cdot 25} = 2\cdot 70.$$

$$A = A_0\left[\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{z}{A_0}(f\,e + c\,l^2)}\right]$$

$$= 19\cdot 6\,(0\cdot 5 + 2\cdot 70) = 62\cdot 6\text{ cm}^2.$$

required, and the area of the channels assumed equals $64\cdot 4$ cm^2., therefore the two channels N.P. No. 20 can be used.

The actual factor of safety for the two No. 20 is found as follows :—

$$k = \frac{R}{A} = \frac{191}{32\cdot 2} = 5\cdot 9\text{ cm. (found by one channel).}$$

$$\frac{f}{k} = \frac{10}{5\cdot 9} = 1\cdot 70.$$

$$\frac{l}{r} = \frac{385}{7\cdot 71} = 50.$$

$$c\left(\frac{l}{r}\right)^2 = 0\cdot 00018 \times 50^2 = 0\cdot 45.$$

$$S = \frac{B}{1 + \frac{f}{k} + c\left(\frac{l}{r}\right)^2} = \frac{3 \cdot 36}{1 + 1 \cdot 70 + 0 \cdot 45} = 1 \cdot 07 \text{ t/cm}^2.$$

Breaking load $A\,S = 64 \cdot 4 \times 1 \cdot 07 = 69$ t.

Factor of safety $\frac{69}{14 \cdot 7} = 4 \cdot 7$ or fully the $4\frac{1}{2}$ required.

If in any case the eccentricity f is greater than the radius of core k there will be tension in part of the metal, and as **Cast Iron** has a small tensile strength the amount of tension should be considered. Prof. Ostenfeld has prepared the following formula for the tensile stress

$$\mathbf{s}^1 = \mathbf{s}\left(\frac{0 \cdot 85\ \mathbf{S}^1 f}{k\,(0 \cdot 85\ \mathbf{S}^1 - s)} - 1\right) \quad . \quad . \quad (28)$$

s^1 is the max. unitary tensile stress.

$s = \frac{P}{A}$ is the stress evenly distributed over the area.

$S^1 = \frac{\pi^2 E}{\left(\frac{l}{r}\right)^2} = \frac{10\ E}{\left(\frac{l}{r}\right)^2}$ is the breaking stress by Euler's formula (3).

For C.I. say $E = 1000$ t/cm² $= 6300$ tons/□″ $= 14\,000\,000$ lbs./□″.

$0 \cdot 85$ is an empirical constant which Prof. Ostenfeld deduced from Tetmajer's test for mild steel and wrought iron (formula (28) holds good for any material) and is so near his approximate theoretical value $\frac{8}{\pi^2} = 0 \cdot 81$ that the formula (28) can be used with confidence.

In case of a great eccentricity the resistance of C.I. column depends entirely upon the tensile stress, and the resistance will in that case not be expressed by (26) but be governed by above formula (28).

The resistance will then be A s where s is found by (28), which can be transcribed to

$$\mathbf{s}^2 + \left[\mathbf{s}^1 + 0 \cdot 85\ \mathbf{S}^1\left(\frac{\mathbf{f}}{\mathbf{k}} - 1\right)\right]\mathbf{s} - 0 \cdot 85\ \mathbf{S}^1\mathbf{s}^1 = 0 \quad (29)$$

Having worked up the numerical values, we find s out of a plain quadratic equation (29).

Prof. Ostenfeld allows for C.I. as working tensile stress: $s^1 = 0 \cdot 2$ to $0 \cdot 3$ t/cm² = $1\frac{1}{4}$ to $1 \cdot 9$ tons/□″ = 2800 to 4300 lbs./□″.

Ex. 11.—A 12″ diam. C.I. column with 1″ metal and $l = 12' \, 6''$ free length is loaded with 3″ eccentricity; find the safe load for factor of safety 10, tensile stress not to exceed $1\frac{1}{2}$ tons/□″.

$\frac{t}{d} = \frac{1''}{12''} = 0 \cdot 083$ and by table for rad. of gyr. (see heading Cast Iron, page 19) $r = 0 \cdot 325 \times 12'' = 3 \cdot 90''$.

$$k = \frac{r^2}{e} = \frac{3 \cdot 90^2}{6} = 2 \cdot 53''.$$

Formula (26) will be used.

$B = 44 \cdot 4$ tons/□″.

$$\frac{f}{k} = \frac{3}{2 \cdot 53} = 1 \cdot 18.$$

$$\frac{l}{r} = \frac{150}{3 \cdot 90} = 38 \cdot 4.$$

$$c\left(\frac{l}{r}\right)^2 = 0 \cdot 00085 \times 38 \cdot 4^2 = 1 \cdot 25.$$

$$S = \frac{B}{1 + \frac{f}{k} + c\left(\frac{l}{r}\right)^2} = \frac{44 \cdot 4}{1 + 1 \cdot 18 + 1 \cdot 25} = \frac{44 \cdot 4}{3 \cdot 43} = 12 \cdot 9$$

tons/□″.

$$A = \frac{\pi}{4} 12^2 - \frac{\pi}{4} 10^2 = 113 \cdot 1 - 78 \cdot 5 = 34 \cdot 6 \square''.$$

Breaking load $A\,S = 34 \cdot 6 \times 12 \cdot 9 = 446$ tons.

Safe load $\frac{446}{10} = 44 \cdot 6$ tons.

However, as the eccentricity $f = 3''$ is greater than the core radius $k = 2 \cdot 53''$, the tensile stress should be examined by formula (28).

$$s = \frac{P}{A} = \frac{44 \cdot 6}{34 \cdot 6} = 1 \cdot 29 \text{ tons/}\square''.$$

$$S^1 = \frac{10\,E}{\left(\frac{l}{r}\right)^2} = \frac{10 \times 6300}{38 \cdot 4^2} = 42 \cdot 7 \text{ tons}/\square''.$$

$$0 \cdot 85\ S^1 = 0 \cdot 85 \times 42 \cdot 7 = 36 \cdot 3.$$

$$0 \cdot 85\ S^1 - s = 36 \cdot 3 - 1 \cdot 29 = 35 \cdot 0.$$

$$\frac{0 \cdot 85\ S^1 f}{k\,(0 \cdot 85\ S^1 - s)} = \frac{36 \cdot 3 \times 3}{2 \cdot 53 \times 35 \cdot 0} = 1 \cdot 23$$

Tensile stress $s^1 = s\left(\frac{0 \cdot 85\ S^1 f}{k\,(0 \cdot 85\ S^1 - s)} - 1\right) = 1 \cdot 29\ (1 \cdot 23 - 1)$

$= 1 \cdot 29 \times 0 \cdot 23 = 0 \cdot 29$ tons/□'': hence safe.

If the load had been acting on a bracket, so that $f = 10''$, all would depend upon the tensile stress, and s must be found by formula (29).

$s^1 = 1 \cdot 5$ tons/□'' is allowed.

$$\frac{f}{k} = \frac{10}{2 \cdot 53} = 3 \cdot 95.$$

$0 \cdot 85\ S^1 = 36 \cdot 3$ as above.

$$0 \cdot 85\ S^1 \left(\frac{f}{k} - 1\right) = 36 \cdot 3\ (3 \cdot 95 - 1) = 36 \cdot 3 \times 2 \cdot 95 = 107 \cdot 1.$$

$$s^1 + 0 \cdot 85\ S^1 \left(\frac{f}{k} - 1\right) = 1 \cdot 5 + 107 \cdot 1 = 108 \cdot 6.$$

$$0 \cdot 85\ S^1 s^1 = 36 \cdot 3 \times 1 \cdot 5 = 54 \cdot 4.$$

hence (29) $s^2 + \left[s^1 + 0 \cdot 85\ S^1 \left(\frac{f}{k} - 1\right)\right] s - 0 \cdot 85\ S^1 s^1 = 0$

gives $s^2 + 108 \cdot 6\, s - 54.4 = 0.$

For the quadratic equation

$$x^2 + a\,x + c = 0$$

the solution is

$$x = -\frac{a}{2} \pm \sqrt{\left(\frac{a}{2}\right)^2 - c}$$

and in this case minus in front of root cannot be used, as the result must be positive.

Hence the quadratic equation for s gives the safe evenly distributed stress

$$s = -54{\cdot}3 + \sqrt{54{\cdot}3^2 + 54{\cdot}4} = -54{\cdot}3 + \sqrt{3003}$$
$$= -54{\cdot}3 + 54{\cdot}30 = 0{\cdot}50 \text{ tons}/\square''.$$

Safe load $\quad A\,s = 34{\cdot}6 \times 0{\cdot}50 = 17$ tons.

If this case of 10″ eccentricity had been worked out by (26) the breaking load would be found to be 7·16 tons/□″. By factor of safety 10 the safe load should be 0·72 tons/□″, while as just found only 0·50 tons/□″ would be permissible.

A Column affected by a Bending Moment.

Prof. Ostenfeld proves that a reasonable result is obtained when a column is affected by an axial load P and a bending moment M when we calculate as if the column was loaded with P, having the eccentricity $f = \dfrac{M}{P}$.

He works out the following example.

A square timber of 4 m. length, is supported at the ends and carries a normal load of 1·4 t. per metre as well as an axial load of 8·4 t. Find the scantling when a stress of 60 kg/cm² is allowed.

$$M = \frac{1{\cdot}4 \times 4^2}{8} = 2{\cdot}8 \text{ m.t. (metre-tons).}$$

$$P = 8{\cdot}4 \text{ t.}$$

$$f = \frac{M}{P} = \frac{2{\cdot}8}{8{\cdot}4} = 0{\cdot}33 \text{ m.} = 33 \text{ cm.}$$

Stress $s_0 = 60$ kg/cm² $= 0{\cdot}06$ t/cm².

$$A_0 = \frac{P}{s_0} = \frac{8{\cdot}4}{0{\cdot}06} = 140 \text{ cm}^2.$$

$z = 12$ for a square section.

Assume a 34 cm. timber, or say $e = 17$ cm.

$fe = 33 \times 17 = 561.$

$l = 4$ m. $= 400$ cm.

$c\,l^2 = 0{\cdot}00035 \times 400^2 = 56.$

$$\frac{z}{A_0}(fe + c\,l^2) = \frac{12}{140}(561 + 56) = \frac{12 \times 617}{140} = 52{\cdot}8.$$

Formula (27) gives

$$A = A_0\left[\tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \frac{z}{A_0}(fe + c\,l^2)}\right]$$

$$= 140\,(0{\cdot}5 + \sqrt{0{\cdot}25 + 52{\cdot}8}) = 140\,(0{\cdot}5 + \sqrt{53{\cdot}0})$$

$$= 140\,(0{\cdot}5 + 7{\cdot}28) = 140 \times 7{\cdot}78 = 1090 \text{ cm}^2.$$

Hence the baulk should be $\sqrt{1090} = 33$ cm.

There is no reason to repeat the calculation, as the difference between $e = \frac{1}{2} \times 33 = 16{\cdot}5$ cm. and the assumed value 17 cm. is so very small.

TABLE I.

BREAKING LOAD AND STRESS FACTOR FOR MILD STEEL AND WROUGHT IRON. CENTRALLY LOADED COLUMNS WITH "FREE" ENDS.

$\frac{l}{r}$	Mild Steel					Stress Factor for Steel or Wrought Iron		Wrought Iron					$\frac{l}{r}$
	t/cm.²		Tons/□"		Lbs /□"			Lbs./□"	Tons/□"		t/cm²		
		Diff.		Diff.			Diff.			Diff.		Diff.	
0	2·72	0	17·3	0	38 700	1·000	1	36 700	16·4	0	2·58	0	0
5	2·72	1	17·3	1	38 700	0·999	2	36 700	16·4	1	2·58	1	5
10	2·71	1	17·2	0	38 500	0·997	4	36 600	16·3	0	2·57	1	10
15	2·70	1	17·2	1	38 400	0·993	6	36 500	16·3	1	2·56	1	15
20	2·69	2	17·1	2	38 300	0·987	8	36 300	16·2	1	2·55	2	20
25	2·67	2	16·9	1	38 000	0·979	9	36 000	16·1	2	2·53	2	25
30	2·65	3	16·8	2	37 700	0 970	11	35 700	15·9	2	2·51	3	30
35	2·62	4	16·6	2	37 300	0·959	12	35 300	15·7	2	2·48	3	35
40	2·58	3	16·4	2	36 800	0·947	14	34 900	15·5	2	2·45	4	40
45	2·55	4	16·2	3	36 300	0·933	16	34 300	15·3	2	2·41	4	45
50	2·51	5	15·9	3	35 700	0·917	18	33 700	15·1	3	2·37	4	50
55	2·46	5	15·6	3	35 000	0·899	19	33 100	14·8	3	2·33	5	55
60	2·41	5	15·3	3	34 300	0·880	21	32 400	14·5	4	2·28	6	60
65	2·36	6	15·0	4	33 600	0·859	22	31 600	14·1	3	2·22	5	65
70	2·30	7	14·6	4	32 700	0·837	24	30 900	13·8	4	2·17	6	70
75	2·23	7	14·2	5	31 700	0·813	26	30 000	13·4	4	2·11	7	75
80	2·16	7	13·7	4	30 700	0·787	28	29 000	13 0	5	2·04	7	80
85	2·09	7	13·3	5	29 800	0·759	29	28 000	12·5	5	1 97	7	85
90	2·02	9	12·8	5	28 700	0·730	31	27 000	12·0	4	1·90	8	90
95	1·93	8	12·3	6	27 500	0·699	32	25 900	11·6	6	1·82	8	95
100	1·85	9	11·7	5	26 300	0·667	34	24 700	11·0	5	1·74	9	100
105	1·76	9	11·2	6	25 000	0·633	36	23 500	10·48	58	1·65	9	105
110	1·67	10	10·58	63	23 800	0·597	38	22 200	9·90	59	1·56	9	110
115	1·57	11	9 95	65	22 300	0·559	39	20 900	9·31	64	1·47	10	115
120	1·46	10	9·30	68	20 800	0·520	40	19 500	8·67	65	1·37	11	120
125	1·36	10	8·62	64	19 300	0·480	36	18 000	8·02	60	1·26	9	125
130	1·26	10	7·98	58	17 900	0·444	32	16 600	7·42	54	1·17	9	130
135	1·16	8	7·40	52	16 500	0·412	29	15 400	6·88	59	1·08	7	135
140	1·08	7	6·88	48	15 400	0·383	26	14 300	6·39	43	1·007	68	140
145	1·009	66	6·40	41	14 400	0·357	26	13 400	5·96	39	0·939	62	145
150	0·943	60	5·99	39	13 400	0·333	21	12 500	5·57	35	0·877	55	150
155	0·883	54	5·60	34	12 600	0·312	19	11 700	5·22	33	0·822	51	155
160	0·829	50	5·26	31	11 800	0·293	18	11 000	4·89	29	0·771	46	160
165	0·779	45	4·95	29	11 100	0·275	15	10 300	4·60	26	0·725	42	165
170	0·734	41	4·66	26	10 450	0·260	15	9 720	4·34	24	0·683	38	170
175	0·693	38	4·40	24	9 860	0·245	14	9 170	4·10	23	0·645	36	175
180	0·655	35	4·16	22	9 320	0·231	12	8 660	3·87	21	0·609	32	180
185	0·620	32	3·94	21	8 820	0·219	11	8 200	3·66	19	0·577	30	185
190	0·588	30	3·73	19	8 360	0·208	11	7 770	3·47	18	0·547	28	190
195	0·558	27	3·54	17	7 940	0·197	10	7 380	3·29	16	0·519	25	195
200	0·531	..	3·37	..	7 550	0·187	..	7 030	3·13	..	0·494	..	200

TABLE II.

BREAKING LOAD OF CAST-IRON AND EUROPEAN PINE. CENTRALLY LOADED COLUMNS WITH "FREE" ENDS.

$\frac{l}{r}$	Cast Iron					European Pine					$\frac{l}{r}$
	t/cm^2		Tons/□"		Lbs./□"	Lbs./□"	Tons/□"		t/cm^2		
		Diff.		Diff.				Diff.		Diff.	
10	7·25	55	46·0	35	103 100	3 900	1·74	6	0 274	10	10
15	6·70	64	42·5	40	95 300	3 750	1·68	7	0·264	10	15
20	6·06	66	38·5	42	86 200	3 610	1·61	6	0·254	10	20
25	5·40	64	34·3	41	76 800	3 470	1·55	6	0·244	9	25
30	4·76	58	30·2	37	67 700	3 340	1·49	6	0·235	10	30
35	4·18	52	26·5	33	59 400	3 200	1·43	6	0·225	9	35
40	3·66	45	23·2	28	52 100	3 070	1·37	6	0·216	10	40
45	3·21	39	20·4	25	45 700	2 930	1·31	6	0·206	10	45
50	2·82	33	17·9	21	40 100	2 790	1·25	7	0·196	10	50
55	2·49	29	15·8	18	35 400	2 640	1·18	6	0·186	9	55
60	2·20	24	14·0	16	31 300	2 510	1·12	6	0·177	10	60
65	1·96	21	12·4	13	27 900	2 370	1·06	6	0·167	10	65
70	1·75	18	11·11	114	24 900	2 230	1·00	7	0·157	10	70
75	1·57	15	9·97	95	22 400	2 090	0·93	5	0·147	9	75
80	1·42	14	9·02	89	20 200	1 960	0·88	7	0·138	10	80
85	1·28	12	8·13	77	18 200	1 820	0·81	6	0·128	10	85
90	1·16	10	7·36	63	16 500	1 680	0·75	6	0·118	9	90
95	1·061	91	6·73	57	15 100	1 550	0·69	6	0·109	10	95
100	0·970	79	6·16	50	13 800	1 410	0·63	6	0·099	9	100
105	0·891	71	5·66	45	12 700	1 280	0·57	5	0·090	8	105
110	0·820	63	5·21	41	11 700	1 170	0·52	4	0·082	7	110
115	0·757	57	4·80	36	10 770	1 070	0·48	4	0·075	6	115
120	0·700	50	4·44	31	9 960	980	0·44	4	0·069	6	120
125	0·650	45	4·13	29	9 240	900	0·40	3	0·063	5	125
130	0·605	42	3·84	27	8 600	830	0·37	3	0·058	4	130
135	0·563	36	3·57	22	8 010	770	0·34	3	0·054	4	135
140	0·527	33	3·35	21	7 490	710	0·32	2	0·050	3	140
145	0·494	31	3·14	20	7 020	670	0·30	2	0·047	3	145
150	0·463	..	2·94	..	6 580	630	0·28	..	0·044	..	150

Radii of Gyration for German Sections.

Common H Beams	r max.	r min.	Broad H Beams	r max.	r min.	⊔ Bars	r max.	r min.	T Bars	r for Axis: Parallel to Table	r for Axis: Normal to Table
No.	*cm.*	*cm.*	No.	*cm.*	*cm.*	No.	*cm.*	*cm.*	No.	*cm.*	*cm.*
8	3·20	0·91	18B	7·64	4·24	8	3·11	1·33	8/4	0·99	1·90
9	3·61	0·99	20B	8·61	4·72	10	3·90	1·47	9/4½	1·12	2·13
10	4·01	1·07	22B	9·45	5·18	12	4·63	1·59	10/5	1·25	2·37
11	4·40	1·15	24B	10·3	5·6	14	5·44	1·75	12/6	1·49	2·84
12	4·80	1·23	25B	10·7	5·8	16	6·21	1·89	14/7	1·74	3·36
13	5·20	1·30	26B	11·1	6·0	18	6·96	2·02	16/8	1·99	3·78
14	5·61	1·39	27B	11·6	6·3	20	7·71	2·14	18/9	2·24	4·26
15	6·00	1·46	28B	12·0	6·6	22	8·50	2·30	20/10	2·47	4·69
16	6·40	1·55	29B	12·4	7·0	24	9·23	2·42			
17	6·80	1·63	30B	12·9	7·0	26	10·0	2·57	7/7	2·05	1·44
18	7·20	1·71	32B	13·7	7·0	28	10·8	2·74	8/8	2·33	1·65
19	7·60	1·79	34B	14·5	7·0	30	11·6	2·90	9/9	2·64	1·85
20	8·00	1·87	36B	15·3	7·0				10/10	2·93	2·05
21	8·40	1·94	38B	16·1	6·9				12/12	3·51	2·45
22	8·80	2·03	40B	16·8	6·9				14/14	4·07	2·88
23	9·20	2·10	42½B	17·8	6·9						
24	9·59	2·18	45B	18·8	6·8						
25	9·98	2·27	47½B	19·8	6·8						
26	10·4	2·32	50B	20·6	6·7						
27	10·8	2·39	55B	22·5	6·6						
28	11·1	2·44	60B	24·4	6·5						
29	11·5	2·50	65B	26·1	6·4						
30	11·9	2·55	70B	28·2	6·3						
32	12·7	2·67	75B	29·0	6·2						
34	13·4	2·79									
36	14·2	2·90									
38	15·0	3·01									
40	15·7	3·14									
42½	16·7	3·29									
45	17·7	3·43									
47½	18·6	3·58									
50	19·6	3·72									
55	21·6	4·06									
60	23·4	4·26									

Above are the Differdange (Differdinger) or Grey Broad Flange Beams

RADII OF GYRATION FOR GERMAN SECTIONS.

Equal Angles	Thickness	r max.	r min.	Two Back to Back r min.	Equal Angles	Thickness	r max.	r min.	Two Back to Back r min.	Tube of 4 Phoenix Bars	Thickness of Tube	r (constant)
No	*mm.*	*cm.*	*cm.*	*cm.*	No.	*mm.*	*cm.*	*cm.*	*cm.*	No.	*mm.*	*cm.*
4	4	1·55	0·79	1·23	9	9	3·50	1·77	2·77	5	4	4·41
,,	6	1·52	0·78	1·20	,,	11	3·46	1·76	2·75	,,	8	4·35
,,	8	1·46	0·77	1·17	,,	13	3·42	1·76	2·72			
										7½	6	6·14
4½	5	1·74	0·88	1·38	10	10	3·88	1·97	3·08	,,	10	6·10
,,	7	1·70	0·88	1·35	,,	12	3·85	1·96	3·05			
,,	9	1·64	0·86	1·31	,,	14	3·81	1·95	3·02	10	8	7·92
										,,	12	7·90
5	5	1·94	0·98	1·54	11	10	4·23	2·16	3·35			
,,	7	1·90	0·98	1·51	,,	12	4·21	2·15	3·34	12½	10	9·72
,,	9	1·85	0·97	1·46	,,	14	4·18	2·14	3·32	,,	14	9·66
5½	6	2·13	1·08	1·69	12	11	4·68	2·36	3·71	15	12	11·5
,,	8	2·09	1·07	1·65	,,	13	4·64	2·35	3·68	,,	18	11·5
,,	10	2·03	1·06	1·63	,,	15	4·60	2·35	3·65			
6	6	2·33	1·18	1·85	13	12	5·00	2·54	3·97			
,,	8	2·29	1·17	1·82	,,	14	4·97	2·53	3·94			
,,	10	2·22	1·15	1·77	,,	16	4·94	2·52	3·92			
6½	7	2·51	1·28	1·99	14	13	5·46	2·76	4·32			
,,	9	2·48	1·27	1·97	,,	15	5·42	2·75	4·30			
,,	11	2·41	1·26	1·92	,,	17	5·33	2·73	4·23			
7	7	2·72	1·38	2·15	15	14	5·77	2 93	4·57			
,,	9	2·68	1·37	2·13	,,	16	5·74	2·93	4·56			
,,	11	2·63	1·35	2·08	,,	18	5·71	2·93	4·54			
7½	8	2·90	1·47	2·30	16	15	6·23	3·15	4·94			
,,	10	2·87	1·47	2·28	,,	17	6·19	3·14	4·91			
,,	12	2·83	1·46	2·25	,,	19	6·10	3·12	4·84			
8	8	3·11	1·57	2·46								
,,	10	3·07	1·56	2·44								
,,	12	3·03	1·56	2·41								

The number of the German Standard indicates the principal dimension in centimetres.

APPENDIX.

Columns of Wood.

Some time after the treatise was written the Author obtained a copy of the results of Prof. Tetmajer's tests. The scantlings Tetmajer used for wood were large enough, being from 12 to 15 cms., and the tests were made with oak and four different classes of pine. Plotting the results showed that J. B. Johnson's Parabola gave too high results, while *T. H. Johnson's Straight Line* (a tangent from compressive stress B to the Euler curve) gave fair results.

The straight line from Tetmajer's mean value of B for oak fell in the mean of the tests, which only deviated very little. Similar results ought to be expected from leaf woods, or at all events from hardwoods.

The tests for pine woods were very erratic, and the straight line from Tetmajer's mean values of B fell above the mean of the tests, but a line from about 10 per cent. lower than the compressive stress gave a fair mean of the tests.

Hence when it is required to make column formulæ for a class of wood for which no column tests exist, Euler's formula should be used for the greater lengths and T. H. Johnson's for the shorter lengths. Use for leaf woods B equal to compressive stress, and for pine woods B about 10 per cent. less than this stress.

T. H. Johnson's formula is for $x = \frac{l}{r}$

$$S = B - Cx \quad . \quad . \quad . \quad . \quad . \quad (30)$$

with limit

$$\frac{l}{r} = x = \sqrt{\frac{3\pi^2 E}{B}} \quad . \quad . \quad (31) \qquad 3\pi^2 = 29{\cdot}61$$

when x is calculated we obtain

$$C = \frac{2\pi^2 E}{x^3} \quad . \quad . \quad (32) \qquad 2\pi^2 = 19{\cdot}74.$$

Ex. pitch pine with $E = 1{,}500{,}000$ lbs./□″ and compressive stress 6400 lbs./□″.

About 10 per cent. less than 6400 gives B to the safe side equal to 5700.

By (31) $\quad \frac{l}{r} = x = \sqrt{\frac{3\pi^2 E}{B}} = \sqrt{\frac{29{\cdot}61 \times 1{,}500{,}000}{5700}} = 88{\cdot}3.$

By (32) $\quad C = \frac{2\pi^2 E}{x^3} = \frac{19{\cdot}74 \times 1{,}500{,}000}{88{\cdot}3^3} = 43{\cdot}1.$

Hence by (30)

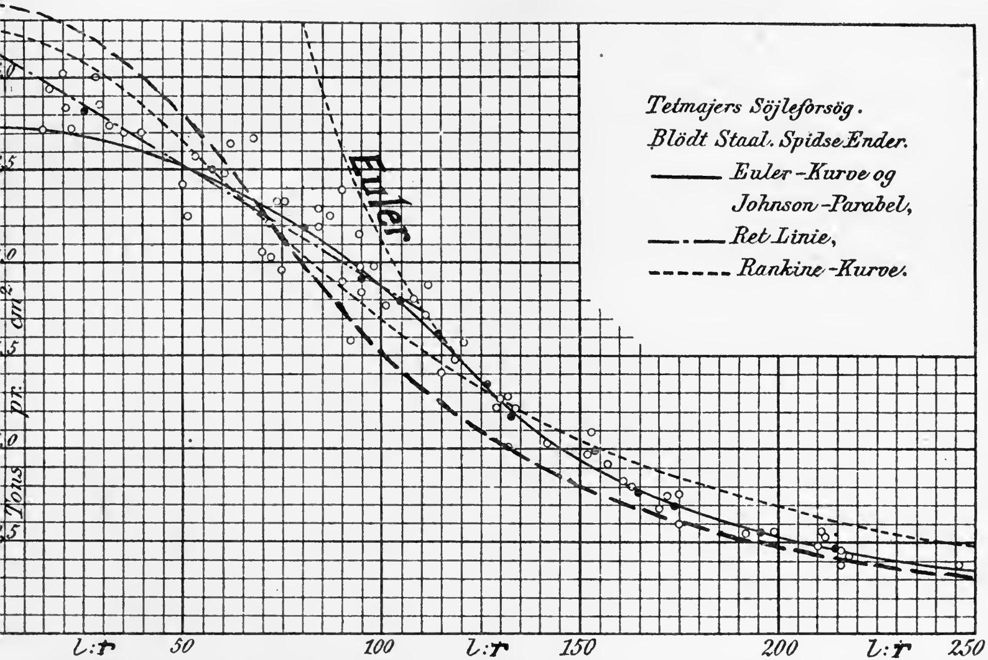
$$S = B - Cx = 5700 - 43{\cdot}1\,\frac{l}{r}\,\text{lbs./□″ up to } \frac{l}{r} = 88.$$

Beyond this, Euler's formula as found by the same example calculated according to J. B. Johnson's formula.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
GREAT WINDMILL STREET, W., AND DUKE STREET, STAMFORD STREET, S.E.

Fig. 1 : MILD STEEL.

From Ostenfeld : Elasticitetslære.



I. *Johnson – Ostenfeld.*
II. *Tetmajer.*
III. *Claxton Fidler.*
IV. *Rankine by Ostenfeld.*

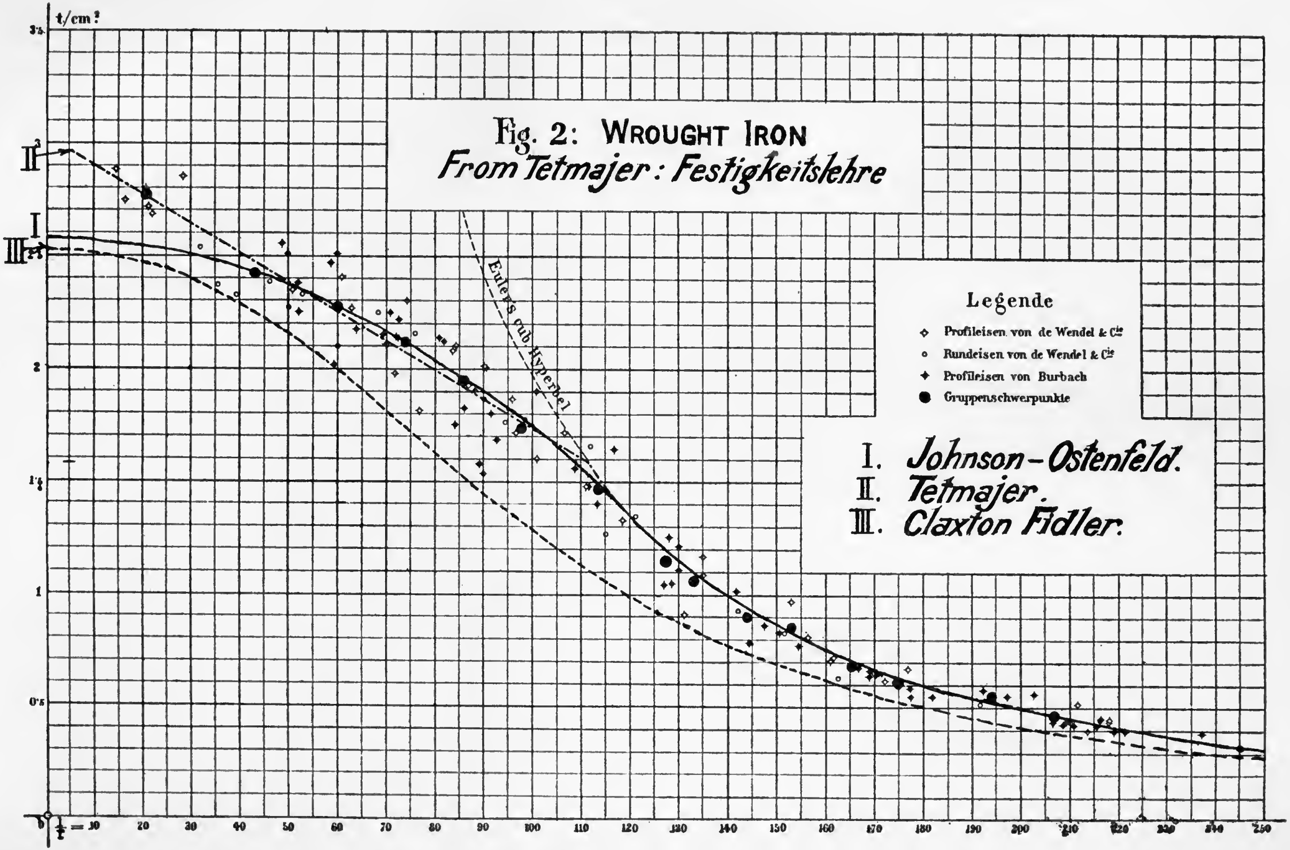


Fig. 2: WROUGHT IRON
From Tetmajer: Festigkeitslehre

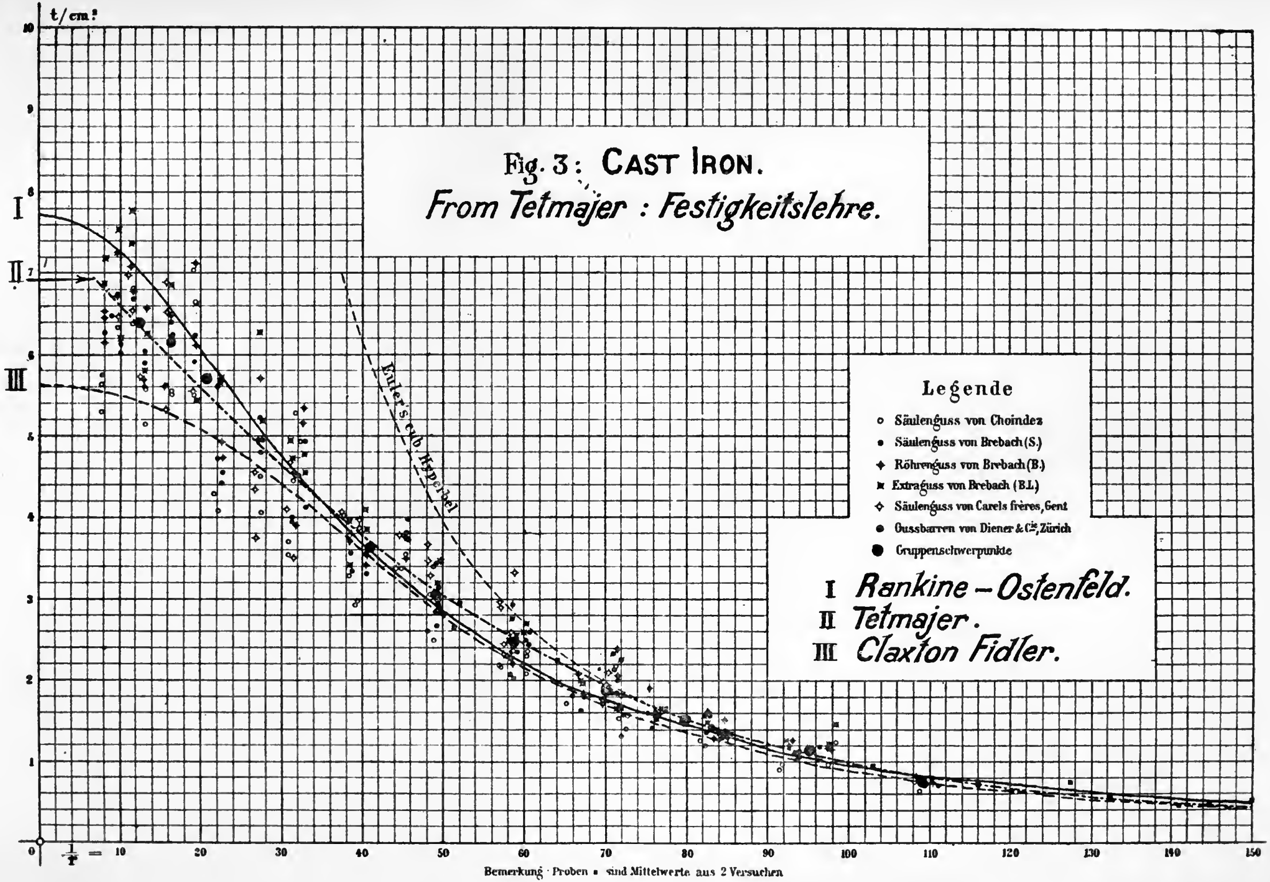


Fig. 3: CAST IRON.
From Tetmajer : Festigkeitslehre.
t/cm²
10
9
8
7
6
5
4
3
2
1
0
I
II
III
$\frac{l}{r}$ =
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Euler's cub. Hyperbel
Legende
Säulenguss von Choindez
Säulenguss von Brebach (S.)
Röhrenguss von Brebach (B.)
Extraguss von Brebach (B.L.)
Säulenguss von Carels frères, Gent
Gussbarren von Diener & Cie, Zürich
Gruppenschwerpunkte
I Rankine – Ostenfeld.
II Tetmajer.
III Claxton Fidler.
Bemerkung: Proben ▪ sind Mittelwerte aus 2 Versuchen

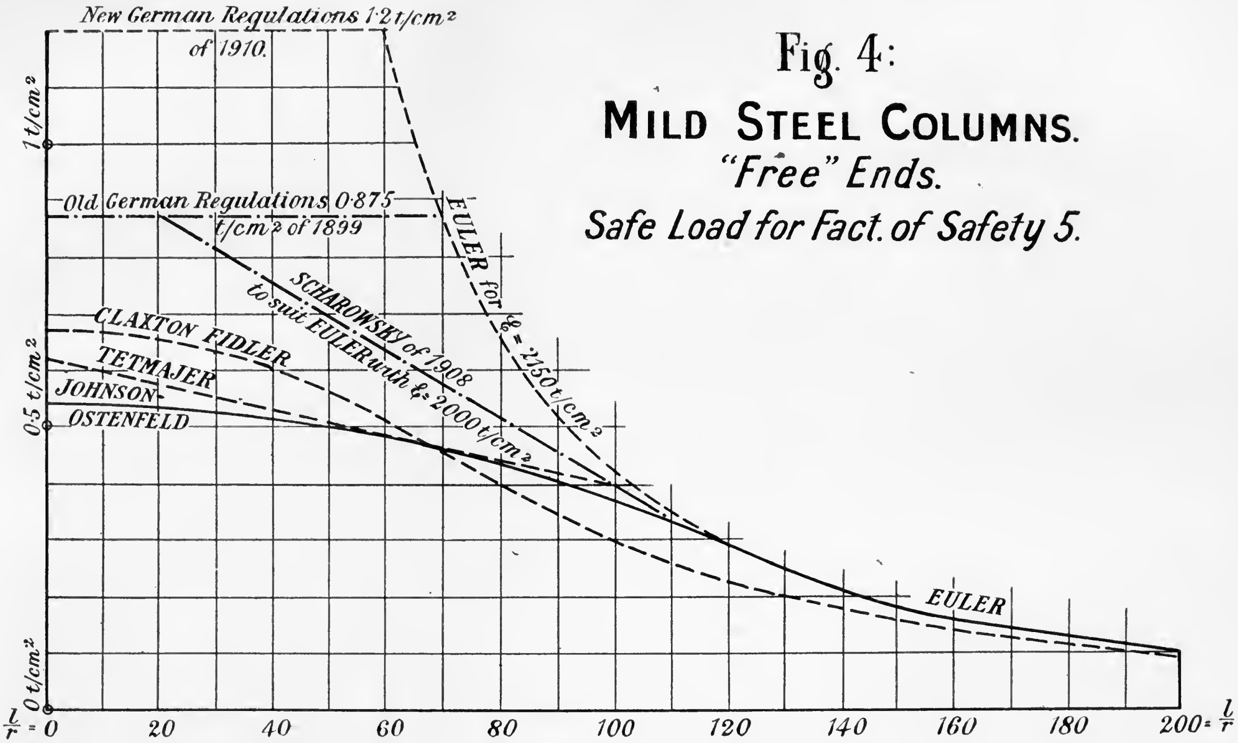


Fig. 4:

MILD STEEL COLUMNS.

"Free" Ends.

Safe Load for Fact. of Safety 5.

October, 1910

A SHORT LIST OF

SCIENTIFIC BOOKS

PUBLISHED AND SOLD BY

E. & F. N. SPON, Limited,

57 Haymarket, London, S.W.

SOLE ENGLISH AGENTS for the Books of—

MYRON C. CLARK, NEW YORK
THE BUSINESS CODE COMPANY, CHICAGO
SPON & CHAMBERLAIN, NEW YORK

Full particulars post free on application.
All books are bound in cloth unless otherwise stated.

NOTE: The Prices in this Catalogue apply to books sold in the United Kingdom only.

AERONAUTICS

The Atmosphere: its characteristics and dynamics. By F. J. B. Cordeiro. With 35 illus., 129 pp. medium 8vo. (*New York, 1910*) ... ... *net* 10 6

Theory and Practice of Model Aeroplaning. By V. E. Johnson. 61 illus. 150 pp. crown 8vo. (*1910*) ... ... *net* 3 6

How to Build a 20-ft. Bi-plane Glider. By A. P. Morgan. 31 illus. 60 pp. crown 8vo, limp. (S. & C. Series, No. 14.) (*New York, 1909*) *net* 1 6

Flight-Velocity. By A. Samuelson. 4 plates, 42 pp. 8vo, sewed. (*1906*) ... ... *net* 2 0

Resistance of Air and the Question of Flying. By A. Samuelson. 23 illus. 36 pp. 8vo, sewed. (*1905*) ... ... *net* 2 0

AGRICULTURE.

Hemp. A Practical Treatise on the Culture for Seed and Fibre. By S. S. Boyce. 13 illus. 112 pp. crown 8vo. (*New York, 1900*) ... ... *net* 2 0

The Fertilisation of Tea. By G. A. Cowie. With 17 illus. 68 pp. crown 8vo, sewed. (*1908*) *net* 2 6

Farm Drainage. By H. F. French. 100 illus. 284 pp. crown 8vo. (*New York, 1904*)... ... *net* 4 6

Talks on Manures. By J. Harris. New edition, 366 pp. crown 8vo. (*New York, 1893*) ... *net* 6 6

Coffee, its Culture and Commerce in all Countries. By C. G. W. Lock. 11 plates, 274 pp. crown 8vo. (*1888*) 12 6

Sugar, a Handbook for Planters and Refiners. By the late J. A. R. Newlands and B. E. R. Newlands. 236 illus. 876 pp. demy 8vo. (*London, 1909*) ... ... *net* 1 5 0

Hops, their Cultivation, Commerce and Uses. By P. L. SIMMONDS. 143 pp. crown 8vo. (*1877*) ... 4 6

The Future of Cocoa-Planting. By H. HAMEL SMITH. With illustrations, 95 pp. crown 8vo, sewed. (*1908*) ... ... *net* 1 0

Estate Fences, their Choice, Construction and Cost. By A. VERNON. Re-issue, 150 illus. 420 pp. 8vo. (*1909*) ... ... *net* 8 6

ARCHITECTURE AND BUILDING.

The Hydropathic Establishment and its Baths. By R. O. ALLSOP. 8 plates, 107 pp. demy 8vo. (*1891*) 5 0

The Turkish Bath, its Design and Construction. By R. O. ALLSOP. 27 illus. 152 pp. demy 8vo. (*1890*) 6 0

Public Abattoirs, their Planning, Design and Equipment. By R. S. AYLING. 33 plates, 100 pp. demy 4to. (*1908*) ... ... *net* 8 6

The Builder's Clerk. By T. BALES. Second edition, 92 pp. fcap. 8vo. (*1904*) 1 6

Glossary of Technical Terms used in Architecture and the Building Trades. By G. J. BURNS. 136 pp. crown 8vo. (*1895*) 3 6

Chimney Design and Theory. By W. W. CHRISTIE. Second edition, 54 illus. 200 pp. crown 8vo. (*New York, 1902*) ... ... *net* 12 6

Approximate Estimates. By T. E. COLEMAN. Third edition, 481 pp. oblong 32mo, leather. (*1907*) ... ... *net* 5 0

Stable Sanitation and Construction. By T. E. COLEMAN. 183 illus. 226 pp. crown 8vo. (*1897*) 6 0

Architectural Examples in Brick, Stone, Wood and Iron. By W. FULLERTON. Third edition, 245 plates, 254 pp. demy 4to. (*1908*) ... *net* 15 0

Bricklaying System. By F. B. GILBRETH. Fully illustrated, 321 pp. 8vo. (*New York, 1909*) *net* 12 6

Field System. By F. B. GILBRETH. 194 pp. 12mo leather. (*New York, 1908*) ... ... *net* 12 6

The Building Trades Pocket Book. Compiled by R. HALL. 12mo. With interchangeable diary ... ... *net* 1 6
Ditto ditto, in leather ... ... *net* 2 6

The Clerk of Works' Vade Mecum. By G. G. HOSKINS. Seventh edition, 52 pp. fcap. 8vo. (*1901*) 1 6

A Handbook of Formulæ, Tables, and Memoranda, for Architectural Surveyors and others engaged in Building. By J. T. HURST. Fifteenth edition, 512 pp. royal 32mo, roan. (*1905*) *net* 5 0

Quantity Surveying, for the Use of Surveyors, Architects, Engineers and Builders. By J. LEANING. Fifth edition, 936 pp. demy 8vo. (*1904*) ... ... *net* 1 5 0

Obstruction to Light. A Graphic Method of determining Problems of Ancient Lights. By H. B. MOLESWORTH. 9 folding plates, 4to. (*1902*) *net* 6 0

Suburban Houses. A series of practical plans. By J. H. PEARSON. 46 plates and 12 pp. text, crown 4to. (*1905*) ... ... *net* 7 6

Solid Bitumens, their Physical and Chemical Properties and Chemical Analysis. By S. F. PECKHAM. 23 illus. 324 pp. 8vo. (*New York, 1909*) ... ... *net* 1 1 0

Roman Architecture, Sculpture and Ornament. By G. B. PIRANESI. 200 plates, reproduced in facsimile from the original. 2 vols. Imperial folio, in wrappers. (*1900*) ... ... *net* 2 2 0

The Seven Periods of English Architecture, defined and illustrated. By E. SHARPE. Third edition, 20 steel plates, royal 8vo. (*1888*) ... 12 6

Our Factories, Workshops and Warehouses, their Sanitary and Fire-Resisting Arrangements. By B. H. THWAITE. 183 illus. 282 pp. crown 8vo. (*1882*) 9 0

Elementary Principles of Carpentry. By T. TREDGOLD and J. T. HURST. Eleventh edition, 48 plates, 517 pp. crown 8vo. (*1904*) 12 6

Practical Stair Building and Handrailing. By W. H. WOOD. 32 plates, 91 pp. crown 4to. (*1894*) 10 6

Spons' Architects' and Builders' Pocket Price-Book, Memoranda, Tables and Prices. Edited by CLYDE YOUNG. Revised by STANFORD M. BROOKS. Illustrated, 552 pp. 16mo, leather cloth (size $6\frac{1}{2}$ in. by $3\frac{3}{4}$ in. by $\frac{1}{2}$ in. thick). Issued annually ... ... *net* 3 0

Heating Engineers' Quantities. By W. L. WHITE and G. M. WHITE. 4 plates, 33 pp. folio. (*1910*) *net* 10 6

ARTILLERY.

Guns and Gun Making Material. By G. EDE. Crown 8vo. (*1889*) 6 0

Treatise on Application of Wire to Construction of Ordnance. By J. A. LONGRIDGE. 180 pp. 8vo. (*1884*) 1 5 0

The Progress of Artillery: Naval Guns. By J. A. LONGRIDGE. 8vo, sewed. (*1896*)... ... ... 2 0

The Field Gun of the Future. By J. A. LONGRIDGE. 8vo, sewed. (*1892*) 2 6

BRIDGES, ARCHES, ROOFS, AND STRUCTURAL DESIGN.

Strains in Ironwork. By HENRY ADAMS. Fourth edition, 8 plates, 65 pp. crown 8vo. (*1904*) ... 5 0

The Practical Designing of Structural Ironwork. By HENRY ADAMS. 13 plates, 194 pp. 8vo. (*1894*) 8 6

Designing Ironwork. By HENRY ADAMS. Second series. 8vo, sewed.

Part I. A Steel Box Girder. (*1894*) *net* 0 9
" II. Built-up Steel Stanchions. (*1901*) *net* 1 3
" III. Cisterns and Tanks. (*1902*) *net* 1 0
" IV. A Fireproof Floor. (*1903*) *net* 1 0

A Practical Treatise on Segmental and Elliptical Oblique or Skew Arches. By G. J. BELL. Second edition, 17 plates, 125 pp. royal 8vo. (*1906*) ... ... *net* 1 1 0

Economics of Construction in relation to Framed Structures. By R. H. BOW. Third thousand, 16 plates, 88 pp. 8vo. (*1873*) 5 0

Theory of Voussoir Arches. By Prof. W. CAIN. Third edition, 201 pp. 18mo, boards. (*New York, 1905*) ... ... *net* 2 0

New Formulæ for the Loads and Deflections of Solid Beams and Girders. By W. DONALDSON. Second edition, 8vo. (*1872*) 4 6

Plate Girder Railway Bridges. By M. FITZMAURICE. 4 plates, 104 pp. 8vo. (*1895*) 6 0

Pocket Book of Calculations in Stresses. By E. M. GEORGE. 66 illus. 140 pp. royal 32mo, half roan. (*1895*) 3 6

Strains on Braced Iron Arches and Arched Iron Bridges. By A. S. HEAFORD. 39 pp. 8vo. (*1883*) 6 0

Tables for Roof Framing. By G. D. INSKIP. Second edition, 451 pp. 8vo, leather. (*New York, 1905*) ... ... *net* 12 6

Stresses in Girder and Roof Frames, for both dead and live loads, by simple Multiplication, etc. By F. R. JOHNSON. 28 plates, 215 pp. crown 8vo. *(1894)* 6 0

A Graphical Method for Swing Bridges. By B. F. LA RUE. 4 plates, 104 pp. 18mo, boards. *(New York, 1892)* ... ... *net* 2 0

Notes on Cylinder Bridge Piers and the Well System of Foundations. By J. NEWMAN. 144 pp. 8vo. *(1893)* 6 0

A New Method of Graphic Statics applied in the Construction of Wrought Iron Girders. By E. OLANDER. 16 plates, small folio. *(1887)* ... 10 6

Reference Book for Statical Calculations. By F. RUFF. With diagrams, 140 pp. crown 8vo. *(1906)* ... ... *net* 5 0

The Strength and Proportion of Riveted Joints. By B. B. STONEY. 87 pp. 8vo. *(1885)* 5 0

The Anatomy of Bridgework. By W. H. THORPE. 103 illus. 190 pp. crown 8vo. *(1906)* ... *net* 6 0

CEMENT AND CONCRETE.

Portland Cement: its Manufacture, Testing and Use. By D. B. BUTLER. Second edition, 97 illus. 396 pp. demy 8vo. *(1905)* ... ... *net* 16 0

Theory of Steel-Concrete Arches and of Vaulted Structures. By W. CAIN. Fourth edition, 27 illus. 212 pp. 18mo, boards. *(New York, 1906)* *net* 2 0

Cement Users' and Buyers' Guide. By CALCARE. 115 pp. 32mo, cloth. *(1901)* ... ... *net* 1 6

Diagrams for Designing Reinforced Concrete Structures. By G. F. DODGE. 31 illus. 104 pp. oblong folio. *(New York, 1910)* ... ... *net* 17 0

Cements, Mortars, and Concretes; their Physical properties. By M. S. FALK. 78 illus. 176 pp. 8vo. *(New York, 1904)* ... ... *net* 10 6

Concrete Construction, Methods and Cost. By H. P. GILLETTE and C. S. HILL. 310 illus. 690 pp. 8vo. (*New York, 1908*) ... ... *net* 1 1 0

Engineers' Pocket-Book of Reinforced Concrete. By E. L. HEIDENREICH. 164 illus. 364 pp. crown 8vo, leather, gilt edges. (*New York, 1909*) *net* 12 6

Concrete Inspection. By C. S. HILL. Illustrated, 179 pp. 12mo. (*New York, 1909*) ... ... *net* 4 6

Reinforced Concrete. By E. McCULLOCH. 28 illus. 128 pp. crown 8vo. (*New York, 1908*) *net* 6 6

Concrete and Reinforced Concrete. By H. A. REID. 715 illus. 884 pp. royal 8vo. (*New York, 1907*) ... ... *net* 21 0

Theory and Design of Reinforced Concrete Arches. By A. REUTERDAHL. 41 illus. 126 pp. 8vo. (*New York, 1908*) ... ... *net* 8 6

Practical Cement Testing. By W. P. TAYLOR. With 142 illus. 329 pp. demy 8vo. (*New York, 1906*) ... ... *net* 12 6

Concrete Bridges and Culverts. By H. G. TYRRELL. 66 illus. 251 pp. crown 8vo, leather *net* 12 6

CIVIL ENGINEERING.

CANALS, SURVEYING.

(*See also* IRRIGATION *and* WATER SUPPLY.)

Practical Hints to Young Engineers Employed on Indian Railways. By A. W. C. ADDIS. With 14 illus. 154 pp. 12mo. (*1910*) ... *net* 3 6

Levelling, Barometric, Trigonometric and Spirit. By I. O. BAKER. Second edition, 15 illus. 145 pp. 18mo, boards. (*New York, 1903*) ... *net* 2 0

Notes on Instruments best suited for Engineering Field Work in India and the Colonies. By W. G. BLIGH. 65 illus. 218 pp. 8vo. (*1899*) ... 7 6

The Sextant and other Reflecting Mathematical Instruments. By F. R. BRAINARD. 33 illus. 120 pp. 18mo, boards. (*New York, 1891*)... *net* 2 0

Practical Designing of Retaining Walls. By Prof. W. CAIN. Fifth edition, 14 illus. 172 pp. 18mo, boards. (*New York, 1908*) ... ... *net* 2 0

The Maintenance of Macadamised Roads. By T. CODRINGTON. Second edition, 186 pp. 8vo. (*1892*) 7 6

Retaining Walls in Theory and Practice. By T. E. COLEMAN. 104 illus. 160 pp. crown 8vo. (*1909*) ... ... *net* 5 0

The Barometrical Determination of Heights. By F. J. B. CORDEIRO. Crown 8vo, limp leather. (*New York, 1898*) ... ... *net* 4 6

On Curved Masonry Dams. By W. B. COVENTRY. 8vo, sewed. (*1894*) 2 0

A Practical Method of Determining the Profile of a Masonry Dam. By W. B. COVENTRY. 8vo, sewed. (*1894*) 2 6

The Stresses on Masonry Dams (oblique sections). By W. B. COVENTRY. 8vo, sewed. (*1894*) ... 2 0

Tables for facilitating the Calculation of Earthworks. By D. CUNNINGHAM. 120 pp. royal 8vo 10 6

Handbook of Cost Data for Contractors and Engineers. By H. P. GILLETTE. 1854 pp. crown 8vo, leather, gilt edges. (*New York, 1910*) *net* 1 1 0

Rock Excavation, Methods and Cost. By H. P. GILLETTE. 56 illus. 376 pp. crown 8vo. (*New York, 1904*) ... ... *net* 12 6

High Masonry Dams. By E. S. GOULD. With illus. 88 pp. 18mo, boards. (*New York, 1897*) *net* 2 0

Grace's Tables for Curves, with hints to young engineers. 8 figures, 43 pp. oblong 8vo. (*1908*) *net* 5 0

Grace's Earthwork Tables. 36 double-page tables, 4to. (*1907*) ... ... *net* 12 6

Railway Tunnelling in Heavy Ground. By C. GRIPPER. 3 plates, 66 pp. royal 8vo. (*1879*) ... 7 6

Levelling and its General Application. By T. HOLLOWAY. Second edition, 53 illus. 147 pp. 8vo. (*1895*)... ... ... 5 0

Waterways and Water Transport in different Countries. By J. S. JEANS. 55 illus. 520 pp. 8vo. (*1890*) ... ... *net* 9 0

Table of Barometrical Heights to 20,000 Feet. By W. H. MACKESY, with some practical suggestions by Sir Guildford Molesworth. 1 plate, 24 pp. royal 32mo. (*1882*) 3 0

Aid Book to Engineering Enterprise. By E. MATHESON. Third edition, illustrated, 916 pp. medium 8vo, buckram. (*1898*) 1 4 0

A Treatise on Surveying. By R E. MIDDLETON and O. CHADWICK. Second edition, royal 8vo.

Part I. 11 plates, 296 pp. (*1904*) ... 10 6
,, II. Fully illustrated, 334 pp. (*1906*) 10 6

A Pocket Book of Useful Formulæ and Memoranda, for Civil and Mechanical Engineers. By Sir G. L. MOLESWORTH and H. B. MOLESWORTH. With an Electrical Supplement by W. H. MOLESWORTH. Twenty-sixth edition, 760 illus. 901 pp. royal 32mo, French morocco, gilt edges. (*1908*) *net* 5 0

The Pocket Books of Sir G. L. Molesworth and J. T. Hurst, printed on India paper and bound in one vol. Royal 32mo, russia, gilt edges *net* 10 6

Metallic Structures: Corrosion and Fouling and their Prevention. By J. NEWMAN. Illustrated, 385 pp. crown 8vo. (*1896*)... ... ... 9 0

Scamping Tricks and Odd Knowledge occasionally practised upon Public Works. By J. NEWMAN. New impression, 129 pp. crown 8vo. (*1908*) *net* 2 0

Earthwork Slips and Subsidences on Public Works. By J. NEWMAN. 240 pp. crown 8vo. (*1890*) 7 6

Co-ordinate Geometry as applied to Land Surveying. By W. PILKINGTON. 5 illus. 44 pp. 12mo. (*1909*) ... ... *net* 1 6

Diagrams for the Graphic Calculation of Earthwork Quantities. By A. H. ROBERTS. Ten cards, fcap. in cloth case ... ... *net* 10 6

Pioneering. By F. SHELFORD, illustrated. 88 pp. crown 8vo. (*1909*) ... ... *net* 3 0

Topographical Surveying. By G. J. SPECHT. Second edition, 2 plates and 28 illus. 210 pp. 18mo, boards. (*New York, 1898*) ... ... *net* 2 0

Spons' Dictionary of Engineering, Civil, Mechanical, Military and Naval. 10,000 illus. 4300 pp. super royal 8vo. (*1874, Supplement issued in 1881*).

Complete with Supplement, in 11 divisions *net* 3 10 0
Ditto ditto in 4 vols. ... ... *net* 3 3 0

Surveying and Levelling Instruments. By W. F. STANLEY. Third edition, 372 illus. 562 pp. crown 8vo. (*1901*) 7 6

Surveyor's Handbook. By T. U. TAYLOR. 116 illus. 310 pp. crown 8vo, leather, gilt edges. (*New York, 1908*) ... ... *net* 8 6

Logarithmic Land Measurement. By J. WALLACE. 32 pp. royal 8vo. (*1910*) ... ... *net* 5 0

Hints on Levelling Operations. By W. H. WELLS. Second edition, 8vo, sewed. (*1890*) ... 1 0

The Drainage of Fens and Low Lands by Gravitation and Steam Power. By W. H. WHEELER. 8 plates, 175 pp. 8vo. (*1888*) ... 12 6

Stadia Surveying, the theory of Stadia Measurements. By A. WINSLOW. Fifth edition, 148 pp. 18mo, boards. (*New York, 1902*) ... ... *net* 2 0

Handbook on Tacheometrical Surveying. By C. XYDIS. 55 illus. 3 plates, 63 pp. 8vo. (*1909*) *net* 6 0

DICTIONARIES.

Technological Dictionary in the English, Spanish, German and French Languages. By D. Carlos Huelin y Arssu. Crown 8vo.

Vol. I. English-Spanish-German-French. 609 pp. (*1906*) ... ... *net* 10 6

Vol. II. German-English-French-Spanish. 720 pp. (*1908*) ... ... *net* 10 6

Vol. III. French-German-Spanish-English. *In preparation.*

Vol. IV. Spanish-French-English-German. 750 pp. (*1910*) ... ... *net* 10 6

English-French and French-English Dictionary of the Motor-Car, Cycle and Boat. By F. Lucas. 171 pp. crown 8vo. (*1905*) ... *net* 5 0

Spanish-English Dictionary of Mining Terms. By F. Lucas. 78 pp. 8vo. (*1905*) ... *net* 5 0

English-Russian and Russian-English Engineering Dictionary. By L. Meycliar. 100 pp. 16mo. (*1909*) ... ... *net* 2 6

Reed's Polyglot Guide to the Marine Engine, in English, French, German and Norsk. Second edition, oblong 8vo. (*1900*). ... ... *net* 6 0

DOMESTIC ECONOMY.

Food Adulteration and its Detection. By J. P. Battershall. 12 plates, 328 pp. demy 8vo. (*New York, 1887*) 15 0

How to Check Electricity Bills. By S. W. Borden. 41 illus. 54 pp. crown 8vo. (*New York, 1907*) ... ... *net* 2 0

Practical Hints on Taking a House. By H. P. Boulnois. 71 pp. 18mo. (*1885*) 1 6

The Cooking Range, its Failings and Remedies. By F. DYE. 52 pp. fcap. 8vo, sewed. (*1888*) ... 0 6

The Kitchen Boiler and Water Pipes. By H. GRIMSHAW. 8vo, sewed. (*1887*) ... ... *net* 1 0

Cookery and Domestic Management, including economic and middle class Practical Cookery. By K. MELLISH. 56 coloured plates and 441 illus. 987 pp. super-royal 8vo. (*1901*) ... *net* 16 0

Spons' Household Manual. 250 illus. 1043 pp. demy 8vo. (*1902*) 7 6
Ditto ditto half-bound French morocco 9 0

Handbook of Sanitary Information for Householders. By R. S. TRACY. 33 illus. 114 pp. 18mo. (*New York, 1900*) 2 6

DRAWING.

The Ornamental Penman's, Engraver's and Sign Writer's Pocket Book of Alphabets. By B. ALEXANDER. Oblong 12mo, sewed 0 6

The Draughtsman's Handbook of Plan and Map Drawing. By G. G. ANDRE. 87 illus. and 34 plain and coloured plates, 162 pp. crown 4to. (*1891*) 9 0

Slide Valve Diagrams: a French Method for their Construction. By L. BANKSON. 18mo, boards. (*New York, 1892*) ... ... *net* 2 0

A System of Easy Lettering. By J. H. CROMWELL. With Supplement by G. MARTIN. Sixth thousand, oblong 8vo. (*New York, 1900*) ... *net* 2 0

Plane Geometrical Drawing. By R. C. FAWDRY. Illustrated, 185 pp. crown 8vo. (*1901*) ... *net* 3 0

Twelve Plates on Projection Drawing. By O. GUETH. Oblong 4to. (*New York, 1903*) ... *net* 3 0

Hints on Architectural Draughtsmanship. By G. W. T. HALLATT. Fourth edition, 80 pp. 18mo. (*1906*) ... ... *net* 1 6

A First Course of Mechanical Drawing (Tracing). By G. HALLIDAY. Oblong 4to, sewed 2 0

Drawings for Medium-sized Repetition Work. By R. D. SPINNEY. With 47 illus. 130 pp. 8vo. (*1909*) ... ... *net* 3 6

Mathematical Drawing Instruments. By W. F. STANLEY. Seventh edition, 265 illus. 370 pp. crown 8vo. (*1900*) 5 0

ELECTRICAL ENGINEERING.

Practical Electric Bell Fitting. By F. C. ALLSOP. Tenth edition, 186 illus. including 8 folding plates, 185 pp. crown 8vo. (*1903*) 3 6

Telephones: their Construction and Fitting. By F. C. ALLSOP. Eighth edition, 184 illus. 222 pp. crown 8vo. (*1909*) 3 6

Thermo-electric Reactions and Currents between Metals in Fused Salts. By T. ANDREWS. 8vo, sewed. (*1896*) 1 0

Auto-Transformer Design. By A. H. AVERY. 25 illus. 60 pp. 8vo. (*1909*) ... ... *net* 3 6

Principles of Electric Power (Continuous Current) for Mechanical Engineers. By A. H. BATE. 63 illus. 204 pp. crown 8vo. (*1905*) (FINSBURY TECHNICAL MANUAL) ... ... *net* 4 6

Practical Construction of Electric Tramways. By WILLIAM R. BOWKER. 93 illus. 119 pp. 8vo. (*1903*) ... ... *net* 6 0

Design and Construction of Induction Coils. By A. F. COLLINS. 155 illus. 272 pp. demy 8vo. (*New York, 1909*) ... ... *net* 12 6

Switchboard Measuring Instruments for Continuous and Polyphase Currents. By J. C. CONNAN. 117 illus. 150 pp. 8vo, cloth. (*1908*) *net* 5 0

Electric Cables, their Construction and Cost. By D. COYLE and F. J. O. HOWE. With many diagrams and 216 tables, 467 pp. crown 8vo, leather. (*1909*) ... ... *net* 15 0

Management of Electrical Machinery. By F. B. CROCKER and S. S. WHEELER. Eighth edition, 131 illus. 223 pp. crown 8vo. (*New York, 1909*) *net* 4 6

Electric Lighting: A Practical Exposition of the Art. By F. B. CROCKER. Royal 8vo. (*New York.*)

Vol. I. **The Generating Plant.** Sixth edition, 213 illus. 470 pp. (*1904*) *net* 12 6

Vol. II. **Distributing Systems and Lamps.** Second edition, 391 illus. 505 pp. (*1905*) ... ... *net* 12 6

The Care and Management of Ignition Accumulators. By H. H. U. CROSS. 12 illus. 74 pp. crown 8vo, limp. (S. & C. SERIES, No. 19.) (*1910*) ... ... *net* 1 6

Elementary Telegraphy and Telephony. By ARTHUR CROTCH. 238 illus. 223 pp. 8vo. (*1903.*) (FINSBURY TECHNICAL MANUAL) ... ... *net* 4 6

Electricity and Magnetism in Telephone Maintenance. By G. W. CUMMINGS. 45 illus. 137 pp. 8vo. (*New York, 1908*) ... ... *net* 6 6

Grouping of Electric Cells. By W. F. DUNTON. 4 illus. 50 pp. fcap. 8vo. (*1906*) ... ... *net* 1 6

Magnets and Electric Currents. By Prof. J. A. FLEMING. Second edition, 136 illus. 417 pp. crown 8vo (*1902*) ... ... *net* 5 0

Notes on Design of Small Dynamo. By GEORGE HALLIDAY. Second edition, 8 plates, 8vo. (*1895*) 2 6

Practical Alternating Currents and Power Tranmission. By N. HARRISON. 172 illus. 375 pp. crown 8vo. (*New York, 1906*) ... *net* 10 6

Making Wireless Outfits. By N. HARRISON. 27 illus. 61 pp. crown 8vo, limp. (S. & C. SERIES, No. 11.) (*New York, 1909*) ... ... *net* 1 6

Wireless Telephone Construction. By N. HARRISON. 43 illus. 73 pp. crown 8vo, limp. (S. & C. SERIES, No. 12.) (*New York, 1909*) ... *net* 1 6

The Phœnix Fire Office Rules for Electric Light and Electrical Power Installations. By M. HEAPHY. Thirty-seventh edition, 8vo, sewed. (*1908*) 0 6

Testing Telegraph Cables. By Colonel V. HOSKIŒR. Third edition, crown 8vo. (*1889*) ... 4 6

Long Distance Electric Power Transmission. By R. W. HUTCHINSON. 136 illus. 345 pp. crown 8vo. (*New York, 1907*) ... ... *net* 12 6

Theory and Practice of Electric Wiring. By W. S. IBBETSON. 119 illus. 366 pp. crown 8vo. (*1909*) ... ... *net* 5 0

Practical Electrical Engineering for Elementary Students. By W. S. IBBETSON. With 61 illus. 155 pp. crown 8vo. (*1910*) ... ... *net* 3 0

General Rules recommended for Wiring for the Supply of Electrical Energy. Issued by THE INSTITUTION OF ELECTRICAL ENGINEERS. 8vo, sewed. (*Revised, April 1907*) ... ... *net* 0 6

Form of Model General Conditions recommended by THE INSTITUTION OF ELECTRICAL ENGINEERS for use in connection with Electrical Contracts. 8vo, sewed. (*1906*) ... ... *net* 1 0

A Handbook of Electrical Testing. By H. R. KEMPE. Seventh edition, 285 illus. 706 pp. demy 8vo. (*1908*) ... ... *net* 18 0

Application of Electricity to Railway Working. By W. E. LANGDON. 142 illus. and 5 plates, 347 pp. 8vo. (*1897*) 10 6

How to Become a Competent Motorman. By V. B. LIVERMORE and J. WILLIAMS. 45 illus. 252 pp. 12mo. (*New York, 1903*) ... ... *net* 4 6

Electromagnets, their design and construction. By A. N. MANSFIELD. 36 illus. 155 pp. 18mo, boards. (*New York, 1901*) ... ... *net* 2 0

Telephone Construction, Methods and Cost. By C. MAYER. With Appendices on the cost of materials and labour by J. C. SLIPPY. 103 illus. 284 pp. crown 8vo. (*New York, 1908*) ... *net* 12 6

Induction Coils. By N. H. SCHNEIDER. Second edition, 79 illus. 285 pp. crown 8vo. (*New York, 1901*) ... ... *net* 4 6

Electric Gas Lighting. By N. H. SCHNEIDER. 57 illus. 101 pp. 12mo. (S. & C. SERIES, No. 8.) (*New York, 1901*) ... ... *net* 2 0

How to Install Electric Bells, Annunciators and Alarms. By N. H. SCHNEIDER. 59 illus. 63 pp. crown 8vo, limp. (S. & C. SERIES, No. 2.) (*New York, 1905*) ... ... *net* 1 6

Modern Primary Batteries, their construction, use and maintenance. By N. H. SCHNEIDER. 54 illus. 94 pp. crown 8vo, limp. (S. & C. SERIES, No. 1.) (*New York, 1905*) ... ... *net* 1 6

Practical Engineers' Handbook on the Care and Management of Electric Power Plants. By N. H. SCHNEIDER. 203 illus. 274 pp. crown 8vo. (*New York, 1906*) ... ... *net* 5 0

Electrical Circuits and Diagrams, illustrated and explained. By N. H. SCHNEIDER. 8vo, limp. (S. & C. SERIES, Nos. 3 and 4.) (*New York*)

Part 1. 217 illus. 72 pp. (*1905*) ... *net* 1 6
Part 2. 73 pp. (*1909*) ... ... *net* 1 6

Electrical Instruments and Testing. By N. H. SCHNEIDER. Third edition. 133 illus. 239 pp. crown 8vo. (*New York, 1907*) ... ... *net* 4 6

Experimenting with Induction Coils. By N. H. SCHNEIDER. 26 illus. 73 pp. crown 8vo, limp. (S. & C. SERIES, No. 5.) (*New York, 1906*) *net* 1 6

Study of Electricity for Beginners. By N. H. SCHNEIDER. 54 illus. 88 pp. crown 8vo, limp. (S. & C. SERIES, No. 6.) (*New York, 1905*) *net* 1 6

Practical Electrics: a Universal Handybook on Every Day Electrical Matters. Seventh edition, 126 illus. 135 pp. 8vo. (S. & C. SERIES, No. 13.) (*New York, 1902*) ... ... *net* 1 6

The Voltaic Accumulator: an elementary treatise. By E. REYNIER. Translated from the French by J. A. BERLY. 62 illus. 202 pp. 8vo 9 0

Dry Batteries: how to Make and Use them. By a DRY BATTERY EXPERT. With additional notes by N. H. SCHNEIDER. 30 illus. 59 pp. crown 8vo, sewed. (S. & C. SERIES, No. 7.) (*New York, 1905*) ... ... *net* 1 6

The Diseases of Electrical Machinery. By E. SCHULZ. Edited, with a Preface, by Prof. S. P. THOMPSON. 42 illus. 84 pp. crown 8vo *net* 2 0

Electric Toy-Making. By T. O. SLOANE. Fifteenth edition, 70 illus. 183 pp. crown 8vo. (*New York, 1903*) ... ... *net* 4 6

Electricity Simplified. By T. O. SLOANE. Tenth edition, 29 illus. 158 pp. crown 8vo. (*New York, 1901*) ... ... *net* 4 6

How to become a Successful Electrician. By T. O. SLOANE. Third edition, illustrated, crown 8vo. (*New York, 1899*) ... ... *net* 4 6

Electricity: its Theory, Sources and Applications. By J. T. SPRAGUE. Third edition, 109 illus. 658 pp. crown 8vo. (*1892*) ... ... *net* 7 6

Telegraphic Connections. By C. THOM and W. H. JONES. 20 plates, 59 pp. oblong 8vo. (*New York, 1892*) ... ... *net* 3 6

Röntgen Rays and Phenomena of the Anode and Cathode. By E. P. THOMPSON and W. A. ANTHONY. 105 illus. 204 pp. 8vo. (*New York, 1896*) ... ... *net* 4 6

Dynamo Electric Machinery. By Prof. S. P. THOMPSON. Seventh edition, demy 8vo. (FINSBURY TECHNICAL MANUAL.)

Vol. I. **Continuous-Current Machinery.** With 4 coloured and 30 folding plates, 573 illus. 984 pp. (*1904*) *net* 1 10 0

Vol. II. **Alternating Current Machinery.** 15 coloured and 24 folding plates, 546 illus. 900 pp. (*1905*) *net* 1 10 0

Design of Dynamos (Continuous Currents). By Prof. S. P. THOMPSON. 4 coloured and 8 folding plates, 243 pp. demy 8vo. (*1903*) ... ... *net* 12 0

Schedule for Dynamo Design, issued with the above. 6*d*. each, 4*s*. per doz., or 18*s*. per 100 *net*

Curves of Magnetic Data for Various Materials. A reprint on transparent paper for office use of Plate L from Dynamo Electric Machinery, and measuring 25 in. by 16 in. ... ... *net* 0 7

The Electromagnet. By C. R. UNDERHILL. 67 illus. 159 pp. crown 8vo. (*New York, 1903*) *net* 6 6

Practical Guide to the Testing of Insulated Wires and Cables. By H. L. WEBB. Fifth edition, 38 illus. 118 pp. crown 8vo. (*New York, 1902*) ... ... *net* 4 6

FOREIGN EXCHANGE.

English Prices with Russian Equivalents (at Fourteen Rates of Exchange). English prices per lb., with equivalents in roubles and kopecks per pood. By A. Adiassewich. 182 pp. fcap. 32mo, roan. (*1908*)... ... ... *net* 1 0

English Prices with German Equivalents (at Seven Rates of Exchange). English prices per lb., with equivalents in marks per kilogramme. By St. Koczorowski. 95 pp. fcap. 32mo, roan. (*1909*) ... ... *net* 1 0

English Prices with Spanish Equivalents. At Seven Rates of Exchange. English prices per lb., with equivalents in pesetas per kilogramme. By S. Lambert. 95 pp. 32mo, roan. (*1910*) *net* 1 0

English Prices with French Equivalents (at Seven Rates of Exchange). English prices per lb. to francs per kilogramme. By H. P. McCartney. 97 pp. 32mo, roan. (*1907*) *net* 1 0

Principles of Foreign Exchange. By E. Matheson. Fourth edition, 54 pp. 8vo, sewed. (*1905*) *net* 0 3

GAS AND OIL ENGINES.

The Theory of the Gas Engine. By D. Clerk. Edited by F. E. Idell. Third edition, 19 illus. 180 pp. 18mo, boards. (*New York, 1903*) ... *net* 2 0

The Design and Construction of Oil Engines. By A. H. Goldingham. Third edition, 112 illus. 260 pp. crown 8vo. (*New York, 1910*) *net* 10 6

Gas Engine in Principle and Practice. By A. H. Goldingham. 107 illus. 195 pp. 8vo, cloth. (*New York, 1907*) ... ... *net* 6 6

Practical Hand-Book on the Care and Management of Gas Engines. By G. LIECKFELD. Third edition, square 16mo. (*New York, 1896*) ... 3 6

Elements of Gas Engine Design. By S. A. MOSS. 197 pp. 18mo, boards. (*New York, 1907*)... *net* 2 0

Gas and Petroleum Engines. A Manual for Students and Engineers. (FINSBURY TECHNICAL MANUAL.) By Prof. W. ROBINSON. *Third edition in preparation*

GAS LIGHTING.

Gas Analyst's Manual (incorporating Hartley's "Gas Analyst's Manual" and "Gas Measurement"). By J. ABADY. 102 illustrations, 576 pp. demy 8vo. (*1902*) ... ... *net* 18 0

Gas Works: their Arrangement, Construction, Plant and Machinery. By F. COLYER. 31 folding plates, 134 pp. 8vo. (*1884*) ... ... *net* 8 6

Transactions of the Institution of Gas Engineers. Edited by WALTER T. DUNN, *Secretary.* Published annually. 8vo ... ... *net* 10 6

Lighting by Acetylene. By F. DYE. 75 illus. 200 pp. crown 8vo. (*1902*) ... ... *net* 6 0

A Comparison of the English and French Methods of Ascertaining the Illuminating Power of Coal Gas. By A. J. VAN EIJNDHOVEN. Illustrated, crown 8vo. (*1897*) 4 0

Gas Lighting and Gas Fitting. By W. P. GERHARD. Second edition, 190 pp. 18mo, boards. (*New York, 1894*) ... ... *net* 2 0

A Treatise on the Comparative Commercial Values of Gas Coals and Cannels. By D. A. GRAHAM. 3 plates, 100 pp. 8vo. (*1882*) ... 4 6

The Gas Engineer's Laboratory Handbook. By J. HORNBY. Third edition, revised, 70 illus. 330 pp. crown 8vo. (*1910*) ... ... *net* 6 0

HISTORICAL AND BIOGRAPHICAL.

Extracts from the Private Letters of the late Sir William Fothergill Cooke, 1836–9, relating to the Invention and Development of the Electric Telegraph; also a Memoir by LATIMER CLARK. Edited by F. H. WEBB. Sec. Inst.E.E. 8vo. (*1895*) 3 0

A Chronology of Inland Navigation in Great Britain. By H. R. DE SALIS. Crown 8vo. (*1897*). 4 6

A History of Electric Telegraphy to the year 1837. By J. J. FAHIE. 35 illus. 542 pp. crown 8vo. (*1889*) 2 0

History and Development of Steam Locomotion on Common Roads. By W. FLETCHER. 109 illus. 288 pp. 8vo 5 0

Life as an Engineer: its Lights, Shades, and Prospects. By J. W. C. HALDANE. 23 plates, 338 pp. crown 8vo. (*1905*) ... ... *net* 5 0

Philipp Reis, Inventor of the Telephone: a Biographical Sketch. By Prof. S. P. THOMPSON. 8vo, cloth. (*1883*) 7 6

The Development of the Mercurial Air Pump. By Prof. S. P. THOMPSON. Illustrated, royal 8vo, sewed. (*1888*) 1 6

HOROLOGY.

Watch and Clock Maker's Handbook, Dictionary and Guide. By F. J. BRITTEN. Tenth edition, 450 illus. 492 pp. crown 8vo. (*1902*) *net* 5 0

The Springing and Adjusting of Watches. By F. J. BRITTEN. 75 illus. 152 pp. crown 8vo. (*1898*) ... ... *net* 3 0

Prize Essay on the Balance Spring and its Isochronal Adjustments. By M. IMMISCH. 7 illus. 50 pp. crown 8vo. (*1872*) 2

HYDRAULICS AND HYDRAULIC MACHINERY.

(*See also* WATER SUPPLY.)

Pumps: Historically, Theoretically and Practically Considered. By P. R. BJÖRLING. Second edition, 156 illus. 234 pp. crown 8vo. (*1895*)		7 6
Pump Details. By P. R. BJÖRLING. 278 illus. 211 pp. crown 8vo. (*1892*)		7 6
Pumps and Pump Motors: A Manual for the use of Hydraulic Engineers. By P. R. BJÖRLING. Two vols. 261 plates, 369 pp. royal 4to. (*1895*)	*net*	1 10 0
Practical Handbook on Pump Construction. By P. R. BJÖRLING. Second edition, 9 plates, 90 pp. crown 8vo. (*1904*)		5 0
Water or Hydraulic Motors. By P. R. BJÖRLING. 206 illus. 287 pp. crown 8vo. (*1903*)		9 0
Hydraulic Machinery, with an Introduction to Hydraulics. By R. G. BLAINE. Second edition with 307 illus. 468 pp. 8vo. (FINSBURY TECHNICAL MANUAL). (*1905*)	*net*	14 0
Practical Hydraulics. By T. BOX. Fifteenth edition, 8 plates, 88 pp. crown 8vo. (*1909*)	*net*	5 0
Hydraulic, Steam, and Hand Power Lifting and Pressing Machinery. By F. COLYER. Second edition, 88 plates, 211 pp. imperial 8vo. (*1892*)	*net*	10 6
Pumps and Pumping Machinery. By F. COLYER.		
Vol. I. Second edition, 53 plates, 212 pp. 8vo (*1892*)	*net*	10 6
Vol. II. Second edition, 48 plates, 169 pp. 8vo. (*1900*)	*net*	10 6
Construction of Horizontal and Vertical Waterwheels. By W. CULLEN. Second edition, small 4to. (*1871*)		5 0

Donaldson's Poncelet Turbine and Water Pressure Engine and Pump. By W. DONALDSON. 4to. (*1883*)	5	0
Principles of Construction and Efficiency of Waterwheels. By W. DONALDSON. 13 illus. 94 pp. 8vo. (*1876*)	5	0
Practical Hydrostatics and Hydrostatic Formulæ. By E. S. GOULD. 27 illus. 114 pp. 18mo, boards. (*New York, 1903*) ... ... *net*	2	0
Hydraulic and other Tables for purposes of Sewerage and Water Supply. By T. HENNELL. Third edition, 70 pp. crown 8vo. (*1908*) *net*	4	6
Hydraulic Tables for finding the Mean Velocity and Discharge in Open Channels. By T. HIGHAM. Second edition, 90 pp. super-royal 8vo. (*1898*)...	7	6
Tables for Calculating the Discharge of Water in Pipes for Water and Power Supplies. Indexed at side for ready reference. By A. E. SILK. 63 pp. crown 8vo. (*1899*)	5	0
Simple Hydraulic Formulæ. By T. W. STONE. 9 plates, 98 pp. crown 8vo. (*1881*)	4	0

INDUSTRIAL CHEMISTRY AND MANUFACTURES.

Perfumes and their Preparation. By G. W. ASKINSON. Translated from the Third German Edition by I. FUEST. Third edition, 32 illus. 312 pp. 8vo. (*New York, 1907*) ... ... *net*	12	6
Brewing Calculations, Gauging and Tabulation. By C. H. BATER. 340 pp. 64mo, roan, gilt edges. (*1897*) ... ... *net*	1	6
A Pocket Book for Chemists, Chemical Manufacturers, Metallurgists, Dyers, Distillers, etc. By T. BAYLEY. Seventh edition, 550 pp. royal 32mo, roan, gilt edges. (*1905*) ... ... *net*	5	0

Practical Receipts for the Manufacturer, the Mechanic, and for Home use. By Dr. H. R. BERKELEY and W. M. WALKER. 250 pp. demy 8vo. (*1902*) ... ... *net* 7 6

A Treatise on the Manufacture of Soap and Candles, Lubricants and Glycerine. By W. L. CARPENTER and H. LEASK. Second edition, 104 illus. 456 pp. crown 8vo. (*1895*) 12 6

A Text Book of Paper Making. By C. F. CROSS and E. J. BEVAN. Third edition, 97 illus. 411 pp. crown 8vo. (*1907*) ... ... *net* 12 6

C.B.S. Standard Units and Standard Paper Tests. By C. F. CROSS, E. J. BEVAN, C. BEADLE and R. W. SINDALL. 25 pp. crown 4to. (*1903*) *net* 2 6

Soda Fountain Requisites. A Practical Receipt Book for Druggists, Chemists, etc. By G. H. DUBELLE. Third edition, 157 pp. crown 8vo. (*New York, 1905*) ... ... *net* 4 6

The Chemistry of Fire and Fire Prevention. By H. and H. INGLE. 45 illus. 290 pp. crown 8vo. (*1900*) 9 0

Ice-Making Machines. By M. LEDOUX and others. Sixth edition. 190 pp. 18mo, boards. (*New York*, 1906) ... ... *net* 2 0

Brewing with Raw Grain. By T. W. LOVIBOND. 75 pp. crown 8vo. (*1883*) 5 0

Sugar, a Handbook for Planters and Refiners. By the late J. A. R. NEWLANDS and B. E. R. NEWLANDS. 236 illus. 876 pp. demy 8vo. (*London, 1909*) ... ... *net* 1 5 0

Principles of Leather Manufacture. By Prof. H. R. PROCTER. 101 illus. 520 pp. medium 8vo. (*1908*) ... ... *net* 18 0

Leather Industries Laboratory Handbook of Analytical and Experimental methods. By H. R. PROCTER. Second edition, 4 plates, 46 illus. 450 pp. demy 8vo. (*1908*) ... ... *net* 18 0

Theoretical and Practical Ammonia Refrigeration. By I. I. REDWOOD. Sixth thousand, 15 illus. 146 pp. square 16mo. (*New York, 1909*) *net*		4	6
Breweries and Maltings. By G. SCAMMELL and F. COLYER. Second edition, 20 plates, 178 pp. 8vo. (*1880*) ... ... *net*		6	0
Factory Glazes for Ceramic Engineers. By H. RUM-BELLOW. Folio. Series A, Leadless Sanitary Glazes. (*1908*) ... ... *net*	2	2	0
Text Book of Physical Chemistry. By C. L. SPEYERS. 224 pp. demy 8vo. (*New York, 1898*)		9	0
Spons' Encyclopædia of the Industrial Arts, Manufactures and Commercial Products. 1500 illus. 2100 pp. super-royal 8vo. (*1882*) In 2 Vols. cloth ... ... *net*	2	2	0
Pigments, Paints and Painting. By G. TERRY. 49 illus. 392 pp. crown 8vo. (*1893*)		7	6
Tables for the Quantitative Estimation of the Sugars. By E. WEIN and W. FREW. Crown 8vo. (*1896*)		6	0
Workshop Receipts. For the use of Manufacturers, Mechanics and Scientific Amateurs. New and thoroughly revised edition, crown 8vo. (*1909*) ... ... *each net*		3	0
Vol. I. ACETYLENE LIGHTING *to* DRYING. 223 illus. 532 pp.			
Vol. II. DYEING *to* JAPANNING. 259 illus. 540 pp.			
Vol. III. JOINTING PIPES *to* PUMPS. 256 illus. 528 pp.			
Vol. IV. RAINWATER SEPARATORS *to* WINES. 250 illus. 520 pp.			
Practical Handbook on the Distillation of Alcohol from Farm Products. By F. B. WRIGHT. Second edition, 60 illus. 271 pp. crown 8vo. (*New York, 1907*) ... ... *net*		4	6
The Manufacture of Chocolate and other Cacao Preparations. By P. ZIPPERER. Second edition, 87 illus. 280 pp. royal 8vo. (*1902*) ... *net*		16	0

IRRIGATION.

The Irrigation Works of India. By R. B. BUCKLEY. Second edition, with coloured maps and plans. 336 pp. 4to, cloth. (*1905*) ... *net*	2	2	0
Facts, Figures, and Formulæ for Irrigation Engineers. By R. B. BUCKLEY. With illus. 239 pp. large 8vo. (*1908*) ... ... *net*		10	6
Irrigated India. By Hon. ALFRED DEAKIN. With Map, 322 pp. 8vo. (*1893*)		8	6
Indian Storage Reservoirs, with Earthen Dams. By W. L. STRANGE. 14 plates and 53 illus. 379 pp. demy 8vo. (*1904*) ... ... *net*	1	1	0
Irrigation Farming. By L. M. WILCOX. Revised edition, 113 illus. 494 pp. crown 8vo. (*New York*) ... ... *net*		8	6
Egyptian Irrigation. By Sir W. WILLCOCKS. Second edition out of Print. *A few copies of the First Edition (1889) are still to be had. Price* 15*s. net.*			
The Nile Reservoir Dam at Assuan, and After. By Sir W. WILLCOCKS. Second edition, 13 plates, super-royal 8vo. (*1903*) ... ... *net*		6	0
The Assuân Reservoir and Lake Moeris. By Sir W. WILLCOCKS. With text in English, French and Arabic. 5 plates, 116 pp. super-royal 8vo. (*1904*) ... ... *net*		5	0
The Nile in 1904. By Sir W. WILLCOCKS. 30 plates, 200 pp. super-royal 8vo. (*1904*) *net*		9	0

LOGARITHM TABLES.

Aldum's Pocket Folding Mathematical Tables. Four-figure logarithms, and Anti-logarithms, Natural Sines, Tangents, Cotangents, Cosines, Chords and Radians for all angles from 1 to 90 degrees. On folding card. *Net* 4*d*. 20 copies, *net* 6*s*.

Tables of Seven-figure Logarithms of the Natural Numbers from 1 to 108,000. By C. BABBAGE. Stereotype edition, 8vo 7 6

Short Logarithmic and other Tables. By W. C. UNWIN. Fourth edition, small 4to 3 0

Logarithmic Land Measurement. By J. WALLACE. 32 pp. royal 8vo. (*1910*) ... ... *net* 5 0

A. B. C. Five-figure Logarithms with Tables, for Chemists. By C. J. WOODWARD. Crown 8vo ... ... *net* 2 6

A. B. C. Five-figure Logarithms for general use, with lateral index for ready reference. By C. J. WOODWARD. Second edition, with cut lateral Index, 116 pp. 12mo, limp leather ... *net* 3 0

MARINE ENGINEERING AND NAVAL ARCHITECTURE.

Marine Propellers. By S. W. BARNABY. Fifth edition, 5 plates, 56 illus. 185 pp. demy 8vo. (*1908*) ... ... *net* 10 6

Marine Engineer's Record Book: Engines. By B. C. BARTLEY. 8vo, roan ... ... *net* 5 0

The Engineer's and Draughtsman's Data Book for Workshop and Office Use. Third edition, crown 8vo, roan 3 0

Yachting Hints, Tables and Memoranda. By A. C. Franklin. Waistcoat pocket size, 103 pp. 64mo, roan, gilt edges ... ... *net*	1 0
Steamship Coefficients, Speeds and Powers. By C. F. A. Fyfe. 31 plates, 280 pp. fcap. 8vo, leather. (*1907*) ... ... *net*	10 6
Steamships and Their Machinery, from first to last. By J. W. C. Haldane. 120 illus. 532 pp. 8vo. (*1893*)	15 0
Tables for Constructing Ships' Lines. By A. Hogg. Second edition, 8vo	7 0
Submarine Boats. By G. W. Hovgaard. 2 plates, 98 pp. crown 8vo. (*1887*)	5 0
Tabulated Weights of Angle, Tee, Bulb, Round, Square, and Flat Iron and Steel for the use of Naval Architects, Ship-builders, etc. By C. H. Jordan. Sixth edition, 640 pp. royal 32mo, French morocco, gilt edges. (*1909*) ... *net*	7 6
Particulars of Dry Docks, Wet Docks, Wharves, etc. on the River Thames. Compiled by C. H. Jordan. Second edition, 7 coloured charts, 103 pp. oblong 8vo. (*1904*) ... ... *net*	2 6
Marine Transport of Petroleum. By H. Little. 66 illus. 263 pp. crown 8vo. (*1890*)	10 6
Questions and Answers for Marine Engineers, with a Practical Treatise on Breakdowns at Sea. By T. Lucas. 12 folding plates, 515 pp. gilt edges, crown 8vo. (*New York, 1902*) ... *net*	8 0
Reed's Examination Papers for Extra First Class Engineers. Fourth edition, 14 plates and 188 illus. 550 pp. 8vo. (*1902*) ... ... *net*	18 0
Reed's Engineers' Handbook to the Board of Trade Examinations for certificates of Competency as First and Second Class Engineers. Nineteenth edition, 37 plates, 358 illus. 696 pp. 8vo ... ... *net*	14 0

Reed's Marine Boilers. Second edition, crown 8vo *net* 4 6

Reed's Useful Hints to Sea-going Engineers. Fourth edition, 8 plates, 50 illus. 312 pp. crown 8vo. (*1903*) ... ... *net* 3 6

MATERIALS.

Practical Treatise on the Strength of Materials. By T. Box. Fourth edition, 27 plates, 536 pp. 8vo. (*1902*) ... ... *net* 12 6

Treatise on the Origin, Progress, Prevention and Cure of Dry Rot in Timber. By T. A. Britton. 10 plates, 519 pp. crown 8vo. (*1875*) 7 6

Twenty Years' Practical Experience of Natural Asphalt and Mineral Bitumen. By W. H. Delano. 33 illus. 73 pp. crown 8vo, parchment. (*1893*) 2 0

Stone: how to get it and how to use it. By Major-Gen. C. E. Luard, R.E. 8vo, sewed. (*1890*) ... 2 0

Testing of Pipes and Pipe-joints in the Open Trenches. By M. M. Paterson. 8vo, sewed (*1879*) 2 0

Solid Bitumens. By S. F. Peckham. 23 illus. 324 pp. 8vo. (*New York, 1909*) ... ... *net* 1 1 0

Lubricants, Oils and Greases. By I. I. Redwood. 3 plates, 8vo. (*1898*) ... ... *net* 6 6

Practical Treatise on Mineral Oils and their By-Products. By I. I. Redwood. 67 illus. 336 pp. demy 8vo. (*1897*) 15 0

Silico-Calcareous Sandstones, or Building Stones from Quartz, Sand and Lime. By E. STOFFLER. 5 plates, 8vo, sewed. *(1901)* ... ... *net* 4 0

Proceedings of the Fifth Congress, International Association for Testing Materials. English edition. 189 illus. 549 pp. demy 8vo. *(1910)*.

Paper ... ... *net* 15 0
Cloth ... ... *net* 18 0

MATHEMATICS.

Imaginary Quantities. By M. ARGAND. Translated by PROF. HARDY. 18mo, boards. *(New York)* *net* 2 0

Text Book of Practical Solid Geometry. By E. H. DE V. ATKINSON. Revised by MAJOR B. R. WARD, R.E. Second edition, 17 plates, 8vo. *(1901)* 7 6

Quick and Easy Methods of Calculating, and the Theory and Use of the Slide Rule. By R. G. BLAINE. Third edition, 6 illus. 152 pp. 16mo, leather cloth. *(1907)* 2 6

Symbolic Algebra, or the Algebra of Algebraic Numbers. By W. CAIN. 18mo, boards. *(New York)* ... ... *net* 2 0

Nautical Astronomy. By J. H. COLVIN. 127 pp. crown, 8vo. *(1901)* ... ... *net* 2 6

Chemical Problems. By J. C. FOYE. Fourth edition, 141 pp. 18mo, boards. *(New York, 1898)*... *net* 2 0

Primer of the Calculus. By E. S. GOULD. Second edition, 24 illus. 122 pp. 18mo, boards. *(New York, 1899)* ... ... *net* 2 0

Elementary Treatise on the Calculus for Engineering Students. By J. GRAHAM. Third edition, 276 pp. crown 8vo. *(1905)*. (FINSBURY TECHNICAL MANUAL) 7 6

Manual of the Slide Rule. By F. A. HALSEY. Second edition, 31 illus. 84 pp. 18mo, boards. (*New York, 1901*) ... ... *net* 2 0

Reform in Chemical and Physical Calculations. By C. J. T. HANSSEN. 4to. (*1897*) ... *net* 6 6

Algebra Self-Taught. By P. HIGGS. Third edition, 104 pp. crown 8vo. (*1903*) 2 6

Galvanic Circuit investigated Mathematically. By G. S. OHM. Translated by WILLIAM FRANCIS. 269 pp. 18mo, boards. (*New York, 1891*) ... *net* 2 0

Elementary Practical Mathematics. By M. T. ORMSBY. 420 pp. demy 8vo. (*1900*) ... *net* 7 6

Elements of Graphic Statics. By K. VON OTT. Translated by G. S. CLARKE. 93 illus. 128 pp. crown 8vo. (*1901*) 5 0

Figure of the Earth. By F. C. ROBERTS. 18mo, boards. (*New York*) ... ... *net* 2 0

Arithmetic of Electricity. By T. O'C. SLOANE. Thirteenth edition, crown 8vo. (*New York, 1901*) ... ... *net* 4 6

Graphic Method for Solving certain Questions in Arithmetic or Algebra. By G. L. VOSE. Second edition with 28 illus. 62 pp. 18mo, boards. (*New York, 1902*) ... ... *net* 2 0

Problems in Electricity. A Graduated Collection comprising all branches of Electrical Science. By R. WEBER. Translated from the French by E. A. O'KEEFE. 34 illus. 366 pp. crown 8vo. (*1902*). ... ... *net* 7 6

MECHANICAL ENGINEERING.

STEAM ENGINES AND BOILERS, ETC.

Handbook for Mechanical Engineers. By HY. ADAMS. Fourth edition, 426 pp. crown 8vo. *(1897)* ... ... *net* 4 6

Appleby's Handbooks of Machinery. Many illustrations, 8vo. Sections 2, 3, 4 and 6... *each* 3 6

Section 5... ... ... 5 0

Section 1.—Prime Movers. *Out of Print.*
Section 2.—Hoisting Machinery, Winding Engines, etc.
Section 3.—*Out of print.*
Section 4.—Machine Tools and Accessories.
Section 5.—Contractors' Plant and Railway Materials.
Section 6.—Mining, Colonial and Manufacturing Machinery.

Engineers' Sketch Book of Mechanical Movements. By T. W. BARBER. Fifth edition, 3000 illus. 355 pp. 8vo. *(1906)* ... ... *net* 10 6

The Repair and Maintenance of Machinery. By T. W. BARBER. 417 illus. 476 pp. 8vo. *(1895)* ... 10 6

Slide Valve and its Functions, with special reference to Modern Practice in the United States. By J. BEGTRUP. 90 diagrams, 146 pp. medium 8vo. *(New York, 1902)* ... ... *net* 8 0

Practical Treatise on Mill Gearing. By T. BOX. Fifth edition, 11 plates, 128 pp. crown 8vo. *(1892)* 7 6

Safety Valves. By R. H. BUELL. Third edition, 20 illus. 100 pp. 18mo, boards. *(New York, 1898)* *net* 2 0

Machine Design. By Prof. W. L. CATHCART.
Part I. FASTENINGS. 123 illus. 291 pp. demy 8vo. *(New York, 1903)* ... *net* 12 6

Chimney Design and Theory. By W. W. CHRISTIE. Second edition, 54 illus. 192 pp. crown 8vo. (*New York, 1902*) ... ... *net* 12 6

Furnace Draft: its Production by Mechanical Methods. By W. W. CHRISTIE. 5 illus. 80 pp. 18mo, boards. (*New York, 1906*) ... ... *net* 2 0

Working and Management of Steam Boilers and Engines. By F. COLYER. Second edition, 108 pp. crown 8vo. (*1902*) 3 6

The Stokers' Catechism. By W. J. CONNOR. 63 pp. limp cloth. (*1906*) ... ... *net* 1 0

Treatise on the use of Belting for the Transmission of Power. By J. H. COOPER. Fifth edition, 94 illus. 399 pp. demy 8vo. (*New York, 1901*) ... *net* 12 6

The Steam Engine considered as a Thermodynamic Machine. By J. H. COTTERILL. Third edition, 39 diagrams, 444 pp. 8vo. (*1896*) ... 15 0

Fireman's Guide, a Handbook on the Care of Boilers. By K. P. DAHLSTROM. Ninth edition fcap. 8vo. (*New York, 1902*) ... ... *net* 1 6

Heat for Engineers. By C. R. DARLING. 110 illus. 430 pp. 8vo. (*1908.*) (FINSBURY TECHNICAL MANUAL.) ... ... *net* 12 6

Diseases of a Gasolene Automobile, and How to Cure Them. By A. L. DYKE and G. P. DORRIS. 127 illus. 201 pp. crown 8vo. (*New York, 1903*) *net* 6 6

Belt Driving. By G. HALLIDAY. 3 folding plates, 100 pp. 8vo. (*1894*) 3 6

Worm and Spiral Gearing. By F. A. HALSEY. 13 plates, 85 pp. 18mo, boards. (*New York, 1903*) *net* 2 0

Commercial Efficiency of Steam Boilers. By A. HANSSEN. Large 8vo, sewed. (*1898*) ... 0 6

Corliss Engine. By J. T. HENTHORN. Third edition, 23 illus. 95 pp. square 16mo. (S. & C. SERIES, No. 20.) (*New York, 1910*) ... *net* 1 6

Liquid Fuel for Mechanical and Industrial Purposes. By E. A. BRAYLEY HODGETTS. 106 illus. 129 pp. 8vo. (*1890*) 5 0

Elementary Text-Book on Steam Engines and Boilers. By J. H. KINEALY. Fourth edition, 106 illus. 259 pp. 8vo. (*New York, 1903*) ... *net* 8 6

Centrifugal Fans. By J. H. KINEALY. 33 illus. 206 pp. fcap. 8vo, leather. (*New York, 1905*) *net* 12 6

Mechanical Draft. By J. H. KINEALY. 27 original tables and 13 plates, 142 pp. crown 8vo. (*New York, 1906*) ... ... *net* 8 6

The A. B. C. of the Steam Engine, with a description of the Automatic Governor. By J. P. LISK. 6 plates, 12mo. (S. & C. SERIES, No. 17.) (*New York, 1910*) ... ... *net* 1 6

Valve Setting Record Book. By P. A. LOW. 8vo, boards... ... ... 1 6

The Lay-out of Corliss Valve Gears. By S. A. MOSS. Second edition, 3 plates, 108 pp. 18mo, boards. (*New York, 1906*) ... ... *net* 2 0

Steam Boilers, their Management and Working. By J. PEATTIE. Fifth edition, 35 illus. 230 pp. crown 8vo. (*1906*) ... ... *net* 4 6

Treatise on the Richards Steam Engine Indicator. By C. T. PORTER. Sixth edition, 3 plates and 73 diagrams, 285 pp. 8vo. (*1902*) 9 0

Practical Treatise on the Steam Engine. By A. RIGG. Second edition, 103 plates, 378 pp. demy 4to. (*1894*) 1 5 0

Power and its Transmission. A Practical Handbook for the Factory and Works Manager. By T. A. SMITH. 76 pp. fcap. 8vo. (*1910*) ... *net* 2 0

Drawings for Medium Sized Repetition Work. By R. D. SPINNEY. With 47 illus. 130 pp. 8vo. (*1909*) ... ... *net* 3 6

Slide Valve Simply Explained. By W. J. TENNANT. Revised by J. H. KINEALY. 41 illus. 83 pp. crown 8vo. (*New York, 1899*) ... *net* 4 6

Shaft Governors. By W. TRINKS and C. HOOSUM. 27 illus. 97 pp. 18mo, boards. (*New York, 1905*) *net* 2 0

Slide and Piston Valve Geared Steam Engines. By W. H. UHLAND. 47 plates and 314 illus. 155 pp. Two vols. folio, half morocco. (*1882*) 1 16 0

How to run Engines and Boilers. By E. P. WATSON. Fifth edition, 31 illus. 160 pp. crown 8vo. (*New York, 1904*) 3 6

Position Diagram of Cylinder with Meyer Cut-off. By W. H. WEIGHTMAN. On card. (*New York*) ... ... *net* 1 0

Practical Method of Designing Slide Valve Gearing. By E. J. WELCH. 69 diagrams, 283 pp. Crown 8vo. (*1890*) 6 0

Elements of Mechanics. By T. W. WRIGHT. Eighth edition, illustrated, 382 pp. 8vo. (*New York, 1909*) ... ... *net* 10 6

METALLURGY.

IRON AND STEEL MANUFACTURE.

Life of Railway Axles. By T. ANDREWS. 8vo, sewed. (*1895*) 1 0

Microscopic Internal Flaws in Steel Rails and Propeller Shafts. By T. ANDREWS. 8vo, sewed. (*1896*) 1 0

Microscopic Internal Flaws, Inducing Fracture in Steel. By T. ANDREWS. 8vo, sewed. (*1896*) 2 0

Relations between the Effects of Stresses slowly applied and of Stresses suddenly applied in the case of Iron and Steel: Comparative Tests with Notched and Plain Bars. By P. BREUIL. 23 plates and 60 illus. 151 pp. 8vo. (*1904*) *net* 8 0

Brassfounders' Alloys. By J. F. Buchanan. Illustrated, 129 pp. crown 8vo. *(1905)* ... *net*		4	6
Foundry Nomenclature. The Moulder's Pocket Dictionary and concise guide to Foundry Practice. By John F. Buchanan. Illustrated, 225 pp. crown 8vo. *(1903)* ... ... *net*		5	0
American Standard Specifications for Steel. By A. L. Colby. Second edition, revised, 103 pp. crown 8vo. *(New York, 1902)* ... ... *net*		5	0
Galvanised Iron; its Manufacture and Uses. By J. Davies. 139 pp. 8vo. *(1899)* ... ... *net*		5	0
Management of Steel. By G. Ede. Seventh edition, 216 pp. crown 8vo. *(1903)*		5	0
Galvanising and Tinning, with a special Chapter on Tinning Grey Iron Castings. By W. T. Flanders. 8vo. *(New York)* ... ... *net*		8	6
Cupola Furnace. A practical treatise on the Construction and Management of Foundry Cupolas. By E. Kirk. Third edition, 78 illus. 450 pp. demy 8vo. *(New York, 1910)* ... *net*		15	0
Practical Notes on Pipe Founding. By J. W. Macfarlane. 15 plates, 148 pp. 8vo		12	6
Atlas of Designs concerning Blast Furnace Practice. By M. A. Pavloff. 127 plates, 14 in. by 10½ in. oblong, sewed. *(1902)* ... ... *net*	1	1	0
Album of Drawings relating to the Manufacture of Open Hearth Steel. By M. A. Pavloff.			
Part I. Open Hearth Furnaces. 52 plates, 14 in. by 10½ in. oblong folio in portfolio. *(1904)* ... ... *net*		12	0
Metallography Applied to Siderurgic Products. By H. Savoia. Translated by R. G. Corbet. With 94 illus. 180 pp. crown 8vo. *(1910)* *net*		4	6

Modern Foundry Practice. Including revised subject matter and tables from SPRETSON'S "Casting and Founding." By J. SHARP. Second edition, 272 illus. 759 pp. 8vo. (*1905*) ... *net* 1 1 0

Roll Turning for Sections in Steel and Iron. By A. SPENCER. Second edition, 78 plates, 4to. (*1894*) 1 10 0

METRIC TABLES.

French Measure and English Equivalents. By J. BROOK. Second edition, 80 pp. fcap. 32mo, roan. (*1906*) ... ... *net* 1 0

A Dictionary of Metric and other useful Measures. By L. CLARK. 113 pp. 8vo. (*1891*) 6 0

English Weights, with their Equivalents in kilogrammes per cent. By F. W. A. LOGAN. 96 pp. fcap. 32mo, roan. (*1906*) ... ... *net* 1 0

Metric Weights with English Equivalents. By H. P. MCCARTNEY. 84 pp. fcap. 32mo. (*1907*) *net* 1 0

Metric Tables. By Sir G. L. MOLESWORTH. Fourth edition, 95 pp. royal 32mo. (*1909*) ... *net* 2 0

Tables for Setting out Curves from 200 metres to 4000 metres by tangential angles. By H. WILLIAMSON. 4 illus. 60 pp. 18mo. (*1908*) *net* 2 0

MINERALOGY AND MINING.

Rock Blasting. By G. G. ANDRE. 12 plates and 56 illus. in text, 202 pp. 8vo. (*1878*) 5 0

Winding Plants for Great Depth. By H. C. BEHR. In two parts. 8vo, sewed. (*1902*) *net* 2 2 0

Practical Treatise on Hydraulic Mining in California. By A. J. BOWIE, Jun. Tenth edition, 73 illus. 313 pp. royal 8vo. (*New York, 1905*) ... ... *net*	1	1	0
Manual of Assaying Gold, Silver, Copper and Lead Ores. By W. L. BROWN. Twelfth edition, 132 illus. 589 pp. crown 8vo. (*New York, 1907*) *net*		10	6
Fire Assaying. By E. W. BUSKETT. 69 illus. 105 pp. crown 8vo. (*New York, 1907*) ... *net*		4	6
Tin: Describing the Chief Methods of Mining, Dressing, etc. By A. G. CHARLETON. 15 plates, 83 pp. crown 8vo. (*1884*)		12	6
Gold Mining and Milling in Western Australia, with Notes upon Telluride Treatment, Costs and Mining Practice in other Fields. By A. G. CHARLETON. 82 illus. and numerous plans and tables, 648 pp. super-royal 8vo. (*1903*) ... *net*	1	5	0
Miners' Geology and Prospectors' Guide. By G. A. CORDER. 29 plates, 224 pp. crown 8vo. (*1907*) ... ... *net*		5	0
Blasting of Rock in Mines, Quarries, Tunnels, etc. By A. W. and Z. W. DAW. Second edition, 90 illus. 316 pp. demy 8vo. (*1909*) ... *net*		15	0
Handbook of Mineralogy; determination and description of Minerals found in the United States. By J. C. FOYE. 18mo, boards. (*New York, 1886*) *net*		2	0
Conversations on Mines. By W. HOPTON. Ninth edition, 33 illus. 356 pp. crown 8vo. (*1891*) ...		4	6
Our Coal Resources at the End of the Nineteenth Century. By Prof. E. HULL. 157 pp. demy 8vo. (*1897*)		6	0
Hydraulic Gold Miners' Manual. By T. S. G. KIRKPATRICK. Second edition, 12 illus. 46 pp. crown 8vo. (*1897*)		4	0

Economic Mining. By C. G. W. LOCK. 175 illus. 680 pp. 8vo. (*1895*) ... ... *net* 10 6

Gold Milling: Principles and Practice. By C. G. W. LOCK. 200 illus. 850 pp. demy 8vo. (*1901*) *net* 1 1 0

Mining and Ore-Dressing Machinery. By C. G. W. LOCK. 639 illus. 466 pp. super-royal 4to. (*1890*) 1 5 0

Miners' Pocket Book. By C. G. W. LOCK. Fifth edition, 233 illus. 624 pp. fcap. 8vo, roan, gilt edges. (*1908*) ... ... *net* 10 6

Tests for Ores, Minerals and Metals of Commercial Value. By R. L. MCMECHEN. 152 pp. 12mo. (*New York, 1907*) ... ... *net* 5 6

Practical Handbook for the Working Miner and Prospector, and the Mining Investor. By J. A. MILLER. 34 illus. 234 pp. crown 8vo. (*1897*) 7 6

Theory and Practice of Centrifugal Ventilating Machines. By D. MURGUE. 7 illus. 81 pp. 8vo. (*1883*) 5 0

Examples of Coal Mining Plant. By J. POVEY-HARPER. Second edition, 40 plates, 26 in. by 20 in. (*1895*) ... ... *net* 4 4 0

Examples of Coal Mining Plant, Second Series. By J. POVEY-HARPER. 10 plates, 26 in. by 20 in. (*1902*) ... ... *net* 1 12 6

ORGANISATION.

ACCOUNTS, CONTRACTS AND MANAGEMENT.

Organisation of Gold Mining Business, with Specimens of the Departmental Report Books and the Account Books. By NICOL BROWN. Second edition, 220 pp. fcap. folio. (*1903*) *net* 1 5 0

Manual of Engineering Specifications and Contracts. By L. M. HAUPT. Eighth edition, 338 pp. 8vo. (*New York, 1900*) ... ... *net* 12 6

Depreciation of Factories, Municipal, and Industrial Undertakings, and their Valuation. By E. MATHESON. Fourth edition, 230 pp. 8vo, cloth. (*1910*) ... ... *net* 10 6

Aid Book to Engineering Enterprise. By E. MATHESON. Third edition, 916 pp. 8vo, buckram. (*1898*) 1 4 0

Office Management. A handbook for Architects and Civil Engineers. By W. KAYE PARRY. New impression, 187 pp. medium 8vo. (*1908*) *net* 5 0

Commercial Organisation of Engineering Factories. By H. SPENCER. 92 illus. 221 pp. 8vo. (*1907*) ... ... *net* 10 6

PHYSICS.

COLOUR, HEAT AND EXPERIMENTAL SCIENCE.

The Entropy Diagram and its Applications. By M. J. BOULVIN. 38 illus. 82 pp. demy 8vo. (*1898*) 5 0

Physical Problems and their Solution. By A. BOURGOUGNON. 224 pp. 18mo, boards. (*New York, 1897*) ... ... *net* 2 0

Heat for Engineers. By C. R. DARLING. 110 illus. 430 pp. 8vo. (*1908*) (FINSBURY TECHNICAL MANUAL) ... ... *net* 12 6

The Colourist. A method of determining colour harmony. By J. A. H. HATT. 2 coloured plates, 80 pp. 8vo. (*New York, 1908*) ... ... *net* 6 6

Engineering Thermodynamics. By C. F. HIRSCHFELD. 22 illus. 157 pp. 18mo, boards. (*New York, 1907*) ... ... *net* 2 0

Experimental Science: Elementary, Practical and Experimental Physics. By G. M. HOPKINS. Twenty-third edition, 920 illus. 1100 pp. large 8vo. (*New York, 1902*) ... ... *net* 1 1 0

Reform in Chemical and Physical Calculations. By C. J. T. HANSSEN. Demy 4to. (*1897*) *net* 6 6

Introduction to the Study of Colour Phenomena. By J. W. LOVIBOND. 10 hand coloured plates, 48 pp. 8vo. (*1905*) ... ... *net* 5 0

Practical Laws and Data on the Condensation of Steam in Bare Pipes; to which is added a Translation of PECLET'S Theory and Experiments on the Transmission of Heat through Insulating Materials. By C. P. PAULDING. 184 illus. 102 pp. demy 8vo. (*New York, 1904*) *net* 8 6

The Energy Chart. Practical application to reciprocating steam-engines. By Captain H. R. SANKEY. 157 illus. 170 pp. 8vo. (*1907*) ... *net* 7 6

PRICE BOOKS.

Approximate Estimates. By T. E. COLEMAN. Third edition, 481 pp. oblong 32mo, leather. (*1907*) ... ... *net* 5 0

Railway Stores Price Book. By W. O. KEMPTHORNE. 500 pp. demy 8vo. (*1909*) ... *net* 10 6

Spons' Engineers' Price Book. A Synopsis of Current Prices and Rates for Engineering Materials and Products. Edited by T. G. MARLOW. 650 pp. folio. (1904)... ... ... *net* 7 6

Spons' Architects' and Builders' Pocket Price-Book, Memoranda, Tables and Prices. Edited by CLYDE YOUNG. Revised by STANFORD M. BROOKS. Illustrated, 552 pp. 16mo, leather cloth (size 6½ in. by 3¾ in. by ½ in. thick). Issued annually ... ... *net* 3 0

RAILWAY ENGINEERING.

Practical Hints to Young Engineers Employed on Indian Railways. By A. W. C. ADDIS. With 14 illus. 154 pp. 12mo. (*1910*) ... *net* 3 6

Railroad Curves and Earthwork. By C. F. ALLEN. Third edition, 4 plates, 198 pp. 12mo, leather, gilt edges. (*New York, 1903*) ... *net* 8 6

Field and Office Tables, specially applicable to Railroads. By C. F. ALLEN. 293 pp. 16mo, leather. (*New York, 1903*) ... ... *net* 8 6

The two above combined in one vol. limp leather ... *net* 12 6

Up-to-date Air Brake Catechism. By R. H. BLACKALL. Twenty-third edit. 5 coloured plates, 96 illus. 305 pp. crown 8vo. (*New York, 1908*) *net* 8 6

Simple and Automatic Vacuum Brakes. By C. BRIGGS, G.N.R. 11 plates, 8vo. (*1892*) ... 4 0

Notes on Permanent-way Material, Plate-laying, and Points and Crossings. By W. H. COLE. Fifth edition, 32 plates, 176 pp. crown 8vo. (*1905*) *net* 7 6

Statistical Tables of the Working of Railways in various countries up to the year 1904. By J. D. DIACOMIDIS. Second edition, 84 pp. small folio, sewed. (*1906*) ... ... *net* 16 0

Locomotive Breakdowns, Emergencies and their Remedies. By GEO. L. FOWLER, M.E. and W. W. WOOD. Fifth edition, 92 illus. 266 pp. 12mo. (*New York, 1908*) ... ... *net* 4 6

Permanent-Way Diagrams. By F. H. FRERE. Mounted on linen in cloth covers. (*1908*) *net* 3 0

Formulæ for Railway Crossings and Switches. By J. GLOVER. 9 illus. 28 pp. royal 32mo. (*1896*) 2 6

Data relating to Railway Curves and Super-elevations, shown graphically. By J. H. Haiste. On folding card for pocket use ... ... *net* 0 6

Setting out of Tube Railways. By G. M. Halden. 9 plates, 46 illus. 68 pp. crown 4to. (*1907*) *net* 10 6

Railway Engineering, Mechanical and Electrical. By J. W. C. Haldane. 141 illus. 563 pp. 8vo. (*1897*) 15 0

Tables for setting-out Railway Curves. By C. P. Hogg. A series of cards in neat cloth case ... 4 6

The Construction of the Modern Locomotive. By G. Hughes. 300 illus. 261 pp. 8vo. (*1894*) 9 0

Practical Hints for Light Railways at Home and Abroad. By F. R. Johnson. 6 plates, 31 pp. crown 8vo. (*1896*) 2 6

Handbook on Railway Stores Management. By W. O. Kempthorne. 268 pp. demy 8vo. (*1907*) *net* 10 6

Railway Stores Price Book. By W. O. Kempthorne. 487 pp. demy 8vo. (*1909*) ... *net* 10 6

Tables for setting out Curves for Railways, Roads, Canals, etc. By A. Kennedy and R. W. Hackwood. 32mo ... ... *net* 2 0

Railroad Location Surveys and Estimates. By F. Lavis. 68 illus. 270 pp. 8vo. (*New York, 1906*) *net* 12 6

Tables for Computing the Contents of Earthwork in the Cuttings and Embankments of Railways. By W. Macgregor. Royal 8vo ... 6 0

Bridge and Tunnel Centres. By J. B. McMasters. Illustrated, 106 pp. 18mo, boards. (*New York, 1893*) ... ... *net* 2 0

Pioneering. By F. Shelford. Illustrated, 88 pp. crown 8vo. (*1909*) ... ... *net* 3 0

Handbook on Railway Surveying for Students and Junior Engineers. By B. STEWART. 55 illus. 98 pp. crown 8vo. (*1909*) ... ... *net*	2	6
Spiral Tables. By J. G. SULLIVAN. 47 pp. 12mo, leather. (*New York, 1908*) ... ... *net*	6	6
Modern British Locomotives. By A. T. TAYLOR. 100 diagrams of principal dimensions, 118 pp. oblong 8vo. (*1907*) ... ... *net*	4	6
Locomotive Slide Valve Setting. By C. E. TULLY. Illustrated, 18mo ... ... *net*	1	0
The Walschaert Locomotive Valve Gear. By W. W. WOOD. 4 plates and set of movable cardboard working models of the valves, 193 pp. crown 8vo. (*New York, 1907*) ... ... *net*	6	6
The Westinghouse E.T. Air-Brake Instruction Pocket Book. By W. W. WOOD. 48 illus. including many coloured plates, 242 pp. crown 8vo. (*New York, 1909*) ... ... *net*	8	6

SANITATION, PUBLIC HEALTH AND MUNICIPAL ENGINEERING.

Sewers and Drains for Populous Districts. By J. W. ADAMS. Ninth edition, 81 illus. 236 pp. 8vo. (*New York, 1902*) ... ... *net*	10	6
Public Abattoirs, their Planning, Design and Equipment. By R. S. AYLING. 33 plates, 100 pp. demy 4to. (*1908*) ... ... *net*	8	6
Sewage Purification. By E. BAILEY-DENTON. 8 plates, 44 pp. 8vo. (*1896*)	5	0
Water Supply and Sewerage of Country Mansions and Estates. By E. BAILEY-DENTON. 76 pp. crown 8vo. (*1901*) ... ... *net*	2	6

Sewerage and Sewage Purification. By M. N. Baker. Second edition, 144 pp. 18mo, boards. (*New York, 1905*) ... ... *net*		2	0
Sewage Irrigation by Farmers. By R. W. P. Birch. 8vo, sewed. (*1878*)		2	6
Sanitary House Drainage, its Principles and Practice. By T. E. Coleman. 98 illus. 206 pp. crown 8vo. (*1896*)		6	0
Stable Sanitation and Construction. By T. E. Coleman. 183 illus. 226 pp. crown 8vo. (*1897*)		6	0
Public Institutions, their Engineering, Sanitary and other Appliances. By F. Colyer. 231 pp. 8vo. (*1889*) ... ... *net*		2	0
Discharge of Pipes and Culverts. By P. M. Crosthwaite. Large folding sheet in case *net*		2	6
A Complete and Practical Treatise on Plumbing and Sanitation: Hot Water Supply, Warming and Ventilation, Steam Cooking, Gas, Electric Light, Bells, etc., with a complete Schedule of Prices of Plumber's Work. By G. B. Davis and F. Dye. 2 vols. 637 illus. and 21 folding plates, 830 pp. 4to, cloth. (*1899*) *net*	1	10	0
Standard Practical Plumbing. By P. J. Davies.			
Vol. I. Fourth edition, 768 illus. 355 pp. royal 8vo. (*1905*) ... ... *net*		7	6
Vol. II. Second edition, 953 illus. 805 pp. (*1905*) ... ... *net*		10	6
Vol. III. 313 illus. 204 pp. (*1905*) ... *net*		5	0
Conservancy, or Dry Sanitation versus Water Carriage. By J. Donkin. 7 plates, 33 pp. 8vo, sewed. (*1906*) ... ... *net*		1	0
Sewage Disposal Works, their Design and Construction. By W. C. Easdale. With 160 illus. 264 pp. demy 8vo. (*1910*) ... ... *net*		10	6
House Drainage and Sanitary Plumbing. By W. P. Gerhard. Tenth edition, 6 illus. 231 pp. 18mo, boards. (*New York, 1902*) ... ... *net*		2	0

Engineering Work in Towns and Cities. By E. McCulloch. 44 illus. 502 pp. crown 8vo. (*New York, 1908*) ... ... *net* 12 6

The Treatment of Septic Sewage. By G. W. Rafter. 137 pp. 18mo, boards. (*New York, 1904*) ... ... *net* 2 0

Reports and Investigations on Sewer Air and Sewer Ventilation. By R. H. Reeves. 8vo, sewed. (*1894*) 1 0

The Law and Practice of Paving Private Street Works. By W. Spinks. Fourth edition, 256 pp. 8vo. (*1904*) ... ... *net* 12 6

STRUCTURAL DESIGN.

(*See* Bridges and Roofs.)

TELEGRAPH CODES.

New Business Code. 320 pp. narrow 8vo. (Size $4\frac{3}{4}$ in. by $7\frac{3}{4}$ in. and $\frac{1}{2}$ in. thick, and weight 10 oz.) (*New York, 1909*) ... ... *net* 1 10 0

Miners' and Smelters' Code (formerly issued as the **Master Telegraph Code**). 448 pp. 8vo, limp leather, weight 14 oz. (*New York, 1899*) *net* 2 10 0

Billionaire Phrase Code, containing over two million sentences coded in single words. 56 pp. 8vo, leather. (*New York, 1908*) ... ... *net* 6 6

WARMING AND VENTILATION.

Hot Water Supply. By F. Dye. Fifth edition, 48 illus. 86 pp. crown 8vo. (*1902*) ... *net* 3 0

A Practical Treatise upon Steam Heating. By F. Dye. 129 illus. 246 pp. demy 8vo. (*1901*) *net* 10 0

Practical Treatise on Warming Buildings by Hot Water. By F. DYE. 192 illus. 319 pp. 8vo. cloth. (*1905*) ... ... *net* 8 6

Charts for Low Pressure Steam Heating. By J. H. KINEALY. Small folio. (*New York*) ... 4 6

Formulæ and Tables for Heating. By J. H. KINEALY. 18 illus. 53 pp. 8vo. (*New York, 1899*) 3 6

Mechanics of Ventilation. By G. W. RAFTER. Second edition, 18mo, boards. (*New York, 1896*) *net* 2 0

Principles of Heating. By W. G. SNOW. 62 illus. 161 pp. 8vo. (*New York, 1907*) ... ... *net* 8 6

Furnace Heating. By W. G. SNOW. Fourth edition, 52 illus. 216 pp. 8vo. (*New York, 1909*) ... *net* 6 6

Ventilation of Buildings. By W. G. SNOW and T. NOLAN. 83 pp. 18mo, boards. (*New York, 1906*) *net* 2 0

Heating Engineers' Quantities. By W. L. WHITE and G. M. WHITE. 4 plates, 33 pp. folio. (*1910*) *net* 10 6

WATER SUPPLY.

(*See also* HYDRAULICS.)

Potable Water and Methods of Testing Impurities. By M. N. BAKER. 97 pp. 18mo, boards. (*New York, 1905*) ... ... *net* 2 0

Manual of Hydrology. By N. BEARDMORE. New impression, 18 plates, 384 pp. 8vo. (*1906*) *net* 10 6

Boiler Waters, Scale, Corrosion and Fouling. By W. W. CHRISTIE. 77 illus. 235 pp. 8vo, cloth. (*New York, 1907*) ... ... *net* 12 6

Water Softening and Purification. By H. COLLET. Second edition, 6 illus. 170 pp. crown 8vo. (*1908*) *net* 5 0

Treatise on Water Supply, Drainage and Sanitary Appliances of Residences. By F. COLYER. 100 pp. crown 8vo. (*1899*) ... ... *net* 1 6

Report on the Investigations into the Purification of the Ohio River Water at Louisville, Kentucky. By G. W. FULLER. 8 plates, 4to, cloth. (*New York, 1898*) 2 2 0

Purification of Public Water Supplies. By J. W. HILL. 314 pp. 8vo. (*New York, 1898*) 10 6

Well Boring for Water, Brine and Oil. By C. ISLER. *New edition in the Press.*

Method of Measuring Liquids Flowing through Pipes by means of Meters of Small Calibre. By Prof. G. LANGE. 1 plate, 16 pp. 8vo, sewed *net* 0 6

On Artificial Underground Water. By G. RICHERT. 16 illus. 33 pp. 8vo, sewed. (*1900*) *net* 1 6

Notes on Water Supply in new Countries. By F. W. STONE. 18 plates, 42 pp. crown 8vo. (*1888*) 5 0

The Principles of Waterworks Engineering. By J. H. T. TUDSBERY and A. W. BRIGHTMORE. Third edition, 13 folding plates, 130 illus. 447 pp. demy 8vo. (*1905*) ... ... *net* 1 1 0

WORKSHOP PRACTICE.

A Handbook for Apprenticed Machinists. By O. J. BEALE. Second edition, 89 illus., 141 pp. 16mo. (*New York, 1901*) ... ... *net* 2 6

Bicycle Repairing. By S. D. V. BURR. Sixth edition, 200 illus. 208 pp. 8vo. (*New York, 1903*) *net* 4 6

Practice of Hand Turning. By F. CAMPIN. Third edition, 99 illus. 307 pp. crown 8vo. (*1883*) 3 6

Calculation of Change Wheels for Screw Cutting on Lathes. By D. DE VRIES. 46 illus. 83 pp. 8vo. (*1908*) ... ... *net* 3 0

Milling Machines and Milling Practice. By D. DE VRIES. With 536 illus. 464 pp. medium 8vo. *(1910)* ... ... *net* 14 0

French-Polishers' Manual. By a French-Polisher. 31 pp. royal 32mo, sewed. *(1902)* ... *net* 0 6

Art of Copper Smithing. By J. FULLER. Third edition, 475 illus. 325 pp. royal 8vo. *(New York, 1901)* ... ... *net* 12 6

Saw Filing and Management of Saws. By R. GRIMSHAW. New edition, 81 illus. 16mo. *(New York, 1906)* ... ... *net* 3 6

Paint and Colour Mixing. By A. S. JENNINGS. Fourth edition. 14 coloured plates, 190 pp. 8vo. *(1910)* ... ... *net* 5 0

The Mechanician: a Treatise on the Construction and Manipulation of Tools. By C. KNIGHT. Fifth edition, 96 plates, 397 pp. 4to. *(1897)* ... 18 0

Turner's and Fitter's Pocket Book. By J. LA NICCA. 18mo, sewed 0 6

Tables for Engineers and Mechanics, giving the values of the different trains of wheels required to produce Screws of any pitch. By LORD LINDSAY. Second edition, royal 8vo, oblong... ... ... 2 0

Screw-cutting Tables. By W. A. MARTIN. Seventh edition, royal 8vo, oblong 1 0

Metal Plate Work, its Patterns and their Geometry, for the use of Tin, Iron and Zinc Plate Workers. By C. T. MILLIS. Fourth edition, 280 diagrams, 470 pp. crown 8vo. *(1906)*... ... ... 9 0

Engineers' and General Smiths' Work. The smith and forgeman's handbook of practical smithing and forging. By T. MOORE. 401 illus. 248 pp. crown 8vo. *(1906)*... ... ... *net* 5 0

Modern Machine Shop Construction, equipment and management. By O. E. PERRIGO. 208 illus. 343 pp. crown 4to. (*New York, 1906*) ... *net*	21	0
Turner's Handbook on Screw-cutting, Coning, etc. By W. PRICE. Fcap. 8vo	1	0
Introduction to Eccentric Spiral Turning. By H. C. ROBINSON. 12 plates, 23 illus. 48 pp. 8vo. (*1906*) ... ... *net*	4	6
Manual of Instruction in Hard Soldering. By H. ROWELL. Sixth edition, 7 illus. 66 pp. crown 8vo. (*New York, 1910*) ... ... *net*	3	0
Pocket Book on Boilermaking, Shipbuilding, and the Steel and Iron Trades in General. By M. J. SEXTON. Sixth edition, 85 illus. 319 pp. royal 32mo, roan, gilt edges. (*1909*) ... ... *net*	5	0
Power and its Transmission. A Practical Handbook for the Factory and Works Manager. By T. A. SMITH. 76 pp. fcap. 8vo. (*1910*) ... *net*	2	0
Spons' Mechanics' Own Book: A Manual for Handicraftsmen and Amateurs. Sixth edition, 1430 illus. 720 pp. demy 8vo. (*1903*)	6	0
Ditto ditto half morocco	7	6
Spons' Workshop Receipts for Manufacturers, Mechanics and Scientific Amateurs. New and thoroughly revised edition, crown 8vo. (*1909*) ... ... *each net*	3	0
Vol. I. ACETYLENE LIGHTING *to* DRYING. 223 illus. 532 pp.		
Vol. II. DYEING *to* JAPANNING. 259 illus. 540 pp.		
Vol. III. JOINTING PIPES *to* PUMPS. 256 illus. 528 pp.		
Vol. IV. RAINWATER SEPARATORS *to* WINES. 250 illus. 520 pp.		
Gauges at a Glance. By T. TAYLOR. Second edition, post 8vo, oblong, with tape converter. (*1900*) ... ... *net*	5	0

Simple Soldering, both Hard and Soft. By E. THATCHER. 52 illus. 76 pp. crown 8vo, limp. (S. & C. SERIES, No. 18.) (*New York, 1910*) *net* 1 6

The Modern Machinist. By J. T. USHER. Fifth edition. 257 illus. 322 pp. 8vo. (*New York, 1904*) *net* 10 6

Practical Wood Carving. By C. J. WOODSEND. 108 illus. 86 pp. 8vo. (*New York, 1897*) ... *net* 4 6

American Tool Making and Interchangeable Manufacturing. By J. W. WOODWORTH. 600 illus. 544 pp. demy 8vo. (*New York, 1905*) ... *net* 17 0

USEFUL TABLES.

Weights and Measurements of Sheet Lead. By J. ALEXANDER. 32mo, roan ... ... *net* 1 6

Tables of Parabolic Curves for the use of Railway Engineers and others. By G. T. ALLEN. Fcap. 16mo 4 0

Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots and Reciprocals. Crown 8vo ... 6 0

Tables of Squares. By E. E. BUCHANAN. Ninth edition, 12mo ... ... *net* 4 6

Land Area Tables. By W. CODD. Square 16mo, on a sheet mounted on linen and bound in cloth 3 6

Tables for Setting out Curves from 101 to 5000 feet radius. By H. A. CUTLER and F. J. EDGE. Royal 32mo ... ... *net* 2 6

Transition Curves. By W. G. FOX. 18mo, boards. (*New York*) ... ... *net* 2 0

Tables of some of the Principal Speeds occurring in Mechanical Engineering, expressed in Metres per second. By P. KEERAYEFF. 18mo, sewed ... 0 6

Calculating Scale. A Substitute for the Slide Rule. By W. KNOWLES. Crown 8vo, leather ... *net*	1	0
Planimeter Areas. Multipliers for various scales. By H. B. MOLESWORTH. Folding sheet in cloth case ... ... *net*	1	0
Tables of Seamless Copper Tubes. By I. O'TOOLE. 69 pp. oblong fcap. 8vo. (*1908*) ... ... *net*	3	6
Rownson's Iron Merchants' Tables and Memoranda, Weights and Measures. 86 pp. 32mo, leather...	3	6
Spons' Tables and Memoranda for Engineers. By J. T. HURST, C.E. Twelfth edition, 278 pp. 64mo, roan, gilt edges. (*1907*) ... ... *net*	1	0
Ditto ditto in celluloid case *net*	1	6
Optical Tables and Data, for the use of Opticians. By Prof. S. P. THOMPSON. Second edition, 130 pp. oblong 8vo. (*1907*) ... ... *net*	6	0
Traverse Table, showing Latitudes and Departure for each Quarter degree of the Quadrant, and for distances from 1 to 100, etc.; 18mo, boards *net*	2	0
Fifty-four Hours' Wages Calculator. By H. N. WHITELAW. Second edition, 8vo ... ... *net*	2	6
Wheel Gearing. Tables of Pitch Line Diameters, etc. By A. WILDGOOSE and A. J. ORR. 175 pp. fcap. 32mo. (*1903*) ... ... *net*	2	0

MISCELLANEOUS.

Time Chart. The time of day at any place in the World at a glance. By Dr. F. J. B. CORDEIRO. On card ... ... *net*	1	0
The Atmosphere: Its Characteristics and Dynamics. By F. J. B. CORDEIRO. With 35 illus. 129 pp. medium 8vo. (*New York, 1910*) ... *net*	10	6

Model Steam Engine Design. By R. M. De Vignier. 34 illus. 94 pp. crown 8vo, limp. (*New York, 1907*) ... ... *net*	1	6
Popular Engineering. By F. Dye. 704 illus. 477 pp. crown 4to. (*1895*) ... ... *net*	5	0
The Phonograph, and how to construct it. By W. Gillett. 6 folding plates, 87 pp. crown 8vo. (*1892*)	5	0
Particulars of Dry Docks, Wet Docks, Wharves, etc. on the River Thames. By C. N. Jordan. Second edition, 7 coloured charts, 103 pp. oblong 8vo. (*1904*) ... ... *net*	2	6
Spons' Engineer's Diary and Year Book, issued annually. 4to	3	6
New Theories in Astronomy. By W. Stirling. 335 pp. demy 8vo. (*1906*) ... ... *net*	8	6
The American Hardware Store. A Manual of approved methods of arranging and displaying hardware. By R. R. Williams. 500 illus. 448 pp. royal 8vo. (*New York, 1896*) ... *net*	7	6
Practical Wood Carving. By C. J. Woodsend. 108 illus. 86 pp. 8 vo. (*New York, 1897*) ... *net*	4	6
Inventions, How to Protect, Sell and Buy Them. By F. Wright. Crown 8vo, limp. (S. & C. Series, No. 10.) (*New York, 1908*) ... *net*	1	6

The Journal of the Iron and Steel Institute.

Edited by G. C. LLOYD, *Secretary*.

Published Half-yearly, 8vo, cloth, 16*s*. *net*.

The Journal of the Institution of Electrical Engineers.

Edited by P. F. ROWELL, *Secretary*.

The Proceedings of the Institution of Municipal and County Engineers.

Edited by THOMAS COLE, Assoc. M. Inst. C.E. *Secretary*.

Published Annually, 8vo, cloth, 21*s*. *net*.

The Transactions of the Institution of Mining and Metallurgy.

Edited by C. McDERMID, *Secretary*.

Published Annually, boards, 21*s*. net, or half-bound, 25*s*. net.

Transactions of the Institution of Gas Engineers.

Edited by WALTER T. DUNN, *Secretary*.

Published Annually, 8vo, cloth, 10*s*. 6*d*. net.

Proceedings of the International Association for Testing Materials.

(English Edition.)

E. & F. N. SPON, Ltd., 57 Haymarket, London, S.W.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED.