AËRIAL NAVIGATION

. • • . . •

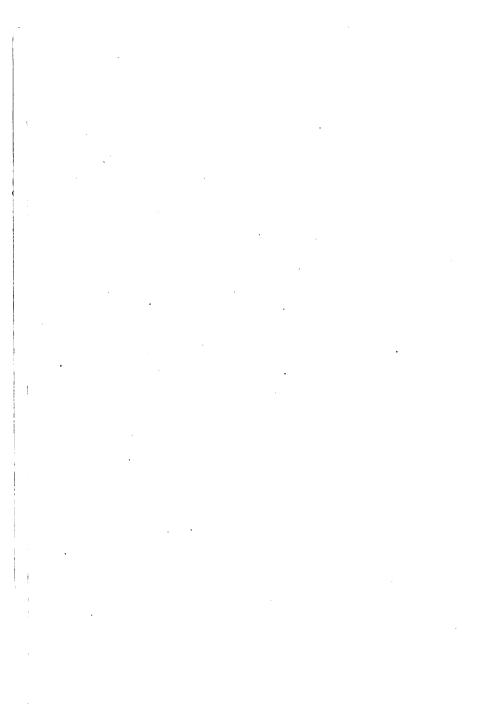




Fig. 105. Aërostat Rounding the Eiffel Tower (p. 146).

AERIAL NAVIGNUOS

A PRINTER AT

TON THE CONSTRUCTOR NOT TO THE FOREST

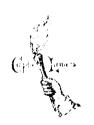
ALROSTATS, ALROSTATS of the control of the control

FREDERICK WANKER CO.

Figure 01 Of CHE at 30 to the Architecture of the Architecture of

AT THOR SHOP THAN FIGURE A MARKET A STATE OF THE ASSET OF THE STATE OF THE ASSET OF

Willith about One Hundred Aller a closes



LONDON CROSBY LOCKWOOD AND SON , COVERNIAS BALL COLOR, LUDGAGE BILL 1992

1. Karaga - Romana

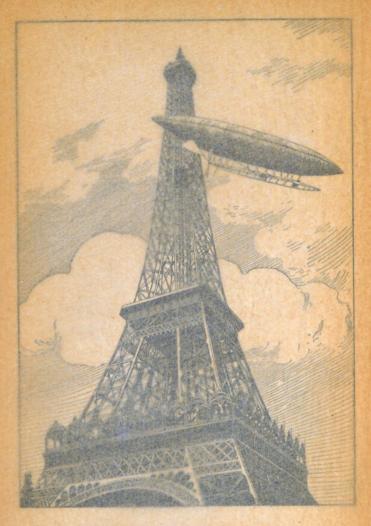


FIG. 105. ARROSTAT ROUNDING THE EIFFEL TOWER (P. 148).

AËRIAL NAVIGATION

A PRACTICAL HANDBOOK

ON THE CONSTRUCTION OF DIRIGIBLE BALLOONS,

AËROSTATS, AËROPLANES, AND AËROMOTORS

BY

FREDERICK WALKER, C.E.

FELLOW OF THE SOCIETY OF PATENT AGENTS, ASSOCIATE MEMBER OF THE
AERONAUTIC INSTITUTE

AUTHOR OF "PRACTICAL DYNAMO BUILDING," "TABLES AND MEMORANDA FOR FLECTRICAL ENGINEERS," "ELECTRICITY IN THE ENGINE ROOM,"
"DESIGN AND EQUIPMENT OF LAUNCHES," BTC.

With about One Hundred Illustrations



LONDON CROSBY LOCKWOOD AND SON 7 STATIONERS' HALL COURT, LUDGATE HILL 1902

[All Rights Reserved]

Printed at THE DARIEN PRESS Edinburgh.

11964 JUL 13 1903 STS W 5

PREFACE.

THE practical development of aërial navigation is slow relatively to other modes of locomotion. The chief cause lies in the fact that any disaster is nearly sure to be fatal to human life, and although ocean navigation is attended by a certain amount of danger to both life and property, the risk is minimised by the adaptability of boats, lifebuoys, and a considerable portion of the debris incidental to shipwrecks, to float upon the surface of the water and sustain the survivors. It is true that in many cases, in the present stage of rapid ocean transit, such life-saving appliances are not always available or successful, but the existence of them engenders a degree of confidence which has as yet no counterpart in aërial navigation.

There have been disasters in this enterprise—as there always will be, to the end of time, whenever man seeks to conquer the unknown. In olden times, when to the adventurous Phænician navigator the unknown waste beyond the Pillars of Hercules was the edge of a veritable Plutonian abyss, men went forth and returned no more. And the wise City Fathers at the gates of Tyre prophesied this and that sad fate to the blasphemous seeker of the secrets of the gods. How many

stark ribs and frames of erstwhile stout galleys strewed the Ionian coasts ere the Pillars were won and the far-off Casseritides reached. No Lloyd's agencies, no shipping news, then existed to supply the record; but we may feel assured that the City Fathers expressed no astonishment, but accepted the fact literally when once accomplished. The ocean greyhound is now an every-day sight, and the air-ship will soon cease to cause astonishment.

Since recent successful experiments and commercial enterprise have combined to render aërial navigation a prominent feature in progressive science, no apology is needed in introducing the present volume, which treats of the laws governing flight as exemplified by animals, birds, and insects, and of the construction of dirigible balloons, aërostats, aëroplanes, and aëromotors to be synthetically deduced therefrom and illustrated by various types already made.

We admit the air-ship in practice to combine the aërostat, aëroplane, and mechanical propeller, and to be absolutely safe, but the exact proportions each must bear to the others is not within the province of a work the aim of which is to convey elementary instruction in a popular manner; and this also applies to the aëroplane, the term here being applied in a broad sense. When the area of the plane is subdivided into aërocurves, or reactionary surfaces of which the curvilinear construction is based upon the cissoid curve, the elaborate calculations governing this would be out of place. And in a similar manner we do not go into the intricate problems relating to the screw propeller in air, and its

reaction upon curved aëroplanes, but have endeavoured to present in readable fashion a thoroughly practical basis upon which the air-ship may be constructed and understood in its action.

From a commercial point of view the advantages to be derived from any increased speed due to aërial navigation as against other modes of locomotion are not immediately apparent, except for light postal services. The aëromotor or air-ship will always be of great value in naval and military tactics, and for Ordnance surveying purposes, still with exactly the same effect that applies to seagoing navies and war-craft generally—that is, each Power, whilst proceeding upon the defined primary lines of construction, will strive to possess the best aërial navy. and this spirit of competition will be good for inventors and for commerce generally. Aërial navigation can only effect a revolution in international matters by the discovery and application of the neutralisation and regulation of the force of gravity. Given this as a secret under the control of a peaceful and highly civilised Power, and war and its concomitant horrors would be a story of the past.

The true co-ordination of physical phenomena brings creative imagination to bear upon the dead side of the world turned to us, and causes us to comprehend the pulsations of its real life beyond the screen of materialism. So co-ordinates light, electricity, magnetism, and each new imaginative construction brings us nearer to the conception of a living universe. As an instance, we may take the now well-known "cathode rays," where force takes material embodiment, and we see that all apparently

quiescent matter is really energy at work in various forms; and again, there are the hitherto undeveloped mysteries of radiation.

The attraction of gravitation up to the present time has not co-ordinated with other forces, and there may yet be a mode of applying known forces in aërostation in this wide and all but untrodden field of research.

FREDK. WALKER.

OXFORD, 2nd June 1902.

CONTENTS.

CHAPTER I. LAWS OF FLIGHT.	
FUNDAMENTAL LAWS; CONDOR; ALBATROSS; BIRDS'	PAGE
WINGS; BATS; COLEOPTERA, WINGS; HYMENOP-	
TERA, WINGS; NERVURES	1
CHAPTER II. AËROSTATICS.	
THE ATMOSPHERE; ALTITUDE AND PRESSURE; BARO-	
METER; TABLES; AERIAL FLOTATION; FORCES;	
BUOYANCY; CALCULATIONS; TEMPERATURE; WEIGHT	
and Gravity	12
CHAPTER III. AËROSTATS.	
Various Aërostats	21
CHAPTER IV. AËRODYNAMICS.	
AIR AS A MEDIUM; DISPLACEMENT AND WEIGHT; COM-	
PARATIVE TABLES; EXPERIMENTS; WAVE OF FLIGHT,	
DIAGRAMS; REACTION, DIAGRAMS; EXPERIMENTAL	
DATA; MECHANISM FOR DOUBLE MOVEMENT;	
THEORY OF MANUMOTIVE WINGS	31

CHAPTER V. SCREW PROPULSION, PADDLES, AND AËROPLANES.	AGE
AIR RESISTANCE; POWER; WIND RESISTANCE; VELOCITY AND POWER; TABLES; SCREW PROPELLERS; TYPES; STRUCTURE; LAWS; SLIP; PITCH; AREA; PADDLES; JETS; AËROPLANES; ANGLES AND PRESSURE; VARIOUS	
TYPES	49
CHAPTER VI. MOTIVE POWER.	
FUEL; THERMIC VALUES AND WEIGHT; TABLES; GENERATORS; BURNERS; INTERNAL COMBUSTION ENGINES; VALUE OF LIQUID FUELS; CHEMICAL CONSTITUENCY; RESIDUUM; VAPORISING; ENGINE TESTS; WEIGHTS; ELECTRICAL MOTIVE POWER;	
WEIGHT	83
CHAPTER VII. STRUCTURE OF AIR-SHIPS AND MATERIALS.	
Models; Wing Action; Rudders; Framework; Strength and Weight; Calculation of Strains and Stresses; Castings; Light Alloys; Solder- ing and Brazing; Bearings; Thrust Blocks; Torsional Strain on Shafts; Hollow Shafts; Velocities and Friction; Wire Rigging; Strength and Weight; Wood, Various Kinds, Nature, Strength, and Weight; Aëroplanes,	

FABRIC AND METAL SHEET; STRENGTH AND WEIGHT 102

		٠	4
37	•	•	•

CONTENTS.

	CHAI	PTEI	R V	III.	AIR.	·SH	IPS.			PAGE
ILLUSTRATED	TYPES	UP	то	DAT	E, F	ULL	DES	CRIPT	IVE	
DETAILS	-	-	-	-	-	-	-	-	-	117
		A	APP:	END	IX.					
Corrections	FOR LA	TITU	DE;	Таві	LES; T	rig	ONOM	ETRI	CAL	
Equivale	NTS;	DIAG	RAM	1S ;	Form	1 C	F A	ËROS	ГАТ	
ENDS; P	LOTTING	TE	MPL	ETS ;	Use	FUL	Log	ARITH	IMS	
FOR CALC	ULATIO	NS IN	г Сн	IAPTI	ERS;	Рно	TOGR	APHS	OF	
THE SANT	ros Dui	MONT	TR	RIAL	-	-	-	-	-	137

LIST OF ILLUSTRATIONS.

FIG.	Aërostat Rounding Eif	EEI T	OWED	Frant	ispiece	PAGE
I.	OSSEOUS FRAME OF BIRD'S			-	<i>-</i>	2
-	BIRD'S WING		_	-	-	3
	Ват	_	_	_	-	5
•	STAG REETLE	_	_	_	-	6
•	FLIGHT DIAGRAM -	_	-	:	-	8
_	WINGS OF HYMENOPTERA	_	-	_	-	9
	SERKIS-BEY AËROSTAT	_	_	-	-	22
•	GOWER AËROSTAT -	-	-	-	-	23
Q.	BATE'S AËROSTAT -	-	-	-	-	24
-	Dale's Aërostat -	-	-		-	25
II.	12. FRYER'S AËROSTAT	-	-	_	_	26
	GLENDINNING'S AËROSTAT	-	-	-	-	27
•	TAPSCOTT'S AËROSTAT	-	_	-	-	28
15.	SCOTT'S AËROSTAT -	-	-	-	-	29
-	WEIGHT DIAGRAM -	-	-	-	-	33
17,	18, 19. WING CURVES -	-	-	-	_	34-36
20.	WING DIAGRAM -	-	-	·_	-	36
21.	PETTIGREW'S PISTON WING	G -	-	-	-	37
22.	WALKER'S WING MOTION	±	-	-	-	38
23.	SMYTHIE'S WING MOTION	-	-	-	-	40
24.	CORNELIUS' WING MOTION	T -	-		-	41
	CAPONE'S WING MOTION	-	-	-	-	43
26.	GALLIENE'S WING MOTION	i -	-	-	-	44
27.	MIDDLETON'S WING MOTIC	ON	-	-	-	45
28.	MARSHALL'S WING MOTIO	N -	-		-	46
29.	VALVULAR WINGS -	-	-	-	-	47
30.	OSCILLATING WING MOTIO	N -	-	-	-	47
31.	RENNIE'S PROPELLER -	-	-	-	-	55
32.	ERICHSEN'S PROPELLER	-	-	-	-	55
33.	CAVLEY'S EXPERIMENT	-	-	-	_	56

LIST OF ILLUS	TRATI	ONS.			xv
FIG.					PAGE
34. LAMINATED PROPELLER	-	-	-	-	57
35. HENDERSON'S PROPELLER	-	-	-	-	57
36. VOGELSAND'S PROPELLER	-	-	-	-	57
37, 38. Boisset and Mercier's I	ROPELI	LER	-	-	58
39. WILLIAMS' PROPELLER	-	-	-	-	59
40. ALEXANDER'S PROPELLER	-	-	-	-	60
41. FÉRAUD'S PROPELLER	-	-	-	-	60
42. SCHMIDT'S PROPELLER	-	-	-	-	61
43. CHILD'S PROPELLER -	-	-	-	-	62
44. STORZ'S PROPELLER -	-	-	-	-	63
45. VOGELSANG'S PROPELLER	_	-	-	-	63
46. Adams' Propeller -	-	-	-	-	64
47. PENNINGTON'S PROPELLER	-	-	-	-	65
48. HEATHORN'S PROPELLER	-	-	-	-	66
49. RAZEAU'S PROPELLER -	-	-	-	-	67
50. OETLING'S PADDLE -	-	-	_	-	68
51. MARTIN'S PADDLE -	_	-	-	-	69
52. AËROPLANE DIAGRAM	-	_	-	-	71
53. PINAUD'S EXPERIMENT	_	-	-	-	72
54. STRINGFELLOW'S AËROPLANE		-	-	-	73
55. HENSON'S AËROPLANE		-	-	-	74
56. CREASE'S AËROPLANE	-	-	-	-	75
57, 58, 59. MAXIM'S AËROPLANE	_	-	-	- 7	6-79
60. BEENEN'S AËROPLANE	_	-	-		80
61, 62, 63. MAXIM'S GENERATOR	_	-	-	-	87
64, 65, 66. TUBULAR GENERATOR		_	_	-	89
67, 68. MAXIM'S GENERATOR	_	-	-	_	91
69. BARBE'S HEATER -		-	-	-	92
70. DAIMLER ENGINE -	_	-	-	-	95
71. KEELCOM ENGINE -	-	-	_	-	97
72. KEELCOM CARBURETTOR	<u>-</u>	-	-	-	99
73. BALANCED WING ACTION	_	_	-	-	104
74. RUDDER WING ACTION	_	_	-	-	106
75. MAXIM'S RUDDER AËROPLAN	E	_	-		107
76. STRAINS DIAGRAM -	-	_		-	109
76A.PARALLELOGRAM OF FORCES		-	-	-	109
77. PARTRIDGE'S AIR-SHIP	_	-	_		117
78. FOLACCI'S AIR-SHIP -		-	-	-	119
79. FALCONNET'S AIR-SHIP	-	-	-	-	119
86. HILFREICH'S AIR-SHIP	-	-	-	-	120
81. MOLESWORTH-HEPWORTH'S A	IR-SHI	P	-	-	121

LIST OF ILLUSTRATIONS.

xvi

FIG.				1	PAGE
82. DE BAUSSET'S AIR-SHIP		-	-	-	122
83. WORM'S AIR-SHIP.	-	-	-	-	122
84. Boisset's Air-ship -		-	-	-	123
85. Roze's Air-ship		-	- .	-	124
86. CHILLINGWORTH'S AIR-SHIP		-	-	-	125
87. MIDDLETON'S AIR-SHIP	_	-	-	-	126
88. PENNINGTON'S AIR-SHIP		_	-	-	127
89. LOCHNER'S AIR-SHIP -		-	-	-	127
90. HITE'S AIR-SHIP	•	-	_	-	128
91. Blumelhuber's Air-ship	-	-			129
92, 93. NAHL'S AIR-SHIP -	-	-	-	-	130
94. LANGLEY'S AIR-SHIP -		_	_	-	131
95, 96. Von Zeppelin's Air-ship		-	-	-	132
97. AËRAONIC AIR-SHIP	_		_	-	134
	_	_	_	137,	•
98-100. DIAGRAMS -	110	_	_		-146
101-104. SANTOS DUMONT'S AIR-SI	111			-43	-

AËRIAL NAVIGATION.

CHAPTER I.

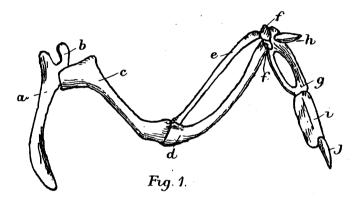
THE LAWS OF FLIGHT.

1

Fundamental Laws.—There is a certain condition of moving bodies which affords a general measure of their force. When a moving body is directly opposed by a vis mortua, such as a pressure or resistance like that of gravity, the measure of such vis mortua required to neutralise the force and bring the moving body to rest must form the basis of the measurement of the force. The problem to be assumed is, in measuring the said force, to consider in which of its different capacities is its effect to be measured. If the length of the line which the moving body describes against a uniform resistance be taken as the effect and measure of the force, the force is as the square of the velocity. Taking the resistance to be that exerted by gravity, the estimation of the force becomes definite, and is measured in terms of the square of the velocity. And a body in true flight must be capable of motion in both directions, against the air resistance in one case and gravity in the other, and the force must be continuous, as will be seen hereafter.

Natural Flight.—The method of rising and progressing in the air varies according to the requirements of the animal, bird, or insect provided by nature with

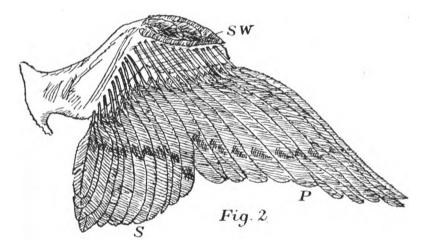
wings. Such birds as the condor (Sacheramphus gryphus) and the albatross (Diomedea exulans) are capable of extended flight, the former poising as it were in the air at an altitude of over 10,000 ft., and the latter following a ship for a thousand miles. The wing surface of these birds is oblique, so that a rapid horizontal movement is attained. This movement, being diagonal or spiral, as the case may be, carries the bird upwards, and when it drops, by partially closing its wings, it does so in a diagonal direction with great rapidity, acquiring such momentum as to carry it upwards again. And the



equipoise of the body is so sensitive, depending as it were on the fulcrum of the wings, that the long flight is maintained without an apparent flap. Soaring birds, such as the skylark, have the wings set horizontally when extended, in order to effect the upward flight in nearly a vertical direction.

The osseous framework of these wings is shown by Fig. 1. The humerus c articulates with a cavity between the coracoid bone b and the scapula a. It is directed backward in repose, approximately parallel with the spine. The humerus articulates at the opposite extremity with

the cubitus or forearm, which is composed of the ulna d and radius e, and is so jointed as to fold when at rest in a direction parallel to that of the humerus. The carpus consists of two small bones f, f placed between the outer extremity of the cubitus and the metacarpus g, which consists of two bones united at both ends. From the anterior edge of the metacarpus projects the pollex h and two digital bones or phalanges i, j. These latter are analogous to the fingers, and the pollex to the thumb of a



hand. The pectoral muscles operating the humerus are immensely powerful, extending from a deep sternum or breast bone, shaped like the keel of a ship. This qualifies the enormous expenditure of force which takes place when the body is not only supported but raised and propelled through the air. The bones of a bird are not only hollow, but in direct communication with the lungs, which admits of a constant supply of rarefied air, of less density than that surrounding it. Also the general structure affords the maximum of strength combined

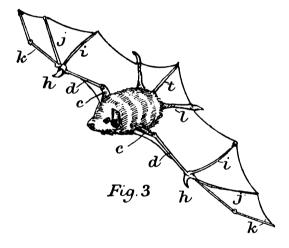
with the minimum of weight. The skeleton of a condor measuring 6 ft. 4 in. over the tips of the wings, when newly articulated, and before the moisture had evaporated, was only 9.7 oz.

Referring to Fig. 2, the arrangement of the feathers is shown, the primaries P springing from the digits i, i and the metacarpus g, as shown by Fig. 1. The secondaries S take their origin from the *cubitus*, and the spurious wing or alula SW springs from the pollex or thumb. The expansion and contraction of the muscular system, in which the primaries and secondaries are held by their extremitics, cause a semi-rotary movement to be imparted to each. feather simultaneously with the movement imparted to the humerus by the pectoral muscles. In all cases the motion due to the action of the wings must be such that the air is struck with less force during the up-stroke than during the down-stroke; otherwise the effect of the former would neutralise that of the latter. semi-rotary movement of the feathers before-mentioned causes the surface of the wing to be altered upon the upstroke, by turning the feathers so as to present the edges to the air, closing them to present a flat surface on the down-stroke. This is analogous to the movement called "feathering" in rowing, and also in using paddle wheels. Referring to the fundamental laws at the commencement of this chapter, it will be seen that the resistance varies as the square of the velocity of the stroke. Hence, if the down-stroke be made at three times the speed rate of the up-stroke, the resistance is nine times greater. as this only operates during one-third of the time, it is in effect equal to three times that which operates against the up-stroke. Therefore the alteration of the effective area of the wing at each portion of the double stroke is essential to flight.

In the case of the flight of bats (Vespertilio) the

method of varying the surface area is necessarily different, since a soft membrane takes the place of feathers.

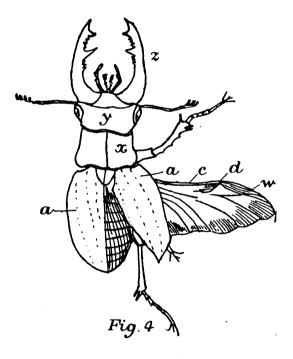
The general structure of a bat's wing is shown by Fig. 3. Here the *cubitus d* articulates with the *humerus c*, and carries the *phalanges i*, j, k and a hooked thumb h. The hinder legs l terminate in a single hooked phalange, and the tail l supports the caudal membrane, which by deflection enables the animal to steer its flight. The method of flight is to rise by flapping, the up-stroke



being made with the wing surface diminished and the membrane slackened by partial closure of the *phalanges* i, j, k, in the same manner as in the case of the flight of birds. The bat swoops downwards with extended wings, fully stretched, and by a sudden deviation ascends again diagonally, impelled by the acquired momentum of the rapid ascent. Or the animal may fly in a spiral or curvilinear direction. The sense of equilibrium is highly developed, and the darting flight is sustained for hours without the necessity for alighting.

The pterodactyl, a huge flying lizard, now extinct, had wings of this description, and its method of flying was undoubtedly the same.

The flight of insects varies somewhat, and although the power is exerted in the same ratio relatively to resistance and velocity as in the cases before-mentioned,



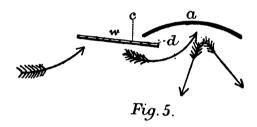
the higher velocity of displacement of air alters the conditions. When a volume of air is displaced by a series of infinitely rapid vibrations, the wave effect is that of the waves given off from the striking surface of the wing at a high velocity and the incoming waves to fill the displacement at a less velocity. Air delivered at a high

velocity in this manner partakes of the attributes of a fluid under similar conditions, that is to say, it is sprayed or atomised, and to a certain extent, rarefied. This phenomenon is of importance when studying the flight of coleopterous insects.*

Fig. 4 shows the arrangement of the organs of flight of the common stag beetle (Lucanus cervus), in which the anterior wings or elytra are corneous in structure. presenting a convex outer surface and a concave inner surface. The *elytra* a form cases for protecting the membranaceous posterior wings w when closed and in repose, and the muscles of the thorax x merely allow of opening and closing, or remaining rigid in either position. The true wing is the posterior w, and consists of two layers of thin membrane, one superimposed above the other, and covering intersecting ribs or nervures, which form the framework and the source of vibratory motion. These nervures, which to the unassisted eye appear like threads, are of varying thicknesses, the thicker nervures passing horizontally through the wing, and the thinner ones intersecting them. The upper faces of the nervures are of a horny structure and adhere closely to the upper membrane, but the under surfaces are not so intimately attached to the under membrane, and are flattened. Thus the under membrane may be separated by skilful dissection for purposes of microscopic examination. These nervures are tubular in form, tapering toward the end or edge of the wing, and within them is disposed a spiral elastic tube, with the inner end communicating

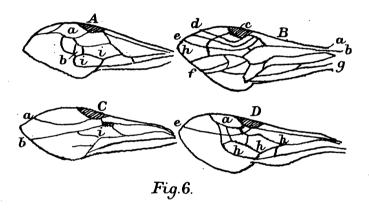
^{*} This theory of vibratory flight is due to M. Chabrier, and explained in his "Essai sur le Vol des Insectes," and carries a certain amount of probability, which has not, by reason of the extreme delicacy of such a mechanical test, been put to the proof of experiment. The subject is worthy of further research,

with the lungs, or an air vessel controlled by muscles so as to dilate or contract at the will of the insect. This spirally rolled tube constitutes a trachea. Thus the air is struck as it were by the flattened stretched surface at one period of the vibration and slackened at the other period. The terms up-stroke and down-stroke are not applicable to a vibrating surface which changes its direction and character many hundreds of times in a second of time. When we consider that the thorax x, y (comprising the prothorax, mesothorax, and metathorax) and the extended claws z are of considerable bulk, and also extend beyond the fulcrum of the wing w, it is idle to



conceive that the anterior fixed wing or elytra a is not an organ of suspension, if not of flight. It will be seen that the outer nervure or radius c terminates in a branch d, the stigma, which forms a junction with the second nervature or cubitus. Since the radius c is thicker than the other nervatures, it forms with the stigma a cup or concavity approximately fitting the edge of the elytra a. Thus, referring to the diagram, Fig. 5, in which the wing w is tense, and vibrating downwards, the direction of the air currents diverted into a is shown by the arrows, and when the wing w is slackened at the other period of vibration, the cup formed by the junction of the radius c and stigma d approximately closes the posterior edge of

the *elytra a*. We have seen that air displaced at a high velocity is subject to rarefaction, and therefore is lighter than the surrounding air. These conditions enable the rigid *elytra* to support the projecting organs. Although the coleoptera are distinguished by a trunk of considerable bulk, it is owing to its membrano-cellular structure, of extreme lightness, and the organs for the diffusion of air, permeating the whole organic formation, render this type of insect capable of a tolerable range of flight.



The wings, and consequently the conditions of flight, vary according to the general shape and bulk of the types of insects, since, in the case of the hemiptera, the elytra are semi-corneous or coriaceous, forming a vibratory anterior wing, and at the same time, by reason of their leathery structure, constituting a sheath for the posterior wing, of membranous consistence. In the lepidoptera and hymenoptera the anterior and posterior wings are alike. Referring to Fig. 6, which shows the disposition of the nervures of the wings of hymenoptera, in B the radius or chief nervure a and the cubital nervure

b join to form the stigma c. These being the primitive nervures, other lesser nervures termed brachial g, spring from the thorax towards the extremity of the wing. In B a radial nervure d springs from the stiema c to the anterior edge, enclosing by an intersecting nervure a membranous space called the radial cell a (sketches A and C). Cubital cells b and e are similarly formed. brachial nervures and their branches form humeral cells h, D, by intersection, and also discoidal cells i, A, C, and extensions of the brachial nervures g towards the posterior edge of the wing, starting from an intersecting nervure, are termed recurrent nervures f, B. Now the theory of flight in the case of such wings is upon the presumed alternation of dilation of the radius and cubitus together, and the brachial nervures together, thus forming a wave-like undulation of the surface from the anterior to the posterior edges of the wing at an approximately right angle to the longitudinal nervures. The progress of the insect during flight is, according to this theory, due to a rapid displacement of air in a given plane, the actions of rising and falling being effected by an alteration of the angle of the surface in the thoracic articulation. To describe the motion in plain language, it may be said that the wing surface rests upon a rapidly moving film of air rarefied by the velocity of impact, the rarefaction and movement being derived from the undulatory motion due to alternate dilations of the spiral internal nervures, the alternations being performed at a high velocity. its proper place it may be shown how artificial flight may be mechanically produced in exactly the same manner.

The membranous skin uniting the fore and hind legs of the flying opossum (*Pataurus sciurus*) and other socalled flying animals, simply acts as an aëroplane or parachute enabling them to drop from a height and travel across a certain space laterally whilst doing so. In the opposition of a wind current, ascension may be effected by angular steering assisted by the momentum acquired by the fall. Flying fish (*Exocetus*) are provided with extended pectoral fins which form aëroplanes, and enable them to skim from wave to wave.

CHAPTER II.

AËROSTATICS.

The Atmosphere.—The elastic medium called air forms a sheath as it were around the earth from 40 to 50 miles in thickness. Air being an elastic fluid, the particles thereof repel each other with a force varying inversely as the distance of the centre of the particles from each other. Therefore the volume and consequently the pressure depend upon each other. The law of altitudes and densities is as follows:—

Take the altitudes above the surface of the earth in arithmetical progression, the equivalent densities will be in geometrical progression decreasing.

Thus, if at a certain altitude above the earth's surface the density of the air be one-half that of the surface density, at twice the altitude the density will be onefourth of the surface density. The height is measured in these terms by a barometer, which is constructed upon the basis that the atmosphere at sea level will support a column of mercury 30 in. in height at a normal temperature of 64° Fahr. This corresponds to a pressure of 14.72 lbs. per square inch. It is necessary to consider the barometer as an instrument for measuring the height above sea level, and also of external surface The usual form of barometer used is that known as "aneroid," the action of which depends upon the variation of external pressure upon an exhausted corrugated cylinder in which nearly a perfect vacuum has been formed. An index, reading inches of mercurv. feet in height above sea level, and pressure is delicately connected to the exhausted cylinder, which expands under decreased atmospheric pressure and indicates the degrees upon the dial. Air is sensitive to variations of temperature, and the barometrical readings have to be corrected accordingly.

At the sea level the air pressure is 2119.8 lbs. per square foot, and the following table shows the decrease at different altitudes:—

Barometer,	Altitude,	Pounds,	Barometer,	Altitude,	Pounds,
Inches.	Feet.	Square Foot.	Inches.	Feet.	Square Foot.
29.5 29.0 28.5 28.0 27.5 27.0 26.5 26.0 25.5 24.0 23.5 23.0 22.5 22.0	351 872 1,340 1,802 2,273 2,753 3,241 3,739 4,276 4,763 5,291 5,830 6,380 6,942 7,516 8,103	2091.0 2055.7 2013.7 1978.4 1943.1 1907.8 1872.4 1837.1 1811.8 1776.5 1731.1 1695.8 1600.4 1625.1 1559.8	20.0 19.5 19.0 18.5 18.0 17.5 17.0 16.5 16.0 15.5 14.0 13.5 13.0	10,593 11,254 11,933 12,630 13,346 14,082 14,839 15,619 16,423 17,252 18,109 18,995 19,911 20,862 21,847 23,412	1413.2 1377.8 1342.5 1307.1 1271.8 1236.5 1201.2 1165.8 1130.5 1095.2 1059.9 1024.5 989.2 953.8 918.5
21.5	8,704	1519.1	12.0	23,874	847.9
21.0	9,319	1483.8	11.5	24,984	812.5
20.5	9,948	1448.5	11.0	26,142	777.2

The altitude may always be computed from the barometer readings according to the formula

$$477I - b \times 6.000 \times t = A.$$

Where 4771 is 30 log. and $b = \log$ of barometer reading in inches, t being the temperature correction according to the following table, and A the altitude in feet.

TABLE SHOWING VALUES OF t, DEGREE FAHR.

Degree Fahr.	t.	Degree Fahr.	t.	Degree Fahr.	t.	Degree Fahr.	t.	Degree Fahr.	t.	Degree Fahr.	t.
40	-973	64	1.000	88	1.027	112	1.053	136	1.080	160	1.106
42	.976	66	1.002	90	1.029	114	1.055	138	1.082	162	1.108
44	.978	68	1.004	92	1.031	116	1.057	140	1.084	164	1.111
46	.980	70	1.007	94	1.033	118	1.060	142	1.087	166	1.113
48	.982	72	1.009	96	1.036	120	1.062	144	1.089	168	1.115
50	.984	74	1.011	98	1.038	122	1.064	146	1.091	170	1.117
52	.987	76	1.013	100	1.040	124	1.066	148	1.093	172	1.120
54	.989	78	1.016	102	1.042	126	1.068	150	1.096	174	1.122
56	.991	80	1.018	104	1.044	128	1.070	152	1.098	176	1.124
58	.993	82	1.020	106	1.047	130	1.073	154	1.100	178	1.126
60	.996	84	1.022	108	1.049	132	1.076	156	1.102	180	1.129
62	.998	86	1.024	110	1.051	134	1.078	158	1.104	182	1.131

In this table t is determined by the sum of the lowest and highest barometrical readings. A further system for correcting inaccurate measuring is given in the tables for latitude, &c., in the Appendix.

Aerial Flotation.—A body immersed in air loses exactly in weight that of the volume of air displaced; therefore in dealing with such a body as an aërostat we have three distinct things to consider; first, the power of an aërostat to rise through the air; second, the velocity of its ascent; and third, the stability of its suspension at any given altitude, against the resist-

ance due to gravity. The aërostat, pure and simple, has an independent part to perform in all aëronautic machines, except the true aëroplanes and aëromotor planes, therefore it is worthy a detailed study. Since heated or rarefied air as a medium for filling an aërostat is not of practical utility in sustained flight of long duration, we will not occupy space with the matter, assuming hydrogen or carburetted hydrogen to be used.

Pure hydrogen (H) (atomic weight I, density I) is a colourless, odourless, tasteless gas, and is 14.43 times lighter than atmospheric air, consequently it is the best medium for filling aërostats. Coal gas or carburetted hydrogen is the next best, and varies according to the material used and the mode of its manufacture. This variation is such as to render the gas from 10 to 6 times lighter than air.

The force exerted in ascent is the excess of the weight of an equal bulk of atmospheric air above the aggregate weight of the included gas, plus the gas-tight envelope and all appendages; in other words the final power of ascent is the difference between the weight of the included gas and of that of an equal volume of external air, further diminished by the weight of the whole apparatus. Supposing the form of the aërostat to be the same in all cases, this load, as a resistance. as it depends upon the quantity of surface contained in the bag or envelope, must be proportioned to the square of the diameter; whereas the difference between the internal or external fluids, which constitutes the whole of the buoyant force, increases with the capacity of the envelope, the proportionate ratio to the cube Therefore it is obvious that however of the diameter. small the excess may be of the specific gravity of the external air above that of the included fluid, there must always exist some corresponding dimension which would

enable an aërostat to mount in the atmosphere. Aërostats are usually constructed to present a spherical form, or an elongated cylinder with hemispherical ends.*

A sphere I ft. in diameter holds 281.75 grains of atmospheric air, and approximately 21.67 grains of hydrogen, and the difference is 260 grains. That is to say, if an aërostat I ft. in diameter were to be filled with hydrogen gas, and the envelope and load together weighed 260 grains, equilibrium would be established, and it would not rise. But if the envelope and load be 100 grains, the buoyancy or flotation value would be equivalent to 160 grains. It is obvious that the efficient power of ascension, or the excess of the whole buoyant force over the absolute weight of the apparatus, would, by acting constantly, produce an accelerated motion if it were not checked, and eventually rendered uniform by the resistance or inertia of the atmosphere. If it were not for this resistance the velocity of ascent which an aërostat would gain would be in the same proportion as a falling body acquires in the same time as the efficient buoyancy is to the aggregate weight of the apparatus and the contained gas. estimate the final or uniform velocity from the following formula, in which D=diameter in feet, and P ascensional power or buoyancy in pounds, and V the ascensional velocity in feet per second, or that velocity which causes an air resistance equal to the buoyant force or flotation value. Then

$$V = \frac{40}{D} \times \sqrt{P}$$

^{*} A "prolate spheroid" affords the maximum of buoyancy with the minimum of resistance to the air (see Prolate Spheroid Table in the Appendix), and may be defined as a solid proceeding from an ellipse.

and for example, take an aërostat 50 ft. in diameter with a force P of 576 lbs. Then the equation becomes

$$v = \frac{40}{50} \times \sqrt{576}$$
, or

$$\frac{4}{5} \times 24 = \frac{96}{5} = 19.2$$
 ft. per second,

or a mile in $4\frac{1}{2}$ minutes.

The final point to be considered is the stability of an aërostat at a certain altitude, at which the forces are in equilibrium.

For purposes of calculation we assume that the atmosphere is of the same density as at the earth's surface for 26,000 ft.—that is to say, homogeneous throughout—in order to find the altitude *a* to which an aërostat will rise until the volume of displaced air equals the capacity, and is as weight to weight.

The density at altitude a is $e^{-g} a \times density$ at earth's surface (d), where e=the base of hyperbolic logarithms, and ka constant, g equivalent of gravity at earth's surface, 32.2.* Then if D=displacement of aërostat and adjuncts, and W=weight of aërostat, gas, and adjuncts,

 $W = Dg \times density of air, and$

$$= Dg\sigma.e - \frac{g}{\bar{k}}a.$$

After the altitude readings are corrected for temperature t and latitude λ , g may be corrected also, but since the error is trifling, as the radius of the earth is 4,000 miles,

^{*} If the Brigg logarithmic system be used, the result must be ×2.3026, being the reciprocal of the modulus.

and a is necessarily less than B, it may be accounted negligible.

Taking an example, air being .08073 lb. per cubic foot, and hydrogen .005592 lb. per cubic foot, an aërostat 100,000 cub. ft. in capacity will weigh with the envelope, car, passengers, and accessories about 3,000 lbs., and the gas 559 lbs. = 3,559 lbs. The air displaced is 8,073 lbs. say, and the effective difference 4,514 lbs. Therefore the altitude a to which the aërostat must rise, at which the capacity weighs 3,559 lbs., is the normal altitude, at which the ascending force is neutralised, and vertical movement ceases. Then

$$a = e - \frac{a}{26000} = \frac{3559}{8073}$$

Therefore $a = \log_{10} .8073 - \log_{10} .3559 = 21,000$ ft. About half the original quantity of gas has probably escaped when this altitude has been attained unless a suitable provision for storing it has been made. Therefore the weight 3,559 lbs. is reduced 280 lbs., and about 200 ft. is added to the altitude a. Nadar, in his large balloon "Le Géant," used a compensator, or a smaller balloon affixed to the neck of the larger balloon, and empty at starting, in order that the expanding gas may be conserved in the ascent. Green, in 1821, used a "guide, or trailing rope," which formed an automatic regulator. since when descending the aërostat was relieved of the weight, and this increased when ascending, device is also useful as a fulcrum in dirigible aërostats. in which steering is imperfectly effected by sails or rudders.

Boyle's law regarding the expansion of gases is, "The density of a gas is proportional to its pressure for the same temperature."

The temperature at various altitudes is variable for

many reasons, such as meteorological changes and the like. The following formulæ are useful for obtaining data in respect of expansion of gas:—

Let P = pressure at 30 in. of mercury.

t = temperature of gas.

V = volume of gas at 30 in. of mercury.

v = volume of gas at any temperature t.

W = weight of gas at 30 in. of mercury.

w = weight of gas at any temperature t.

p = pressure at any temperature t.

k = co-efficient of expansion with each degree of temperature = .002036° Fahr., .003665° Cent.

(a)
$$p = P(I + kt)$$
.

$$(b) v = V(I + kt).$$

(c)
$$V = \frac{v}{1 + kt}$$

$$(d) w = \frac{W}{I + kt}$$

$$(e) W = w (1 + kt).$$

Hydrogen gas varies with the method of manufacture, but when made by the decomposition of zinc by water and sulphuric acid, and the gas evolved is treated with quick or unslaked lime to eliminate the moisture, the lifting power is approximately 14.6 cub. ft. to 1 lb. in weight. And it may be assumed that 20 sq. ft. of varnished silk weighs 1 lb. In ascertaining the diameter and weight of an aërostat, let

W = total weight to be raised (aërostat included, with accessories).

w = weight of a cubic foot of air = .080728 lb.

w' = weight of the gas.

D = diameter of aërostat.

Then

$$D = \sqrt[3]{\frac{W}{.5236 (w - w')}}$$

$$W = D^{3} (w - w') \times .5236.$$

We may, from the data afforded by the formulæ given, estimate the proportions of an aërostat to suit the conditions of various cases of adaptation, and may proceed to describe and analyse the different types that have been used for experimental or practical purposes.

CHAPTER III.

AËROSTATS.

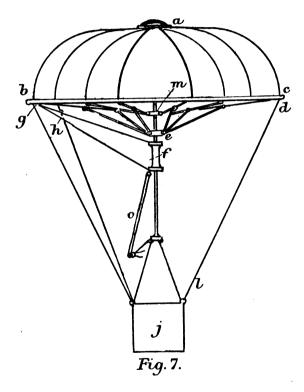
IN dealing with the subject of aërostats it is not within the scope of this work to detail the older types of ordinary heated air and gas balloons, nor the record of aërial voyages already well known to the reading public, but rather to describe the various improvements of later date.

It is unlikely that the aërostat will in the future occupy any other position in aëronautics than that of a buoyant support for motive power and steering apparatus in combination with aëroplanes and aëromotors, except for military or surveying purposes, therefore we may enlarge upon it as an auxiliary appendage in the proper place.

The Serkis-bey aërial machine is a combination of an aërostat and a parachute, and when used in the latter capacity it may to some extent be steered.

The apparatus, as shown by the elevation, Fig. 7, consists of a light framework of radial rods m, with strengthening rods attached to a collar e upon the central hollow stalk which supports the structure. The convex surface inside e is lined or covered by an impervious membrane which forms the lower part of the umbrella-shaped aërostat a, b, c. The outer rim b, c forms the supporting hoop g for the car j. When it is desired to descend, the gas is allowed to escape by a valve at a, and the envelope when wholly or partially exhausted is

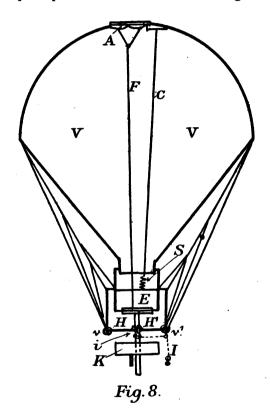
inversely compressed by the resistance of the air, and acts as a parachute. The cord or suspensory stay l,d is then tightened or released, and by thus changing the centre of gravity the envelope a,b,c is obliquely inclined, and the direction of descent may be guided or steered



by a rudder f,h controlled by cords o. If the gas is not wholly exhausted, a fresh ascent may be made by throwing out ballast, and another oblique descent effected. This is noteworthy as an ingenious device rather than a practical machine.

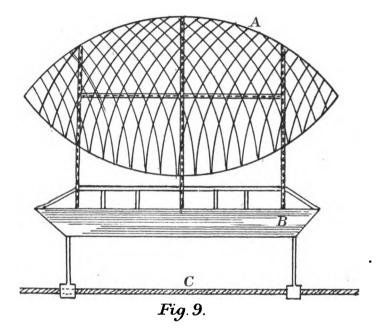
The Gower aërostat is essentially a military machine, and is designed to automatically control the elevation, and also to release explosives at a predetermined time and place.

The principal feature consists in utilising the varia-



tion of the vertical length of the aërostat as it tends to rise or fall, to open the gas valve A, Fig. 8, or ballast valve E by cords C and F respectively, and in this manner to maintain automatically the desired altitude.

A spring S is interposed in order to preserve the tension of the cord C, and so to prevent the valve A from being operated until the shortening of the aërostat V exceeds a certain amount, which can be regulated by adjusting the length of C. The discharge of the explosive body or other freight K is effected by the release, by a time fuse I, of the latch *i*, thus allowing the rods H, H' to



hinge upwards about v, v' and the suspending rings to slide off. Successive discharges may be effected by fuses of different lengths, or a number of cases may be arranged to be dispersed by the explosion of a small initial charge by the fuse.

The Bate aërostat is simply the adaptation of an aërostat to relieve the load carried by an endless rope

or chain transport way, and is shown by Fig. 9. The aërostat A supports a car B which is provided with grips for gripping the moving rope or chain C, and may cause the car B to move horizontally, and be stopped or

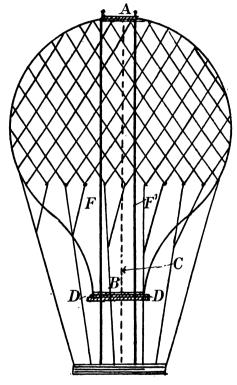
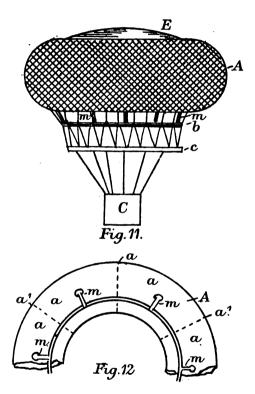


Fig. 10.

started by operating the grips. The function of the aërostat in this case is to relieve the rope C of the dead weight of the load.

The Dale aërostat is capable of conversion into a parachute, and is shown by the elevation, Fig. 10.

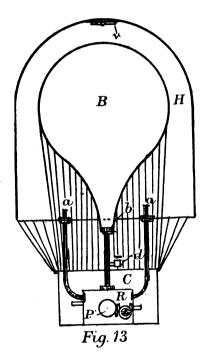
The aërostat is fitted with an upper valve A and a lower valve B, the valve A being covered on the inner side by wire netting, over which is stretched a strip of oiled silk or any other impermeable material. When it is desired to convert the aërostat into a parachute the strip is



withdrawn by pulling a cord C; the gas then escapes, and as the aërostat descends the lower half is forced into the upper half, B being guided by rollers at D, D' along vertical guides F, F'. The lower valve B may be opened or closed to regulate the rapidity of the descent,

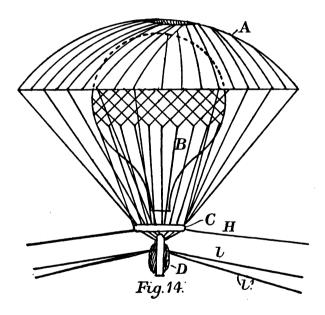
since the upper valve A is permanently open when the covering strip is withdrawn.

Sir W. A. Fryers has constructed an annular aërostat, shown by the elevation, Fig. 11, and the part plan, Fig. 12. The aërostat A is made in the form of an annulus, so that in the case of descending into the sea, the car C may



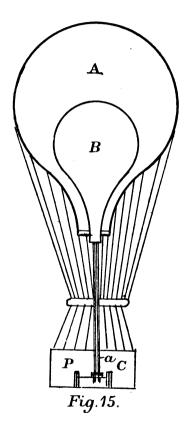
float inside the annulus, which forms a protection against the sea. It is preferably divided by partitions a' into cells or compartments a, so that if one compartment is injured by shot in cases where the apparatus is used for military purposes, or similar accidents, the uninjured compartments may sustain the car. Each compartment

a is provided with a branch pipe and valve m terminating in a common pipe b. The car C is suspended from an insulating ring c, which is in turn supported by the netting covering the annular aerostat A. A piece of waterproof fabric E is stretched across the top to act as a parachute when descending. For reconnoitring in wartime a car is suspended from C by a long cable, so that the aerostat may float at a safe height.



In Glendinning's aërostat, Fig. 13, the aërostat B is enclosed by a bag H, into which air is compressed, and supplied from a reservoir R in the car C through pipes a, a. The pressure is maintained by a pump P. Part of the reservoir R is divided so that the gas from the aërostat B may be stored, a safety valve d regulating the compression in order to protect the envelope, the neck b being closed;

a valve v at the top of the bag H enabling the air pressure to be regulated. The object of the device is broadly to effect regulation of the altitude by increasing or diminishing the surface pressure upon the outside of the envelope



of the aërostat B. The inversion of the bag H may be utilised as a parachute in descending.

Tapscott's combined aërostat and parachute, shown by Fig. 14, is devised to support life-saving appliances clear of the waves when rescuing shipwrecked persons by means of a cable and cradle or saddle. A parachute A is attached to the top of an aërostat B, and an insulating ring C is suspended from the outer circumference of A. The ring C carries the cable H, and a double sheave block D over which the life lines l and l' are rove.

Scott's aërostat (Fig. 15) is exactly the reverse of Glendinning's, before described, since air pressure is applied internally instead of externally. The outer envelope of the aërostat A is made of unusual strength, and an air bag B is fitted within it, which may be dilated or contracted by the manipulation of the pump P in the car C, and a suitable releasing valve, thus varying the buoyancy of the aërostat.

CHAPTER IV.

AËROD YNAMICS.

Air as a Medium.—Water is as a medium heavy and inelastic, and air is light and elastic. In propulsion water presents the maximum of recoil with the minimum of displacement, whilst in the case of air the conditions are exactly opposite. Therefore in constructing an aëromotor capable of practical work, the peculiar nature of the medium in which the apparatus has to float and to move by mechanical reaction calls for a structural form and adaption of motive power entirely different from that required upon sea or land. In marine propulsion, a part only of the ship is immersed in the water, and being lighter than the medium in which it floats, is enabled to use this denser element as a fulcrum from which by oars, paddle wheels, screws, or jets, to obtain the reaction necessary to move it against the resistance of the water beneath and the air above the water line. A submarine vessel, when totally submerged, presents the nearest analogy to the aëromotor in practice.

The absolutely perfect aëromotor, the air-ship of the future, must necessarily be heavier than the surrounding air. We have noted in dealing in a preliminary manner with flight in nature, that the organism of such birds, animals, and insects are comparatively light in structure relatively to their bulk, not as regards the wing area or surface opposed to the air resistance in sustaining the body at a certain altitude or propelling it at a certain

velocity. We can construct a framework of metal, and provide a prime motor, but within our closest limits we could not, weight for weight, and space for space, make an aeromotor upon the scale of the stag beetle (*Lucanus cervus*) with the same conservation of energy and mechanical action.

But it is essential that an aëromotor should have the weight much in excess of the air displaced by it when at rest. The inertia of the mass is indispensable to the control and regulation of such an apparatus, so that it may be steered and propelled in exactly the same manner and with the same facility as a floating ship in the sea.

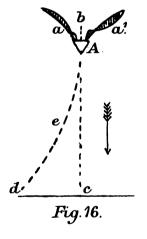
Weight.—A simple aërostat cannot be rendered dirigible by rudders or sails, since it is entirely surrounded by the medium it floats in, and is subjected to every air current in such a manner as to drift with it. Therefore, as may be seen by a weight-area table appended, the true air-ship should be of considerable weight, should start from a position of rest upon the earth by means of its self-contained motive power, and this force should propel it in any direction independently of any air currents; and at the same time the structure must be of sufficient strength to withstand the onslaught of a possible hurricane. All this is within the range of modern mechanical genius and engineering enterprise. but the one fatal objection stands in the way, and subverts the true lines of construction. This is not a scientific obstacle, but it may rather be termed a prudential one, and may be summed up by the consideration of the fallibility of all machinery, and the absolute dependence upon continuous action to prevent a terrible catastrophe in case of failure. Therefore, so far as one can foresee, the aërostat will always be an accessory to the air-ship, unnecessary in the propulsion, and a decided

disadvantage in steering, but certainly a safeguard to some extent against the worst form of accidents. It is only requisite to allow the buoyancy of the aërostat to balance the weight of the apparatus, the ascension and propulsion depending upon the motive power.

Flight may be attained by heavy powerful animals with a comparatively small wing area, there being no established ratio between wing area and weight, but an unvarying relation between the weight and velocity of motion. The following table shows the approximate area in square feet per pound avoirdupois for different types of birds and insects:—

Name.			W Squar	ing Area, e Feet per lb
Gnat -	-	-	-	40.8
Bee -	-	-	-	5.5
Stag Beetle	-	-	-	5.0
Swallow	-	-	-	5.48
Condor -	-	-	-	1.3
Albatross		-	-	1.28

The little experiment illustrated by Fig. 16 shows the value of weight as a factor in propulsion. A cork A, pointed at the lower end, and having two feathers a, a' obliquely fixed in the flattened top, is let fall from

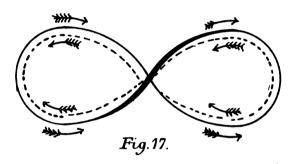


a point b, and directly by the force of gravity should descend in the direction b, c. But the falling weight causes the oblique planes a, a' to displace the air, and by rotating against the resistance compels A to describe the trajectory b, e, d.

Thus the problem resolves into the relative values of weight, power, velocity, and small surface area versus buoyancy, small power, slow speed, and extensive sur-

face area. No rule can be laid down for establishing a basis for construction. Each form or type must be calculated according to the various conditions that are to be fulfilled.

Wing Movements.—Professor J. Bell Pettigrew, in his records of experimental research, gives a theory of wing motion which is borne out by practical experiments in producing artificial wing flight in exactly the same manner in which it is performed by nature; and Professor E. J. Marey has also by means of the sphygmograph produced graphic records of the actual natural movement. Professor Pettigrew does not agree with the



theories adduced to prove the dilation and contraction of the spiral nervures, but holds that the *radius* and *brachial* nervures are operated from the thoracic articulation as ball and socket, or universal joints having such a combined movement as to cause the margin and tip of the wing to describe a figure of 8. Thus the wings obtain leverage by presenting an oblique surface to the air, the obliquity increasing behind forward and backward during extension, when a sudden effective stroke is given, and decreasing oppositely during flexion or slow return stroke. Fig. 17 shows the figure of 8 described by the tip and margin of a wing in the motion

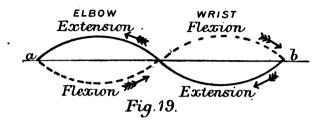
of flight. The continuous line shows the extension, and the dotted line the flexion. A second line midway

between the extension full and flexion dotted line would indicate the movements of the tip. but it is not shown for purposes of clearness. In Fig. 18 we see this movement carried out in a wave-like direction as in horizontal flight. Here a, b represent the wave crests, and c, d, e up-strokes, and f is a point corresponding to the anterior margin of the wing (radius). forming the centre of the semirotary down-stroke a, g, and g is a point corresponding to the posterior margin (brachials), forming the centre for the semi-rotary up-stroke d, f. In Fig. 10 the diagram shows the mechanical action of the muscles, in order to spread the wing in extension and close it in flexion, the arrows showing the direction.

The fact that the wing is both elastic and flexible is a necessary factor in considering its efficiency as a means for converting energy into useful work. The compound semi-rotary motion, aided by elas-

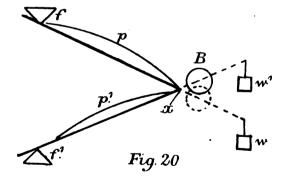
ticity and flexibility, enables the wing in performing its functions to twist and untwist by partly vital and partly mechanical means, that is to say, partly by muscular action and partly by the air resistance, the wing meets its own reverse current upon the return stroke which materially aids in the progressive flight.

If the wings were not disposed in such a manner as



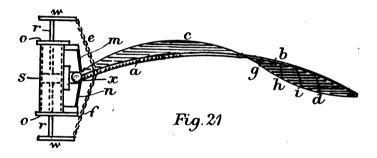
to have a semi-rotary movement on two axes (radius and brachial) with an eccentric stroke, the structure would be so cumbrous as to be controlled by the air instead of controlling it.

When the wing descends the body is slightly elevated,



that is, the wing comparatively is active and the body passive. The descending body causes the wings to elevate, the body being active and the wing passive. The muscular force of depression upon the reaction of the compressed air reverses the order. Four wings are most suitable for artificial wing flight, two on each side of the apparatus, the driving mechanism causing two to be elevated whilst two are depressed.

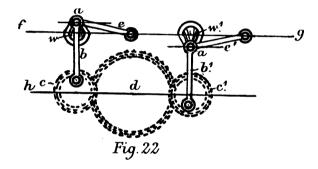
Fig. 20 illustrates the action of the wing upon the air, f, f' being the movable fulcra, or air resistance, p, p' power applied to the wing surface, B the body, and x a universal joint, w, w' being weights upon extensions of p, p'. When the wing ascends at p the resistance f retards it, and forces B or w down slightly. The opposite resistance f', when p' is on the downward stroke, similarly raises B or w'.



We come now to the production of winged flight by mechanism, to imitate nature as far as possible, and for purposes of illustration have chosen experimental subjects, some of which are capable of development for practical purposes, although hitherto made upon a small scale for laboratory experiments. Pettigrew's piston wing (Fig. 21) is an example worthy of notice, although its motion is confined to a single axis.

A curved wing c, b is supported by the radius a in a universal joint, and connected by chains e, f to the upper and lower crossheads of a piston rod r, r attached to a piston s within a cylinder o, o, two elastic bands m, n

being added, and placed so as to support the wing in its normal horizontal position when at rest. Air or gas under pressure is admitted by suitable valves alternately to the top and bottom sides of the piston s, and the reciprocatory movement thereof causes the wing to be correspondingly raised and depressed. The wing surface is strengthened by transverse bars g, h, i, d between the radius and the posterior horizontal member. Another movement adapted to the use of four wings is that employed by Walker in his experiments. The wings are operated from universal or ball and socket joints w, w',



shown by Fig. 22, these joints having their centres in one plane f, g, and a cranked extension a, a' upon the rolling part of the joint. Each crank a, a' is oppositely situated relatively to the other. Two pinions c, c' are driven by a central spur wheel d, the axes being upon the line h, i. Crank pins upon the pinions c, c' drive the joints w, w' by means of connecting rods b, b'. Thus, although the crank pins complete a whole revolution, the joints w, w' make a semi-rotation only, the dip being from forwards to backwards. This is effected by means of short links on the line f, g jointed to the crank pins a, a' at one end and to the framework at the other. Thus

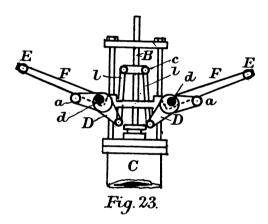
the displacement of air and consequent reaction tends to give a forward and upward movement to the apparatus, and the posterior pair of wings, by reason of the opposite movement imparted to them, continue the action of the first pair. A modification* of this arrangement provides for a rapid down and back stroke, and slow upward and forward strokes. The spur wheel d is made with two diameters, and each of the pinions c, c' similarly shaped. The larger diameter of d engages with the smaller diameter of c when that wheel is effecting the quick down-stroke, and the smaller diameter of d is simultaneously driving the larger diameter of c' whilst it is performing the slow up-stroke of the posterior wing. The arrangement is analogous to the quick return motion of an ordinary shaping machine.

In Smythie's system he employs a carriage mounted upon wheels, the wings being flapped by a steam or any reciprocating motor. The resistance of the air to the up-stroke is reduced by making the wings of several overlapping parts, and giving the shafts liberty to turn in their sockets through an angle of about 35°. Each wing may be made of a silken or linen web stretched between the tapering steel shaft corresponding to the radius, and a cord attached to a point just below the pin a, Fig. 23, the shaft being held by a pin in a tubular socket E. The cranked double lever D has within it a circular eccentric sheave with an eccentric strap carrying the end of the link F, and centred at d. The ascent of the piston rod B pulls up the lower end of D by the links l, l

^{*} The last described differential gearing was used by me to operate valvular flapping planes of large area. The automatic valvular surface was found to be a failure, even at low velocities, the undulation of the displaced volume of air in no way conforming to the disposition and arrangement of the valves.

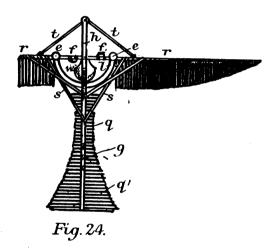
jointed to the crosshead c, the link F pulling down the tube E with a very oblique action. The shaft of the wing thus turns through an angle of 35° by the action of the air. During the descent of the piston in the cylinder C the pin a presses the tube E and link F upwards. A flat sail is used as a steering tail.

The apparatus made by Cornelius (Fig. 24) is designed to embody the mechanical principles brought into exercise in the flight of a bird, and consists in the combination of



a body capable of supporting the aeronaut with wings and tail of special construction. It is intended to utilise the atmospheric pressure by "giving to the machine a larger underneath or supporting surface than the upper surface, and the reacting motion of the atmosphere against the action of the wings; the principal feature in realising the latter effect being that such reaction shall take the same direction as that in which the flying body is to move." In flying, the wings and tail present concave surfaces backwards and downwards. The body *l*

is strapped to the aeronaut's back, and may be provided with a saddle a. The wings r, r, having ball and socket joints e, e, and handles f, f, are worked by the arms, and the part q' of the tail q is spring-jointed at g, and controlled by a cord and lever worked by the feet. Cords t, t' from a flat spring h bent overhead assist the forward strokes of the wings r, r, and the elastic cords or springs s impart a kind of feathering motion. A similar apparatus



may be provided with a motor, and attached to a car and aërostat.

It is not a practical idea to construct a machine to carry a man, and to depend upon his unaided efforts to produce the required velocity of motion and power; apart from the fact that continuous exertion is impossible owing to the muscular structure not being adapted to the requirements of sustained flight, we must consider the actual work done. Let a man weigh say 150 lbs.,

and a specially light machine 10 lbs., and the comparatively low rate of velocity be 60 ft per minute, then

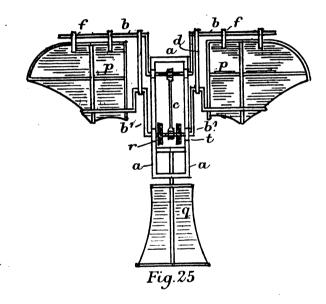
$$150 + 10 \times 60 = 9,600$$
 foot pounds

and the average work of a man is

$$\frac{33000}{8}$$
 = 4,125 foot pounds,

which is less than half that which is needed. In this instance the value of the wings as aëroplanes must be depreciated, since the sensitive anticipatory function incidental to equipoise, such as obtains with birds and other flying animals, is non-existent in man. instance, if a perfect mechanical model of a man was made in perfect proportion, and the walking movement exactly imitated, the body could not for a moment be supported upon the area of the soles of the feet. Yet in nature a man may immediately stand upon one leg, and cannot lucidly define the alteration of the equipoise nor the stages of its progress. That is because it is anticipatory, and man has it in walking perfectly, and a bird in flying, but the same sense is imperfect in the bird when walking, as in the man when attempting to fly. Therefore the basis of the apparatus for artificial flight is not to render a man capable of flying, but to construct a machine that will fly and carry a man who may control it without the necessity for an anticipatory or ultrasensitive function of equilibrium. We do not for this reason enlarge upon this type of machine, although many have been invented and tried experimentally with indifferent success, some being adapted to cycles and wheeled frames.

In Quartermain's apparatus the wings are actuated by an ordinary steam engine in which the steam is mixed with the products of combustion. These wings are balanced by springs and arranged to flap together, and are mounted on rocking shafts which are on a swivel piece, and swivel joints are introduced in the connections to the cranks, so that the plane of flapping can be altered, a special arrangement being provided for altering the front pair independently of the others for steering purposes. The wings are curved transversely, and a flexible blade runs along the posterior margin of each. They

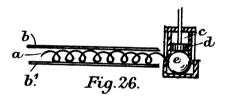


are arranged to swivel through a regulated distance about a longitudinal axis, which is nearer the anterior than the posterior margin, by which arrangement useful effect may be derived from both up and down strokes.

Capone's machine is shown in plan by the diagram, Fig. 25, in which the wings p, p are actuated by crank arms b, b' working in a frame a, and connected by rods c, d. They are freely suspended from the arms b, b by means

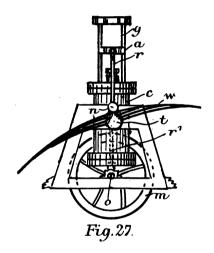
of rings f, but are independent of the arms b', which serve merely to regulate their inclination. The rear part of each wing is preferably hinged to the main part, and works against stops, so that at the commencement of the upward movement it has a greater inclination to the horizon than the wing itself. The frame a is provided with a steering tail q, and the mechanism is driven from any suitable light motor by the wheels r, t.

Upon reference to Chapter I., dealing with the membranous wings of insects, we have noted that the longitudinal nervures each contain an inner spiral trachea, and that a theory of vibratory flight due to the dilation and contraction of these trachea has been propounded.



M. Victor Galliene has experimented in this direction, as shown by the sectional view, Fig. 26, in which a is a spiral elastic tube representing a trachea, and terminating in an elastic ball or air reservoir e. This is rapidly expanded and contracted by the vibration of a piston d within a cylinder c. Two elastic membranes b, b' are stitched or sewn together in seams, so as to enclose the several trachea extending radially from the root of the wing, and operated alternately in pairs. Finely tempered steel wires of tapering form are used to impart the necessary rigidity to the structure. In the experiment there were eight cylinders, each operating the corresponding artificial nervure on opposite wings, four nervures to the anterior wings and four to the posterior.

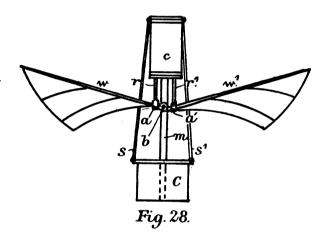
The weight of the model was 9.42 oz., and an inflated aërostat attached to the frame had a buoyancy equal to 8 oz., leaving 1.42 oz. to be raised by the wings; a small electro-motor with a rocking shaft or beam operating the pistons with the requisite progressive alternations. The power was derived from eight accumulator cells, not carried, but connected by flexible wires. The entire wing surface was 1.94 sq. ft., and the piston strokes 480 per minute. The result was to raise the machine 18 in.



from the bench, where it floated indefinitely with no progressive motion due to the mechanical effect, but very sensitive to air currents. When screened so as to be free from the effect of these currents, the movement was gyratory around an eccentric axis, which was probably due to unequal balancing. The addition of two more accumulator cells in series had no further effect than to increase the velocity of gyration. Without condemning the theory as absolutely untenable upon

the result of this experiment, it does not appear feasible that the trachea are intended to produce the movement necessary for flight, but rather that they stiffen the wing at certain periods during its stroke in order to utilise the reaction of the air displaced.

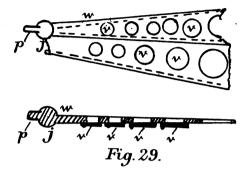
Middleton's wing motion is shown by Fig. 27, in which an oscillating cylinder c is mounted upon trunnions at t, the piston rod carrying a crosshead a within guides g. A connecting rod r couples the crosshead a with a



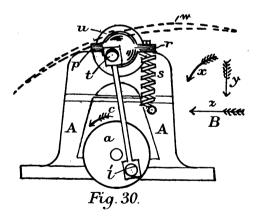
crank pin n upon a universal joint carrying the wing w, this joint being attached by its bearings to the trunnion t, so that it may oscillate with the cylinder c. A second connecting rod r' operates a crank shaft o at the base of the frame, upon which is fitted a flywheel m to secure uniformity of motion, and also to maintain the oscillation of c, which, in addition to the flapping movement due to the rod r and pin n, is necessary to produce the angular progressive action.

In Marshall's apparatus (Fig. 28) a cylinder c is

mounted upon a car C by a hollow rigid mast m and stays s, s'. The wings w, w' are jointed to the mast at b, and connected at a, a' to two piston rods r, r', which are



both attached to the same piston head. Upper and lower wings may be used, in which case the mast is



carried beyond the cylinder, and two pistons are employed. Steering is effected by a pivoted vertical plane.

In many cases valves or louvres are employed to lessen the resistance during the upward stroke, and an

example of this arrangement is shown by Fig. 29, in which the wing w is mounted upon a ball joint j with a crank pin p, and the surface is pierced for valves v hinged or freely suspended on the under surface so as to be closed by the air pressure on the down-stroke, as shown by the section. In actual practice these valves are useless.

A wing motion is shown by Fig. 30, in which a crank disc a is rotated by a suitable motor, and connected by a connecting rod to the crank pins t, t', the pin t operating the ball joint u carried by the frame A, and forming the root of the wing w. The first movement of u is rotary until the pin p is stopped by the stop on A, when the continuation of the motion is downward, as shown by y in the diagram B, the first movement being according to x, and the result of the whole as z. A spiral spring s attached to a prolongation r upon u reverses this motion on the return or upward stroke.

So far we have dealt with artificial wing propulsion briefly as according to known experiments, but in treating of aëromotors or air-ships these and other motions will be detailed, since the aërostat, aëroplane, wing and screw propeller are frequently employed one with the other, or all in combination.

CHAPTER V.

SCREW PROPULSION, PADDLES, AND AËROPLANES.

In dealing with the problem of the best mode of applying motive power to overcome air resistance, we have to consider that the displacement and reaction of a volume of air at a given velocity is essential in the first instance, and secondly the added resistance of the wind when it is opposite to the plane of motion, or as an aid to such motion when it has the same direction.

Air Resistance.—In calculating the resistance of the air as a pressure against a plane surface moved through it at a given velocity, we may deduce from experiment that the air resistance varies as the square of the velocity nearly, and to an inclined surface as the 1.84 power of the sine x cosine. The conformation of a plane surface makes no appreciable difference in the resistance, but the convex surface of a hemisphere with a surface area double that of the base has only half the resistance, hence the approximation of the true shape of the ends of elongated aërostats, or, what is still better, the employment of prolate spheroids.*

^{*} The resistance tables are based upon Smeaton's definition of Rouse's experiments, viz., an air current with a velocity of 88 ft. per minute exerts a pressure of .005 lbs. per square foot on a flat surface. Dr Hutton shows that the resistance of a sphere is $\frac{I}{2.4}$, that of a disc having the same diameter. Sir George Cayley found the resistance to a prolate spheroid, whose major axis was three times the length of the minor axis, to be $\frac{I}{4.8}$ that of a circular plate, the diameter of which is equal to the minor axis.

Let P = pressure against plane a area in square feet, and v velocity in feet per second.

Then $P = .002288 \ av^2 = \text{pounds per square foot.}$

Power.—Having determined this factor, the following table will give the relative velocities and power:—

Ven	OCITY.	Power.		
Miles per Hour.	Feet per Minute.	Horse Power per Square Foot.		
10	886	0.013		
15	1,320	0.044		
20	1,760	0.105		
25	2,200	0.205		
30	2,640	0.345		
50	4,400	1.64		
75	6,600	5-54		
100	8,800	13.13		
150	13,200	44.29		
200	17,600	105.00		

Calculated from HP = $.00000000001926 \ av^2$, varying nearly as the square.

Wind Resistance.—When air passes as a wind current into air of less density, the velocity of its passage is measured by the difference of the densities of the air in both cases.

Let D= the maximum density, and d the minimum density in inches of mercury; and t the temperature in degrees Fahrenheit at the time of passage, and v the velocity in feet per second.

Then
$$V = 1347.4 \sqrt{\frac{D-d}{d}(1 + 0.002088 t)}$$
.

And to calculate I = direct impulse in pounds per square foot.

 $I = V^2 \times .006667$ where V is knots per hour.

 $I = V^2 \times .005016$ where V is statute miles per hour.

TABLE OF VALUES OF I.

V. Miles per Hour.	I.	V. Knots per Hour.	I.	V. Miles per Hour.	I.	V. Knots per Hour.	I.
ı	.0050	1	.0067	24	2.89	24	3.84
2	.020	2	.027	26	3.39	26	4.51
3	.045	3	.060	28	3.93	28	5.23
4	.080	4	. 107	30	4.51	30	6.00
5	.125	5	. 167	32	5.14	32	6.83
6	.181	6	.240	34	5.80	34	7.71
7	.246	7	. 327	36	6. 5 0	36	8.64
8	.321	8	.427	38	7.24	38	9.63
9	.406	9	. 540	40	8.02	40	10.7
10	. 502	10	.667	45	10.2	45	13.5
11	.607	11	.807	50	12.5	50	16.7
12	.722	12	.960	55	15.9	55	20.2
13	.848	13	1.13	60	18.1	60	24.0
14	.983	14	1.31	65	21.8	65	29.3
15	1.13	15	1.50	70	24.6	70	32.7
16	1.28	16	1.71	75	26.9	75	37.6
17	1.45	17	1.93	8o	32. I	8o	42.7
18	1.63	18	2.16	85	36.4	85	48.59
19	1.81	19	2.41	90	40.6	90	54.0
20	2.00	20	2.67	95	44.9	95	58.78
21	2.21	21	2.88	100	50.2	100	66.7
22	2.43	22	3.23				

The relative kind of wind accompanying these velocities and pressures:—

			Miles per Hour.			Pounds per Foot.			
Hardly perceptible -			From	I to 2		From .005 to		.006	
Just perceptible	-	-	,,	2 to	3	٠,,	.02	to	.04
Light wind -	-	-	,,	4 to	5	,,	.08	to	.125
Light breeze -	-		,,	6 to	7	,,	. 181	to	.246
Moderate breeze	-	-	,,	8 to	9	,,	.321	to	.406
Fresh breeze -	-	-	,,	9 to	14	,,	.406	to	.983
Strong breeze -	-	-	,,	15 to	20	,,	1.13	to	2.00
Moderate gale	-	-	,,	22 to	24	,,	2.43	to	2.89
Fresh gale -	-	-	,,	26 to	30	,,	3.39	to	4.51
Strong gale -	-	-	,,	32 to	36	٠,,	5.14	to	6. 5 0
Heavy gale -	-	-	,,	38 to	40	,,	7 ·34	to	8.02
Storm	-	-	٠,,	45 to	50	,,	10.2	to	12.5
Great storm -	-	-	,,	60 to	70	,,	18. i	to	24.6
Hurricane -	-	-	,,	80 to	100	,,	32. I	to	50.2

From the above data the details may be deduced by calculation respecting the area, angles or pitch, and velocity of screw propellers, paddles, jets, and the lifting power of aëroplanes when propelled under varying conditions of the air currents. It is obvious that the structure of an air-ship or aëromotor must be of sufficient strength to withstand the onslaught of a storm, which may suddenly arise before the ordinary precautions can be taken, the premonitory signs not being apparent at considerable altitudes in the same manner that obtains at or near the sea level. For instance, when the earth is obscured a fall in the barometer may mean an increased altitude, since under these conditions the rapid changes of the instrument render it comparatively useless as a weather guide.

Screw Propellers.—The action of a screw propeller as a means of moving a body through air is analogous to that of a similar propeller totally immersed in water, allowing however for the different degrees of density between the two media, and more especially that air is an elastic medium, and water is comparatively non-elastic.

The work done in propulsion is due to the reaction of a volume of air projected backwards, which must be equal to the air resistance at the given velocity of propulsion. There occurs a negative quantity termed slip, which is approximately S = P - d where P = length of pitch, and d = distance advanced in one revolution, then S = slip in feet or other terms of measurement of P and d.

Unless the volume of air displaced be of infinite quantity, the slip is a necessary factor.

In calculating the proportions of a screw propeller, before type and form are considered, the first problem is: What is the best proportion between these and the volume of air displaced? Or in other words, the proper ratio of diameter and pitch, with a constant or varying velocity. It may be borne in mind that the weight of a prime motor generally varies inversely as the speed in revolutions per minute, and the energy of reaction of displaced air r varies as $r \times V^2$. Thus the propeller area which will propel an air-ship with a given slip ratio is directly as the air resistance and inversely as the square of the speed, and at such moderate speeds as are attainable, the same propeller area will overcome a given air resistance with a given slip ratio, and areas varying directly as the squares of the resistances. At high velocities the slip ratio increases with the given propeller area.

The maximum of efficiency is not obtained by extending the area of the propelling plane to minimise

the slip, but the slip angle that gives the maximum. The value of θ (= $\sqrt{.00047}$) which gives the maximum efficiency is the same whatever be the actual pitch angle.

The speed rule is (exclusive of slip)—

V = velocity in miles per hour. P = pitch of propeller in feet. R = revolutions per minute.

Then
$$R = \frac{88 \text{ V}}{P}$$

$$P = \frac{88 \text{ V}}{R}$$

$$V = \frac{PR}{88}$$

The pitch of screws varies as the ratio of the area of the disc or circle described by the tips to the area of the air-ship affording resistance to the air through which it passes, *i.e.*, the maximum sectional area.*

IN THE CASE OF TWO BLADES.

Ratio of disc to section is 1 to - - 6.0 5.0 4.5 4.0 3.5 3.0 2.5 Ratio of pitch to diameter of disc is 1 to 0.8 1.02 1.11 1.2 1.27 1.31 1.4

AND IF FOUR BLADES ARE USED.

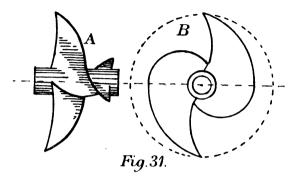
Ratio of pitch to diameter of disc is 1 to 1.08 1.37 1.49 1.62 1.71 1.76 1.89

The area depends upon (a) the shape or type of propeller; (b) the situation of it in the air-ship or aëromotor;

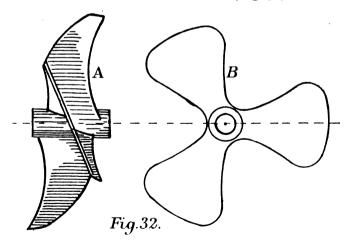
^{*} Haussmann gives as the best proportions for air screw propellers, the angle to be from 18° to 23° pitch=diameter × 1.333, the latter being for three blades, which he considers to be a preferable arrangement to one or two blades of large area, or four blades of less area. This prevents the double displacement of the volume of air, and the consequent loss of power by subjecting the surface area to air in which the density is increased by displacement, and to which the maximum velocity is already imparted.

(c) whether it is shrouded or not; and (d) how many propellers are used.

Fig. 31 shows in the side elevation A and end elevation



B the evolution of Rennie's screw propeller from Erichsen's original adaptation of a double helix (Fig. 32). Rennie

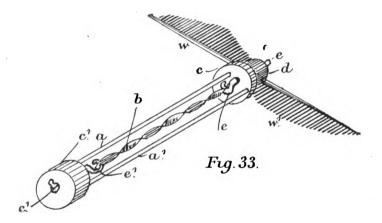


adopted an inverted cone as a basis of construction and modifications of these types.

Sir George Cayley made many experiments in the

application of an elastic screw propeller for aërial propulsion, but did not go beyond laboratory practice.

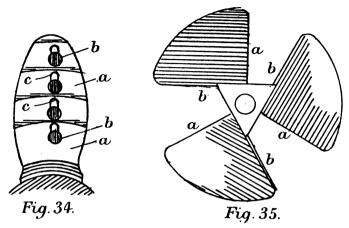
In Fig. 33 is shown one of his aeromotors, which, although a toy, serves to mark a distinct advance in the progress of this branch of science. Two corks c, c' are connected by light cane rods a, a', and a wire hook e' is rigidly attached to c'. A similar wire hook e passes freely through c, and is fixed to a cork d carrying two vanes or feathers w, w' forming the blades of the propeller. An elastic band b is stretched between the hooks



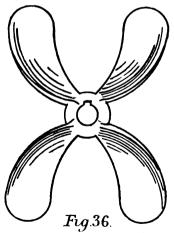
e, e', which may be wound up by twisting the propeller on d in the opposite direction to which it is to travel. When released, the tension of b causes the propeller to revolve rapidly in the right direction, resulting in a short aërial flight of the apparatus. Cayley further duplicated this arrangement by adding a reverse propeller to the hook e'.

Various types of elastic propellers have been constructed upon the lines of Erichsen or Rennie, such as that shown by Fig. 34, in which the blade is built up of

thin metal sheets or laminæ a superimposed upon each, and slotted to freely receive a stud b attached to the

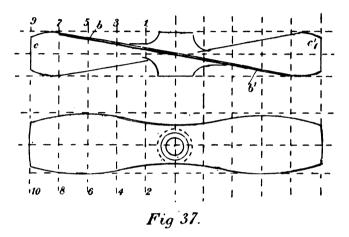


preceding plate, in a similar manner to the building up of a coach spring.

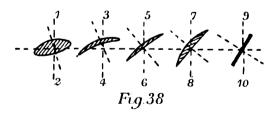


Henderson's propeller (Fig. 35) has a triangular boss, and the blades a are tangential to the boss at their lines

of attachment b. The sections of each blade a parallel to the edges follow regular parabolic or hypobolic curves, and the lines or edges b are in planes parallel to the axis, and the other edges are perpendicular thereto.



In Fig. 36 is shown Vogelsand's propeller, in which the blades are arranged equidistantly around the boss, or in pairs, each being similar to the one diametrically



opposite, but has its leading and trailing edges reversed in direction to, but similar in curvature to, the trailing and leading edges of that on either side. They are alternately bent back and forward in the plane of rotation, so that the water is thrown away from and towards the hub alternately. In the example shown, the blades may be made integral with the boss, but the design is equally applicable if they are bolted on. One edge of each blade may be straight, or partly straight and partly curved, and the other in the form of an ogee; and the pitch may be uniform or variable throughout the blade. The tips may lie in different planes, but the roots must lie in approximately the same plane.

Boisset and Mercier's screw propeller is shown by the elevations, Fig. 37, and the corresponding cross sections, Fig. 38. The efficient maximum width is estimated at one-fifth diameter at a point three-fifths of its length from the boss. The pitch is six times the



diameter, and the maximum inclination of the blade at the tip about 64° . The edges of the blades from b to b' are straight, and project beyond the boss, and the edges from b to c and from b' to c' are curved, while the tips are straight. Near the boss the propeller is convex, and becomes concave about the middle of the length, and straight near the tip, while the angle it makes with the axis increases from the boss outwards. This form of propeller in its revolution drives the displaced air toward a point in the axis about twice its diameter to the rear. It is preferable in practice to obtain the highest efficiency by using two propellers of opposite hand, arranged tandem-wise.

Fig. 39 illustrates Williams' propeller, in which the

distinguishing feature is that the blades are so constructed that the pitch increases uniformly from the periphery to the axis, where it is infinite.

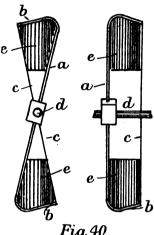
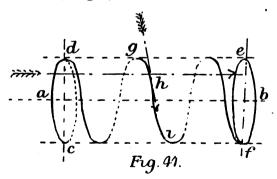


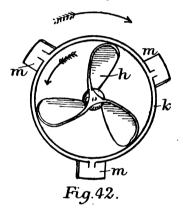
Fig. 40.

Alexander's flexible propeller is shown by the side and end views, Fig. 40. A tubular Z frame ab is



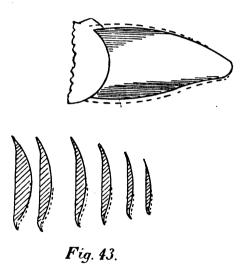
mounted upon an axis d, the ends being connected by a strong but light wire stay c, the blades e being attached to abc, and made of thin elastic sheet metal, or of fabric, and suitably curved. The device is not a true propeller, since it cannot be properly pitched, but as a light elastic impulse appliance in air it has some merit.

According to Féraud, the proper method of construction of propellers for air displacement is to set out a series of concentric cylinders as shown by Fig. 41. The concentric cylinders cd, ef have a common axis ab, which is also the centre line of the propeller shaft. Upon each cylinder is described a helix ghi of given inclination, gd being the pitch equivalent of the periphery. The surfaces between this and the axis are filled in to correspond to the curves set forth by the helices.



Schmidt uses a shrouding which has inverse blades and may revolve oppositely to the propeller proper, or may be stationary. This is shown by the end view, Fig. 42. The ordinary screw propeller h revolves in the direction of the arrow, and is enclosed by a ring k with vanes or blades m inclined in a contrary direction to those upon the propeller h. The ring k and propeller h are revolved in opposite directions at the same angular velocity, and the object of using k is to utilise the energy of the displacement of air caused by h.

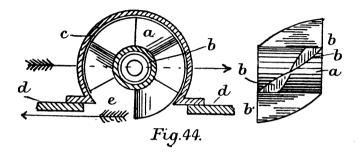
In Fig. 43 a propeller blade with "gliding lips" is shown, the invention of Mr W. Child. These lips are formed upon the leading and trailing edges of the blade as indicated by the dotted outline on the end elevation and cross sections in the figure. The circumference of the boss at its greatest diameter is equal to the pitch of the screw, and the contour is such that upon cutting it by a series of equidistant planes perpendicular to the



axis the enclosed area diminishes as the rear end of the boss is approached, on account of its increased size. This form of propeller is particularly adapted to enclosing rings or casing, both fixed and movable.

Another instance illustrating enclosed propellers is that of Storz, shown by Fig. 44. The propeller boss a is comparatively massive, and of considerable diameter relatively to the curved blades b, and revolves in a partially closed casing c, so that the skin or frame d

of the aerial machine is tangential to the boss a. The direction of the arrows indicates the direction of the air current. It has not yet been deduced from experiment or demonstration that a real gain is effected in the work



done by a propeller by enclosing it peripherally in an immobile casing. It is an undoubted advantage to obtain the full value of the reaction thrust.

This has more or less been provided for by Vogelsang,

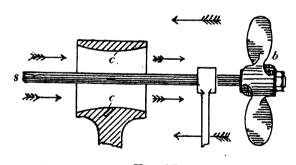
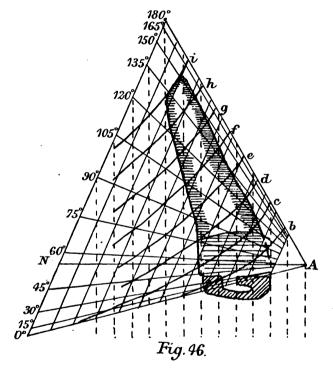


Fig. 45.

as shown by Fig. 45. Here, in front of the propeller b, revolving on the shaft s, and concentric therewith a portway mounted upon a bracket, and contracted at the central cross section c, so that the air displaced by the

revolution of the propeller b may, in rushing through the contracted portway, set up a reaction which materially assists propulsion.

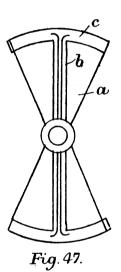
The difference in the density and behaviour of displaced air in the case of effecting propulsion by screw



propellers relatively to water as a medium has given rise to the inception of various kinds of screw to produce the required effect with due regard to the elasticity of the air. Some inventors rely upon a rigid structure, carefully plotting the curves comprised in the blades to displace, and at the same time to utilise the comparative solidity due to the reaction of the mass. Others, again, depend upon automatic adjustment according to the air resistance against some form of elastic spring, in some cases applied to otherwise rigid blades, and in others adopting an elastic structure for the blade itself upon a boss which is immobile except for its revolution upon its axis.

The construction of a screw propeller in which the face of each blade is a portion of the surface of a cone,

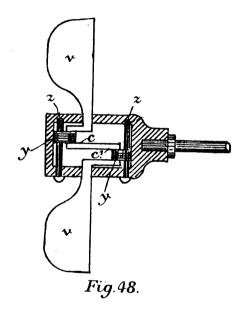
the axis of which is inclined to the surface of the shaft, is shown in setoff by Fig. 46. The pitch lines b, c, d, e, f, g, h, i are the intersections of the conical surface with cylinders concentric with the axis AN of the propeller, the relative angles being shown as from 0° to 180°. This type is generally known as the Adams propeller, and may be formed with semi-elastic blades of sheet metal pressed into shape by inverse templets constructed upon the lines set down in the diagram. Another type of semi-elastic propeller is that of Pennington and New (Fig. 47), in which a radial rib of steel b has a heavy curved head c forming the



periphery of the propeller and also acting as a fly-wheel. The surface or web a of the blade may be made of thin sheet metal, wood, or with edges of semi-elastic, light material, and filled in with fabric of some suitable texture.

An example of the mobile type of blade is that of Heathorn. The propeller blades v shown by Fig. 48 are mounted upon a hollow boss upon a shaft cranked

oppositely at c, c' and common to both opposite blades. Stout elastic bands y of rubber, or steel springs, tend to maintain by their tension the cranks c, c' in close proximity to fixed pins z, which are coupled to the cranks by the bands or springs y. The blades v thus resist the angular inclination in rotation automatically, and adapt such inclination as may be induced by the

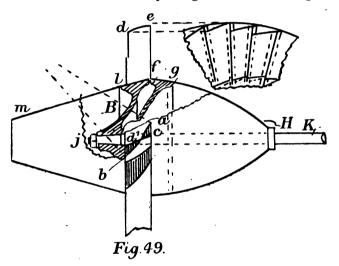


velocity. It is obvious that a considerable loss of power must result from an indefinite angle and variable pitch, especially in the case of high velocities.

Razeau's propeller is of the multivane type, and is shown by the two views, Fig. 49. A number of helical blades a, b, c, d' are attached to a large boss B on the shaft K to form the screw propeller; the outer edges of these may be free, or are attached to a conoidal ring or

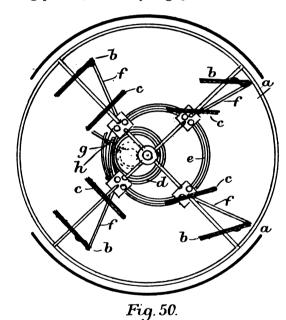
hoop de. Curved surfaces f, g, H, and l, m, are fixed to the shaft K, one on each side of the propeller, to deflect the currents of displacement to the blades, and recombine them so that all the energy due to reaction may be utilised in propulsion without undue shock due to intermittent impulse.

Paddle Propellers.—The use of paddles in aërial propulsion is not broadly advocated for the reasons that as a means of displacing air and utilising the



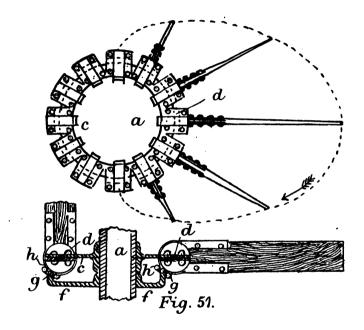
reaction of the induced currents, the necessary high velocities cannot be sustained effectively, since the feathering motion of the paddles, an essential function, at all times attended with considerable friction in the moving parts, is retarded by the action of centrifugal force upon the fulcrums of the vanes. This is negligible at low rates of speed, but as high speed is indispensable it is a decided disadvantage. An open paddle with radially fulcrummed vanes is impracticable unless the

leverage upon the axis is varied considerably during its rotation. That is to say, an ordinary feathering paddle wheel must be partially cased, or if the wheel is open the feathering action must be modified so as to reduce the radius of the leverage. Two examples are shown illustrating both methods. First, Oetling's feathering paddle, shown by Fig. 50.



In this device the wheel revolves in a partially open casing a, and the vanes b, c are pivoted upon the arms, and are feathered by turning them once about their axes for every two revolutions of the wheel. This is accomplished by means of two eccentric cams d, e, into which the inner ends of the arms f are directed alternately by tongues g, h engaging in the grooved cam

paths. The openings in the casing a may be regulated by suitable doors. In Martin's wheel, shown in elevation and plan by Fig. 51, the blades are pivoted at d to a revolving boss c, and carry riding irons g, h, which ride on a cam f, and shift the blades from the right hand in which they make their down-stroke, the propelling



position, to the left hand, or idle position, in which they make the up-stroke.

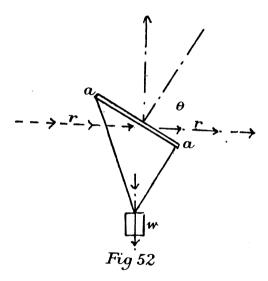
Jet Propulsion.—Many inventors have sought to effect aërial propulsion by pressure jets, of steam, gases, or the reaction of explosion. The point at which the jet issues, a nozzle, for instance, is of small area, so that the area of displacement is also small where the maximum pressure is available by impact to produce

motion. The fluid issuing from the nozzle at a high pressure expands as an inverted cone of which the apex is the orifice. The volume thus increases and the pressure diminishes in inverse ratio, thus the effective work done may be estimated by the displacement of air in proportion to the volume of the cone at the mean pressure in a given period of time. If the pressure is derived directly from a steam generator, it is a wasteful method of utilising the initial energy; and if from a storage reservoir, the waste is greater, since power has to be employed to store gas under pressure. The system is equally inefficient when surfaces are added to utilise the energy of reaction, whether with single or multiple nozzles. It is equivalent to an attempt to convert a gun carriage into a locomotive vehicle by employing the energy of the recoil due to successive discharges as a motive power. Therefore, among the many recorded but unsuccessful experiments in this direction there are none to which we can refer in detail.*

Aeroplanes.—Probably the lifting power of a kite, and the pull exerted upon the cord, originated the idea of a plane surface suitably inclined so as to rise when a forward movement is imparted to it, and maintained during the flight. It has been amply demonstrated that a suitably designed aëroplane will rise in the air, and carry its load, but no extended flights have hitherto been accomplished. There is, in such a machine, a considerable inert mass which is unavoidable, and thus

^{*} The only way in which a jet can be used with any degree of efficiency, is to employ it within a trumpeted casing so that it may, by its initial velocity, set up a lesser velocity in a larger volume of air which may appreciably react upon the surrounding atmosphere to cause motion. The analogy in this case is that of the steam pressure ejector, and not that of the oft-quoted H.M.S. Waterwitch.

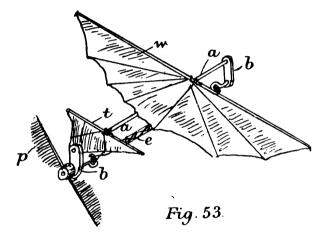
when once in the air, at the mercy of every variation of the wind currents, the maintenance of equilibrium must be automatic, involuntary and anticipatory as it were, as in the action of a man standing or walking, or a bird soaring. This attribute is yet in the future, so far as mechanical action is concerned, whether automatic or under human control. The larger motive aëroplanes have been provided with a railed track, to attain the



required velocity previous to actual flight. An upper rail restrains the tendency to premature ascent. No provision has been made as yet for descent in the open country or elsewhere, nor is the direction of motion capable of being diverted far from the point from which the wind is blowing. We shall presently find, when dealing with the construction of an air-ship which alone renders aërial navigation possible, that the aëroplane, if

impracticable as a means for flight used alone, is a valuable accessory to the air-ship.

Before entering into the subject of the aëroplane and its development, it will be well to consider the action of the wind upon an inclined surface at rest. Referring to the diagram, Fig. 52, let a be an inclined surface at rest, r the wind pressure, w a suspended weight, and θ angle of inclination to the wind, and p pressure of wind per square foot at normal, *i.e.*, if the



surface was directly opposed to it instead of being inclined. Then the resultant pressure per square foot on the oblique surface P is—

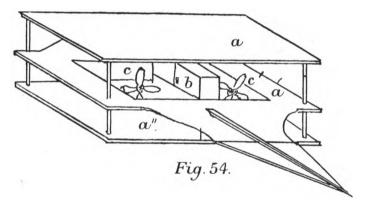
$$P = p \times \frac{2 \cos \theta}{1 + \cos^2 \theta}$$

and $p = .005v^2$ in miles per hour, or $p = .0023v^2$ in feet per second.

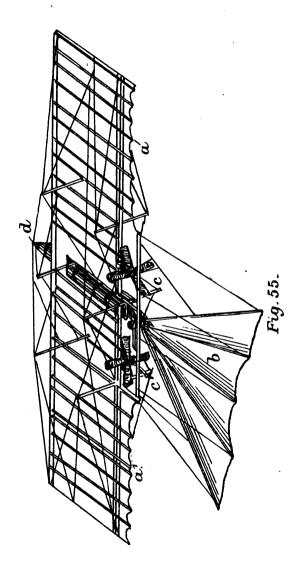
So the value of the lifting power upon w may be calculated if the area of the plane a is defined in square feet, or the weight of w in pounds if it is raised.

M. Pinaud carried out many experiments in motive aëroplanes, one of which, a toy, is a modification of Sir George Cayley's device shown by Fig. 53. An aëroplane w and tail vane t are attached to a frame a, between the ends b, b' of which is stretched a twisted rubber band e, which, when wound up in tension, rotates a propeller p, affording a sustained oblique flight.

Mr Wenham devised a multivaned aëroplane, in which the lifting vanes were superimposed upon each other similar to a set of bookshelves. This doubtless

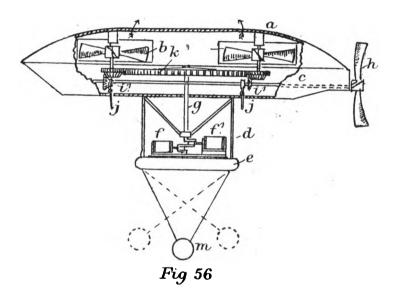


has developed into the "box" kite in use for military purposes. Stringfellow improved upon this apparatus in 1868, adding motive power and screw propellers, and his machine is illustrated by Fig. 54. The planes a, a', a'' are superimposed as in Wenham's device, and the generator and motor b fixed on the lower plane a'', the propellers c, c' revolving through spaces formed in a', which also carries the prow and tail vanes. The total weight was only 12 lbs., inclusive of the water required to generate the steam, although the power developed was 1.3 H.P. A trial took place at the Crystal Palace

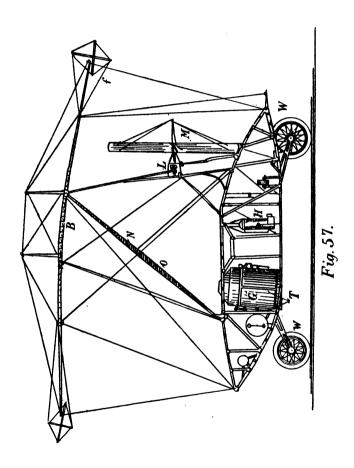


under the auspices of the Aëronautical Society of Great Britain, and Mr Stringfellow obtained an award of £100 on account of the lightness and efficiency of the motor apparatus. The apparatus ran upon an extended wire, and although the machine travelled at a high rate of speed, it did not leave the wire.

Henson at the same time made a large aëroplane



shown by Fig. 55, in which the horizontally extended planes a, a' were 40 ft. from end to end. A cigar-shaped car d carried the motive power apparatus for operating the screw propellers c and also the aëronaut. Steering was effected by a tail vane b, and broad-tyred wheels were fitted below the car to carry it while the initial velocity was attained previous to ascent, and also to facilitate landing when descending. This made several



flights of short duration, but was generally a failure for the reasons we have previously explained.

In Crease's aeroplane the lifting planes are merely adjuncts, the actual lifting being accomplished by screw propellers with vertical axes. This device is shown by Fig. 56, in which an aeroplane a has a light framework covered by fabric. A deep keel i supports a tubular platform or car d having a hollow base e for storing the liquid fuel or gas under pressure. Two motors f, f' on the platform d drive a vertical shaft g which transmits the power by means of a spur wheel k and pinions to two propellers b, over which two orifices are formed in the fabric of the aeroplane for the emission of the displaced air. A stern propeller h controlled by clutches f, f affords horizontal propulsion, and steering is effected by changing the position of the balance weight m as shown by the dotted lines.

Sir Hiram Maxim has carried out extensive experiments in dirigible aëroplanes, and in the course of developing his ideas, has been successful in producing effective motors and generators of extreme lightness and portability, which will be noted under the head of Motive Power in a succeeding chapter.

In one of Maxim's machines (Fig. 57) the aëroplane B is trussed and stayed with wires, and covered on both sides with fabric, which is stretched tight on the under side, and is perforated for the air to pass through, so that the weight is supported by the top surface. The lifting planes N are arranged step-wise as shown, and made long and narrow, and in some cases hollow to form a surface condenser, and are supported by bowed tubes O, carrying the exhaust steam and condensed water. The motor L drives the propeller M by steam pressure from a generator G. A vaporiser H is connected to a suitable burner T under the generator G. The whole is supported

when at rest upon wheels W, and steered in flight by sail rudders f fixed on pivots to B, fore and aft.

In another machine, constructed by Maxim, and shown by Fig. 58, the main aëroplane a is pivoted upon a vertical support b^2 carrying a car b mounted upon wheels f, and the inclination of a may be adjusted and regulated by suitable ropes, pulleys, and a winch. Wings may be attached to a to which a downward motion is automatically imparted by the impact of the wheels f

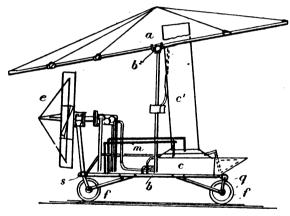


Fig. 58.

upon the earth in descent, the arms q being connected to drums s for that purpose. Light screw propellers e are rotated by engines driven by the pressure generated in a boiler or other generator e, a chimney e' carrying off the products of combustion, pipes m conveying the vapour or gas under pressure to the engines. A supplementary condenser of the flat film type is added to the tubular framework, and by its structure may form part of the sustaining planes of the apparatus.

Sir Hiram Maxim has further modified his aëroplane

in the manner shown by Fig. 59, in which the machine is supported in the air by two large screw propellers, one upon each side, driven by nearly vertical shafts. One of these screws C^1 is shown in the elevation. It is four-bladed, and is of small pitch. The shaft b is slightly inclined from the vertical in a forward direction, and is driven by the four-cylinder steam or gas engine D. The blades of the screws are stayed so as to automatically diminish the pitch as the air pressure below them increases. The leading edges of the screws C^3 are stayed to a fixed

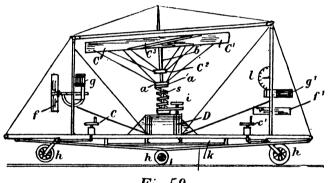
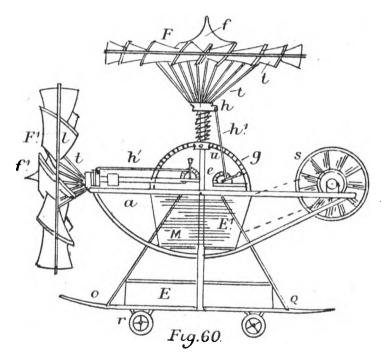


Fig. 59

collar C^2 upon the shaft b, and the rear edges to a sliding collar a attached by a spring s to the bearing collar, and controlled by a hand wheel i. The frame is mounted upon three wheels b, the leading and trailing wheels being adjusted in height by means of hand wheels c, c'. In addition to the large screws already described, the machine also carries two smaller screws f, f', one in front and the other behind. These are mounted with their motors g, g' on trunnions, so that the screens may be either lifting, lowering, or propelling, and are preferably, like the lifting screws C^1 , made of a light metal frame-

work, and covered with strong fabric. In starting the machine it is run forward upon the wheels until the screws C^1 exert their effect in lifting the apparatus, and act in the manner of aëroplanes or wings. The loose collar a and spring s admit of a feathering action by presenting the least surface in front. Rolling is counter-



acted by the automatic action of a weighted pendulum which cuts off the motive fluid from the engine on the rising side, and giving a full supply to that upon the lower side. Fore and aft balancing is effected by a sliding platform controlled by a hand wheel. The motors D have four cylinders arranged in pairs opposite

one another and driving cranks at 180° , so that with a four-stroke cycle an impulse is obtained every half revolution. The motors are preferably driven by acetylene, which is stored in reservoirs k and mixed with about $\frac{1}{50}$ by volume with acetone or acetic ether to produce a mixture which can be kept liquid at a lower pressure than acetylene alone. The tubular framing may be utilised as a condenser.

Beenen follows this mode of construction in the apparatus shown by Fig. 60. Two cars E, E' are used, the former for passengers and the latter for carrying the motor M (not shown). A lifting screw F and horizontal propelling screw F' are adapted to the frame, and driven by suitable gearing by the motor. The machine is steered by means of a fan or propeller s. The shafts of the lifting and propelling screws F, F' may be inclined so as to allow the screw F' to assist in lifting, the collar u being adjustable around the quadrant g. The screws F, F' are constructed with a hollow conical centre f, f', and a ring of vanes made concave on the pressure side are pivoted in radial bearings. The inclination of these blades l can be adjusted by rods t joined to a sliding collar h, the position of which can be regulated by a sliding collar h, rod h', and handle within a suitable quadrant. Wheels r and runners o are provided to facilitate movement upon the ground in ascent and descent.

Davenport constructed an aëroplane shaped like a bird, the body being the car, and carrying the motive power apparatus. The wings were rigidly attached to the body, and of great superficial area. The wings were strongly made in two layers superimposed with a space intervening. The lower surface was of open framework, carrying a number of fans with vertical axes, and driven by the motor through bands, or rope gearing. The upper surface was slotted and provided with valves at

close intervals, which closed automatically by pressure underneath, but freely opened under top external pressure. A large tail vane effected the vertical and horizontal steering, and the mode of progression was to ascend vertically, and glide forwards and downwards, and this process being repeated, propulsion was effected.

The aërocurve is a formation of the aëroplane proper, in which the latter is stepped into a series of curvilinear surfaces, derived from a cissoid, the upper or passive surface being parallel to the asymptote thereof. It is a complicated and somewhat expensive mode of construction, but when the opposing angle is between 7° and 15° at a velocity of 88 ft. per minute, the retardation due to the shape and angle gives a lifting power of .00397 lbs. per square foot, and proportionately according to v^2 .

CHAPTER VI.

MOTIVE POWER.

In dealing with the subject of motive power, we must bear in mind that the construction of any motor, generator, and storage apparatus must afford the maximum of effective power at a high rate of speed, and the minimum of weight. We may divide the various types suitable for the purpose under the following heads, viz., vapour engines (explosive), such as petroleum and other internal combustion motors; steam engines (water or spirit vapour), generators, electric motors and accumulators, and motors operated by compressed air or gases stored in reservoirs.

Fuel.—In the first place, we may compare the value of fuels as adapted for storage, consumption, and application to aërial navigation. Coal and solid fuels are not adapted to close storage, and the calorific power is far below that of liquid fuels. The three units of heat now in use are the B.T.U. (British thermal unit), being the amount of heat required to raise I lb. of water I° Fahr. This unit is in ordinary acceptance in this country, but to facilitate general research we may give the equivalent values of the P.C.U. (pound Centigrade unit), the amount of heat required to raise I lb. of water I° Cent., and the cal. which is the amount of heat required

to raise I kilogram of water I° Cent. The conversion factors are—

Convert B.T.U. into P.C.U. × 0.555

" B.T.U. " Cal. × 0.252

" P.C.U. " B.T.U. × 1.8

" P.C.U. " Cal. × 0.3423

" Cal. " B.T.U. × 3.968

" Cal. " P.C.U. × 2.921

The combustion of a hydrocarbon occurs when the temperature is sufficient for the heat evolved to produce luminosity, and complete combustion takes place when the highest point of oxidation is reached. Incomplete combustion is shown by unconsumed by-products, and the escape of the gaseous residue at a low degree of oxidation. For instance, the by-products should consist only of water and carbon dioxide (CO₂), and the result of inefficiency is the presence of soot as a solid carbon by-product, and free hydrocarbon or carbon monoxide (CO) as a gaseous by-product.

The following table shows the values in B.T.U. of various fuels and constituents, upon the basis of Pullen's calculations:—

Solid Liquid or Gas.	Atomic Weight, H=1.	Density, Pounds per Cubic Foot.	Specific Heat, Constant Pressure.	Specific Heat, Constant Volume.	Molecular Weight, H ₂ =2.	B.T.U.
Air		.0809	.2377	. 1690		
*Carbon	11.97	108.7	.2411		• •••	14,540
Carbon dioxide -		. 1225	.2164	.1535	CO ₂ .43.9	
Carbon oxide -		.0784	.2479	.1758	CO.27.9	4,370
Coal gas		.0335	•••		•••	17,800
Hydrogen	1.00	.0056	3.404	2.414	H ₂ . 2	61,260
Nitrogen	14.01	.0784	.2440	.1730	N ₂ . 28	
Marsh gas		.0448	.5929	.4701	CH4.15.9	26,400
Olefiant gas -		.0784	.404		C2H4.27.9	21,300
Oxygen	15.96	.0896	.2182	.156	O ₂ .31.9	
Steam, 212° -		.05	.4750	.34	H ₂ O. 17.9	
Sulphur	31.98	. 127	.2026		S2.63.9	4,000
Sulphur dioxide -		.1792			S ₂ O.62.9	
Petroleum, refined		52.61				22,000
,, crude		54-3			•••	20,000

^{*} This applies to approximately pure carbon—graphite.

Petroleum in most of its many forms has theoretically, weight for weight, 33 per cent. higher evaporative value than the best steam coal. Its useful effect is 15 per cent. greater than that of anthracite, which is the best known kind of steam-raising coal, since petroleum can be reckoned as 75 per cent. efficiency instead of 60 per cent. So, to sum up, petroleum may, weight for weight,

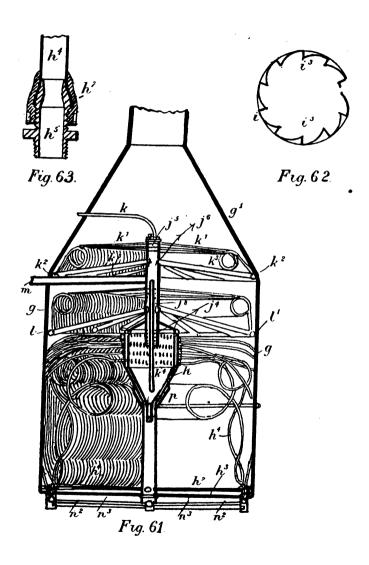
be practically considered as from 63 to 75 per cent. higher than the best coal.

The following table shows the comparative values of petroleum, fuel, and coal:—

FUEL.	Specific Gravity, 32° Fahr.	B.T.U.	Evaporation Pounds Water at 212° Fahr.
Best steam coal	1.380	14,112	12.16
Refined petroleum	0.928	17,832	17.10
Caucasian heavy crude	0.938	20,850	17.30
Caucasian light	0.884	22,027	22.79
American crude	0.886	20,736	21.48

Therefore we may assume that for purposes of aërial navigation liquid petroleum fuel will be preferably used.

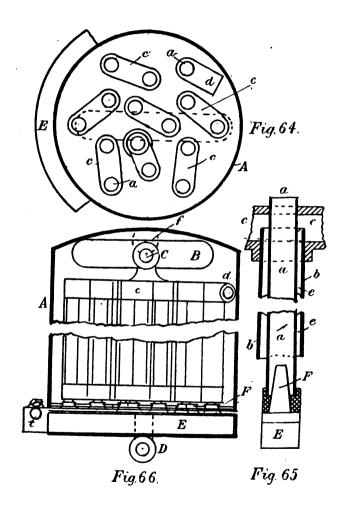
Generators.—The requirements of the equipment of an air-ship demand the maximum amount of power with the minimum of weight, therefore the tubular form of construction appears best to meet the circumstances. A relatively small and continuously injected volume of fluid and a restricted steam space renders the generator rather a rapid high-pressure gas producer than a steam boiler. Sometimes a volatile liquid is employed, the boiling point of which is less than that of water, and the tubular structure of the frame of the aërial machine is utilised as a surface condenser, with an auxiliary condenser if necessary. The disadvantages are in the difficulty of efficiently packing the glands and stuffing boxes of the moving parts, the vapour being extremely rarefied, and permeating freely what would be a steam-



tight joint; and the leakage is also attended with danger, as its admixture with atmospheric air is highly explosive. If, on the other hand, absolutely pure or distilled water is not maintained in the circulating system, scaling takes place to the detriment of the tubes, and the nature of the construction does not allow of any cleaning process but by the use of a chemical solvent, which is in itself a source of degeneration.

We can, within the limited space afforded, only give examples of the best generators suitable for the purpose, making no comparisons advocating or depreciating any particular design.

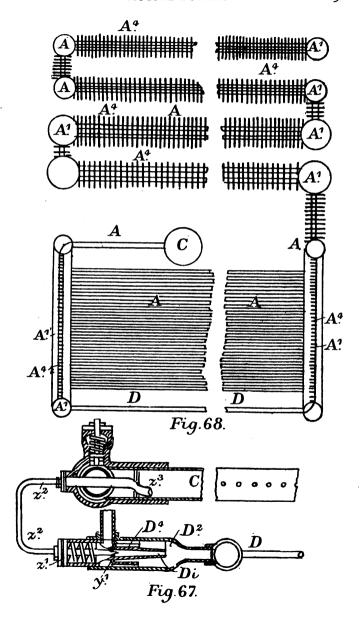
Maxim's generator is shown by Figs. 61, 62, and 63. The medium may be water, or gasoline or other liquid hydrocarbon that is volatilised at a low temperature. This is supplied through a feed pipe k to the boiler g, leading through a chamber j^5 , pipes k^1 , k^2 , k^3 , a chamber j^6 , and pipes k^4 to the bottom of a central chamber from which it forces by induction the re-condensed vapour into the heating pipes h^2 above the heater n^1 , n^2 , n^3 . The vapour passes from the annular pipe h^3 through tubes h^4 into the annular space between the chamber h and the central chamber i, from whence it passes to the latter chamber tangentially through suitably formed orifices i^3 , Fig. 62, to chamber j^4 , pipes l, l^1 , l^2 to another chamber j^8 , from which it passes to the engine by the steam pipe m. The tubes h^4 are connected to the pipe h^3 and chamber hby specially constructed unions, consisting of a conical screwed nipple h^5 , Fig. 63, and a corresponding nut h^7 . The tubes n^1 , n^2 and deflectors n^3 of the burner are made of nickel or an alloy of nickel and iron. The supply of gas or vapour is regulated automatically by the boiler pressure or by the temperature, the latter of which acts by the expansion of water in a chamber p, forming an annular jacket to h. The heating surface in this type of



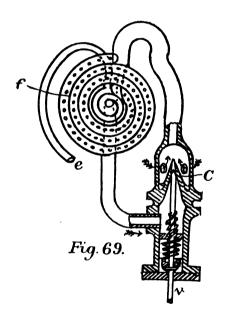
generator is very great, and consequently the liquid and steam spaces are restricted, requiring a constant feed.

Another generator, preferably for water produced steam pressure, is shown by Figs. 64, 65, and 66. is the combined result of several inventions, and therefore cannot be classed as a distinctive apparatus. consists of an outer shell A, at the base of which is a hydrocarbon vaporising chamber E provided with a number of Bunsen burners F. A number of tubes b are fitted with specially constructed tee unions c at each end, so that a uniform fluid circulation may be obtained from the inner to the outer ring of tubes. Central tubes a pass through the middle of the outer tubes, and also through the unions c, and these form the outer tubes of the Bunsen burners F, the heat from combustion passing through and heating the inner surfaces of the tubes a, and being diverted by diaphragms or baffle plates (not shown) passes downwards, thus heating the outer surfaces of the tubes b before passing to the atmosphere by the orifice f. The system is kept full of fluid by a constant and regulated feed at D, the steam passing from d to a steam reservoir or holder B, from which it is taken to the engine by the steam pipe C. Thus the annular capillary space e between each inner tube a and outer tube b presents a large surface for heating a comparatively small volume of fluid. The liquid hydrocarbon fuel is supplied under pressure to E by an inlet t. The drawing, Fig. 65, being to a larger scale, illustrates the arrangement of the two tubes.

Another form of generator designed by Maxim is shown by Figs. 67 and 68. This consists of a large number of thin metal tubes A of small diameter, connected with larger tubes A¹ forming headers or water chambers, and arranged in tiers as to the upper part, but entirely surrounding the furnace at the bottom. The



tubes are furnished with ribs or wings A⁴ for facilitating the transfer of heat. The headers A¹ are divided so that the water which is forced in by pumps follows a sinuous course from the cooler to the hotter portion of the furnace, and finally delivered into a steam drum C completely vaporised. The capacity of the generator is sufficient for effecting a few strokes of the engine only,



and the circulation of water is provided for by the exhaust, which is condensed and used continuously. The generator is heated by liquid or gaseous fuel, which with the water is supplied by a combination of pumps in predetermined relative proportions. The burners, shown detached in section by Fig. 67, consist of a series of perforated tubes D into which the fuel is forced along

with air by an injector Di, of which the fuel admission valve Y^1 is controlled by a thermostatic regulator. The air is admitted through openings in the casing at D^4 , and the fuel after passing through a heat vaporiser is forced through the injector nozzle D^2 by a pump. The thermostat is fixed within the steam drum C, and consists of a closed tube z^3 containing a suitable liquid, and communicating by a pipe z^3 with a diaphragm z^1 . The valve Y^1 is operated by the movements of the diaphragm z^1 against a coiled or spiral spring.

Barbe's heater is shown by Fig. 69, and is designed for liquid hydrocarbon fuel with any kind of generator having a large heating surface. The liquid enters by the pipe e and is vaporised at the centre of the burner, and passes in regular quantities through the injector C, controlled by the valve v, to the spiral tubular burner f which is perforated. A lamp or any suitable device is employed for igniting the jets.

Internal Combustion Engines.—These may be defined as engines in which the liquid hydrocarbon is vaporised within the engine, the supply being regulated with a corresponding air supply, forming an explosive compound when ignited by an electrical high-tension spark or heated tube. Hydrocarbons of low-flashing points are preferable in point of economy, but there are legal restrictions as to storage and transport in respect of public safety generally which militate against their use. From the heavier petroleum products we get a wide range of hydrocarbons, as the following table will show, the normal paraffins being specified.

Definition	n.		Symbol and Boiling Point.	Nature.	
Methane -			CH ₄ Gaseous	Gas.	
Ethane -	-	-	C_2H_6 ,,	Gas.	
Prophane -		-	C ₃ H ₈ ,,	Gas.	
Butane -	-	-	C_4H_{10} 1°	Solvent for resins.	
Pentane -	-	-	$C_5H_{12} \ 38^{\circ}$,, ,,	
Hexane -	-	-	C ₆ H ₁₄ 70°	Illuminant and	
Heptane -	-	-	C ₇ H ₁₆ 99°	motive power.	
Octane -	•	-	C ₈ H ₁₈ 124°	Motive power.	
Dodecane -	-	-	C ₁₂ H ₂₆ 202°	Vaseline.	
Hecdecane	-	-	C ₁₆ H ₃₄ 278°	Paraffin wax.	

Benzol, C_0H_0 , is obtained either synthetically by heating acetylene, C_2H_2 , to nearly a red heat, or by the destructive distillation of coal. Its boiling point is 80.5°, and it is frequently used as a liquid fuel, either alone, or in combination with other hydrocarbons.

The internal combustion oil engine, therefore, takes the liquid hydrocarbon, vaporises it by heat, mixes the air, compresses and ignites for an impulse to be given. There are many kinds of vaporising devices, which may be distinguished as—

- (a.) Hydrocarbon liquid injected into a reservoir chamber, and mixed with the proper air supply therein by a spray, before admission into the cylinder.
- (b.) Liquid injected into a small chamber with part of air supply, the rest of air entering the cylinder by

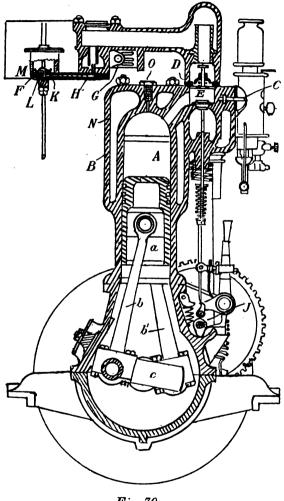


Fig. 70.

another valve. Therefore the contents of the vaporiser are inexplosive until after admission to the cylinder.

- (c.) The same as (a), except that no air-spraying nozzle is used.
- (d.) The liquid is injected directly to the combustion chamber, and there vaporised, and air is drawn in by the piston through a separate valve, and mixed in compression.

The Hornsby-Akroyd engine is constructed upon this principle, and although in practice this engine gives excellent results, the piston area is relatively large, probably by reason of the imperfect admixture of gases.

When considering the calorific values of liquid hydrocarbons used in this way, we must note that in the exhaust a volume of water is produced by the union of H and O, according to the weight of the percentage of hydrogen in the mixture. This amounts to a little over I lb. weight of water per pound of liquid hydrocarbon. The heat thus carried away must be deducted from the computation of the thermal value of the fuel.

There are many light motors of this type now in the market, but we can point out amongst them a few of the best adapted for the purposes of aerial navigation.

The Daimler engine, shown in section by Fig. 70, is of the two-cylinder vertical type. The liquid hydrocarbon is forced into the float chamber F by pressure applied to the reservoirs containing it in bulk. When starting the motor the air is pumped into the reservoir, but after running for some little time, a part of the exhaust serves to keep up the necessary pressure. Either ignition tubes heated by a lamp or electric spark ignition may be used.

On the down-stroke a slight vacuum is formed in the cylinder A. The valve E is held in place by a spiral spring, is operated automatically, and when open allows air to enter through the grating C and along the hori-

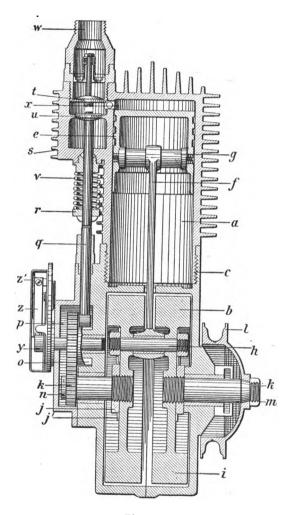


Fig. 71.

zontal pipe to E, and by thence to the cylinder. At the same time the liquid hydrocarbon is sucked through the nozzle at H, and mingles with the air in the cylinder to form the charge. On the up-stroke the compressed mixture is ignited at C, and a fresh impulse imparted to the piston a, and the exhaust released by the exhaust valve at E being actuated by a "hit-or-miss" striker worked by a cam I. The cylinders are water-jacketed at B. The connecting rods b, b' and crank c are shown in position. The Diesel engine is an improved device, since the charge of hydrocarbon is not introduced until the full charge of air has been compressed sufficiently in the cylinder, so as to be ignited directly the addition of the hydrocarbon completes the mixture. A corresponding test of a 20 H.P. Daimler engine by M. Holbert and 20 H.P. Diesel engine by Professor Schorter shows the relative efficiencies.

Daimler 20 H.P. engine—Diameter of piston, 8.5 in.; stroke, 12 in.; speed, 200; brake horse-power, 16.9; indicated horse-power, 24.8; petrol, .053 lb. per I.H.P.

Diesel 20 H.P. engine—Diameter of piston, 9.8 in.; stroke, 15.7 in.; speed, 163 revs.; brake horse-power, 18.84; indicated horse-power, 26.31; consumption of hydrocarbon per I.H.P., 0.40 lb.

The Keelcom motor, with its special spray carburettor, is another excellent type of engine, having automatic action, and especially adapted for aërial navigation. The motor is shown in section by Fig. 71, and the carburettor by Fig. 72.

Referring to Fig. 71, a is the cylinder attached to the neck of the crank chamber b by screws c. The crank chamber b is made in two parts, and held together by bolts. The piston is shown by e, piston rod f and its fulcrum g, and the crank pin h. The cranks and flywheel discs i are secured to the crank shaft j by nuts j¹ and locking plate j². On one end of the crank shaft

j the driving pulley l is fixed by a key and nut m, the other end of the shaft carrying a pinion n gearing with a wheel o of the half-speed gear of the ignition device. To the wheel o is fixed a cam p, operating the stems q and r of the exhaust valve. The combustion chamber s contains the inlet valve t and exhaust valve u, v being the spiral spring controlling the exhaust valve. The inlet port is shown by w, and s is the combustion port to the cylinder. On the outer end of the shaft carrying

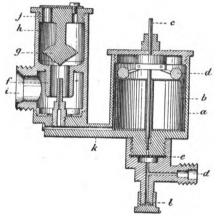


Fig. 72.

the half-speed gear wheel o is fixed a cam y which operates the contact breaker z forming part of the electrical ignition z^1 . The carburettor is shown in section by Fig. 72. A float chamber a contains a float b, through which passes the needle valve c, the latter being held off its seat by the counterbalances d. The petrol inlet d^1 is covered by the wire gauze strainer e, and f is the spraying nozzle, g the atomising cone, h the mixing chamber, i the hot-air inlet, j the suction regu-

lating port, and k the connecting neck, l being a nozzle and cap for cleansing purposes.

These engines are compact, and work well and economically at high rates of speed, but as yet no certified test has been made. The choice of a suitable motor depends upon lightness relatively to power, and the comparative weight of fuel to last a reasonable time.

Electrical Motive Power. — There are scores of light motors of high efficiency especially adapted to aërial propulsion, but the storage of electrical energy is up to the present time prohibitive on account of the great weight to be carried, and the absence of convenience for re-charging except at certain places, unless accumulators of sufficient capacity for an out-and-home charge are provided. This may be obviated if a system of aërial navigation was once established, because every city or town of any importance would have a special charging station. It must be remembered as a set-off to the weight of the accumulators that no intermediate gearing is required between the electric motor and its work, since the propellers may be proportioned to the speed, and this again regulated within certain limits according to the design and winding of the motor.

In calculating electrical power we take E to be the potential or electro-motive force, and C the current or flow in ampères, using simple phraseology. Then

$$E \times C = W$$

where w means work or electrical energy in watts. Then

$$\frac{W}{746}$$
 = E.H.P. (electrical horse-power).

Assuming then that 10 E.H.P. is required for five hours, say at an E.M.F. of 120 volts and 62 ampères.

10 E.H.P. =
$$\frac{120 \text{ E} \times 62 \text{ C}}{746} = \frac{7460}{746}$$

Then as each accumulator cell is equal to 2 volts, 60 cells of the lightest pattern are required, and these weigh, inclusive of the electrolyte (sulphuric acid diluted 1 to 11), 68 lbs. each, or 4,080 lbs. or 2 tons with accessories, and with 19 plates will give a discharge of 300 ampère hours. Compare this with the steam or hydrocarbon engine, taking a mean of the former at 0.9 lb. per horse-power per hour, and 0.8 lb. per horse-power per hour for the latter. When an efficient substitute for lead of much less weight is found to produce the same storage effect by electrolysis, electricity will be found to be the form of energy best suited to air propulsion, but no advance in that direction has hitherto been successful.

But in cases where several propelling shafts are to be driven by the prime motor or engine, and these have their axes arranged in several planes, no more efficient intermediate gear can be devised than a dynamo generator driven by the engine shaft, and operating motors to rotate each propeller independently. In this respect, light, compact, and efficient propelling mechanism may be made by the proper utilisation of electrical energy.

CHAPTER VII.

STRUCTURE OF AIR-SHIPS AND MATERIALS.

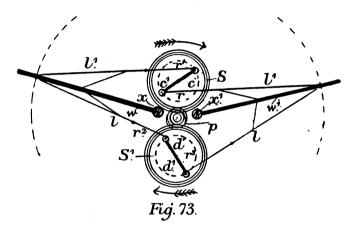
WHEN we review the march of scientific knowledge and practical development that renders the elements subservient to advancing civilisation, we cannot see a single instance in everyday life that has not been built up of failures. The fast express trains, ocean greyhounds, telephony, telegraphic systems, and the thousand and one improvements that contribute to our daily wants. owe their origin not to one, but to many inventors. Some are in advance of the time for the actual demand. others fail, others concentrate all their mental energy on this failure, and master it, to fail in some other point. And so the wheel of time rolls on; new brains with better auxiliary appliances come upon the scene, and at last man is the conqueror, and the result is then merely competitive as to details and efficiencies, the basis of success being attained. The inventors who, if they failed individually, contributed to the grand attainment collectively, their names are recorded in sand. We have reached a stage now in aërial navigation in which engineering skill and forethought can suggest the best structure for lightness and strength, and more especially the materials best suited to the purpose.

Models.—Working models are delusive unless they are made for a practical purpose in a practical manner. Of what use would a model of an automobile omnibus car be if made exactly to scale and about the size of an

automotor tricycle. The true demonstration would be to build the tricycle as a tricycle, and suitably equip it as such. Suppose a model was made of a large ocean liner 600 ft. long upon a scale of $\frac{1}{4}$ in. to the foot, say $\frac{1}{\sqrt{3}}$ th full size, and to demonstrate by that model what could be done upon a larger scale. Here the model would be 12.6 ft. in length, 1.9 ft. midship beam, with a depth of 2 ft. Here the low-pressure cylinder of one of the twin screw engines would be 2.75 in. in diameter, and the high-pressure cylinder 0.87 in., and the boilers and fuel spaces equally useless, although strictly to scale. Would it not be better to consider the model as a launch, engine it as such, and demonstrate it as a successful launch, but not as a sample of what an ocean liner fortyeight times its size should be. As a matter of fact, the ocean liner is far more efficient than a small launch could be.

The waste and leakage incidental to machinery and friction do not increase proportionately to the size and power. Therefore, if an air-ship be made to carry two persons, it should be clearly understood that the calibre and structure are suited to such a load, but a ship to carry one hundred persons would be a specially constructed apparatus, not following the lines of the first with proportionate dimensions. Let the demonstration be regarding the model, if so considered, that two persons can be carried by vertical and horizontal propulsion through the air at a certain speed, and it is fair to suppose that a more efficient apparatus may carry one hundred persons, the whole structure being designed with that object alone.

An automobile car may be correctly defined as a substitute for animal power for drawing loads and passengers. It is, however, obvious to the merest tyro that to adapt the mechanical power derived from the motor to a set of artificial legs is not to efficiently carry out the required object. Therefore our substitute takes the form of wheels mechanically driven from the axis. A continuous rolling motion is sustained by the motive power, resulting in progression upon the surface of the ground against the resistances of a load and of traction, in contradistinction to the pedaneous movement of animals. No analogy can be instituted between these mechanical functions, except in that the same duties are fulfilled in both cases. Again, the propulsion of a



ship is in no way analogous to the invisible darting movements of the bonito or the dolphin. We do not intend to assert that wings are not suitable to the mechanical movements derived from motors, but that such a mode of artificial flight must, to be effective, be supplemented by the screw propeller. Some engineers have pronounced against the possible use of wings upon the grounds that the strains and stresses set up by unbalanced forces in the application of sufficient power to effectively act upon the comparatively large surface

would prove immediately destructive to the apparatus. A reference to Fig. 73 shows that the forces need not be unbalanced if the vertical motion is produced and sustained by the wings, partly flapping, and partly as an aëroplane, the horizontal progression depending upon a propeller or propellers.

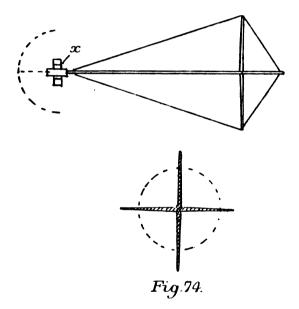
Let w, w^1 be the wings, jointed at the fulcrums x, x^1 , and p a pinion driven directly by the motor, and gearing with two spur wheels S, S¹ of equal diameter. c, c^1 is a pair of opposite cranks on S, and d, d^1 a similar pair on S¹, the latter effecting the downward stroke, and that of S the corresponding upward stroke. The wings are linked to the connecting rods r, r^1 , r^2 , r^3 by means of plate links l, l^1 , and the surfaces are plain or may be valvular, opening upon the up-stroke and closing upon the down-stroke. As a lifting and soaring mechanism this has a greater efficiency per square foot per H.P. than a rotating propeller or set of propellers, yet for horizontal propulsion the latter is without doubt the best mode of utilising power.

Adverting to the subject of sensitive equilibrium, it is obvious that a large air-ship is less sensitive than one of smaller calibre, in the same degree as an eight-oared outrigger is to a yacht. The control is not necessarily anticipatory, it becomes a method of steering, and can be automatically effected by a suitable gyrostat. Also while an aërostat forms part of an air-ship, the equilibrium is more easily maintained.

The aërostat, without departing from the range of foresight incidental to common-sense, will not eventually form any part of the structure of the practical air-ship. The want of confidence in entrusting life and property to suspension in an unstable element by reliance upon the fallibility of mechanism will keep the aërostat for some time until security is assured, and the contempt born of

familiarity prevails. It will not disappear at first, but will be used to render the comparatively heavy structure more buoyant, and so will die away by degrees, unless used for towage, and the flotation of loads.

The steering of an air-ship is an important feature bearing upon its general structure. The steering has not only to be operated from side to side, but also up-

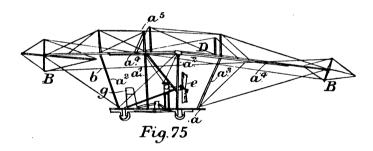


wards or downwards. The only effective rudder is shown by Fig. 74 in plan and cross section, x being a gimbal fulcrum, and the dotted outlines the directions of motion.

The area of each plane should be one-third that of the total area of the ship. The steering may be better controlled by small electro-motors operating worms or endless

screws and toothed quadrants, the current being derived from a small dynamo-generator driven from the shaft of one of the propelling motors. A pair of two-way switches may thus constitute the steering board, upon which will also be fixed the aneroid barometer, magnetic shielded compass, thermometer, hygrometer, and clinometer.

Sir Hiram Maxim has adopted such a pair of rudders to one of his recent aëroplanes, Fig. 75, which it may not be out of place to describe fully in connection with the tail vanes or rudders B. The frame is built up of two main side trusses a, a^1, a^2, a^3, a^4 , and the framework is also



provided with tubular struts, braces, and guys, and a^1 and a^3 are extended above a^4 so as to allow of the suspension of pivoted auxiliary wings or vanes, as at a^5 . Longitudinal stays or wires support the main aëroplane D. Tail vanes or rudders B are pivoted at each end of a^4 , and tied together by crossed wires b, and are operated from the platform by cords and winch, or a piston and cylinder. Means are provided for the adjustment of the inclination of the aëroplane. Two screw propellers of light and elastic formation, e, are driven by twin engines operated by pressure derived from a steam generator g of peculiar construction. The

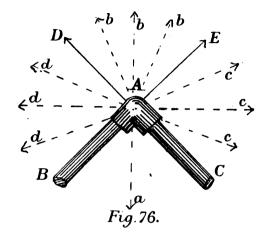
medium is the vapour of gasoline or other easily volatilised fluid, which may be condensed after exhaustion by the exposure of the surface of the tubular framework to the atmosphere, from which it is returned to the generator by the feed pumps. The platform or car is supported by wheels when upon the ground to facilitate the ascent and descent.

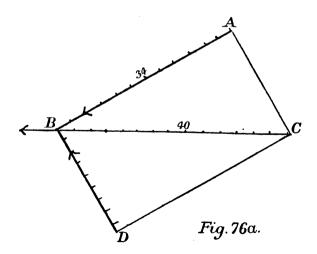
Having thus considered as far as possible the general details, we may deal with the structure of any air-ship, taking the suitable materials and application of them in due order.

Framework.—We see, since the adoption by the public of cycles and autocars to such an extent as to create a separate branch of manufacture, that tubular frames have reached the highest point of efficiency, which is the attainment of the maximum of strength with the minimum of weight.

The "modulus of rupture" is eighteen times the load that is required to break a bar I in square cross section, supported at points I ft. apart and loaded in the centre, and the following table gives the values in tons per square inch, according to Rankine and Clark's tests:—

Material.								Modulus Tons per Square Inch.
Steel tube	•	-		-	-			20 to 28
Wrought-iron l	oar	-	-	-		-	-	20 to 21
Riveted tubes,	plate	iron	-			-	-	13 to 15
Plate beams			-	-			-	18 to 20
Cast-iron bar	-	•		-	-	-	-	13 to 15
Cast-iron tube	-		-	-		-	-	II to I2
Wood-Red pi	ne	-		-	-		-	3 to 4
Spruce	fir	-	-	-		-	-	4 to 5
Larch	-	-				-	-	2 to 4
Saul	٠,	-	-	-			-	7 to 10
Teak	• 3	•	•	•	•	•	-	6 to 9





And the corresponding weights of drawn steel tube, suitable for framework, are here tabulated according to pounds per lineal foot per gauge:—

Bore in	THICKNESS OF METAL IN PARTS OF AN INCH.									
Inches.	Inches.	1 16	18	1 ³ 6	ł	5 T 0	23 8	7 1 6	1/2	
1	.098	.21	.5	.9	1.3	1.9	2.5	3. I	3.9	
38	.118	.3	.7	I. I	1.6	2.3	2.9	3.8	4.6	
1/2	.178	٠4	.83	1.4	2.0	2.7	3⋅5	4.3	5.3	
5		.46	1.1	1.6	2.3	3.1	3.9	4.9	5.9	
3 4		.54	1.2	1.9	2.6	3.5	4.5	5.5	6.6	
1		.7	1.5	2.4	3.3	4.3	5.5	6.7	7.9	
114		.87	1.8	2.9	3.9	5.2	6.4	7.8	9.3	
1 1/2		1.0	2. I	3.3	4.7	5.9	7.4	8.9	10.6	
2.0		1.4	2.8	4.3	5.9	7.6	9.5	11.3	13.2	

In polygonal framing, in order to determine the character of any strain, we will suppose AB and AC (Fig. 76) to be any two bars of a frame. Produce the lines AB, AC, to D and E. Let a represent the direction of the load if it passes in any direction between B and C, or b if it passes in any direction between D and E, c if between E and C, or d if between B and D. Then a will be in compression on AB and on AC, and b will be in tension on AB and AC, c will be in tension on AB and in compression on AC. The resultant strains may then be computed in numerical value by constructing a parallelogram of forces, as Fig. 76a.

Let AB and BD be two forces, strains, or loads, be measured off to any scale according to the known value,

and the direction in which they tend. Join DC and AC parallel to AB, BD. The diagonal BC then represents the resultant, in direction and value when scaled off corresponding with AB, BD.

Castings.—For lightness and strength all joints for framework should be made of one of the aluminium alloys of either of the following grades:*—

Co	omposition per ce	Strength,	Elongation	
Aluminium.	Copper.	Zinc.	Tensile, per sq. in.	per cent.
5.8	67.4	26.8	95.712	1
3.3	63.3	33.3	85.867	7.6
3.0	67.0	30.0	67.341	12.5
1.5	77.5	21.0	32.356	41.7
1.5	71.0	27.5	41.952	27.0
1.25	70.0	28.0	35.059	25.0
2.5	70.0	27.5	40.982	28. 0
1.0	57.0	42.0	68.218	2.0
1.15	55.8	48.0	69.520	4.0

* A binary aluminium alloy containing 7.5 per cent. of tungsten has recently been put on the market, gives a tensile strength of 15 tons per square inch, the specific gravity being 5.58. A ternary alloy, Wolframinium, contains 98 per cent. aluminium, 1 per cent. tungsten, and 1 per cent. copper; specific gravity 2.74, tensile strength wrought 15 tons per square inch, cast in chills 12 tons, rolled or drawn 22 tons. Romanium contains 1 per cent. tungsten, 1 per cent. nickel, and the specific gravity is 2.75. It is harder and possesses greater elasticity than the former alloys, and takes tooling better than Heroult aluminium.

Magnatium.—This is an aluminium-magnesium-antimony alloy, tensile strength 14 tons per square inch, specific gravity 2.52+0.03. It may readily be integrally joined by soldering or semifusion, analogous to welding, and is in great demand in Germany in automobile car frames.

The first composition shows the best result, and its weight per cubic inch is 0.2873 lb. In casting it flows well, and gives a sharp clean casting, and is best made by adding the aluminium to the copper after the zinc has thoroughly melted and combined with it.

Aluminium solders may be made by melting 20 parts of aluminium and adding 80 parts of zinc, and when both are mingled add some Russian tallow, stir with an iron rod before casting into sticks. The flux is 3 parts copaiba balsam, I part Venice turpentine, and half a teaspoonful of lemon juice.

For blow-pipe soldering the following is the best composition:—

Alumin	ium	-	-	-	-	20 part	S
Copper	-	-	-	-	-	10 "	
Tin	-	-	-	-	-	60 "	
Silver	-	-	-	-	-	10 "	
Zinc	-	-	-	-	-	3 0 "	

Bearings.—The most important bearings are the thrust bearings of the propeller shaft. These should be made so as to run in an oil bath, and have thin radiator plates cast around it to dissipate the heat generated by friction. If the thrust be upwards, as in vertical propulsion, the outer shell of the jacketed casting should be cast with lugs on it to which may be attached the carrying stays, strong spiral springs being interposed to prevent excessive vibration, and to neutralise shocks. A guard plate with a collar on the shaft should be added above the thrust bearing, with separate stays to prevent accidents if the thrust should give way. The pressure on the thrust bearings may be estimated at 60 lbs. per square inch.

The external diameter of the collars should be as D+D 0.23, and the number of collars proportioned directly to the load W in pounds, A being the total bearing contact area of the collars.

$$A = \frac{W}{60}$$
 and $\frac{A}{n} =$ area of

one collar, n being the number.

The ordinary high-speed engine bearings have a pressure of 200 lbs. per square inch, and the length should be D4.3 to D6 for shafts from 2 to 1½ in. diameter, and D3 as a standard from 3 in. diameter upwards.

Shafting.—The diameter of mild steel shafting in inches is calculated from

$$D = 5^{3} \sqrt{\frac{HP}{V}}$$
 where $V =$

revolutions per minute. This formula shows that the greater the velocity, the less torsional strain is imposed, and hollow shafts resist torsion better than solid ones of the same area. The weight w in pounds per lineal foot is

$$w = D^2 \times 2.647$$

and for hollow shafts the lesser diameter is deducted—

$$w = D^2 \times 2.647 - d^2 \times 2.647.$$

The distance between bearings where no work is taken off the shaft, b being in feet—

$$b = 5^{\circ} \sqrt{D^2}$$
 (D in inches).

Wire Stays.—Wire rope and single strand stays are best made of Delta metal, No. 1 alloy, since by the following comparison the tenacity is good according to

test, and since a smaller diameter may be used to resist a greater strain than is the case with iron or steel wire, with the further advantage of being non-corrosive under atmospheric changes, it may be used for aëroplane, wing, and rudder rigging.

A comparative table gives the tenacity in tons per square inch:—

Metal.				Tena per S	city in Tons Square Inch.
Delta metal, No. 1	-	-	-	-	48
Delta metal, No. 2	-		-	-	41
Manganese steel -	-		•	-	38
Nickel steel -	•	•	-	-	34
Aluminium, 1 per c	ent. bronze	-	-	-	35

The weight of Delta metal is 0.3236 lb. per cubic inch, therefore the weight is

 $D^2 \times 9.24 \times 0.3236 = w$ in pounds.

Wood.—In the construction of air-ships a certain quantity and quality of wood must be used, and there are various kinds suitable for special purposes, among which we may instance:—

Ash, for elasticity, but not good for weather alternations. American varieties are best.

Beech.—The white variety admits of thin division.

Wych Elm.—Especially suitable for steam bending.

Rock Elm (American).—Closer grain, and better to work.

Oak.—Durable in exposure to weather; light, hard grain, but works well. On account of the tannin contained, it must not be used in contact with iron.

Plane (Sycamore).—Works well, very durable.

Willow.—Suitable for friction pieces—brake blocks, sheaves, &c.; the weight per cubic foot being given in order to facilitate calculation.

	Woo	D.		Specific Gravity.	Pounds per Cubic Foot.	
Ash -		-	-	-	800	50
Beech -		-		-	690	43.12
Wych elm		•	-	-	570	35.62
Rock elm	-		-	.	671	41.93
Oak -		-	-	-	872	54∙5
Plane -		-	-	-	623	38.93
Willow	-	-	•	-	486	30.37

Aeroplanes and Aerocurves.—When these are made of fabric, yacht duck may be employed if a broad mesh about 8 in. pitch of No. 18 S.W.G. Delta metal wire is used on the back surface against the pressure. The ends of the mesh should be twisted and soldered around the bolt ropes or wires forming the hemmed edges. The weight of a square foot of undressed duck canvas is .0512 lb., and fine sail canvas is .0678 lb. per square foot; pegamoid, .1032 lb. per square foot; sylamoid (deteriorates rapidly when subjected to heat), .0785 lb. per square foot. For gas envelopes undressed Tussore silk weighs .0175 lb. per square foot, dressed .048 lb. Urtalaine, a fabric made of Rhea fibre, similar to silk, but weight for weight of less tenacity, .03986 lb. per square foot dressed. Calico, dressed, .0598 lb. per square foot.

If sheet metal, such as aluminium, be used, the

following	table	gives	the	weight	per	square	foot	in
pounds, ro	lativel	y to th	e gai	uge :				

B.W.G.	Thickness, Inches.	Pounds per Square Foot.	B.W.G.	Thickness, Inches.	Pounds per Square Foot.
28	.015	.20	22	.029	-39
27	.018	.24	20	.035	.47
26	.020	.27	18	.048	.68
25	.021	.28	16	110	.83
24	.025	•33	14	.080	1.07
23	.028	•34	12	.109	1.49

From the data given as to suitable materials, strength and weight, with a reasonable design in view which may be practically applied, an air-ship may be constructed, always bearing in mind that the dimensions requisite in order to successfully carry I ton are not to be considered as a unit that has but to be doubled in every particular in order to carry 2 tons, and the same reservation equally applies to velocities. And hitherto we have presumed a still atmosphere, but the structure should be designed and proportioned to withstand the strains and stresses imposed by a gale of wind, plus the contained power to sustain a reasonable speed under the circumstances.

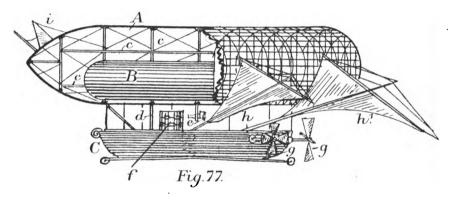
This points at once to the greater efficiency to be attained by air-ships of greater calibre, relatively to the best work of the one or two passenger air-yachts.

CHAPTER VIII.

AIR-SHIPS.

In this chapter we propose to treat of air-ships as combinations of aërostat, aëroplane, and propelling apparatus, dealing with all the best experimental types categorically without reference to the merits of each.

It is, however, worthy of remark, that Mr J. M. Partridge in 1847 invented and made an air-ship which

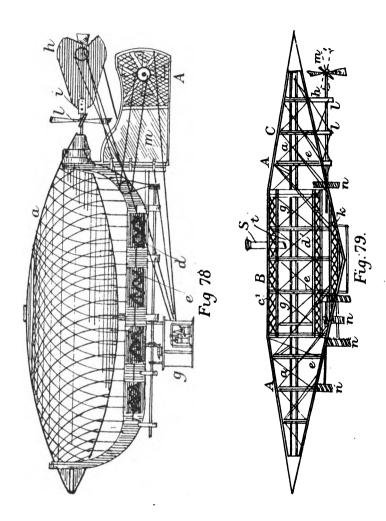


he termed "Pneumadrome," and made several successful flights, the steering, however, being imperfect. Many valuable points of his invention have lain dormant for fifty-five years, to be resuscitated as chief and prominent features in our latest practical development of aërial navigation. Partridge, however, had neither oil engines, aluminium, nor pure hydrogen available in his day. This air-ship is shown by Fig. 77.

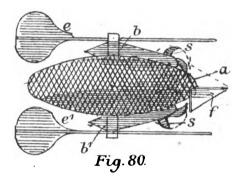
The aërostat A is formed upon a light frame consisting of rings, held together by longitudinal bars c, and trussed to equalise the strain. The fabric was drill canvas, treated with caoutchouc in solution, and weighed I lb. per square yard. An internal air-bag or envelope B was controlled by a valve and pump e in connection with the generator f. A head sail i and stern sails h, h' had braces and halliards for steering. The car C contains the motors, and the apparatus was driven by three propellers g, of which only two are visible. The body of the aërostat was covered by a light wire netting, in addition to that carrying the car, and the sails h, h' acted as aëroplanes as well as for steering purposes. The air-chamber B fully compensated the variations of gas volume and pressure in A, and this, with other parts of the structure. have been utilised in later machines.

Folacci and Bertius' air-ship is shown by Fig. 78, in which the aërostat a is provided with a deep under-hung keel d in which horizontal propelling screws e revolve in casings. A rudder m has a cased propeller A, and a tail rudder i has another cased fan h, and both rudders may be moved laterally to effect horizontal steering. The mechanism is driven by a motor in the car g.

Fig. 79 illustrates Falconnet's air-ship, in which two hollow cones A, A abut against an intervening cylinder B, the whole constructed on one frame of steel tubing, strengthened and stayed by double braced trussing c', d', ties g, and stanchions e. The shell of the aërostat is made of very thin metal, or fabric rendered impervious to gas and water, and is divided by partitions into subsections a, having manholes, gas supply, and exhaust pipes with stopcocks arranged for filling or exhausting any of the chambers independently. The double trussing d' forms the roof of, and supports the engine-room and cabin k, which is partly within and partly extends



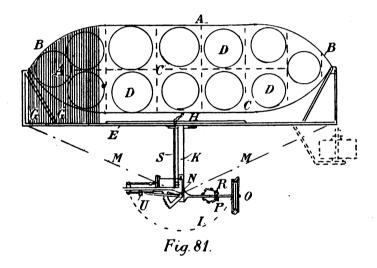
below the structure of the air-ship. A chimney s is provided to carry off the products of combustion and foul air from a vertical uptake t. The cabin is formed with sharp ends to reduce resistance, and also has suitable doors and windows. Horizontal longitudinal shafts carry propellers n, with an after propeller m which may be moved by universal joints in any direction for steering, and effecting horizontal or vertical deviations in the direction of flight, the brackets l being properly constructed for this purpose, the dotted outline l showing such deviation.



The Hilfreich air-ship (Fig. 80) is shown in plan, and the aërostat a is elliptical in shape, and supports two cars b, b' connected by a transverse gangway (not shown). It is propelled by two feathering paddles e, e' which afford the horizontal propulsion, and two screw propellers s, s' effect the vertical movement. Steering is performed by a movable vane or fin f, and the mechanism is driven by an internal combustion engine.

Molesworth-Hepworth's air-ship is shown by Fig. 81, in which the aërostat A, having pointed ends B, is divided into compartments by divisions C in which are separate gas-bags D, with independent inflating and deflating

appliances. A longitudinal bar E supports an aëroplane H, itself being supported by rigging C from the aërostat A. The car I is supported by and below the bar E, and forms the centre of buoyancy of the air-ship, the supporting bars K being rigid, except for horizontal angular deviation by means of the ropes M, by means of a quadrant or bell crank lever N or a windlass. One or more propellers O are driven by the motor through



gearing R, these propellers having stiff leading edges and elastic or flexible rear ones. The buoyancy of the aërostat A is controlled by varying the pressure of air in the intervening spaces between the gas-bags D by means of a pump U, and flexible pipe S, with a suitable liberating valve. A rudder is shown in dotted outline.

De Bausset's air-ship is shown with the aërostat in section by Fig. 82. The aërostat A is built up of steel or thin metal plates, with internal bands and cross ties to

strengthen the structure. Conical ends o are provided which are normally held in position by the external atmospheric pressure, since the inside of A is partially exhausted, spiral springs in tension tending to open

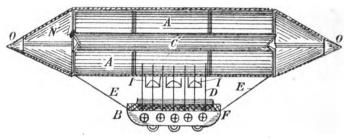
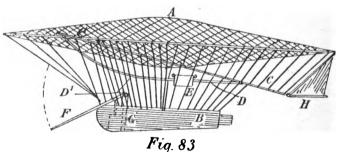


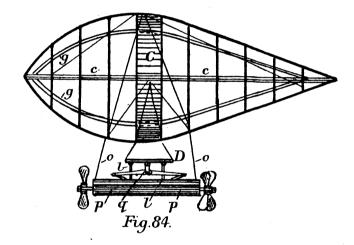
Fig. 82.

o if the internal pressure increases. Central sustaining planes or steadying plates C are fixed centrally within the aërostat A. The boat-shaped car B is adapted for floating upon the water, or for land transport upon the wheels, and is suspended by means of jointed rods D,



and a rope E upon a windlass allows of its being adjusted forwards and backwards. Boxed or cased propellers I provide the necessary propelling force, and these are independently driven by the current derived from accumulators in the car B. The altitude is varied by admitting air to or exhausting the interior of the aërostat A, a suitable electrically driven pump performing this operation.

Fig. 83 represents Worm's air-ship. The aërostat A is nearly buoyant enough to support the whole mass, and has attached to each side inclined aëroplanes, the edge C of which only is visible upon the elevation. A curved rod D extends from one end to the other of the



machine, which carries a balance weight E. H is a tailpiece or rudder, capable of being moved upon a vertical
axis. Propulsion is effected by means of feathering
wings F, to which motion is imparted by an internal
combustion or other motor D'. By adjusting the balance
weight E upon the rod D, the aëroplane C and the whole
machine may be made to assume an inclined position, so
that the combined action of the wings F and aëroplane C
tend to raise the air-ship and propel it forwards. The
car B is of wedge shape in plan, and carries the generator,

storage tank, or the like, G, and the motor D' with the fulcrums of the wings F.

Boisset's air-ship is illustrated by Fig. 84, and consists of an aërostat, the frame of which is formed of a number of light metal or bamboo rings with radial struts threaded upon an axial tube c. Transverse stays g tie the ends of c to the upper periphery of the central ring of the frame, and the whole is covered by a double layer of silk cemented together by indiarubber solution. The car r is suspended from a plate D secured to a band C round the largest circumference of the aërostat and

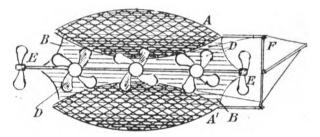


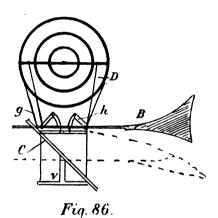
Fig. 85

steadied by ropes o. The actual suspension is effected by link work l, q, which tends to keep the car in position when the weights therein are shifted. Propulsion is effected by a single screw propeller in front of the car, and twin propellers at the rear end, the steering being performed by the manipulation of the latter.

An air-ship with twin aërostats has been invented by L. E. Roze, and shown by Fig. 85, which is a plan view. The two aërostats A, A' support the car B, and are so connected that the internal pressure is equal in both, and a collapsible reservoir is provided in order that the gas may expand without loss. Propulsion is effected by two

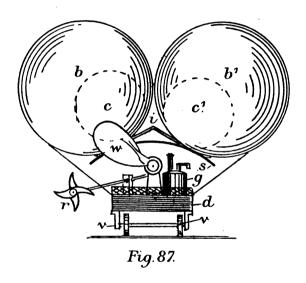
horizontal propellers E, and vertically by three similar propellers the axes of which are at right angles to the horizontal plane. The air-ship is steered by a tail-piece or rudder F. The framing of the car B is provided with buffers or check springs to neutralise shocks when coming to rest.

Fig. 86 is an end sectional view of Chillingworth's air-ship, which consists of an aërostat D supporting a car v, and propelled by feathering wings B, formed of an elastic framework covered by textile material, the dotted



outline showing the position assumed when at rest. The inner ends of the wing arms carry toothed segments which gear with each other, shown by g, h, which are worked by a reciprocating motor, the feathering being actuated by stop links. A rudder attached to the car c admits of steering in any direction. The aërostat is divided into three or more internal chambers, the inner of which may be inflated or deflated with air to compensate the variation of the volume of gas in the outer envelopes.

Middleton's air-ship, an elevation of which is shown by Fig. 87, also consists of two parallel aërostats b, b' similar to that of Roze, previously described. The aërostats b, b' are drawn together by a bent longitudinal frame i to which is attached a curved shield plate, which effectually screens the aërostats from the heat radiating from the motors and generator g. Internal bags or envelopes, shown by the dotted lines c, c' within the



aërostats b, b', are provided to act as partial condenser for the exhaust from the motor, the heat thus dissipated expanding the volume of the surrounding gas. Propulsion and steering are effected by a propeller w and an auxiliary propeller r, the rotation being performed by the motor and the variation of the planes by hand in both cases.

Fig. 88 is an elevation of Pennington's air-ship, which consists of an aërostat A of sheet aluminium carrying at

its bow a propeller F driven by a motor M placed within a recess in the aërostat, accessible from outside. Central aëroplanes E are attached to each side of the aërostat A,

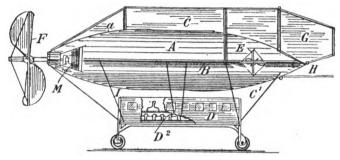
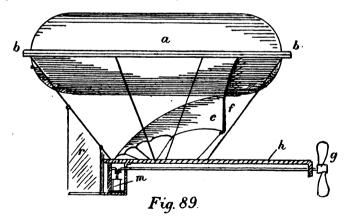


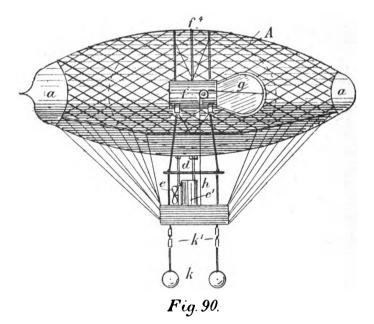
Fig. 88.

and lifting propellers E are fixed to revolve within suitable frames in these aëroplanes. A fin or central vertical plane C is attached to the top of the aërostat. The car



D is divided into two compartments, one above the other, the upper one being for passengers and auxiliary appliances, and the lower D² for electrical accumulators which

supply the current to electro-motors driving the lifting fans E and the vertical and horizontal rudders G, H, also the ignition for the explosion in the cylinders of the vapour engine M. The liquid hydrocarbon is stored under pressure, and the framework and all parts are hollow, and filled with gas. Stays C' maintain the rigid position of the car D.



Lochner's air-ship is illustrated by Fig. 89, and has an aërostat a, with a central aëroplane bb surrounding it, and a curved adjustable aëroplane e below it, this having a rigid weather edge f which is carried upward to the central aëroplane bb. The reaction of the air currents escaping from the rear lower edge of e tends to an impulse forwards. The aërostat e may be circular in plan,

and the lower portion may, by collapsing into bb, act as a parachute. A narrow horizontal beam h carries the propeller g and its shaft and bearings, a small car containing the motor m, and steering gear for controlling the rudder r.

Hite's air-ship, shown by Fig. 90, consists of an aërostat A, with metal end caps a, and has an internal air-bag, as shown by the dotted outline, which is inflated

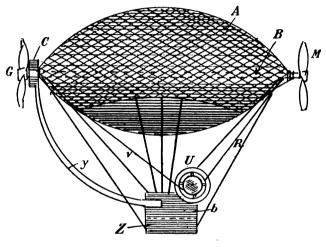
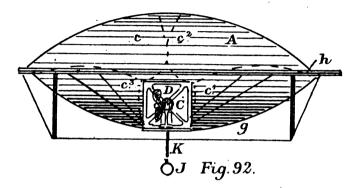


Fig. 91.

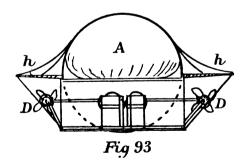
or deflated according to the pressure of gas in the aërostat. The gas envelope of the aërostat A is connected to a heated elastic vessel e' through a pipe d, and is kept in circulation by a fan e'. Cased propellers f are attached to the machine by saddle frames f^4 , and to each is hinged a rudder g which is operated from the car by ropes and pulleys. Ballast chambers k are suspended from the car by cords or links k'.

Fig. 91 illustrates Blümelhuber's air-ship, consisting

of an aërostat A, with a central horizontal tube B of metal, shown by dotted lines, through which a shaft passes, carrying two propellers G, M, driven by an electromotor C which is supported by the thrust bearings of



the shaft B and a curved bracket y upon the car. The steering is effected by mounting the propeller M upon a universal joint, so that its plane of rotation may be inclined. Electrical accumulators are provided in the lower-



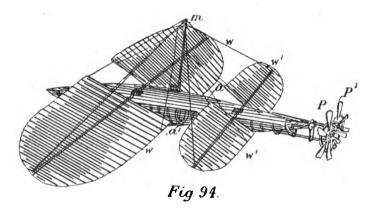
partition z of the car, to furnish the driving power for the motor C.

Nahl's air-ship is shown in elevation by Fig. 92, and a midship section Fig. 93. The aërostat A is internally

divided by gas envelopes c, c^1, c^2, c^3 , and the car C is fixed to the framework of the outer casing of the aërostat and is actually inside it, below the central surrounding aëroplane h.

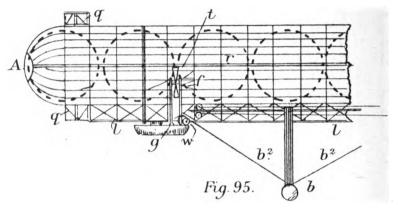
An electro-motor drives two propellers D, D, effecting horizontal propulsion, and a weight J supported by a rod K admits of the adjustment of the centre of buoyancy, and also for ballast.

Professor Langley, of the Smithsonian Institute, U.S.A., has constructed an air-ship (Fig. 94) in which

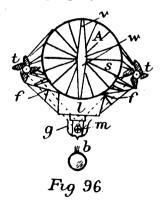


the upper part of the body a is an aërostat, and the lower part a' an open framework carrying the motors operating the horizontal twin propellers P, P', steering being effected by varying the rates of rotation of these independently of each other. Aëroplanes w, w' maintain by their angle of inclination the vertical lift, and are supported by and controlled from a mast m.

Count von Zeppelin's air-ship is shown in clevation by Fig. 95 and midship section by Fig. 96. The aërostat comprises a framework of longitudinal tubes r interspaced by wire ropes s proceeding radially from central hubs w, a vertical strut v being placed at intervals across the diameter of the aërostat throughout its length. It is divided into compartments containing gas-bags shown



by the dotted lines. The aërostat is very long relatively to its diameter, and supports two boat-cars g, one only of which is shown. A gangway l runs the whole length



of the machine from which any part may be reached by ladders f. Several aërostats may be joined together forming a flexible train propelled by the air-ship, and

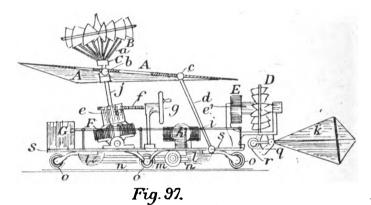
carrying goods or passengers. The junctions are coupled by universal joints and the fabric of the aërostats joined by strips of similar fabric.

Horizontal steering is effected by rudders q, q', and the inclination of the axis is adjusted by means of a weight b suspended from a wire rope along which it is made to travel by an endless rope b^2 operated by a winch w' in each car g. The internal combustion engine m is contained in the car g, and drives the propellers f for horizontal propulsion by suitable shafts and gearing within the framework and ladder f.

Santos Dumont has successfully accomplished the steering of an aërostat, notably in open competition in which he was the winner of 15,000 francs by rounding the Eiffel Tower. Since this the inventor has made several successful steering flights. The air-ship consists of an aërostat inflated with hydrogen, and containing an air-bag for compensation, and a screw propeller, the axis of which is inclined, and a rudder of relatively large area is under the control of the aëronaut, who is placed in a small shielded car which also carries the motor engine, preferably an internal combustion liquid hydrocarbon type. M. Dumont has invented a very light and powerful twin or multi-cylinder engine for the purpose, each pair of cylinders being placed in tandem, operating one piston rod, the explosions having the effect of a double-acting single-cylinder engine.

Dr Barton in the United States has just built an air-ship, the trial of which has not as yet been reported. The aërostat has three aëroplanes placed below the centre with an aggregate area of 1,944 sq. ft., which he claims to have a lifting power of 972 lbs. or 1 lb. to 2 sq. ft., equivalent to an air velocity of 880 ft. per minute. There are eighteen propellers arranged at different angles. The aërostat has an internal compensator or

air vessel capable of being inflated or deflated. It is noteworthy that nearly every modern type of air-ship adopts this compensator, and it is invariably referred to as a special feature, although employed, as we have seen, by Partridge in his air-ship the "Pneumodrome" in 1849. Dr Barton renders his air-ship stable longitudinally by forward and rear water tanks, the water of which is kept in constant circulation through a double tubular system by an electrically driven pump. A valve is fitted in each section, these being controlled automati-



cally by a heavy pendulum, one of the tanks being filled and the opposite one emptied inversely according to the tendency of the inclination.

The "Aëraonic" air-ship is as yet the most successful experimental apparatus yet tried, and lengthy trials have been made of a 10 ft. model in which the air-ship was held captive at a height of 100 ft. by a hawser, around which it was steered from the ground by two double pole link switches, the conductors being attached to the hawser and included in the circuits of the steering motor. The electrical current for this and the propelling motors was

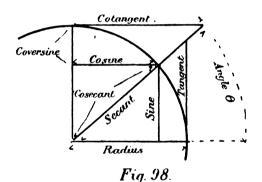
generated by a dynamo upon the shaft of a 41 H.P. petrol twin cylinder motor upon the platform of the ship, and vertical ascent was accomplished without extraneous aid. These successful trials led to the formation of a syndicate. and an air-ship 50 ft. in length and 40 H.P. is now in process of building. Fig. 97 is an elevation of this airship, in which a platform s carries the whole of the mechanism, and when at rest is supported upon the ground by wheels o. A lifting propeller B has a collar C upon the shaft normally held back by the tension of a spring to keep the rear edges of the blades in full pitch position by means of rods a. The shaft i and electro-motor F which drives it are based upon a pivoted plate upon the platform s, the oil-bath thrust block e intervening between the motor F and the propeller B. the whole being inclined backwards or forwards by a screw f and hand wheel g. The aëroplane A is inclined at the same time, being carried by a trunnion bearing b on the shaft i. Links d connect the aëroplane A with the platform s and carry the rear weight, being pivoted to A at c. The length of the links d is such as to bring the aëroplane A parallel with the platform s when moved rearward by g. The horizontal propeller D is driven by an electro-motor E, and a thrust block e' is mounted upon the same bracket. Steering is effected by a fourvaned rudder k operated vertically by a toothed quadrant a, and horizontally by a similar quadrant, small electromotors r, controlled by the aeronaut by means of switches, furnishing the requisite power. The current is derived from a dynamo electric generator i driven directly by a compound internal combustion hydrocarbon engine h. The liquid fuel is stored in a wedge-shaped tank G, the apex forming the beak of the platform. Two tanks containing water *l*, *l'*, and connected by pipes and an electrically driven centrifugal pump m, are placed on

each side of the under part of the platform s, so that the two forward tanks are connected to the after tanks by the corresponding pipes, forming the "fore and rear" equilibrium system, and either the two right-hand tanks or the two left-hand tanks the "lateral" equilibrium system. Therefore since a current of fluid is maintained. a flux to the two forward tanks causes a dip forwards and vice versa, or a flux to the two right-hand tanks causes a lateral dip in that direction; and this is automatically effected by two pivoted hollow beams slightly bellied in the centre and partially filled with mercury, and these being arranged at right angles to each other, are connected to the controlling valves of the two fluid circulating systems. The sensitiveness of the mercury balance renders the equilibrium control nearly anticipatory.

No human mind can foresee the air-ship of the future, except that aërial navigation will be a matter of every-day usage, and will give rise to a new industry throughout the world. Unless some future discovery renders the control of the force of gravitation possible by other than mechanical means, the germ of the air-ship is among the many that are described in these pages, doubtless with many modifications and additional details that may be found necessary to accomplish perfect success.

APPENDIX.

TRIGONOMETRICAL EQUIVALENTS.



THE diagram shows the trigonometrical functions in terms of the angle θ to the radius, the value of which is given as = 1.

Cos = ...
$$\sqrt{(1 - \sin^2)}$$
 = cosine.
Cos = ... $\frac{\sin}{\tan}$ = cosine.
Cos = ... $\sin \times \cot$ = cosine.
Tan = ... $\frac{\sin}{\tan}$ = tangent.

$$\cot = \dots \frac{\cos}{\sin} = \text{cotangent.}$$

$$Sin = \dots \frac{\cos}{\cot} = sine.$$

Sec =
$$\dots \frac{\tan}{\sin}$$
 = secant.

$$Sin = \dots \frac{tan}{sec} = sine.$$

Radius = . . .
$$tan \times cot = radius$$
.

Sin =
$$\sqrt{(1 - \cos^2)}$$
 = sine.

Tan =
$$\cdot \cdot \frac{I}{\cot}$$
 = tangent.

$$Cosec = ... \frac{I}{sin} = cosecant.$$

Sec =
$$\dots \frac{1}{\cos}$$
 = secant.

$$Sin = ... \frac{I}{cosec} = sine.$$

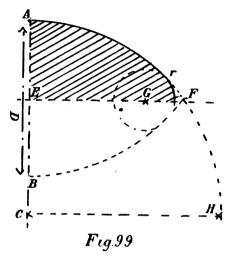
$$Cos = ... \frac{I}{sec} = cosine.$$

$$Cot = \frac{1}{\cot} = \cot a gent.$$

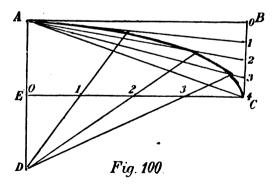
Versin $= 1 - \cos =$ versed sine.

Coversin = $I - \sin = \text{coversed sine}$.

Form of Aerostat Ends, Plotting Templets (Fig. 99).—Let $AC = D \times 1.25$, and AB = D. Then from



centre C strike off AE, and upon EF mark off G, that GF = CB, and strike the semicircle radius Gr cutting AF at r. This forms an approximate parabolic outline.



To describe an ellipse for an end templet, set off the major axis EC, and mark it off in equal parts, which in Fig. 99 are four. Let AD = the minor axis, and CB the half of this, which should be divided into an equal number of corresponding parts to EC. From the centre A draw lines cutting divisions on BC, and from the centre D draw lines cutting the divisions on EC. Where the lines intersect are the points cut by the semi-ellipse.

CORRECTION TABLE OF ALTITUDES AND LATITUDE.

Apparent Altitudes,	LATITUDE. + from 0° to 45°; - from 45° to 90°.							
Feet.	o° lo°		20°	30°	40°	45°		
	9 0°	8o°	70°	60°	50°			
1,000	2.6	2 5	2.0	1.3	.5			
2,000	5.3	5.0	4.1	2.6	.9			
3,000	7.9	7.5	6. 1	4.0	1.4			
4,000	10.6	10.0	8.1	5.3	1.8	\$5		
5,000	13.2	12.4	10.1	6.6	2.3	Į.		
6,000	15.9	14.9	12.2	7.9	2.8	8		
7,000	18.5	17.4	14.2	9.3	3.2	ecti		
8,000	21.2	19.9	16.2	10.6	3.7	orr.		
9,000	23.8	22.4	18.3	11.9	4.1	No correction for 45°.		
10,000	26.5	24.9	20.3	13.2	4.6	Z		
11,000	29. I	27.4	22.3	14.6	5. 1			
12,000	31.8	29.9	24.4	15.9	5 .5			

USEFUL CONSTANTS AND LOGARITHMS.

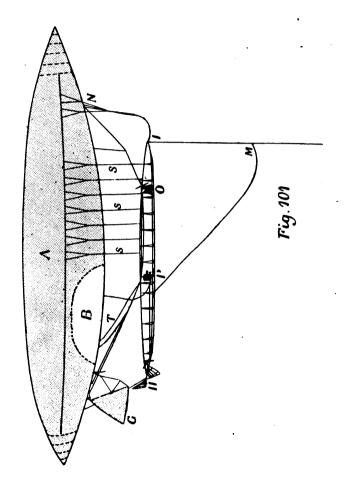
									Number.	Logarithms.
π	-	-	-	-	-	-	•	-	3.1416	.4971
π^2	-	-	-	-		-	-	-	9.8696	.9943
$\sqrt{\pi}$	-	-	-	-	-	-	-	-	1.7724	.2486
$\frac{\pi}{4}$	•	-	•	-	-	-	•	-	.7854	.8951
Centin	netres	in 1	in.	-	-	-	- ,		2.54	.4048
Yards	in 1 r	netre		-	-	-	-	-	1.0936	.0388
Kilom	etres	in I n	nile		-	-	-		1.6093	.2066
Miles	in 1 k	not	-	-	-	-	-		1.1528	.0618
Square	e mils	per s	quare	milli	metre	:	-		1550	3. 1904
Cubic	centir	netres	s in I	cub.	in.	-	-		16.386	1.2145
Cubic	centi	n e tres	s in 1	pint	-	-	-		567.93	2.7543
Cubic	inche	s in 1	pint	-	-	-			34.659	1.5398
Pints i	in 1 li	tre	-	-	-		-		1.7608	.2457
Grains	in I	gram	-	-	-	-	-	-	15.432	1.1883
Pound	ls avoi	rdup	ois in	ı kile	ogram	ı	-		2.2046	•3433
Pound	ls in I	cub.	ft. of	wate	r (39°	Fahi	r.)	-	62.425	1.7953
Forces	s d e (cheva	l in	ı hoı	rse-po	wer ((33,0	00		
fo	ot po	unds)	-	-	•	-	-	•	1.01385	.0058
Foot p	oound	s in I	В.Т.	U.	•	•	-	•	775-47	2.8895
B.T.U	J. in 1	calo	rie	-	-	-	-	-	3.968	. 5986
Degre	es Fal	hrenh	eit in	ı° C	ent.	-	-	-	1.8	.2553
Feet p	er sec	ond i	n ı n	nile p	er hoi	ar	-	•	1.4666	. 1664
Metre	s per s	secon	d in 1	kilo	metre	per h	our	-	2.7777	•4437
Pressu	re po ater (e inch	of:	I ft.	of -	· 4 333	1.6368
Pressu	re po ercur		•	square -		of 1		of •	.4907	1.6368
Value	of g a	t Gre	enwi	ch in	inch s	secon	ds		386.29	2.5869
Lengt ir	h of		ds pe	ndulı -	ım at -	Gree	enwic	h, -	39.139	1.5926

TABLE OF PROLATE SPHEROIDS.

Semi-major axis = a. Semi-minor axis = b. Volume = $\frac{1}{2}\pi a^2b$.

Weight Raised, Lbs. (Avoir.)	Cubic Feet of Gas (any shape), $h = \frac{20}{.0684}$	Linear Feet Radius, $b = \sqrt[3]{\frac{k}{2.929}}$	Linear Feet Diameter, d=2b.	Square Feet Area = #b ² .	Linear Feet Length, l=12b.	Square Feet Surface Area, f=60.008b2.
1	14.60	.834	1.669	2.19	10.013	41.78
10	146.0	1.798	3-595	10.17	21.573	194.00
100	1460.0	3.873	7.746	47.12	46.478	899.64
150	2192.0	4-435	8.870	61.79	53.220	1180.30
200	2920.00	4.879	9.759	74.81	58. 557	1429.70
250	3655 o	5.259	10.518	86 .8 9	63.109	1659.60
340	5000.0	5.838	11.676	107.08	70.058	2021.80
440	6000 o	6.203	12.407	120.91	74.446	2317.60
500	7310.0	6.626	13.252	137.93	79.512	2634.60
547	8000.0	6.828	13.656	146.48	81.939	2784.10
650	9000.0	7.101	14.203	158.44	85.220	3026.70
684	10000.0	7-355	14.711	169.97	88.226	3247.10
750	I 1000.0	7.593	15.186	181.12	91.116	3459.60
800	11695.0	7.749	15.499	188.67	92.995	3604.20
850	12000.0	7.816	15.632	191.94	93.796	3665.8 0
890	13000.0	8.027	16.055	202.46	96.333	3 867.5 0
960	14000.0	8.228	16.457	212.72	98.739	4063.60
1,000	14620.0	8.348	16.696	218.95	100.179	4182.10
1,100	16000.0	8.602	17.204	232.48	103.228	4440.30
1,160	17000.0	8.778	17.557	242.11	105.334	4624.80
1,230	18000.0	8.947	17.895	251.57	107.371	4807.00
1,350	19000.0	9.110	18.220	260.74	109.323	4980.30
1,368	20000.0	9.267	18.554	269.81	111.208	5153.40

The following diagram (Fig. 101) illustrates the dirigible aërostat of M. Santos Dumont. It will be noted



that the structure is very light, and offers very little resistance to the air relatively to the power and buoyancy.

The aërostat A is pointed at each end, and an interior balloon or envelope B containing air is placed inside, and controlled from the motor P by a pipe T. This is the arrangement first adopted by Partridge in his "Pneumadrome," which is previously described. A trailing rope I,

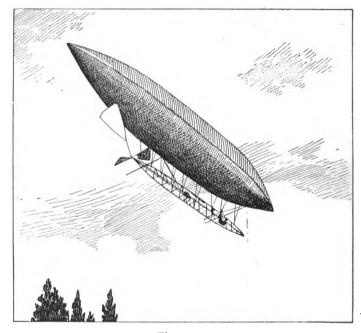
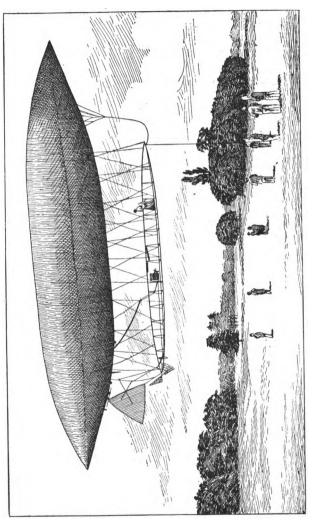


Fig. 102.

with a guide M, is provided, in addition to a rudder G. The aeronaut sits in a light wicker basket chair O, from whence he may control the mechanism. The engine P develops 16 H.P., and is actuated by the explosion of vaporised petrol. The screw propeller H is made with flexible rear edges, and at 150 revolutions per minute



ig. 103.

exerts a thrust of 60 lbs. The total weight of the apparatus is 550 lbs.

Fig. 102 shows the machine progressing against the wind, and Fig. 103 illustrates the start from the Parc d'Orient in the 15,000 franc competition, 13th July 1901,

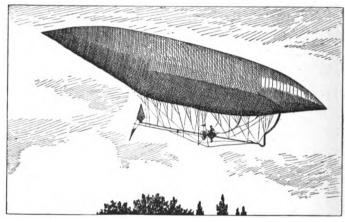


Fig. 104.

which, after some discussion, was awarded to M. Santos Dumont. Fig. 104 shows the progression of the aërostat against the wind. Fig. 105 (see Frontispiece) shows the aërostat rounding the Eiffel Tower during the competition.

INDEX.

CCUMULATORS, 101 Adams' propeller, 65 "Aëraonic" ship, 134 Aërial flotation, 14 Aërocurves, 82, 115 Aërodynamics, 31-48 Aëroplanes, 70, 115 Aërostatics, 12-20 Aërostats, 15, 20, 105 Air, 31-48 Air-ships, 117-136 Albatross, 2 Alexander's propeller, 60 Alloys, strength, weight, 111 Altitude and latitude, 140 Altitudes, 13, 140 Aluminium alloys, 111 Angle propeller, 54 Angular equivalents, 137 Ash, 114 Atmosphere, 12

Barbe's heater, 93
Barometer, 12
Barton's air-ship, 133

Bate's aërostat, 24
Bats, 4, 5
Bearings, 112
Beech, 114
Beenen's aëroplane, 81
Beetle, 6, 7
Benzol, 94
Binary alloys, 111
Birds, 2
Blades, propeller, 54
Blümelhuber's air-ship, 129
Boisset-Mercier propeller, 59
Boisset's air-ship, 124
Brachials, 10
Butane, 94

Carpus, 3
Cast iron, 108
Castings, 111
Cayley's experiments, 56
Child's propeller, 62
Chillingworth's air-ship, 125
Coleoptera, 7
Compression, 110

Condor, 2
Constants, 141
Coracoid, 2
Cornelius' wing motion, 41
Crease's aëroplane, 77
Cubitus, 2, 3
Curves of flight, 34

DAIMLER engine, 96
Dale aërostat, 25
Davenport's aëroplane, 81
De Bausset's air-ship, 121
Delta metal, 114
Density, 17
Diesel engine, 98
Discoidals, 10
Dodecane, 94
Drawn steel tube, 110
Duck canvas, 115
Dynamo, 101

ELECTRIC motive power, 100
Ellipse, 139
Elm, 114
Elytra, 7
Ends, aërostat, 139
Equilibrium, 105
Equipoise, 42
Equivalents, angular, 137
Erichsen's propeller, 55
Ethane, 94

Féraud's propeller, 61
Fish, flying, 11

Flight curves, 34
laws of, 1
man, 41
mechanical, 37
natural, 1
Flexibility, 35
Folacci's air-ship, 118
Framework, 108
Fryer's aërostat, 27
Fuel, 83
comparative, 86
table, 86
thermic value, 85

GALLIENE'S wing, 44
Géant, Le, 18
Generators, 86
Glendinning's aërostat, 28
Gower aërostat, 23
Green, 18
Gyrostat, 105

HEAT units, 84
conversion, 84
Heathorn's propeller, 65
Hecdecane, 94
Hemiptera, 9
Henderson's propeller, 57
Henson's aëroplane, 75
Heptane, 94
Hexane, 94
Hilfreich's air-ship, 120
Hite's air-ship, 129
Hollow shafting, 113
Hornsby-Akroyd engine, 96

Hydrocarbon engines, 94 Hydrocarbons, 94 Hydrogen, 15 Hymenoptera, 9 Humerus, 2

MPULSE, 51 Insects, 6 Internal combustion engines, 98 Iron tube, 108

[ET propulsion, 69

K EELCOM motor, 98

Langley's air-ship, 131
Latitude tables, 140
Lifting power aëroplanes, 72
Liquid fuel, 85, 94
Lochner's air-ship, 128
Logarithms, useful, 141
Louvre valves, 48

Man flight, 42
Manganese steel, 114
Marey's experiments, 34
Marshall's wing motion, 46
Martin's paddle, 69
Materials, 102
Maxim's aëroplanes, 77-79, 107
generators, 88, 90
Metacarpus, 3

Methane, 94
Middleton's air-ship, 126
wing motion, 46
Models, 102
Modulus of rupture, 108
strength, 108
Molesworth-Hepworth air-ship, 120
Motive power, 83-101
Multivane aëroplane, 73
propeller, 66

Nahl's air-ship, 130 Nervures, 7 Nickel steel, 114

Octane, 94 Octling's paddle, 68 Opossum, flying, 10

ADDLE propellers, 67 Parabola, 139 Parallelogram of forces, 110 Partridge's air-ship, 117 Pectoral-fins, 11 Pegamoid, 115 Pennington's propeller, 65 air-ship, 126 Pettigrew's experiments, 34 Petroleum, 85 Phalanges, 3 Pitch, propeller, 54-65 Pinaud's experiments, 73 Plotting templets, 139 Pneumadrome, 117 Pollex, 3

Polygonal frame, 110 Power, 50 Prolate spheroids, 49, 142 Propeller ratios, 54 Propellers, 53 Prophane, 94 Propulsion, 49 Pterodactyl, 6

Ouartermain's wing motion, 42

RADIUS, 3
Razeau's propeller, 66
Recurrent nervures, 10
Rennie's propeller, 55
Resistance, air, 49
wind, 50
Rhea fibre, 115
Romanium, 111
Roze's air-ship, 124
Rudder, 106

Santos Dumont air-ship, 133,
144
Scapula, 2
Schmidt's propeller, 61
Scott's aërostat, 30
Sensitive equilibrium, 105
Serkis-bey aërostat, 21
Sheet metal, 110, 116
Shafting, 113
Silk, 115

CAILS, 118

Slip ratio, 53

Smythie's wing motion, 39
Solder, composition, 112
Solders, 112
Spheroids, prolate, 49, 142
Stag beetle, 6, 7
Steel, 108
Steering, 1c6
Sternum, 3
Stigma, 8
Storz's propeller, 62
Stringfellow's aëroplane, 73
trial experiment, 75
Structure of air-ships, 102
Sylamoid, 115

TAPSCOTT'S aërostat, 29
Templets, 139
Tensile strength, 111
Tension, 110
Ternary alloys, 111
Thorax, 7
Trigonometrical equivalents, 137
Tubular frames, 108
Tussore silk, 115

ULNA, 3 Urtalaine, 115 Useful constants, 141

VALUES of temperature, 14
Valvular wings, 48
Vaporising, 94
Velocities, 50, 51
Vogelsand's propeller, 58, 63
Von Zeppelin's air-ship, 131

WALKER'S experiment, 38
Wave movement, 34
Weight, 32
Wenham's aëroplane, 73
Williams' propeller, 59
Willow, 115
Wind pressure, 52
resistance, 50
Winds, 52
Wing area, 32, 33
birds, &c., 2-6
movements, 34

Wire stays, 113
Wolframinium, 111
Woods, various, 108, 114, 115
weight, 115
Worm's air-ship, 123

YACHT duck, 115

ZEPPELIN'S, Von, air-ship, 131

CROSBY LOCKWOOD & SON'S Catalogue of

Scientific, Technical and Industrial Books.

PAG	E 1 PAGE
MECHANICAL ENGINEERING .	1 CARPENTRY & TIMBER 28
CIVIL ENGINEERING 10	DECORATIVE ARTS 80
MARINE ENGINEERING, &c 1	NATURAL SCIENCE 82
MINING & METALLURGY 19	CHEMICAL MANUFACTURES . 84
COLLIERY WORKING, &c 2	1 INDUSTRIAL ARTS 86
ELECTRICITY 2	COMMERCE, TABLES, &c 41
ARCHITECTURE & BUILDING . 20	AGRICULTURE & GARDENING 48
SANITATION & WATER SUPPLY 2	AUCTIONEERING, VALUING, 40. 46
LAW & MIRCE	I LANFOUR A7

MECHANICAL ENGINEERING, &c.

THE MECHANICAL ENGINEER'S POCKET-BOOK.

Comprising Tables, Formulæ, Rules, and Data: A Handy Book of Reference for Daily Use in Engineering Practice. By D. Kinnear Clark, M. Inst. C.E., Fourth Edition. Small 8vo, 700 pp., bound in flexible Leather Cover, rounded corners.

COTHERS

SUMARY OF CONTENTS:—MATHEMATICAL TABLES.—MRASUREMENT OF SURFACES AND SOLIDS.—ENGLISH AND FOREIGN WRIGHTS AND MEASURES.—MONEYS.—SPECIAC CR. VIERGISH AND FOREIGN WRIGHTS AND MEASURES.—MONEYS.—SPECIAC CR. VIERGISH AND VOLUME MANUFACTURED METALS.—STREET JPESS.
SPECIAC CR. VIERGISH OF WROUGHT AND CAST IRON.—STRENGTH OF LEAD, TIN. ZINC.—STRENGTH OF TIMBER.—STRENGTH OF CAST IRON.—STRENGTH OF WROUGHT IRON.—STRENGTH OF STREL—TENSILE STRENGTH OF COPPER, LEAD, &C.—RESISTANGE OF STONES AND OTHER BUILDING MATERIALS.—RIVETED JOINTS IN BOILER PLATES.—BOILER SHELLS.—WIRE ROPES AND HEMP ROPES.—CHAINS AND CHAIN CHAIS.—MECHANICAL PRINCIPLES.—GRAVITY AND FALL OF BODIES.—LABOUK OF ANIMALS.—MECHANICAL PRINCIPLES.—GRAVITY AND FALL OF TRANSMISSION OF MOTIVE POWER.—HEAT.—COMBUSTION: FURIS.—WARMING, CE.—TRANSMISSION OF MOTIVE POWER.—HEAT.—COMBUSTION: FURIS.—WARMING, VENTILATION, COOKING STOVES.—STRAM.—STRAM ENGINES AND BOILERS.—RAIWAYS.—TRAMWAYS.—STRAM SHIPS.—PUMPING STEAM ENGINES AND BOILERS.—COLI GAS, GAS.—CAIR IN MOTION.—COMPRESSED AIR.—HOT AIR ENGINES.—WATER POWER.—SPEED OF CUTTING TOOLS.—COLOURS.—ELECTRICAL ENGINEERING.

"Mr. Clark majdless what is a linguic percention of what is likely to be useful in a pocket."

"Mr. Clark manifests what is an innate perception of what is likely to be useful in a pocketbook, and he is really unrivalled in; the art of condensation. It is very difficult to hit upon any
mechanical engineering subject concerning which this work supplies kno information, and the
excellent index at the end adds to its utility. In one word, it is an exceedingly handy and efficient
tool, possessed of which the engineer will be saved many a weartsome calculation, or yet more
wearisome hunt through various text-books and treatises, and, as such, we can heartily recommend
it to our readers."—The Engineer.

"It would be found difficult to compress more matter within a similar compass, or produce a book of 650 pages which should be more compact or convenient for pocket reference. . . . Will be appreciated by mechanical engineers of all classes."—Practical Engineers.

MR. HUTTON'S PRACTICAL HANDBOOKS.

THE WORKS' MANAGER'S HANDBOOK.

Comprising Modern Rules, Tables, and Data. For Engineers, Millwrights, and Boiler Makers; Tool Makers, Machinists, and Metal Workers; Iron and Brass Founders, &c. By W. S. HUTTON, Civil and Mechanical Engineer, Author of "The Practical Engineer's Handbook." Sixth Edition, carefully Revised, with Additions. In One handsome Volume, medium 8vo, strongly bound.

[Just Published. 15/0]

The Author having compiled Rules and Data for his own use in a great variety of modern engineering work, and having found his notes extremely useful, decided to publish them—revised to date—believing that a practical work, suited to the DAILY REQUIREMENTS OF MODERN ENGINEERS, would be favourably received.

"Of this edition we may repeat the appreciative remarks we made upon the first and third. Since the appearance of the latter very considerable modifications have been made, although the total number of pages remains almost the same. It is a series useful collection of rules, tables, and workshop and drawing office data." "The Engineer, May 10, 1895.

"The author treats every subject from the point of view of one who has collected workshop notes for application in workshop practice, rather than from the theoretical or literary aspect. The volume contains a great deal of that kind of information which is gained only by practical experience, and is seldom written in books."—The Engineer, June 5, 1885.

"The volume is an exceedingly useful one, brimful with engineer's notes, memoranda, and rules, and well worthy of being on every mechanical engineer's bookshelf."—Machanical World.

"The information is precisely that likely to be required in practice. . . . The work forms a desirable addition to the library not only of the works' manager, but of any one connected with general engineering."—Mining Journal.

"Brimful of useful information, stated in a concise form, Mr. Hutton's books have met a pressing want among engineers. The book must prove extremely useful to every practical man possessing a copy."—Practical Engineer.

THE PRACTICAL ENGINEER'S HANDBOOK.

Comprising a Treatise on Modern Engines and Boilers, Marine, Locomotive, and Stationary. And containing a large collection of Rules and Practical Data relating to Recent Practice in Designing and Constructing all kinds of Engines, Boilers, and other Engineering work. The whole constituting a comprehensive Key to the Board of Trade and other Examinations for Certificates of Competency in Modern Mechanical Engineering. By WALTERS. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook for Engineers," &c. With upwards of 422 Illustrations. Sixth Edition, Revised and Enlarged. Medium 8vo, 560 pp., strongly bound. [Just Published. 18/0

This Work is designed as a companion to the Author's "Works' MANAGER'S HANDBOOK." It possesses many new and original features, and contains, like its predecessor, a quantity of matter not originally intended for publication but collected by the Author for his own use in the construction of a great variety of MODERN ENGINEERING WORK.

The information is given in a condensed and concise form, and is illustrated by upwards of 422 Illustrations; and comprises a quantity of tabulated matter of great value to all engaged in designing, constructing, or estimating for Engines, Boilers, and other Engineering Work.

"We have kept it at hand for several weeks, referring to it as occasion arose, and we have not on a single occasion consulted its pages without finding the information of which we were in quest."

On a single constraint.

Alternation.

"A thoroughly good practical handbook, which no engineer can go through without learning something that will be of service to him."—Marine Engineer.

"An excellent book of reference for engineers, and a valuable text-book for students of the constraint of the c

"An excellent book of reference for engineers, and a variation with the engineering,"—Socisman.
"This valuable manual embodies the results and experience of the leading authorities on mechanical engineering,"—Building News.
"The author has collected together a surprising quantity of rules and practical data, and has shown much judgment in the selections he has made. . . There is no doubt that his book is one of the most useful of its kind published, and will be a very popular compendium."—Engineer.
"A mass of information set down is simple language, and in such a form that it one easily referred to at any time. The matter is uniformly good and well chosen, and is greatly elucidated by the illustrations. The book will find its way on to most engineers' shelves, where it will rank as one of the most useful books of reference."—Practical Engineer.
"Full of useful information, and should be found on the office shelf of all practical engineers.
—Enritish Michanic.

MR. HUTTON'S PRACTICAL HANDBOOKS-continued.

STEAM BOILER CONSTRUCTION.

A Practical Handbook for Engineers, Boiler-Makers, and Steam Users. A Practical Handbook for Engineers, Boller-Makers, and Steam Users. Containing a large Collection of Rules and Data relating to Recent Practice in the Design, Construction, and Working of all Kinds of Stationary, Locomotive, and Marine Steam-Boilers. By WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. With upwards of 500 Illustrations. Third Edition, Revised and much Enlarged, medium 8vo, cloth 18/0

THIS WORK is issued in continuation of the Series of Handbooks written by the Author, vis.:—"The Works' Manager's Handbook" and "The Practical Engineer's Handbook," which are so highly appreciated by engineers for the practical nature of their information; and is consequently written in the same style as those works.

The Author believes that the concentration, in a convenient form for easy reference, of such a large amount of thoroughly practical information on Steam-Boilers, will be of considerable service to those for whom it is intended, and he trusts the book may be deemed worthy of as favourable a reception as has been accorded to its predecessors.

"One of the best, if not the best, books on boilers that has ever been published. The information is of the right kind, in a simple and accessible form. So far as generation is concerned, this is, undoubtedly, the standard book on steam practice."—*Electrical Review.*"Every detail, both in boiler design and management, is clearly laid before the reader. The volume shows that boiler construction has been reduced to the condition of one of the most exact sciences; and such a book is of the utmost value to the fin de siècle Engineer and Works Manager."

sciences; and such a book is of the utmost value to the fin de siècle Engineer and Works Manager."

"Marine Engineer."

"There has long been room for a modern handbook on steam boilers; there is not that room now, because Mr. Hutton has filled it. It is a thoroughly practical book for those who are occupied in the construction, design, selection, or use of boilers."—Engineer.

"The book is of so important and comprehensive a character that it must find its way into the literaries of every one interested in boiler using or boiler manufacture if they wish to be thoroughly bindormed. We strongly recommend the book for the intrinsic value of its contents."—Machinery Market.

PRACTICAL MECHANICS' WORKSHOP COMPANION.

Comprising a great variety of the most useful Rules and Formulæ in Mechanical Science, with numerous Tables of Practical Data and Calculated Results for Facilitating Mechanical Operations. By WILLIAM TEMPLETON, Author of "The Engineer's Practical Assistant," &c., &c. Eighteenth Edition, Revised, Modernised, and considerably Enlarged by WALTER S. HUTTON, C.E., Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. Fcap. 8vo, nearly 500 pp., with 8 Plates and upwards of 250 Illustrative Diagrams, strongly bound for workshop or pocket wear and tear. 6/0

trative Diagrams, strongly bound for workshop or pocket wear and tear. 6.00 "In its modernised form Hutton's 'Templeton' should have a wide sale, for it contains much valuable information which the mechanic will often find of use, and not a few tables and notes which he might look for in value the original editions of 'Templeton.'"—English Mechanic.

"It has met with great success in the engineering workshop, as we can testify; and there are a great many men who, in a great measure, owe their rise in life to this little book."—Building News.

"This familiar text-book—well known to all mechanics and engineers—is of essential service to the every-day requirements of engineers, milwrights, and the various trades connected with engineering and building. The new modernised edition is worth its weight in gold."—Building News. (Second Notice.)

"This well-known and largely-used book contains information, brought up to date, of the sort so useful to the foreman and draughtsman. So much fresh information has been introduced as to constitute it practically a new book. It will be largely used in the office and workshop."—

Mechanical World.

Mechanical Wo

"The publishers wisely entrusted the task of revision of this popular, valuable, and useful book to Mr. Hutton, than whom a more competent man they could not have found."—Iron,

ENGINEER'S AND MILLWRIGHT'S ASSISTANT.

A Collection of Useful Tables, Rules, and Data. By WILLIAM TEMPLETON. Eighth Edition, with Additions. 18mo, cloth 2/6

"Occupies a foremost place among books of this kind. A more suitable present to an apprentice to any of the mechanical trades could not possibly be made."—Building News.

"A deservedly popular work. It should be in the 'drawar' of every mechanic."—Buglith

THE MECHANICAL ENGINEER'S REFERENCE BOOK.

For Machine and Boiler Construction. In Two Parts.

ENGINEERING DATA. Part II. BOILER CONSTRUCTION. With 51 Plates and numerous Illustrations. By Nelson Foley, M.I.N.A. Second Edition, Revised throughout and much Enlarged. Folio, half-bound, net . 23 3.

PART I.—MEASURES.—CIRCUMFERENCES AND AREAS, &c., SQUARES, CUBES, FOURTH POWERS.—SQUARE AND CUBE ROOTS.—SUFFACE OF TUBES.—RECIPROCALS.—LOGARITHMS. — MEMSURATION. —SPECIFIC GRAVITIES AND WEIGHTS.—WORK AND FOWER.—HEAT.—COMBUSTION.—EXPANSION AND CONTRACTION.—EXPANSION OF GASES.—STEAM.—STATIC FORCES.—ACCUMULATED WORK.—CENTRE AND RADIUS OF GYRATION.—MOMENT OF INBRITIA.—CENTRE OF OSCILLATION.—ELECTRICITY.—STRENGTH OF MATERIALS.—ELASTICITY.—TEST SHEETS OF METALS.—FICTION.—TRANSMISSION OF POWER.—FLOW OF LIQUIDS.—FLOW OF GASES.—AIR PUMPS, SUFFACE CONDENSERS, &c.—SPEED OF STEAMSHISS.—PROPELLERS.—CUTTING TOOLS.—FLANGES.—COPPER SHEETS AND TUBES.—SCREWS, NUTS, BOLT HEADS, &c.—VARIOUS RECIPS AND MISCELLANEOUS MATTER.—WITH DIAGRAMS POR VALVEGEAR, BELTING AND ROPES, DISCHARGE AND SUCTION PIPES, SCREW PROPELLERS, AND COPPER PIPES.

PART II.—TREATING OF POWER OF BOILERS.—USEPUL RATIOS.—NOTES ON CONSTRUCTION.—CYLINDRICAL BOILER SHELLS.—CIRCULAR FURNACES.—FLAT PLATES.—STAYS.—GIRDERS.—SCREWS.—HYDRAULIC TESTS.—RIVETING.—BOILER SETTING, CHIMNEYS, AND MOUNTINGS.—FUELS, &c.—EXAMPLES OF BOILERS AND SPREDS OF STEAMSHIPS.—NOMINAL AND NORMAL HORSE POWER.—WITH DIAGRAMS FOR ALL BOILER CALCULATIONS AND DRAWINGS OF MANY VARIETIES OF BOILERS.

"Mr. Foley is well fitted to compile such a work. . . . The diagrams are a great feature of the work. . . . Regarding the whole work, it may be very fairly stated that Mr. Foley has produced a volume which will undoubtedly fulfil the desire of the author and become indispensable to all mechanical engineers."—Marine Engineer.

"We have carefully examined this work, and pronounce it a most excellent reference book for the use of marine engineers."— Journal of American Society of Naval Engineers.

COAL AND SPEED TABLES.

A Pocket Book for Engineers and Steam Users. By Nelson Foley, Author of "The Mechanical Engineer's Reference Book." Pocket-size, cloth . 3/6

TEXT-BOOK ON THE STEAM ENGINE.

With a Supplement on Gas Engines, and Part II. on Heat Engines. By T. M. GOODEVE, M.A., Barrister-at-Law, Professor of Mechanics at the Royal College of Science, London; Author of "The Principles of Mechanics," "The Elements of Mechanism," &c. Fourteenth Edition. Crown 8vo, cloth . 6/0 "Professor Goodeve has given us a treatise on the steam engine which will bear comparison with anything written by Huxley or Maxwell, and we can award it no higher praise." Engineer.

ON GAS ENGINES.

"Like all Mr. Goodeve's writings, the present is no exception in point of general excellence It is a valuable little volume."—Machanical World.

THE GAS-ENGINE HANDBOOK.

A Manual of Useful Information for the Designer and the Engineer. By E. W. ROBERTS, M.E. With Forty Full-page Engravings. Small Fcap. 8vo, leather. [Just Published. Net 816

A TREATISE ON STEAM BOILERS.

"The best treatise that has ever been published on steam boilers."—Engineer.

"The author shows himself perfect master of his subject, and we heartly recommend all employing steam power to possess themselves of the work."—Ryland's Iron Trade Circular.

THE MECHANICAL ENGINEER'S COMPANION

of Areas, Circumferences, Decimal Equivalents, in inches and feet, millimetres, squares, cubes, roots, &c.; Weights, Measures, and other Data. Also Practical Rules for Modern Engine Proportions. By R. Edwards, M.Inst. & Fcap. 8vo, cloth. [Just Published. 3/6]

"A very useful little volume. It contains many tables, classified data and memoranda generally useful to engineers "-Engineer.

"What it professes to be, 'a handy office companion,' giving in a succinct form, a variety of information likely to be required by engineers in their everyday office work."—Nature.

A HANDBOOK ON THE STEAM ENGINE.

With especial Reference to Small and Medium-sized Engines. For the Use of Engine Makers, Mechanical Draughtsmen, Engineering Students, and users of Steam Power. By Herman Harder, C.E. Translated from the German with considerable additions and alterations, by H. H. P. Powles, A.M.I.C.E., M.I.M.E. Second Edition, Revised. With nearly 1,100 Illustrations Crown 8vo, cloth

"A perfect encyclopædia of the steam engine and its details, and one which must take a permanent place in English drawing-offices and workshops."—A Foreman Pattern-maker.

"This is an excellent book, and should be in the hands of all who are interested in the construction and design of medium-sized stationary engines. . . A careful study of its contents and the arrangement of the sections leads to the conclusion that there is probably no other book like it in this country. The volume aims at showing the results of practical experience, and it certainly may claim a complete achievement of this idea."—Nature.

BOILER AND FACTORY CHIMNEYS.

Their Draught-Power and Stability. With a chapter on Lightning Conductors.

By ROBERT WILSON, A.I.C.E., Author of "A Treatise on Steam Boilers," &c.

8/8

"A valuable contribution to the literature of scientific building."-The Builder.

BOILER MAKER'S READY RECKONER & ASSISTANT.

With Examples of Practical Geometry and Templating, for the Use of Platers, Smiths, and Riveters. By John Courtney, Edited by D. K. Clark, M.I.C.E. Third Edition, 480 pp., with 140 Illustrations. Fcap. 8vo . 7/0

"No workman or apprentice should be without this book."-Iron Trade Circular.

REFRIGERATION. COLD STORAGE. & ICE-MAKING:

A Practical Treatise on the Art and Science of Refrigeration. By A. J. WALLIS-TAYLER, A.M. Inst.C.E., Author of "Refrigerating and Ice-Making Machinery." 600 pp., with 360 Illustrations. Medium 8vo, cloth. [/ust Published. Net 15/0]

"The author has to be congratulated on the completion and production of such an important work and it cannot fail to have a large body of readers, for it leaves out nothing that would in any way be of value to those interested in the subject."—Steamship.
"No one whose duty it is to handle the mammoth preserving installations of these latter days can afford to be without this valuable book."—Glasgow Herald.

THE POCKET BOOK OF REFRIGERATION AND ICE-MAKING FOR 1002.

Edited by A. J. Wallis-Tayler, A.M.Inst.C.E. Author of "Refrigerating and Ice-making Machinery," &c. With Diary and Almanac. Small Crown 8vo. cloth. [Just Published. Net 2/6

REFRIGERATING & ICE-MAKING MACHINERY.

A Descriptive Treatise for the Use of Persons Employing Refrigerating and Ice-Making Installations, and others. By A. J. WALLIS-TAYLER, A.-M. Inst. C.E. Third Edition, Revised and Enlarged. With Illustrations. Crown 8vo, cloth. [Just Published. 7/6

"Practical, explicit, and profusely illustrated."—Glasgow Herald.
"We recommend the book, which gives the cost of various systems and illustrations showing details of parts of machinery and general arrangements of complete installations."—Builder.
"May be recommended as a useful description of the machinery, the processes, and of the facts, figures, and tabulated physics of refrigerating. It is one of the best compilations on the subject.—Engineer.

TEA MACHINERY AND TEA FACTORIES.

A Descriptive Treatise on the Mechanical Appliances required in the Cultiva-tion of the Tea Plant and the Preparation of Tea for the Market. By A. J. WALLIS-TAYLER, A.-M. Inst. C.E. Medium 8vo, 468 pp. With 218 Medium 8vo, 468 pp. With 218
[Just Published. Net 25/0] Illustrations.

"When tea planting was first introduced into the British possessions little, if any, machinery was employed, but now its use is almost universal. This volume contains a very full account of the machinery necessary for the proper outfit of a factory, and also a description of the processes best carried out by this machinery."—Towrnal Society of Arts.

ENGINEERING ESTIMATES, COSTS, AND ACCOUNTS.
A Guide to Commercial Engineering. With numerous examples of Estimates and Costs of Millwright Work, Miscellaneous Productions, Steam Engines and Steam Boilers; and a Section on the Preparation of Costs Accounts. By A GENERAL MANAGER. Second Edition. 8vo, cloth. [Just Published. 12/0

"This is an excellent and very useful book, covering subject-matter in constant requisition in every factory and workshop. ... The book is invaluable, not only to the young engineer, but also to the estimate department of every works." — **Bullder** ... **Bullder** ...

AERIAL OR WIRE-ROPE TRAMWAYS.

Their Construction and Management. By A. J. WALLIS-TAYLER, A.M. Inst. C.E. [Just Published. 7/6 With 81 Illustrations. Crown 8vo, cloth.

"This is in its way an excellent volume. Without going into the minutize of the subject, it yet lays before its readers a very good exposition of the various systems of rope transmission in use, and gives as well not a little valuable information about their working, repair, and management. We can safely recommend it as a useful general treatise on the subject."—The Engineer.

MOTOR CARS OR POWER-CARRIAGES FOR COMMON ROADS.

By A. J. Wallis-Tayler, Assoc. Memb. Inst. C.E., Author of "Modern Cycles," &c. 212 pp., with 76 Illustrations. Crown 8vo, cloth . . . 4/6

"Mr. Wallis-Tayler's book is a welcome addition to the literature of the subject, as it is the production of an Engineer, and has not been written with a view to assist in the promotion of companies.

The book is clearly expressed throughout, and is just the sort of work that an engineer, thinking of turning his attention to motor-carriage work, would do well to read as a preliminary to starting operations."—Engineering.

PLATING AND BOILER MAKING.

A Practical Handbook for Workshop Operations. By JOSEPH G. HORNER, A.M.I.M.E. 380 pp. with 338 Illustrations. Crown 8vo, cloth . . 7/6

"The latest production from the pen of this writer is characterised by that evidence of close acquaintance with workshop methods which will render the book exceedingly acceptable to the practical hand.

A practical handbook on a subject which has not hithertor recived much attention from those qualified to deal with it in a satisfactory manner."—Machanical World.

PATTERN MAKING.

A Practical Treatise, embracing the Main Types of Engineering Construction, and including Gearing, both Hand and Machine-made, Engine Work, Sheaves and Pulleys, Pipes and Columns, Screws, Machine Parts, Pumps and Cocks, the Moulding of Patterns in Loam and Greensand, &c., together with the methods of estimating the weight of Castings; with an Appendix of Tables for Workshop Reference. By Joseph G. Horner, A.M.I.M.E. Third Edition, Enlarged. With 468 Illustrations. Crown 8vo, cloth. Net 718

"A well-written technical guide, evidently written by a man who understands and has practised what he has written about. . . We cordially recommend it to engineering students, young journeymen, and others desirous of being initiated into the mysteries of pattern-making."—Budler. "An excellent vade mecum for the apprentice who desires to become master of his trade." -English Mechanic

MECHANICAL ENGINEERING TERMS

Lockwood's Dictionary of). Embracing those current in the Drawing Office,

"Just the sort of handy dictionary required by the various trades engaged in mechanical engineering. The practical engineering pupil will find the book of great value in his studies, and every foreman engineer and mechanic should have a copy,"—Building News.

TOOTHED GEARING.

-

A Practical Handbook for Offices and Workshops. By JOSEPH HORNER A.M.I.M.E. With 184 Illustrations. Crown 8vo, cloth · 6/O

"We must give the book our unqualified praise for its thoroughness of treatment, and we can lly recommend it to all interested as the most practical book on the subject yet written." heartily recommend Mechanical World.

FIRES, FIRE-ENGINES, AND FIRE BRIGADES.

With a History of Fire-Engines, their Construction, Use, and Manage-

"To such of our readers as are interested in the subject of fires and fire apparatus we can most heartily commend this book."—Engineering.

AËRIAL NAVIGATION.

A Practical Handbook on the Construction of Dirigible Balloons, Aë:ostats, Aërop'anes, and Aëremotors. By FREDERICK WALKER, C.E., Associate Member of the Aëronautic Institute. With 104 Illustrations. Large Crown Yust Published. Net. 7/8

STONE-WORKING MACHINERY.

"Should be in the hands of every mason or student of stonework."—Colliery Guardian.
"A capital handbook for all who manipulate stone for building or ornamental purposes."—Machinery Market.

PUMPS AND PUMPING.

A Handbook for Pump Users. Being Notes on Selection, Construction, and Management. By M. Powis Bale, M.I.M.E. Fourth Edition. Crown 8vo. cloth. [Just Published. 3/6]

"The matter is set forth as concisely as possible. In fact, condensation rather than diffuseness has been the author's aim throughout; yet he does not seem to have omitted anything likely to be of use." "Journal of Gas Lighting."

MILLING MACHINES AND PROCESSES.

A Practical Treatise on Shaping Metals by Rotary Cutters. Including Information on Making and Grinding the Cutters. By PAUL N. HASLUCK, Author of "Lathe-Work." 352 pp. With upwards of 300 Engravings. Large crown 8vo, cloth 12/6

"A new departure in engineering literature. . . We can recommend this work to all interested in milling machines; it is what it professes to be—a practical treatise."—*Engineer*.

"A capital and reliable book which will no doubt be of considerable service both to those who are already acquainted with the process as well as to those who contemplate its adoption."—

LATHE-WORK.

A Practical Treatise on the Tools, Appliances, and Processes employed in the Art of Turning. By P. N. HASLUCK. Seventh Edition. Crown 8vo. 5/0 "Written by a man who knows not only how work ought to be done, but who also knows how to do it, and how to convey his knowledge to others. To all turners this book would be valuable."

Registerries. We can safely recommend the work to young engineers. To the amateur it will simply be invaluable. To the student it will convey a great deal of useful information."—Bugister.

SCREW-THREADS.

And Methods of Producing Them. With numerous Tables and complete Directions for using Screw-Cutting Lathes. By PAUL N. HASLUCK, Author of "Lathe-Work," &c. Fifth Edition. Waistcoat-pocket size 1/6

"Full of useful information, hints and practical criticism. Taps, dies, and screwing tools generally are illustrated and their actions described."—Mchansical World.
"It is a complete compendium of all the details of the screw-cutting lathe; in fact a multum-iss-parse on all the subjects it treats upon."—Carpenter and Builder.

TABLES AND MEMORANDA FOR ENGINEERS, MECHANICS, ARCHITECTS, BUILDERS, &c.

Selected and Arranged by Francis Smith. Sixth Edition, Revised, including ELECTRICAL TABLES, FORMULE, and MEMORANDA. Waistcoat-pocket size, Waistcoat-pocket size, [Just Published. 1/6 limp leather.

"It would, perhaps, be as difficult to make a small pocket-book selection of notes and formulæ
to suit ALL engineers as it would be to make a universal medicine; but Mr. Smith's waistcoatpocket collection may be looked upon as a successful attempt."—*Engineer.*The best example we have ever seen of 270 pages of useful matter packed into the dimnsions of a card-case." *Building News.*"A veritable pocket treasury of knowledge." *Iron.*

POCKET GLOSSARY OF TECHNICAL TERMS.

English-French, French-English; with Tables suitable for the Architectural, Engineering, Manufacturing, and Nautical Professions. By JOHN JAMES FLETCHER. Third Edition, 200 pp. Waistcoat-pocket size, leather . 1/6

"It is a very great advantage for readers and correspondents in France and England to have 5.1 large a number of the words relating to engineering and manufacturers collected in a lilliputian volume. The little book will be useful both to students and travellers." "Architect.
"The glossary of terms is very complete, and many of the Tables are new and well arranged, we cordially commend the book." "Aucharical World

THE ENGINEER'S YEAR BOOK FOR 1002.

Comprising Formulæ, Rules, Tables, Data and Memoranda in Civil, Mechanical, Electrical, Marine and Mine Engineering. By H. R. Kempe, A. M. Inst. C. E., M. I. E. E., Principal Technical Officer, Engineer-in-Chief's Office, General Post Office, London, Author of "A Handbook of Electrical Testing," "The Electrical Engineer's Pocket-Book," &c. With 1,000 Illustrations, specially Engraved for the work. Crown 8vo, 900 pp., leather. [Just Published. 8]

"Kempe's Year Book really requires no commendation. Its sphere of usefulness is widely known, and it is used by engineers the world over."—The Bagineer.

"The volume is distinctly in advance of most similar publications in this country."—
Engineering.

"This valuable and well-designed book of reference meets the demands of all descriptions of engineers."—Saturday Review.

"Teems with up-to-date information in every branch of engineering and construction."—
Building News.

The needs of the engineering profession could hardly be supplied in a more admirable, complete and convenient form. To say that it more than sustains all comparisons is praise of the highest sort, and that may justly be said of it. — Mining Journal.

"There is certainly room for the newcomer, which supplies explanations and directions, as well as formulæ and tables. It deserves to become one of the most successful of the technical annuals."—Architect.

"Brings together with great skill all the technical information which an engineer has to use day by day. It is in every way admirably equipped, and is sure to prove successful."—Scottman.

"The up-to-dateness of Mr. Kempe's compilation is a quality that will not be lost on the busy people for whom the work is intended."—Glasgow Hevald.

THE PORTABLE ENGINE.

"This is a work of value to those who use steam machinery. . . . Should be read by every one who has a steam engine, on a farm or elsewhere."—Mark Lane Express.

"We cordially commend this work to buyers and owners of steam-engines, and to those who have to do with their construction or use."—Timber Trades Journal

"Such a general knowledge of the steam-engine as Mr. Wansbrough furnishes to the reader should be acquired by all intelligent owners and others who use the steam-engine."—Building News.

"An excellent text-book of this useful form of engine. The 'Hints to Purchasers' contain a good deal of common-sense and practical wisdom,"—English Mechanic.

STATIONARY STEAM ENGINES.

Their Care and Management. By CHARLES HURST, Autnor of "Valves and Valve Gearing" Crown 8vo. [In the press.

IRON AND STEEL.

A Work for the Forge, Foundry, Factory, and Office. Containing ready, useful, and trustworthy Information for Ironmasters and their Stock-takers; Managers of Bar, Rail, Plate, and Sheet Rolling Mills; Iron and Metal Founders; Iron Ship and Bridge Builders; Mechanical, Mining, and Consulting Engineers; Architects, Contractors, Builders, &c. By Charles Hoars, Author of "The Slide Rule," &c. Ninth Edition. 32mo, leather . 6/0

"For comprehensiveness the book has not its equal."—Iron.
"One of the best of the pocket books."—Bnglish Mechanic.

CONDENSED MECHANICS.

A Selection of Formulæ, Rules, Tables, and Data for the Use of Engineering Students, &c. By W. G. C. Hughes, A.M.I.C.E. Crown 8vo, cloth. 2/6

"The book is well fitted for those who are either confronted with practical problems in their work, or are preparing for examination and wish to refresh their knowledge by going through their formulae again." "Marine Engineer.

THE SAFE USE OF STEAM.

"If steam-users would but learn this little book by heart, boiler explosions would become sensations by their rarity."—English Mechanic,

THE LOCOMOTIVE ENGINE.

The Autobiography of an Old Locomotive Engine. By ROBERT WEATHER-BURN, M.I.M.E. With Illustrations and Portraits of George and Robert Stephenson. Crown 8vo, cloth. [Just Published. Net 2/6]

SUMMARY OF CONTENTS: — PROLOGUE.—CYLINDERS.—MOTIONS.—CONNECTING RODS.—FRAMES.—WHEELS.—PUMPS, CLACKS, &c.—INJECTORS.—BOILERS.—SMOKE BOX.—CHIMMEY.—WEATHER BOARD AND AWNING.—INTERNAL DISSENSIONS.—ENGINE

"It would be difficult to imagine anything more ingeniously planned, more cleverly worked out, and more charmingly written. Readers cannot fail to find the volume most enjoyable."—Glasgow Herald.

THE LOCOMOTIVE ENGINE AND ITS DEVELOPMENT.

A Popular Treatise on the Gradual Improvements made in Railway Engines between 1803 and 1806. By CLEMENT E. STRETTON, C.E. Fifth Edition, Enlarged. With 120 Illustrations. Crown 8vo, cloth. [Just Published. 3/6]

"Students of railway history and all who are interested in the evolution of the modern locomotive will find much to attract and entertain in this volume,"—The Times.

LOCOMOTIVE ENGINE DRIVING.

A Practical Manual for Engineers in Charge of Locomotive Engines. By MICHAEL REYNOLDS, Member of the Society of Engineers, formerly Locomotive Inspector, L. B. & S. C. R. Eleventh Edition. Including a KEY TO THE LOCOMOTIVE ENGINE. Crown 8vo, cloth 4/8

"Mr. Reynolds has upplied a want, and has supplied it well. We can considently recommend the book not only to the practical driver, but to everyone who takes an interest in the performance of locomotive engines."—The Engineer.
"Mr. Reynolds has opened a new chapter in the literature of the day. His treatise is admirable."—Alterneum.

THE MODEL LOCOMOTIVE ENGINEER.

Fireman, and Engine-Boy. Comprising a Historical Notice of the Pioneer Locomotive Engines and their Inventors. By MICHAEL REYNOLDS. Second Edition, with Revised Appendix. Crown 8vo, cloth. [Just Published. 4/6

"From the technical knowledge of the author, it will appeal to the railway man of to-day more forcibly than anything written by Dr. Smiles. . The volume contains information of a technical kind, and facts that every driver should be familiar with. "English Michaen" "We should be glad to see this book in the possession of everyone in the kingdom who has ever laid, or is to lay, hands on a locomotive engine.""—From.

CONTINUOUS RAILWAY BRAKES.

"A popular explanation of the different brakes. It will be of great assistance in forming public opinion, and will be studied with benefit by those who take an interest in the brake."—English Mechanic.

STATIONARY ENGINE DRIVING.

ENGINE-DRIVING LIFE.

Stirring Adventure and Incidents in the Lives of Locomotive Engine-Drivers. By Michael Reynolds. Third Edition. Crown 8vo, cloth . 1/6 "Perfectly fascinating. Wilkie Collins's most thrilling conceptions are thrown into the shade by true incidents, endless in their variety, related in every page."—North British Mail.

THE ENGINEMAN'S POCKET COMPANION.

And Practical Educator for Enginemen, Boiler Attendants, and Mechanics. By MICHAEL REVNOLDS. With 45 Illustrations and numerous Diagrams. Fourth Edition, Revised. Royal 18mo, strongly bound for pocket wear. 3/6 "This admirable work is well suited to accomplish its object, being the honest workmanship of a competent engineer."—Glasgow Herald,

CIVIL ENGINEERING. SURVEYING. &c.

LIGHT RAILWAYS FOR THE UNITED KINGDOM, INDIA, AND THE COLONIES.

A Practical Handbook setting forth the Principles on which Light Railways should be Constructed, Worked, and Financed; and detailing the Cost of Construction, Equipment, Revenue and Working Expenses of Local Railways already established in the above-mentioned countries, and in Belgium, France, Switzerland, &c. By J. C. Mackay, F.G.S., A.M. Inst. C.E. Illustrated with Plates and Diagrams. Medium 8vo, cloth. [Just Published. 15/0]

TUNNELLING.

A Practical Treatise. By Charles Prelini, C.E. With additions by Charles S. Hill, C.E. Including 150 Diagrams and Illustrations. Royal [Just Published. Net 16/0 8vo. cloth.

PRACTICAL TUNNELLING.

Explaining in detail Setting-out the Works, Shaft-sinking, and Heading-driving, Ranging the Lines and Levelling underground, Sub-Excavating, Timbering and the Construction of the Brickwork of Tunnels, with the amount of Labour required for, and the Cost of, the various portions of the work. By Frederick W. Simms, M. Inst. C.E. Fourth Edition, Revised and Further Extended, including the most recent (1805) Examples of Sub-aqueous and other Tunnels, by D. Kinnear Clark, M. Inst. C.E. Imperial 8vo, with 34 Folding Plates and other Illustrations. Cloth. [Just Published. &2 2s.

"The present (1896) edition has been brought right up to date, and is thus rendered a work to which civil engineers generally should have ready access, and to which engineers who have construction work can hardly afford to be without, but which to the younger members of the profession is invaluable, as from its pages they can learn the state to which the science of tunnelling has attained."—Railway News.

"The estimation in which Mr. Simms's book has been held for many years cannot be more truly expressed than in the words of the late Prof. Rankine: 'The best source of information on the subject of tunnels is Mr. F. W. Simms's work on Practical Tunnelling,'"—"Arthitical".

THE WATER SUPPLY OF TOWNS AND THE CON-STRUCTION OF WATER-WORKS.

A Practical Treatise for the Use of Engineers and Students of Engineering. By W. K. Burton, A.M. Inst. C.E., Professor of Sanitary Engineering in the Imperial University, Tokyo, Japan, and Consulting Engineer to the Tokyo Water-works. Second Edition, Revised and Extended. With numerous Plates and Illustrations. Super-royal 8vo, buckram. [Just Published. 25/0]

Plates and Illustrations. Super-royal 8vo, buckram. [Just Published. 25/0]

I. INTRODUCTORY.— II. DIFFERENT QUALITIES OF WATER.— III. QUANTITY OF WATER TO BE PROVIDED.—IV. ON ASCERTAINING WHETHER A PROPOSED SOURCE OF SUPPLY IS SUFFICIENT.—V. ON ESTIMATING THE STORAGE CAPACITY REQUIRED TO BE PROVIDED.—VI. CLASSIFICATION OF WATER-WORKS.—VII. IMPOUNDING RESERVOIRS.—VIII. EARTHWORK DAMS.—IX. MASONRY DAMS.—X. THE PURIFICATION OF WATER.—XI. SETTLING RESERVOIRS.—XII. SAND FILTRATION.—XIII. PURIFICATION OF WATER BY ACTION OF IRON, SOFTENING OF WATER BY ACTION OF LIME, NATURAL FILTRATION.—XIV. SERVICE OR CLEAN WATER RESERVOIRS.—WIRE TOWERS—STAND FIPES.—XV. THE CONNECTION OF SETTLING RESERVOIRS, FILTER BEDS AND SERVICE RESERVOIRS.—XVII. PUMPING MACHINERY.—XVII. FLOW OF WATER IN CONDUITS—PIPES AND OPEN CHANNELS.—XVIII. DISTRIBUTION SYSTEMS.—XIX. SPECIAL PROVISIONS FOR THE EXTINCTION OF FIRE.—XX. PIPES FOR WATER-WORKS.—XXI. PREVENTION OF WASTE OF WATER.—XXII. VARIOUS APPLICATIONS USED IN CONNECTION WITH WATER-WORKS.—XXI. PREVENTION OF WATER.—XXII. VARIOUS APPLICATIONS USED IN CONNECTION WITH WATER-WORKS.—XXI. PREVENTION OF WATER.—XXIII. VARIOUS APPLICATIONS USED IN CONNECTION WITH WATER-WORKS.—

VENTION OF WASTE OF WATER.—XXII. VARIOUS APPLICATIONS USED IN CONNECTION WITH WATER-WORKS.

APPENDIX I. By PROF. JOHN MILNE, R.S.—CONSIDERATIONS CONCERNING THE PROBABLE EFFECTS OF EARTHQUAKES ON WATER-WORKS, AND THE SPECIAL PRE-CAUTIONS TO BE TAKEN IN EARTHQUAKE COUNTRIES.

APPENDIX II. By JOHN DE RIJKE, C.E.—ON SAND DUNES AND DUNE SAND AS A SOURCE OF WATER SUPPLY.

"The chapter upon filtration of water is very complete, and the details of construction well ulustrated. . . The work should be specially valuable to civil engineers engaged in work in Japan, but the interest is by no means confined to that locality."—Engineer.

"We congratulate the author upon the practical commonsense shown in the preparation of this work. . . The plates and diagrams have evidently been prepared with great care, and cannot fail to be of great assistance to the student."—Builder.

"The whole art of water-works construction is dealt with in a clear and comprehensive fashion in this handsome volume. . . Mr. Burton's practical treatise shows in all its sections the fruit of independent study and individual experience. It is largely based upon his own practice in the branch of engineering of which it treats."—Sainvila Review.

THE WATER SUPPLY OF CITIES AND TOWNS.

By WILLIAM HUMBER, A. M. Inst. C.E., and M. Inst. M.E., Author of "Cast and Wrought Iron Bridge Construction," &c., &c. Illustrated with 50 Double Plates, 1 Single Plate, Coloured Frontispiece, and upwards of 250 Woodcuts, and containing 400 pp. of Text. Imp. 4to, elegantly and substantially . Net £6 6. half-bound in morocco

LIST OF CONTENTS.

ROTHERHAM, DUBLIN, AND OTHERS.

"The most systematic and valuable work upon water supply hitherto produced in English, or in any other language. It is characterised almost throughout by an exhaustiveness much more distinctive of French and German than of English technical treadises." Engineer.

RURAL WATER SUPPLY.

A Practical Handbook on the Supply of Water and Construction of Waterworks for small Country Districts. By Allan Greenwell, A.M.I.C.E., and W. T. Curry, A.M.I.C.E., F.G.S. With Illustrations. Second Edition, Revised. Crown 8vo, cloth.

"We conscientiously recommend it as a very useful book for those concerned in obtaining water for small districts, giving a great deal of practical information in a small compass."—Butlder.

"The volume contains valuable information upon all matters connected with water supply.

Full of details on points which are continually before water-works engineers."—Nature.

HYDRAULIC POWER ENGINEERING.

A Practical Manual on the Concentration and Transmission of Power by Hydraulic Machinery.

By G. Croydon Marks, A.M. Inst. C.E. With nearly 200 Illustrations.

8vo, cloth.

[Just Published. Net 9/0]

SUMMARY OF CONTENTS:—PRINCIPLES OF HYDRAULICS.—THE OBSERVED FLOW OF WATER.—HYDRAULIC PRESSURES, MATERIAL—TEST LOAD PACKINGS FOR SILDING SURPACES.—PIPE JOINTS.—CONTROLLING VALVES.—PLATFORM LIFTS.—WORKSHOP, FACTORY, AND DOCK CRANES.—HYDRAULIC ACCUMULATORS.—PRESSES.—SHEET METAL WORKING AND FORGING MACHINERY.—HYDRAULIC RIVETTERS.—HAND, POWER, AND STEAM PUMPS.—TURBINES.—IMPULSE AND RE-ACTION TURBINS.—DESIGN OF TURBINS.—BINES.—WATER WHEELS.—HYDRAULIC ENGINES.—RECENT ACHIEVEMENTS.—TABLES.

"We have nothing but praise for this thoroughly valuable work. The author has succeeded in rendering his subject interesting as well as instructive."—Practical Engineer.
"Can be unhesitatingly recommended as a useful and up-to-date manual on hydraulic transmission and utilisation of power."—Mechanical World.

HYDRAULIC TABLES, CO-EFFICIENTS, & FORMULÆ.

For Finding the Discharge of Water from Orifices, Notches, Weirs, Pipes, and Rivers. With New Formulæ, Tables, and General Information on Rain-fall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, Civil Engineer, M.R.I.A. Third Edition, revised, with additions. Numerous Illustrations. Crown 8vo, cloth . 14/0 "It is, of all English books on the subject, the one nearest to completeness."-Architect.

HYDRAULIC MANUAL.

Consisting of Working Tables and Explanatory Text. Intended as a Guide in Hydraulic Calculations and Field Operations. By Lowis D'A. Jackson, Author of "Aid to Survey Practice," "Modern Metrology," &c. Fourth Edition, Enlarged. Large crown 8vo, cloth

"The author has constructed a manual which may be accepted as a trustworthy guide to this branch of the engineer's profession."—Engineering.

WATER ENGINEERING.

A Practical Treatise on the Measurement, Storage, Conveyance, and Utilisation of Water for the Supply of Towns, for Mill Power, and for other Purposes. By C. Slagg, A. M. Inst. C.E. Second Edition. Crown 8vo, cloth . 7/8

"As a small practical treatise on the water supply of towns, and on some applications of water-power, the work is in many respects excellent."—Engineering.

THE RECLAMATION OF LAND FROM TIDAL WATERS.

Works of Reclamation. By ALEXANDER BEAZELEY, M. Inst. C.E. With Illustrations. 8vo, cloth.

"The book shows in a concise way what has to be done in reclaiming land from the sea, and the best way of doing it. The work contains a great deal of practical and useful information which cannot fail to be of service to engineers entrusted with the enclosure of salt marshes, and to land-owners intending to reclaim land from the sea."—The Engineer.

"The author has carried out his task efficiently and well, and his book contains a large amount information of great service to engineers and others interested in works of reclamation."

-Nature

MASONRY DAMS FROM INCEPTION TO COMPLETION.

Including numerous Formulæ, Forms of Specification and Tender, Pocket Diagram of Forces, &c. For the use of Civil and Mining Engineers. By C. F. COURTNEY, M. Inst. C.E. 8vo, cloth. [Just Published. 9/0]

* The volume contains a good deal of valuable data, and furnishes the engineer with practical advice. Many useful suggestions will be found in the remarks on site and position, location of dam, foundations and construction."—Building News.

RIVER BARS.

The Causes of their Formation, and their Treatment by "Induced Tidal Scour"; with a Description of the Successful Reduction by this Method of the Bar at Dublin. By I. J. Mann, Assist. Eng. to the Dublin Port and Docks Board. Royal 8vo, cloth

"We recommend all interested in harbour works—and, indeed, those concerned in the mprovements of rivers generally—to read Mr. Mann's interesting work,"—Engineer,

TRAMWAYS: THEIR CONSTRUCTION AND WORKING.

Embracing a Comprehensive History of the System; with an exhaustive Analysis of the Various Modes of Traction, including Horse Power, Steam, Cable Traction, Electric Traction, &c.; a Description of the Varieties of Rolling Stock; and ample Details of Cost and Working Expenses. New Edition, Thoroughly Revised, and Including the Progress recently made in Tramway Construction, &c., &c. By D. KINNEAR CLARK, M. Inst. C. E. With 400 Illustrations. 8vo, 780 pp., buckram.

[Just Published. 28/0]

"The new volume is one which will rank, among tramway engineers and those interested in tramway working, with the Author's world-famed book on railway machinery."—The Engineer.

SURVEYING AS PRACTISED BY CIVIL ENGINEERS AND SURVEYORS

Including the Setting-out of Works for Construction and Surveys Abroad, with many Examples taken from Actual Practice. A Handbook for use in the Field LAW, Jun., A.M. Inst. C.E., Author of "Points and Crossings." With about 260 Illustrations. Demy 8vo, cloth.

[Just Published. Net 10/8]

PRACTICAL SURVEYING.

A Text-Book for Students preparing for Examinations or for Survey work in the Colonies. By George W. Usill, A.M.I.C.E. With 4 Plates and upwards of 330 Illustrations. Seventh Edition. Including Tables of Natural Sines, Tangents, Secants, &c. Crown 8vo, cloth 7/8; or, on Thin Paper, leather, gilt edges, for pocket use. 12/8

"The best forms of instruments are described as to their construction, uses and modes of employment, and there are innumerable hints on work and equipment such as the author, in his experience as surveyor, draughtsman and teacher, has found necessary, and which the student in his inexperience will find most serviceable."—Engineer.

"The latest treatise in the English language on surveying, and we have no hesitation in saying that the student will find it a better guide than any of its predecessors. Deserves to be recognised as the first book which should be put in the hands of a pupil of Civil Engineering."—

Architect.

AID TO SURVEY PRACTICE.

SURVEYING WITH THE TACHEOMETER.

A practical Manual for the use of Civil and Military Engineers and Surveyors. Reducing two series of Tables specially computed for the Reduction of Readings in Sexagesimal and in Centesimal Degrees. By NEIL KENNEDY, M. Inst. C.E. With Diagrams and Plates. Demy 8vo, cloth. Net 10/6

"The work is very clearly written, and should remove all difficulties in the way of any surveyor desirous of making use of this useful and rapid instrument."—Nature.

ENGINEER'S & MINING SURVEYOR'S FIELD BOOK.

Consisting of a Series of Tables, with Rules, Explanations of Systems, and

"The book is very handy; the separate tables of sines and tangents to every minute will make it useful for many other purposes, the genuine traverse tables existing all the same."—A then aum.

LAND AND MARINE SURVEYING.

"This book must prove of great value to the student. We have no hesitation in recommending it, feeling assured that it will more than repay a careful study."—Mechanical World.

"A most useful book for the student. We strongly recommend it as a carefully-written and valuable text-book. It enjoys a well-deserved repute among surveyors."—Builder.

PRINCIPLES AND PRACTICE OF LEVELLING.

"The text-book on levelling in most of our engineering schools and colleges."—*Bagisaes*.

"The publishers have rendered a substantial service to the profession, especially to the younger members, by bringing out the present edition of Mr. Simms's useful work." —*Bagisaering*.

AN OUTLINE OF THE METHOD OF CONDUCTING A TRIGONOMETRICAL SURVEY.

For the Formation of Geographical and Topographical Maps and Plans, Military Reconnaissance, LEVELLING, &c., with Useful Problems, Formula, and Tables. By Lieut.-General Frome, R.E. Fourth Edition, Revised and partly Re-written by Major-General Sir CHARLES WARREN, G.C.M.G., R.E. With 19 Plates and 115 Woodcuts, royal 8vo, cloth 16/0

"No words of praise from us can strengthen the position so well and so steadily maintained by this work. Sir Charles Warren has revised the entire work, and made such editions as were necessary to bring every portion of the contents up to the present date."—Broad Arrow.

TABLES OF TANGENTIAL ANGLES AND MULTIPLES FOR SETTING-OUT CURVES.

From 5 to 200 Radius. By A. BEAZELEY, M. Inst. C.E. 6th Edition, Revised. With an Appendix on the use of the Tables for Measuring up Curves. Printed on 50 Cards, and sold in a cloth box, waistcoat-pocket size.

"Each table is printed on a card, which, placed on the theodolite, leaves the hands free to manipulate the instrument—no small advantage as regards the rapidity of work."—Engineer.

"Very handy: a man may know that all his day's work must fall on two of these cards, which he puts into his own card-case, and leaves the rest behind."—Athenaum.

HANDY GENERAL EARTH-WORK TABLES.

Giving the Contents in Cubic Yards of Centre and Slopes of Cuttings and Embankments from 3 inches to 80 feet in Depth or Height, for use with either 66 feet Chain or 100 feet Chain. By J. H. Watson Buck, M. Inst. C.E. On

EARTHWORK TABLES.

"The way in which accuracy is attained, by a simple division of each cross section into three elements, two in which are constant and one variable, is ingenious."—Atheraum.

A MANUAL ON EARTHWORK.

By ALEX. J. S. GRAHAM, C.E. With numerous Diagrams. Second Edition. 18mo, cloth

THE CONSTRUCTION OF LARGE TUNNEL SHAFTS.

A Practical and Theoretical Essay. By J. H. Watson Buck, M. Inst. C.E., Resident Engineer, L. and N. W. R. With Folding Plates, 8vo, cloth 12/0

"Many of the methods given are of extreme practical value to the mason, and the observa-tions on the form of arch, the rules for ordering the stone, and the construction of the templates, till be found of considerable use. We commend the book to the engineering profession."—

Butlding News.

"Will be regarded by civil engineers as of the utmost value, and calculated to save much time and obviate many mistakes."—Colliery Guardian.

CAST & WROUGHT IRON BRIDGE CONSTRUCTION

(A Complete and Practical Treatise on), including Iron Foundations. In Three Parts.—Theoretical, Practical, and Descriptive. By William Humber, A. M. Inst. C. E., and M. Inst. M. E. Third Edition, revised and much improved, with rrs Double Plates (so of which now first appear in this edition), and numerous Additions to the Text. In 2 vols., imp. 4to, half-board in morocco . £6 16s. 6c.

"A very valuable contribution to the standard literature of civil engineering. In addition to evations, plans, and sections, large scale details are given, which very much enhance the instructive worth of those illustrations. "Civil Engineer and Architect Fournal." "Mr. Humber's stately volumes, lately issued—in which the most important bridges exected during the last five years, under the direction of the late Mr. Brunel, Sir W. Cubitt, Mr. Hawkshaw, Mr. Page, Mr. Fowler, Mr. Hemans, and others among our most eminent engineers, are drawn and specified in great detail." "Engineer, are drawn and specified in great detail." "Engineer, are drawn and specified in great detail."

ESSAY ON OBLIQUE BRIDGES

(Practical and Theoretical). With 13 large Plates. By the late George WATSON BUCK, M.I.C.E. Fourth Edition, revised by his Son, J. H. WATSON BUCK, M.I.C.E.; and with the addition of Description to Diagrams for Facilitating the Construction of Oblique Bridges, by W. H. BARLOW, M.I.C.E. 12/0 Royal 8vo, cloth

"The standard text-book for all engineers regarding skew arches is Mr. Buck's treatise, and it would be impossible to consult a better."—Engineer.
"Mr. Buck's treatise is recognised as a standard text-book, and his treatment has divested the subject of many of the intricacies supposed to belong to it. As a guide to the engineer and architect, on a confessedly difficult subject, Mr. Buck's work is unsurpassed."—Butléary News.

THE CONSTRUCTION OF OBLIQUE ARCHES

. 8/0

GRAPHIC AND ANALYTIC STATICS.

In their Practical Application to the Treatment of Stresses in Roofs, Solid Girders, Lattice, Bowstring, and Suspension Bridges, Braced Iron Arches and Piers, and other Frameworks. By R. Hudson Graham, C.E. Containing Diagrams and Plates to Scale. With numerous Examples, many taken from existing Structures. Specially arranged for Class-work in Colleges and Universities. Second Edition, Revised and Enlarged. 8vo, cloth . 16/0 "Mr. Graham's book will find a place wherever graphic and analytic statics are used or studied."—Engineer.

"The work is excellent from a practical point of view, and has evidently been prepared with much care. The directions for working are simple, and are illustrated by an abundance of well-selected examples. It is an excellent text-book for the practical draughtsman."—Albemoum.

WEIGHTS OF WROUGHT IRON & STEEL GIRDERS.

PRACTICAL GEOMETRY.

THE GEOMETRY OF COMPASSES.

HANDY BOOK FOR THE CALCULATION OF STRAINS

"The formulæ are neatly expressed, and the diagrams good."—Athenaum.
"We heartly commend this really handy book to our engineer and architect readers."—
English Michanic.

TRUSSES OF WOOD AND IRON.

Practical Applications of Science in Determining the Stresses, Breaking Weights, Safe Loads, Scantlings, and Details of Construction. With Complete Working Drawings. By WILLIAM GRIFFITHS, Surveyor. 8vo, cloth. 4/8 "This handy little book enters so minutely into every detail connected with the construction of roof trusses that no student need be ignorant of these matters."—Practical Engineer.

THE STRAINS ON STRUCTURES OF IRONWORK.

A TREATISE ON THE STRENGTH OF MATERIALS.

With Rules for Application in Architecture, the Construction of Suspension Bridges, Railways, &c. By Peter Barlow, F.R.S. A new Edition, revised by his Sons, P. W. Barlow, F.R.S., and W. H. Barlow, F.R.S.; to which are added, Experiments by Hodgkinson, Fairbairn, and Kirkaldy; and Formulæ for calculating Girders, &c. Arranged and Edited by W.M. Humber, A. M. Inst. C.E. 8vo, cloth.

"Valuable allke to the student tyro, and the experienced practitioner, it will always rank in future as it has hitherto done, as the standard treatise on that particular subject."—Engineer.

"As a scientific work of the first class, it deserves a foremost place on the bookshelves of every civil engineer and practical mechanic."—English Mechanic.

SAFE RAILWAY WORKING.

"A book for the engineer, the directors, the managers; and, in short, all who wish for information on railway matters will find a perfect encyclopædia in 'Safe Railway Working.'"—
Railway Review.
"We commend the remarks on railway signalling to all railway managers, especially where a uniform code and practice is advocated."—Herepath's Railway Journal.

EXPANSION OF STRUCTURES BY HEAT.

The aim the author has set before him, viz., to show the effects of heat upon metallic and other structures, is a laudable one, for this is a branch of physics upon which the engineer or architect can find but little reliable and comprehensive data in books."—Buttleer.

THE PROGRESS OF MODERN ENGINEERING.

Complete in Four Volumes, imperial 4to, half-morocco, price £12 12s.

LIST OF THE PLATES AND DIAGRAMS.

VICTORIA STATION AND ROOF, L. B. & S. C. R. (8 PLATES); SOUTHFORT PIER (9 PLATES); VICTORIA STATION AND ROOF, L. C. & D. AND G. W. R. (6 PLATES); ROOF OF CREMORNE MUSIC HALL; BRIDGE OVER G. N. RAILWAY; ROOF OF STATION, DUTCH RHENISH RAIL (2 PLATES); BRIDGE OVER THE THAMES, WEST LONDON EXTENSION RAILWAY (5 PLATES); ARMOUR PLATES; SUSPENSION BRIDGE, THAMES (4 PLATES); THE ALLEN ENGINE; SUSPENSION BRIDGE, THAMES (4 PLATES); THE ALLEN ENGINE; SUSPENSION BRIDGE, AVON (2 PLATES); UNDERGROUND RAILWAY (5 PLATES).

HUMBER'S MODERN ENGINEERING.

LIST OF THE PLATES AND DIAGRAMS.

BIRKENHEAD DOCKS, LOW WATER BASIN (15 PLATES); CHARING CROSS STATION ROOF, C. C. RAILWAY (5 PLATES); DIGSWELL VIADUCT, GREAT NORTHERN RAILWAY; ROBBERY WOOD VIADUCT, GREAT NORTHERN RAILWAY; ROOF PERMANENT WAY; CLYDACH VIADUCT, MERTHYR, TREDEGAR, AND ABERGAVENNY RAILWAY; EDUCEG WOOD VIADUCT, MERTHYR, TREDEGAR, AND ABERGAVENNY RAILWAY; COLLEGE WOOD VIADUCT, CORNWALL RAILWAY; DUBLIN WINTER PALACE ROOF (3 PLATES); BRIDGE OVER THE THAMES, L. C. & D. RAILWAY (6 PLATES); ALBERT HARBOUR, GREENOCK

HUMBER'S MODERN ENGINEERING.

LIST OF THE PLATES AND DIAGRAMS.

MAIN DRAINAGE, METROPOLIS.—North Side.—MAP SHOWING INTERCEPTION OF SEWERS; MIDDLE LEVEL SEWER (2 PLATES); OUTFALL SEWER, BRIDGE OVER RIVER LEA (3 PLATES); OUTFALL SEWER, BRIDGE OVER RIVER LEA (3 PLATES); OUTFALL SEWER, BRIDGE OVER MASSH LANR, NORTH WOOLWICH RAILWAY, AND BOW AND BARKING RAILWAY (3 PLATES); OUTFALL SEWER, BRIDGE OVER EAST LONDON WATER-WORKS' FEEDER (2 PLATES); OUTFALL SEWER, BRIDGE OVER EAST LONDON WATER-WORKS' FEEDER (2 PLATES); OUTFALL SEWER, RESERVOIR (2 PLATES); OUTFALL SEWER, FEEDER, BERMONISEY BRANCH (2 PLATES); OUTFALL SEWER, RESERVOIR ADDITIONS OF SEWERS, POSTH AND OUTLET (4 PLATES); OUTFALL SEWER, FILTH HOIST; SECTIONS OF SEWERS NORTH AND

THAMES EMBANKMENT.—SECTION OF RIVER WALL; STEAMBOAT PIER, WEST-MINSTER (9 PLATES); LANDING STAIRS BETWEEN CHARING CROSS AND WATERLOOD BRIDGES; YORK GATE (9 PLATES); OVERFLOW AND OUTLET AT SAVOY STREET SEWER (9 PLATES); FEAMBOAT PIER, WATERLOO BRIDGE (9 PLATES); JUNCTION OF SEWERS, PLANS AND SECTIONS; GULLIES, PLANS AND SECTIONS; GULL

AND IRON FORTS.

HUMBER'S MODERN ENGINEERING.

FOURTH SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of John Fowler, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c. Half-morocco .

LIST OF THE PLATES AND DIAGRAMS.

ABBEY MILLS PUMPING STATION, MAIN DRAINAGE, METROPOLIS (4 PLATES);
BARROW DOCKS (5 PLATES); MANQUIS VIADUCT, SANTIAGO AND VALPARAISO RAILWAY,
(2 PLATES); ADAM'S LOCOMOTIVE, ST. HELEN'S CANAL RAILWAY (3 PLATES); CANNON
STREET STATION ROOF, CHARING CROSS RAILWAY (3 PLATES); ROAD BRIDGE OVER
THE RIVER MOKA (2 PLATES); TELEGRAPHIC APPARATUS FOR MESOPOTAMIA, VIADUCT
OVER THE RIVER WYE, MIDLAND RAILWAY (3 PLATES); ST. GERMANS VIADUCT,
CONNWALL RAILWAY (2 PLATES); WROUGHTIRON CYLINDER FOR DIVING BELL
MILLWALL DOCKS (6 PLATES); MINGUST PATENT EXCAVATOR; METROPOLITAN DISTRICT RAILWAY (6 PLATES); HARBOURS, FORTS, AND BREAKWATERS (3 PLATES).

MARINE ENGINEERING, SHIPBUILDING, NAVIGATION. &c.

THE NAVAL ARCHITECT'S AND SHIPBUILDER'S

POCKET-BOOK of Formulæ, Rules, and Tables, and Marine Engineer's and Surveyor's Handy Book of Reference. By CLEMENT MACKROW, M.I.N.A. Eighth Edition, Carefully Revised and Enlarged. Fcap., leather.

[Just Published. Net 12/6]

EIGUIN EGILION, CARRILLIY KEVISCH AND EINIATED. P. (PASP., IEARIDET. [Just Published. Net 12/6]
SUMMARY OF CONTENTS:—SIGNS AND SYMBOLS, DECIMAL FRACTIONS.—TRIGONOMETRY.—PRACTICAL GEOMETRY.—MENSURATION.—CENTRES AND MOMENTS OF FIGURES.
—MOMENTS OF INERTIA AND RADII OF GYRATION.—ALGEBRAICAL EXPRESSIONS FOR SIMPSON'S RULES.—MECHANICAL PRINCIPLES.—CENTRE OF GRAVITY.—LAWS OF MOTION.
—DISPLACEMENT. CENTRE OF BUOYANCY.—CENTRE OF GRAVITY.—LAWS OF MOTION.
—DISPLACEMENT. CENTRE OF BUOYANCY.—CENTRE OF GRAVITY.—LAWS OF MOTION.
—DISPLACEMENT. CENTRE OF BUOYANCY.—CENTRE OF GRAVITY OF SHIP'S HULL.
OF SHIPS.—PROPULSION AND RESISTANCE OF VESSELS.—SPEED TRIALS.—SAILING
CENTRE OF EFFORT.—DISTANCES DOWN RIVERS, COAST LINES.—STEERING AND
RUDDERS OF VESSELS.—LAUNCHING CALCULATIONS AND VELOCITIES.—WEIGHT OF
MATERIAL AND GEAR.—GUN PARTICULARS AND WEIGHT.—STANDARD GAUGES.—
RIVETED JOINTS AND RIVETING.—STRENGTH AND TESTS OF MATERIALS.—BINDING
AND SHEARING STRESSES, &c. —STRENGTH AND TESTS OF MATERIALS.—BINDING
AND SHEARING STRESSES, &c. —STRENGTH AND TESTS OF MATERIALS.—BINDING
OF CHAINS, WORK.—BOARD OF TRADE REGULATIONS FOR BOILERS AND ENGINES.—BOARD
OF TRADE REGULATIONS FOR SHIPS.—LLOYD'S RULES FOR BOILERS.—LLOYD'S WEIGHT
OF CHAINS.—LLOYD'S SCANTLINGS FOR SHIPS.—DATA OF ENGINES AND WESSELS.—
SHIPS FITTINGS AND MESSELS.—SEASONING PRESERVIN TIMBER.—MEASALEMMETAR.

FINDER—CULATIONS, RULES FOR HORSE-POWER, SCREW ROPELLERS, &c.—PARECENTRACES OF FOREIGN PORTS.—TONNAGE TABLES.—VOCABULARY OF
PRENCH AND ENGLISH TERMS.—ENGLISH WEIGHTS AND MEASURES.—FOREIGN
AND WEIGHTS AND MEASURES.—DEGIMAL EQUIVALENTS.—FOREIGN MOBEY.—DISCOUNT
AND WAGES TABLES.—USEFUL NUMBERS AND READY RECKONERS.—FOREIGN
AND WEIGHTS AND MEASURES.—TABLES OF AREAS OF AND CIRCUMFERENCES OF CIRCLES.—
TABLES OF AREAS OF SEGMENTS OF CIRCLES.—TABLES OF PAREAS OF SUMBERS.—TABLES OF PAREAS
FOLICAL MEASURES.—TABLES OF NATURAL SINES, TANCENTS, &c.—TABLES OF
CIRCULAR MEASURES.—TABLES OF LOCASITHMS OF NUMBERS.—TABLES OF PAREAS
FOLICALS.—TABLES OF LOCASITHMS OF NUMBERS.—TABLES OF PAREAS
FO

"In these days of advanced knowledge a work like this is of the greatest value. It contains a vast amount of information. We unhesitatingly say that it is the most valuable compilation for its specific purpose that has ever been printed. No naval architect, engineer, surveyor, or seaman, wood or iron shipbuilder, can afford to be without this work."—Nauhical Magazine.

"Should be used by all who are engaged in the construction or design of vessels. . . Will be found to contain the most useful tables and formulæ required by shipbuilders, carefully collected from the best authorities, and put together in a popular and simple form. The book is one of

from the best authornes, and pur together in a popular and simple form. The book is one exceptional merit."—Engineer.

"The professional shipbuilder has now, in a convenient and accessible form, reliable data for solving many of the numerous problems that present themselves in the course of his work."—Iron.

"There is no doubt that a pocket-book of this description must be a necessity in the shipbuilding trade. . . The volume contains a mass of useful information clearly expressed and presented in a handy form,"—Marine Engineer.

WANNAN'S MARINE ENGINEER'S GUIDE

To Board of Trade Examinations for Certificates of Competency. Containing all Latest Questions to Date, with Simple, Clear, and Correct Solutions; 302 Elementary Questions with Illustrated Answers, and Verbal Questions 302 Elementary Questions with Illustrated Answers, and Veroal Questions and Answers; complete Set of Drawings with Statements completed. By A. C. Wannan, C. E., Consulting Engineer, and E. W. I. Wannan, M. I. M. E., Certificated First Class Marine Engineer. Illustrated with numerous Engravings. Third Edition, Revised and Enlarged. 500 pages. Large crown 800, cloth. [Just Published. Net 10/6]

"The book is clearly and plainly written and avoids unnecessary explanations and formulas, and we consider it a valuable book for students of marine engineering."—Nautical Magazine.

WANNAN'S MARINE ENGINEER'S POCKET-BOOK

Containing the Latest Board of Trade Rules and Data for Marine Engineers. By A. C. WANNAN. Third Edition, Revised, Enlarged, and Brought Up to Date. Square 18mo, with thumb Index, leather. [Just Published. 5]0 "There is a great deal of useful information in this little pocket-book. It is of the rule-of-thumb order, and is, on that account, well adapted to the uses of the sea-going engineer."—

Rusineer.

SEA TERMS. PHRASES, AND WORDS

(Technical Dictionary of) used in the English and French Languages (English-French, French-English). For the Use of Seamen, Engineers, Pilots, Shipbuilders, Shipbwarers, and Ship-brokers. Compiled by W. Pirrie, late of the African Steamship Company. Fcap. 8vo, cloth limp. 5/0

"This volume will be highly appreciated by seamen, engineers, pilots, shipbuilders and shipowners. It will be found wonderfully accurate and complete." "Scotsman." A very useful dictionary, which has long been wanted by French and English engineers, masters, officers and others." "Shipping World."

ELECTRIC SHIP-LIGHTING.

A Handbook on the Practical Fitting and Running of Ships' Electrical Plant, for the Use of Shipowners and Builders, Marine Electricians and Sea-going Engineers in Charge. By J. W. URQUHART, Author of "Electric Light," "Dynamo Construction," &c. Second Edition, Revised and Extended, 326 pp., with 88 Illustrations. Crown 8vo, cloth. [Just Published. 7/6]

MARINE ENGINEER'S POCKET-BOOK.

Consisting of useful Tables and Formulæ. By FRANK PROCTOR, A.I.N.A. Third Edition. Royal 32mo, leather, gilt edges, with strap . . 4/0

"We recommend it to our readers as going far to supply a long-felt want."—Naval Science.
"A most useful companion to all marine engineers."—United Service Gazette.

ELEMENTARY ENGINEERING.

A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, Construction and Management of Marine Engines and Boilers, Geometry, &c., &c. With an Appendix of Useful Tables. By J. S. Brewer. Crown 8vo, cloth . 1/8 "Contains much valuable information for the class for whom it is intended, especially in the chapters on the management of boilers and engines."—Nautical Magasine.

MARINE ENGINES AND STEAM VESSELS.

A Treatise on. By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with considerable Additions by the Author and by GEORGE CARLISLE, C.E., Senior Surveyor to the Board of Trade. 12mo, cloth. 4/6

PRACTICAL NAVIGATION.

THE ART AND SCIENCE OF SAILMAKING.

"This extremely practical work gives a complete education in all the branches of the manuature, cutting out, roping, seaming, and goring. It is copiously illustrated, and will form a first-rate text-book and guide."—Perturbulk Times.

CHAIN CABLES AND CHAINS.

Comprising Sizes and Curves of Links, Studs, &c., Iron for Cables and Chains, Chain Cable and Chain Making, Forming and Welding Links, Strength of Cables and Chains, Certificates for Cables, Marking Cables, Prices of Chain Cables and Chains, Historical Notes, Acts of Parliament, Statutory Tests, Charges for Testing, List of Manufacturers of Cables, &c., &c. By THOMAS W. TRAILL, F.E.R.N., M.Inst.C.E., Engineer-Surveyor-in-Chief, Board of Trade, Inspector of Chain Cable and Anchor Proving Establishments, and General Superintendent Lloyd's Committee on Proving Establishments. With numerous Tables, Illustrations, and Lithographic Drawings. Folio, cleb, heaviled beautiful. cloth, bevelled boards.

"It contains a vast amount of caluable information. Nothing spems to be wanting to make it a complete and standard work of reference on the subject."—Nausteel Magazine.

MINING. METALLURGY, AND COLLIERY WORKING.

THE DEEP LEVEL MINES OF THE RAND.

And their Future Development, considered from the Commercial Point of View. By G. A. Denny, M. N. E. Inst. M. E., Consulting Engineer to the General Mining and Finance Corporation, Ltd., of London, Berlin, Paris, and Johannesburg. Fully Illustrated with Diagrams and Folding Plates. Royal 80, buckram.

[Just Published. Net 25/0]

"Mr. Denny by confining himself to the consideration of the future of the deep-level mines of the Rand breaks new ground, and by dealing with the subject rather from a commercial stand-point than from a scientific one, appeals to a wide circle of readers. The book cannot fail to prove of very great value to investors in South African mines."—Afining Journa!.

The volume will interest all who are concerned in any way with the Witwatersrand Goldfields."—The Timus.

PROSPECTING FOR GOLD.

A Handbook of Information and Hints for Prospectors based on Personal Experience. By Danibl J. Rankin, F.R.S.G.S., M.R.A.S. Author of "The Zambesi Basin," &c.; formerly Manager of the Central African Company, and Leader of African Gold Prospecting Expeditions. With Illustrations specially Drawn and Engraved for the Work. F'cap. 8vo, leather. Net 7/6

"This well-compiled book contains a collection of the richest gems of useful knowledge for the prospector's benefit. A special table is given to accelerate the spotting at a glance of minerals associated with gold."—Mining Journal.

THE METALLURGY OF GOLD.

A Practical Treatise on the Metallurgical Treatment of Gold-bearing Ores. Including the Assaying, Melting, and Refining of Gold. By M. EISSLER, A.I.M.E., M. Inst. M.M. Fifth Edition, Enlarged. With 300 Illustrations and Folding Plates. Medium 8vo, cloth. [Just Published. Net 21/0]

"In book throughly deserves its title of a 'Practical Treatise.' The whole process of gold marriative and with much, but not too much, fulness of detail."—"Saturday Review. "The work is a storehouse of information and valuable data, and we strongly recommend it to all professional men engaged in the gold-mining industry."—"Mining Yournal."

THE CYANIDE PROCESS OF GOLD EXTRACTION.

"This book is just what was needed to acquaint mining men with the actual working of a process which is not only the most popular, but is, as a general rule, the most successful for the extraction of gold from tailings."—Mining Journal.

DIAMOND DRILLING FOR GOLD & OTHER MINERALS.

A Practical Handbook on the Use of Modern Diamond Core Drills in Pro-A Practical Handbook of the Use of Modern Diamond Cote Drins in Prospecting and Exploiting Mineral-Bearing Properties, including Particulars of the Costs of Apparatus and Working. By G. A. DENNY, M.N.E. Inst. M.E., M.I.M. and M. Medium 8vo, 168 pp., with Illustrative Diagrams. 12/6

"Mr. Denny deserves grateful recognition for supplying a decided want. We strongly recommend every board of directors to carefully peruse the pages of this valuable volume of emily practical data, which should be in the possession of those interested in mining."—Mining Tournal.

FIELD TESTING FOR GOLD AND SILVER.

A Practical Manual for Prospectors and Miners. By W. H. MERRITT, M.N.E. Inst. M.E., A.R.S.M., &c. Fcap. 8vo, leather. Net 5/0

"As an instructor of prospectors' classes Mr. Merritt has the advantage of knowing exactly the information likely to be most valuable to the miner in the field. The work will be a useful addition to a prospector's kit."—Mining Tournal.
"It gives the gist of the author's experience as a teacher of prospectors, and is a book which no prospector could use habitually without finding it pan out well."—Scotsman.

THE PROSPECTOR'S HANDBOOK.

A Guide for the Prospector and Traveller in search of Metal-Bearing or other Valuable Minerals. By J. W. ANDERSON, M.A. (Camb.), F.R.G.S. Ninth Edition. Crown 8vo, cloth, 3/6; or, leather, pocket-book form.

"Will supply a much-felt want, especially among Colonists, in whose way are so often thrown many mineralogical specimens the value of which it is difficult to determine."—*Hoptimes*.

How to find commercial minerals, and how to identify them when they are found, are the leading points to which attention is directle. The author has managed to pack as much practice detail into his pages as would supply material for a book three times its size. "—Mining Tournal."

THE METALLURGY OF SILVER.

A Practical Treatise on the Amalgamation, Roasting, and Lixiviation of Silver Ores. Including the Assaying, Melting, and Refining of Silver Bullion. By M. EISSLER, Author of "The Metallurgy of Gold," &c. Third Edition. Crown 8vo, cloth

"A practical treatise, and a technical work which we are convinced will supply a long-felt want amongst practical men, and at the same time be of value to students and others indirectly connected with the industries."—Misning Yournal.

"From first to last the book is thoroughly sound and reliable."—Colliery Guardian.
"For chemists, practical miners, assayers, and investors alike we do not know of any work on the subject so handy and yet so comprehensive."—Gaszgow Herald.

THE HYDRO-METALLURGY OF COPPER.

Being an Account of Processes Adopted in the Hydro-Metallurgical Treatment of Cupriferous Ores, Including the Manufacture of Copper Vitriol, with Chapters on the Sources of Supply of Copper and the Roasting of Copper Ores. By M. EISSLER, M.I.M.M. Medium 8vo, cloth. [Just Published. Net 12/8]

THE METALLURGY OF ARGENTIFEROUS LEAD.

A Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Including Reports on various Smelting Establishments and Descriptions of Modern Smelting Furnaces and Plants in Europe and America. By M. EISSLER, M.E., Author of "The Metallurgy of Gold," &c. Crown 8vo, 400 pp., with 183 Illustrations, cloth 12/6

"The numerous metallurgical processes, which are fully and extensively treated of, embrace all the stages experienced in the passage of the lead from the various natural states to its issue from the refinery as an article of commerce."—Practical Engineer.

"The present volume fully maintains the reputation of the author. Those who wish to obtain a thorough insight into the present state of this industry cannot do better than read this volume, and all mining engineers cannot fail to find many useful hints and suggestions in it."—Industries.

METALLIFEROUS MINERALS AND MINING.

By D. C. DAVIES, F.G.S. Sixth Edition, thoroughly Revised and much Enlarged by his Son, E. Henry Davies, M.E., F.G.S. 600 pp., with 173 Illustrations. Large crown 8vo, cloth [Just Published. Net 12/6]

"Neither the practical miner nor the general reader, interested in mines, can have a better book for his companion and his guide."—Mining Journal.
"As a history of the present state of mining throughout the world this book has a real value, and it supplies an actual want."—Albenaum.

MACHINERY FOR METALLIFEROUS MINES.

A Practical Treatise for Mining Engineers, Metallurgists, and Managers of Mines. By E. Henry Davies, M.E., F.G.S. Medium 8vo, cloth, 6co pp. With Folding Plates and other Illustrations. [Just Published. Net 25/0]

"Mr. Davies, in this handsome volume, has done the advanced student and the manager of mines good service. Almost every kind of machinery in actual use is carefully described, and woodcuts and plates are good."—Almost every kind of machinery in actual use is carefully described, and woodcuts and plates are good."—Almost every kind of machinery in actual use is carefully described, and therefore to cover the work exhibits all the same characteristics which excit the confidence and attract the attraction of the student as he peruses the first page. The work may safely be recommended. By its publication the literature connected with the industry will be enriched and the reputation of its author enhanced."—Missing Journal.

EARTHY AND OTHER MINERALS AND MINING.

By D. C. Davies, F.G.S., Author of "Metalliferous Minerals," &c. Third Edition, Revised and Enlarged by his Son, E. Henry Davies, M.E., F.G.S. With about 100 Illustrations. Crown 8vo, cloth 12/6

"We do not remember to have met with any English work on mining matters that contains the same amount of information packed in equally convenient form."—Academy.

"We should be inclined to rank it as among the very best of the handy technical and trades manuals which have recently appeared."—British Quarterly Review.

BRITISH MINING.

A Treatise on the History, Discovery, Practical Development, and Future Prospects of Metalliferous Mines in the United Kingdom. By Robbyt Hunt, F.R.S., late Keeper of Mining Records. Upwards of 950 pp., with 230 Illustrations. Second Edition, Revised. Super-royal 8vo, cloth 22 2a.

"The book is a treasure-house of statistical information on mining subjects, and we know of no other work embodying so great a mass of matter of this kind. Were this the only merit of Mr. Hunt's volume it would be sufficient to render it indispensable in the library of every one interested in the development of the mining and metallurgical industries of this country."—

POCKET-BOOK FOR MINERS AND METALLURGISTS.

Comprising Rules, Formulæ, Tables, and Notes for Use in Field and Office Work. By F. Danvers Power, F.G.S., M.E. Second Edition, Corrected. Fcap. 8vo, leather. [Just Published. 9/0

"This excellent book is an admirable example of its kind, and ought to find a large sale amongst English-speaking prospectors and mining engineers."—Engineering.

THE MINER'S HANDBOOK.

A Handy Book of Reference on the subjects of Mineral Deposits, Mining Operations, Ore Dressing, &c. For the Use of Students and others interested in Mining Matters. By John MILNE, F.R.S., Professor of Mining in the Imperial University of Japan. Third Edition. Fcap. 8vo, leather . 7/6 "Professor Milne's handbook is sure to be received with favour by all connected with mining, and will be extremely popular among students."—Athenaum.

THE IRON ORES of GREAT BRITAIN and IRELAND.

Their Mode of Occurrence, Age and Origin, and the Methods of Searching for and Working Them. With a Notice of some of the Iron Ores of Spain. By J. D. KENDALL, F.G.S., Mining Engineer. Crown 8vo, cloth .

MINE DRAINAGE.

A Complete Practical Treatise on Direct-Acting Underground Steam Pumping Machinery. By STEPHEN MICHELL. Second Edition, Re-written and Enlarged, 390 pp. With 250 Illustrations. Royal 8vo, cloth. Net 25/0

SUMMARY OF CONTENTS:—HORIZONTAL PUMPING ENGINES.—ROTARY AND NON ROTARY HORIZONTAL ENGINES.—SIMPLE AND COMPOUND STEAM PUMPS.—VERTICAL PUMPING ENGINES.—ROTARY AND NON-ROTARY VERTICAL ENGINES.—SIMPLE AND COMPOUND STEAM PUMPS.—TRIPLE-EXPANSION STEAM PUMPS.—PULSATING STEAM PUMPS.—PUMPS ALVES.—SINKING PUMPS. &c., &c.

"This volume contains an immense amount of important and interesting new matter. The book should undoubtedly prove of great use to all who wish for information on the subject, inasmuch as the different patterns of steam pumps are not alone lucidly described and clearly illustrated, but in addition numerous tables are supplied, in which their sizes, capacity price, &c., are set forth, hence facilitating immensely the rational selection of a pump to suit any purpose that the reader may desire, or, on the other hand, supplying him with useful information about any of the pumps that come within the scope of the volume. "The Engineer.

ELECTRICITY AS APPLIED TO MINING.

A Practical Treatise for Mining Engineers. By Arnold Lupton, M. Inst. C. E., M. I. E. E., G. D. Aspinall Parr, M. I. E. E., and Herbert Perkin, M. I. M. E. With a large number of Illustrations. Medium 8vo, cloth.

[Just Published. Net 7/6

THE COLLIERY MANAGER'S HANDBOOK.

A Comprehensive Treatise on the Laying-out and Working of Collieries, Designed as a Book of Reference for Colliery Managers, and for the Use of Coal Mining Students preparing for First-class Certificates. By CALEB PAMELY, Mining Engineer and Surveyor; Member of the North of England Institute of Mining and Mechanical Engineers; and Member of the South Wales Institute of Mining Engineers. With 700 Plans, Diagrams, and other Illustrations, Fourth Edition, Revised and Enlarged, medium 8vo, over 900 pp. Strongly bound. ∞ pp. £1 5s. Strongly bound .

SUMMARY OF CONTENTS:—GROLOGY.—SEARCH FOR COAL.—MINRAL LEASES AND OTHER HOLDINGS.—SHAFT SINKING.—FITTING UP THE SHAFT AND SURFACE ARRANGEMENTS.—STEAM BOILERS AND THEIR FITTINGS.—TIMBERING AND WLING.—NARROW WORK AND METHODS OF WORKING.—UNDERGROUND CONVEYANCE.—DRAINAGE.—THE GASES MET WITH IN MINES; VENTILATION.—ON THE FRICTION OF AIR IN MINES.—THE PRIESTMAN OIL ENGINE; PETROLEUM AND NATURAL GAS.—SURVEYING AND PLANNING.—SAPETY LAMPS AND FIREDAMP DETECTORS. SUNDRY AND INCIDENTAL OPERATIONS AND APPLIANCES.—COLLERY EXPLOSIONS.—MISCELLARBOUS QUESTIONS AND ANSWERS.—Appender: SUMMARY OF REPORT OF H.M. COMMISSIONERS ON ACCIDENTS IN MINES.

"Mr. Pamely has not only given us a comprehensive reference book or a very high order, suitable to the requirements of mining engineers and colliery managers, but has also provided mining students with a class-book that is as interesting as it is instructive. "Colliery Manager." Mr. Pamely's work is eminently suited to the purpose for which it is intended, being clear, interesting, exhaustive, rich in detail, and up to date, giving descriptions of the latest melines in every department. A mining engineer could scarcely go wrong who followed this work."—Colliery Guardian.

"This is the most complete 'all-round work on coal-mining published in the English language. , . . No library of coal-mining books is complete without it."—Colliery Engineer Scranton, Pa, U.S.A.).

COLLIERY WORKING AND MANAGEMENT.

Comprising the Duties of a Colliery Manager, the Oversight and Arrangement of Labour and Wages, and the different Systems of Working Coal Seams. By H. F. BULMAN and R. A. S. REDMAYNE. 350 pp., with all Plates and other Illustrations, including Underground Photographs. Uust Published. 15/0 Medium 8vo, cloth.

Medium 8vo, cloth.

"This is, indeed, an admirable Handbook for Colliery Managers, in fact it is an indispensable adjunct to a Colliery Manager's education, as well as being a most useful and interesting work on the subject for all who in any way have to do with coal mining. The underground protographs are an attractive feature of the work, being very lifelike and necessarily true representations of the scenes they deptic."—Colliery Guardian.

"Mr. Bulman and Mr. Redmayne, who are both experienced Colliery Managers of great literary ability, are to be congratualted on having supplied an authoritative work dealing with a side of the subject of coal mining which has hitherto received but scant treatment. The authorite it cert by 1ny woodcuts and 26 places, most of the latter being admirable reproductions of photographs taken underground with the aid of the magnesium flash-light. These illustrations are excellent."—Nature.

COAL AND COAL MINING.

By the late Sir Warington W. Smyth, F.R.S., Chief Inspector of the Mines of the Crown. Eighth Edition, Revised and Extended by T. Forster Brown, Mining Engineer, Chief Inspector of the Mines of the Crown and of the Duchy of Cornwall. Crown 8vo, cloth. [Just Published. 3/6] "As an outline is given of every known coal-field in this and other countries, as well as of the principal methods of working, the book will doubtless interest a very large number of readers.—Mining Yournal.

NOTES AND FORMULÆ FOR MINING STUDENTS.

By JOHN HERMAN MERIVALE, M.A., Late Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne. Fourth Edition, Revised and Enlarged. By H. F. BULMAN, A.M.Inst.C.E. Small crown 800, cloth. 2/6 "The author has done his work in a creditable manner, and has produced a book that will be of service to students and those who are practically engaged in mining operations."—Engineer.

INFLAMMABLE GAS AND VAPOUR IN THE AIR

(The Detection and Measurement of). By Frank Clowes, D.Sc., Lond., F.I.C., Prof. of Chemistry in the University College, Nottingham. With a Chapter on The Detection and Measurement of Petroleum Varour by Boverton Redwood, F.R.S.E., Consulting Adviser to the Corporation of London under the Petroleum Acts. Crown 8vo, cloth. Net 5/0 "Professor Clowes has given us a volume on a subject of much industrial importance."

Those interested in these matters may be recommended to study this book, which is easy of comprehension and contains many good things. "—The Engineer.

"A book that no mining engineer—certainly no coal miner—can afford to ignore or to leave unread."—Mining Journal.

COAL & IRON INDUSTRIES of the UNITED KINGDOM.

Comprising a Description of the Coal Fields, and of the Principal Seams of Coal, with Returns of their Produce and its Distribution, and Analyses of Special Varieties. Also, an Account of the Occurrence of Iron Ores in Veins or Seams; Analyses of each Variety; and a History of the Rise and Progress of

Pig Iron Manufacture. By RICHARD MEADE. 8vo, cloth . . . £1 8s.
"Of this book we may unreservedly say that it is the best of its class which we have ever met. . . . A book of reference which no one engaged in the iron or coal trades should omit from his library."—Iron and Coal Trades Review.

ASBESTOS AND ASBESTIC.

Their Properties, Occurrence, and Use. By ROBERT H. JONES, F.S.A. Mineralogist, Hon. Mem. Asbestos Club, Black Lake, Canada. Wit Ten Collotype Plates and other Illustrations. Demy 8vo, cloth. With

[Just Published. 16/0 "An interesting and invaluable work,"-Colliery Guardian.

GRANITES AND OUR GRANITE INDUSTRIES.

By GEORGE F. HARRIS, F.G.S., Membre de la Société Belge de Géologie, Lecturer on Economic Geology at the Birkbeck Institution, &c. With Illustrations. Crown 8vo, cloth "A clearly and well-written manual for persons engaged or interested in the granite industry. -Scotsman.

TRAVERSE TABLES.

For use in Mine Surveying. By W. LINTERN, Mining Engineer. Crown 8vo. cloth. [Just Published. Net 3/0]

ELECTRICAL ELECTRICITY. ENGINEERING, &c.

SUBMARINE TELEGRAPHS.

Their History, Construction, and Working. Founded in part on WÜNSCHENDORFF'S "Traité de Télégraphie Sous-Marine," and Compiled from Authoritative and Exclusive Sources. By CHARLES BRIGHT, F.R.S.E. Royal 80, 780 pp., fully Illustrated, including Maps and Folding Plates. Net 23 3.

750 pp., ruliy liustrated, including Maps and Folding Flates. Net 23 3e.,
"There are few, if any, persons more fitted to write a treatise on submarine telegraphy and Mr. Charles Bright. The author has done his work admirably, and has written in a way which will appeal as much to the layman as to the engineer. This admirable volume must, for many years to come, hold the position of the English classic on submarine telegraphy."—Engineer.
"Mr. Bright's interestingly written and admirably illustrated book will meet with a welcome reception from cable men."—Electrician.
"The author deals with his subject from all points of view—political and strategical as well as scientific. The work will be of interest, not only to men of science, but to the general public. We can strongly recommend it."—Athernaum.

DYNAMO ELECTRIC MACHINERY: its CONSTRUC-TION, DESIGN, and OPERATION.

By SAMUEL SHELDON, A.M., Ph.D., Professor of Physics and Electrical Engineering at the Polytechnic Institute of Brooklyn, assisted by HOBART MASON, B.S.

In two volumes, sold separately, as follows:—
Vol. I.—DIRECT CURRENT MACHINES. Third Edition, Revised. Large crown 8vo. 280 pages, with 200 Illustrations.

[Just Published. Net 12/0
Vol. II.—ALTERNATING CURRENT MACHINES. Large crown Net. 200 pages, with 184 Illustrations. Unst Published. Net 12/0

Designed as Text-books for use in Technical Educational Institutions, and by Engineers whose work includes the handling of Direct and Alternating Current Machines respectively, and for Students proficient in mathematics.

THE ELECTRICAL ENGINEER'S POCKET-BOOK.

Consisting of Modern Rules, Formulæ, Tables, and Data. By H. R. Kempe, M.Inst. E. E., A. M. Inst. C. E., Technical Officer Postal Telegraphs, Author of "A Handbook of Electrical Testing," &c. Second Edition, Revised, with Additions. With numerous Illustrations. Royal 32mo, oblong, leather 5/0

"It is the best book of its kind."—Electrical Engineer."—Electrician.
"The Electrical Engineer's Pocket-Book is a good one."—Electrician.
"Strongly recommended to those engaged in the electrical industries."—Electrical Review.

ELECTRIC LIGHT FITTING.

A Handbook for Working Electrical Engineers, embodying Practical Notes on

"This volume deals with what may be termed the mechanics of electric lighting, and is addressed to men who are already engaged in the work, or are training for it. The work traverses a great deal of ground, and may be read as a sequel to the same author's useful work on 'Electric Light.'"—Electrician.

ELECTRIC LIGHT.

Its Production and Use, Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators, and Electric Lamps. By J. W. URQUHART, C.E. Sixth Edition, Revised, with Additions and 145 Illustrations. Crown 8vo, cloth.

[Just Published. 7/6]

"The whole ground of electric lighting is more or less covered and explained in a very clear non-maner."—*Electrical Review*.
"A vade-macum of the saltent facts connected with the science of electric lighting." and concise manner

DYNAMO CONSTRUCTION.

"Mr. Urquhar's book is the first one which deals with these matters in such a way that the engineering student can understand them. The book is very readable, and the author leads his rea lers up to difficult subjects by reasonably simple tests."—**Engineering Review.

ELECTRICAL AND MAGNETIC CALCULATIONS.

For the Use of Electrical Engineers and Artisans, Teachers, Students, and all others interested in the Theory and Application of Electricity and Magnetism. By A. A. Atkinson, Professor of Electricity in Ohio University. Crown 8vo, cloth. [Just Published. Net 9/0]

THE ELEMENTS OF ELECTRICAL ENGINEERING.

A First Year's Course for Students and Workmen By Tyson SEWELL, A I.E.E., Assistant Lecturer and Demonstrator in Electrical Engineering at the Polytechnic Regent Street, London. With upwards of 200 Illustrations Demy 8vo, cloth. [Just Published. Nat 7/8]

THE MANAGEMENT OF DYNAMOS.

A Handy Book of Theory and Practice for the Use of Mechanics, Engineers, Students, and others in Charge of Dynamos. By G. W. Lummis-Paterson. Second Edition, thoroughly Revised and Enlarged. Crown 8vo, cloth. 4/8 "An example which deserves to be taken as a model by other authors. The subject is treated in a manner which any intelligent mas who is fit to be entrusted with charge of an engine should be able to understand. It is a useful book to all who make, tend, or employ electric machinery.

-Archited.

THE STANDARD ELECTRICAL DICTIONARY.

A Popular Encyclopædia of Words and Terms Used in the Practice of Electrical Engineering. By T. O'Conor Sloane, A.M., Ph.D. Third Edition, with Appendix. Crown 8vo, 680 pp., 390 Illustrations, cloth . . . Net 7/6.
"The work has many attractive features in its and is beyond doubt a well put together and

"The work has many attractive features in it, and is, beyond doubt, a well put together and useful publication. The amount of ground covered may be gathered from the fact that in the index about 5,600 references will be found. "Electrical Review."

ELECTRIC SHIP-LIGHTING.

A Handbook on the Practical Fitting and Running of Ships' Electrical Plant. For the Use of Shipowners and Builders, Marine Electri ians, and Seagoing Engineers-in-Charge. By J. W. URQUHART, C.E. Second Edition, Revised and Extended. 326 pp., with 88 Illustrations, Crown 8vc, cloth 7/8

"The subject of ship electric lighting is one of vast importance, and Mr. Urquhart is to be highly complimented for placing such a valuable work at the service of marine electricians."—The Steamship.

ELECTRIC LIGHT FOR COUNTRY HOUSES.

A Practical Handbook on the Erection and Running of Small Installations, with Particulars of the Cost of Plant and Working. By J. H. Knight. Third Edition, Revised. Crown 8vo, wrapper. [Just Published. 1/0]

ELECTRIC LIGHTING (ELEMENTARY PRINCIPLES OF).

By ALAN A. CAMPBELL SWINTON, M. Inst. C. E., M. Inst. E. E. Fourth Edition, Revised. With 16 Illustrations. Crown 8vo, cloth. [Just Published. 1/6

DYNAMIC ELECTRICITY AND MAGNETISM.

By Philip Atkinson, A.M., Ph.D., Author of "Elements of Static Electricity," &c. Crown 8vo, 417 pp., with 120 Illustrations, cloth . 10/8

POWER TRANSMITTED BY ELECTRICITY

And applied by the Electric Motor, including Electric Railway Construction. By P. Atkinson, A.M., Ph.D. Third Edition, Fully Revised, and New Matter added. With 94 Illustrations. Crown 8vo, cloth . . . Net 9'0

HOW TO MAKE A DYNAMO.

A Practical Treatise for Amateurs. Containing numerous Illustrations and Detailed Instructions for Constructing a Small Dynamo to Produce the Electric Light. By ALFRED CROFTS. Sixth Edition, Revised and Enlarged. Crown 8vo, cloth. [Just Published. 2/0]

THE STUDENT'S TEXT-BOOK OF ELECTRICITY.

ARCHITECTURE, BUILDING, &c.

PRACTICAL BUILDING CONSTRUCTION.

A Handbook for Students Preparing for Examinations, and a Book of Reference for Persons Engaged in Building. By John Parnell Allen, Surveyor, Lecturer on Building Construction at the Durham College of Science, Newcastle-on-Tyne. Third Edition, Revised and Enlarged Medium 8vo, 450 pp., with 1,000 Illustrations, cloth. [Just Published. 7/6]

"The most complete exposition of building construction we have seen. It contains all that is ecessary to prepare students for the various examinations in building construction."—Building

necessary to prepare students for the various examination.

"The author depends nearly as much on his diagrams as on his type. The pages suggest the hand of a man of experience in building operations—and the volume must be a blessing to many teachers as well as to students."—The Architect.

"The work is sure to prove a formidable rival to great and small competitors alike, and bids fair to take a permanent place as a favourite student's text-book. The large number of illustrations deserve particular mention for the great merit they possess for purposes of reference in exactly corresponding to convenient scales."—Fournal of the Royal Institute of British Architects.

PRACTICAL MASONRY.

A Guide to the Art of Stone Cutting. Comprising the Construction, Setting Out, and Working of Stairs, Circular Work, Arches, Niches, Domes, Pendentives, Vaults, Tracery Windows, &c. For the Use of Students, Masons, and other Workmen. By WILLIAM R. PURCHASE, Building Inspector to the Borough of Hove. Third Edition, with Glossary of Terms. Royal 8vo, 142 pp., with 52 Lithographic Plates, comprising nearly 400 separate Diagrams, cloth.

[Just Published. 7/8]

CIOID.

"Mr. Purchase's 'Practical Masonsy' will undoubtedly be found useful to all interested in this important subject, whether theoretically or practically. Most of the examples given are from actual work carried out, the diagrams being carefully drawn. The book is a practical retastise on the subject, the author hinself having commenced as an operative mason, and afterwards acted as foreman mason on many large and important buildings prior to the attainment of hypresent position. It should be found of general utility to architectural students and others, as well as those to whom it is specially addressed."—Fournal of the Reyal Institute of British Architects.

MODERN PLUMBING. STEAM AND HOT WATER HEATING.

A New Practical Work for the Plumber, the Heating Engineer, the Architect, A New Practical Work for the Flumber, the Heating Engineer, the Architect, and the Builder. By J. J. Lawler, Author of "American Sanitary Plumbing," &c. With 284 Illustrations and Folding Plates. 4to, cloth.

[Just Published. Net 21-

HEATING BY HOT WATER.

"We confidently recommend all interested in heating by hot water to secure a copy of this valuable little treatise."—The Plumber and Decorator.

CONCRETE: ITS NATURE AND USES.

A Book for Architects, Builders, Contractors, and Clerks of Works. By GEORGE L. SUTCLIFFE, A.R.I.B.A. 350 pp., with numerous Illustrations. Crown 8vo, cloth.

The author treats a difficult subject in a lucid manner. The manual fills a long-felt gap. It is careful and exhaustive; equally useful as a student's guide and an architect's book of reference."—Journal of the Royal Institute of British Architects.

"There is room for this new book, which will probably be for some time the standard work on the subject for a builder's purpose."—Glasgow Herald.

LOCKWOOD'S BUILDER'S PRICE BOOK for 1902.

A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. Re-constructed, Re-written, and Greatly Enlarged. By Francis T. W. Miller. 800 closely-printed pages.

"This book is a very useful one, and should find a place in every English office connected with the building and engineering professions."—Industries.

"An excellent book of reference."—Industries.
"In its new and revised form this Price Book is what a work of this kind should be—comprehensive, reliable, well arranged, legible, and well bound."—British Architect.

THE DECORATIVE PART OF CIVIL ARCHITECTURE.

By Sir William Chambers, F.R.S. With Portrait, Illustrations, Notes, and an Examination of Grecian Architecture, by Joseph Gwilt, F.S.A. Revised and Edited by W. H. LEEDS. 66 Plates, 4to, cloth

THE MECHANICS OF ARCHITECTURE.

A Treatise on Applied Mechanics, especially Adapted to the Use of Architects. By E. W. Tarn, M.A., Author of "The Science of Building," &c. Second Edition, Enlarged. Illustrated with 125 Diagrams. Crown 8vo, cloth 7/6 "The book is a very useful and helpful manual of architectural mechanics "-Rudder.

A HANDY BOOK OF VILLA ARCHITECTURE.

"The whole of the designs bear evidence of their being the work of an artistic architect, and they will prove very valuable and suggestive."—Building News.

THE ARCHITECT'S GUIDE.

ARCHITECTURAL PERSPECTIVE.

"It is the most intelligible of the treatises on this ill-treated subject that I have met with."—
E. INGRESS BELL, ESQ., in the R.I.B.A. Yourna!

PRACTICAL RULES ON DRAWING.

For the Operative Builder and Young Student in Architecture. By GEORGE

MEASURING AND VALUING ARTIFICER'S WORK

(The Student's Guide to the Practice of). Containing Directions for taking Dimensions, Abstracting the same, and bringing the Quantities into Bill, with Tables of Constants for Valuation of Labour, and for the Calculation of Areas and Solidities. Originally edited by E. Dobson, Architect. With Additions by E. W. Tarn, M.A. Seventh Edition, Revised. With 8 Plates and 63 Woodcuts. Crown 8vo, cloth.

"This edition will be found the most complete treatise on the principles of measuring and valuing artificer's work that has yet been published."—Building News.

TECHNICAL GUIDE, MEASURER, AND ESTIMATOR.

For Builders and Surveyors. Containing Technical Directions for Measuring Work in all the Building Trades, Complete Specifications for Houses, Roads, and Drains, and an Easy Method of Estimating the parts of a Building collectively. By A. C. Braton. Ninth Edition. Waistcoat-pocket size, silt edges. 1/6 gilt edges "No builder, architect, surveyor, or valuer should be without his 'Beaton,'"-Building News,

SPECIFICATIONS FOR PRACTICAL ARCHITECTURE.

A Guide to the Architect, Engineer, Surveyor, and Builder. With an Essay on the Structure and Science of Modern Buildings. Upon the Basis of the Work by ALFRED BARTHOLOMEW, thoroughly Revised, Corrected, and greatly added to by FREDERICK ROGERS, Architect. Third Edition, Revised. 8vo,

"The work is too well known to need any recommendation from us. It is one of the books with which every young architect must be equipped."—Architect.

THE HOUSE-OWNER'S ESTIMATOR.

Or, What will it Cost to Build, Alter, or Repair? A Price Book for Unprofessional People as well as the Architectural Surveyor and Builder. By J. D. Simon. Edited by F. T. W. MILLER, A.R.I.B.A. Fifth Edition. Carefully Revised. Crown 8vo, cloth. [Just Published. Net 3/6] "In two years it will repay its cost a hundred times over."-Field.

SANITATION AND WATER SUPPLY.

THE BACTERIAL PURIFICATION OF SEWAGE:

Being a Practical Account of the Various Modern Biological Methods of Purifying Sewage. By SIDNEY BARWISE, M.D. (Lond.), D.P.H. (Camb.), etc. With 10 Page Plates and 2 Folding Diagrams. Royal 8vo, cloth.

[Just Published. Net 6/0]

THE PURIFICATION OF SEWAGE.

Being a Brief Account of the Scientific Principles of Sewage Purification, and their Practical Application. By SIDNEY BARWISE, M.D. (Lond.), M.R.C.S., D.P.H. (Camb.), Fellow of the Sanitary Institute, Medical Officer of Health to the Derbyshire County Council. Crown 8vo, cloth. [Just Published. 5/0]

WATER AND ITS PURIFICATION.

A Handbook for the Use of Local Authorities, Sanitary Officers, and others interested in Water Supply. By S. RIDEAL, D.Sc. Lond., F.I.C. Second Edition, Revised, with Additions, including numerous Illustrations and Tables. Large Crown 8vo, cloth.

[Just Published. Net 9/0]

RURAL WATER SUPPLY.

A Practical Handbook on the Supply of Water and Construction of Water-works for Small Country Districts. By Allan Greenwell, A.M.I.C.E., and W. T. Curry, A.M.I.C.E. Revised Edition. Crown 8vo, cloth 5/0

THE WATER SUPPLY OF CITIES AND TOWNS.

THE WATER SUPPLY OF TOWNS AND THE CON-STRUCTION OF WATER-WORKS.

WATER ENGINEERING.

A Practical Treatise on the Measurement, Storage, Conveyance, and Utilisation of Water for the Supply of Towns. By C. SLAGG, A.M. Inst. C.E. 7/6

SANITARY WORK IN SMALL TOWNS AND VILLAGES. By Charles Slagg, A. M. Inst. C.E. Crown 8vo, cloth . . . 3/0

SANITARY ARRANGEMENT OF DWELLING-HOUSES. By A. J. Wallis-Tayler, A.M. Inst. C.E. Crown 8vo, cloth . . . 2/8

MODERN PLUMBING. HOT WATER HEATING. &c.

A New Practical Work for the Plumber, the Heating Engineer, the Architect, and the Builder. By J. J. LAWLER, Author of "American Sanitary Plumbing," &c. With 284 Illustrations and Folding Plates. 4to, cloth.

[/ust Published (see page 25). Net 21/-

PLUMBING.

A Text-book to the Practice of the Art or Craft of the Plumber. By W. P. Buchan, R.P. Ninth Edition, Enlarged. Crown 8vo, cloth . . . 3/6

VENTILATION.

THE HEALTH OFFICER'S POCKET-BOOK.

A Guide to Sanitary Practice and Law. For Medical Officers of Health, Sanitary Inspectors, Members of Sanitary Authorities, &c. By Edward F. Willoughby, M.D. (Lond.), &c. Second Edition, Revised and Enlarged Fcap. 8vo, leather. [/ust Published. Net 10/6]

CARPENTRY, TIMBER. &c.

THE ELEMENTARY PRINCIPLES OF CARPENTRY.

A Treatise on the Pressure and Equilibrium of Timber Framing, the Resistance of Timber, and the Construction of Floors, Arches, Bridges, Roofs, Uniting Iron and Stone with Timber, &c. To which is added an Essay on the Nature and Properties of Timber, &c., with Descriptions of the kinds of Wood used in Building; also numerous Tables of the Scantlings of Timber for different purposes, the Specific Gravities of Materials, &c. By Thomas Tredgold, C. E. With an Appendix of Specimens of Various Roofs of Iron and Stone, Illustrated. Seventh Edition, thoroughly Revised and considerably Enlarged by E. Wyndham Tarn, M.A., Author of "The Science of Building," &c. Wyndham Tarn, M.A., Author of "The Science of Building," &c. With 61 Plates, Portrait of the Author, and several Woodcuts. In One large Vol., 4to, cloth

"Ought to be in every architect's and every builder's library."—Builder.
"A work whose monumental excellence must commend it wherever skilful carpentry is concerned. The author's principles are rather confirmed than impaired by time. The additional plates are of great intrinsic value."—Building News.

WOODWORKING MACHINERY.

"Mr. Bale is evidently an expert on the subject, and he has collected so much information that his book is all-sufficient for builders and others engaged in the conversion of timber."—Architect.

"The most comprehensive compendium of wood-working machinery we have seen. The author is a thorough master of his subject."—Building News.

SAW MILLS.

Their Arrangement and Management, and the Economical Conversion of Timber. By M. Powis Bale, A.M. Inst. C.E. Second Edition, Revised. Crown 8vo, cloth. [Just Published. 10/6]

"The administration of a large sawing establishment is discussed, and the subject examined from a financial standpoint. Hence the size, shape, order, and disposition of saw mills and the like are gone into in detail, and the course of the timber is traced from its reception to its delivery in its converted state. We could not desire a more complete or practical treatise."—Builder.

THE CARPENTER'S GUIDE.

Or, Book of Lines for Carpenters; comprising all the Elementary Principles essential for acquiring a knowledge of Carpentry. Founded on the late PETER NICHOLSON'S standard work. A New Edition, Revised by ARTHUR ASHPITER, F.S.A. Together with Practical Rules on Drawing, by GEORGE PYNE. With 74 Plates, 440, cloth

A PRACTICAL TREATISE ON HANDRAILING.

Showing New and Simple Methods for Finding the Pitch of the Plank, Drawing the Moulds, Bevelling, Jointing-up, and Squaring the Wreath. By George Collings. Second Edition, Revised and Enlarged, to which is added A TREATISE ON STAIR-BUILDING. With Plates and Diagrams . 2/8 will be found of practical utility in the execution of this difficult branch of joinery. "—Builder."

"Will be found of practical utility in the execution of this difficult branch of joinery."—Builder.

"Almost every difficult phase of this somewhat intricate branch of joinery is elucidated by the ald of plates and explanatory letterpress."—Furniture Gazette.

CIRCULAR WORK IN CARPENTRY AND JOINERY.

A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. With Diagrams. Third Edition, 12mo, cloth . 2/6

"An excellent example of what a book of this kind should be. Cheap in price, clear in definition, and practical in the examples selected."—Builder.

THE CABINET-MAKER'S GUIDE TO THE ENTIRE CONSTRUCTION OF CABINET WORK.

By RICHARD BITMEAD. Illustrated with Plans, Sections and Working Drawings. Crown 8vo, cloth. [Just Published. 2/6]

z .

Z

11

HANDRAILING COMPLETE IN EIGHT LESSONS.

On the Square-Cut System. By J. S. GOLDTHORP, Head of Building Department, Halifax Technical School. With Eight Plates and over 150 Practical Exercises. 4to, cloth .

"Likely to be of considerable value to joiners and others who take a pride in good work.

The arrangement of the book is excellent. We heartily commend it to teachers and students."—
Timber Trades Journal.

TIMBER MERCHANT'S and BUILDER'S COMPANION.

"We are glad to see a fourth edition of these admirable tables, which for correctness and simplicity of arrangement leave nothing to be desired."—Timber Trades Journal,

THE PRACTICAL TIMBER MERCHANT.

A Guide for the Use of Building Contractors, Surveyors, Builders, &c., comprising useful Tables for all purposes connected with the Timber Trade, Marks of Wood, Essay on the Strength of Timber, Remarks on the Growth of Timber, &c. By W. RICHARDSON. Second Edition. Fcap. 8vo, cloth . 3/8 "Contains much valuable information for timber merchants, builders, foresters, and all others connected with the growth, sale, and manufacture of timber,"— Journal of Forestry,

PACKING-CASE TABLES.

Showing the number of Superficial Feet in Boxes or Packing-Cases, from six inches square and upwards. By W. RICHARDSON, Timber Broker. Third Edition. Oblong 4to, cloth "Invaluable labour-saving tables."-Ironmonger.

GUIDE TO SUPERFICIAL MEASUREMENT.

Tables calculated from 1 to 200 inches in length by 1 to 108 inches in breadth. For the use of Architects, Surveyors, Engineers, Timber Merchants, Builders, &c. By James Hawkings. Fifth Edition. Fcap., cloth. 3/6 "A useful collection of tables to facilitate rapid calculation of surfaces. The exact area of any surface of which the limits have been ascertained can be instantly determined. The book will be found of the greatest utility to all engaged in bullding operations."—Scotsman.

PRACTICAL FORESTRY.

And its Bearing on the Improvement of Estates. By CHARLES E. CURTIS, F.S.I., Professor of Forestry, Field Engineering, and General Estate Management, at the College of Agriculture, Downton. Second Edition, [Just Published. 3/6 Revised. Crown 8vo, cloth.

SUMMARY OF CONTENTS: —PREPATORY REMARKS, —OBJECTS OF PLANTING.—
CHOICE OF A FORESTER.—CHOICE OF SOIL AND SITE.—LAYING OUT OF LAND FOR PLANTING.—PREPARATION OF THE GROUND FOR PLANTING.—DRAINAGE.—PLANTING.—DISTANCES AND DISTRIBUTION OF TREES IN PLANTATIONS.—TREES AND GROUND GOME.—ATTENTION AFTER PLANTING.—THINNING OF PLANTATIONS—PRUNING OF FOREST TREES.—REALIZATION.—METHODS OF SALE.—MEASUREMENT OF TIMBER.—COST OF MEASUREMENT AND VALUATION OF LARCH PLANTATION.—FIRE LINES.—COST OF PLANTING.

"Mr. Curtis has in the course of a series of short pithy chapters afforded much informa-tion of a useful and practical character on the planting and subsequent treatment of trees."— Illustrated Carpetter and Builder.

THE ELEMENTS OF FORESTRY.

Designed to afford Information concerning the Planting and Care of Forest Trees for Ornament or Profit, with suggestions upon the Creation and Care of Woodlands. By F. B. Hough. Large crown 8vo, cloth .

THE TIMBER IMPORTER'S, TIMBER MERCHANT'S, AND BUILDER'S STANDARD GUIDE.

By RICHARD E. GRANDY. Comprising:—An Analysis of Deal Standards, Home and Foreign, with Comparative Values and Tabular Arrangements for fixing Net Landed Cost on Baltic and North American Deals, including all

DECORATIVE ARTS. &c.

SCHOOL OF PAINTING FOR THE IMITATION OF WOODS AND MARBLES.

As Taught and Practised by A. R. VAN DER BURG and P. VAN DER BURG, Directors of the Rotterdam Painting Institution. Royal folio, 18½ by 12½ in., Illustrated with 24 full-size Coloured Plates; also 12 plain Plates, comprising 154 Figures. Third Edition, cloth. [Just Published. £1 11s. 65.

154 Figures. Third Edition, cloth.

(Just Published. £1 11s. 60.

List of Plates:—I. Various Tools Reguired for Wood Painting.—1, 2 Walnut: Preliminary Stages of Graining and Finished Specimen.—4. Tools Used for Marble Painting and Method of Manipulation.—5, 6. St. Remi Marble: Farlier operations and Finished Specimen.—7. Methods of Sketching Different Grains, Knots, &c.—4, 9. Ash: Preliminary Stages and Finished Specimen.—10. Methods of Sketching Marble Grains—11, 12. Breche Marble; Preliminary Stages of Working and Finished Specimen.—13. Maple; Methods of Producing the Different Grains.—14, 15 Bidden.—13. Maple; Methods of Producing the Different Grains.—14, 15 Bidden.—13. Maple; Methods of Producing The Different Grains.—14, 15 Bidden.—19. Maple; Preliminary Stages and Finished Specimen.—19. Mahogany; Specimens of Various Grains and Methods of White Marble; 17, 12. White Marble; Preliminary Stages and Finished Specimen.—22, 23, 24. Sienna Marble; Varieties of Grain, Preliminary Stages and Finished Specimen.—23, 24. Sienna Marble; Varieties of Grain, Preliminary Stages and Finished Specimen.—24. 26, 27. [Unifer Wood) Methods of Producing Grain, &c.; Preliminary Stages and Finished Specimen.—3, 26, 27. [Unifer Wood) Methods of Producing Grain, &c.; Preliminary Stages and Finished Specimen.—3, 26, 37. [Unifer Wood) Methods of Monifolation. Preliminary Stages and Finished Specimen.—3, 35. 36. Waulsort Marble; Varieties of Grain, Unfinished and Finished Specimen.—34, 35, 36. Waulsort Marble; Varieties of Grain, Unfinished And Finished Specimen.—34, 35, 36. Waulsort Marble; Varieties of Grain, Unfinished And Finished Specimen.—34, 35, 36. Waulsort Marble; Varieties of Grain, Unfinished And Finished Specimen.—34, 35, 36. Waulsort Marble; Varieties of Grain, Unfinished And Finished Specimen.—34, 35, 36. Waulsort Marble; Varieties of Grain, Unfinished And Finished Specimen.—34. 35. Waulsort Marble; Varieties of Grain, Unfinished And Finished Specimen.—34. 35. Waulsort Marble; Varieties of Grain, Unfinished And Finish

"Those who desire to attain skill in the art of painting woods and marbles will find advantage in consulting this book. ... Some of the Working Men's Clubs should give their young men the opportunity to study it."—Builder at. The explanations of the processes, their young men "A comprehensive guide to the art. The explanations of the processes, the ramplulation and management of the colours, and the beautifully executed plates will not be the least valuable to the student who aims at making his work a faithful transcript of nature."—Building News.
"Students and novices are fortunate who are able to become the possessors of so noble a

ELEMENTARY DECORATION.

HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING.

A Practical Manual of. By ELLIS A. DAVIDSON. Eighth Edition. With Coloured Plates and Wood Engravings. 12mo, cloth boards. . 6/0 "A mass of information of use to the amateur and of value to the practical man."-English Mechanic

THE DECORATOR'S ASSISTANT.

A Modern Guide for Decorative Artists and Amateurs, Painters, Writers, Gilders, &c. Containing upwards of 600 Receipts, Rules, and Instructions; with a variety of Information for General Work connected with every Class of Interior and Exterior Decorations, &c. Seventh Edition. 152 pp., cr. 8vo. 1/0

"Full of receipts of value to decorators, painters, gilders, &c. The book contains the gist of larger treatises on colour and technical processes. It would be difficult to meet with a work so full of varied information on the painter's art."—Busidesing News.

MARBLE DECORATION

"This most useful and much wanted handbook should be in the hands of every architect and builder."—Swilding World.
"A carefully and usefully written treatise; the work is essentially practical."—Swisman.

DELAMOTTE'S WORKS ON ALPHABETS AND ILLUMINATION.

ORNAMENTAL ALPHABETS, ANCIENT & MEDIÆVAL.

"For those who insert enamelled sentences round gilded chalices, who blazon shop legends over shop-doors, who letter church walls with pithy sentences from the Decalogue, this book will be useful."—Abenacum.

MODERN ALPHABETS, PLAIN AND ORNAMENTAL.

Including German, Old English, Saxon, Italic, Perspective, Greek, Hebrew, Court Hand, Engrossing, Tuscan, Riband, Gothic, Rustic, and Arabesque; with several Original Designs, and an Analysis of the Roman and Old English Alphabets, large and small, and Numerals, for the use of Draughtsmen, Surveyors, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. Collected and Engraved by F. DELMOTTE, and printed in Colours, New and Cheaper Edition. Royal 8vo, oblong, ornamental boards. 2/8

"There is comprised in it every possible shape into which the letters of the alphabet and numerals can be formed, and the talent which has been expended in the conception of the various plain and ornamental letters is wonderful."—"Lieandard.

MEDIÆVAL ALPHABETS AND INITIALS FOR ILLUMINATORS.

A PRIMER OF THE ART OF ILLUMINATION.

For the Use of Beginners; with a Rudimentary Treatise on the Art, Practical Directions for its Exercise, and Examples taken from Illuminated MSS., printed in Gold and Colours. By F. DELAMOTTE. New and Cheaper Edition. Small 4to, ornamental boards.

"The examples of ancient MSS. recommended to the student, which, with much good sense, the author chooses from collections accessible to all, are selected with judgment and knowledge as well as taste."—Alteraum.

THE EMBROIDERER'S BOOK OF DESIGN.

"The book will be of great assistance to ladies and young children who are endowed with the art of plying the needle in this most ornamental and useful pretty work."—East Anglian Times.

INSTRUCTIONS IN WOOD-CARVING FOR AMATEURS.

With Hints on Design. By A Lady. With 10 Plates. New and Cheaper Edition. Crown 8vo, in emblematic wrapper 2/0
"The handicraft of the wood-carver, so well as a book can impart it, may be learnt from 'A Lady's 'publication."—Athenaum.

PAINTING POPULARLY EXPLAINED.

By Thomas John Gullick, Painter, and John Timbs, F.S.A. Including Fresco, Oil, Mosaic, Water-Colour, Water-Glass, Tempera, Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. Fifth Edition. Crown 8vo, cloth

*** Adopted as a Prize Book at South Kensington.

"Much may be learned, even by those who fancy they do not require to be taught, from the careful perusal of this unpretending but comprehensive treatise."—Art Journal.

NATURAL SCIENCE, &c.

THE VISIBLE UNIVERSE.

"A valuable and lucid summary of recent astronomical theory, rendered more valuable and attractive by a series of stellar photographs and other illustrations."—The Times.

"In presenting a clear and concise account of the present state of our knowledge Mr. Gore has made a valuable addition to the literature of the subject."—Nature.

"Mr. Gore's 'Visible Universe' is one of the finest works on astronomical science that have recently appeared in our language. In spirit and in method it is scientific from cover, but the style is so clear and attractive that it will be as acceptable and as readable to those who make no scientific pretensions as to those who devote themselves specially to matters astronomical."— Leeds Mercury.

STAR GROUPS.

"The volume contains thirty maps showing stars of the sixth magnitude—the usual naked-eye limit—and each is accompanied by a brief commentary adapted to facilitate recognition and bring to notice objects of special interest. For the purpose of a preliminary survey of the midnight pomp of the heavens nothing could be better than a set of delineations averaging scarcely twenty square inches in area and including nothing that cannot at once be identified.—Saturday Review.

AN ASTRONOMICAL GLOSSARY.

Or, Dictionary of Terms used in Astronomy. With Tables of Data and Lists of Remarkable and Interesting Celestial Objects. By J. ELLARD GORE, F.R.A.S., Author of "The Visible Universe," &c. Small crown 8vo, cloth.

"A very useful little work for beginners in astronomy, and not to be despised by more advanced students."—The Times.

"A very handy book ... the utility of which is much increased by its valuable tables of astronomical data."—Alternaum.

THE MICROSCOPE.

Its Construction and Management. Including Technique, Photo-micrography, and the Past and Future of the Microscope. By Dr. Henri van Heurck. Re-Edited and Augmented from the Fourth French Edition, and Translated by WYNNE E. BAXTER, F.G.S. 400 pp., with upwards of 250 Woodcuts, imp. 8vo. cloth 18/Ó

"A translation of a well-known work, at once popular and comprehensive."—Times.
"The translation is as felicitous as it is accurate."—Nature.

ASTRONOMY.

By the late Rev. ROBERT MAIN, M.A., F.R.S. Third Edition, Revised by WILLIAM THYNNE LYNN, B.A., F.R.A.S., formerly of the Royal Observatory, Greenwich. 12mo, cloth . . 2/0

"A sound and simple treatise, very carefully edited, and a capital book for beginners."-Knowledge.
"Accurately brought down to the requirements of the present time by Mr. Lynn."—

A MANUAL OF THE MOLLUSCA.

A Treatise on Recent and Fossil Shells. By S. P. WOODWARD, A.L.S., F.G.S. With an Appendix on RECENT AND FOSSIL CONCHOLOGICAL DISCOVERIES, by RALPH TATE, A.L.S., F.G.S. With 23 Plates and upwards of 300 Woodcuts. Reprint of Fourth Edition (1880). Crown 800,

"A most valuable storehouse of conchological and geological information,"—Science Gassip,

THE TWIN RECORDS OF CREATION.

. 5/0

"A valuable contribution to the evidences of Revelation, and disposes very conclusively of the arguments of those who would set God's Works against God's Word. No real difficulty is shirked, and no sophistry is left unexposed."—*The Reck*.

HANDBOOK OF MECHANICS.

"The perspicuity of the original has been retained, and chapters which had become obsolete have been replaced by others of more modern character. The explanations throughout are studiously popular, and care has been taken to show the application of the various branches of physics to the industrial arts, and to the practical business of like."—Mining Yournal.

HANDBOOK OF HYDROSTATICS AND PNEUMATICS.

By Dr. LARDNER. New Edition, Revised and Enlarged by BENJAMIN LOEWY. F.R.A.S. With 236 Illustrations. Post 8vo, cloth . 5/0

"For those 'who desire to attain an accurate knowledge of physical science without the profound methods of mathematical investigation,' this work is well adapted."—Chemical News.

HANDBOOK OF HEAT.

. 6/0

"The style is always clear and precise, and conveys instruction without leaving any cloudiness or lurking doubts behind."—Engineering.

HANDBOOK OF OPTICS.

-Mechanics' Magazine.

By Dr. LARDNER. New Edition. Edited by T. OLVER HARDING, B.A. Lond. "Written by one of the ablest English scientific writers, beautifully and elaborately illustrated."

ELECTRICITY, MAGNETISM, AND ACOUSTICS.

By Dr. LARDNER. Edited by GEO. CAREY FOSTER, B.A., F.C.S. With 400 Illustrations. Small 8vo, cloth . . 5/0

"The book could not have been entrusted to any one better calculated to preserve the terse and lucid style of Lardner, while correcting his errors and bringing up his work to the present state of scientific knowledge."—Popular Science Review.

HANDBOOK OF ASTRONOMY.

By Dr. LARDNER. Fourth Edition. Revised and Edited by EDWIN DUNKIN, F.R.A.S., Royal Observatory, Greenwich. With 38 Plates and upwards of 100 Woodcuts. 8vo, cloth . 9/6

"Probably no other book contains the same amount of information in so compendious and well arranged a form—certainly none at the price at which this is offered to the public."—A there are with the can do no other than pronounce this work a most valuable manual of astronomy, and we strongly recommend it to all who wish to acquire a general—but at the same time correct—acquaintance with this sublime science."—Quarterly Yournal of Science.

MUSEUM OF SCIENCE AND ART.

Edited by Dr. LARDNER. With upwards of 1,200 Engravings on Wood. In Six Double Volumes, £1 1s. in a new and elegant cloth binding; or hand-somely bound in half-morocco

"A cheap and interesting publication, alike informing and attractive. The papers combine subjects of importance and great scientific knowledge, considerable inductive powers, and a popular style of treatment."—Spectator.

Separate books formed from the above.

Common Things Explained. 5s. The Microscope. 2s. cloth. Popular Geology. 2s. 6d. cloth. Popular Physics. 2s. 6d. cloth.

Steam and its Uses. 2s. cloth.
Popular Astronomy. 4s. 6d. cloth.
The Bee and White Ants. 2s. cloth. The Electric Telegraph. 13. 6d.

NATURAL PHILOSOPHY FOR SCHOOLS.

By Dr. LARDNER. Fcap. 8vo . "A very convenient class book for junior students in private schools."-British Quarterly

ANIMAL PHYSIOLOGY FOR SCHOOLS.

By Dr. LARDNER. Fcap. 8vo . 3/6 "Clearly written, well arranged, and excellently illustrated."-Gardener's Chronicle.

THE ELECTRIC TELEGRAPH.

By Dr. LARDNER. Revised by E. B. BRIGHT, F.R.A.S. Fcap. 8vo. . 2/6 "Que of the most readable books extant on the Electric Telegraph."-English Mechanic.

CHEMICAL MANUFACTURES. CHEMISTRY, &c.

THE GAS ENGINEER'S POCKET-BOOK.

Comprising Tables, Notes and Memoranda relating to the Manufacture, Distribution and Use of Coal Gas and the Construction of Gas Works. By H. O'Connor, A.M.Inst.C.E. Second Edition, Revised. 470 pp., crown 8vo, fully Illustrated, leather.

"The book contains a vast amount of information. The author goes consecutively through the engineering details and practical methods involved in each of the different processes or parts of a gas-works. He has certainly succeeded in making a compilation of hard matters of fact absolutely interesting to read."—Gas World.

"A useful work of reference for the gas engineer and all interested in lighting or heating by gas, while the analyses of the various descriptions of gas will be of value to the technical chemist. All matter in any way connected with the manufacture and use of gas is dealt with. The book has evidently been carefully compiled, and certainly constitutes a useful addition to gas literature."—

eviciently been carefully complex, and certainly consistent adultion to gas intended. —

"The volume contains a great quantity of specialised information, compiled, we believe, from trustworthy sources, which should make it of considerable value to those for whom it is specifically produced. —Engineer.

LIGHTING BY ACETYLENE

Generators, Burners, and Electric Furnaces. By WILLIAM E. GIBBS, M.E. [/ust Published. 7/8 With 66 Illustrations. Crown 8vo, cloth.

ENGINEERING CHEMISTRY.

A Practical Treatise for the Use of Analytical Chemists, Engineers, Iron Masters, Iron Founders, Students and others. Comprising Methods of Analysis and Valuation of the Principal Materials used in Engineering Work, with Analyses, Examples and Suggestions. By H. J. Phillips, F.I.C., F.C.S. Third Edition, Revised and Enlarged. Crown 8vo, 420 pp., with Plates and other Illustrations, cloth.

"In this work the author has rendered no small service to a numerous body of practical mea. . . . The analytical methods may be pronounced most satisfactory, being as accurate as the despatch required of engineering chemists permits."—Chemical News.

"Full of good things. As a handbook of technical analysis, it is very welcome."—Butlater.

"The analytical methods given are, as a whole, such as are likely to give rapid and trustworthy results in experienced hands. . . . There is much excellent descriptive matter in the work, the chapter on 'Oils and Lubrication being specially noticeable in this respect."—Engineer.

NITRO-EXPLOSIVES.

A Practical Treatise concerning the Properties, Manufacture, and Analysis of Nitrated Substances, including the Fulminates, Smokeless Powders, and Celluloid. By P. G. SANFORD, F. I. C., Consulting Chemist to the Cotton Powder Company, &c. With Illustrations. Crown 8vo, cloth. [Just Published. 9/0]

"Any one having the requisite apparatus and materials could make nitro-glycerine or guncotton, to say nothing of other explosives, by the aid of the instructions in this volume. This is one of the very few text-books in which can be found just what is wanted. Mr. Sanford goes through the whole list of explosives commonly used, names any given explosive, and tells us of what it is composed and how it is manufactured. The book is excellent throughout."—Engineer.

A HANDBOOK ON MODERN EXPLOSIVES.

Practical Treatise on the Manufacture and Use of Dynamite, Gun-Cotton, Nitro-Glycerine and other Explosive Compounds, including Collodion-Cotton. With Chapters on Explosives in Practical Application. By M. EISSLER, Mining Engineer and Metallurgical Chemist. Second Edition, Enlarged. With 150 Illustrations. Crown 8vo, cloth. [Just Published. 12/6]

"Useful not only to the miner, but also to officers of both services to whom blasting and the use of explosives generally may at any time become a necessary auxiliary."—Nature.

DANGEROUS GOODS.

Their Sources and Properties, Modes of Storage and Transport. With Notes Their Sources and Properties, Modes of Storage and Aransport. With Avoice and Comments on Accidents arising therefrom, together with the Government and Railway Classifications, Acts of Parliament, &c. A Guide for the Use of Government and Railway Officials, Steamship Owners, Insurance Companies and Manufacturers, and Users of Explosives and Dangerous Goods. By H. JOSHUA PHILLIPS, F.I.C., F.C.S. Crown 8vo, 374 pp., cloth. Merits a wide circulation, and an intelligent, appreciative study."-Chemical News

A MANUAL OF THE ALKALI TRADE.

Including the Manufacture of Sulphuric Acid, Sulphate of Soda, and Bleaching Powder. By JOHN LOMAS, Alkali Manufacturer, Newcastle-upon-Tyne and London. 300 pp. of Text. With 232 Illustrations and Working Drawings, Second Edition, with Additions. Super-royal 8vo, cloth £1 10a.

"This book is written by a manufacturer for manufacturers. The working details of the most approved forms of apparatus are given, and these are accompanied by no less than 232 wood engravings, all of which may be used for the purposes of construction. Every step in the manufacture is very fully described in this manual, and each improvement explained."—Alkenesum. "We find not merely a sound and luminous explanation of the chemical principles of the trade, but a notice of numerous matters which have a most important bearing on the successful conduct of alkali works, but which are generally overlooked by even experienced technological authors."—Chemical Review.

THE BLOWPIPE IN CHEMISTRY, MINERALOGY, AND GEOLOGY.

Containing all known Methods of Anhydrous Analysis, many Working Examples, and Instructions for Making Apparatus. By Lieut.-Colonel W. A. Ross, R.A., F.G.S. With 120 Illustrations. Second Edition, Enlarged. Crown 8vo, cloth **5/0**

"The student who goes conscientiously through the course of experimentation here laid down will gain a better insight into inorganic chemistry and mineralogy than if he had 'got up' any of the best text-books of the day, and passed any number of examinations in their contents."—Chemical

THE MANUAL OF COLOURS AND DYE-WARES.

Their Properties, Applications, Valuations, Impurities and Sophistications For the Use of Dyers, Printers, Drysalters, Brokers, &c. By J. W. SLATER. Second Edition, Revised and greatly Enlarged. Crown 8vo, cloth 7/6

"A complete encyclopædia of the *materia tinctoria*. The information given respecting each article is full and precise, and the methods of determining the value of articles such as these, so liable to sophistication, are given with clearness, and are practical as well as valuable."—Chemist and Druggist.

"There is no other work which covers precisely the same ground. To students preparing for examinations in dyeing and printing it will prove exceedingly useful."—Chemical News.

A HANDY BOOK FOR BREWERS.

Being a Practical Guide to the Art of Brewing and Malting. Embracing the Conclusions of Modern Research which bear upon the Practice of Brewing. By HERBERT EDWARDS WRIGHT, M.A. Second Edition, Enlarged. Crown Byo, 530 pp., cloth. [Just Published. 12/6] 8vo, 530 pp., cloth.

"May be consulted with advantage by the student who is preparing himself for examinational tests, while the scientific brewer will find in it a returned of all the most important discoveries of modern times. The work is written throughout in a clear and concise manner, and the author takes great care to discriminate between vague theories and well-established facts."—Brewer'

Takes great care to discriminate between vague meories and well-established tacts. — Dreater fournal.

"We have great pleasure in recommending this handy book, and have no hesitation in saying that it is one of the best—if not the best—which has yet been written on the subject of beer-brewing in this country; it should have a place on the shelves of every brewer's library.— Brewer's

on this county, a county of the student are primarily considered, an acquaintance of half-an-hour's duration cannot fail to impress the practical brewer with the sense of having found a trustworthy guide and practical counsellor in brewery matters."—Chemical Trade Journal.

FUELS: SOLID, LIQUID, AND GASEOUS.

Their Analysis and Valuation. For the Use of Chemists and Engineers. By H. J. Phillips, F.C.S., formerly Analytical and Consulting Chemist to the G.E. Rlwy. Third Edition, Revised and Enlarged. Crown 8vo, cloth 2/0

"Ought to have its place in the laboratory of every metallurgical establishment and wherever fuel is used on a large scale."—Chemical News.

THE ARTISTS' MANUAL OF PIGMENTS.

Showing their Composition, Conditions of Permanency, Non-Permanency, and Adulterations; Effects in Combination with Each Other and with Vehicles; and the most Reliable Tests of Purity. By H. C. STANDAGE. Crown 8vo. 2/8

"This work is indeed multum-in-parvo, and we can, with good conscience, recommend it to all who come in contact with pigments, whether as makers, dealers, or users."—Chemical Review.

A POCKET-BOOK OF MENSURATION AND GAUGING.

"This handy and useful book is adapted to the requirements of the Inland Revenue Department, and will be a favourite book of reference."—(Fortian.
"Should be in the hands of every practical brower."—Browers' Journal.

INDUSTRIAL ARTS, TRADES, AND MANUFACTURES.

TEA MACHINERY AND TEA FACTORIES.

A Descriptive Treatise on the Mechanical Appliances required in the Cultivation of the Tea Plant and the Preparation of Tea for the Market. By A. J. WALLIS-TAYLER, A. M. Inst. C.E. Medium 8vo, 468 pp. With 218 Illustrations.

SUMMARY OF CONTENTS:—MECHANICAL CULTIVATION OR TILLAGE OF THE SOIL—PLUCKING OR GATHERING THE LEAF.—TEA FACTORIES.—THE DRESSING MANUFACTURE, OR PREPARATION OF TEA BY MECHANICAL MEANS.—ARTIFICIAL WITHERING OF THE LEAF.—MACHINES FOR ROLLING OR CURLING THE LEAF.—FERMENTING PROCESS.—MACHINES FOR THE AUTOMATIC DEVING OR FIRING OF THE LEAF.—DRACHINES FOR NON-AUTOMATIC DRYING OF FIRING OF THE LEAF.—DRACHINES FOR NON-AUTOMATIC DRYING OR FIRING OF THE LEAF.—DRACHING THE TEA.—MEANS OF TRANSPORT ON TEA PLANTATIONS.—MISCELLANEOUS MACHINERY AND APPARATUS.—FINAL TREATMENT OF THE TEA.—TABLES AND MEMORANDA.

"The subject of tea machinery is now one of the first interest to a large class of people, to whom we strongly commend the volume."—Chamber of Commerce Fournal.

"When tea planting was first introduced into the British possessions little, if any, machinery was employed, but now its use is almost universal. This volume contains a very full account of the machinery necessary for the proper outfit of a factory, and also a description of the processes best carried out by this machinery."—Fournal Society of Arts.

FLOUR MANUFACTURE.

"This valuable work is, and will remain, the standard authority on the science of milling...

The miller who has read and digested this work will have laid the foundation, so to speak, of a successful career; he will have acquired a number of general principles which he can proceed to apply. In this handsome volume we at last have the accepted text-book of modern milling in good, sound English, which has little, if any, trace of the German idom."—The Miller.

COTTON MANUFACTURE.

A Manual of Practical Instruction of the Processes of Opening, Carding, Combing, Drawing, Doubling and Spinning of Cotton, the Methods of Dyeing, &c. For the Use of Operatives Overlookers, and Manufacturers. By JOHN LISTER, Technical Instructor, Pendleton. 8vo, cloth .

"A distinct advance in the literature of cotton manufacture."—Mackinery.
"It is thoroughly reliable, fulfilling nearly all the requirements desired."—Glasgow Herald.

MODERN CYCLES.

A Practical Handbook on their Construction and Repair. By A. J. WALLIS-TAVLER, A. M. Inst. C. E., Author of "Refrigerating Machinery," &c. With upwards of 300 Illustrations. Crown 8vo, cloth. [Just Published. 10/6]

"The large trade that is done in the component parts of bicycles has placed in the way of men mechanically inclined extraordinary facilities for building bicycles for their own use. . . The book will prove a valuable guide for all those who aspire to the manufacture or repair of their own machines."—The Field.

"A most comprehensive and up-to-date treatise."—The Cycle.
"A very useful book, which is quite entitled to rank as a standard work for students of cycle construction."—Wheeling.

CEMENTS, PASTES, GLUES, AND GUMS.

A Practical Guide to the Manufacture and Application of the various Aggluti-nants required in the Building, Metal-Working, Wood-Working, and Leather-Working Trades, and for Workshop, Laboratory or Office Use. With upwards of 900 Recipes and Formulæ. By H. C. STANDAGE, Chemist. Third Edition. [Just Published. 2/0 Crown 8vo, cloth.

"We have pleasure in speaking favourably of this volume. So far as we have had experience, which is not inconsiderable, this manual is trustworthy."—Atkeneum.

"As a revelation of what are considered trade secrets, this book will arouse an amount of curiosity among the large number of industries it touches."—Daily Chronicle.

THE ART OF SOAP-MAKING.

A Practical Handbook of the Manufacture of Hard and Soft Soaps, Toilet A Practical Handbook of the Manufacture of Hand and Soft Soaps, &c. Including many New Processes, and a Chapter on the Recovery of Glycerine from Waste Leys. By Alx. WATT. Sixth Edition, including an Appendix on Modern Candlemaking. Crown 8vo, cloth.

[Just Published. 7/6

"The work will prove very useful, not merely to the technological student, but to the practical soap boiler who wishes to understand the theory of his art."—Chemical News.

"A thoroughly practical treatise on a nart which has almost no literature in our language. We congratulate the author on the success of his endeavour to fill a void in English technical

PRACTICAL PAPER-MAKING.

A Manual for Paper-Makers and Owners and Managers of Paper-Mills. With Tables, Calculations, &c. By G. CLAPPERTON, Paper-Maker. With Illustrations of Fibres from Micro-Photographs. Crown 8vo, cloth . . . 5/0 "The author caters for the requirements of responsible mill hands, apprentices, &c., whilst his manual will be found of great service to students of technology, as well as to veteran papermakers and mill owners. The illustrations form an excellent feature,"—The World's Paper Trade

Review.
"We recommend everybody interested in the trade to get a copy of this thoroughly practical book."-Paper Making.

THE ART OF PAPER-MAKING.

A Practical Handbook of the Manufacture of Paper from Rags, Esparto, Straw, and other Fibrous Materials. Including the Manufacture of Pulp from

It may be regarded as the standard work on the subject. The book is full of valuable information. The 'Art of Paper-Making' is in every respect a model of a text-book, either for a technical class, or for the private student."—Paper and Printing Trades Journal.

A TREATISE ON PAPER.

For Printers and Stationers. With an Outline of Paper Manufacture; Complete Tables of Sizes, and Specimens of Different Kinds of Paper. By RICHARD PARKINSON, late of the Manchester Technical School. Demy 8vo, cloth. 15: "M Just Published. 316

THE ART OF LEATHER MANUFACTURE.

"A sound, comprehensive treatise on tanning and its accessories. The book is an eminently valuable production, which redounds to the credit of both author and publishers."—Chemial

THE ART OF BOOT AND SHOE MAKING.

A Practical Handbook, including Measurement, Last-Fitting, Cutting-Out, Closing and Making, with a Description of the most approved Machinery Employed.

By JOHN B. LENO, late Editor of St. Crispin, and The Boot and Shos-Maker.

12mo, cloth.

2/0

WOOD ENGRAVING.

A Practical and Easy Introduction to the Study of the Art. By W. N. BROWN.

"The book is clear and complete, and will be useful to any one wanting to understand the set elements of the beautiful art of wood engraving."—Graphic.

MODERN HOROLOGY, IN THEORY AND PRACTICE.

"There is no bordolgical work in the English language at all to be compared to this production of M. Saunier's for clearness and completeness. It is alike good as a guide for the student and as a reference for the experienced horologist and skilled workman."—Horological Town-logical Town-lo

THE WATCH ADJUSTER'S MANUAL.

A Practical Guide for the Watch and Chronometer Adjuster in Making, Springing, Timing and Adjusting for Isochronism, Positions and Temperatures. By C. E. FRITTS. 370 pp., with Illustrations, 8vo, cloth . . . 16/0

THE WATCHMAKER'S HANDBOOK.

Intended as a Workshop Companion for those engaged in Watchmaking and Intended as a Workshop Companion for those engaged in Watchmaking and the Allied Mechanical Arts. Translated from the French of CLAUDIUS SAUNIER, and enlarged by JULIEN TRIPPLIN, F.R.A.S., and EDWARD RIGG, M.A., Assayer in the Royal Mint. Third Edition. 8vo, cloth. 9/0 "Each part is truly a treatise in itself. The arrangement is good and the language is clear and concise. It is an admirable guide for the young watchmaker."—Engineering. "It is impossible to speak too highly of its excellence. It fulfils every requirement in a handlook intended for the use of a workman. Should be found in every workshop."—Watch and

A HISTORY OF WATCHES & OTHER TIMEKEEPERS.

By JAMES F. KENDAL, M.B.H. Inst. Boards, 1/6; or cloth, gilt . 2/6

"The best which has yet appeared on this subject in the English language."—Industries.

"Open the book where you may, there is Interesting matter in it concerning the ingenious devices of the ancient or modern horologer."—Saturday Review.

ELECTRO-PLATING & ELECTRO-REFINING OF METALS.

Being a new edition of ALEXANDER WATT'S "ELECTRO-DEPOSITION." Revised and Largely Rewritten by ARNOLD PHILIP, B.Sc., A.I.E.E., Principal Assistant to the Admiralty Chemist. Large Crown 8vo, cloth.

[Just Published. Net. 12/6]

"Eminently a book for the practical worker in electro-deposition. It contains practical descriptions of methods, processes and materials, as actually pursued and used in the workshop."—

ELECTRO-METALLURGY.

Practically Treated. By ALEXANDER WATT. Tenth Edition, including the most recent Processes. 12mo, cloth

"From this book both amateur and artisan may learn everything necessary for the successful prosecution of electroplating."—Iron.

JEWELLER'S ASSISTANT IN WORKING IN GOLD.

"This manual of technical education is apparently destined to be a valuable auxiliary to a handicraft which is certainly capable of great improvement."—The Times.

ELECTROPLATING.

A Practical Handbook on the Deposition of Copper, Silver, Nickel, Gold, Aluminium, Brass, Platinum, &c., &c. By J. W. URQUHART, C.E. Fourth Edition, Revised. Crown 8vo, cloth.

"An excellent practical manual."—Engineering.
"An excellent work, giving the newest information."—Horological Journal.

ELECTROTYPING.

"The book is thoroughly practical; the reader is, therefore, conducted through the leading laws of electricity, then through the metals used by electrotypers, the apparatus, and the depositing processes, up to the final preparation of the work."—Art Journal.

GOLDSMITH'S HANDBOOK.

By George E. Gee, Jeweller, &c. Fifth Edition. 12mo, cloth . . . 3/0
"A good, sound educator, and will be generally accepted as an authority."—Horological Sournal.

SILVERSMITH'S HANDBOOK.

By George E. Gee, Jeweller, &c. Third Edition, with numerous Illustrations. 12mo, cloth
"The chief merit of the work is its practical character... The workers in the trade will speedly discover its merits when they sit down to study it."—English Mechanic.

*** The above two works together, strongly half-bound, price 7s.

SHEET METAL WORKER'S INSTRUCTOR.

Comprising a Selection of Geometrical Problems and Practical Rules for Describing the Various Patterns Required by Zinc, Sheet-Iron, Copper, and Tin-Plate Workers. By REUBEN HENRY WARN. New Edition, Revised and greatly Enlarged by JOSEPH G. HORNER, A.M.I.M.E. Crown 8vo, 254 pp., with 430 Illustrations, cloth. [Just Published. 7]6

BREAD & BISCUIT BAKER'S & SUGAR-BOILER'S ASSISTANT.

Including a large variety of Modern Recipes. With Remarks on the Art of Bread-making. By ROBERT WELLS. Third Edition. Crown 8vo, cloth. 2/0
"A large number of wrinkles for the ordinary cook, as well as the baker."—Saturday Review.

PASTRYCOOK & CONFECTIONER'S GUIDE.

"We cannot speak too highly of this really excellent work. In these days of keen competition our readers cannot do better than purchase this book."—Bakers: Times.

ORNAMENTAL CONFECTIONERY.

A Guide for Bakers, Confectioners and Pastrycooks; including a variety of Modern Recipes, and Remarks on Decorative and Coloured Work. With 120 Original Designs. By ROBERT WELLS. Second Edition. Crown 8vo. 5/0 "A valuable work, practical, and should be in the hands of every baker and confectioner. The Illustrative designs are alone worth treble the amount charged for the whole work."—Bakers' Times.

THE MODERN FLOUR CONFECTIONER, WHOLESALE AND RETAIL.

Containing a large Collection of Recipes for Cheap Cakes, Biscuits, &c. With remarks on the Ingredients Used in their Manufacture. By ROBERT WELLS, Author of "The Bread and Biscuit Baker," &c. Crown 8vo, cloth . 2/0 "The work is of a decidedly practical character, and in every recipe regard is had to economical working."—North British Daily Mail.

RUBBER HAND STAMPS

HANDYBOOKS FOR HANDICRAFTS.

BY PAUL N. HASLUCK.

Editor of "Work" (New Series), Author of "Lathe Work," "Milling Machines. &c. Crown 8vo, 144 pp., price 1s. each.

These Handybooks have been written to supply information for Workmen, Students, and Amateurs in the several Handicrafts, on the actual Practice of the Workshop, and are intended to convey in plain language Technical Know-LEDGE of the several CRAFTS. In describing the processes employed, and the manipu-lation of material, workshop terms are used; workshop practice is fully explained; and the text is freely illustrated with drawings of modern tools, appliances, and brocesses.

THE METAL TURNER'S HANDYBOOK.

A Practical Manual for Workers at the Foot-Lathe. With over 100 Illustrations. "The book will be of service alike to the amateur and the artisan turner. It displays thorough knowledge of the subject."-Scotsman.

THE WOOD TURNER'S HANDYBOOK.

A Practical Manual for Workers at the Lathe. With over 100 Illustrations. "We recommend the book to young turners and amateurs. A multitude of workmen has hitherto sought in vain for a manual of this special industry."—Mechanical World.

THE WATCH JOBBER'S HANDYBOOK.

A Practical Manual on Cleaning, Repairing, and Adjusting. With upwards of 100 Illustrations "We strongly advise all young persons connected with the watch trade to acquire and study this inexpensive work."—Clerkenwell Chronicle.

THE PATTERN MAKER'S HANDYBOOK.

A Practical Manual on the Construction of Patterns for Founders. With upwards of 100 Illustrations
"A most valuable, if not indispensable manual for the pattern maker."—Knowledge.

THE MECHANIC'S WORKSHOP HANDYBOOK.

A Practical Manual on Mechanical Manipulation, embracing Information on various Handicraft Processes. With Useful Notes and Miscellaneous Memoranda. Comprising about 200 Subjects . 1/0
"A very clever and useful book, which should be found in every workshop; and it should certainly find a place in all technical schools."—Saturday Review.

THE MODEL ENGINEER'S HANDYBOOK.

A Practical Manual on the Construction of Model Steam Engines. With upwards of 100 Illustrations.
"Mr. Hasluck has produced a very good little book."—Builder.

THE CLOCK JOBBER'S HANDYBOOK.

A Practical Manual on Cleaning, Repairing, and Adjusting. With upwards of 100 Illustrations "It is of inestimable service to those commencing the trade."—Coventry Standard.

THE CABINET MAKER'S HANDYBOOK.

A Practical Manual on the Tools, Materials, Appliances, and Processes employed in Cabinet Work. With upwards of 100 Illustrations . . . 1/0 "Mr. Hasluck's thorough-going little Handybook is amongst the most practical guides we have seen for beginners in cabinet-work."—Saturday Review.

WOODWORKER'S HANDYBOOK OF MANUAL THE INSTRUCTION.

Embracing Information on the Tools, Materials, Appliances and Processes Employed in Woodworking. With 104 Illustrations. 1/0 OPINIONS OF THE PRESS.

"Written by a man who knows, not only how work ought to be done, but how to do it, and

"Written by a man who knows, not only how work ought to be done, but how to do it, and how to convey his knowledge to others,"—Engineering.

"Mr. Hasluck writes admirably, and gives complete instructions,"—Engineer.

"Mr. Hasluck combines the experience of a practical teacher with the manipulative skill and scientific knowledge of processes of the trained mechanician, and the manuals are marvels of what can be produced at a popular price,"—Schooimaster.

"Helpful to workmen of all ages and degrees of experience."—Datly Chronicle,
"Practical, sensible, and remarkably cheap."—Journal of Education.

"Concide, clear, and practical."—Saturday Review.

COMMERCE. COUNTING-HOUSE WORK. TABLES. &c.

LESSONS IN COMMERCE.

By Professor R. Gambaro, of the Royal High Commercial School at Genoa. Edited and Revised by James Gault, Professor of Commerce and Commercial Law in King's College, London. Fourth Edition. Crown 8vo, cloth . 3/6

"The publishers of this work have rendered considerable service to the cause of commercial education by the opportune production of this volume. . . The work is peculiarly acceptable to English readers and an admirable addition to existing class books. In a phrase, we think the work attains its object in furnishing a brief account of those laws and customs of British trade with which the commercial man interested therein should be familiar."—Chamber of Commerce Tournal. "An invaluable guide in the hands of those who are preparing for a commercial career, and, in fact, the information it contains on matters of business should be impressed on every one."—Counting House.

THE FOREIGN COMMERCIAL CORRESPONDENT.

Being Aids to Commercial Correspondence in Five Languages—English, French, German, Italian, and Spanish. By CONRAD E. BAKER. Third French, German, Italian, and Spanish. By CONRAD E. BAKER. Edition, Carefully Revised Throughout. Crown 8vo, cloth.

[Just Published. 4/8

"Whoever wishes to correspond in all the languages mentioned by Mr. Baker camet do better than study this work, the materials of which are excellent and conveniently arranged. They consist not of entire specimen letters, but—what are far more useful—short passages, sentences, or phrases expressing the same general idea in various forms,"—#thenexum.

"A careful examination has convinced us that it is unusually complete, well arranged and reliable. The book is a thoroughly good one."—Schoolmaster.

FACTORY ACCOUNTS: their PRINCIPLES & PRACTICE.

A Handbook for Accountants and Manufacturers, with Appendices on the Nomenclature of Machine Details; the Income Tax Acts; the Rating of Factories; Fire and Boiler Insurance; the Factory and Workshop Acts, &c., including also a Glossary of Terms and a large number of Specimen Rulings. By EMILE GARCKE and J. M. Fells. Fifth Edition, Revised and Enlarged, Demy 8vo, cloth.

[Just Published. 7/8]

"A very interesting description of the requirements of Factory Accounts... The principle of assimilating the Factory Accounts to the general commercial books is one which we thoroughly agree with. "Accountants Journal." "Characterised by extreme thoroughness. There are few owners of factories who would not derive great benefit from the perusal of this most admirable work." "Local Government Chronicle.

MODERN METROLOGY.

A Manual of the Metrical Units and Systems of the present Century. With an Appendix containing a proposed English System. By Lowis D. A. Jackson, A. M. Inst. C. E., Author of "Aid to Survey Practice," &c. Large

"We recommend the work to all interested in the practical reform of our weights and measures."—Nature.

A SERIES OF METRIC TABLES.

In which the British Standard Measures and Weights are compared with those of the Metric System at present in Use on the Continent. By C. H. DOWLING, C.E. 8vo, strongly bound

"Mr. Dowling's Tables are well put together as a ready reckoner for the conversion of one system into the other."—Athenaum.

THE IRON AND METAL TRADES' COMPANION.

For Expeditiously Ascertaining the Value of any Goods bought or sold by

"A most useful set of tables, nothing like them before existed."—Building News.

"Although specially adapted to the iron and metal trades, the tables will be found useful in every other business in which merchandise is bought and sold by weight."—Reilwey News.

NUMBER, WEIGHT, AND FRACTIONAL CALCULATOR.

Containing upwards of 250,000 Separate Calculations, showing at a Glance the Value at 422 Different Rates, ranging from 711th of a Penny to 203. each, or per cwt., and £20 per ton, of any number of articles consecutively, from 1 to 470. Any number of cwts., qrs., and lbs., from 1 cwt. to 470 cwts. Any number otons, cwts., qrs., and lbs., from 1 to 1,000 tons. By William Chadwick, Public Accountant. Third Edition, Revised. 8vo, strongly bound . 18/0

"It is as easy of reference for any answer or any number of answers as a dictionary. For making up accounts or estimates the book must prove invaluable to all who have any considerable quantity of calculations involving price and measure in any combination to do."—Engineer.

"The most perfect work of the kind yet prepared."—Classgew Herald.

THE WEIGHT CALCULATOR.

Being a Series of Tables upon a New and Comprehensive Plan, exhibiting at one Reference the exact Value of any Weight from 1 lb. to 15 tons, at 300 Progressive Rates, from 1d. to 168s. per cwt., and containing 186,000 Direct Progressive Rates, from 1d. to 108s, per cwt., and containing 180,000 Direct Answers, which, with their Combinations, consisting of a single addition (mostly to be performed at sight), will afford an aggregate of 10,266,000 Answers; the whole being calculated and designed to ensure correctness and promote despatch. By HENRY HARBEN, Accountant. Fifth Edition, carefully Corrected. Royal 8vo, strongly half-bound 21 5s.

"A practical and useful work of reference for men of business generally."—Ironmonger.
"Of priceless value to business men. It is a necessary book in all mercantile offices,"—
Shaffeld Independent.

THE DISCOUNT GUIDE.

Comprising several Series of Tables for the Use of Merchants, Manufacturers, Comprising several Series of Tables for the Use of Merchants, Manufacturers, Ironmongers, and Others, by which may be ascertained the Exact Profit arising from any mode of using Discounts, either in the Purchase or Sale of Goods, and the method of either Altering a Rate of Discount, or Advancing a Price, so as to produce, by one operation, a sum that will realise any required Profit after allowing one or more Discounts: to which are added Tables of Profit or Advance from 1½ to 90 per cent., Tables of Discount from 1½ to 98½ per cent., and Tables of Commission, &c., from ½ to to per cent. By Henry Harben, Accountant. New Edition, Corrected. Demy 8vo, half-bound . £15s.

"A book such as this can only be appreciated by business men, to whom the saving of time means saving of money. The work must prove of great value to merchants, manufacturers, and general traders."—Brikish Trade Journal.

TABLES OF WAGES.

At 54, 52, 50 and 48 Hours per Week. Showing the Amounts of Wages from One quarter of an hour to Sixty-four hours, in each case at Rates of Wages

IRON-PLATE WEIGHT TABLES.

For Iron Shipbuilders, Engineers, and Iron Merchants. Containing the Calculated Weights of upwards of 150,000 different sizes of Iron Plates from 1 foot by 6 in. by \(\frac{1}{2}\) in. to 10 feet by 5 feet by 1 in. Worked out on the Basis of 40 lbs. to the square foot of Iron of 1 inch in thickness. By H. Burlinson and W. H. SIMPSON. 4to, half-bound

MATHEMATICAL TABLES (ACTUARIAL).

Comprising Commutation and Conversion Tables, Logarithms, Cologarithms, Antilogarithms and Reciprocals. By J. W. Gordon. Royal 8vo, mounted on canvas. in cloth case. [Just Published. 5/0]

AGRICULTURE. FARMING. GARDENING. &c.

THE COMPLETE GRAZIER AND FARMER'S AND CATTLE BREEDER'S ASSISTANT.

A Compendium of Husbandry. Originally Written by WILLIAM YOUATT. Fourteenth Edition, entirely Re-written, considerably Enlarged, and brought routeenth Equirements, by WILLIAM FREAM, LL.D., Assistant Commissioner, Royal Commission on Agriculture, 1893, Author of "The Elements of Agriculture," &c. Royal 8vo, 1,100 pp., with over 450 Illustrations, handsomely bound.

[Just Published. £1 11s. 65.

SUMMARY OF CONTENTS.

BOOK I. ON THE VARIETIES, BREEDING, REARING, FATTENING AND MANAGE-MENT OF CATTLE. BOOK II. ON THE ECONOMY AND MAN-AGBMENT OF THE DAIRY. BOOK III. ON THE BREEDING, REARING, AND MANAGEMENT OF HOSEY

AND MANAGEMENT OF HORSES.

BOOK IV. ON THE BREEDING, REARING,

BOOK IV. ON THE BREEDING, REARING, AND FATTENING OF SHEEP. BOOK V. ON THE BREEDING, REARING, AND FATTENING OF SWINE. BOOK VI. ON THE DISEASES OF LIVE

STOCK.

BOOK VII. ON THE BREEDING, REARING.

BOOK VII. ON THE BREEDING, REARING, AND MANAGEMENT OF POULTRY.
BOOK VIII. ON FARM OFFICES AND IMPLEMENTS OF HUSBANDRY.
BOOK IX. ON THE CULTURE AND MANAGEMENT OF GRASS LANDS.
BOOK X. ON THE CULTUATION AND APPLICATION OF GRASSES, PULSE AND ROOTS.
BOOK XI. ON MANURES AND THEIR APPLICATION TO GRASS LAND AND CROPS.
BOOK XII. MONTHLY CALENDARS OF FARMWORK.

*** OPINIONS OF THE PRESS ON THE NEW EDITION.

"The New EDITION.

"Dr. Fream is to be congratulated on the successful attempt he has made to give us a work which will at once become the standard classic of the farm practice of the country. We believe that it will be found that it has no compere among the many works at present in extense. The illustrations are admirable, while the frontispiece, which represents the well-known bull, New Year's Gift, owned by the Queen, is a work of art."—The Times.

"The book must be recognised as occupying the proud position of the most exhaustive work of reference in the English language on the subject with which it deals."—Alkenaum.

"The most comprehensive guide to modern farm practice that exists in the English language to-day.

"The book is one that ought to be on every farm and in the library of every land owner."—Mark Lane Express.

"In point of exhaustiveness and accuracy the work will certainly hold a pre-eminent and unique position among books dealing with scientific agricultural practice. It is, in fact, an agricultural library of itself."—North British Agriculturist.

EADM LINE** EXTOCK** OF CADE** T. DDITAIN.

FARM LIVE STOCK OF GREAT BRITAIN.

By ROBERT WALLACE, F.L.S., F.R.S.E., &c., Professor of Agriculture and Rural Economy in the University of Edinburgh. Third Edition, thoroughly Revised and considerably Enlarged. With over 120 Phototypes of Prize

"A really couplete work on the history, breeds, and management of the farm stock of Great Britain, and one which is likely to find its way to the shelves of every country gentleman's library."

—The Times.

"The latest edition of Fem. You Go.

"The latest edition of 'Farm Live Stock of Great Britain' is a production to be proud of, and its issue not the least of the services which its author has rendered to agricultural science."—

Scottish Farmer.

NOTE-BOOK OF AGRICULTURAL FACTS & FIGURES FOR FARMERS AND FARM STUDENTS.

By PRIMROSE MCCONNELL, B.Sc., Fellow of the Highland and Agricultural Society, Author of "Elements of Farming." Sixth Edition, Re-written, Revised, and greatly Enlarged. Fcap. 8vo, 480 pp., leather. [Just Published. 6/0 SUMMARY OF CONTENTS: SURVEYING AND LEVELING.—WEIGHTS AND MEASURES.—MACHINERY AND BUILDINGS.—LABOUR.—OPERATIONS.—DRAINING.—BEMBANKING.—GEOLOGICAL MEMORANDA.—SOILS.—MANURES.—CROPPING.—CROPS.—ROTATIONS.—WEBDS.—FEBDING.—DAIRYING.—LIVE STOCK.—HORSES.—CATTLE.—SHEEP.—PIGS.—POULTRY.—FORESTRY.—HORTICULTURE.—MISCELLANEOUS.

"No farmer, and certainly no agricultural student, ought to be without this multum-in-parvo manual of all subjects connected with the farm."—North British Agriculturist.
"The amount of information it contains is most surprising; the arrangement of the matter is so methodical—although so compressed—as to be intelligible to everyone who takes a glance through its pages. They teem with information."—Farm and Home.

THE ELEMENTS OF AGRICULTURAL GEOLOGY.

A Scientific Aid to Practical Farming. By PRIMROSE McCONNELL, Author of "Note-Book of Agricultural Facts and Figures." Royal 8vo, cloth. es." Royal 8vo, cloth.
[Just Published. Net 21/0

"On every page the work bears the impress of a masterly knowledge of the subject dealt with, and we have nothing but unstituted praise to offer."—The Field.

BRITISH DAIRYING.

A Handy Volume on the Work of the Dairy-Farm. For the Use of Technical Instruction Classes, Students in Agricultural Colleges and the Working Dairy-Farmer. By Prof. J. P. Sheldon. With Illustrations. Second Edition, Revised. Crown 8vo, cloth. [Just Published. 2/8]

"Confidently recommended as a useful text-book on dairy farming."—Agricultural Gazette.
"Probably the best half-crown manual on dairy work that has yet been produced."—North British Apriculturist.
"It is the soundest little work we have yet seen on the subject."—The Times.

MILK, CHEESE, AND BUTTER.

A Practical Handbook on their Properties and the Processes of their Production. Including a Chapter on Cream and the Methods of its Separation from Milk. By JOHN OLIVER, late Principal of the Western Dairy Institute, Berkeley. With Coloured Plates and 200 Illustrations. Crown 8vo, cloth.

"An exhaustive and masterly production. It may be cordially recommended to all students and practitioners of dairy science."—North British Agriculturist.

"We recommend this very comprehensive and carefully-written book to dairy-farmers and students of dairying. It is a distinct acquisition to the library of the agriculturist.—Agricultural

SYSTEMATIC SMALL FARMING.

Or, The Lessons of My Farm. Being an Introduction to Modern Farm Practice for Small Farmers. By R. Scott Burn, Author of "Outlines of Modern Farming," &c. Crown 8vo, cloth.

"This is the completest book of its class we have seen, and one which every amateur farmer will read with pleasure, and accept as a guide."—Field.

OUTLINES OF MODERN FARMING.

By R. Scott Burn. Soils, Manures, and Crops—Farming and Farming Economy—Cattle, Sheep, and Horses—Management of Dairy, Pigs, and Poultry—Utilisation of Town-Sewage, Irrigation, &c. Sixth Edition. In One Vol., 1,250 pp., balf-bound, profusely illustrated 12/0

FARM ENGINEERING. The COMPLETE TEXT-BOOK of.

Comprising Draining and Embanking; Irrigation and Water Supply; Farm Roads, Fences and Gates; Farm Buildings; Barn Implements and Machines; Field Implements and Machines; Agricultural Surveying, &c. By Professor JOHN SCOTT. In One Vol., 1,150 pp., half-bound, with over 600 Illustrations.

12/0

"Written with great case, as well as with knowledge and ability. The author has done his work well; we have found him a very trustworthy guide wherever we have tested his statements. The volume will be of great value to agricultural students."—Mark Lane Espress.

THE FIELDS OF GREAT BRITAIN.

A Text-Book of Agriculture. Adapted to the Syllabus of the Science and Art Department. For Elementary and Advanced Students. By HUGH CLEMENTS (Board of Trade). Second Edition, Revised, with Additions. 18mo, cloth . . 2/6

"It is a long time since we have seen a book which has pleased us more, or which contains such a vast and useful fund of knowledge."—Educational Times.

TABLES and MEMORANDA for FARMERS, GRAZIERS, AGRICULTURAL STUDENTS, SURVEYORS, LAND AGENTS, AUCTIONEERS, &c.

"Weighing less than 1 oz., and occupying no more space than a match-box, it contains a mass of facts and calculations which has never before, in such handy form, been obtainable. Every operation on the farm is dealt with. The work may be taken as thoroughly accurate, the whole of the tables having been revised by Dr. Fream. We cordially recommend it."—Bell's Weak! Messenger.

ROTHAMSTED EXPERIMENTS AND THEIR THE PRACTICAL LESSONS FOR FARMERS.

Part I. STOCK. Part II. CROPS. By C. J. R. TIPPER. Crown 8vo, cloth. [Just Published. 3/6]

"We have no doubt that the book will be welcomed by a large class of farmers and others interested in agriculture."—Standard.

FERTILISERS AND FEEDING STUFFS.

A Handbook for the Practical Farmer. By Bernard Dver, D.Sc. (Lond.). With the Text of the Fertilisers and Feeding Stuffs Act of 1893, &c. Third Edition, Revised. Crown 8vo, cloth. [Just Published. 1/0]

"This little book is precisely what it professes to be—'A Handbook for the Practical Farmer.' Dr. Dyer has done farmers good service in placing at their disposal so much useful information in so intelligible a form.' —The Times.

BEES FOR PLEASURE AND PROFIT.

BOOK-KEEPING for FARMERS and ESTATE OWNERS.

A Practical Treatise, presenting, in Three Plans, a System adapted for all Classes of Farms. By JOHNSON M. WOODMAN, Chartered Accountant. Fourth Edition. Crown 8vo, cloth

"The volume is a capital study of a most important subject."—A pricultural Gasette.

VOODWANIE VEADLY FADIE ACCOUNT DOOK

WOODMAN'S YEARLY FARM ACCOUNT BOOK.

Giving Weekly Labour Account and Diary, and showing the Income and Expenditure under each Department of Crops, Live Stock, Dairy, &c., &c. With Valuation, Profit and Loss Account, and Balance Sheet at the End of the Year. By JOHNSON M. WOODMAN, Chartered Accountant. Second Edition. Folio, half-bound

"Contains every requisite form for keeping farm accounts readily and accurately."—
Agriculture.

THE FORCING GARDEN.

Or, How to Grow Early Fruits, Flowers and Vegetables. With Plans and Estimates for Building Glasshouses, Pits and Frames. With Illustrations. By SAMUEL WOOD. Crown 8vo, cloth 3/6
"A good book, containing a great deal of valuable teaching."—Gardeners' Magasine.

A PLAIN GUIDE TO GOOD GARDENING.

Or, How to Grow Vegetables, Fruits, and Flowers. By S. Wood. Edition, with considerable Additions, and numerous Illustrations. 8/6.

"A very good book, and one to be highly recommended as a practical guide. The practical directions are excellent."—Athenaum.

MULTUM-IN-PARVO GARDENING.

"We are bound to recommend it as not only suited to the case of the amateur and gentleman's gardener, but to the market grower."—Gardeners' Magazine.

THE LADIES' MULTUM-IN-PARVO FLOWER GARDEN.

And Amateur's Complete Guide. By S. Wood. Crown 8vo, cloth . 3/6 "Full of shrewd hints and useful instructions, based on a lifetime of experience."—Scotsman.

POTATOES: HOW TO GROW AND SHOW THEM.

MARKET AND KITCHEN GARDENING.

By C. W. Shaw, late Editor of Gardening Illustrated. Cloth . . . 3/6
"The most valuable compendium of kitchen and market-garden work published."—Farmer

AUCTIONEERING, VALUING, LAND SURVEYING, ESTATE AGENCY, &c.

INWOOD'S TABLES FOR PURCHASING AND FOR THE VALUATION OF PROPERTIES.

Including Advowsons, Assurance Policies, Copyholds, Deferred Annuities, Freeholds, Ground Rents, Immediate Annuities, Leaseholds, Life Interests, Mortgages, Perpetuities, Renewals of Leases, Reversions, Sinking Funds, &c., &c. 26th Edition, Revised and Extended by WILLIAM SCHOOLING, F.R.A.S., with Logarithms of Natural Numbers and Thoman's Logarithmic Interest and Annuity Tables. 360 pp., Demy 8vo, cloth.

[Just Published. Net 8/0

"Those interested in the purchase and sale of estates, and in the adjustment of compensation cases, as well as in transactions in annuities, life insurances, &c., will find the present edition of eminent service."—*Emgineering*.

"This valuable book has been considerably enlarged and improved by the labours of Mr. Schooling, and is now very complete indeed."—*Economist*.

"Altogether this edition will prove of extreme value to many classes of professional men in saving them many long and tedious calculations."—*Investor's Review*.

THE APPRAISER, AUCTIONEER, BROKER, HOUSE AND ESTATE AGENT AND VALUER'S POCKET ASSISTANT.

For the Valuation for Purchase, Sale, or Renewal of Leases, Annuities, and Reversions, and of Property generally; with Prices for Inventories, &c. By JOHN WHEELER, Valuer, &c. Sixth Edition, Re-written and greatly Extended by C. Norris, Surveyor, Valuer, &c. Royal 32mo, cloth 5/0

"A neat and concise book of reference, containing an admirable and clearly-arranged list of prices for inventories, and a very practical guide to determine the value of furniture, &c."—Standard, "Contains a large quantity of varied and useful information as to the valuation for purchase, sale, or renewal of leases, annuities and reversions, and of property generally, with prices fuventories, and a guide to determine the value of interior fittings and other effects."—Distilder.

AUCTIONEERS: THEIR DUTIES AND LIABILITIES.

A Manual of Instruction and Counsel for the Young Auctioneer. By ROBERT SQUIBBS, Auctioneer. Second Edition, Revised and partly Re-written. Demy

"The standard text-book on the topics of which it treats."—Alkeneum.
"The work is one of general excellent character, and gives much information in a compendious and satisfactory form."—Bwilder.
"May be recommended as giving a great deal of information on the law relating to auctioneers, in a very readable form."—Law "Gournal.
"Auctioneers may be congratulated on having so pleasing a writer to minister to their special needs. "Solicitors" [Governal.

THE AGRICULTURAL VALUER'S ASSISTANT.

A Practical Handbook on the Valuation of Landed Estates; including A Practical Handbook on the valuation of Langed Essates; including Example of a Detailed Report on Management and Realisation; Forms of Valuations of Tenant Right; Lists of Local Agricultural Customs; Scales of Compensation under the Agricultural Holdings Act, and a Brief Treatise on Compensation under the Lands Clauses Acts, &c. By Tom Bright, Agricultural Valuer. Author of "The Agricultural Surveyor and Estate Agent's Handbook." Fourth Edition, with Appendix containing a Digest of the Agricultural Holdings Acts, 1883 and 1900. Crown 8vo, cloth.

[Just Published. Net 6/0]

"Full of tables and examples in connection with the valuation of tenant-right, estates, labour, contents and weights of timber, and farm produce of all kinds."—A pricultural Gasette.

"An eminently practical handbook, full of practical tables and data of undoubted interest and value to surveyors and auctioneers in preparing valuations of all kinds."—Farmer.

POLE PLANTATIONS AND UNDERWOODS.

A Practical Handbook on Estimating the Cost of Forming, Renovating, Improving, and Grubbing Plantations and Underwoods, their Valuation for Purposes of Transfer, Rental, Sale or Assessment. By Tom Bright. Crown 8vo, cloth . 3/6

"To valuers, foresters and agents it will be a welcome aid."—North British Agriculturist.
"Well calculated to assist the valuer in the discharge of his duties, and of undoubted interest and use both to surveyors and autohoese in preparing valuations of all kinds, "Kent Parale."

AGRICULTURAL SURVEYOR AND ESTATE AGENT'S HANDBOOK.

Of Practical Rules, Formulæ, Tables, and Data. A Comprehensive Manual of the Use of Surveyors, Agents, Landowners, and others interested in the Equipment, the Management, or the Valuation of Landed Estates, By Tom Bright, Agricultural Surveyor and Valuer, Author of "The Agricultural Valuer's Assistant," &c. With Illustrations. Fcap. 8vo, Leather, [Just Published. Net 7/8

"An exceedingly useful book, the contents of which are admirably chosen. The classes for whom the work is intended will find it convenient to have this comprehensive handbook accessible for reference."—Live Stock Journal.

"It is a singularly compact and well informed compendium of the facts and figures likely to be required in estate work, and is certain to prove of much service to those to whom it is addressed."—Scotiman.

THE LAND VALUER'S BEST ASSISTANT.

Being Tables on a very much Improved Plan, for Calculating the Value of Estates. With Tables for reducing Scotch, Irish, and Provincial Customary Acres to Statute Measure, &c. By R. Hudson, C.E. New Edition. Royal 32mo, leather, elastic band

"Of incalculable value to the country gentleman and professional man. -Farmers Journal.

THE LAND IMPROVER'S POCKET-BOOK.

Comprising Formulæ, Tables, and Memoranda required in any Computation relating to the Permanent Improvement of Landed Property. By JOHN EWART, Surveyor. Second Edition, Revised. Royal 32mo, oblong, leather . 4/0 "A compendious and handy little volume."-Spectator.

THE LAND VALUER'S COMPLETE POCKET-BOOK.

Being the above Two Works bound together. Leather . . 7/6

HANDBOOK OF HOUSE PROPERTY.

A Popular and Practical Guide to the Purchase, Mortgage, Tenancy, and Compulsory Sale of Houses and Land, including Dilapidations and Fixtures: with Examples of all kinds of Valuations, Information on Building and on the right use of Decorative Art. By E. L. TARBUCK, Architect and Surveyor. Sixth Edition. 12mo, cloth

"The advice is thoroughly practical."—Law Yournal.

"For all who have dealings with house property, this is an indispensable guide."—Decoration.

"Carefully brought up to date, and much improved by the addition of a division on Fine Art.

A well-written and thoughful work."—Land Agent's Record.

LAW AND MISCELLANEOUS.

MODERN JOURNALISM.

A Handbook of Instruction and Counsel for the Young Journalist. By JOHN B. MACKIE, Fellow of the Institute of Journalists. Crown 8vo, cloth . 2/0 "This invaluable guide to journalism is a work which all aspirants to a journalistic career will read with advantage."—Journalist.

HANDBOOK FOR SOLICITORS AND ENGINEERS

Engaged in Promoting Private Acts of Parliament and Provisional Orders for

PATENTS for INVENTIONS, HOW to PROCURE THEM.

Compiled for the Use of Inventors, Patentees and others. By G. G. M. HARDINGHAM, Assoc. Mem. Inst. C.E., &c. Demy 8vo, cloth . . . 1/6

ON & ARBITRATION in LABOUR DISPUTES.

EVERY MAN'S OWN LAWYER.

A Handy-Book of the Principles of Law and Equity. With a Concise Dictionary of Legal Terms. By A BARRISTER. Thirty-ninth Edition, carefully Revised, and inclinding New Acts of Parliament of 1901. Comprising the Youth'al Crienders Act, 1901; the Larreny Act, 1901; the Internating Liquers Act, 1901; the Factory and Werkshop Act, 1901, and other enactments of the year. Judicial Decisions during the year have also been duly noted. Crown 8vo, 800 pp., strongly bound in circh.

Unst Published. 6.8

. This Standard Work of Reserves forms a Complete Epitone of the Laws of England. comprising (amount other matter):

THE RIGHTS AND WRONGS OF INDIVIDUALS—LANDLORD AND THRANT—VENDORS AND PURCHASERS—LEASES AND MORTGAGES—PRINCIPAL AND AGERT—PARTNERSHIP AND COMPANIES—MASTERS, SERVANTS AND WORKERS—CONTRACTS AND AGREEMENTS—BORROWERS, LEXORES AND SURETHS—SALE AND PURCHASE OF GOODS—CREQUES, BILLS AND SALE—BANKRUPITCY—RAILWAY AND SHIPPIGE LAW—LIFE, FIRE, AND MARINE INSURANCE—ACCIDENT AND FIDELITY INSURANCE—CRIMINAL LAW—PARLIAMENTARY ELECTIONS—COLUNTY COUNCILS—DISTRICT COUNCILS—PARISH COUNCILS—MUNICIPAL CORPORATIONS—LIFEL AND SLANDER—PUBLIC HEALTH AND NUISANCES—COPYRIGHT, PATENTS, TRADE MARKS—HUSBAND AND WIFE—DISTORY—CUSTODY OF CHILDREN—TRUSTEES AND EXECUTORS—CLEEGY, CHURCH-WARDENS, &C.—GAME LAWS AND SYNGTHOS—INVESTEES—HUSBAND AND WIFE—CHILDREN—TRUSTEES AND DRATH DUTIES—FORMS OF AGREEMENTS, WILLS, CODICILS, NOTICES, &C.

The object of this work is to enable those who consult it to help themselves to the low; and thereby to dispense, as for as possible, with professional assistance and advice. There are many wrongs and prisonance which persons submit to from thim to time the time through mot hopping how or where to apply for reducts; and many persons have as great a deriad of a largeyer's office as of a limit den. With this book at hand it is believed that many a class of the time that the standard length and the stands of the stands of the standard length of the standard length and wany on evil abstact. The work has established itself as the standard length adviser of all classes, and has also made a reputation for itself as a susful book of reference for lawyers residing at a distance from the libraries, who are glad to have at hand a work ambodying vaccoid decidence and one-thousests.

OPINIONS OF THE PRESS.

- "It is a complete code of English Law written in plain language, which all can understand.

 Should be in the hands of every business man, and all who wish to abolish lawyers bills."—

 Wealthy Times.
 - "A useful and concise epitome of the law, compiled with considerable care."—Law Magazine.
 - "A complete digest of the most useful facts which constitute English law."-Globe.
- "This excellent handbook. . . . Admirably done, admirably arranged, and admirably cheap."—Leads Mercury.
- "A concise, cheap, and complete epitome of the English law. So plainly written that he who runs may read, and he who reads may understand."—Figure.
 - "A dictionary of legal facts well put together. The book is a very useful one."—Speciator.

THE PAWNBROKER'S, FACTOR'S, AND MERCHANT'S GUIDE TO THE LAW OF LOANS AND PLEDGES.

LABOUR CONTRACTS.

A Popular Handbook on the Law of Contracts for Works and Services. By DAVID GIBBONS. Fourth Edition, with Appendix of Statutes by T. F. UTLLEY, Solicitor. Fcap. 8vo, cloth

SUMMARY OF THE FACTORY AND WORKSHOP ACTS

(1878-1891). For the Use of Manufacturers and Managers. By EMILE GARCKE and J. M. FELLS. (Reprinted from "FACTORY ACCOUNTS.")
Crown 8vo, sewed

BRADBURY, AGNEW, & CO. LD., PRINTERS, LONDON AND TONBRIDGE.

WEALE'S SERIES

OF

SCIENTIFIC AND TECHNICAL WORKS.

"It is not too much to say that no books have ever proved more popular with or more useful to young engineers and others than the excellent treatises comprised in Weale's Series."—Engineer.

A New Classified List.

PAGE	f .	PA	
PAGE CIVIL ENGINEERING AND SURVEYING 2	ADOUTECTURE AND DUM DATE	FA	ut.
CIAIL EUGINEENING YND SOKAETING S	ARCHITECTURE AND BUILDING .	•	6
MINING AND METALLURGY 8	INDUSTRIAL AND USEFUL ARTS.		9
MECHANICAL ENGINEERING 4	1		_
NAVIGATION, SHIPBUILDING, ETC 5	MATHEMATICS, ARITHMETIC, ETC.		12
BOOKS OF REFERENCE AND MIS	SCELLANEOUS VOLUMES . 14		



CROSBY LOCKWOOD AND SON, 7, STATIONERS' HALL COURT, LONDON, E.C. 1902.

CIVIL ENGINEERING & SURVEYING.

Civil Engineering.	
By HENRY LAW, M.Inst.	C.E. Including a Treatise on HYDRAULIC RNBLL, M.I.C.E. Seventh Edition, revised,
Engineering by G. R. Bu with Large Additions by	RNBLL, M.I.C.E. Seventh Edition, revised, D. K. CLARK, M.I.C.E 6/6
Pioneer Engineering:	D. R. CLARK, M.I.C.E
A Treatise on the Engineering	g Operations connected with the Settlement of
Waste Lands in New Cou	ntries. By Edward Dobson, M.Inst.C.E.
With numerous Plates. Sec	***
Iron Bridges of Moder	ate Span: tion. By Hamilton W. Pendred. With 40
Illustrations	
Iron and Steel Bridge	
A Practical Treatise upon	their Construction for the use of Engineers,
Draughtsmen, and Students. Illustrations	By Francis Campin, C.E. With numerous 3/6
Constructional Iron an	ate, and Domestic Buildings. By Francis
	3/6
Tubular and other Iro	n Girder Bridges.
Describing the Britannia and	Conway Tubular Bridges. By G. DRYSDALE
DEMPSEY, C.E. Fourth Ed	—· •
Materials and Constru	
tion of Works of Construction	Treatise on the Strains, Designing, and Erecon. By Francis Campin, C.E 3/0
	maller Towns and in Villages.
By Charles Slagg, Assoc	M.Inst.C.E. Third Edition 3/0
Roads and Streets (Th	e Construction of).
In Two Parts: 1. THE AR	T OF CONSTRUCTING COMMON ROADS, by H. K. CLARK, C.E.; II. RECENT PRACTICE: In-
LAW, C.E., Revised by D.	K. CLARK, C.E.; II. RECENT PRACTICE: In- Asphalte, &c. By D. K. CLARK, C.E. 4/6
Gas Works (The Const	
And the Manufacture and D	istribution of Coal Gas. By S. HUGHES, C.E.
Re-written by WILLIAM RIC	HARDS, C.E. Eighth Edition 5/6
Water Works	
	Towns. With a Description of the Principal ngland as influencing Supplies of Water. By
Samuel Hughes, F.G.S.,	C.E. Enlarged Edition 4/O
The Power of Water,	
As applied to drive Flour M	Iills, and to give motion to Turbines and other
Wells and Well-Sinkin	OSEPH GLYNN, F.R.S. New Edition . 2/0
	S. R.I.B.A., and G. R. BURNELL, C.E. Revised
Edition. With a New Appen	dix on the Qualities of Water. Illustrated 2/0
The Drainage of Land	s, Towns, and Buildings. Revised, with large Additions on Recent
By G. D. DEMPSEY, C.E. Practice, by D. K. CLARK,	Revised, with large Additions on Recent
The Blasting and Qua	
For Building and other Pu	rrying of Stone,
Bridges. By Gen. Sir J. Bu	rposes. With Remarks on the Blowing up of
	rposes. With Remarks on the Blowing up of ORGOVNE, K.C.B
Foundations and Conc	rete Works.

Pne	ımatics,
	Including Acoustics and the Phenomena of Wind Currents, for the Use of
	Beginners. By Charles Tomlinson, F.R.S. Fourth Edition . 1/6
Land	and Engineering Surveying.
-co.11	For Students and Practical Use. By T. BAKER, C.E. Eighteenth Edition
	Revised and Extended by F. E. Divon A. M. Inst. C. F. Professional Asso.
	Revised and Extended by F. E. DIXON, A.M. Inst. C.E., Professional Associate of the Institution of Surveyors. With numerous Illustrations and tw
	Lithographic Plates [/ust published 2/0
Man	suration and Measuring.
ALL CAL.	For Students and Practical Use With the Meneuration and Levelling of
	For Students and Practical Use. With the Mensuration and Levelling of Land for the purposes of Modern Engineering. By T. BAKER, C.E. New
	Edition by E. Nugent, C.E
	MINING AND MÉTALLURGY.
Wini	ng Calculations,
THILL	
	For the use of Students Preparing for the Examinations for Collier
	Managers' Certificates, comprising numerous Rules and Examples i Arithmetic, Algebra, and Mensuration. By T. A. O'DONAHUE, M.E. First-Class, Certificated Colliery Manager. [/ust published. 3]6
	First-Class Certificated Colliery Manager [Just hublished. 316
Mine	oralogy,
AM.111.	Rudiments of. By A. RAMSAY, F.G.S. Fourth Edition, revised an
	enlarged. Woodcuts and Plates
Cool	and Coal Mining.
Coai	A Dudimentous Trustice on De the late Cir Wennesday W Samur
	A Rudimentary Treatise on. By the late Sir Warington W. Smyth F.R.S. Eighth Edition, revised by T. Forster Brown 3/6
35.4.	11
mets	illurgy of Iron.
	Containing Methods of Assay, Analyses of Iron Ores, Processes of Mant facture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. With numeroul Illustrations. Sixth Edition, revised and enlarged
	lacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. With numerous
	Illustrations. Sixth Edition, revised and enlarged
The	Mineral Surveyor and Yaluer's Complete Guide
	By W. LINTERN. Fourth Edition, with an Appendix on Magnetic an
	Angular Surveying
Slate	e and Slate Quarrying:
	Scientific, Practical, and Commercial. By D. C. DAVIES, F.G.S. Wit
	numerous Illustrations and Folding Plates. Fourth Edition 3/6
AF	irst Book of Mining and Quarrying,
	With the Sciences connected therewith, for Primary Schools and Self In
	With the Sciences connected therewith, for Primary Schools and Self Instruction. By J. H. COLLINS, F.G.S. Second Edition 1/0
Subt	erraneous Surveying,
2000	With and without the Magnetic Needle. By T. FENWICK and T. BAKE
	C.E. Illustrated
Mini	C.E. Illustrated
AMARIA	Manual of. By WILLIAM MORGANS, Lecturer on Practical Mining at th
	Bristol School of Mines
Mini	ing Tools, Atlas
MA LILL	Of Engravings to Illustrate the above, containing 235 Illustrations of Minin
	Tools, drawn to Scale. 4to
D1	
Phy	sical Geology,
	Partly based on Major-General PORTLOCK'S "Rudiments of Geology. By RALPH TATE, A.L.S., &c. Woodcuts
Hist	orical Geology,
	Partly based on Major-General PORTLOCK'S "Rudiments." By RALF
	TATE, A.L.S., &c. Woodcuts
Geol	ogy, Physical and Historical.
	Consisting of "Physical Geology," which sets forth the Leading Principle
	Consisting of "Physical Geology," which sets forth the Leading Principle of the Science; and "Historical Geology," which treats of the Miner
	and Organic Conditions of the Earth at each successive epoch. By KALP
	Tate, F.G.S

	MECHANICAL ENGINEERING.
The	Workman's Manual of Engineering Drawing. By John Maxton, Instructor in Engineering Drawing, Royal Naval College, Greenwich. Seventh Edition. 300 Plates and Diagrams . 3/6
Fuel	s: Solid, Liquid, and Gaseous.
	Their Analysis and Valuation. For the Use of Chemists and Engineers, By H. J. PHILLIPS, F.C.S., formerly Analytical and Consulting Chemist to the Great Eastern Railway. Third Edition
Fual	Its Combustion and Economy.
r uei	Consisting of an Abridgment of "A Treatise on the Combustion of Coal and
m.	Consisting of an Abridgment of "A Treatise on the Combustion of Coal and the Prevention of Smoke." By C. W. WILLIAMS, A.I.C.E. With Extensive Additions by D. K. CLARK, M. Inst. C.E. Fourth Edition 3/6
Tue	Boilermaker's Assistant In Drawing, Templating, and Calculating Boiler Work, &c. By J. Court-
	NEY, Practical Boilermaker. Edited by D. K. CLARK, C.E 2/0
The	Boiler-Maker's Ready Reckoner.
	With Examples of Practical Geometry and Templating for the Use of
	Platers, Smiths, and Kiveters, by John Courtney, Edited by D. K.
_	CLARK, M.I.C.E. Fourth Edition
•	MAKER'S READY-RECKONER AND ASSISTANT." By J. COURTNEY and
	D. K. CLARK. Price 7/0.
Stea	
	Their Construction and Management. By R. Armstrong, C.E. Illustrated
Stea	m and Machinery Management.
	A Guide to the Arrangement and Economical Management of Machinery.
G4	By M. Powis Bale, M. Inst. M. E
Btea	m and the Steam Engine, Stationary and Portable. Being an Extension of the Treatise on the Steam
	Engine of Mr. J. Sewell. By D. K. Clark, C.E. Fourth Edition 3/6
The	Steam Engine,
	A Treatise on the Mathematical Theory of, with Rules and Examples for
mb.	Practical Men. By T. BAKER, C.E
The	Steam Engine. By Dr. Lardner. Illustrated 1/6
Logo	omotive Engines,
	By G. D. DEMPSEY, C.E. With large Additions treating of the Modern
_	Locomotive, by D. K. CLARK, M. Inst. C.E
Loca	omotive Engine-Driving. A Practical Manual for Engineers in charge of Locomotive Engines. By
	MICHAEL REYNOLDS. Tenth Edition. 3s. 6d. limp; cloth boards. 4/6
Stat	ionary Engine-Driving.
	A Practical Manual for Engineers in charge of Stationary Engines. By
m.	MICHAEL REVNOLDS. Sixth Edition. 3s. 6d. limp; cloth boards . 4/6
THE	Smithy and Forge. Including the Farrier's Art and Coach Smithing. By W. J. E. CRANK.
	Fourth Edition
Mod	ern Workshon Practice.
	As applied to Marine, Land, and Locomotive Engines, Floating Docks, Dredging Machines, Bridges, Ship-building, &c. By J. G. WINTON. Fourth Edition, Illustrated
	Fourth Edition, Illustrated 2/8
Mec	hanical Engineering.
	Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of the Steam Engine,
	Machinery, Mechanical Manipulation, Manufacture of the Steam Engine,
Dets	&c. By Francis Campin, C.E. Third Edition 2/6 ails of Machinery.
	Comprising Instructions for the Execution of various Works in Iron in the
	Fitting-Shop, Foundry, and Boiler-Yard. By FRANCIS CAMPIN, C.E. 3/0

Elementary Engineering:
A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, &c. by J. S. Brewer. Fourth Edition
Questions and Answers on Metals, Alloys, Strength of Materials, &c.
By J. S. Brewer. Fourth Edition 1/6 Power in Motion:
Horse-power Motion, Toothed-Wheel Gearing, Long and Short Driving
Horse-power Motion, Toothed-Wheel Gearing, Long and Short Driving Bands, Angular Forces, &c. By James Armour, C.E. Third Edition 2/0
Iron and Heat,
Exhibiting the Principles concerned in the Construction of Iron Beams, Pillars, and Girders. By J. Armour, C.E
Practical Mechanism,
And Machine Tools. By T. BAKER, C.E. With Remarks on Tools and
Machinery, by J. Nasmyth, C.E
Mechanics: Being a concise Exposition of the General Principles of Mechanical Science,
and their Applications. By CHARLES TOMLINSON, F.R.S 1/6
Cranes (The Construction of),
And other Machinery for Raising Heavy Bodies for the Erection of Buildings, &c. By JOSEPH GLYNN, F.R.S
ings, &c. By Joseph Glynn, F.R.S 1/6
NAVIGATION, SHIPBUILDING, ETC.
The Sailor's Sea Book:
A Rudimentary Treatise on Navigation. By JAMES GREENWOOD, R.A.
A Rudimentary Treatise on Navigation. By JAMES GREENWOOD, B.A. With numerous Woodcuts and Coloured Plates. New and enlarged
Edition. By W. H. ROSSER
Practical Navigation.
Consisting of The Sailor's Sea-Book, by James Greenwood and W. H. Rosser; together with Mathematical and Nautical Tables for the Working of the Problems, by Henry Law, C.E., and Prof. J. R. Young. 7/0
of the Problems, by HENRY LAW, C.E., and Prof. J. R. Young. 7/0
Navigation and Nautical Astronomy,
In Theory and Practice. By Prof. J. R. Young. New Edition. 2/6. Mathematical Tables.
For Trigonometrical, Astronomical, and Nautical Calculations; to which is
prefixed a Treatise on Logarithms. By H. LAW, C.E. Together with a Series of Tables for Navigation and Nautical Astronomy. By Professor J.
Series of Tables for Navigation and Nautical Astronomy. By Professor J.
R. Young. New Edition
Masting, Mast-Making, and Rigging of Ships. Also Tables of Spars, Rigging, Blocks; Chain, Wire, and Hemp Ropes, &c., relative to every class of vessels. By ROBERT KIPPING, N.A 2/0
&c., relative to every class of vessels. By ROBERT KIPPING, N.A 2/0
Sails and Sail-Making.
With Draughting, and the Centre of Effort of the Sails. By ROBERT
Kipping, N.A
Marine Engines and Steam Yessels.
By R. MURRAY, C.E. Eighth Edition, thoroughly revised, with Additions by the Author and by George Carlisle, C.E
Naval Architecture:
An Exposition of Elementary Principles. By JAMES PEAKE 3/6
Ships for Ocean and River Service,
Principles of the Construction of. By HAKON A. SOMMERFELDT . 1/6
Atlas of Engravings
To Illustrate the above. Twelve large folding Plates. Royal 4to, cloth 7/6
The Forms of Ships and Boats.
By W. BLAND. Ninth Edition, with numerous Illustrations and
Models

BUILDING ARTS.

ARCHITECTURE AND THE

Constructional Iron and Steel Work, As applied to Public, Private, and Domestic Buildings. By Francis Camerin, C.E. Building Estates: The Science of Building: The Art of Building: General Principles of Construction, Strength, and Use of Materials, Working Drawings, Specifications, &c. By EDWARD DOBSON, M.R.I.B.A. . 2/0 A Book on Building, Civil and Ecclesiastical. By Sir EDMUND BECKETT, Q.C. (Lord GRIM-THORPE). Second Edition Dwelling-Houses (The Erection of), Illustrated by a Perspective View, Plans, and Sections of a Pair of Villas, with Specification, Quantities, and Estimates. By S. H. BROOKS, Architect 2/6 Cottage Building. Acoustics in Relation to Architecture and Building: The Laws of Sound as applied to the Arrangement of Buildings. By Professor T. ROGER SMITH, F.R.I.B.A. New Edition, Revised . . 1/6 The Rudiments of Practical Bricklaying. General Principles of Bricklaying; Arch Drawing, Cutting, and Setting; Pointing; Paving, Tiling, &c. By Арам Наммонр. With 68 Woodcuts The Art of Practical Brick Cutting and Setting. By Adam Hammond. With 90 Engravings · 1/6 Brickwork: A Practical Treatise, embodying the General and Higher Principles of Bricklaying, Cutting and Setting; with the Application of Geometry to Roof Tiling, &c. By F. Walker. 1/6 Bricks and Tiles. The Practical Brick and Tile Book. Comprising: BRICK AND TILE MAKING, by E. Dosson, M.Inst.C.E.; Practical Bricklaying, by A. Hamsond; Brick-cutting and Setting, by A. Hammond. 550 pp. with 270 Illustratious, half-bound. . . . 6/0 Carpentry and Joinery-THE ELEMENTARY PRINCIPLES OF CARPENTEY. Chiefly composed from the Standard Work of THOMAS TREDGOLD, C.E. With Additions, and TREATISE ON JOINERY, by E. W. TARN, M.A. Seventh Edition 3/6

Carpentry and Joinery—Atlas
Of 35 Plates to accompany and Illustrate the foregoing book. With

Descriptive Letterpress. 4to

A Practical Treatise on Handrailing; Showing New and Simple Methods. By GEO. COLLINGS. Second Edition, Revised, including a TREATISE ON STAIRBUILDING. With Plates . 2/6
Circular Work in Carpentry and Joinery. A Practical Treatise on Circular Work of Single and Double Curvature. By George Collings. Third Edition
Roof Carpentry: Practical Lessons in the Framing of Wood Roofs. For the Use of Working Carpenters. By GEO. COLLINGS
The Construction of Roofs of Wood and Iron; Deduced chiefly from the Works of Robison, Tredgold, and Humber. E. Wyndham Tarn, M.A., Architect. Third Edition 1/6
The Joints Made and Used by Builders. By WYVILL J. CHRISTY, Architect. With 160 Woodcuts 3/0
Shoring And its Application: A Handbook for the Use of Students. By George H. Blagrove. With 31 Illustrations
The Timber Importer's, Timber Merchant's, and Builder's Standard Guide. By R. E. Grandy
Plumbing:
A Text-Book to the Practice of the Art or Craft of the Plumber. With Chapters upon House Drainage and Ventilation. By WM. PATON BUCHAM. Eighth Edition, Re-written and Enlarged, with 500 Illustrations . 3/6
Wentilation: A Text Book to the Practice of the Art of Ventilating Buildings. By W. P. Buchan, R.P., Author of "Plumbing," &c. With 170 Illustrations 3/6
The Practical Plasterer: A Compendium of Plain and Ornamental Plaster Work. By W. KEMP 2/0
House Painting, Graining, Marbling, & Sign Writing. With a Course of Elementary Drawing, and a Collection of Useful Receipts. By Ellis A. Davidson. Eighth Edition. Coloured Plates 5/0 *** The above, in cloth boards, strongly bound, 6/0
A Grammar of Colouring, Applied to Decorative Painting and the Arts. By George Field. New Edition, enlarged, by Ellis A. Davidson. With Coloured Plates . 3/0
Elementary Decoration As applied to Dwelling Houses, &c. By James W. Facey. Illustrated 2/0
Practical House Decoration. A Guide to the Art of Ornamental Painting, the Arrangement of Colours in Apartments, and the Principles of Decorative Design. By JAMES W. FACEY
2/6 ** The last two Works in One handsome Vol., half-bound, entitled "House Decoration, Elementary and Practical," price 5/0.
Portland Cement for Users. By HENRY FAIJA, A.M.Inst.C.E. Third Edition, Corrected
Limes, Cements, Mortars, Concretes, Mastics, Plas-
tering, &c. By G. R. Burnell C.E. Fifteenth Edition 1/6

Mas	onry and Stone-Cutting. The Principles of Masonic Projection and their application to Construction By Edward Dosson, M.R.I.B.A
Arcl	nes, Piers, Buttresses, &c.: Experimental Essays on the Principles of Construction. By W. BLAND. 1/6
Qua	In Bricklayers', Masons', Plasterers', Plumbers', Painters', Paperhangers', Gilders', Smiths', Carpenters' and Joiners' Work. By A. C. Beaton 1/6
The	Complete Measurer: Setting forth the Measurement of Boards, Glass, Timber and Stone. By R. Horron. Sixth Edition
	, The above, strongly bound in leather, price 5/0.
Ligh	At: An Introduction to the Science of Optics. Designed for the Use of Students of Architecture, Engineering, and other Applied Sciences. By E. Wyndham Tarn, M.A., Author of "The Science of Building," &c 1/6
Hin	By GEORGE WIGHTWICK, Architect. Sixth Edition, revised and enlarged by G. Huskisson Guillaume, Architect
Arcl	nitecture—Orders: The Orders and their Æsthetic Principles. By W. H. LEEDS. Illustrated. 1/6
Arcl	hitecture—Styles: The History and Description of the Styles of Architecture of Various Countries, from the Earliest to the Present Period. By T. TALBOT BURY, F.R.I.B.A. Illustrated
	, Orders and Styles of Architecture, in One Vol., 3/6.
	hitecture—Design: The Principles of Design in Architecture, as deducible from Nature and exemplified in the Works of the Greek and Gothic Architects. By Edw. LACY GARBETT, Architect. Illustrated
Per	Adapted to Young Students and Amateurs in Architecture, Painting, &c. By George Pyne
Arc	hitectural Modelling in Paper. By T. A. RICHARDSON. With Illustrations, engraved by O. Jewitt 1/6
Glas	IS Staining, and the Art of Painting on Glass. From the German of Dr. Gessert and EMANUEL OTTO FROMBERG. With an Appendix on The Art of ENAMELLING 2/6
	Puvius—The Architecture of. In Ten Books. Translated from the Latin by Joseph Gwilt, F.S.A., F.R.A.S. With 23 Plates
Ure(JIAN Architecture, An Inquiry into the Principles of Beauty in. With an Historical View of the Rise and Progress of the Art in Greece. By the EARL OF ABERDEEN 1/O

*. The two preceding Works in One handsome Vol., half bound, entitled "Ancient Architecture," price 6/0.

	IDUSTRIAL AND USEFUL ARTS.
Cem	ents, Pastes, Glues, and Gums.
	A Guide to the Manufacture and Application of Agglutinants. With 900 Recipes and Formulæ. By H. C. STANDAGE
Cloc	ks and Watches, and Bells,
	A Rudimentary Treatise on. By Sir Edmund Beckett, Q.C. (Lord Grimthorps). Seventh Edition
Elec	tro-Metallurgy,
	Practically Treated. By ALEXANDER WATT. Tenth Edition, enlarged
	Practically Treated. By ALEXANDER WATT. Tenth Edition, enlarged and revised including the most Recent Processes 3/6
The	Goldsmith's Handbook.
	Colouring Collecting and Refining Recovery of Wests Salders Francis
	Containing full Instructions in the Art of Alloying, Melting, Reducing, Colouring, Collecting and Refining, Recovery of Waste, Solders, Enamels, &c., &c. By George E. Ger. Fifth Edition
The	Silversmith's Handbook,
	On the same plan as the GOLDSMITH'S HANDBOOK. By G. E. GER. 3/0
	** The last two Works, in One handsome Vol., half-bound, 7/0.
The	Hall-Marking of Jewellery.
	Comprising an account of all the different Assay Towns of the United Kingdom; with the Stamps and Laws relating to the Standards and Hall
	Marks at the various Assay Offices. By George E. Gee 3/0
Fren	ch Polishing and Enamelling.
	A Practical Work of Instruction, including numerous Recipes for making
D	Polishes, Varnishes, Glaze-Lacquers, &c. By R. BITMEAD 1/6
Prac	tical Organ Building. By W. E. Dickson, M.A. Second Edition, Revised, with Additions 2/6
Coac	h-Building:
-	A Practical Treatise. By JAMES W. BURGESS. With 57 Illustrations 2/6
The	
	To the Entire Construction of Cabinet Work. By R. BITMEAD . 2/6
The	
The	Instructions for Modelling, Pattern Making, &c. By W. GRAHAM. 2/0 Sheet-Metal Worker's Guide.
TIIG	A Practical Handbook for Tinsmiths, Coppersmiths, Zincworkers, &c., with
	46 Diagrams. By W. J. E. CRANE. Third Edition, revised 1/6
Sewi	ing Machinery:
	Its Construction, History, &c. With full Technical Directions for Adjust-
a	ing, &c. By J. W. Urquhart, C.E
GRR	Fitting: A Practical Handbook. By JOHN BLACK. New Edition 2/6
Cons	truction of Door Locks.
	From the Papers of A. C. Hobbs. Edited by C. Tomlinson, F.R.S. 2/6
The	Model Locomotive Engineer, Fireman, and
	Engine-Boy.
	By Michael Reynolds
The	Art of Letter Painting made Easy.
	By J. G. BADENOCH. With 12 full-page Engravings of Examples . 1/6
The	Art of Boot and Shoemaking.
	Including Measurement, Last-fitting, Cutting-out, Closing and Making. By JOHN BRDFORD LENO. With numerous Illustrations. Fourth Edition 2/0
Mecl	nanical Dentistry:
	A Practical Treatise on the Construction of the Various Kinds of Artificial
	Dentures. By CHARLES HUNTER. Fourth Edition 3/0
AA 00	d Engraving:
T.022	A Practical and Easy Introduction to the Art. By W. N. Brown . 1/9 adry Management.
-au	A Handbook for Use in Private and Public Laundries 2/0

AGRICULTURE, GARDENING, ETC.
Draining and Embanking: A Practical Treatise. By Prof. John Scott. With 68 Illustrations 1/6
Irrigation and Water Supply: A Practical Treatise on Water Meadows, Sewage Irrigation, Warping, &c. on the Construction of Wells, Ponds, Reservoirs, &c. By Prof. John Scott. With 34 Illustrations
Farm Roads, Fences, and Gates: A Practical Treatise on the Roads, Tramways, and Waterways of the Farm: the Principles of Enclosures; and the different kinds of Fences, Gates, and Stiles. By Prof. John Scott. With 75 Illustrations . 1/6
Farm Buildings: A Practical Treatise on the Buildings necessary for various kinds of Farms, their Arrangement and Construction, with Plans and Estimates. By Prof. John Scott. With 105 Illustrations
Barn Implements and Machines: Treating of the Application of Power and Machines used in the Threshingbarn, Stockyard, Dairy, &c. By Prof. J. Scott. With 123 Illustrations.
Field Implements and Machines: With Principles and Details of Construction and Points of Excellence, their Management, &c. By Prof. John Scott. With 138 Illustrations 2/0
A Treatise on Land Surveying, Levelling, and Setting-out; with Directions for Valuing Estates. By Prof. J. Scott. With 62 Illustrations . 1/6
Farm Engineering. By Professor John Scott. Comprising the above Seven Volumes in One, 1,150 pages, and over 600 Illustrations. Ilelf-bound 12/0
Outlines of Farm Management. Treating of the General Work of the Farm; Stock; Contract Work; Labour, &c. By R. Scott Burn
Outlines of Landed Estates Management. Treating of the Varieties of Lands, Methods of Farming, Setting-out of Farms, Roads, Fences, Cates, Drainage, &c. By R. SCOTT BURN. 2/6 ** The above Two Vols. in One, handsomely half-bound, price 6/0
Soils, Manures, and Crops. (Vol. I. Outlines of Modern Farming.) By R. Scott Burn . 2/0
Farming and Farming Economy. (Vol. II. Outlines of Modern Farming.) By R. Scott Burn 3/0
Stock: Cattle, Sheep, and Horses. (Vol. III. Outlines of Modern Farming.) By R. Scott Burn 2/6
Dairy, Pigs, and Poultry. (Vol. IV. Outlines of Modern Farming.) By R. Scott Burn 2/0
Utilization of Sewage, Irrigation, and Reclamation of Waste Land. (Vol. V. Outlines of Modern Farming.) By R. Scott Burn. 2/6
Outlines of Modern Farming. By R. Scott Burn. Consisting of the above Five Volumes in One, 1,250 pp., profusely Illustrated, half-bound 12/0

Book-keeping for Farmers and Estate Owners. A Practical Treatise, presenting, in Three Plans, a System adapted for all classes of Farms. By J. M. WOODMAN. Third Edition, revised . 2/6
Ready Reckoner for the Admeasurement of Land. By A. Arman. Fourth Edition, revised and extended by C. Norris 2/0
Miller's, Corn Merchant's, and Farmer's Ready Reckoner. Second Edition, revised, with a Price List of Modern Flour Mill Machinery, by W. S. HUTTON, C.E
The Hay and Straw Measurer. New Tables for the Use of Auctioneers, Valuers, Farmers, Hay and Straw Dealers, &c. By John Steele
Meat Production. A Manual for Producers, Distributors, and Consumers of Butchers' Meat. By JOHN EWART
Sheep: The History, Structure, Economy, and Diseases of. By W. C. Spooner, M.R.V.S. Fifth Edition, with fine Engravings 3/6
Market and Kitchen Gardening. By C. W. Shaw, late Editor of "Gardening Illustrated" 3/0
Kitchen Gardening Made Easy. Showing the best means of Cultivating every known Vegetable and Herb, &c., with directions for management all the year round. By George M. F. Glenny. Illustrated
Cottage Gardening: Or Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. 1/8
Garden Receipts. Edited by Charles W. Quin 1/6
Fruit Trees, The Scientific and Profitable Culture of. From the French of M. Du Breuil. Fifth Edition, carefully Revised by George Glenny. With 187 Woodcuts
The Tree Planter and Plant Propagator: With numerous Illustrations of Grafting, Layering, Budding, Implements, Houses, Pits, &c. By Samuel Wood
The Tree Pruner: A Practical Manual on the Pruning of Fruit Trees, Shrubs, Climbers, and Flowering Plants. With numerous Illustrations. By SAMUEL WOOD 1/8
. The above Two Vols. in One, handsomely half-bound, price 3/6.
The Art of Grafting and Budding. By Charles Balter. With Illustrations

MATHEMATICS, ARITHMETIC, ETC.
Descriptive Geometry,
An Elementary Treatise on; with a Theory of Shadows and of Perspective extracted from the French of G. Monge. To which is added a Description of the Principles and Practice of Isometrical Projection. By J. F. Heathel M.A. With 14 Plates
Practical Plane Geometry: Giving the Simplest Modes of Constructing Figures contained in one Plan and Geometrical Construction of the Ground. By J. F. HEATHER, M.A. With 215 Woodcuts
A Rudimentary Treatise on. By James Hann. A New Edition, rewritten and enlarged by Professor j. R. Young
With many Additional Propositions and Explanatory Notes; to which is prefixed an Introductory Essay on Logic. By Henny Law, C.E 2/6
*** Sold also separately, viz:— Euclid. The First Three Books. By Henry Law, C.E 1/6 Ruclid. Books 4, 5, 6, 11, 12. By Henry Law, C.E 1/6
Plane Trigonometry, The Elements of. By James Hann 1/6
Spherical Trigonometry, The Elements of. By James Hann. Revised by Charles H. Dow-Ling, C.E. 1/0 1/2 1/2 1/3
Differential Calculus, Elements of the. By W. S. B. WOOLHOUSE, F.R.A.S., &c 1/6
Integral Calculus. By Homersham Cox, B.A 1/6
Algebra, The Elements of. By James Haddon, M.A. With Appendix, containing Miscellaneous Investigations, and a Collection of Problems 2/0
A Key and Companion to the Above. An extensive Repository of Solved Examples and Problems in Algebra. By J. R. Young
With Commercial Phrases and Forms in English, French, Italian, and German. By James Haddon, M.A
Arithmetic, A Rudimentary Treatise on. With full Explanations of its Theoretical Principles, and numerous Examples for Practice. For the Use of Schools and for Self-Instruction. By J. R. YOUNG, late Professor of Mathematics in Belfast College. Thirteenth Edition 1/6
A Key to the Above. By J. R. Young 1/6
Equational Arithmetic, Applied to Questions of Interest, Annuities, Life Assurance, and General Commerce; with various Tables by which all Calculations may be greatly facilitated. By W. Hirsley
Arithmetic, Rudimentary, for the Use of Schools and Self-Instruction. By JAMES HADDON, M.A. Revised by ABRAHAM ARMAN 1/6
A Key to the Above. By A. Arman 1/6

Mathematical Instruments: Their Construction, Adjustment, Testing, and Use concisely Explained By J. F. HEATHER, M.A., of the Royal Military Academy, Woolwich Fourteenth Edition, Revised, with Additions, by A. T. WALMISLEY M.I.C.E. Original Edition, in 1 vol., Illustrated
** In ordering the above, be careful to say "Original Edition," or give th number in the Series (32), to distinguish it from the Enlarged Edition i 3 vols. (as follows)—
Drawing and Measuring Instruments. Including—I. Instruments employed in Geometrical and Mechanical Drawing, and in the Construction, Copying, and Measurement of Maps an Plans. II. Instruments used for the purposes of Accurate Measurement and for Arithmetical Computations. By J. F. Heather, M.A 1/6
Optical Instruments. Including (more especially) Telescopes, Microscopes, and Apparatus for producing copies of Maps and Plans by Photography. By J. F. HEATHER M.A. Illustrated
Surveying and Astronomical Instruments. Including—I. Instruments used for Determining the Geometrical Feature of a portion of Ground. II. Instruments employed in Astronomical Olservations. By J. F. Heather, M.A. Illustrated 16
. The above three volumes form an enlargement of the Author's original work "Mathematical Instruments," price 2/0. (Described at top of page.)
Mathematical Instruments: Their Construction, Adjustment, Testing and Use. Comprising Drawing Measuring, Optical, Surveying, and Astronomical Instruments. By J. Heather, M.A. Enlarged Edition, for the most part entirely re-writter The Three Parts as above, in One thick Volume.
The Slide Rule, and How to Use It. Containing full, easy, and simple Instructions to perform all Business Ca culations with unexampled rapidity and accuracy. By CHARLES HOARE C.E. With a Slide Rule, in tuck of cover. Seventh Edition
Logarithms. With Mathematical Tab'es for Trigonometrical, Astronomical, and Nautica Calculations. By Henry Law, C.E. Revised Edition 3/0
Compound Interest and Annuities (Theory of). With Tables of Logarithms for the more Difficult Computations of Interest Discount, Annuities, &c., in all their Applications and Uses for Mercantif and State Purposes. By Fedor Thoman, Paris. Fourth Edition . 4/0
Mathematical Tables, For Trigonometrical, Astronomical, and Nautical Calculations; to which prefixed a Treatise on Logarithms. By H. Law, C.E. Together with Series of Tables for Navigation and Nautical Astronomy. By Professor R. YOUNG. New Edition
Mathematics, As applied to the Constructive Arts. By Francis Campin, C.E., &c Third Edition
Astronomy. By the late Rev. Robert Main, F.R.S. Third Edition, revised and corrected to the Present Time. By W. T. Lynn, F.R.A.S
Statics and Dynamics, The Principles and Practice of. Embracing also a clear development of Hydrostatics, Hydrodynamics, and Central Forces. By T. BAKER, C. Fourth Edition

BOOKS OF REFERENCE AND
MISCELLANEOUS VOLUMES.
A Dictionary of Painters, and Handbook for Picture Amateurs.
Being a Guide for Visitors to Public and Private Picture Galleries, and for Art-Students, including Glossary of Terms, Sketch of Principal Schools of Painting, &c. By PHILIPPE DARVL, B.A. 2/6
Painting Popularly Explained. By T. J. Gullick, Painter, and John Timbs, F.S.A. Including Fresco, Oil, Mosaic, Water Colour, Water-Glass, Tempera Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. Sixth Edition 5/0
A Dictionary of Terms used in Architecture, Building, Engineering, Mining, Metallurgy, Archæology, the Fine Arts, &c. By John Weale. Sixth Edition. Edited by R. Hunt, F.R.S 5/0
Music: A Rudimentary and Practical Treatise. With numerous Examples. By CHARLES CHILD SPENCER
Pianoforte, The Art of Playing the. With numerous Exercises and Lessons. By CHARLES CHILD SPENCER
The House Manager. A Guide to Housekeeping, Cookery, Pickling and Preserving, Household Work, Dairy Management, Cellarage of Wines, Home-brewing and Winemaking, Gardening, &c. By AN OLD HOUSEKEEPER . 3/6
Manual of Domestic Medicine. By R. Gooding, M.D. Intended as a Family Guide in all cases of Accident and Emergency. Third Edition, carefully revised 2/0
Management of Health. A Manual of Home and Personal Hygiene. By Rev. JAMES BAIRD 1/O
Natural Philosophy, For the Use of Beginners. By Charles Tomlinson, F.R.S 1/6
The Elementary Principles of Electric Lighting. By ALAN A. CAMPBELL SWINTON, M.INST.C.E., M.I.E.E. Fourth Edition, Revised
The Electric Telegraph, Its History and Progress. By R. Sabine, C.E., F.S.A., &c 3/0
Handbook of Field Fortification. By Major W. W. Knollys, F.R.G.S. With 163 Woodcuts 3/0
Logic, Pure and Applied. By S. II. EMMENS. Third Edition 1/6
Locke on the Human Understanding, Selections from. With Notes by S. H. EMMENS 1/6
The Compendious Calculator (Intuitive Calculations). Or Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions; together with Useful Tables, &c. By Daniel O'Gornan, Twenty-seventh Edition carefully revised by C. North

Measures, Weights, and Moneys of all Nations. With an Analysis of the Christian, Hebrew, and Mahometan Calendars. By W. S. B. WOOLHOUSE, F.R.A.S., F.S.S. Seventh Edition . 2/6
Grammar of the English Tongue, Spoken and Written. With an Introduction to the Study of Comparative Philology. By HYDE CLARKE, D.C.L. Fifth Edition 1/6
Dictionary of the English Language. As Spoken and Written. Containing above 100,000 Words. By Hyde CLARKE, D.C.L. Complete with the GRAMMAR, 5/6.
Familiarly Explained for these who have neglected the Study of Grammar. By JUSTIN BRENAN. 18th Edition
French Grammar. With Complete and Concise Rules on the Genders of French Nouns. By G. L. Strauss, Ph.D
English-French Dictionary. Comprising a large number of Terms used in Engineering, Mining, &c. By Alfred Elwes
French Dictionary.
In two Parts—I. French-English. II. English-French, complete in One Vol. *** Or with the Grammar, 4/6.
French and English Phrase Book. Containing Introductory Lessons, with Translations, Vocabularies of Words, Collection of Phrases, and Easy Familiar Dialogues 1/6
German Grammar. Adapted for English Students, from Heyse's Theoretical and Practical Grammar, by Dr. G. L. STRAUSS
German Triglot Dictionary. By N. E. S. A. Hamilton. Part II. German-French-English. Part II. English-German-French. Part III. French-German-English 3/0
German Triglot Dictionary. (As above). Together with German Grammar, in One Volume . 5/0
Italian Grammar. Arranged in Twenty Lessons, with Exercises. By Alfred Elwes. 1/6
Italian Triglot Dictionary, Wherein the Genders of all the Italian and French Nouns are carefully noted down. By Alfred Elwes. Vol. I. Italian-English-French. 2/6
Italian Triglot Dictionary. By Alfred Elwes. Vol. II. English-French-Italian 2/6
Italian Triglot Dictionary. By Alfred Elwes. Vol. III. French-Italian-English 2/6
Italian Triglot Dictionary. (As above). In One Vol
Spanish Grammar. In a Simple and Practical Form. With Exercises. By Alfred Elwes 1/6
Spanish-English and English-Spanish Dictionary. Including a large number of Technical Terms used in Mining, Engineering, &c., with the proper Accents and the Gender of every Noun. By Alfred Elwes *,* Or with the Grammar, 6/0.

Portuguese Grammar,

In a Simple and Practical Form. With Exercises. By ALFRED ELWES 1/6

Portuguese-English and English-Portuguese Dictionary.

Animal Physics,

Animal Physics. By Dr. Lardner. Part I., Chapters I.—VII. 4/O Animal Physics. By Dr. Lardner. Part II., Chapters VIII.—XVIII.

3/0