# THE
# MODEL ENGINEER'S
# HANDYBOOK.

THE

# MODEL ENGINEER'S HANDYBOOK.

## A Practical Manual

ON

## MODEL STEAM ENGINES

*EMBRACING INFORMATION ON THE TOOLS, MATERIALS AND PROCESSES EMPLOYED IN THEIR CONSTRUCTION.*

BY

PAUL N. HASLUCK,

AUTHOR OF "LATHE WORK," "THE METAL TURNER'S HANDYBOOK," "THE PATTERN MAKER'S HANDYBOOK," "THE MECHANIC'S WORKSHOP HANDYBOOK," ETC.

*WITH UPWARDS OF ONE HUNDRED ILLUSTRATIONS.*

Seventh Edition.

Capio Lumen

LONDON:

CROSBY LOCKWOOD AND SON,

7, STATIONERS' HALL COURT, LUDGATE HILL.

1902.



D. VAN NOSTRAND COMPANY,

NEW YORK

LONDON:
PRINTED BY H. VIRTUE AND COMPANY, LIMITED,
CITY ROAD.

# *PREFACE.*

Model Engineering is a branch of the mechanical arts that has received but a scanty share of literary treatment. The subject seems, however, to be particularly suited for such discussion, it being so closely associated with experimental work.

The reader of this Handybook is assumed to have some practical experience in handling tools, and some knowledge of mechanical manipulation, such as can be gleaned from other volumes in this series; turning, filing, fitting, soldering, etc., having been already treated upon.

This Handybook contains a large number of carefully-engraved Illustrations, accurately reduced from working drawings of model engines that have been made under my own supervision. The value of these accurate illustrations will be appreciated by those who are interested in models of the kind they represent. I may remind readers that their value is not to be estimated by any number of pages of letterpress. A single drawing often shows at a glance what could not be so clearly explained in volumes of type.

Large extracts from some articles written originally by me for the *Boy's Own Paper* are incorporated in this Handybook. I am indebted to the kindness of Mr. G. A. Hutchison, the Editor of that paper, for permission to reproduce them here.

P. N. HASLUCK.

London,

*December*, 1888.

# CONTENTS.

# LIST OF ILLUSTRATIONS.

THE

# MODEL ENGINEER'S HANDYBOOK

## CHAPTER I.

### *PRINCIPLES OF THE STEAM-ENGINE.*

THE making of model engines is a mechanical exercise which finds great favour amongst amateurs, and indeed all young beginners at engineering. The work is seldom pursued with any very satisfactory result, as really considerable skill is necessary to construct working models. The tyro who commences his miniature engineering labours finds very little published information which is of use to him.

Model engines, in every stage of manufacture, from the rough castings direct from the foundry to the complete, highly-finished working model, may now be purchased in nearly every town of importance throughout Great Britain. Though this trade is of but recent growth, its continual extension proves that model engines are objects of interest to a large number of the rising generation, and it is felt that information as to their manufacture will prove acceptable to very many readers.

It will be advisable to gain an insight into the principles which govern the action of a steam-engine, and to learn some of the technical peculiarities, before proceeding to attempt its manufacture. There are numerous text-books on the steam-engine which may be studied with advantage, and which explain the theoretical principles.

The modern engine, which now claims our attention, is the result of numerous successive improvements. The application of steam as a motive power was probably originally made by Hero, who, 150 B.C., constructed, or at least described, an Æolipile. This was a hollow sphere, with hollow bent arms attached; water was placed inside the sphere and heated: when steam generated, it issued from the arms and caused the sphere to rotate, by reacting on the air. A model of this, the primogenitor of the modern steam-engine, can be bought at many opticians' shops for about one shilling, and in the streets of London for one penny.

The first known practical application of steam to perform useful work was made by Thomas Savery, in 1698, who arranged what was then called a fire-engine, to raise water to a height of about 19 feet. Savery's engine acted on the principle of the barometer; the water was forced upwards by atmospheric pressure into an empty receiver, and was afterwards carried higher by steam pressure.

The commencement of the eighteenth century began the first steps towards the development of the modern form of engine. Savery and Newcomen made improvements which were perfected by James Watt, who was born at Glasgow in 1737. Amongst other valuable improvements he first contrived to convert the reciprocating motion into a rotary one by means of the crank. In the year 1800, Watt retired from business, leaving the steam-engine in much the same condition as we find it now. The application of steam-power for locomotion, both on land and on water, followed; and now stationary, locomotive, and marine engines, driven by steam, are distributed all over the civilised world.

Thomas Newcomen was the first to arrange the moving parts of the steam-engine in such a way that the steam did not act directly on the water to be raised. He was the first to work out the idea of a piston, which made a distinct advance in the application of steam as a general moving power. Newcomen's engine consisted of three principal parts: the boiler, a vessel in which the steam was generated; the cylinder, in which steam was condensed; and the beam, the movements of which followed the alternate admission and condensation of the steam, and communicated the motion to the pump-rod. The cylinder was placed directly above the boiler, from which the steam passed through a stop-cock into the lower part of the cylinder, and acted against the piston, which then made a stroke upwards, the pump-rod end of the beam being balanced to suit the pressure. When the piston was at the end of its stroke, a cock was opened, which admitted cold water, this condensed the steam in the cylinder. A vacuum being thus obtained, the atmosphere acted above the piston, forcing it down with a pressure of 15 lb. per square inch of surface, the motion of the piston causing the up-stroke of the pump-rods, water, &c. By the successive repetition of these operations, the engine was steadily worked. Newcomen's was a single-acting engine, the steam acting on one side of the piston only, and was called an atmospheric engine, because it depended upon the pressure of the atmosphere to perform the down stroke, which did the useful work.

In the modern steam-engine, which owes its general design to Watt, the dimensions of the cylinder, to an extent, indicate the power; but the pressure of steam must also be considered. The friction in models is very great in proportion to their size, and for this reason very small ones are often barely able to generate sufficient power to keep themselves going. The bore of the cylinder governs the area of the piston, and this multiplied by the pressure of steam and the length of stroke gives the power of the engine.

Let us compare the power of two small cylinders, one $\frac{1}{2}$ in. in bore and 1 in. in stroke, the other 1-in. bore and 2-in. stroke. We will suppose the pressure of steam to be the same in both cases, say, 10 lb. to the square inch. Speaking off-hand, many persons are apt to say that one cylinder is twice the size of the other, and, as a natural deduction, twice as powerful. Comparison will at once show the fallacy of the idea.

The area of the $\frac{1}{2}$-in. cylinder is nearly $\frac{2}{10}$ of a square inch, that of the other nearly $\frac{8}{10}$. Thus we see that the larger one has four times the area; also the length of stroke is twice as much. According to the rule given above we find the powers thus: $\frac{2}{10} \times 10 \times 1 = 2$ lb. and $\frac{8}{10} \times 10 \times 2 = 16$ lb. So that the power of the larger cylinder is precisely eight times that of the small one. In every case it is necessary to allow a certain percentage of the power to overcome friction. The smaller the engine the greater will be the percentage lost in friction. These simple facts will at once show that size is a most important consideration. If the friction in the small engine was 2 lb. the power would not drive it, whereas if it were that much in the large one there would still be 14 lb. of available power.

A cylinder 1 $\frac{3}{8}$-in. bore and the same length of stroke, viz., 2 in., would give exactly double the power of the 1-in. bore cylinder just mentioned. If the bore was increased to 2 in., the power would be exactly four times that of the 1-in. bore, the length of stroke and pressure of steam remaining the same in each.

The velocity of the piston also forms a factor in calculating the power, which is increased in the same proportion as the velocity. It will be readily understood that when the pressure of the steam is constant, the speed of the engine will depend on the amount of work it has to do. It must also be remembered that the pressure of steam against the piston is by no means necessarily the same as it is in the boiler. In passing from the boiler to the cylinder the steam pressure is always reduced, and the greater the distance and more exposed or tortuous the steam-pipe, the greater will be the loss of pressure.

Everyone knows that the power of steam-engines is given in "horse-power." This was a term originated by James Watt, and it is now universally adopted. The mechanical equivalent is a lifting power that will raise 33,000 lb. one foot high in one minute. On this estimate the power of an engine is calculated. The rule is this: Multiply the pressure in pounds per square inch on the piston by velocity per minute and divide by 33,000. The velocity of the piston is twice the length of stroke in feet multiplied by the number of revolutions per minute.

Let us calculate the horse-power of the 1 × 2-in. cylinder, already dealt with at a pressure of 10 lb., the speed being 100 revolutions per minute. By the previous calculation we found that the pressure was 16 lb. The velocity is $\frac{4}{12} \times 100 = 33\frac{1}{3}$ (feet). Multiply these together, $16 \times 33\frac{1}{3} = 533\frac{1}{3}$, and divide $\frac{533}{33000} = \cdot016 \ldots$ That is, the engine is $\frac{16}{1000}$ of a horse-power, or capable of raising 528 lb. one foot high in one minute. That is supposing all the power was available for *duty*. In large engines about 20 per cent. is allowed for friction, and in the model we must allow at least 50 per cent. This allowance for friction at once reduces the calculated power to half.

The *power* of an engine is the nominal, and the *duty* is the actual work that it will perform. When the horse-power of an engine is spoken of, it must be taken in a qualified sense.

By urging the furnace greater effect may be obtained, and by keeping the furnace low an effect less than the nominal power is produced. *Duty* is the term used to represent the amount of work absolutely done; it disregards the size of the engine, and simply inquires how much work is done by a given expenditure of fuel. True economy in working will add to the duty of an engine, whilst woeful waste in no way affects the power.

Let us now trace the effect of the steam when admitted to the cylinder. When the governor valve is opened the steam flows along the pipe to the slide valve chest, and if one of the ports is open it reaches the cylinder. In traversing the pipes which conduct it to the cylinder the steam is cooled considerably and its force diminished. In course of time the parts become heated to a certain degree, and then the loss of power is less. When the steam enters the cylinder it at once exerts a certain force on the piston. This has the effect of turning the crank shaft, and in due course the slide valve closes the steam inlet. Now the steam within the cylinder acts expansively, and continues to drive the crank shaft to the end of the stroke. Then the exhaust port is opened, and allows the spent or dead steam to escape. At the same time the inlet at the other end is opened and the live steam rushes in and exerts its full pressure on the piston, causing it to travel in the opposite direction. The opening and shutting of the steam ports is effected by an eccentric on the crank shaft. In treating of the construction of these parts, the relative sizes are given and the correct motion explained.

Boilers, which are the vessels in which water is converted into steam, are usually described by their shape and position. They may be cylindrical, spherical, &c., and horizontal, vertical, &c. The construction also forms a distinguishing characteristic. Tubes are usually inserted in the boiler to convey the heat from the fire. These tubes—which are more properly called flues, especially in large boilers—vary in number from one of large size to scores of small ones, thus naming the respective boilers single-flue or multiflue. It may be advisable to mention here that *tubular* boilers are those in which the water circulates in the tubes, and the fire impinges on the outer surface. When the fire operates inside the tube it is called a *flue*. A tube carries water; a flue carries flame and the volatile products of combustion.

Boilers, or steam generators, that are used to contain the water which, when converted into steam, drives the engine, require to be sufficiently strong to withstand an internal or bursting pressure. This pressure is very great in high-pressure engines, but in common models it is generally very low, and seldom exceeds 20 lb. to the square inch. The evaporating capacity of the boiler is according to the requirements of the engine it has to supply. The resistance of the piston to the steam shows the pressure at which it should be supplied. Boilers are generally tested, by means of a hydraulic pump, to stand a pressure of at least double that at which they are intended to be used. It is unsafe to generate steam in any vessel that has not been properly tested. This fact cannot be too strongly impressed upon the mind of the reader.

Suppose a double-action cylinder, 1-in. bore and 2-in. stroke, is to make 100 revolutions of the crank per minute, let us see how much steam will be wanted to drive it. The area of the piston is ·785 in., and each revolution of the crank will require the cylinder to be filled twice—that is, one stroke in each direction. This will take a column of steam ·785 in. in diameter and 4 in. long for each revolution, or 314 cubic inches of steam per minute. If the speed is greater the quantity of steam must be increased proportionately; and when running at the rate of 1,000 revolutions per minute—a speed often attained—3,140 cubic inches of steam will be wanted to supply the cylinder. That is at the rate of about 100 cubic feet per hour.

The pressure of the steam has not yet been taken into account, but it obviously forms a most important factor in the calculation. Water in an open vessel boils at a temperature of 212° Fahr. Provided that the vessel allows the steam to escape freely, all the heat that can be applied will only generate steam at the same pressure, though it will escape faster. As the bubbles of steam ascend to the surface they escape, having only the pressure of the atmosphere to overcome. When water is confined in a closed vessel, like the boiler of a steam-engine, the temperature may be raised to considerably above the usual boiling-point. The heat is always proportionate to the pressure, and steam at a pressure of 120 lb. per square inch is equivalent to the heat represented by 345° Fahr.

Tables are published showing the relation of the heat to the pressure, and a short one is indicated below.

A correct knowledge of the fact that pressure depends on temperature cannot be urged too strongly on the mind of the model engineer. In many model boilers it is quite impossible to raise the heat sufficiently to produce an adequate pressure. Boiling water at 212° Fahr. does not produce any available pressure of steam, it merely counterbalances the weight of the atmosphere, which is 15 lb. to the square inch. By increasing the heat, which can only be done in a closed vessel, available pressure is obtained. Thus 228° = 5 lb., 241° = 10 lb., 251° = 15 lb., and so on. The steam, and the water from which it is generated, and with which it remains in contact, have both the same temperature.

A cubic foot of water weighs 62·5 lb., and it will produce 882 cubic feet of steam, at a pressure of 15 lb. to the square inch above the normal atmospheric pressure; this is equal to a temperature of 251° Fahr. If the pressure is raised to 150 lb., which requires a temperature of 371°, only 187 cubic feet of steam will be produced. Steam is elastic, and hence the more it is compressed the greater will be its force. If one cubic inch of steam, at a pressure of 30 lb., is admitted into a cylinder, and the supply cut off when half filled, the steam will expand till it has filled the cavity, and in increasing its bulk twofold its force will diminish in inverse ratio. The pressure will therefore diminish to 15 lb. to the square inch The expansive force of steam is always at work on the piston of the engine, and it varies in accordance with the arrangement of the valves.

In order to supply the requisite quantity of steam, boilers should evaporate at the rate of one cubic foot of water per hour per horse-power; that will produce 1,700 cubic feet of free steam. The capacity of a boiler should be four or five times as much as the water it boils off per hour, and the steam space should be at least 10 times as large as the consumption of steam at each stroke. The heating surface should be from 15 to 20 square feet per horse-power. Many circumstances tend to modify these rules, but they may be taken as fairly trustworthy in ordinary practice.

# CHAPTER II.

## *MODEL STEAM-ENGINES.*

THIS handybook is intended to supply the information most generally useful to a maker of model engines. It is assumed that some knowledge of mechanical manipulation has been acquired by the reader. He should be able to use the lathe with tolerable certainty of result; in short, the handybooks which I have already produced in this series all form useful guides for the tyro maker of model engines.

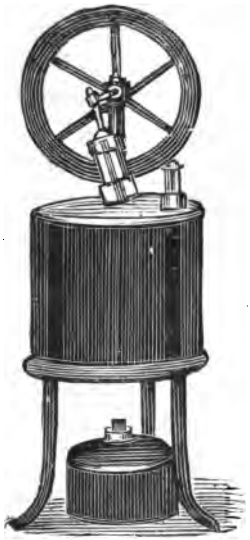


FIG. 1.
Most Inexpensive form of Engine.

In order to give familiar illustrations of those types of engines commonly forming the stock-in-trade of the usual dealers, the blocks in this chapter have been borrowed from their catalogues. The most inexpensive type of working model is shown at Fig. 1, and is more fully described in a later chapter. A similar engine, but slightly improved in its design, is shown at Fig. 2 on the opposite page.

Engines shown in the later chapters, and all the fittings belonging to them, are mostly original, illustrated from model engines that have been made specially, and which are not commonly to be purchased, either complete or in parts, from the usual trade supplies. Those readers who have acquired some manual dexterity in the use of tools will find little difficulty in making the engines illustrated, if the instructions given are carefully followed. In each case details of each process incidental to our engineering work will be carefully described, so that those even but slightly acquainted with the mechanical arts will be able to comprehend the method of procedure.

One of probably the tiniest working models in the world is in the possession of Messrs. Penn (of Greenwich), the eminent makers of the great engines of which it is the reduced counterpart. It will stand on a silver threepenny-piece; but it really covers less space, for its base-plate measures only $\frac{5}{8}$ of an inch by about $\frac{3}{10}$. The engines are of the trunk form introduced by Penn. They are fitted with reversing gear, and are generally similar in design to the great engines with which ships are equipped. The cylinders measure $\frac{1}{8}$ of an inch in diameter, and the trunk $\frac{1}{20}$. The length of stroke is $\frac{3}{40}$ of an inch. From the extreme smallness of this model, a few of the most minute details have necessarily been omitted; some of the parts are so small that a powerful magnifying-glass is required to show their form. The bolts which hold the engine together are only $\frac{1}{80}$ of an inch in diameter, and these are all duly furnished with hexagonal nuts, which can be loosened and tightened by a Liliputian spanner. The weight of the whole model is less than a threepenny-piece.

FIG. 2.
Toy Engine with Oscillating Cylinder.

Another tiny working model is that of the famous *Great Britain* steamship, made to a scale of $\frac{1}{40}$ of an inch to the foot. The length of the model is about eight inches, and the breadth about $1\frac{1}{4}$ inch. It is full-rigged, with six masts and their accompanying spars, and has all the hatchways and deck fittings. The deck of this tiny vessel is lifted off and, by the aid of a powerful magnifier, an accurate model of the original engines with which the *Great Britain* was fitted may be critically examined. This model is so small that it stands

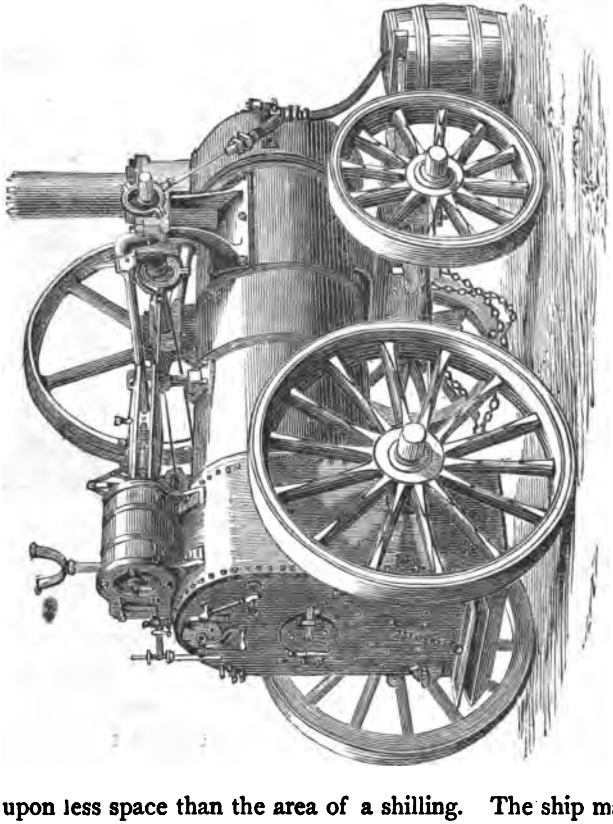


FIG. 3. Portable Engine for Agricultural Work.

upon less space than the area of a shilling. The ship may be launched in an annular trough of water, and, when a tap is turned, off goes the tiny ship to circumnavigate its little sea. The total weight of the boat, with deck and rigging, engines, boiler, all complete, is less than an ounce! The weight of the actual working part of the engines—that is, all excepting the boiler—is just that of a sovereign.

The varieties of model engines are in many cases indicated by their names, but they may be classed into two principal divisions—those in which the cylinder is fixed, and the admission of the steam is regulated by means of a sliding-valve moving parallel with the piston, and actuated by an eccentric on the crank shaft; and those engines which have the cylinder pivoted at right angles to its bore, so that the rotary motion of the crank, coupled direct with the piston-rod, imparts an oscillatory movement to the cylinder. In this class

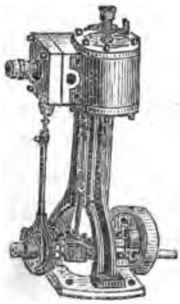


FIG. 4.
Vertical Launch Engine.

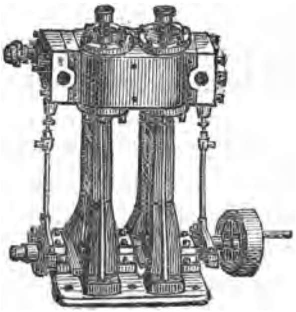


FIG. 5.
Double Cylinder Vertical Engine.

the steam ports of the cylinder are alternately brought immediately over a hole, through which issues the steam from the boiler, and an exhaust hole, through which the steam escapes from the cylinder. The former are called slide-valve engines, and the latter oscillating engines. There are many varieties of each class, but the difference pointed out is so obviously discernable that it affords a ready means of distinction.

Stationary engines are intended to be fixed, as are those used for driving machinery. Portable engines are self-contained, so that they may be moved from place to place, and put to temporary work. They are often used for agricultural purposes, such as for driving steam ploughs, thrashing machines, &c. The illustration, Fig. 3, on page 12, shows an engine of this type. It is mounted on wheels, so that it may be drawn by horses along the highway roads.

Locomotives are those which are intended to travel by steam, and are self-moving. Marine engines are those used to propel ships. Figs. 4 and 5 are types. Of these classes we shall, for the present, exclude locomotives, which are much more complicated in their construction and consequently are more difficult to make.

Horizontal engines are those having the cylinder lying with its axis in a horizontal position.

There are many modifications in the designs, but the essential characteristic is that the cylinder be placed with its bore lying horizontally. The illustration on the next page, Fig. 6, shows a horizontal engine of a usual type. The bed-plate is sheet metal, mounted on six pillars, and cut away to allow the crank-arm and cross-head to pass. The six pillars often have their lower ends screwed into a wooden board slightly larger than the metal bed-plate. The crank-shaft carries the fly-wheel at one end, and the belt pulley at the other.

Vertical engines have the cylinder upright; sometimes they are designated by the latter adjective. Beam engines have an oscillating beam, as shown at Fig. 10, p. 19; one end is connected to the piston, and the other to a rod which drives the crank. Cylinders are single-acting when the steam is admitted only at one end, and consequently with these the crank is propelled only during half of its rotation. Double-acting cylinders are provided with valves which admit the steam at each end of the cylinder alternately. Oscillating cylinders are fitted to oscillate with the motion of the crank, see Figs. 43 to 46, and the steam-valves are usually contrived to act by this oscillating motion. Slide-valve cylinders have a sliding valve

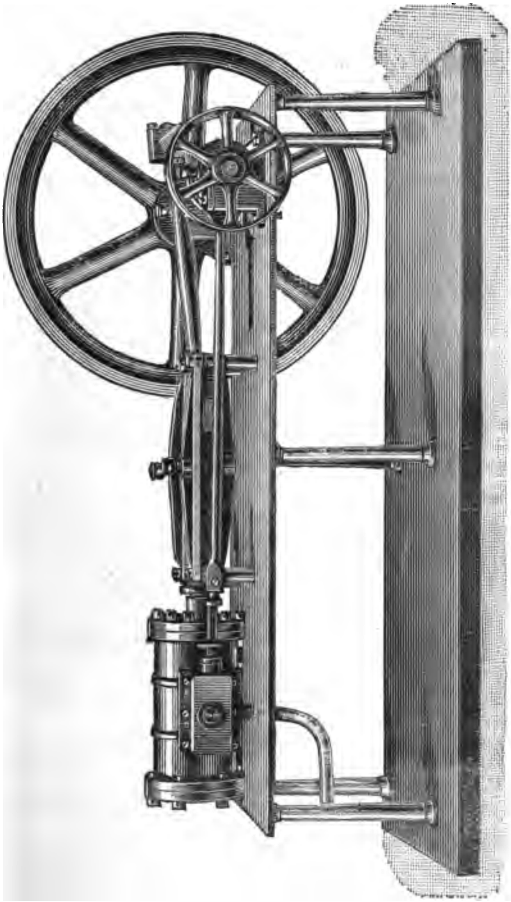


FIG. 6. Horizontal Engine.

worked by a rod connected to an eccentric on the crank-shaft, which opens the steam ports to alternately admit live steam and exhaust at both ends of the cylinder. Slide-valve cylinders are invariably double-acting.

A semi-portable engine, with oscillating cylinder, is shown at Fig. 7. This is self-contained, and may be moved about, but is not mounted on wheels. A slide-valve cylinder engine of similar design is shown at Fig. 8.

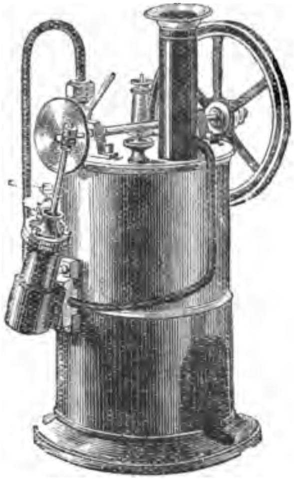


FIG. 7.
Semi-portable Oscillating Engine.

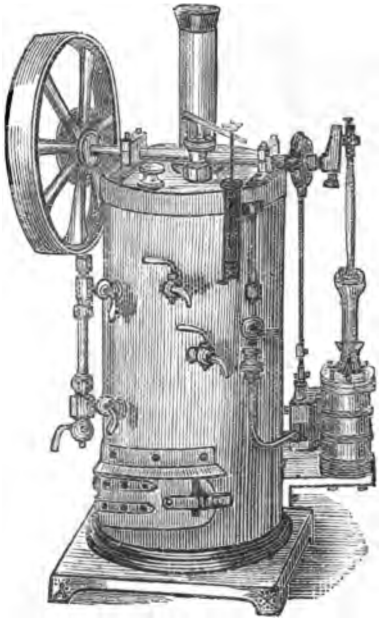


FIG. 8.
Semi-portable Slide-Valve Engine.

Small model engines are composed mainly of brass castings, and of steel which requires no special forging for the purpose. The screws or bolts used to unite the parts are usually purchased in a finished state. Makers of these employ machinery, which acts almost automatically, and the screws are sold at a very cheap rate. Large models require special forgings for the crank-shaft, and the castings employed are of iron, which is considerably cheaper than brass.

The castings are made from patterns which are counterparts of the object required. These are imbedded in sand, and leave a matrix, into which molten metal is poured, producing, on solidifying, a facsimile of the pattern. The operation is always carried out in a foundry where the necessary furnaces and moulding appliances are at hand. The founders charge for the rough castings by weight, and the price is reckoned to cover the cost of labour over the value of the metal. It is, however, necessary to supply the requisite patterns before a founder can proceed to do his part of the work.

THE PATTERN MAKER'S HANDYBOOK may be consulted in this connection with advantage.

All vendors of castings have patterns from which their castings are moulded, and of course they charge, in addition to the cost of labour and a profit on the cost of the metal, something for the use of the patterns. The patterns for a founder's use require certain modifications, which it is unnecessary to explain in detail. Some are made in two or more parts, with pins to hold them together. Some have projections affixed to them ; these make prints in the mould to receive cores, which form holes in the casting. Those patterns which enter deeply into the moulding sand are made tapering, to draw out easily. In all cases they must be made sufficiently large to allow for shrinkage in the metal. Ordinary iron castings shrink about one-eighth of an inch to the foot; brass about half as much again. Pattern-makers use a "contraction-rule" to work by; this is made longer than the standard measurement and patterns made according to it are the correct size to allow for shrinkage. All these details are fully explained in the Handybook above mentioned.

Models are often made with the boilers and engines forming but one machine. Fig. 9 shows an ordinary type of this kind. It is very like the horizontal engine shown on page 15, Fig. 6, but has an oscillating cylinder. A plain cylindrical boiler placed horizontally is let partially through the bed-plate, and the heat is applied by a spirit lamp beneath.

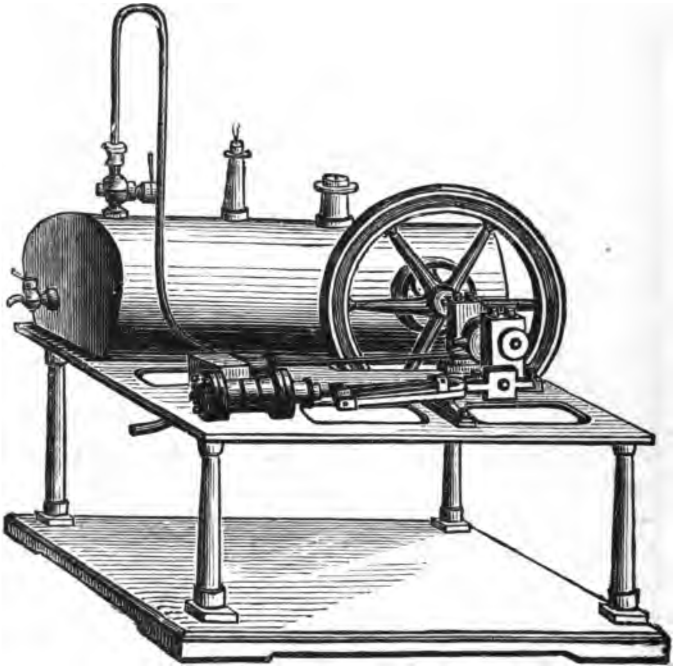


FIG. 9.
Horizontal Engine with Boiler.

A complete beam engine is shown at Fig. 10, and needs no special description. The boiler of this engine is placed vertically.

From what has been said it will be readily understood that vendors of castings charge various prices for their goods. Nor in every case is the quality in accordance with the price, and it is difficult to give even approximate sums that should be paid for good castings. Speaking generally, the price is regulated by the weight, and the rate per pound is decided by the seller. In the catalogues issued by various firms will be

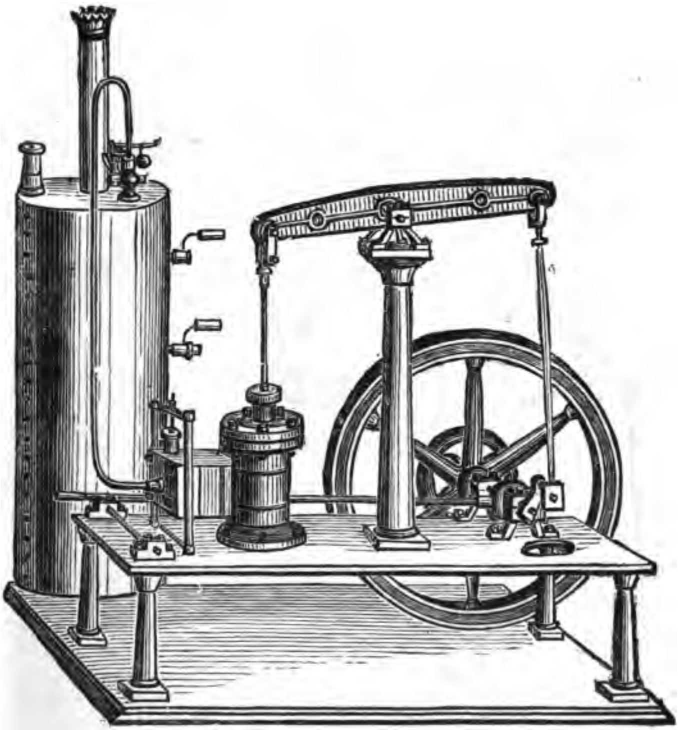


FIG. 10.
Beam Engine with Vertical Boiler.

found the prices charged. As an example of the difference, a certain size of bolts made by one wholesale firm, are retailed by shopkeepers at rates varying from 33 to 200 per cent. profit; the same rule probably holds good in all other items.

Another form of engine, differing from those previously illustrated, is shown at Fig. 11. This type is well suited for model work. The engraving illustrates a semi-portable Robey engine; the smoke-stack is jointed and lowered for travelling.

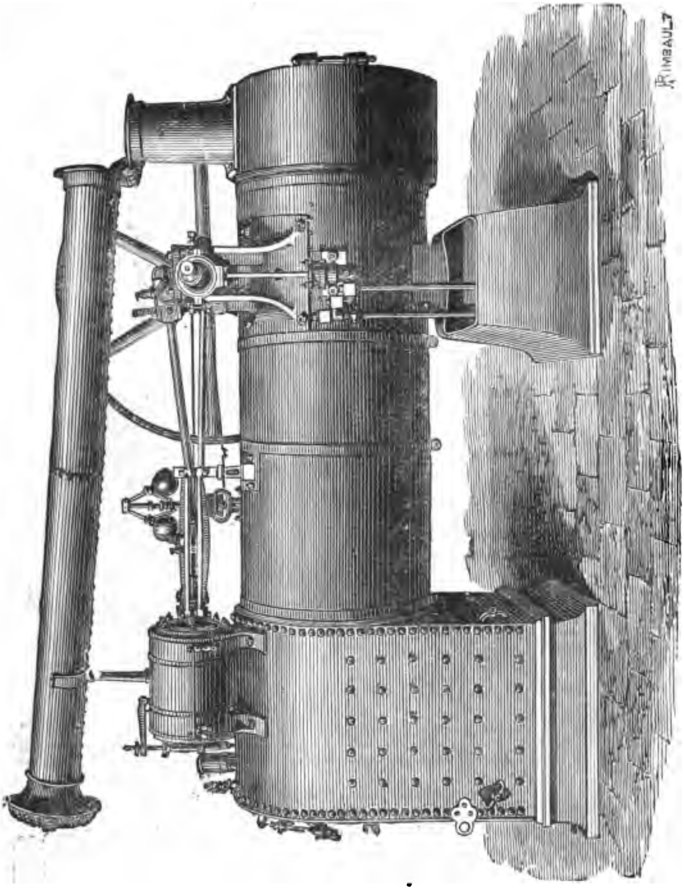


FIG. 11. Semi-portable Engine and Boiler.

The boiler forms the foundation on which are fixed the cylinder, the crank-shaft bearings, and other parts of the engine.

Those readers who are not possessed of a lathe will not have the means of finishing the cylinders and some other parts which have to be turned. These can, however, be bought in various stages of completion, and the beginner, armed with only a screw-driver, may now purchase the component parts, and, having screwed his engine together, he may claim some merit for his share in the erecting department.

Sets of castings quite finished and ready to be screwed together are now sold. These are generally of the cheaper class, and, tacked on cards, may be seen in the windows of opticians. The prices for the complete engine, with boiler, lamp and all other parts, range from about five shillings upwards.

A few words on the better type of partially finished parts. These castings are more expensive than those quite rough, but they afford an opportunity of displaying considerable skill and judgment in completing them.

Boring the cylinders is the operation most likely to baffle the tyro. This is done by vendors of castings for various prices, according to size, and this charge usually includes turning the flanges ready to receive the covers, and also boring the steam-ways and cutting the port-holes. When all this has been done it will be necessary to use a lathe to turn the covers for the cylinder, and also for making the piston.

The cylinder may be purchased complete with the covers screwed on and the slide-valve fitted. Similarly every piece of an engine may be bought separately in a finished state, so that they only require putting together, and when the young engineer has not the tools required for doing the work, his best plan will be to purchase the finished parts.

An examination of a finished engine will show that nearly every part of it has been fashioned on a lathe. This machine is indispensable for all kinds of engineering work, but, being somewhat costly, tyros are frequently compelled to forego its ownership, and in this case get the necessary turning executed by a professional latheman. Those who are happily possessed of this king of machines—the father of mechanism as it has been aptly called—will have the advantage of being themselves able to execute the work throughout. For want of space we cannot discuss the lathe best suited for the work treated upon in this handbook. There are now many useful lathes manufactured in large numbers, and which may be purchased at a moderate cost. The fitting up of a lathe oneself is not an altogether impossible task, though there is some really very high-class work necessary to produce a good lathe suited for model engine making.

The young beginner should not choose a very small lathe; it is a mistake to suppose that better or finer work can be done on miniature lathes. Three inch centres—that is, a lathe which swings six inches—is the smallest useful size, though one about four and a-half inch centres would be better adapted for model engine making, and a larger lathe is necessary for some of this work. A slide-rest is an almost indispensable adjunct to a lathe required for turning parallel cylinders in metal. By means of a slide-rest, steam cylinders of any diameter of bore, within the capacity of the lathe, can be bored true, but without it a special boring bar is necessary for each size.

THE METAL TURNER'S HANDYBOOK, which is a companion volume to this, contains illustrations and descriptions of many lathes and their appurtenances suited for model engine making. Various chucks and tools employed in this and similar work are also shown in that book.

A few particulars of the different kinds of engines which a beginner may make will assist him in deciding as to the form and size best suited to his requirements. An idea of the general forms and peculiarities of engines may be gleaned from the illustrations already given and from what has been said in this chapter. It is entirely at the discretion of the maker whether he will build a vertical or a horizontal engine —whether it shall have oscillating or slide-valve cylinders, and whether it shall be of microscopic dimensions or a powerful model. All these points are for the consideration of the constructor, though some hints will be of service to and assist him in arriving at the desired result—that is the production of a working model.

# CHAPTER III.

## *SINGLE-ACTING TOY-ENGINE.*

THE most simple form of toy-engine is that illustrated below, and fully described in detail in this chapter. It consists of a tin boiler, a single-action oscillating cylinder, and a fly-wheel. These parts are sold, ready for putting together, at a very low price, and a complete engine may be bought for a couple of shillings, though one usually described as of "superior make" at twice that sum is by far a preferable investment.

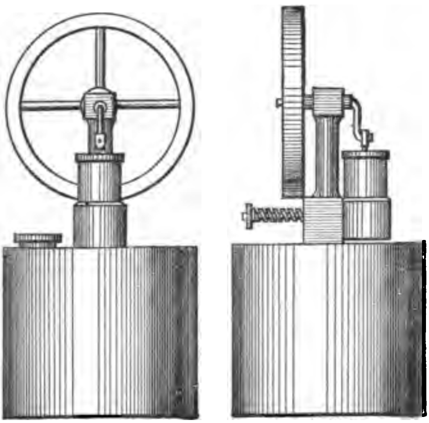


FIG. 12. FIG. 13.
Two Views of Toy Oscillating Engine.

The drawings represent the most simple way of constructing a steam-engine, and, if the workmanship is fairly good, a working model will be produced. First is the boiler; a tin box $1\frac{3}{4}$ in. deep and 2 in. in diameter will serve for this. The joint at the side should be made by folding the edges of metal one over the other, and then soldering. The top and bottom are both soldered steam-tight on their respective places. The top of the boiler must be provided with small bosses of metal, soldered on the inner side, into which the pillar (Fig. 14) and the safety-valve (Fig. 18) are screwed.

The tin plate is not sufficiently thick to afford a hold for the threads on the pillar and on the valve. A disc of brass, say the size of a sixpence, and $\frac{1}{8}$ in. thick, is soldered on the under side of the lid, and the holes, which are tapped to receive the pillar and valve, are bored and threaded before the lid is fixed. By this means a strong hold is secured for the fittings. The screw plug in Fig. 12 is similarly provided for. When each piece is screwed into its place, a little hemp or cotton, placed between the shoulder of the "fitting" and the surface of the tin plate, will assist to ensure a steam-tight joint.

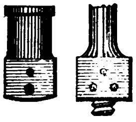


FIG. 14.
Cylinder and Pillar, showing Steam Ports.

The standard, or pillar, is brass, about 2 in. long from end to end. Any form may be given to it, according to fancy, the one shown in Fig. 14 being perhaps as good as any. The lower part is circular, $\frac{1}{2}$ in. in diameter, and it has a flat face on one side, against which the valve-face of the cylinder works. Fig. 14 shows this. The centre of the pillar is bored up in the middle of the screwed part to meet *one* of the two lower holes, it is immaterial which. The other hole is bored right through the pillar to the opposite side, and forms the exhaust port, the one communicating with the central hole in the pillar being the steam port. For the sake of distinction we will suppose the hole to the left is bored into the central hole, and that to the right is bored through the pillar; then when the pillar is screwed on to the boiler and steam is generated, it issues from the porthole on the left.

The upper end of the pillar is bored through at right angles to the flat at the bottom (see Fig. 13). Through the top a piece of brass tubing about $\frac{5}{8}$ in. long is fixed, generally by soldering; this is the bearing for the crank-shaft. The crank-shaft itself is a piece of steel wire bent to the form required. The fly-wheel is fixed to one end, and prevents the shaft coming out of the bearing, the bend of the arm serving the same purpose at the other end.

The cylinder itself is shown at Fig. 14, and also in Figs. 12 and 13. The piston, piston-rod, and piston-head which fits the crank-pin are shown in Fig. 15. It will be evident that the dimensions of this engine are microscopic. The bore of the cylinder is $\frac{5}{16}$ in., and the barrel itself is often made of triblet-drawn brass tube. The enlarged part at the bottom is a casting with a flat face on one side, as shown in Fig. 14. Some makers use a casting for the entire cylinder, but the tube is perhaps the cheaper method of making. A piece of good tube is sufficiently accurate in the bore for use as bought, so that the trouble of boring the cylinder is dispensed with. The base, for the tube to fit in, is bored to the external diameter, and the tube fixed with solder. The lid or cover is fixed only by being snapped on. Its object is only to guide the piston-rod.

Cylinders may be easily bored by the aid of a slide rest, if such an attachment forms part of the lathe available. Failing that, it is advisable to have the cylinder bored by someone having the requisite tools, or to purchase a cylinder casting already bored. A makeshift way of doing the job is to make a bit of the required size and broach out the cylinder. The bit is made of a flat bar of steel made true on the edges, and properly tempered; a bar $\frac{1}{4}$ in. thick would do. Pieces of wood are put on both sides of the bar to keep it central and prevent either edge digging in and so spoiling the bore. It is improbable that a satisfactory job would be made by means of this latter arrangement, and one of the methods previously mentioned would be far preferable. Another makeshift would be to solder a piece of triblet-drawn brass tube inside the brass casting.

A reference to Fig. 14 will show the working of the oscillating valve. The face of the pillar is shown on the right. On this, to the left, is the hole from which the live steam issues, and to the right is the exhaust hole through which the dead steam escapes. These holes are technically called ports. The upper hole is bored through the pillar, and takes the trunnion or pin on which the cylinder oscillates. Fig. 13 shows this trunnion pin prolonged and having a nut on the end. A spiral spring around the trunnion, between the nut and the pillar, keeps the valve-face in close contact with the pillar-face. Now, turning to Fig. 14, on the left is the cylinder, with two holes—the upper, into which the trunnion is screwed, and the lower, the steam-way. When the cylinder is in the position shown in Figs. 12 and 13, the port-hole of the cylinder is over the solid metal between the holes in the pillar. On turning the fly-wheel the crank draws the piston-rod out and inclines the cylinder sideways, bringing the port-hole to the left. The live steam from the boiler at once enters and forces the piston upwards, and on the crank reaching the highest point the cylinder is again vertical, and the hole in it is midway between port and exhaust. The momentum of the fly-wheel carries the crank round and brings the hole opposite the exhaust, allowing the steam to escape. The only force that keeps the engine going during this part of the time is the momentum of the fly-wheel. When the cylinder again inclines to the opposite side, the hole comes over the steam-port, and force—in the form of live steam—is again applied under the piston. This series of actions will keep the engine going.

The single-action oscillating cylinder, being supplied with steam at one end only, exerts power only during half the revolution of the crank. The return stroke is dependent entirely on the momentum of the fly-wheel, which also has to drive the dead steam out of the cylinder. Steam acts only in the lower part of the cylinder, and as there is no power tending to force off the cover it may be snapped on like the lid of a pill-box.

The piston (Fig. 15) has for its head a disc of brass, with a V-shaped groove in its edge. This is packed with hemp or lamp-cotton, to make it fit the cylinder steam-tight. The piston-rod is a steel wire, about $\frac{1}{16}$ in. diameter. It is fixed in the piston-head by riveting, to save the trouble of screwing. The end of the rod has a small piece of brass fixed on it, which forms the cross-head, and fits on the crank-pin.

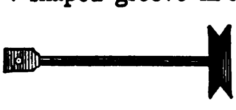


FIG. 15. Piston.

The crank is itself all in one piece. A straight length forms the shaft. It is bent at right angles to form the throw, and a piece bent from this parallel to the shaft forms the pin. This is the most simple way of making a crank, and when large quantities are made the wire is bent upon a template.

A better type of crank is made by using a steel rod for the shaft, with a brass arm riveted to it, and a steel pin riveted into that. In Chapter IV., on the construction of the horizontal engine, will be found a more complete description of such a crank, and an illustration of it is shown at Fig. 32.

The safety-valve is very important as a safeguard in working. Though sometimes omitted from model engines, yet safety-valves are essential for security. They are intended to allow steam to escape freely from the boiler when the pressure exceeds a certain amount, and thus a dangerous explosion is provided against.

The types of safety-valve are shown in the accompanying figures. The weighted lever (Fig. 16) is most simple, and best when there is no chance of it becoming useless through motion. For locomotives and ships a spring safety-valve as shown at Fig. 18 is used, and for models the small spring-valve (Fig. 17) is used.

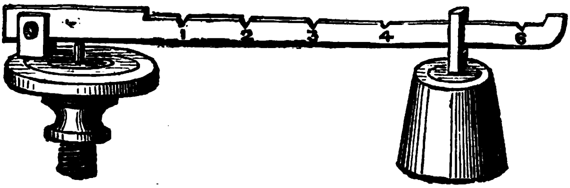



**FIG. 16.**
**Weighted Lever Safety-Valve.**

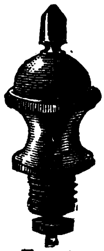


**FIG. 17.**
**Spring Safety-Valve.**

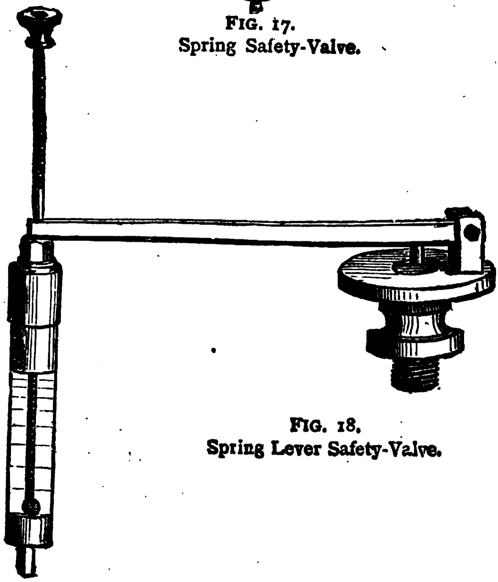


**FIG. 18.**
**Spring Lever Safety-Valve.**

The valve used for the toy-engine now being described is illustrated at Fig. 19. It has a spiral spring to keep the valve on its seat. This is effective when the power of the spring has been definably gauged; but when the valves are put together haphazard, no dependence can be placed upon the pressure at which the valve will blow off.

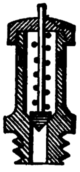


FIG. 19. Section of Safety-Valve.

The body of the valve is shown in section. The valve is fitted on the rod; it rests on the conical seat of the body, and is pressed down by the spiral spring within the barrel. The body is screwed into the top part of the boiler by the thread at the bottom, and steam, coming up the hole, presses the under side of the valve. When the pressure of the steam is sufficient to overcome the pressure of the spiral spring, the valve is lifted, and the steam escapes through the holes shown at the top of the barrel.

The cover is screwed on the body-part, and confines the spring. It has a hole through its centre, to allow the valve-rod to pass. Especial attention should always be given to the safety-valve at the time heat is applied to the boiler. See that the valve is not fixed to its seat, nor in any way confined, as an explosion may follow if these precautions are neglected.

The engine shown by the illustration is usually mounted on a three-legged stand, which raises it from two to three inches. A wire stand may be made according to fancy, or perhaps some contrivance may be improvised to support the boiler at a convenient height for applying heat beneath. A glance at the illustrations on pages 10 and 11 will show this.

A small lamp, burning methylated spirit—that is, spirits of wine—will supply the requisite heat. It should have a clean and dry wick of lamp cotton. The size of the flame may be regulated to a certain extent by the quantity of wick that is drawn out. The lamp must not be quite filled with spirit;

about two-thirds full is ample, and then the spirit will not be liable to overflow when warmed.

When charging the boiler, it is best to use boiling water from a kettle. This will save lots of time that would be lost in heating cold water with the spirit-lamp. The water is poured into the boiler through the water plug-hole (Fig. 12). The boiler should be only about half filled with water. The plug is replaced, and the lighted lamp put under the boiler, when steam will be generated in due course; and if the fly-wheel is turned in the right direction by hand for a few turns, the engine will presently work of its own accord.

It is scarcely necessary to repeat that the engine just described is of the most simple description, and every detail not strictly necessary is omitted.

# CHAPTER IV.

## *HORIZONTAL ENGINES.*

ENGINES of the horizontal type are usually employed to furnish the power required to drive fixed machinery in factories. The construction is simple, and the form is adapted for fixing readily wherever a tolerably level foundation is to be found.

The two illustrations (pages 34 and 35) show both sides of a newly-designed small power engine, by Messrs. Lucas and Davies. This design possesses several characteristic features. The main casting is modelled from the I-sectioned girder; this gives strength without unnecessary weight. The cylinder is bolted to the main casting; the guide for the piston-head being solid with the latter. By this plan much of the usual work of fitting is obviated. Some special tools are necessary to bore the guide-ways true, and to face the end against which the cylinder abuts, but when this is done the completion of the work is very easy, as but few parts have to be fitted. The illustrations show the engine fitted with governors and pump. Four outline drawings which show all principal dimensions are given on page 33. The Figs. 20, 21, 22 and 23, are reduced to $\frac{1}{8}$ scale from the drawings of an engine having the cylinder 2-in. bore and 4-in. stroke. The diameter of fly-wheel is 12 in. Complete sets of castings for engines this size and also for one smaller size and two larger sizes are supplied by the designers.

The several illustrations given next, show another simple

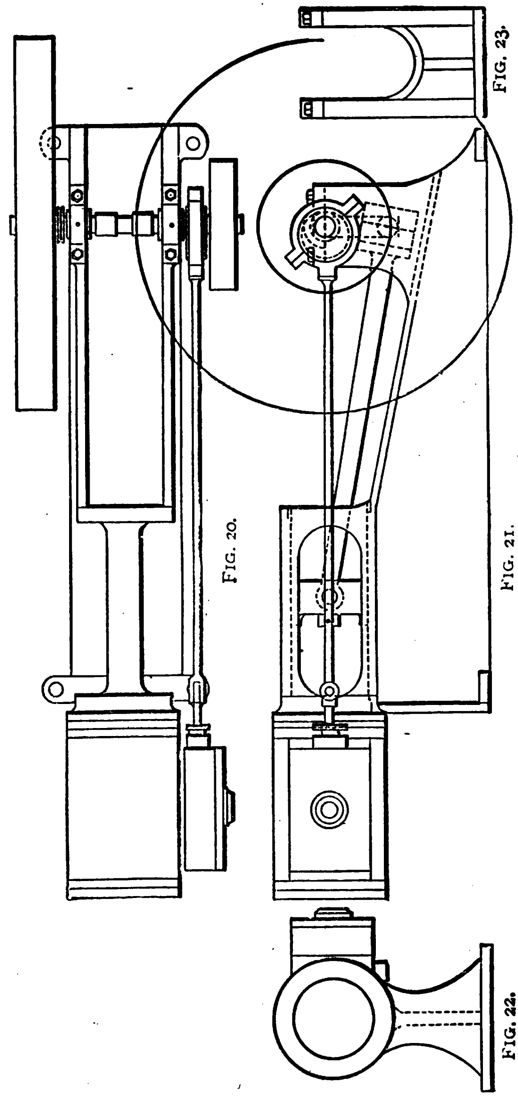


FIG. 20.

FIG. 21.

FIG. 22.

FIG. 23.

FIGS. 20, 21. 22, and 23. Working Drawings of Horizontal Engine.

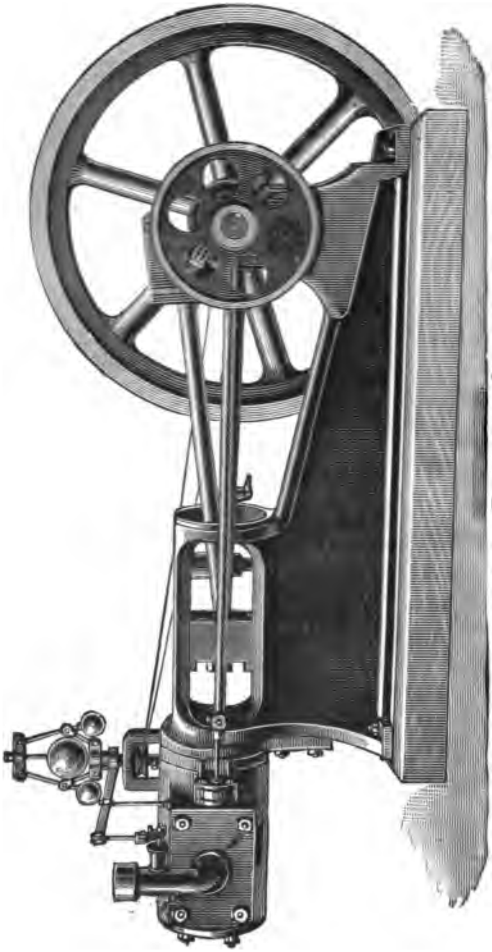


FIG. 24.
Front View of Horizontal Engine.

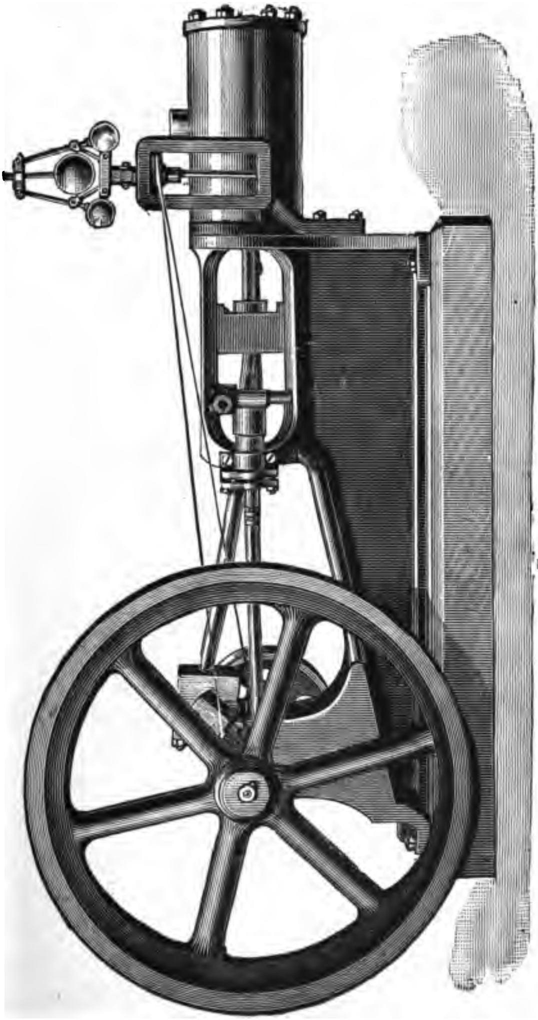


FIG. 25.
**Back View of Horizontal Engine.**

engine; they are drawn to scale, and they will show at a glance constructive details which could not well be explained in letterpress. Fig. 26 shows a plan view, and Fig. 27 an elevation of the complete engine. The bed-plate is the foundation on which the parts of the engine are fixed. A piece of sheet brass is used for small models, but larger ones have cast-iron foundations. Cylinders $1\frac{1}{2}$ in. in the bore and upwards are usually mounted on iron bed-plates, the saving in cost of metal being considerable when the castings are so large. Cast bed-plates have a moulded edge, which adds both to their strength and appearance. Sheet metal has to be mounted on columns sufficiently high to raise the fly-wheel above the ground-level.

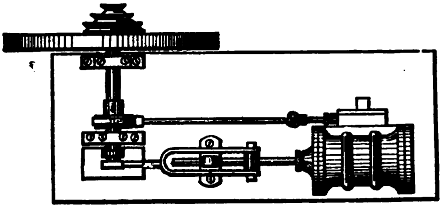


FIG. 26.
Plan of Horizontal Engine.

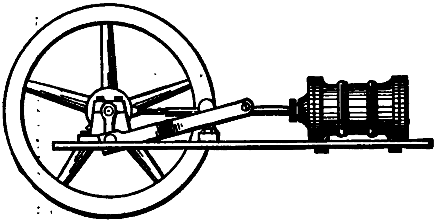


FIG. 27.
Elevation of Horizontal Engine.

The cylinder is shown in Figs. 26 and 27. The steam-chest containing the slide-valve is shown in Fig. 26 only. The fly-wheel fixed on the shaft, Fig. 30, which has at its opposite end the crank (Fig. 32). The piston-rod is shown passing through a guide (Fig. 33) fixed to the bed by two screws. The connecting-rod from the piston to the crank-pin is shown in Figs. 26 and 27. The eccentric is shown at Fig. 35, the rod from it to the steam-chest is called the eccentric-rod. Two screws fix the cylinder to the bed-plate. These references are sufficient to enable the inexperienced reader to identify the principal parts of this engine. By carefully studying the drawings the whole combination of the machine will be understood.

Each of the chief component parts which possess any intricacy of detail is shown on a much larger scale. The description of each one may be taken as generally applicable to engines of the type shown in Figs. 26 and 27. The dimensions are suited to the size known as "$\frac{3}{4}$-in. bore and $1\frac{1}{2}$-in. stroke." These measurements refer to the cylinder. It will not be difficult to modify any of the minor details to suit another size, whether it be larger or smaller.

A section of the cylinder is shown in Fig. 28; the piston and its rod are absent, to prevent confusion of the parts. The cylinder with the covers on is 2 in. long and $1\frac{5}{8}$ in. diameter across the flanges. The bore is $\frac{3}{4}$ in. and $1\frac{5}{8}$ in. (full) long. The face of the cylinder where the valve works is level with the diameter of the flanges. This face is shown at Fig. 29, where the size and position of each port-hole may be seen. The rectangle represents the steam-chest itself, and the four small circles are the screw-holes in the valve-face for attaching the steam-chest.

Returning to Fig. 28, the steam-ways are shown at the top. These are drilled from the ends to meet the inlet steam-ports, which are closed by the slide-valve (see Fig. 29). The exhaust-way is in the middle, and the port-hole communicating with it needs no special mention. The steam inlet is above; the threaded exterior is for attaching the steam-pipe from the boiler. The glands and stuffing-boxes, for keeping the piston and valve-rod steam-tight, are shown in section. The glands are screwed into the castings, parts being bored out to

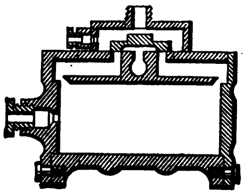


FIG. 28.
Section of Cylinder.

receive the packings. It will not be necessary to make special reference to the body of the cylinder, the covers, etc., as the reader will have become acquainted with these in the previous chapters.

By reference to Fig. 28, the passage of the steam may be traced. It enters from above, filling the steam-chest, and as the valve is shown it could find no outlet. The valve on being moved would uncover one port, and allow the steam to enter by the steam-way, through the slot filed in the edge. When in the cylinder the steam would force the piston towards the other end, the action of the eccentric meanwhile pushing the valve along and further opening the port. When the piston had made half ts stroke the valve would commence to close again, and by the time the end was reached the valve would be again in the position shown. The momentum of the fly-wheel would carry round the eccentric, and with it the valve would move so as to open the way to the exhaust, thus allowing the steam in the cylinder to escape. The other port-hole would also be opened to the live steam, which would then exert its pressure on the other side of the piston. By the motion of the valve the steam is let into the cylinder from each end alternately and thus the reciprocating motion of the piston is maintained.

The slide-valve is shown in Fig. 29, the left is a view of the face. The centre is hollowed out as shown at the section in the middle, to allow the steam to pass into the exhaust. The back is shown at the right; the saw-cut receives the valve-rod, which is thinned down to fit it. The face of the valve, that is, all the outer part of it, is made perfectly flat to fit steam-tight on the valve-face of the cylinder. Contact is ensured by the pressure of the live steam in the steam-chest; this is always more than that of the exhaust.

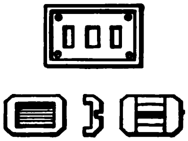


FIG. 29.
Slide-Valve.

The crank-shaft, forming the fly-wheel axle, is shown alone half-size at Fig. 30. This is a rod of round steel ½ in. in diameter, the total length is 3½ in. At the right-hand end it is reduced in size a length of ⅞ in., to receive the fly-wheel and the driving-pulley. These are generally screwed on to a thread cut on the shaft, but wedging is a more workmanlike way of securing driving-wheels and pulleys. The two journals are to rest in the plummer blocks shown at Fig. 31; the neck at the left-hand end is to receive the crank-arm. The collars on the shaft outside of each journal are of the widths shown. One of the bearings for the crank-shaft is shown at Fig. 31, which shows a side view, an edge view, and a view from the top; in this the dotted lines represent the screw-heads. These bearings are usually brass castings; they are fixed on to the bed-plate by two screws each, and the cap is also held on by two other screws. Various designs may be obtained, but the one illustrated is as good as any. The thickness of the bearing is nearly ½ in. The height must be precisely that which will bring the centre of the crank-shaft level with the centre of the piston-rod.

FIG. 30. Crank-Shaft.

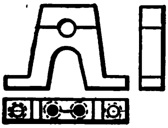


FIG. 31. Crank-Bearing.

Fig. 32 is the crank-arm, giving an end and side view. It should be made of steel and fixed on the shaft by keying, though more often it is screwed on. The thickness is shown about $\frac{3}{16}$; the shape may be according to fancy. The hole at the bottom is for the crank-pin, which is riveted in. The "throw" of the crank is an important point, and it must never be so much that the piston touches the ends of the cylinder. In the present case the "throw," that is the dis-

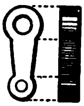


FIG. 32. Crank-Arm.

tance from the centre of the crank-shaft to the centre of the crank-pin, is $\frac{5}{8}$ in. This gives $1\frac{1}{4}$-in. stroke; there is plenty of space in the cylinder for another $\frac{3}{16}$ in., and possibly the nominal stroke, $1\frac{1}{2}$ in. could be managed by using a thin piston-head. The crank-pin is shown at the top of Fig. 34.

The guide-block, Fig. 33, serves to guide the piston-rod, and steadies it against the influence of the crank. The shape is shown by the illustrations. The hole for the piston-rod is bored level with the axis of the cylinder and the centre of the crank-shaft. The block is secured to the bed-plate by two screws, holes for which are shown in the top view.

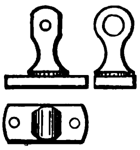


FIG. 33.
Guide-Block.

Fig. 34 shows the crank-pin and five views of the ends of the connecting-rod. The crank-pin is steel $\frac{3}{16}$ in. diameter, turned down to $\frac{1}{8}$ in. at the journal and at the neck, which is riveted into the arm, Fig. 32. The head of the rod is fitted with a cap, held by two screws, so that it may be placed over the crank-pin into the groove. The other end of the rod, which is forked, is shown to the right. Here a section and an elevation are given; the round piece, called the cross-head, which receives the two screws (see section) is bored to fit the piston-rod, and it is clamped to this by the points of the screws shown. The sides of the fork are bored to fit freely over the threads of the screws, so that it may oscillate with the motion of the crank. The position of the cross-head on the piston is determined when the engine is together; it is placed so that the piston slides midway between the ends of the cylinder.

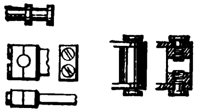


FIG. 34.
Crank-Pin and Connecting-Rod.

Fig. 35 shows the eccentric and the eccentric strap. The first is a piece of brass; the large circle has a groove turned in it to receive the strap, and the boss is eccentric, as shown in the left-hand figure. The amount of eccentricity is $\frac{1}{16}$ in., which gives a travel of $\frac{1}{8}$ in. to the slide-valve. These eccentrics are turned on a mandrel having double centres, one pair serving when turning the boss, and the other when turning the eccentric itself. A set screw tapped through the boss serves to secure it on the crank-shaft.

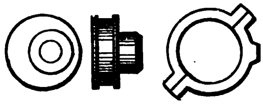


FIG. 35.
Eccentric and Strap.

The strap on the right in Fig. 35 is cast in the form shown, the centre is bored to fit the groove in the eccentric, and the strap then cut in halves through the lugs. These lugs serve to take screws, which hold the strap together. The projecting piece on the right is to receive the eccentric rod, which is screwed into the strap at this point.

This completes the description of the various parts of a model horizontal engine. A glance at Figs. 26 and 27 will show the relative position of each, and the detail figures show the dimensions, which may be measured on the illustrations.

The engine next illustrated is of a much more substantial type. The Figs. are reduced from full-size drawings of an engine having a cylinder 4-in. bore and 5-in. stroke. The dimensions given in the text are those of the full-sized engine, but a smaller size will make up very nicely if the same proportions are observed throughout.

The first illustration, Fig. 36, shows an elevation, and the plan immediately below drawn about $\frac{1}{6}$ scale. The details are shown about twice as large. Referring to Fig. 37, the bed-plate, which forms the main casting is 34 in. long and 7 in. wide at the base. By constructing a scale to suit these measurements, the illustrations may be made to serve for

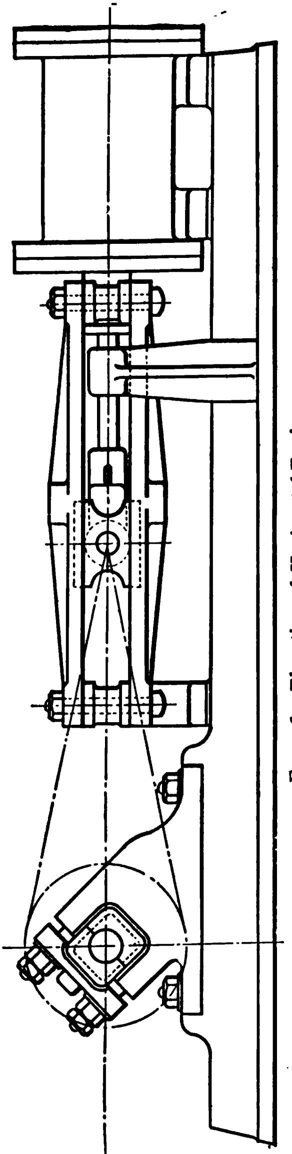


FIG. 36. Elevation of Horizontal Engine.

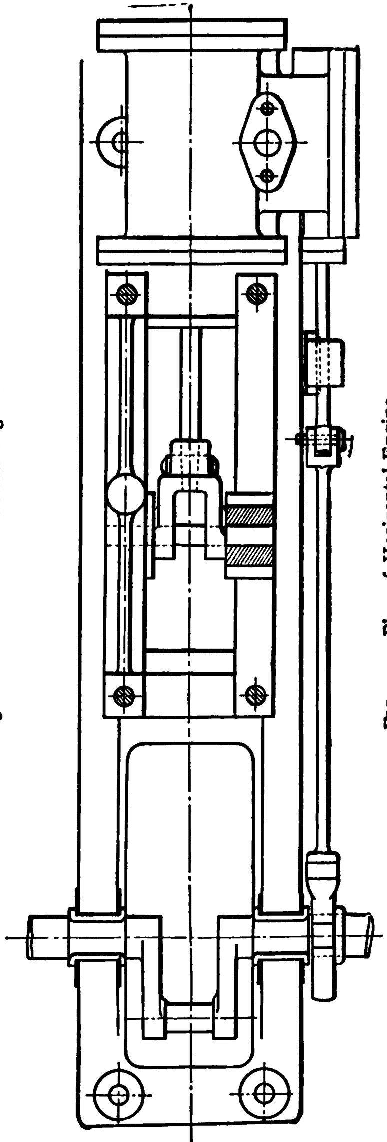


FIG. 37. Plan of Horizontal Engine.

a model of any size. It is necessary to make complete working drawings of the size intended and, of course, all the small parts, such as bolts and screws, would be made to some standard measurement. When reducing the size of machines,

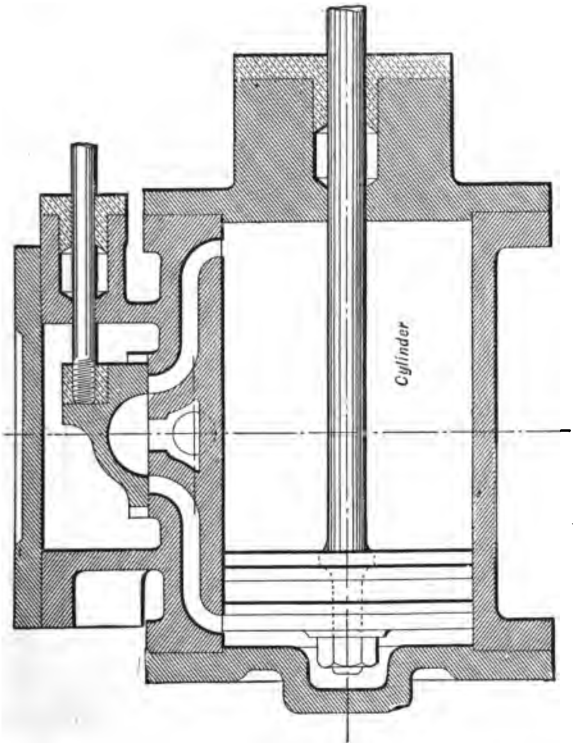
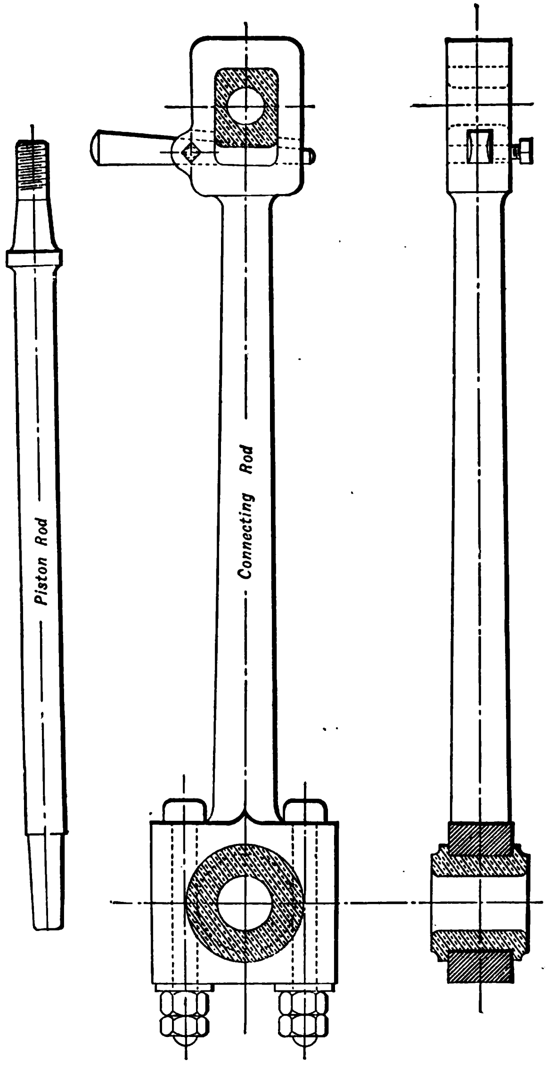



FIG. 38. Section of Cylinder.

the tendency is to somewhat increase the relative dimensions of the small parts. Also the necessity, which practically exists, of using certain fittings of fixed gauge, compels a certain amount of departure from the strict adherence to exactly proportionate alterations in size. As an example, refer to the bearings of the crank-shaft shown in the plan. They




FIGS. 39 & 40. Piston and Connecting Rods.

are 1 in. diameter in the original engine and, reduced to $\frac{1}{6}$ scale, show $\frac{1}{6}$ in. diameter. It would be an inconvenient size to adopt, and $\frac{3}{16}$ in. would be at the same time more suited to our common methods of measurement and also to the reduced size of the engine. The bolts which hold together the guide-bars for the piston-head are $\frac{1}{2}$ in. diameter, and, though shown $\frac{1}{12}$ in. diameter in the drawing, should be made $\frac{1}{8}$ in. in a model of this reduced scale.

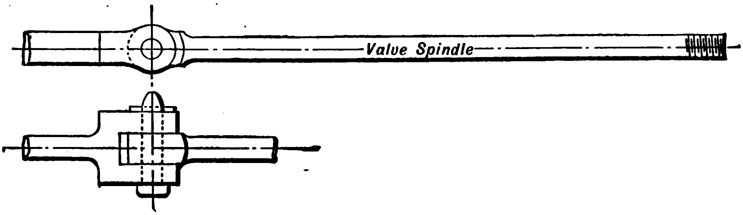



FIG. 41. Valve-Rod.

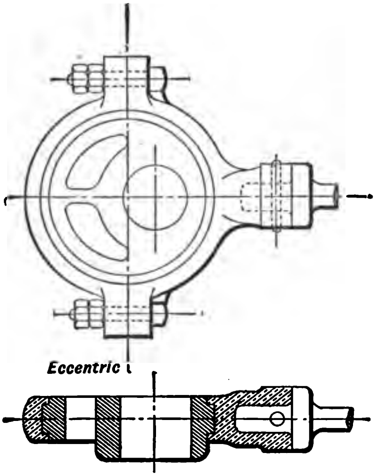



FIG. 42. Eccentric and Strap.

In illustrating the details, only those of somewhat pecular construction have been selected. All details are shown $\frac{1}{8}$

scale. Fig. 38 shows a section of the cylinder, and from it all details of slide-valve arrangement can be seen. The complete piston-rod is shown at Fig. 39; it measures 12½ in. from end to end. The end that is fixed in the piston has a collar forged upon it to butt against the piston-head, into which it is fitted with a cone. The extreme end is threaded for a nut, as shown in the section of cylinder.

The connecting-rod, shown in elevation and in plan at Fig. 40, is a forging. Brasses are fitted in both ends. The end that connects with the cross-head has its brass fixed by a taper key, which is itself fixed by a set screw. The crank-pin brasses are secured by a cap held on by two bolts, each fixed by lock-nuts. The pair of brasses are shaped to fit a somewhat elliptical hole in the connecting-rod; by this plan the brasses are prevented from turning in the rod.

The valve-rod is made of round steel, having an eye at one end fitted by a knuckle joint to a rod, which is fixed by a transverse pin to the eccentric strap. These details are shown at Figs. 41 and 42.

The eccentric itself is made of cast iron and has spaces cored out in the large sizes. The elevation and the section views, Fig. 42, show these and the method of connecting with the valve-rod, sometimes called the vavle-spindle, and so marked on the illustration.

# CHAPTER V.

## *OSCILLATING ENGINES.*

THE action of oscillating cylinders has been described, but before giving the details of an engine of this type it may be well to show this form of cylinder. A single-action oscillating cylinder is shown at Fig. 43. The action can be understood by reference to the description of the toy engine shown at Figs. 12 and 13. A pair of double-acting oscillating cylinders are shown at Fig. 44. These cylinders have their

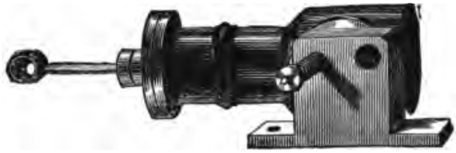


FIG. 43.
Single-Acting Oscillating Cylinder.

steam ports acting on the face of the block placed between them. The live steam acts at both ends of the cylinder and drives the piston in both directions. This gives these cylinders the distinction of double acting. The small space occupied by cylinders of this form makes them particularly suited for confined spaces. Oscillating cylinders are, for this reason, mostly used in ships.

The following set of drawings show an engine with an oscillating cylinder.

This form of construction economises space and weight; it is also more simple than slide-valve cylinders. In all oscillating engines the cylinder is mounted on trunnions or gudgeons, so that it may swing to and fro through a small arc, and allow the piston-rod to follow the motion of the crank. No con-

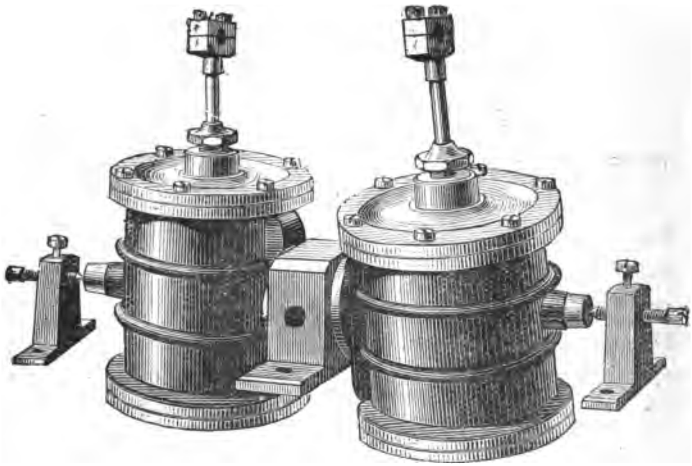


FIG. 44.
Pair of Double-Acting Oscillating Cylinders.

necting-rod is required in this engine, the piston-rod being attached direct to the crank-pin.

The illustration shows an engine specially adapted for propelling a model boat. The entire machine is kept low down, which is generally necessary for small boats. The fly-wheel is much heavier than are those attached to toyshop engines, but it is not unnecessarily large. Experiments show that a weighty fly-wheel is required on an engine which has the constant drag of a screw propeller to overcome. This fact is ignored by some makers of engines, and in some cases a useless engine has been made effective by the substitution of a much heavier fly-wheel.

The framework on which the cylinder is mounted, and which also generally serves to carry the bearings for the driving-shaft, may be of almost any design. There is no set pattern for this purpose, and it rests with the designer to fashion his pattern according to fancy. The form shown possesses the essential characteristics. It is strong, yet light; there is a good base by which to secure the engine to the hull of the boat. Suitable provisions are made for the bearings of the crank-shaft, also for the valve-face and the cylinder-trunnion. So long as these are provided for, the mere outline is of little importance.

Boring the cylinder is often the most difficult job to accomplish by a beginner who has not had some experience at the lathe. Some methods of doing this have been given, but there are several other ways in which it can be done. By fixing the cylinder, with a clip and two bolts, to an angle-plate on the face-plate of lathe, placing the valve-face upon the angle-plate, the cylinder can be firmly secured and at the same time easily centred. After being set true it can be bored with a tool fixed in the slide-rest, but this method requires the slide-rest to be properly adjusted in order to get the bore parallel. Cylinders can be bored very well with a flat boring bit turned true on the edges, and two pieces of half-round wood screwed to it. The bit should be turned parallel and size of bore; the two pieces of wood can be removed, and the bit, the end of which is made to cut the same as an ordinary drill, hardened and tempered; the wood must then be replaced. Holding this drill with a hooked spanner, and feeding up very carefully with back centre of lathe, a good bore can be got. The cylinder should then be placed on a perfectly true mandrel, and the flanges turned and faced up at one chucking.

Fig. 45 gives a side elevation, and Fig. 46 an end view of the same engine. The cylinder is 1-in. bore and 1-in. stroke, The length without covers is $1\frac{1}{2}$ in., that allows $\frac{1}{4}$ in. for thickness of piston, $\frac{1}{16}$ in. for each of the spigots of the two covers, and the same distance left vacant at each end. The diameter of the cylinder across the flanges is 1½ in., and a semicircular rib is shown in the middle. Each cover is held on

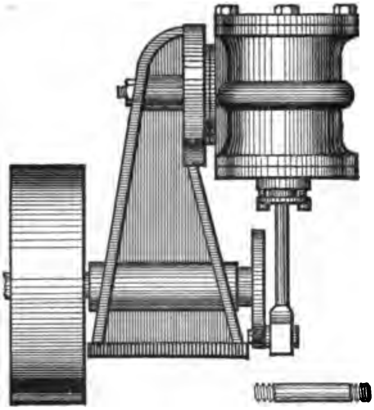


FIG. 45.
Side View of Oscillating
Cylinder Engine.

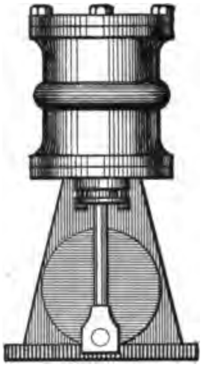


FIG. 46.
End View of Oscillating
Cylinder Engine.

by six hexagon-headed bolts, placed equidistant round it, tapped into the flange. These bolts are not shown in the lower cover.

The piston-rod is shown out from the cylinder to its fullest extent. The rod is of round steel ⅛ in. diameter. The cross-head for the crank-pin is of brass, screwed on to the end of the rod. Though shown as a solid piece, it would be better if this head was cut across horizontally at the diameter of the crank pin, and the cap secured by two screws.

The piston-rod can be made from a piece of steel rod. It must be truly centered, and made quite straight; one end is turned tapering ¼ in. from the end, and screwed. The other end is slightly tapered to fit into cross-head, and a key-way cut through it; a small hole can be drilled, and then made to draw the parts together, as shown at Fig. 83, with a small round file.

The piston-head is in two parts, and can be made from sheet brass; one must have a taper hole bored to fit the rod, the other half is made to answer the purpose of a nut. Having fitted and turned up the faces, they may be fixed on the rod; the half that is for the nut must have two holes drilled in the back so that a forked turnscrew can be used to screw up the piston; it can then be turned on the rod the exact size of cylinder bore, and a $\frac{3}{16}$ in. groove turned for packing-rings. The rings can be cut from brass tube, and made so that the two fit in the groove of piston-head. The rings at this stage must be slightly larger than the cylinder bore. A slanting cut should be made in each ring; they must then be placed in the piston and pressed together until the cuts are close up; the two rings are then fixed by their edges, and may then be turned until they will just go in the cylinder. The rings must be ground sufficiently narrow so that they will be free to expand when the piston plates are screwed together.

The crank-pin is turned from steel, and is riveted into the disc which forms the crank. A crank-arm would do equally well, and the disc is shown simply as illustrating a different plan. The disc is fixed on the crank-shaft either by screwing, by a transverse pin, or by a key.

The crank-shaft is $\frac{1}{4}$-in. steel, and should be turned smooth and parallel to fit the hole in the standard. This hole should also be smooth and parallel, which it will be if properly bored with a suitable tool. A long bearing has no more friction than a short one, though a contrary opinion seems to be prevalent. A small hole for supplying the oil necessary for lubrication should be made near the middle of this bearing. The same remarks apply to the bearing through which the trunnion passes.

The fly-wheel on the left in Fig. 45 is cast iron, $2\frac{1}{2}$ in. in dameter, and $\frac{3}{4}$ in. wide on the rim. The rim should be $\frac{1}{2}$ in. thick at least, and the boss in the centre as wide as the rim. If bored fairly true, the casting need not be turned on its edge, though it will look better if bright. A small key should be used to fix the fly-wheel on the shaft. This latter, shown broken off in the drawing, projects slightly, and carries a small disc with two pins, which engage in a fork on the end of the propeller-shaft and so drive it, and the screw propeller attached to its end.

The valve-face of the standard must be made perfectly flat, and at right angles to the boring for the crank-shaft. Fig. 48 shows the face of this standard as it would be seen in Fig. 46 if the cylinder were removed. The section of cylinder, shows valve-face and steam-ways. It is convenient to turn the valve-face in the lathe, and, at the same time, to cut the circular groove, which, after being stopped by plugging at both top and bottom, forms the supply and exhaust ports respectively. The face may be made flat by filing when a lathe is not available, and the groove cut by means of an annular bit with teeth on its edge which cut a channel, but do not touch the inner circular part.

Through the centre of the valve-face a hole is bored to receive the cylinder-trunnion. This trunnion is a steel pin, illustrated between Figs. 45 and 46, it screws into the valve-face of the cylinder. The outer end is threaded for a nut, which has a washer beneath it, and keeps the cylinder close against the standard, with the faces of the valves held together steam-tight, yet so that the cylinder may oscillate freely. A spiral spring beneath the nut is sometimes used, but, in good work, the adjustment is made with a pair of lock-nuts. The hole through the standard must be perfectly at right angles to the face, and the trunnion in the cylinder must also be perpendicular to the valve-face, or the two faces cannot come together steam-tight.

The stuffing-box of the piston-rod is made with a gland drawn down on the packing by two screws. This arrangement is shown in section at Fig. 47. The method of fitting the gland, whether by screwing direct into the boss of the cylinder cover, as shown on the right, or by screws tapped through the flange, as on the left-hand, in the illustration, is quite optional. By referring to Fig. 47 the construction of the two forms of stuffing-boxes will be understood. The gland belonging to each is shown separate immediately above the sections. The same description applies to both. First the cylinder cover with the projecting boss into which the gland is fitted; higher is the space for the stuffing or packing. This is filled with lamp cotton, and, when the gland is screwed down, the cotton is compressed so that it makes a steam-tight fitting for the piston-rod to slide in. The hole for the piston-rod is shown through the centres of both sections.

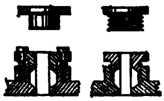


FIG. 47.
Glands and Stuffing-Boxes.

As before explained, the gland on the left is secured by two screws shown in the section; it is fitted into a plain cylindrical hole. The other gland is threaded to screw direct into the cylinder cover, which is tapped to receive it. The first method is the one always employed in large engines. The screwed gland has a knurled edge, so that it may be turned with the thumb and finger.

The action of the valves in a double-action oscillating cylinder will be best explained by reference to Fig. 48. This shows the face of the standard and the section of the cylinder. There is a flat face to the cylinder, usually circular; this has the usual steam-ways bored in it. These holes meet others, drilled from the ends of the cylinder, parallel with its bore, and conduct the steam to the ends of the cylinder through the

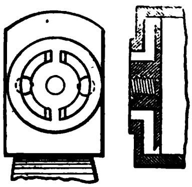


FIG. 48.
Valve-Face of Oscillating Engine.

side passages. On the face of the standard are two holes, drilled from the back, one to receive the steam from the boiler, the other to take the exhaust pipe. These holes are not bored through, but communicate with the semi-circular grooves. The cylinder is placed against the standard, and held close to it, as shown in Fig. 45, by means of the trunnion illustrated in the same Fig.

When the cylinder is vertical, as shown in Fig. 46, the port-holes are opposite the solid parts of the valve-face. Suppose live steam issues from the boiler and fills one of the semi-circular channels; directly the cylinder is moved on one side, and one of the port-holes comes over the groove, the steam enters the cylinder, and, pressing against the piston, compels the crank to revolve. By the same motion the other port is brought over the other semi-circular channel, and the dead steam escapes. When the cylinder again reaches a vertical position the steam-ports are again closed, but the momentum of the fly-wheel carries it over the dead centre, and then the positions of the ports are reversed. The one formerly over the exhaust now opens to the live steam, and the port just charged with steam comes over the exhaust. Thus the steam is admitted alternately at both sides of the piston, and so the engine continues to work.

## CHAPTER VI.

### *LAUNCH ENGINE.*

THE engine shown in this chapter is one that has worked well and may be depended upon. The large drawings are reduced to $\frac{1}{4}$ scale, and all details are shown $\frac{1}{8}$ scale, of the original engine.

The base on which the engine is built is of cast iron. It is 12 in. wide and the side strips are 9 in. long. It is $\frac{7}{8}$ in.

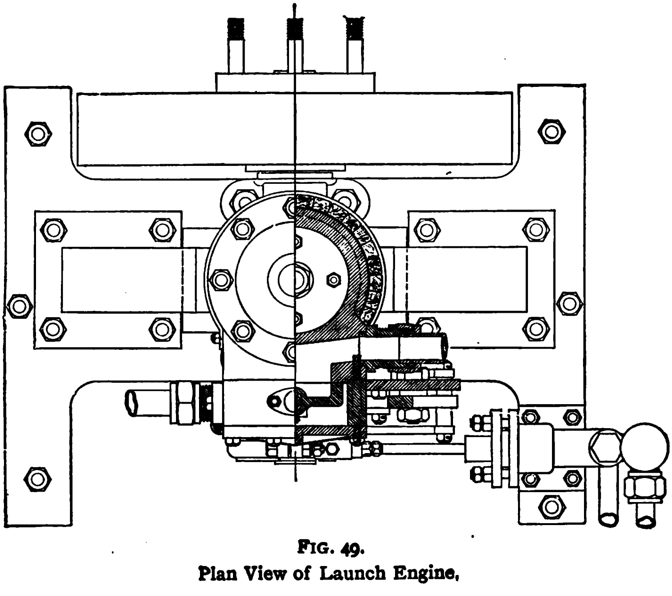


FIG. 49.
**Plan View of Launch Engine.**

thick with a hole in the centre; see plan view, Fig. 49. The cross-pieces which support the bearings for crank-shaft are strengthened by webs underneath. The top of this base has "chipping-pieces" projecting where the standards rest. These

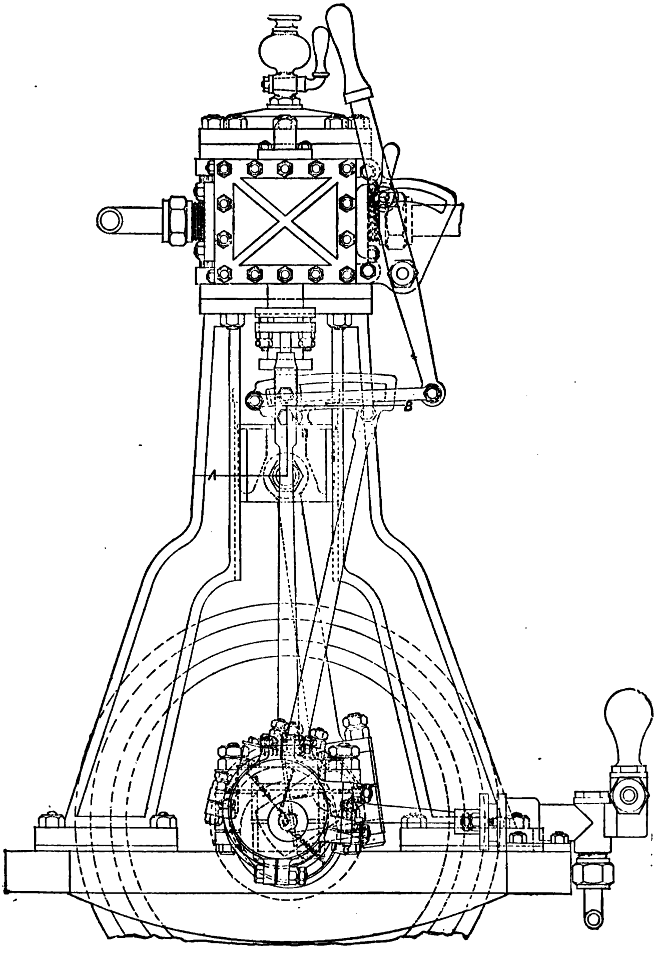



FIG. 50.—Front View of Launch Engine.

should be faced off level in a planing machine. The chipping-pieces of course save a great deal of work when chipping and filing is the process by which the base is prepared to receive the parts to be bolted to it.

The six hexagon nuts shown in the plan view, and not in the other drawings, are to fix the engine to its place in the boat.

Next is Fig. 50, a front view; Fig. 51 is a side view. From these the general design of this engine may be seen, and the principal dimensions taken. The design is one that will make up very satisfactorily on a reduced scale. Some of the details may be regulated in a model under half size, and, when reducing, some attention must be paid to dimensions of

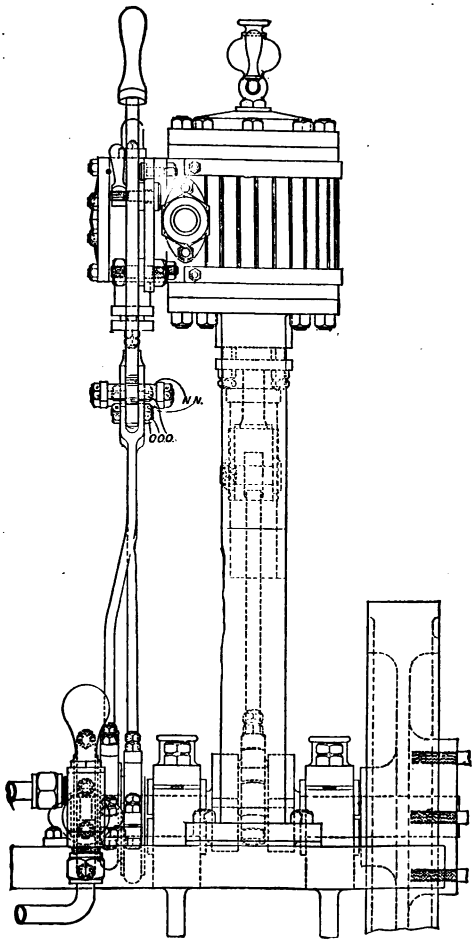


FIG. 51. Side View of Launch Engine.

the smaller parts, which must be slightly larger than precise proportion would give. The engine is $2\frac{1}{4}$-in. bore and $2\frac{1}{4}$-in.

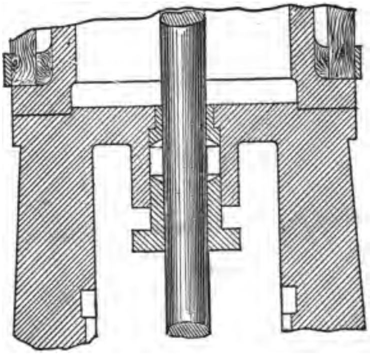
stroke. It has reversing gear to make it practically useful; though the double eccentrics and link motion give a good deal of extra work, and they may be left out of a smaller model. The pump shown on the illustrations is also quite an auxiliary and may be dispensed with. It is fully described in Chap. IX.

The standards are cast together, the top forming the cylinder cover. It may be questioned whether this plan is to be preferred to casting each standard separate. Probably this will depend entirely on the appliances that are available for finishing the castings. This engine can have the insides of the standards, which form the guides for the piston cross-head, finished on a 6-in. centre lathe, if it is strong enough for such work.

The method of finishing the insides of these standards is this: First carefully prepare the feet so that the pair of standards rest fairly and stand quite upright. The holes for the holding-down bolts can then be bored, one near the corner of each foot. The casting is next mounted on a face-plate and fixed quite upright and with the end disc, which will form the cylinder cover, running true. If chucked carefully and firmly, the disc can be centred and a hole bored through—this will afford a bearing for the back poppet-head centre. The disc, which is to form the cylinder cover, can now be roughly turned nearly to size and shape.

The hole in the centre of the cover can be bored out much larger than the piston-rod requires and can be finished afterwards. By this plan a boring bar can be used through this hole, and with its other end on the mandrel-cone centre point, which would be projecting in the centre of the face-plate. A cutter-block and cutter, arranged to bore the inner faces of the standards to about 2⅛ in. diameter will finish the guides for the cross-head. Sections of the standards are shown at Figs. 52 and 53. It is advisable to get the cylinder fitted on the bottom cover, and to turn the lower flange and cover together, so as to ensure a perfect agreement of their surfaces. This can be done by boring the cylinder and turning the flange-face for the lower end at least, before the standards are mounted in the lathe; so as to have it prepared for fitting on and fixing when the boring bar is in use.

In Figs. 52 and 53 we have sectional views of the upper part of standards. One view vertical and one horizontal. The upper vertical view shows how the cylinder fits the top of the standards, also the stuffing-box for piston. Near the bottom are shown cross slots which are the ends of the cross-head guides. In the lower horizontal section may be seen the sectional form of the standards, also the plan form of cross-head. The oil chambers are shown.



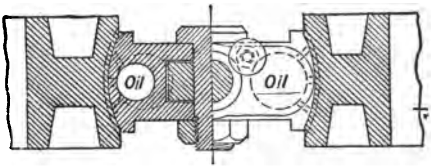



FIG. 52. Vertical Section of Cylinder Cover.
FIG. 53. Horizontal Section of Standard.

The pair of standards may be cast apart and have ears at their tops to attach them to the cover of cylinder. In this case the guide-faces may be got up with a file, but only in a way far inferior to the method previously described. When there is no chance of using a lathe, this inferior method must be adopted.

It is unnecessary to say much in connection with these drawings of the complete engine. The various parts are all clearly shown in position. Each one of special importance is illustrated on an enlarged scale later on in this chapter. Many of the special features of construction have been discussed in previous chapters. There are points of similarity in this and the horizontal engine described in Chapter VII. The section, Fig. 54, through the side elevation affords a means of comparing many measurements.

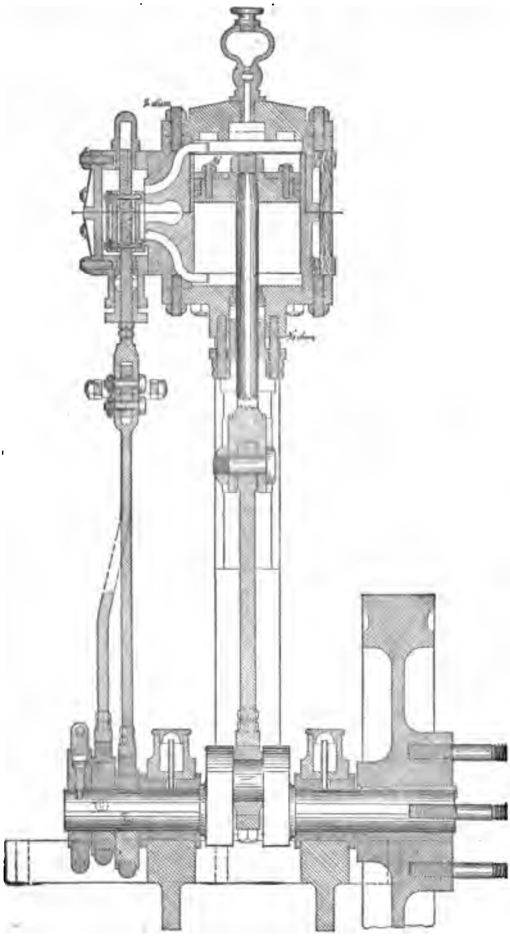


FIG. 54. Sectional View of Launch Engine.

The crosshead is formed solid with the piston, and a vertical section is shown at Fig. 55, where the oil chambers are seen, and also the method of securing the cover which is a plate fixed by the knurled-headed screw.

The connecting-rod is shown at Fig. 56, which gives three views and needs no explanation. The rod is rectangular in section and has a T-piece forged at one end The other end has an eye, which is jointed to the cross-head. The brasses in this connecting-rod are fitted as shown. They have the clamping bolts passed right through them, and these should fit. A strap at the outer end and the T-piece on the rod serve to hold the two bolts together. Lock-nuts are required to guard against these bolts becoming loosened in wear.

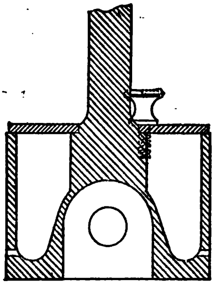


FIG. 55.
Section of Cross-head.

The eccentric and its belongings are shown at Fig. 57. A plan and side view of the eccentric are given. The eccentric is $\frac{1}{2}$ in. thick, it has a screw tapped through the widest part of it. The throw of each eccentric is $\frac{3}{16}$ in., giving a travel of $\frac{3}{8}$ in. to the slide-valve. The pump eccentric is made precisely as illustrated, but has $\frac{5}{16}$-in. throw, so as to give the pump-plunger a travel of $\frac{5}{8}$ in.

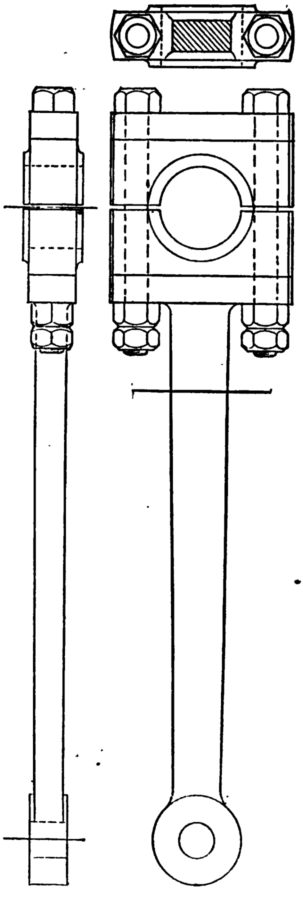


FIG. 56. Connecting Rod.

The straps for valve eccentric and also for pump eccentric are of the form illustrated at Fig. 57. It will be noticed that each is intended to be fixed to a T-piece connection on the eccentric rod. The two screwed studs are for this purpose, and a glance at the eccentric rod, shown at Fig. 58, will show

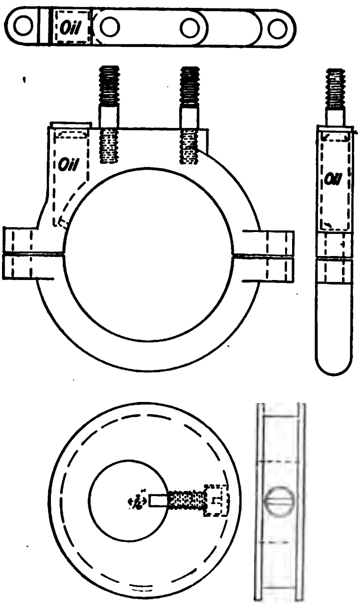



FIG. 57. Eccentric and Strap.

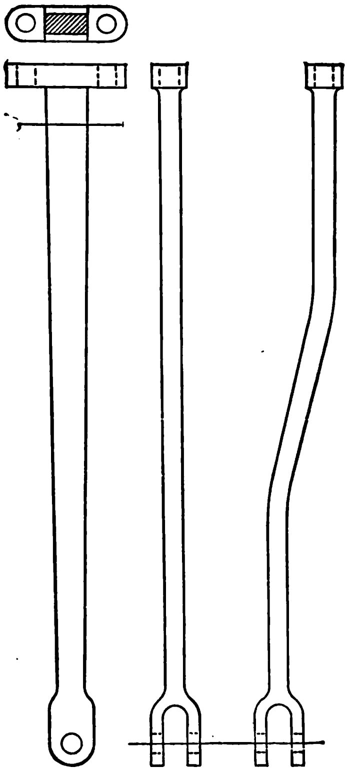


FIG. 58. Eccentric Rods.

the method of application. A recess is cast in the strap to contain oil for lubrication. It has a small cover fitted, to prevent the contents from being thrown out.

The eccentric rods to work the link for valve gear are shown at Fig. 58. They are both alike sideways, but one is straight and the other bent, as shown in the two edge views. Each rod is T-shaped at one end and forked at the other, to connect with the eccentric strap and with the link respectively. The pump eccentric rod and all the pump construction will be found described in Chapter IX.

Reversing the motion of this engine is managed with a link. Slide-valves when fitted with the link motion, work satisfactorily. With the aid of this contrivance, engines can be reversed by simply moving the reversing lever. Steam can be worked with almost any amount of expansion, the change being rapidly made by a small movement of the lever. By altering the amount of expansion, the greatly-varying power required in some kinds of engines can be obtained. Not only reversed motion but the varying speed required for boats, and the varying power required for locomotives, can be readily obtained by simply shifting the lever to the required position.

The motion illustrated at Fig. 59 is that usually arranged with the slot-link shifting. The concave part is then towards the crank axle. Each end of the link is worked by a separate eccentric, the radius of the

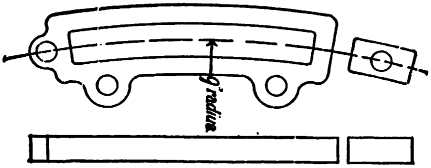


FIG. 59. Link and Die: side and edge views.

curved slot being equal to the effective length of eccentric rods. The slide-valve rod is connected with a block which moves in the slotted link. The slide-valve is worked by either of the eccentrics, as wished, by merely shifting the link by

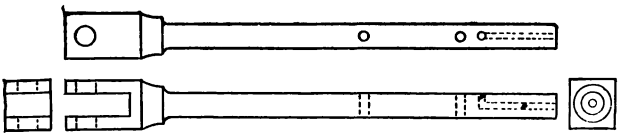


FIG. 60. Valve-rod and Cross-head.

moving the reversing lever, to which it is connected by means of links and levers.

The slide-valve rod and cross-head are shown at Fig. 60.

The valve-rod has a cross-head to take the die which travels in the link, Fig. 59. This is slotted to a radius of 9 in. A forging is generally used for a full-size link, but smaller sizes may be cut from a piece of bar metal, mild steel being good material to use. The small hole shown in the end of valve-rod is drilled to a depth of about 1 in., and met by a hole drilled in sideways to allow the free passage of air or steam between the valve-box and the recess into which the end of the valve-rod works. Without this hole a vacuum might be formed. The two other holes are to take screws put through the slide-valve to fix it to the valve-rod. The method of doing this is shown at Fig. 65. Views of both ends of the valve-rod are given at Fig. 60.

The quadrant-plate, which holds the reversing lever, is shown at Fig. 61. It is bolted with lugs cast on the cylinder.

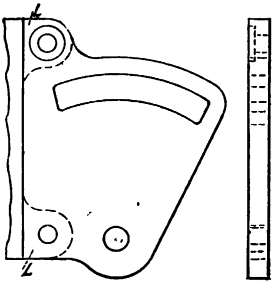


FIG. 61. Quadrant Plate—Side and Edge Views.

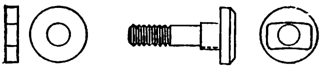


FIG. 62.
Clamping Bolt for Quadrant.

FIG. 63. Bolt for Link Motion Connections.

The bolt, used for securing the reversing lever, and its washer are shown at Fig. 62. The pins of the reversing motion are also shown at Figs. 63 and 64—where their dimensions can be measured. A reference to Figs. 50, 51, and 54 will show the position of each pin or screw.

The valve-face is shown at Fig. 65, and the slide-valve also. The ports are very wide, so as to get quick action in opening and closing. Each port is $1\frac{1}{2}$ in. long and $\frac{3}{16}$ wide. The exhaust being double that width. The method of securing the slide-valve to its rod is shown here; it has been explained in a previous paragraph. A piece of copper wire secures the screws from loosening. The steam inlet is arranged in this engine by bolting a union on to the steam-chest. This union is shown at Fig. 66.

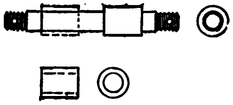


FIG. 64.
Pin in Link, for Couplings of Reversing Lever.

The brasses for crank-shaft are shown at Fig. 67, a top view, side view, and bottom view being given. The latter shows a wide channel cut for free lubrication. This is a very important point in an engine, and more especially when run at a quick speed. The caps which fit on the plummer-blocks are provided with large receptacles for oil. These are made in the castings, as shown at Fig. 68. A piece of brass tube is fitted in each oil box, and a wick of lamp cotton used to conduct the oil to the bearing. A cover is fitted to each receptacle.

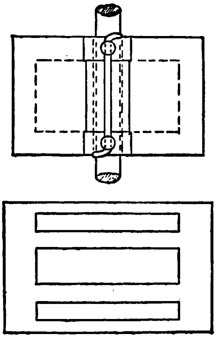


FIG. 65.
Valve and Valve-Face.

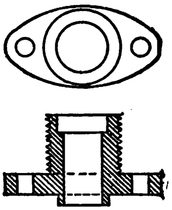


FIG. 66.
Union for Steam Chest.

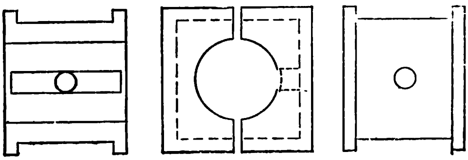


FIG. 67.
Brasses for Crank-Shaft.

The cylinder grease cup is shown in section at Fig. 69.

The construction of this grease cup can be seen by reference to the several illustrations where it is shown attached to the engine cylinder. Figs. 50 and 51 show the grease cup in elevation, the first shows the cock plug across the illustration, the second at right angles to the former position. In Fig. 54 is shown the section of the grease cup in the same position as in Fig. 51; and in Fig. 69 the section is shown as in Fig. 50. Very small grease cups and cocks of all kinds are best made from solid rolled metal—castings are likely to be defective and are always liable to breakage when reduced to finished dimensions.

A detailed description of the process of making this grease cup will be interesting, and much of the information is applicable to other fittings for model engines. The finished grease cup is 2 in. long and $1\frac{1}{8}$ in. diameter; a piece of metal large enough to finish to these sizes is therefore requisite. The first operation is to bore a hole $\frac{1}{8}$ in. diameter through the centre. A twist drill will run through easily and will leave two holes sufficiently straight and smooth for all requirements. Each end should now be carefully steam-fired so that the piece can be run on the lathe centres without any fear of its going out of true in wear. The threaded part at one end has to be turned down to $\frac{5}{16}$ in. diameter, and $\frac{3}{8}$ in. long, and whilst this is being done the bulk of the metal may be turned off to the shape shown in the drawings.

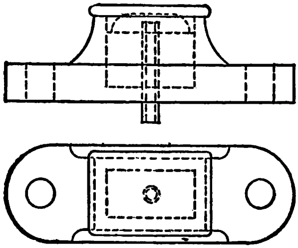


FIG. 68. Cap for Brasses—Elevation and Plan Views.


FIG. 69. Section of Cylinder Lubricator.

The threaded part, screwed into a true hole in some chuck, will form the best means of chucking the piece to completely finish it. Turn away the end, which forms the top, to get it the correct distance from the shoulder, which is $1\frac{5}{8}$ in.—then enlarge the $\frac{1}{8}$ in. hole to $\frac{1}{4}$ in. diameter for a depth of $\frac{7}{8}$ in.; now turn away the interior to form the space for grease—this is done with bent tools. The sectional drawings show this space very evenly made, but, if a metal lubricator were cut in halves to show the section, it is very probable that the workmanship of the turner would not compare advantageously with those of the draughtsman, so far as the interior construction is concerned. The $\frac{1}{4}$ in. hole can now be tapped with a $\frac{5}{16}$ in. thread to take the knurled nut which forms the cover. This nut is best turned from a piece of stick metal; the thread having been cut on the screwed part, the nut should be knurled and then cut of. It may be finished in its place.

The hole for the plug is just $\frac{1}{2}$ in. from the shoulder; it must cross the $\frac{1}{8}$ in. hole exactly midway, and should be a $\frac{1}{4}$ in. diameter. It is advisable to make a much smaller hole first and to bore it from both sides, first filing two flats precisely opposite and centre-punch these to start the drill fairly. If these holes do not exactly middle, a small round file can be used to draw the hole over as required. The hole is finally tapered slightly, the largest end being about $\frac{5}{16}$ in. diameter: an ordinary taper broach will do for this purpose.

The plug is turned in one piece with its handle. To make it, a piece $2\frac{1}{4}$ in. long and $\frac{3}{8}$ in. diameter is wanted. This is turned to the shape shown, and the tapering part is ground to fit the hole at an early stage. The small end is screwed with a $\frac{3}{16}$-in. thread, and behind that is a square for the washer. The handle is bent at right angles to the plug when all is finished. Don't try to bend brass when hot, but anneal and cool before bending. The hole in the plug is made by drilling up the $\frac{1}{8}$-in. hole; the rough edges are best removed from

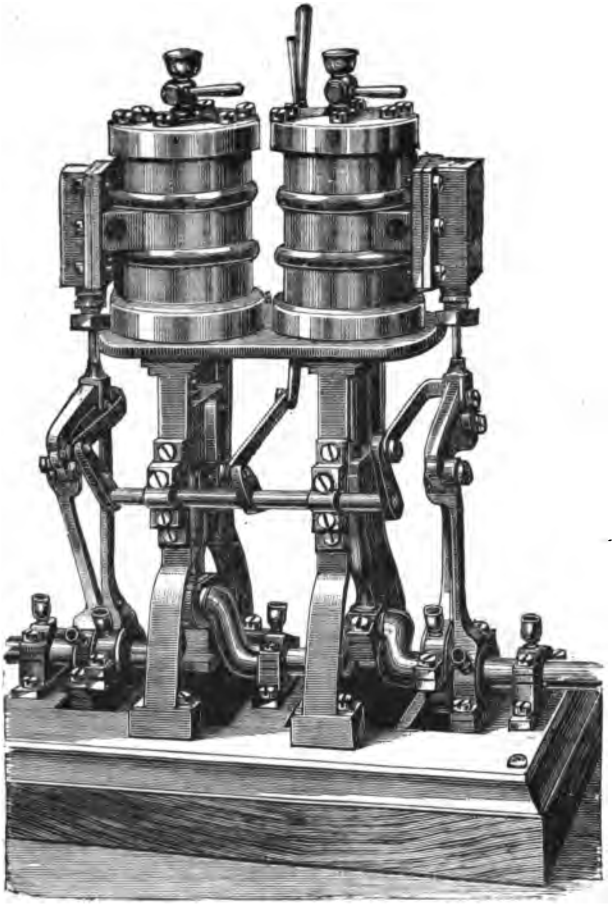


FIG. 70.
Double Cylinder Launch Engine.

the plug by slightly chamfering. The grease cup is thus completed.

The pump for this engine is fully illustrated and described in Chap. IX.—See Figs. 93, 94, 95 and 96, page 104.

On the opposite page is shown, Fig. 70, a double cylinder launch engine fitted with reversing motion. The illustration, taken from a photograph of one of Messrs. Lucas and Davies' engines, is sufficiently clear to show details of construction. Sets of castings for three sizes, viz., ½-in., ¾-in. and 1-in. bore of cylinder may be had. The design shows two single cylinder engines built on one bed-plate, and acting on one crank-shaft. If the bed-plate, crank-shaft, and the plate forming the cylinder covers were all divided vertically down the centre of the illustration, two independent engines would be the result.

# CHAPTER VII.

## *TANK ENGINE.*

THE following pages are devoted to the minute description of a small steam engine that can exert a considerable amount of power in proportion to its size and not knock itself to pieces, as many low-priced and flimsily-built engines do. The design is one which has been found to fully satisfy exacting requirements. The plan and elevation of engine can be used to measure from by taking a suitable scale. The illustrations are printed $\frac{1}{8}$ scale of the dimensions given in the text. The details are shown on a larger scale. This engine, of the dimensions given in the text, is worked at a mean pressure in the cylinder of about 45 lb. of steam per square inch, and, being run at 1,000 revolutions per minute, gives over $\frac{1}{4}$ h.p., the power resulting principally from the high speed. Many doubt the possibility of running the engine so quickly, though such engines very often run at much higher speeds. An advantage of high speed is the superior controlling power of the fly-wheel. The regular working of the engine increases as the square of the speed—that is, a fly-wheel running at 1,000 revolutions per minute has four times the controlling power that it would have if running at 500 revolutions. Another advantage of high speed is, that it often enables the engine to over-run the resistance, and this, especially in the case of very small engines, is of great benefit in ensuring regularity of speeds.

A reference to the plan and elevation of the complete engine, shown at Figs. 71 and 72, affords an idea of the design. The engine is built upon a cast iron oblong base having semicircular ends made hollow, and serving as a water tank. The bottom is covered by a plate of sheet iron cut to shape and fixed by a dozen screws tapped into the casting.

A sheet of metal, $\frac{1}{16}$ in. thick, and cut to fit inside of the bed-plate, is required to form a cover for this tank. It rests on a ledge of the casting, as shown by dotted lines in elevation and plan of engine. It is held down by screws, and has a man-hole at the fly-wheel end to admit a supply of water. The sheet metal will require to be slightly dished just under the crank-pin, so as to allow the connecting-rod end to pass. The tank part of bed can be cast best without a bottom and have a plate screwed on, as shown, but it may be cast in one piece with the bottom. The Fig. illustrating the elevation should be examined, so as to get an idea of the shape of the casting.

The bed-plate, formed by making the top rim of the tank sufficiently massive, can be proceeded with first when the construction of this engine is undertaken. The seatings for the lugs of the cylinder must be filed or planed out perfectly square on the bed, so that the cylinder will fit tightly into them. The seatings for supports of the guide-bar are each $1\frac{1}{8}$ in. long, the distance apart of the inner sides being $2\frac{7}{16}$ in. The distance from the centre of guide-bars to the centre of cylinder is $5\frac{1}{16}$ in. bare. The plummer-block seating is $3\frac{1}{4}$ in. long, and from its centre to the centre of cylinder is $10\frac{11}{16}$ in. full. The guide-bars are $3\frac{15}{16}$ in. long from centre to centre of holes for studs, the width of bars being $\frac{9}{16}$ in.; they are rounded at ends. The distance-pieces between the bars are tubular pieces of metal, they are $\frac{9}{16}$ in. diameter, and $\frac{1}{2}$ in. long, the holes through them and through the bars being $\frac{3}{16}$ in. full diameter. The distance from centre to centre of the two sets of guide-bars is 3 in. It will be much easier to file up the edges of the cast iron guide-bars if

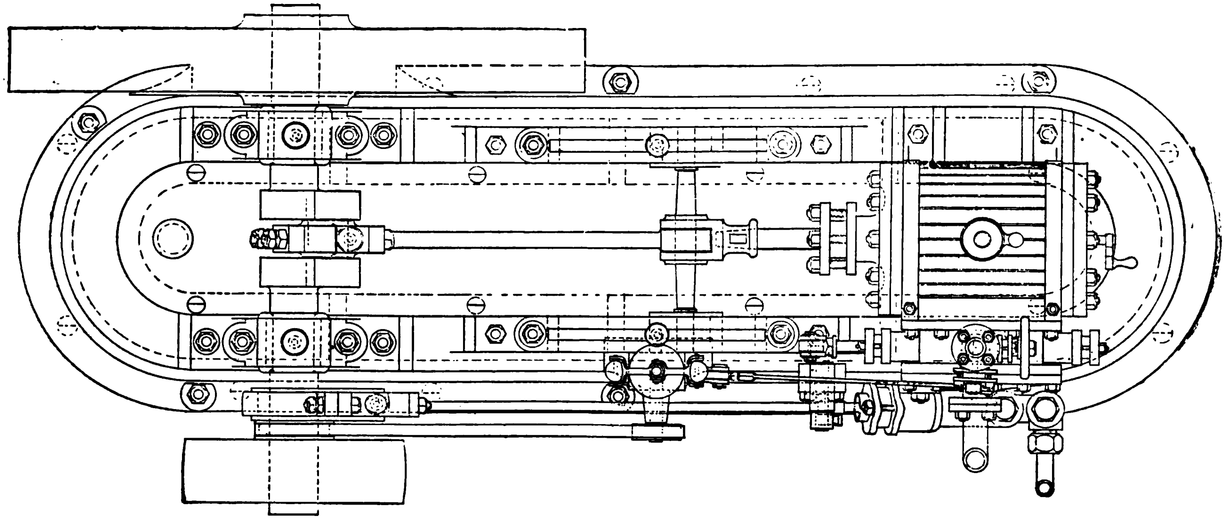


FIG. 71. Plan of Tank Engine.

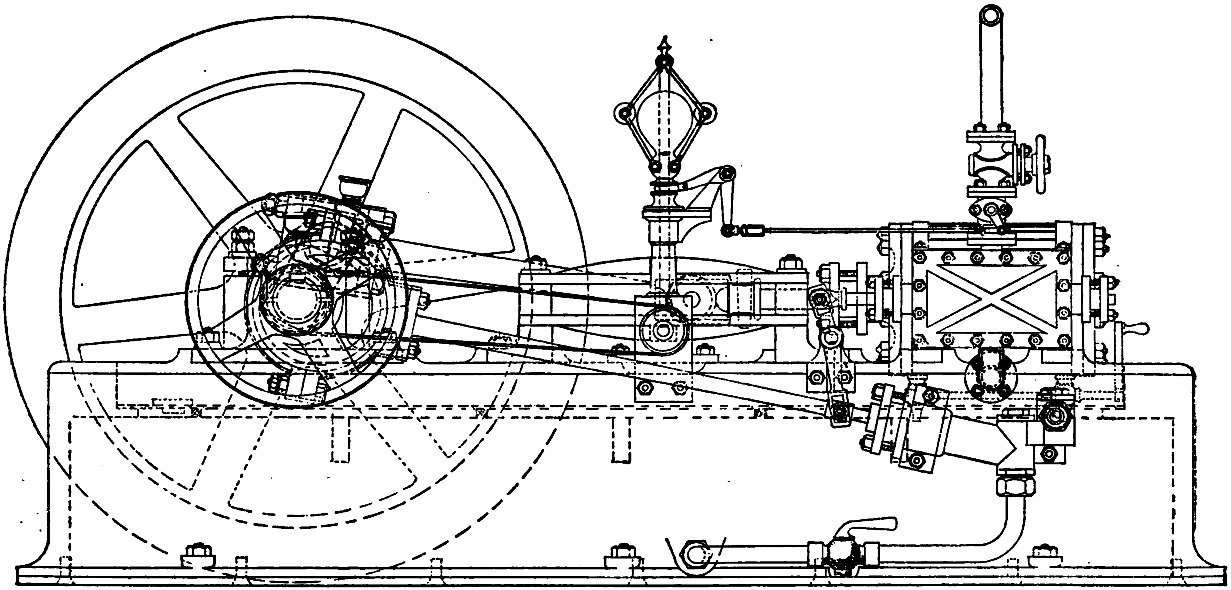


FIG. 72.—Elevation of Tank Engine.

the holes are first drilled through the ends, the distance-pieces then put in their places, and a couple of bolts put through to hold them together, as the two bars, being half an inch apart, will offer a better support to the file than the narrow edge of one would do. The rubbing faces of guide-bars are, of course, filed up as true as possible before the block is ground in. The supports for the guide-bars are $\frac{19}{32}$ in. high, and rounded to the same shape as the bar ends. The studs for holding down the guide-bars are tapped into this support, which also has a $\frac{3}{16}$-in. hole for holding it down by a bolt shown in the drawing. The thin part of support, which forms its foot, is $\frac{7}{32}$ in. thick, and the same width as guide-bars, viz., $\frac{9}{16}$ in. The bars have the edge of rib on top polished, the remainder being painted. Each of the top bars has a $\frac{3}{16}$-in. hole tapped in the centre of boss, to receive an oil-cup, as shown on drawing.

The plummer-blocks, shown at Fig. 73, are iron, and have their bases filed up, so as to fit tightly in their places between the lugs cast on the bed, the edges of base being left bright, all the rest of the blocks and also the caps being painted, excepting the tops of circular bosses on which the nuts rest, which are bright. The plummer-blocks are $1\frac{3}{8}$ in. high from bed, exclusive of cap, and are filed or planed out to a width of $\frac{5}{8}$ in. to take "brasses," the bottom being rounded to fit the bearings, so as to bring their centres 1 in. from bed. The

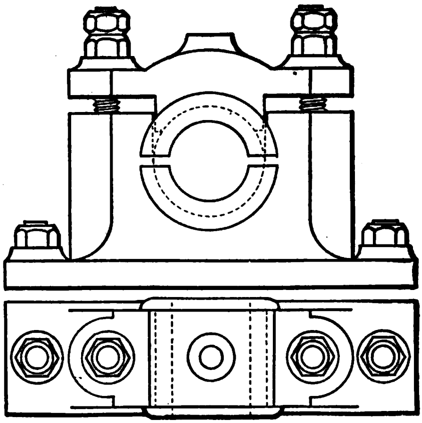


FIG. 73.—Plummer-Block.

bearings, which are of gun-metal, are bored out $\frac{5}{8}$ in. diameter, and turned $\frac{7}{8}$ in. on outside; the flanges at ends are $1\frac{3}{32}$ in. diameter. The length of each bearing is $\frac{15}{16}$ in., and $\frac{3}{4}$ in. between flanges, where they fit in plummer-blocks. The outer edges of flanges can either be rounded or chamfered. The bearings can be bored and turned in the way described for the cylinder without putting them on a mandrel, which might injure the boring. They are then to be fitted in the plummer-blocks; and, after making sure that the centre of the hole is just 1 in. above the bed, the plummer-block cap is fitted on to its place over the turned gun-metal bearing, the under-side of the cap and top of plummer-block being left barely $\frac{1}{8}$ in. apart. The studs for holding down the plummer-block and also the cap are $\frac{3}{16}$ in. diameter, and placed as shown in the plan view, Fig. 73.

A hole $\frac{1}{8}$ in. diameter is drilled through centre of cap and top of bush for oiling the bearing of crank-shaft; this hole is $\frac{1}{16}$ in. diameter through the bush and bottom of cap, the top being tapped with a $\frac{3}{16}$ in. thread for oil-cup, which is illustrated at Fig. 74. A small pin is put through the bottom bush into plummer-block to prevent bush from turning.

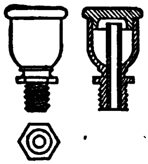


FIG. 74. Oil-Cup.

We can next commence operations on the cylinder, which is made of gun-metal in this case, though cast-iron is as good, and proceed in the following way: with a coarse file burr up one end of the cylinder, so as to get it square with the flanges, fix it with ordinary soft solder on the face of a perfectly true brass chuck. Turn the outer end of the cylinder true, the flange being $\frac{3}{16}$ in. thick, then reverse and resolder on the chuck, the flanges being got to run as true as possible. By soldering the cylinder on the chuck it is held much more firmly than by the ordinary ways of chucking, and also it can be bored, and flanges and both lugs turned at one chucking, thus getting all quite true with the bore, which is difficult to do if the cylinder has to be chucked several times. The cylinder is then bored out to $1\frac{1}{2}$ in. diameter. The bore must be perfectly parallel throughout, as upon this the satisfactory working of the engine greatly depends. The flanges are made $2\frac{7}{16}$ in. diameter, the length of cylinder over flanges is $2\frac{13}{16}$ in. Both sides of the lugs for holding down the cylinder can be turned at the same time. If the seats in the bed-plate are made square with the bed, the axis of cylinder will be parallel with the bed. The outsides of lugs are $2\frac{7}{16}$ in. apart, the width of each being $\frac{7}{16}$ in., and the thickness $\frac{3}{16}$ in. The centre of cylinder bore must be 1 in. from under side of lugs, to correspond with centre of bearings in the plummer-blocks.

A few grooves should be turned in the face of each flange to hold the red lead used for packing the joints.

We can now commence the crank-shaft, for which a wrought iron forging will have to be obtained, about $\frac{1}{8}$-in. larger in every way than the finished size, which is as follows:—Total length, $8\frac{1}{8}$ in.: diameter of shaft, $\frac{3}{4}$ in.; diameter of journals, $\frac{5}{8}$ in.; distance apart, centre to centre, $3\frac{5}{16}$ in.; length of each journal, $\frac{15}{16}$ in.; throw of crank, which is measured from centre of crank-pin to centre of shaft, 1 in.; diameter of crank-pin, $\frac{5}{8}$ in; length, $\frac{5}{8}$ in.; outside width of crank, $1\frac{9}{16}$ in.; the width of each throw thus being $\frac{15}{32}$ in., and its thickness is $\frac{13}{16}$ in.; the crank is midway between the journals, but it is $\frac{5}{8}$ in. from the middle of the crank-shaft. The crank is usually forged solid, and the crank-pin cut out afterwards; this is a much sounder job than if the crank-pin and slot were worked out in the forging. The bent cranks, as illustrated on page 78, are, however, even better.

Cranks may be made in several forms, as illustrated in the engines shown at Figs. 12, 26, 45, &c. &c. The block crank, made by welding a piece of bar iron on to a rod and then cutting away the metal to form the throw, is most common. This form is not good for strength, and recently large cranks have been generally made by bending from the rod of iron or steel. On page 78 are shown several cranks, as bent by the Grantham Crank Company, and some of the model makers supply small cranks made in a similar way. Powerful hydraulic presses are used to bend the large cranks, and the ends are forced inwards as the throws are formed. Thus the continuity of the fibre and the uniformity of section at the bends is not injured, and the work is done with less heats.

When the space between the bearings is limited, that part of the rod forming the crank throws, is made elliptical in section. This adds strength where needed and decreases the space necessary between the bearings. Fig. 76 shows the crank made with the throws of elliptical section. Fig. 75 is an ordinary-shaped crank, which has collars on the shaft to make the shoulders of the bearings. By this method the crank-shaft is not weakened by reducing in diameter to form the bearings. Fig. 77 shows a three-throw crank, and Fig. 78 the end view of same. The three throws are equal, and this crank is suited for such an engine as a triple cylinder, after the style of the one illustrated at Fig. 70.

All the cranks shown on page 78 are bent from the plain rolled rod of steel or iron by special hydraulic machinery, and by this process the fibre of the material is not fractured, but continued round the throw of the crank, and the arms are found to be as strong as the shaft. In making an ordinary block crank, the material is greatly deteriorated by the number of heats required, and the fibre running across the web is destroyed by cutting out the throw. The cost is much in favour of a bent crank, as that of a finished block crank often exceeds double that of a bent crank of equal strength. A practice is becoming general now to make vertical, horizontal and other types of engines with outside bearings, so

FIG. 76.
Finished Crank with Elliptical Throws.

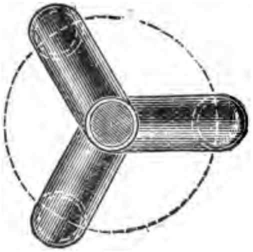


FIG. 78.
End View of Three-Throw Crank.

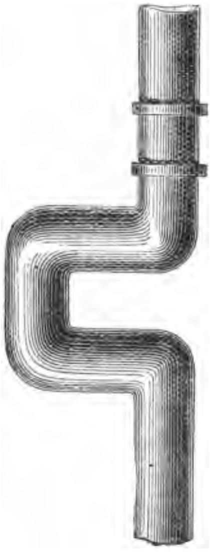


FIG. 75.
Plain Bent Crank.

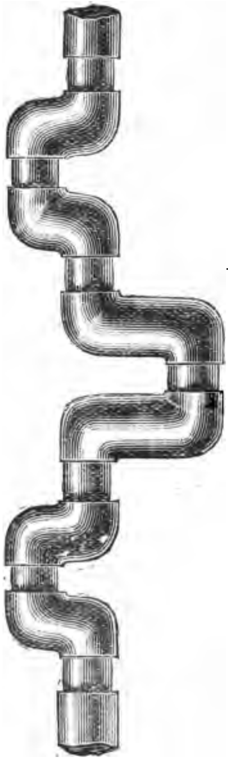


FIG. 77.
Three-Throw Bent Crank.

dispensing with the disc and substituting a bent crank. In launch engines, pumps, &c., the block crank is still largely used; for the reason, no doubt, that the distances between the bearings are short. These cases are met in bent cranks by making the arms of the throw of oval section.

For turning the crank-pin of an ordinary forged crank, always have a throw-piece on each end forged to correspond to the throws of the crank. These arms are centred, and have small holes drilled in them corresponding to the centre of crank-pin, and thus serve to carry the shaft between the lathe centres while the pin is being turned, after which these arms can be cut off and the ends of shaft turned. It is best to turn the shaft and outsides of the crank webs first; the insides and the pin can be turned after. It is important that the crank-pin should be quite parallel with the shaft, in order that the connecting-rod does not bind when it is bolted up tight.

To mark off the centres for turning the crank-pin, proceed as follows:—Lay the shaft on a flat surface, with the crank-throw horizontal, and scribe a line level with centre of the crank-pin along each of the arms on end of shaft; these lines will be *parallel* with the surface on which the shaft lies; set off 1 in. with dividers, and place one leg in the shaft centres, and scribe a line cutting across those previously made. If this be carefully done at each end of the shaft, the point of intersection of each two lines will represent the true centre of the crank-pin, and a small hole can be drilled in each point to take the lathe centres, so as to turn the pin. It will be noticed that the shaft and crank-pin are finished up to the crank-throws with a circular curve; the journals must also be finished in the same way, as the shaft is much stronger and less likely to break than if finished up square. The sides of the crank-throws can be turned; the outer sides at the time the shaft is turned, the inner when the pin is turned. The edges of the throw can be filed or planed, as most convenient.

The ends of the crank-shaft which project outside the journals may be turned just a trifle taper, as the fly-wheel, eccentric, and belt-drum can then be fitted with less trouble, though it will be as well to also put a key in each. The key-ways in the crank-shaft may be $\frac{1}{4}$ in. wide and $\frac{3}{32}$ in. deep, and extend from the ends to within $\frac{1}{8}$ in. of the journals. To make a perfect fit of the shaft in its bearings, it will be as well to slightly grind it in. To do this, the bearings must be firmly fixed in their places, and the shaft put in them with a little silver sand, or what is better, powdered pumice-stone and oil, the longest end of shaft being to the left side of bed-plate, as shown by the illustrations. The top halves of the brasses and the caps are put on, and the shaft turned round pretty quickly, the caps being pressed down as the brasses wear, until it is found on inspection that the shaft bears equally all over the bearings, when both shaft and brasses must be thoroughly cleaned from all grit.

The fly-wheel, which is of iron, is 9 in. diameter and 1 in. wide on rim, and should weigh about 9 lb., a lighter wheel not being sufficient to carry the engine steadily over the centres. Being too large to turn on a mandrel easily, it may be clamped on a face-plate, and, after turning both sides and the edge, the hole for the crank-shaft must be carefully bored to $\frac{3}{4}$ in. diameter, and very slightly tapering to fit tightly on the shaft. A key-way must be made $\frac{1}{4}$ in. wide and $\frac{3}{32}$ in. deep, to correspond to that in shaft, and for which a steel key will be required with a head on large end. This should be $\frac{1}{8}$ in. thicker than rest of key, and $\frac{1}{4}$ in. long. This head is for the purpose of extracting the key from its place in wheel. The belt-drum is $3\frac{1}{2}$ in. diameter, and 1 in. broad on face, and slightly rounded, as shown in illustrations, so as to prevent the belt slipping off. This wheel can be fixed on a face-plate, or in a boxwood chuck, and bored out the same as fly-wheel, after which it can be driven on a mandrel and the rim turned. A key-way is also required the same as in the fly-wheel. The mandrel on which the wheel is turned ought to be very short, and the wheel fixed on it as near the back centre as it can be, to prevent the chattering that is inevitable on turning heavy things on long mandrels.

The smaller work belonging to this engine will be dealt with in the next chapter.

# CHAPTER VIII.

## *TANK ENGINE DETAILS.*

THE heavy work of this engine having been disposed of in the last chapter, the smaller parts can now be proceeded with. A transverse section of the complete cylinder is shown at Fig. 79.

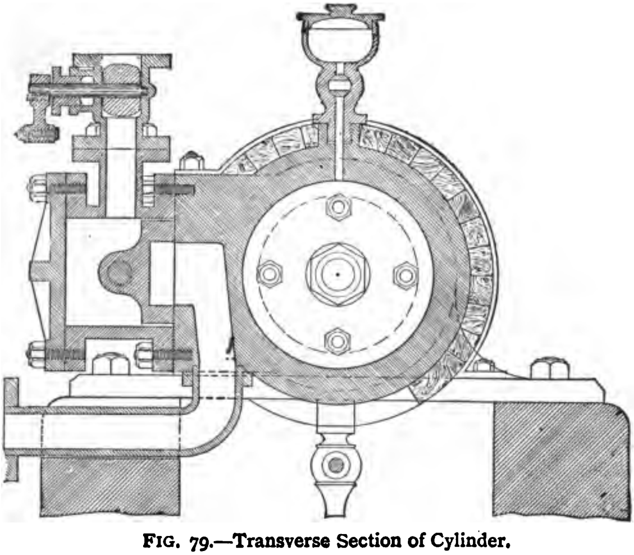


FIG. 79.—Transverse Section of Cylinder.

To turn the top cylinder cover, it will be best to chuck it by the stuffing-box, and turn the back, making the spigot project barely $\frac{1}{8}$ in., and fitting it very tightly into the cylinder. Two or three grooves must also be turned on the face of the cover to help hold the red lead with which the joint is made. A $\frac{5}{16}$-in. hole is drilled right through centre of this cover, for the piston-rod. The cylinder bottom is turned in the same way, and a $\frac{1}{16}$-in. hole drilled through its centre. The bottom and the cover are then fixed on the cylinder, each by eight studs $\frac{1}{8}$ in. diameter, and the complete cylinder chucked between centres in the lathe. The flanges of both covers can then be turned the same size as those of the cylinder. This makes a true joint, not always the case if each flange and cover were turned separately. The covers are the same thickness as the flanges of cylinder, and are slightly hollowed on their outer faces, as shown on drawings, Figs. 80 and 81. The stuffing-box on cover of the cylinder is $\frac{3}{4}$ in. diameter, the flange being $1\frac{5}{32}$ in. diameter and $\frac{5}{32}$ in. thick. To take the gland, the stuffing-box is bored out $\frac{9}{16}$ in. full diameter, and to within $\frac{1}{4}$ in. of the inside face, the bottom of the hole being cham-

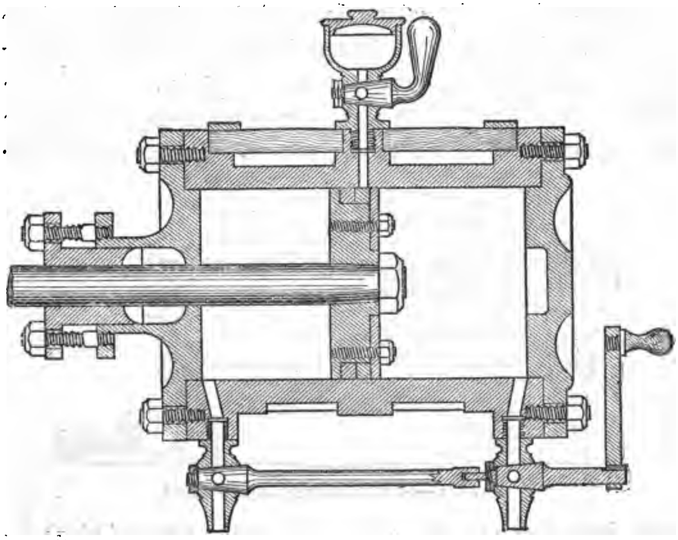


FIG. 80.—Longitudinal Section of Cylinder.

fered or rounded, to cause the packing to press against piston-rod. The gland is $\frac{9}{16}$ in. diameter, $\frac{3}{4}$ in. long, the flange being the same diameter and thickness as that of the stuffing-box. The hole through the gland for piston-rod is $\frac{5}{16}$ in. full diameter, and is chamfered or rounded out at end for packing. The glands of stuffing-boxes have studs $\frac{1}{8}$ in. diameter.

The next thing is to true up the valve-face on the cylinder. This must be quite square with the feet or lugs, and project $\frac{1}{16}$ in. beyond the flanges of the cylinder. The length of valve-face is $2\frac{7}{16}$ in., and its width $1\frac{9}{16}$ in. All the ports in the cylinder are $1\frac{1}{2}$ in. long, the steam ports are $\frac{3}{16}$ in. broad, and the exhaust port $\frac{3}{8}$ in. broad, and the distance between the neighbouring ports $\frac{1}{8}$ in. In making these steam ports, it will be easiest to drill several holes close together, and to chip away the intervening metal to make the ports to required size. To make the steam passages in cylinder, several holes, as large as the casting allows, are drilled up from the ends to meet those in valve-face. The ends of cylinder are filed away on the side next the bore to a depth of $\frac{3}{16}$ in., and the same width as steam port, thus leaving a good passage for steam into cylinder when the covers are on. The spigots of the

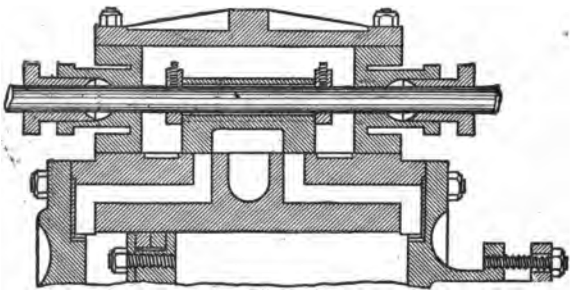


FIG 81.—Section through Slide-valves.

cylinder-covers are also chipped away the same width as the ports, and $\frac{3}{16}$ in. from the edge, to prevent them blocking the port when they are on the cylinder.

The slide-valve is fully illustrated at Fig. 81. It is $\frac{1}{4}$ in.

long across the face, and $1\frac{1}{16}$ in. broad on the outside. The exhaust cavity is $\frac{1}{2}$ in. long, $\frac{9}{16}$ in. wide, and $\frac{3}{16}$ in. deep. On the back of the valve a projection is cast, through which the valve-rod passes, and this is secured in its place by two collars and set screws. It is always desirable that the steam should enter the cylinder as quickly as possible at the commencement of the stroke, and the ports ought to be long, more particularly when the engine is intended to run at a very high speed. When this engine is required to run at 1,000 revolutions per minute, which it can easily do when working, the cylinder has to be filled with steam 2,000 times, and emptied as often, in the course of one minute; the steam and exhaust ports necessarily must be of ample capacity. Not only must they be large enough, but properly designed, in order that the valve opens a large enough area of the port at once to ensure a quick supply of steam to keep the piston moving at the required speed. The exhaust also should be sudden and ample, otherwise there will be a considerable loss of power from back pressure. How to set the slide-valve and the lap, lead, and compression are explained in the directions for putting the engine together.

Failing a planing machine, the easiest way of facing up the slide-valve box is to solder it on a chuck and turn one face, then reverse it and turn the other, at the same time making it the right thickness, viz., $\frac{17}{32}$ in. The box must then be put on its face on a surface-plate, and the centres of the stuffing-boxes carefully marked with a scribing block, and a hole $\frac{3}{16}$ in. diameter bored through each, care being taken to have the two holes in a straight line. The cover, if filed flat, can be temporarily soldered to the valve-box, so that its edges can be turned at the same time as those of box. The ribs and edges are got up bright with a file, the spaces between ribs will be painted the same as the rough parts of valve box. The box can be put between centres in the lathe, and the flanges of stuffing-boxes turned to $\frac{3}{4}$ in. diameter, and $\frac{1}{8}$ in. thick. The end flanges of the box can be turned at the same time, the length of box over flanges being same as the valve-face. The slide-valve box must again be put on the surface-plate, so that the centre of the flange for throttle-valve and the piece cast on under side of box can be both marked from face and ends of box. The top and bottom flanges may then be turned to size, the flange for throttle-valve being $\frac{3}{4}$ in. diameter, and $\frac{3}{32}$ in. thick. A smooth file passed over flanges will lay a straight grain. This way of making the valve box will be found much easier than filing it to shape, and also makes a much better job, as the work should be left perfectly square.

The recesses in stuffing-boxes for glands are $\frac{11}{32}$ in. diameter, and reach within $\frac{3}{16}$ in. of the inside of the box. The glands are $\frac{9}{16}$ in. each long, and fit the recess; the flanges being same diameter and thickness as those of stuffing-boxes. The flanges of glands and stuffing-boxes are then filed on two opposite sides, so as to make them elliptical, $\frac{9}{16}$ in. across. The holes through the glands for valve-rod are $\frac{3}{16}$ in. diameter to fit the valve, which is a piece of $\frac{3}{16}$-in. bright steel wire. The studs for nuts in valve-box and glands are $\frac{1}{16}$ in. diameter, and are placed as shown on drawings. The inside of box must be filed out to $\frac{7}{8}$ in. wide, so as to allow the valve to work freely. The valve-rod having bearings at both ends of box causes the valve to work much better, and also helps to prevent leakage at the stuffing-box. The piston-rod does not require to be carried through both covers, as the cross-head and guides prevent any tilting action that would wear the hole in the gland oval, and thus cause leakage.

For the piston rings it will be best to obtain two steel forgings large enough to turn into rings $1\frac{1}{4}$ in. diameter and $\frac{1}{8}$ in.

square in section. They can be easily turned by soldering them on a chuck and turning one side, then reversing and turning the other side till each ring is  in. thick. The two can then be soldered together and on the chuck, and the insides bored out to $1\frac{1}{4}$ in. diameter, the outsides being made about $\frac{1}{100}$ in. too large to go into the cylinder. The edges of rings must be carefully polished to prevent them scratching the cylinder, and a piece cut out of each, about $\frac{3}{32}$ in. long, to allow them to be sprung into the cylinder, all burr being removed from the edges of cut. They are then ground into their place on piston, to insure a steam-tight joint, the rings being left just free enough to spring open, when the back disc of the piston-head is screwed up tight. The cuts in the rings are placed on opposite sides of piston, so that the steam which passes one cut is stopped by the other ring.

The exhaust-port is carried through to under-side of cylinder, where it is connected to exhaust-pipe by a short length of $\frac{3}{8}$-in. copper tubing, with flanges on each end, and bent, as shown in transverse section of cylinder, see Fig. 79. To bend the tube, fill with lead, when it can be easily bent to the required curve, after which the lead can be melted out. The flange on end of pipe next to cylinder is elliptical, its greatest diameter being $\frac{7}{8}$ in., and its least $\frac{5}{8}$ in., the greatest diameter being parallel with cylinder. The pipe is fastened to cylinder by two $\frac{1}{8}$-in. studs and nuts, which pass through wide part of flange. The flanges can be made separately, and either brazed or silver-soldered on ends of tube, the one on cylinder end being set back $\frac{3}{16}$ in. from end of tube, so as to allow a leather or rubber washer to be inserted between the flange and the cylinder. The flange on outer end of tube is $\frac{13}{16}$ in. in diameter, and has four $\frac{1}{16}$-in. studs in it (see Fig. 79). Both flanges are $\frac{1}{8}$ in. thick. The steam pipe has also four $\frac{1}{16}$-in studs, as shown.

The piston-rod is made from a piece of $\frac{5}{16}$-in. bright steel wire 5 in. long. It must be centred perfectly true, and the end for piston being screwed with a $\frac{1}{4}$-in. thread, and then turned tapering for a length of $\frac{3}{8}$ in. The piston-head has a taper hole through it, into which the tapered end of piston-rod is forced as tightly as possible, and a $\frac{1}{4}$-in. nut screwed on the small end of rod keeps the piston in its place. The piston-rod is then put in the lathe, and the piston turned till it will just go easily into the cylinder. The thickness of piston-head is $\frac{3}{8}$ in., see Fig. 80. It is then turned for a distance of $\frac{5}{16}$ in. from the side the nut is on, to a diameter of $1\frac{1}{4}$ in., leaving a flange at the front, of the same diameter as the cylinder, and $\frac{1}{16}$ in. thick. The back of the piston is then turned away to a depth of $\frac{1}{16}$ in., excepting the boss in the centre, for the piston-rod nut to press against, which is $\frac{1}{2}$ in. diameter. A disc is required the same diameter as the front flange of piston, and $\frac{1}{16}$ in. thick, with a $\frac{1}{2}$-in. hole through it. This is put over boss on back of piston, and four $\frac{1}{8}$-in. holes are drilled through into piston, into which four studs are tightly screwed, and on which nuts are put, to keep piston back in its place. The holes in back must of course be large enough to allow studs to slip through, so that it can be taken off when the nuts are removed.

The exact length of the piston-rod can be best determined when the guide-bars and cross-head, &c., are in their places. It will not be necessary to polish the work until the engine is finished, as it will get tarnished, and possiby scratched, in the progressive stages of fitting together.

FIG. 82.—Pin for Cross-head.

The dimensions of cross-head pin, Fig. 82, are:—Length over all, $3\frac{9}{16}$ in.; diameter, $\frac{11}{32}$ in.; length between *outsides* of collars, $2\frac{1}{4}$ in.; thickness of collars, $\frac{1}{16}$ in.; length of parallel part for cross-head, $\frac{11}{16}$ in.; diameter of journals that go in slide-block and of small tapered part, $\frac{1}{4}$ in. The small end of tapered part is finished up to collars with a curve, as shown. This pin is made of steel, and should be hardened in the middle to prevent wear.

The cross-head for the piston-rod, shown at Fig. 83, is also of steel, and the easiest, as well as the best, way of making it is to drill a hole, $\frac{1}{4}$ in., through it to fit the small taper end of piston-rod, and put it on a steel mandrel—near the end of the mandrel to prevent springing—then turn it to the following dimensions and to the shape shown by the three views in Fig. 83: Diameter of collar on end next piston-rod, $\frac{5}{8}$ in.; diameter of hollow, $\frac{7}{16}$ in. full; the length from square part of cross-head to outside of collar being $\frac{9}{16}$ in. In marking off the hole in the cross-head for the pin, the truest way will be to mark the centre of hole on one side of cross-head $1\frac{1}{8}$ in. from the collar on end, and put between centres; advance a sharp-pointed tool in slide-rest till the point just enters the centre-punch mark previously made. Draw the tool away, turn the cross-head half round, and again advance the tool; then, by working the cross-head slightly, another scratch will be made.

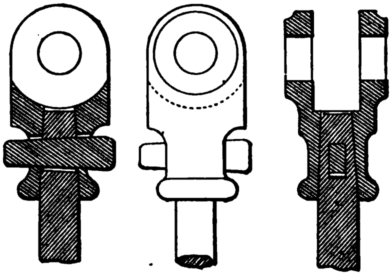


FIG. 83.—Cross-head.

A hole drilled through both of these marks is at right angles with the axis of piston-rod; but it might be not exactly across the diameter. Turn the cross-head round till the original centre-punch mark is exactly opposite the point of tool in slide-rest; then, supposing the lathe has a divided pulley, draw back the tool a little, and turn the mandrel exactly half-way round, and the cross-head with it, and press the tool-point tightly against the cross-head. It can then be worked along by the slide-rest screw, thus making a scratch at right angles to and across the one previously made.

A hole drilled through the point of intersection of these two scratches and through centre punch-mark on opposite side, will be both at right angles to the axis of, and exactly diametrically across the piston-rod. It is really only the work of a few minutes to do the centreing, and when this is done it allows of the sides of the cross-head being turned, which they could not well be if the holes were out of truth. The hole for cross-head pin is bored $\frac{5}{16}$ in. diameter. The $\frac{1}{4}$-in. mandrel is then taken out, and replaced by one put in holes for pin. The sides of cross-head can then be turned to shape like drawing, Figs. 83, and to the following dimensions:—Extreme width of cross-head, $\frac{13}{16}$ in.; width of square part, $\frac{5}{8}$ in.; depth of square part, $\frac{3}{4}$ in.; and diameter of circular bosses on each side of cross-head, $\frac{5}{8}$ in. The ends of cross-head are rounded, as shown. The width of opening in the fork is $\frac{3}{8}$ in. for small end of connecting-rod, and depth $\frac{7}{16}$ in. from centre of bosses.

The two slide-blocks are of gun-metal; one is shown in detail, Fig. 84. It is $1\frac{1}{8}$ in. long, $\frac{1}{8}$ in. thick, and $\frac{9}{16}$ in. wide on the working face, the flange on inner side being $\frac{3}{32}$ in. thick, and the same in height. The hole for cross-head pin is $\frac{1}{4}$ in. diameter, and if the block is chucked on a mandrel the sides and ends can be turned up true; the rubbing surfaces will have to be filed or planed. If the ends of the block are left rounding as they are turned, they will

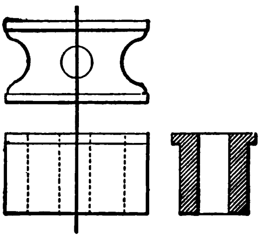


FIG. 84.—Slide Blocks.

ride over the oil on the guide-bars, and not tend to scrape it up, as they would do if they were left quite square and sharp.

Each slide-block should be made a tight fit between the bars, and should be put between them with some powdered pumicestone or fine silver sand and oil, and worked backwards and forwards till it works freely, and still is a tight fit; after which every particle of grit must be removed from the block and guide-bars.

Having proceeded thus far, the exact length of the piston-rod can be determined. The hole in cross-head must be broached out till the cross-head pin will nearly fit it; then the pin, Fig. 82, can be ground into its place, it being necessary that it should fit in the cross-head tightly, otherwise the engine will hammer when working. The hole in cross-head for piston-rod will have to be broached out taper to a diameter of $\frac{5}{16}$ in. at the outer end, so that the piston-rod may be fitted into it.

Put the slide-blocks, Fig. 84, on the ends of pin, and place them between the guide-bars, and push them towards the cylinder till the centre of pin is exactly 1 in. from centre of guide-bar. The cylinder, without the bottom on, can now be put in its place on the bed, and the piston pushed back till it is exactly $\frac{7}{32}$ in. from end of cylinder. The position of end of cross-head can now be marked on piston-rod; this is then turned taper, so as to fit the hole in cross-head tightly to that point. When the rod is fitted in cross-head, it should not go to within $\frac{1}{32}$ in. of its proper position, this space being left for the key to pull up. The key, shown in Fig. 83, is a piece of tapered steel $\frac{7}{8}$ in. long, full $\frac{1}{8}$ in. thick, $\frac{1}{4}$ in. wide at top, and $\frac{3}{16}$ in. at bottom. The slots in cross-head and in piston-rod for this key are each $\frac{1}{16}$ in. wider than key, but in opposite directions, when cross-head is in its place on rod; the end of the slot in the rod on the end next to the piston is $\frac{1}{16}$ in. nearer to piston than the corresponding end of slots in cross-head: and ends of slots in cross-head on side next the cross-head pin are $\frac{1}{16}$ in. nearer to the pin than slot in piston-rod; consequently, when the key is forced in its place, it draws the tapering piston-rod and cross-head closely together and wedges them tightly.

For the connecting-rod it is unnecessary to give a special drawing, as similar connecting-rods have been illustrated at Figs. 40 and 56, and the exact shape of this one is shown in Figs. 71 and 72; an iron forging, large enough to work to the following finished dimensions, will be required:—Length from centre of hole for cross-head pin to big end (outside) $5\frac{1}{8}$ in.; diameter of boss, little end, $\frac{3}{4}$ in. full; width, $\frac{5}{8}$ in. bare; width of big end, $\frac{7}{16}$ in.; depth, $1\frac{7}{16}$ in.; thickness, $\frac{1}{4}$ in.; width of rod, $\frac{1}{4}$ in., parallel from end to end; depth, little end, $\frac{11}{32}$ in.; big end, $\frac{1}{2}$ in. full. If the rod is put between centres, the flange for bolts at big end can be turned at top and bottom, and back and front, the sides being turned when it is bolted on the brasses. The hole in little end can either be bored out the right size and the iron afterwards case-hardened, or a small hardened steel bush can be made and forced into the rod, the bush being about $\frac{1}{16}$ in. thick all round, and of course forced very tightly so as to fix in the rod. Great care must be taken that the hole is perfectly square with the rod. The cross-head pin must be as tight a fit in the rod, consistent with working properly. A small hole must be drilled through top of boss on rod, for the purpose of lubricating the pin. It will be advisable to have a small oil-cup fitted on, with a cap to keep out the dirt.

The brasses for big end of rod are gun-metal castings, and are to be finished to $1\frac{1}{32}$ in. long, that is, parallel with connecting-rod; depth, $1\frac{7}{16}$ in.; width, $\frac{7}{16}$ in.; width across boss in centre, $\frac{5}{8}$ in. bare; diameter of boss, $1\frac{3}{8}$ in., and rounded off as shown. In making the brasses, first file the two inner faces square and smooth, then solder them together; they can then be fixed on a chuck and the centre bored out for the crank-pin to a diameter slightly less than $\frac{5}{8}$ in., it being finished to the size by grinding. The pair of brasses are now put on a mandrel, and both the sides and bosses turned to the requisite width and diameter. The two ends will now have to be turned flat and parallel, care being taken to keep the division line of brasses in the centre, both top and bottom. Particular care must be taken that the ends of the brasses which pull against the connecting-rod are perfectly square with the axis of crank-pin, otherwise the big end will be twisted and will bind on pin. The top and bottom edges will have to be turned at the same time as the ends.

A piece of iron, $\frac{1}{4}$ in. thick, is required to go on outside of big end. The holes for the two bolts are $\frac{3}{16}$ in. diameter, and are 1 in. apart, centre to centre. The brasses will require to be ground to the crank-pin; this is done by placing the little end on the cross-head, putting the pin through it and the guide-blocks, and the big end with the brasses on the crank-pin with some powdered pumicestone and oil; then by turning the shaft round and tightening the nuts on big end a good fit will be made of the bearing. A hole will have to be drilled in the top of the big end to take an oil-cup with a $\frac{3}{16}$-in. thread. The position of cup is shown on drawing, Fig. 72, and a cup of suitable design is shown at Fig. 74.

The eccentric will next engage our attention. Great care must be paid to fitting the strap on the sheave; otherwise they will work with a deal of unnecessary friction. The following is a good means to adopt in making eccentrics up to about 3 in. in diameter. The strap, which is of gun-metal, is first soldered on a chuck and bored out to $1\frac{7}{8}$ in. diameter, and the side is also turned; it can then be reversed on the chuck, and the other side turned until the strap is $\frac{3}{8}$ in. thick. The holes in the lugs for holding together the two halves of strap are next made to clear the bolts, which are $\frac{3}{16}$ in. bare in diameter. These holes must be made before the strap is cut, so as to insure their being opposite in both lugs. The flat part of strap, for taking end of eccentric rod, is $1\frac{3}{16}$ in. long, and $\frac{3}{8}$ in. from inner edge of strap. It is fastened on by two $\frac{3}{16}$-in. studs and nuts, as shown, the studs being tightly screwed into eccentric strap. An oil-cup will be required on strap, as shown. A drawing showing the inside of these cups is given at Fig. 74.

The eccentric sheave, which is of cast iron, can be soldered on a chuck, and turned on one side, then reversed and turned on the other side, till it is $\frac{1}{2}$ in. full in thickness. The edge is now turned till the sheave is $2\frac{1}{8}$ in. in diameter, and a groove sunk in edge for the strap; this groove is $\frac{3}{8}$ in. bare in width, and $1\frac{7}{8}$ in. full in diameter. The strap, which has been cut in two, is now carefully ground into this groove, with a little fine silver sand and oil, until it bears equally all over, but the grinding must stop when the two halves of strap are within $\frac{1}{32}$ in. of together, so as to allow room for tightening up. Having marked the centre of sheave, the chuck must now be warmed till the solder melts, and the sheave then pushed over $\frac{3}{8}$ in. to one side. The centre of hole is now marked, and a $\frac{5}{8}$-in. drill put through, and the hole then bored out with a tool in the slide-rest, to the exact size of that part of shaft on which it is to fit.

The best way to fix the sheave on the shaft will be by a pointed steel screw passing diameterway through centre of widest part of sheave. This screw, owing to the strain from it passing through the centre of sheave, always keeps sheave perfectly square with shaft, while a key, especially in filed key-ways, almost always bears unequally, and thus twists the eccentric sheave, and causes the strap to bind in the groove. A countersunk hole in shaft should be made for the point of this screw, but it must not be drilled till the slide-valve has been set.

The eccentric rod, which also works the feed pump, is of wrought iron, and of the following dimensions:—Length from end to centre of pin for working valve gear, $6\frac{7}{8}$ in.; rod at large end, depth, $\frac{3}{8}$ in.; at small end, $\frac{3}{16}$ in.; block for valve-gear pin, depth, $\frac{5}{16}$ in.; thickness, $\frac{7}{32}$ in.; rod parallel, thickness, $\frac{5}{32}$ in.; end for eccentric strap, thickness, $\frac{3}{16}$ in. full; length, $1\frac{3}{16}$ in.; width, $\frac{3}{8}$ in; block for valve-motion pin, length, $\frac{3}{8}$ in.; diameter of pin, $\frac{3}{32}$ in.; length of working part, $\frac{3}{16}$ in; diameter of hole for pin of pump plunger, $\frac{5}{32}$ in.; diameter of boss on end of rod, $\frac{5}{16}$ in.; thickness, $\frac{1}{4}$ in. Fig. 72 shows the shape of this rod.

The valve levers and supports are clearly shown in the details illustrated by Fig. 85, and are drawn double. The eccentric-rod lever is $1\frac{5}{32}$ in. long from centre of rocking shaft to centre of slot for sliding block; length of slot, $\frac{7}{16}$ in.; width, $\frac{3}{16}$ in. full; width of slotted end of rod, $\frac{5}{16}$ in.; length, $\frac{9}{16}$ in.; thickness, $\frac{6}{16}$ in. bare; widths of tapered part of rod, large end, $\frac{1}{4}$ in.; small end, $\frac{5}{32}$ in.; thickness, $\frac{1}{8}$ in.; diameter of circular head of rod, $\frac{11}{32}$ in.; length, $\frac{1}{4}$ in.; diameter of hole for rocking shaft, $\frac{3}{16}$ in.

The small lever is similar to the large one, with the exception that it is slightly bent, as shown, this being to allow the boss to clear the nut which holds down one of the guide-bar supports. The rod can be made straight at first, and cranked to the extent of $\frac{1}{16}$ in. full, as shown, when finished. The outer edge of the tapered part is flush at bottom with edge of boss, as shown in Fig. 85. The boss is $\frac{11}{32}$ in. diameter, and $\frac{1}{4}$ in. long; diameter of centre hole, $\frac{3}{16}$ in.; distance from centre to centre of slot, $\frac{19}{32}$ in.; length of slot, $\frac{13}{32}$ in.; width, $\frac{3}{16}$ in.; full width of head, $\frac{5}{16}$ in.; length, $\frac{17}{32}$ in.; thickness, $\frac{3}{16}$ in.; thickness of tapered part, $\frac{1}{8}$ in.; width of wide end, $\frac{1}{4}$ in.; small end, $\frac{3}{16}$ in. full. The distance apart of the two levers, that is, between the bosses on rocking shaft, is $\frac{3}{4}$ in., the rocking shaft being $\frac{3}{16}$ in. diameter, and the levers fixed to it by two small keys, as shown.

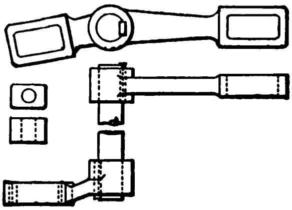


FIG. 85.
Lever for Slide-valve and Force Pump.

The angular position which these two levers form can be best determined in the process of erection. The small blocks that slide in the slots in levers are the same thickness as ends of levers, and are, for the large lever, $\frac{5}{16}$ in. bare, long, and for the small lever, $\frac{1}{4}$ in. long. Each block has a full $\frac{3}{32}$-in. hole through it for the pins to work in. These blocks are shown in Fig. 85, and must be a good working fit in the levers. Both the levers and blocks are best made in forged steel, for the sake of strength. The rocking shaft is a piece of bright steel wire. The steel bolt for valve-rod cross-head is shown in Fig. 86; it is $\frac{3}{32}$ in. diameter, and is $\frac{5}{8}$ in. long between nut and head.

The valve-rod cross-head is shown large size in Fig. 86; it is screwed with a $\frac{3}{16}$-in. screw, and a pin put through, as shown, to prevent it turning. The dimensions of cross-head are:—Length from centre of pin to end next valve, $\frac{13}{32}$ in.; diameter of beading on end, $\frac{3}{8}$ in.; diameter of circular part of sides, $\frac{1}{4}$ in.; depth of cross-head, $\frac{5}{16}$ in.; width, $\frac{5}{16}$ in.; width

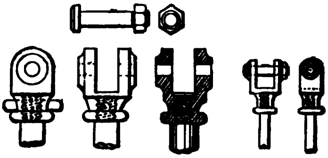


FIG. 86.
Cross-heads for Valve-rod and for Throttle-valve coupling.

across circular bosses, $\frac{3}{8}$ in.; width of opening for rocking lever, $\frac{3}{16}$ in. full; depth, sufficient to allow lever to work freely. Hole for pin is $\frac{3}{32}$ in. diameter. The length of valve-rod is $4\frac{1}{8}$ in., in addition to the part in the cross-head.

The bracket marked Fig. 87 carries the valve-lever rocking-shaft, and is made of cast iron. The bracket is bolted to the bed by two $\frac{1}{8}$-in. studs and nuts, the studs being screwed firmly into the bed. The bracket is $\frac{3}{4}$ in. long, and $\frac{5}{32}$ in. thick where the studs pass through, the curved rib in front being the same thickness.

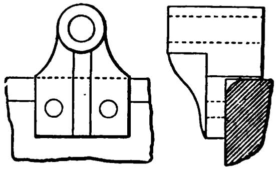


Fig. 87.
Bracket for Rocking Lever.

The depth is $\frac{1}{2}$ in. from top of bed to bottom of bracket, and the centre of the $\frac{3}{16}$-in. hole for rocking shaft is $\frac{13}{16}$ in. from top of bed; the diameter of top of bracket is $\frac{3}{8}$ in., and length, $\frac{3}{4}$ in. bare; the width of bearing surface of bracket on top of bed is $\frac{9}{32}$ in., measuring inwards from edge of bed, the rest of the length of the top of bracket thus projecting over the bed. The distance from centre of bracket to centre of cylinder is $2\frac{7}{16}$ in.

This completes the details of tank engine shown on pages 72 and 73.

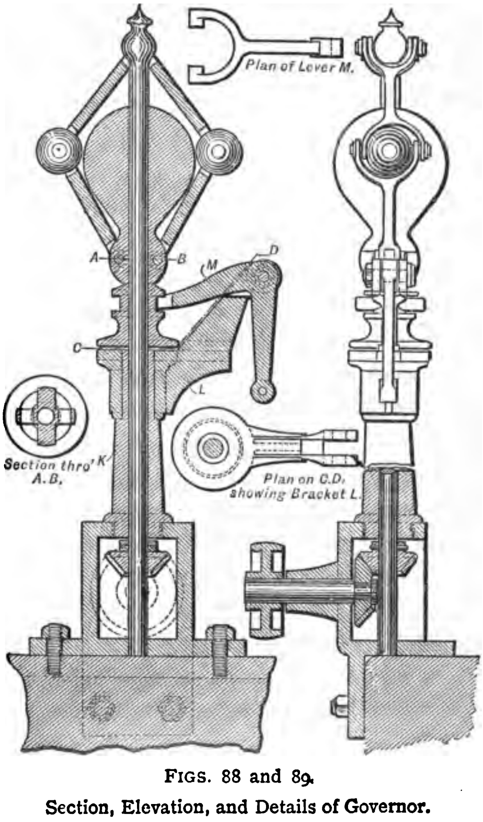
# CHAPTER IX.

## *GOVERNORS AND PUMPS.*

THESE adjuncts are necessary to a complete model, though often both are neglected. In this chapter the governor of the engine shown on pages 72 and 73 and two pumps for engines shown at Figs. 50 and 72 are illustrated and described.

The governor, or regulator, was for many years used by millers to regulate the speed of their grindstones, and was adapted by Watt for the purpose of working the throttle-valve in the steam pipe. The motion of the governor is derived, in the first instance, from the engine itself, by a cord or strap running round the crank-shaft and communicating its motion to the vertical governor spindle. Two weighted arms are attached to the spindle, revolving with it; they have joints, so that the arms can be raised from or depressed towards the spindle. The arms are connected by levers which move freely on joints at their ends, and are connected to a ring, free to move up and down the spindle. When the engine is moving with great velocity, its increased rate of motion will be communicated to the governor spindle, and the weights or balls attached to the arms will fly further from the spindle, moving the ring on the spindle; this ring moves a bent lever, at the end of which is the throttle-valve. When the velocity of the engine is excessive, the action of this lever contracts the opening through throttle-valve, consequently less steam will pass into the cylinder, and the velocity of the engine will be decreased. Should the engine be running too slow, the balls would fall, the throttle-valve be opened, more steam admitted, and the engine would have its velocity increased. It is called a pendulum governor, because the time of a revolution is affected by the length of the axis of the cone formed during the rotation, in a manner analogous to that in which the time of swing of an ordinary pendulum is affected by the length of the pendulum.

The governors and throttle-valve, &c., for the tank engine described in two previous chapters are shown full size on accompanying illustrations, Figs. 88 and 89, the dimensions can therefore be easily obtained by direct measurement. The governor is made of the following materials:—Central spindle, steel;




FIGS. 88 and 89.
Section, Elevation, and Details of Governor.

large weight, small balls, bell-crank lever, and central pillar, all wrought iron; the base box and upper part, which forms the bearing for the bell-crank lever, are cast iron. The lever bracket (L) can be turned on the column as shown; this is for the purpose of getting the bell-crank in a line with throttle-valve; when once set it is prevented from turning by a small set screw in the side pinching it against the pillar.

All pins for holding together are steel, and the mitre wheels are gun-metal. The wheel on central spindle is fixed by means of a pin, as shown; and the one on driving spindle is put on a square, with a screw in end to keep it on, as also shown. The small driving pulley may be cast iron.

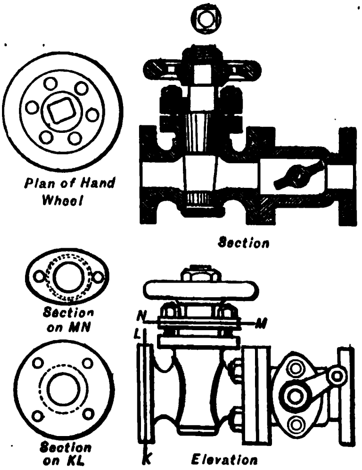
The governor is driven by a belt $\frac{3}{16}$ in. wide, from an iron pulley $1\frac{1}{2}$ in. diameter, and $\frac{5}{8}$ in. wide, and with a $\frac{1}{4}$-in. groove round it. This is on the crank-shaft between driving pulley and eccentric, and is fixed with a key.

The joints for connecting bell-crank of governor to throttle-valve are shown at Fig. 86, the rod connecting the two being a piece of $\frac{3}{32}$-in. bright steel wire. Great care must be exercised in making throttle-valve and stop-cock, to prevent any leakage of steam, as it would greatly impair the action of the throttle-valve in regulating the speed of the engine. An external leak in the stop-cock would make everything very unpleasant, besides spoiling the lagging of the cylinder.

The stop-cock and throttle-valve are made separately; section and illustrations are shown at Figs. 90 and 91, so as to simplify the construction, and also to get a sufficiently large chamber for the throttle-valve. It will be seen that the plug of the stop-cock does not go right through the shell, it being kept up steam-tight by a gland piece on outer end. The shell of cock ought to be cast solid, the steam-ways being too small to core easily.

The best way to make the steam-cock will be to bore a hole the same size as small end of plug, nearly through, as shown. Full $\frac{3}{32}$ in. of metal should be left. The hole is then bored out with a taper broach to the size shown, the taper stopping

$\frac{1}{16}$ in. from end of hole in order to allow plug to come further through in tightening up. The steam-way in the casting is to be bored next, and the ends next the plug are to be widened lengthways of plug, as shown on detail, in order to give a full passage to the steam. The broach is then put into hole for plug to clear away all burr. The plug is to be turned to the size shown, and carefully ground into its place; but before it is quite finished the steam-way must be drilled through it, and filed out to the length and width shown on sectional drawings of cylinder (Fig. 79). The plug can now be finally ground in till it is within $\frac{1}{16}$ in. of the end of hole, this space being left for future regrinding. The projecting end of plug should be parallel from end of shell to its end, so as to offer no impediment to its being ground in further. The grinding must be done very carefully, care being taken not to press more on one side than on another. Two studs and nuts, $\frac{3}{32}$ in. diameter, are required to hold the plug-gland on its place. The hand wheel is fixed with a nut on a square.




FIGS. 90 and 91.
Section, Elevation and details of Steam-Tap and Throttle-valve.

The throttle-valve chamber is larger than the bore of stop-cock, so as to allow room for the valve without choking the passage of the steam. The valve is an oval disc with a square hole through it for the spindle. If it has projecting pieces cast on purpose, it can be turned on the slant to the same size as the chamber, and so would fit it perfectly steam-tight. The pieces it is turned on can then be cut off. The lever on end of spindle is to be in the position shown on elevation (Fig. 72) when the valve is open. This lever is iron, and the spindle—which is steel—is reduced near its end to a square to take the valve, and then further reduced at end of square to a round, so as to form an inner bearing inside valve-chamber, as shown on section. The lever is fixed on end of spindle by a small set screw. The spindle is made steam-tight in the stuffing-box by having a cord formed of two or three strands of lamp cotton twisted round it, and then forced tightly down into stuffing-box by the gland. The construction of this part is shown on sectional drawing of cylinder (Fig. 79). The steam-pipe, stop-cock, and throttle-valve are bolted to each other and to the cylinder by four $\frac{1}{16}$ in. studs and nuts in each, as shown. The throttle-valve and stop-cock are gun-metal, and the steam pipe, which is $\frac{11}{32}$ in. external diameter, is copper, as are also the exhaust and pump pipes. This completes the governor.

In large steam-engines the feed water, to replace that used to make steam, is usually forced into the boiler by a feed pump, worked by the engine or by an injector. The feed pipes are often fitted with a weighted valve, which allows the water to pass to the cistern when the feed cock is closed. A donkey pump is sometimes attached to the boiler, to feed it when the engine is at rest. The feed water is generally heated before it enters the boiler, by passing it through a multitubular water heater, so placed that the gases from the furnace may pass by and heat them.

The usual type of pump sold for use on models is shown at Fig. 92.

Force-pumps for very small boilers are usually a mistake. They deliver more water than the boiler can take, or they will not act at all. If wanted for the sake of appearance, it would be much the best to put on a dummy pump. A pump can often be made of a workable and useful size by gearing from the plunger of the pump to the crank-shaft in such a way that the stroke of the pump represents a dozen revolutions of the fly-wheel; or the pump may be made so that it can be disconnected as a rule and set to work as occasion may require.

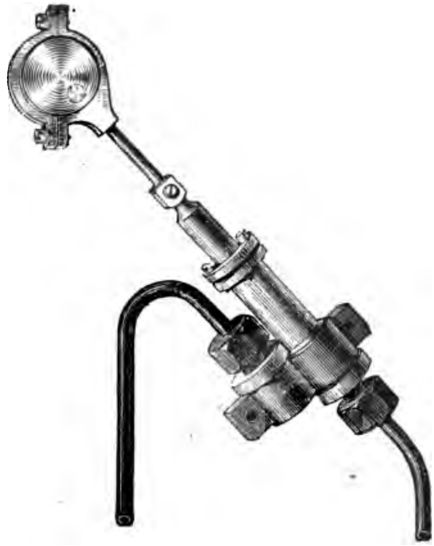


FIG. 92.
Diagonal Force-Pump.

Feed pumps are generally single-acting and are often arranged with a trunk plunger, so that an eccentric-rod can be directly connected with the plunger by means of a joint without the use of a guide. With this arrangement, care should be taken to make the stuffing-box, which guides the plunger, at least equal in length to the stroke.

In ordinary practice the capacity or theoretical quantity a feed pump will inject in a given time is at least equal to twice the quantity evaporated by the boiler, or in marine engines about four times.

The efficiency of feed pumps is about from 20 per cent. to 70 per cent. of their theoretical delivery, due to the area of the plunger and speed of the strokes. This loss of efficiency is mainly caused by the fact that unless the pump plunger is moved slowly the barrel is not filled at the end of a complete

FIG. 96.

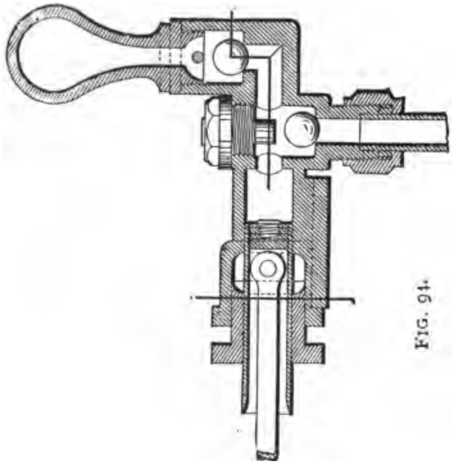


FIG. 94.

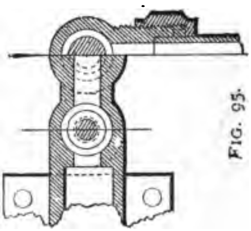


FIG. 95.

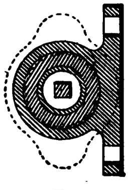


FIG. 93.

FIGS. 93, 94, 95 and 96.

**Cross, Vertical and Horizontal Sections of Force-pump for Launch Engine.**

stroke. This is due to the inertia of water, which cannot follow the plunger when moving rapidly. As a general rule, the quicker the pump runs the smaller the efficiency. The size of pump depends upon the quantity of water to be delivered, and is best calculated from the particulars of the engines to be worked.

The length of stroke and the area of plunger govern the work done by feed pumps.

The accompanying illustrations (Figs. 93, 94, 95 and 96) show the construction of the feed pump shown in its place on the launch-engine described in Chapter VI. The illustrations are scale drawings, and for the most part explain themselves. As before mentioned the plunger has ⅝-in. stroke, and is ½ in. in diameter. The plunger is made of brass tube with one end closed by a disc of brass fixed by hard solder. The joint by which the plunger is attached to the eccentric-rod is screwed into the centre of the disc, and a pin put diametrically through the plunger forms an effectual fitting (see Fig. 96). The connecting-rod is shown at Fig. 97.

The valves are made by spheres resting on seatings as shown in the sectional view. The best method of making these spheres is to bore a hole through a short piece of round steel rod, so as to leave only about ⅛ in. thickness all round. Then turn away the steel from the inside so as to get the middle part of the boring bigger than the ends. File the ends flat, then harden and temper. The bore should be ground out with a cylindrical grinder so as to get the ends quite true, and the ends should then be polished on a flat surface. This tool should be made about two-thirds of the diameter of the ball on

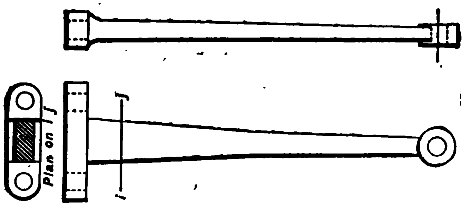


FIG. 97.
Connecting-rod for Force-Pump.

which it is intended to act. It should be fitted in a handle, and one end may be used for roughing, and the other for finishing the spheres.

To produce true spheres turn a ball roughly to shape—gun-metal is good material for the balls—and make a cup-shaped wood-chuck to hold it very loosely. The tool applied to the rough ball will soon remove all irregularities, and when it ceases to cut, a perfect sphere will be produced in a few minutes' work. If too large for the purpose it must be reduced by filing, and then trued again by the cutting tool.

These balls must not be allowed much play when working, or the seatings will be damaged. The drawing shows the methods of checking the rise of both balls in this pump.

The seatings should be very narrow, in fact, merely the edge taken off the sharp arris. The ball may be used itself to very slightly grind its own seat. Large balls are made hollow to reduce the weight, and so prevent injury to the valve seatings.

This pump is provided with an air chamber, to equalise the flow of water, and it forms a cushion to break the force of the hammering caused by the water being injected. A back-pressure valve is used in some cases to prevent the flow of water in one direction. One is illustrated by Fig. 98. Its object is to relieve the pump of the weight of all that water which has passed the valve.

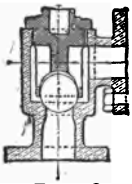


FIG. 98. Back-pressure Valve of Force-Pump.

In all fast-running hydraulics an air chamber should be attached to the delivery side of a pump (to equalise the pressure and flow), and if a very fast-running pump, to the suction side also. The suction pipe should be made as short as possible. A feed escape-valve is sometimes attached to the delivery side of a pump or to air chamber, if one is used. This valve is weighted, so that in the event of the engine going too fast, and the pipe not getting cleared quick enough, the slight increase of pressure opens the valve and allows the water to escape. When a feed escape-valve is used, a feed check-valve is made adjustable, and the quantity of water entering the boiler can be regulated, or the supply stopped, by screwing down the stop which regulates the lift of valve. The pet-cock often fixed to a feed pump barrel is used to test the action of the pump (to see whether it is drawing water), and to draw off confined steam or air. Lift of valves in feed pumps should be restricted and carefully adjusted, because with great lift the valve acquires too much velocity, and thereby increases the pressure in barrel each time the valve closes, and increases wear of seatings. In large pumps it is often better to use, instead of a single large valve, two small valves. As before noted, spherical valves are sometimes made hollow for lightness.

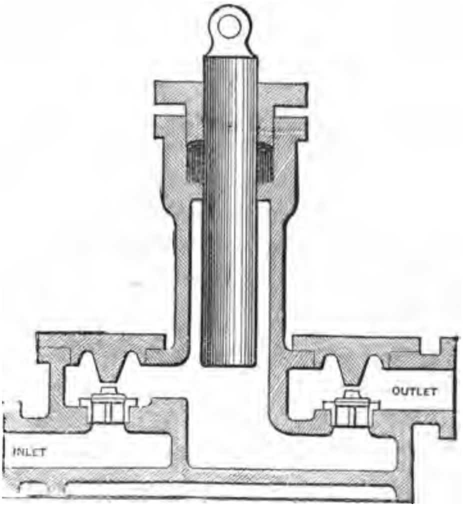



FIG. 99.
Section of Force-Pump.

Fig. 99 shows a sectional view of a force-pump, from which may be seen the general principles on which these pumps act. The inlet and outlet for water are shown.

The feed pump for the tank engine, already fully described, is shown by complete scale drawings in Figs. 100, 101, 102 and

103; it may be made in gun-metal. It is on the trunk principle, this form throwing much less friction on the gland than that with a solid plunger with the eccentric-rod fixed to the outer end. It is of extra large dimensions, in order to allow the engine to be worked from a boiler of good size, besides which, it is very unpleasant to be working an engine the pump of which is barely able to keep up the supply of water; and there is also another reason, viz., that very small pumps often refuse to act. A good model boiler is often spoiled through inability to keep up the water level.

If it is desired, a return pipe and tap can be screwed into pump between first and second delivery valves, as shown in Figs. This arrangement allows the pump to be always pumping water, which, when not being sent into the boiler, can be returned to tank; and thus preventing valves getting stuck on their seats, and ensuring the water going into boiler immediately it is turned on. The amount of feed can also be regulated by it better than by shutting off the tap on suction pipe, as if this latter is done, the pump, owing to its not being filled properly at each stroke, will hammer very much. The barrel of the pump may be cored out in the casting, but it will be better to have the clack-boxes cast solid and bore them out afterwards.

The plunger of this pump is made of a piece of $\frac{3}{8}$-in. triblet brass tube $1\frac{7}{8}$ in. long, into one end of which a disc of brass, $\frac{1}{8}$ in. thick, is silver soldered. In the centre of this, a $\frac{3}{16}$-in. hole is drilled and tapped. Into this is to be screwed a joint for eccentric-rod of the shape and size figured on sectional drawings, page 109. A lock nut will be required on end of screw to prevent joint working loose. The pump will require three $\frac{1}{8}$-in. studs to hold it to bed-plate: one in each foot on sides of stuffing-box and one under clack-box, as shown.

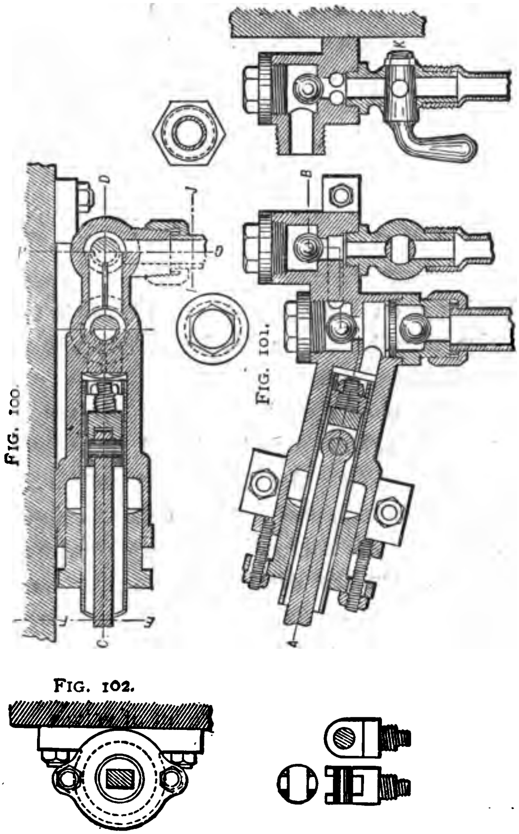
The barrel of pump is bored out to $\frac{3}{8}$ in. diameter to within $\frac{1}{8}$ in. of bottom, the stuffing-box being afterwards enlarged to $\frac{5}{8}$ in. diameter and $\frac{9}{16}$ in. deep, the gland being $\frac{5}{8}$ in. long, diameter, $\frac{5}{8}$ in. bare, thickness of flange, $\frac{1}{8}$ in.,

FIG. 103.

FIG. 100.

FIG. 101.

FIG. 102.



FIGS. 100 to 103. Horizontal, Vertical and Cross Sections, and details of Force Pump for Tank Engine.

length, $1\frac{1}{16}$ in., width, $\frac{13}{16}$ in., and of shape shown in Fig. 102 The outside diameter of pump barrel is $\frac{5}{8}$ in., and that of stuffing-box, $\frac{3}{4}$ in, full, and length $\frac{5}{8}$ in. Flange for fixing to bed, measures, from end to end, $1\frac{5}{16}$ in., and width $\frac{1}{2}$ in. The centre line of pump is to be $\frac{13}{32}$ in. from face of bed, and the face of flange consequently this distance from centre. Thickness of flange, $\frac{3}{16}$ in., and flange under clack-box the same; length of flange being $\frac{1}{2}$ in., and depth, $\frac{5}{16}$ in. The length of pump barrel from commencement of curve in stuffing-box to upper side of first clack-box is $\frac{11}{16}$ in. The diameter of both clack-boxes is $\frac{9}{16}$ in., the length of first one being $\frac{3}{4}$ in., and the second one $\frac{11}{16}$ in., and the top raised $\frac{5}{16}$ in. above the first one, the two being connected by a square piece $\frac{3}{8}$ in. wide and $\frac{3}{8}$ in. deep. This piece is in one casting with pump, and serves as a passage for the water.

The construction and dimensions of the valves and seatings is so clearly shown on the scale drawings that it is not necessary to give sizes here, so a few hints as to how to set about making it will be given.

The box next barrel is first carefully centred at top and bottom, and a full $\frac{3}{16}$-in. hole is to be drilled right through. A large hole of the diameter and depth figured on drawing is then drilled into each end, thus leaving a flat disc in about centre of box. These holes will require to be tapped with a fine thread to size given. On this disc the first delivery-valve is seated. The $\frac{3}{16}$-in. hole in central disc will require to be very carefully smoothed on the upper edge to form a seating for valve. The two caps on top of clack-boxes are as shown, with central pieces projecting inside to regulate lift of valves.

The exact length of these pieces can be determined when valves are in, and should be such as to allow valves to lift not more than $\frac{1}{16}$ in. bare. The suction-valve is prevented from rising too much by a piece of $\frac{1}{16}$-in. brass wire passed through two holes in top of valve-seating piece before it is screwed into clack-box. Construction is shown in details.

The passage from first to second delivery-valves can be made by drilling two holes fully $\frac{1}{8}$ in. diameter through the piece joining the two clack-boxes. They can be drilled from near the top of the first clack-box slightly slanting downwards to the bottom of second box, that is, within $\frac{1}{8}$ in. of the bottom. The second box is then to be centred top and bottom, and a $\frac{3}{16}$-in. hole drilled right through, if it is desired to put a return pipe to pump; if not, to within $\frac{1}{8}$ in. of bottom. This hole must have full communication with the two holes from first box. The top of box is bored out and tapped same as previously described, and a cap fitted to it. The valve-seat is also treated the same.

To connect the delivery-pipe union there is a $\frac{3}{8}$-in. piece cast on the second clack-box close to the top, as shown; this piece has a $\frac{3}{8}$-in. thread on it to take the union, and has a $\frac{3}{16}$-in. hole through it into box. The thread for suction-pipe union is $\frac{7}{16}$-in. diameter.

The bore of suction-pipe of pump is $\frac{1}{4}$ in., and delivery-pipe $\frac{3}{16}$ in. Pipes have collars on end to keep unions on. The connection of pump suction-pipe with tank is made with a union and screw piece, same as to pump, but, of course, without a valve in it. The tap is shown on elevation of tank engine, page 73.

The return tap of pump may be connected to tank by an indiarubber tube stretched over tap, and the tube should be wrapped with wire to secure it to the tap.

Valves are the most likely parts of these pumps to give trouble. The mitre seating cone valves, as shown at Fig. 99, are often considered easier to make than the ball valves illustrated in connection with the pumps for the Launch Engine and Tank Engine previously described. It is not difficult to substitute the one for the other, but balls are the better form, and the method of making these, described on page 106, is really not difficult.

# CHAPTER X.

## *ERECTING A MODEL.*

WHEN all the parts of an engine are made, we can proceed to the pleasantest part of the work, that is, erecting—the technical term for putting together. If the preceding chapters have been read carefully, there will be very little trouble in putting together the Tank Engine described in Chapters VII. and VIII., as the dimensions and drawings were taken from an engine already constructed and working most satisfactorily. All the bright parts must first be polished. The zinc plate is first fitted to the bed, and then the cylinder can be dealt with. The front cover must have a thin layer of red lead spread over the part that fits against cylinder; after which it is bolted to cylinder as firmly as possible, all the lead that squeezes out from between the joint being wiped off, as also any that may chance to have got into the cylinder. The piston and rod—minus the rings and back – are then put in, and the rings sprung into the cylinder, the cuts being at opposite sides. The piston is then pushed up into the rings, and the disc put on and bolted down to it, leaving the rings just free to expand. The back cover of cylinder is then treated with red lead, the same as the front one; but after being forced down as tightly as possible it is taken off again to see that no red lead has got into the cylinder, after which it can be bolted down permanently. The gland on cylinder cover is now to be packed, by wrapping a cord of about eight strands of lamp cotton several times round piston-rod and gradually forcing it into the stuffing-box; and after oiling it, the gland should be tightly bolted down, care being taken that it bears equally on the piston-rod all round. The cross-head is now put on the piston-rod and fixed by the cross key. If all the flange joints are faced up absolutely true, all that will be necessary to make them steam-tight will be to rub them with a little boiled oil before putting together. This, of course, is the best joint, but where it cannot be made, a thin layer of red lead, or disc of brown paper soaked in oil will do. It must not be forgotten to make a hole through the paper to let the steam pass where necessary.

The valve-chest is now to be bolted to the cylinder, the flanges being packed with red lead, and then the cylinder can be bolted to the bed-plate. Two holes will be required in the zinc cover of the tank for the ends of the blow-off cocks —which are already fixed in their places—to project through.

The blow-off cocks are of the shape shown in Figs. 79 and 80, which illustrate sections of the cylinder. It will be seen that one handle opens both cocks at the same time, the plugs of both cocks being connected. The plug of cock in front of cylinder has a rod left on it, as shown, which has a square socket made in the end of it, into which the squared end of the second plug fits. In screwing the taps into the cylinder, the one next to the front has to be put in first, after which screw in the shell of the second one; then put in the plug, first placing the nut and washer in their place on the rod between shell and socket. The nut can be screwed up as the plug comes through shell, while, at the same time, the square on end of plug will slide into the socket. When the cocks are full open, the handle that works them will have to be at an angle of 45° from the vertical, so as to allow of the necessary motion for shutting off. The cylinder lubricator is shown both in Figs. 79 and 80. The lagging for cylinder is best prepared now that it is not liable to get damaged in putting together.

The cylinder is held down by two $\frac{3}{16}$-in. studs and nuts on the outside; but the two studs under valve-chest, instead of having nuts on them, are $\frac{1}{4}$ in. diameter, and have washers and taper pins through them, these being easier to fix than nuts would be in this position, though they are just as effective. Great care must be taken to get cylinder exactly in line with the bed, though it would be difficult to do otherwise if the previous instructions have been followed. The exhaust-pipe connecting elbow will have to be fixed to cylinder before it is bolted down, the joint being made with red lead or brown paper and oil. The lower guide bars and supports are now to be fixed down, and then the small end of connecting-rod and the cross-head, with the cross-head pin through them, are put in their place between the guide blocks, and then the distance pieces and top guide bars are bolted down. The plummer-blocks being bolted down, the crank-shaft in its place, and the caps on, the big end of connecting-rod can be fixed on the crank-pin. The fly wheel may now be fixed, when it can be seen whether the piston, guide blocks, &c., work properly.

At this stage of the work it is necessary to know something of the action of the slide-valve, illustrated at Figs. 104, 105 and 106. The following points should be remembered:—

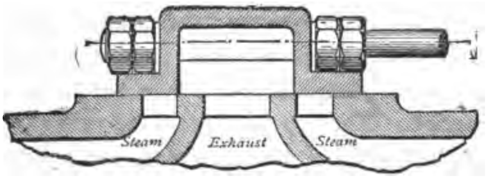


FIG. 104.
Steam-ways in Cylinder.

Lead is the amount of opening which a valve has when the engine is on the centre.

A slide-valve is said to have no lap when the valve will just span the exhaust port and bridges, and the faces just equal the ports in width; when the valve does not bridge the ports it has negative lap (see Fig. 105).

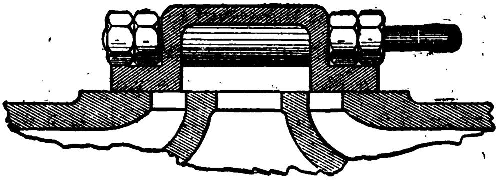


FIG. 105.
Negative lap in Cylinder.

When a slide-valve has neither lap nor lead the eccentric is set at an angle of 90° with the crank on the side toward which the engine is to run. Moving the eccentric forward makes the action of the valve earlier with reference to the crank at all its points.

Moving the eccentric backward makes the action of the valve later with reference to the crank at all its points.

When the face of the valve exceeds the ports in width, the amount which it projects over the edges of the port when in its central position is termed lap. The projection of the outside edge over the port—that is, the edge at which the opening for admission takes place—is called the outside or steam lap; the projection on the inside or exhaust side of the face is called the inside or exhaust lap (see Fig 106).

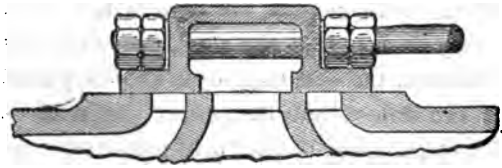


FIG. 106.
Exhaust lap in Cylinder.

When outside lap is added, the eccentric must be set enough further ahead of the crank to take up the lap, so that the valve may be all ready to open when the engine is upon the centre. Usually a little lead is also given in order that the steam may get in and the port be opening as the piston advances. The effect of outside lap is to close the valve earlier and allow the steam to expand. The effect of inside lap is to close the exhaust earlier and introduce compression.

Having a clear idea of the working of the valve, we may proceed to set the eccentric. This is a work requiring great care, so most minute instructions are given how to do it. The slide-valve rod is first to be put in its place in the valve-box. The slide-valve being in the box, with a collar at each end, the rod passes through them. The bracket for valve levers, with the levers in their place, is next bolted down, and the small lever connected to the valve-rod cross-head. The eccentric and strap is next put on the crank-shaft and fixed there—the position does not matter at first—and the eccentric rod is connected to the long valve lever, the eccentric-rod being next the bed-plate, and parallel to it. The crank-shaft is now turned round till the wide side of eccentric is next the cylinder, and then the slide-valve is fixed on its rod in such a position that the back port is open $\frac{1}{8}$ in. Now turn the shaft half round till the wide side of eccentric is furthest from cylinder, and note if the front port is also open $\frac{1}{8}$ in. If both ports open exactly the same amount, the valve is in its right place on rod; if they do not open the same, the valve must be moved a little towards the one most open until they both open the same. The slide-valve is then securely fixed on its rod, after which the eccentric can be fixed in its proper position.

This is done as follows: Turn the crank on its near centre, the piston-rod will be thus into the cylinder as far as possible, then place the eccentric with its widest side down, then keep turning this side round *towards* the cylinder until a strip of writing paper can just be inserted between the valve and the back port. Now fix the eccentric tightly on the shaft by the set screw, then turn the shaft round till the crank is on the other centre, that is, the piston-rod fully out, and note if the strip of paper can just be inserted into the front port. When so, the eccentric is in its proper position, and after working the pointed set screw about a little so as to make a decided mark in the shaft, a small hole should be drilled for the point of screw to go in, and so prevent eccentric shifting. This amount of opening of port before the commencement of the stroke is called the lead, and is for the purpose of checking the momentum of the moving parts, and thus preparing for the return stroke. It is absolutely essential to the silent and good working of all engines, but more particularly of those that run at a high speed.

If the setting of the valve on its rod is carefully done, the lead will be the same at both ends of the stroke. The collars for holding the valve in its place are provided with set screws, as shown on Fig. 81.

The feed-pump is bolted on bed in the position shown on drawing, the plunger being within $\frac{1}{32}$ in. of bottom of barrel, when fully in. The axis of pump is parallel with that of eccentric-rod when in either extremity of its throw. The suction and delivery pipes are connected after pump is fixed. To connect eccentric-rod to pump plunger, it will have to be unbolted from eccentric strap and valve gear and the plunger taken out of pump. The small joint can then be connected to rod and screwed into plunger, the lock nut fixed, and the parts connected up again. The governor pedestal is bolted to bed-plate with four studs and nuts, as shown in Figs. 88 and 89.

The stop-cock and throttle-valve may next be fixed up to cylinder valve-box, the joint being made as described; and connection made between the governors and throttle-valve by the piece of $\frac{3}{32}$-in. steel wire and adjustable screwed joints. The pump and valve-box glands now require to be packed the same as described for cylinder glands. It will be as well to make the joint of valve-box cover with brown paper, as the cover may require to be taken off, and a red lead joint has to be re-made each time it is broken, while a brown paper one does not. The throttle-valve connecting-rod to governors will require to be cranked out a little to meet the crank on valve-spindle (see plan of engine on page 72). The exact length of this rod can only be determined when the engine is under steam. It can be lengthened or shortened by unscrewing or screwing up one of the joints according to the speed at which it is desired the engine should run. Lengthening the rod will cause the engine to run quicker, that is, within certain limits. The driving pulley, and that for the governor, are next to be put on, and the lubricators screwed in (these latter are shown in position on Figs. 71 and 72). The last thing to be done before painting is to lag the cylinder. The lagging may be made of mahogany or rosewood, cut into strips ½ in. wide and ⅛ in. thick. These are got up to as smooth a surface as possible and *oiled:* French polish will not do, as the heat causes it to blister. The engine is now ready for painting—the colour may be according to choice. The parts to be painted are the fly-wheel and driving-pulley spokes, all the bed-plate, with the exception of the tops of the lugs, the body of the pump, recesses in valve-box cover, body of valve-box, guide bars, governor stand, plummer-blocks, etc.; in fact, everything, except those parts which have been got up bright with the file or have been turned.

Before painting, the castings should be trimmed up smooth and well-cleaned by brushing; a coat of lead colour should then be applied. When this is thoroughly dry it should be smoothed with glass-paper, and again painted. These processes may be repeated again before the final coat of colour is applied.

A boiler that would best suit this engine should work safely at 50 lbs or 60 lbs. pressure, and is beyond the power of most amateurs to make. It ought to be vertical, from 20 in. to 24 in. high and 9 in. to 12 in. in diameter, and about 24 tubes ¾ in. diameter through. A boiler this size will make enough steam for all purposes, but if it is only desired to work the engine as a model, a very much less one will do, say about 6 in. diameter by 12 in. high, to burn charcoal as fuel.

## CHAPTER XI.

### *MODEL BOILERS.*

A FEW words on model boilers and their construction will now be advisable. They have been mentioned several times incidentally in the preceding chapters, but, with the exception of the small tin boiler for the oscillating engine described in Chapter III., particulars of their construction have been omitted. It is not an easy task making a steam boiler, and in most cases it will be found cheapest in the end to purchase ready made.

The materials most generally used are brass and copper; sometimes iron, or, what amounts to the same thing, tin-plate, is employed. Brass or copper, from the ease with which they can be manipulated, are the best for a beginner to work on.

Brass can be bought in the form of tube of sufficient size for small models, and strong enough to stand the steam pressure. The edges of the bought tube are brazed together, and thus the joint is made nearly as strong as the other part. The tube is afterwards drawn, and except from a slight discolouration, the joint is not noticeable.

Brass tube, from two inches to six inches in diameter, cut in lengths suited for boilers, is sold by most of the model engineers. The price of the tube ranges from about 2*s.* per foot for the small to about 10*s.* per foot for the large size; the short length necessary for a boiler being charged at about the same proportion. This is merely for the tubular body part of the boiler, and it may be placed vertically or horizontally as required.

The ends or flanges which have to be fitted on are extra pieces. Sometimes a plain disc of metal is fixed by soldering with pewter, but this plan should be strenuously avoided. The ends should at least be brazed on. It is best also to use discs with a rim round them to fit outside the boiler shell. This gives a much stronger hold than is possible with a plain disc of sheet metal.

Castings used for the boiler ends must be quite free from any flaws, as the weak part will be apt to give way under the steam pressure. It is often advisable to use castings, which may be made of a shape exactly suited to certain requirements. An inverted cup-shaped casting for the lower end of a vertical boiler gives a good heating surface. A flue for the chimney must be put in it, and this goes up to the top end of the boiler, which may appropriately be dome-shaped.

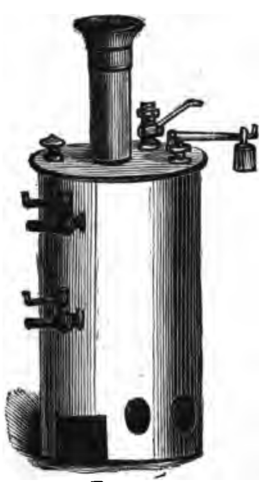


FIG. 107.
Vertical Boiler.

FIG. 108.
Vertical Boiler.

Two vertical boilers of the ordinary type sold at the shops are shown at Figs. 107 and 108.

The flue and both ends of the boiler should be brazed in their places, not soft-soldered. Some prefer to use silver solder for such purposes, and this is an excellent material. When the joints are made to fit properly, as they should do before soldering, only very little solder is required to unite the parts. Borax is used as the flux, both for the alloy employed in brazing and for silver solder. The heat required to flow these properly may be got from an ordinary gas jet, with the burner or nipple removed, using a common blowpipe to urge the flame.

A horizontal boiler is frequently only a plain tube, with ends soldered in, and supported on legs to raise it sufficiently to allow a lamp to be put underneath. The heat applied in this manner does not take effect as it should. The flame is deflected from the surface of the boiler, and, moreover, any breath of wind stirring will blow the flame aside. A plain saddle-shaped boiler is much better; in this form the heating surface is large, and the heat from the furnace is applied to it direct, and cannot well be deflected.

Flues or tubes are very desirable in any form of boiler, and one or the other should be used. The plain straight chimney put through the boiler is the most simple form of flue. If this is of spiral form, like a corkscrew, the effect is infinitely increased, because the heat, instead of ascending straight up through the vertical tube, is met at every turn with a fresh surface of metal. In winding its way through a spiral flue, the heat is absorbed in a way quite unattainable when a straight tube is used. Several small flues are of course better than one large one of the same area. By increasing the number of flues the cost of making a boiler is also increased, and it is to save expense that large flues are used.

Boilers for locomotives, which are required to make steam very fast, have an immense number of flues running through them. The space between the flues, which is occupied by the water, is often very small, and in fact the flues are put as closely together as possible. As the heat rushes through them it is absorbed by the water in contact with the flues, and turns it into steam. The greater the heating surface the more readily is the steam generated.

A boiler suited to the engine shown at Fig. 3, on page 12 is described below by a coppersmith.

Fig. 109 shows boiler quarter-size. It will be seen that

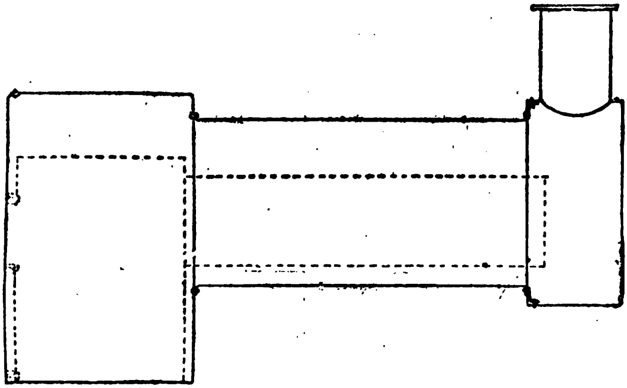


FIG. 109.
Horizontal Boiler.

only one large flue passes from fire-box to smoke-box, instead of a number of small ones. It has been found that for small models, intended to burn charcoal, one large flue gives good results and is much easier to make than one having a number of smaller flues.

The first thing will be to get some sheet copper; those who do not possess the skill to do it themselves may have the boiler brazed together. Others who have not the conveniences for brazing may prefer riveting, but it will be found to take very much longer time. In either case it requires care: in brazing to avoid burning the copper, and on the other hand to keep from bruising the boiler in the process of riveting.

To make that part of boiler that contains fire-box, cut two pieces of the copper 6¼ in. by 4½ in.; this will leave ¼ in. to flange over for riveting. The other plates must be cut as Fig. 110. The oval hole is the fire-hole. The round hole is where the body of boiler fits on. To flange both plates, we require some tinplate workers' tools, but in the absence of these we must get a piece of round iron, 2-in. diam., and square up one end; fix this in vice after having carefully marked the plate all round ¼ in. from edge, lay it on the iron, and, with a hammer, bring the edge over square. It will be better to cut out fire-hole, &c., after the edge is turned over. Now we want another piece 4 in. wide to rivet ends to, and to get the length measure round the edge of one of the plates with a piece of string. This plate must be bent in shape of a U, Fig. 110, and riveted to the two plates. To do this we

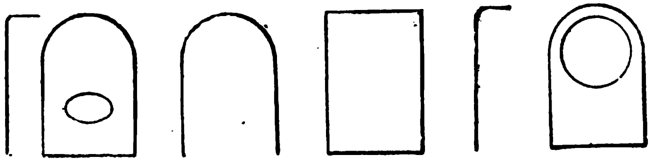


FIG. 110.
Fire-Box and Ends of Boiler.

shall want a riveting stake made round at the end, and some copper rivets $\frac{1}{16}$ thick; they can be made from copper wire, or purchased at the ironmonger's.

It will be best to drill the holes for rivets. Put one at the top and one on each side, near bottom corner; space the holes with a pair of compasses—they may be ⅜ in. apart; rivet with a small hammer, and, for appearance sake, finish with a snap. This tool is made by drilling a conical hole in the end of a piece of steel. To use it, give the rivets a few blows with a hammer, then place on the punch, and strike the end with the hammer until you have a nice conical rivet head. The body of boiler is 7 in. long, and flanged at both ends. The copper must be cut off 7½ in. by 11 in., and bent round, the seam either brazed or riveted, and the flanges at the ends brought out. One end is riveted to the fire-box part, the other carries the tube-plate at smoke-box end. In riveting these parts together, the holes may be counter-sunk on the outside, and the punch or snap dispensed with, as the lagging will cover these rivets. The tube-plate at the end of boiler must be thicker than the rest, and the hole for tube bored out, so that the tube can be nicely driven in. This plate is also flanged to take the smoke-box, which is 2 in. wide by 4½ in ; one end is flanged inwards to form a ledge for fire door. The chimney bottom may be made either from sheet copper or cast brass. The fire-box must be made in the same manner as the boiler, and riveted; one side that the tube fits in must have ¼ in. space left all round for water. A ring is put round the fire-hole, and riveted through. The same with the bottom, only this will want to be square, and made to fit well between boiler and fire-box. The whole is riveted all round. Before putting in the fire-box the hole for tube must be made. It should be screwed with a fine thread, and tube made to fit before putting it together. When all is riveted the joints may be smelted with soft solder, which will make it steam tight.

The sheet copper used for this boiler should be 12 and 16 gauge on the Birmingham plate.

Tubes are often put across the fire-grate; they are then called cross tubes. Two, placed one above the other and crossing each other, will give a large amount of heating surface. By adding this simple contrivance to a vertical boiler with a straight flue it may be made to give off much more steam. One or two cross tubes generally suffice to convert a useless boiler—that is, one that will not generate enough steam—into an effective one.

The fuel used to heat very small boilers is generally spirits of wine. This is put in a suitable receptacle, and burnt through a cotton wick. Several wicks are used in large boilers, and they are placed to heat the largest surface available. Spirit-lamps are a source of danger if proper precautions are not taken. Unless there is a free outlet for the air within the lamp, it will be expanded by the heat, and cause the spirit to rise too quickly in the wick. Sometimes it will overflow, and then it burns wherever it may be. Care must therefore be exercised in using spirit fuel. In model boats it occasionally happens that the spirit overflows, and the boat is all ablaze. An iron tea-tray, or some such utensil, should be used to stand the boiler on when the furnace is to be lighted.

Charcoal is a better fuel when there is sufficient space in the fire-box to contain a supply. The waste steam from the cylinder must always be conveyed to the chimney, and escape up it to make a draft through the fire. Without this it cannot be made to burn sufficiently fierce for the purpose. A charcoal fire will act very well with a little attention, and except for the smallest engines it is always preferable to methylated spirit.

As it is not possible to give any adequate instructions on boiler-making in the limited space at my disposal, the above hints are chiefly intended for the guidance of purchasers.

A safety-valve should always be fitted to a steam boiler. One of the spring valves has been illustrated in the chapter treating of the small oscillating engine. The lever safety-valve is more certain in its action, especially in model work, and is better adapted for stationary purposes. A weighted lever is of no use to a locomotive or marine boiler, as the motion of travelling would disarrange the gear. The safety-valve of every engine should be tested frequently, to make sure that it does not stick in its place and that all works perfectly free.

A glass gauge, by which the height of water may be seen at a glance, is frequently attached to boilers having any pretension to high-class workmanship. There is a good deal of work in a properly made gauge, and the cost is correspondingly high. Two or three stop-cocks are required in a gauge, and these involve good workmanship, or they will not stand the pressure. Leaky taps are a sign of inferior work.

Gauge-cocks are sometimes used instead of the water-gauge just mentioned. These are plain taps with straight noses. Two are wanted on a boiler; they are screwed in, one at high water and the other at low water level. By turning on these taps it is easy to see whether the water is within these limits, but the precise height cannot be ascertained. The gauge-glass is therefore much preferable.

Whistles are fitted to boilers only as ornaments. They are quite useless; as signals, except such as can be given by word of mouth, are not required in working model engines. These attachments are made to sound by allowing the steam to act as the breath does in common whistles.

A chapter is devoted to force-pumps, used to force water into the boiler to make up for that converted into steam, and conveyed through the cylinder. These pumps are actuated by an eccentric on the crank-shaft, and at every revolution of the crank, throw a small quantity of water into the boiler. When we consider how much water is evaporated to make the quantity of steam used for each revolution of the cylinder, we may arrive at an idea of the work required of a force pump. Practically the water to be injected at each stroke is too small to be dealt with, unless a large cylinder has to be supplied.

The only way to work a force-pump for a model satisfactorily is by gearing, so that a stroke of the plunger is performed about once to each hundred revolutions of the crank.

A better plan for feeding small boilers is by hand. The force pump is attached to the boiler in the usual way, but not connected to the engine. The plunger is worked by a hand-lever, and when it is seen that water is wanted in the boiler, a few strokes of the lever will suffice.

Governors are used to control the speed of the engine. Without any such contrivance the engine runs at a speed corresponding to the work it has to do. The heavier the load the slower the speed, and immediately that the load is decreased the speed increases. A governor consists of a pair of balls, which are attached to arms pivoted to an axis revolved by the engine. The faster the speed the greater is the centrifugal force of the balls, and by connecting these with a valve, called a throttle-valve, in the steam-pipe, the supply of steam is reduced as the speed increases. By this means a uniform rate of speed is attained, irrespective of the steam pressure or the duty demanded of the engine.

# CHAPTER XII.

## *MISCELLANEOUS ITEMS*

IN this chapter we have space for some brief notes on those processes incidental to the work already described, which have been mentioned but not explained in previous chapters.

*Drills and Drilling.*—Small drills, those under $\frac{1}{8}$in. diameter are generally made by filing the round steel wire slightly tapering and then spreading the small end with a single blow from a tolerably heavy hammer. Using a light hammer, and spreading by a series of gentle taps, will effectually spoil the steel. There is no occasion to anneal the steel for hammering, providing it is moderately soft. For all drills up to one-eighth of an inch diameter, the steel should not be forged, as the bulk of the metal is too small to heat any predetermined temperature with any degree of certainty. Very small drills can be made from good sewing-needles, which are of convenient form to be readily converted into a drill. Firstly, the needle must be made sufficiently soft for working by heating till it assumes a deep blue colour. The extreme end may be made quite soft, and filed slightly tapering to a trifle less than the size of the hole to be drilled. The point is now spread out by a sharp blow of a hammer—not by a series of gentle taps, which would cause the metal to crack—and filed up to shape. The thickness of the drill across the flattened part should be about a third the diametrical measurement. Finish up the end on a strip of Arkansas stone a file being too coarse for such small work.

Drills should have their cutting ends shaped so that the cutting edges form an angle of from 90° to 120°. The blade of a drill about ⅛in. diameter should be about one-fifth of its diameter at that part where it is widest, and the point should be thinner down to about one-eighth. The thinner the point the easier will the drill enter.

It is the great difficulty of getting such a very small piece of steel to an exact predetermined degree of temperature—hot enough to harden, but not so hot that it is burned—which makes the manufacture of these small tools uncertain; and this is abundantly proved by the fact that of half-a-dozen drills made from the same wire, thereby assuring uniformity of quality in the material, it often happens that some are exceedingly good and others of no use whatever, the difference being caused by the manipulation during hardening. This does not apply to drills or other steel things which are of sufficient size to show, by the colour of their surface, how hot they are; but it is the tiny pieces that are difficult to manage, which, by the contact with the flame, are immediately rendered white hot.

By heating the drill and plunging it into the body of a tallow candle, the hardening will be effected, but the steel will not be rendered so hard that it crumbles away under pressure in use. Thus, in one operation, the drill will be hardened and tempered. Instead of tallow, white wax, sealing wax, and such like materials, are adapted to the purpose. There is another method which finds favour with some: it is to envelop the thin point of the drill in a metal casing, and so get a bulk of metal which can be heated to a nicety, the drill inside being, of course, raised to the same temperature as the surrounding metal. The whole is then plunged into oil or water. Still there is the difficulty of tempering to overcome, though the danger of burning is avoided; burnt steel is of no use for tools. The best plan is to exercise the greatest possible care not to over-heat the drill, and harden and temper in one operation by plunging into tallow

*Filing.*—This is an art not to be learned without considerable practice. The file must be used with long, slow and steady strokes, taken right from point to tang, moderate pressure being brought to bear during the forward stroke. The file must be relieved of all pressure during the return stroke, otherwise the teeth will be liable to be broken off, just in the same manner that the point of a turning tool would be broken if the lathe were turned the wrong way. It is not necessary to lift the file altogether off the work, but it should only have its bare weight pressing during the back stroke. One of the chief difficulties in filing flat is that the arms have a tendency to move in arcs from the joints, but this will be conquered by practice. Work which has been filed up properly will present a flat, even surface, with the file marks running in straight parallel lines. Each stroke of the file will have been made to obtain a like end, but work which has been done by a careless or an inexperienced workman will often bear evidence that each stroke of the file was made without regard to any others, and the surface will be made up of a number of facets, varying in size, shape and position. Those who have never received any practical instruction in the use of files, generally have a bad habit of pressing heavily on the tool, during both forward and backward stroke, and, at the same time, work far too quickly. These habits, combined, will almost invariably spoil whatever is operated on, producing surfaces more or less rounding, but never flat.

The position of the vice at which we are to operate is a most important point to be decided before commencing our filing proper. The vice should be fixed at the correct height, and so that the work held in the jaws will lie level. As to what is really the correct height, some slight difference of opinion exists. This is, probably, owing to the fact that the height of people varies. For filing general work, the top of the vice jaws should be placed so as to be level with the elbow of the workman, which will be found to range from 40in. to 44in. from the floor; therefore 42in. may be considered as an average height best suited for all heights of workmen, when the vice is to be permanently fixed.

If the work to be filed is small and delicate, requiring simply a movement of the arms, or right hand and arm alone, the vice should be higher, not only in order that the workman may more closely scrutinise the work, but that he may be able to stand more erect. If the work to be filed is heavy and massive, requiring great muscular effort, its surface should be below the elbow-joint, as the operator stands further from his work, with his feet separated from 10in. to 30in., and his knees somewhat bent, thus lowering his stature; besides, in this class of work it is desirable to throw the weight of the body upon the file, to make it penetrate, and thus, with a comparative fixedness of the arms, depend largely upon the momentum of the body to drive the file.

Thus, in fixing the height of the vice, the nature of the work and the stature of the operator should be considered. Having the vice fixed properly, the correct position to assume, when filing, is the next consideration. The left foot should be about 6in. to left and 6in. to front of the vice leg; the right foot being about 30in. to front, that is to say, 30in. away from the board in a straight line with the vice post. This position gives command over the work, or, rather, over the tool, and is at once characteristic of a good vice-man. The file must be grasped firmly in the right hand, by the handle.

The operation of filing an iron casting just home from the foundry would be preceded by thoroughly brushing the casting with a hard brush, so as to remove all the loose sand.

Then take an old file and file away steadily at the skin till you come to a surface of pure metal. Having by then removed those parts which spoil files, the old file, with which but slow progress is made, can be changed for a better one. The best, as well as the most economical, will be one which has been used for filing brass till it has become too much blunted for that material. Such a file is in first-class condition for working on cast iron after its sandy skin has been removed, and when worn out on that, it will serve first-rate for steel.

When the object is to remove a mass of metal, the file requires to be as large as can be conveniently handled upon the work. For machinists' use this need not, for the largest work, exceed a 20-in. file, which, to make it bite well and take a fair cut, will require all the power a man can exert continuously. The cut of the file should be, for roughing wrought iron, a bastard cut; for steel, a second cut; and for brass, a rough cut.

To obtain the greatest amount of duty, the file, if a large one, requires applying on the forward stroke with all the power the operator can put on it; while, if a small one, with as much power as can be without danger of breaking the file. The end of the file-handle should rest against the palm of the hand, so that the file is pushed, and not dragged. The left hand must just hold the point of the file lightly, so as to guide it, and, when taking the forward cut, a fairly heavy pressure must be applied, proportionate to the size of the file in use and the work being done.

On the forward stroke, the front foot should be almost entirely relieved of the operator's weight, which will fall on the file; while on the back stroke, the front foot should take most of the weight, so that the file may be relieved. The file strokes should not all be made parallel one to another, but first at one angle and then at another, so that the file marks will cross and recross each other, which enables the tool to cut easier. The speed of the file may be as quick as it can be pushed, providing the file is pressed to the work with all the weight possible, or if a small one, with all its strength will stand.

When it is necessary to file up a small surface—say 2 in. or 3 in. square—the file must be applied in continually changing directions, not always at right angles to chops of the vice. In that case, though the work might be made perfectly straight in that direction, yet there would not be any means of assuring a like result on the part lying parallel to the jaws. When the surface is fairly flat, the file should be applied diagonally both ways; thus any hollow or high places, otherwise unobservable, will be at once seen, without the aid of straight edges. This method of crossing the file cuts from corner to corner is recommended in all cases.

The file should invariably travel right across the work, using the whole length of the file, not only an inch or so as is often the case. When in use the file must be held quite firmly, yet not so rigid that the operator cannot feel the work as it progresses. The sense of touch is brought into use to a far greater extent than the inexperienced would imagine, and a firm grasp of the tool, at the same time preserving a light touch to feel the work, is an essential qualification for a good filer.

For filing to shape, a smaller file must be used, so that even while removing the mass of the metal, the shape of the work can be readily observed by a slight lateral motion of the file, without entirely removing it from the work, or without stopping the file strokes. In filing to fit lies the greatest art of filing, for in this it is necessary that the file be of true outline, and to be so applied that it touches the work at the required spot only.

*Hardening and Tempering Steel.*—If we heat a piece of cast steel to redness and plunge it into clean cold water until its temperature is reduced to that of the water, the result will be that the steel will be hardened. The degree of the hardness will depend upon the quality of the steel, the temperature to which it was heated, and to a small degree upon the temperature of the water in which it was cooled. In any event the operation will be termed "hardening." If we reheat the steel, a softening process will accompany the increasing temperature, until upon becoming again red-hot it will assume its normal softness, and if allowed to cool in the atmosphere the effects of the first hardening will be entirely removed.

The soft steels, approaching more in their nature to wrought iron, are exceedingly difficult to harden and temper to a uniform degree, because of the difficulty experienced in producing them of uniform grade. Many kinds of these steels are made of so low a grade as to make it difficult to determine the line of demarcation separating them from wrought iron.

As a rule, the steel that shows a fracture of fine dull grain, the face of the fracture being comparatively level, is of better quality than that showing a coarse or granulated surface: brightness denoting hardness, and fibrousness toughness.

The higher the grade of steel, the lower the temperature at which it will harden, and the harder it will be if cooled in water from a given temperature.

The part of the tool required to be hardened must be heated through, and heated evenly, but must on no account be overheated. The tool must be finished by sudden cooling, and if this does not give to the steel a fine grain and silky texture—if, after the cooling, were it broken in the hardened part, the fracture should show a coarse grain and dull colour, instead of a fine grain and glossy lustre—the tool is spoiled. The special dangers to be avoided in hardening each kind of tool must be learned by experience. Some tools will warp if they are not plunged into the water in a certain way.

A piece of hardened steel heated slightly, and allowed to cool again, becomes tempered. It suddenly changes from brittle glass to supple whalebone, and in the process of changing its nature, fortunately it changes colour, so that the workman can judge by the hue of the colour the extent of the elasticity which it has acquired, and can give to each tool the particular degree of temper which is most adapted to its special purpose. After the steel is hardened, if we polish one of its surfaces and slowly reheat it, that surface will assume various tints, beginning with a pale yellow and ending in a blue with a green tinge, each colour appearing as the steel attains a definite temperature; by the appearance of the colours we are informed of the temperature of the steel, or in other words, how far, or to what extent the resoftening has progressed.

The various colours which tempered steel successively passes are as follows: straw, gold, chocolate, purple, violet and blue. Of course, in passing from one colour to another, the steel passes through the intermediate tints. It really passes through an infinite series of colours, of which the six above mentioned are arbitrarily selected as convenient stages. The elasticity of tempered steel is acquired at the expense of its hardness. It is supposed that the maximum of hardness and elasticity combined is obtained by tempering down to a straw colour.

In tempering steel, regard must be had to the quality most essential in the special tool to be tempered. A turning tool may be required to be very hard, and is often taken out of the water hot enough to temper itself down to a degree so slight that no colour is perceptible, whilst a spring is required to be very elastic, and may be tempered down to a blue.

*Lacquering.*—Properly-lacquered brass work will retain its colour, and resist the action of the atmosphere for a long time, hence the practice of always lacquering work which should retain a good appearance. The process is rather difficult to execute on large surfaces, where the tyro will find the lacquer continually getting a smeary look.

The process is only to preserve the bright surface of the metal by coating it with a layer of varnish. The colour of this varnish may be modified to suit the work to which it has to be applied. Lacquer contains either seed-lac or shell-lac, hence its name. Seed-lac is the gum in its original form, and when it has been purified and prepared by moulding into thin sheets it is called shell-lac. This material may be bleached so as to become almost colourless; but in that condition it is not so strong or effective for lacquering purposes. With regard to applying the lacquer, it should be understood that much depends on the condition of the work. Perfect cleanliness and a tolerable polish are necessary to insure a successful application of the lacquer. The work must be heated to about the temperature of boiling water before lacquering, and this must be laid on evenly with a camel-hair brush.

With regard to the lacquer itself, a good pale gold lacquer is made by dissolving 5oz. of seed-lac in half a gallon of methylated spirits, and then adding a small quantity—less than half an ounce—of red sanders: yellow is made by mixing turmeric with lac varnish; deep gold is made with dragon's blood and lac varnish; red contains a larger proportion of dragon's blood. Lacquers suffer a chemical change through heat and light, and for this reason must be kept in a cool place, and away from the light. The brushes used should always be carefully washed out in methylated spirits, and be kept scrupulously clean.

Lacquering is done in two ways, called cold lacquering and hot lacquering. By the former, a little lacquer being taken on a common camel-hair brush is laid carefully and evenly over the work, which is placed in an oven or on a hot stove; the heat from this continued only a minute or two is sufficient to set the lacquer, and the work is finished. Care must be taken not to have the work too hot so as to burn the lacquer, nor yet too cold, for in this case the lacquer will not be thoroughly set. By the second method, the work is heated first to about the temperature of boiling water, and the lacquer quickly brushed over it in this state, the work being afterwards placed in an oven for a minute or so. If very small, the article will require this, because it will have parted with most of its heat to the lacquer; if heavy, it will retain sufficient to perfect the process without being placed in the oven. The greatest difficulty is to know the exact degree of heat, and this knowledge is only attained by experience—so different is the nature of the materials, the quality of the different lacquers, and the effect to be produced. When work is newly lacquered the lacquer is soft, and the work ought to be exposed to a gentle heat for a short time to evaporate the alcohol and harden the lacquer. Small gas cooking-stoves are very suitable for this purpose, and it will be found that after newly lacquered work has been baked for a short time, any little unevenness in the laying on the lacquer will be much improved.

*Soldering and Brazing.*—In using ordinary "soft" or pewter solder for uniting surfaces that are already tinned—such as tinned iron plate and tinned copper—resin is the best and cheapest flux; but when surfaces of iron, brass, or copper, that have not been tinned are to be joined by soft solder, soldering fluid is by far the most convenient flux. Resin possesses this important advantage over soldering fluid, that it does not induce subsequent corrosion of the article to which it is applied. When acid fluxes have been applied to anything that is liable to rust, it is necessary to see that they are thoroughly washed off with clean warm water, and the articles carefully and thoroughly dried. Oil and powdered resin mixed together make a good flux for tinned articles. The mixture can be applied with a small brush, or a swab tied to the end of a stick.

For soft solders, the best flux is a soldering fluid which may be prepared by saturating hydrochloric acid with zinc. The addition of a little salammoniac improves it. To prepare this, put ½ pint of muriatic acid (also called spirits of salts and hydrochloric acid) into a glass, and add small pieces of clean zinc, which will be dissolved by the acid. Let it stand for several hours, till the acid has ceased to act; then add a small quantity of water—say a wine-glass full—when ebullition will re-commence. Let it stand undisturbed for a few hours, and again add a small quantity of water. Continue this until the quantity of water added equals that of the acid (½ pint). When all action has ceased, add 1 oz. of salammoniac; let it stand 12 hours, then decant the clear liquid into a bottle, which should be kept well fastened when not in use. Throw away the sediment. A solution of phosphoric acid in alcohol makes, it is said, an excellent soldering fluid, which has some advantages over chloride of zinc.

When uniting work of copper, iron, brass, etc., the solder generally used is a fusible brass, and the process is called brazing. The work to be soldered is prepared by filing or scraping perfectly clean the edges or parts to be united. The joints are then put into proper position and bound securely together with binding wire or clamps; the granulated spelter solder and powdered borax are mixed in a cup with a very little water and spread with a strip of sheet metal or a small spoon along the joint to be united. The work is then placed upon a clear fire and heated gradually to evaporate the water used with the solder and borax, and also to drive off the water contained in the crystallised borax, which causes it to boil up with a frothy appearance. If the work is heated hastily the boiling of the borax may displace the solder, and for this reason it is better to roast the borax before mixing with the solder. When the borax ceases to boil the heat is then increased, and when the metal becomes a faint red the borax fuses like glass, and shortly after, as the heat of the metal is increased to a bright red, the solder also fuses, which is indicated by a small blue flame, from the burning of the zinc. Just at this time the work should be jarred slightly by being tapped lightly with the poker or hammer, to put the solder in vibration and cause it to run into the joint. For some work there is no necessity to tap it, for the solder is absorbed into the joint without.

# INDEX.

PRINTED BY H. VIRTUE AND COMPANY, LIMITED, CITY ROAD, LONDON.

# CROSBY LOCKWOOD & SON'S

## Catalogue of

# Scientific, Technical and Industrial Books.



## 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 . . . . . . . . . . . . . **6/0**

SUMMARY OF CONTENTS:—MATHEMATICAL TABLES.—MEASUREMENT OF SURFACES AND SOLIDS.—ENGLISH AND FOREIGN WEIGHTS AND MEASURES.—MONEYS.—SPECIFIC GRAVITY, WEIGHT, AND VOLUME.—MANUFACTURED METALS.—STEEL PIPES.—BOLTS AND NUTS.—SUNDRY ARTICLES IN WROUGHT AND CAST IRON, COPPER, BRASS, LEAD, TIN, ZINC.—STRENGTH OF TIMBER.—STRENGTH OF CAST IRON.—STRENGTH OF WROUGHT IRON.—STRENGTH OF STEEL.—TENSILE STRENGTH OF COPPER, LEAD, &c.—RESISTANCE OF STONES AND OTHER BUILDING MATERIALS.—RIVETED JOINTS IN BOILER PLATES.—BOILER SHELLS.—WIRE ROPES AND HEMP ROPES.—CHAINS AND CHAIN CABLES.—FRAMING.—HARDNESS OF METALS, ALLOYS, AND STONES.—LABOUR OF ANIMALS.—MECHANICAL PRINCIPLES.—GRAVITY AND FALL OF BODIES.—ACCELERATING AND RETARDING FORCES.—MILL GEARING, SHAFTING, &c.—TRANSMISSION OF MOTIVE POWER.—HEAT.—COMBUSTION: FUELS.—WARMING, VENTILATION, COOKING STOVES.—STEAM.—STEAM ENGINES AND BOILERS.—RAILWAYS.—TRAMWAYS.—STEAM SHIPS.—PUMPING STEAM ENGINES AND PUMPS.—COAL GAS, GAS ENGINES, &c.—AIR IN MOTION.—COMPRESSED AIR.—HOT AIR ENGINES.—WATER POWER.—SPEED OF CUTTING TOOLS.—COLOURS.—ELECTRICAL ENGINEERING.

"Mr. Clark manifests what is an innate perception of what is likely to be useful in a pocket-book, 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 no 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 wearisome 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 Engineer.*

## 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 very 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."—*Mechanical 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 WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook for Engineers," &c. With upwards of 420 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 420 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."—*Athenæum.*

"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 engineering."—*Scotsman.*

"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 this 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 in simple language, and in such a form that it can be 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."—*English Mechanic.*

## MR. HUTTON'S PRACTICAL HANDBOOKS—*continued.*

## STEAM BOILER CONSTRUCTION.

A Practical Handbook for Engineers, Boiler-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, viz.:*—"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."—*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 libraries of every one interested in boiler using or boiler manufacture if they wish to be thoroughly informed. 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**

"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 vain in other works. This modernised edition will be appreciated by all who have learned to 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, millwrights, 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.*

"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 'drawer' of every mechanic."—*English Mechanic.*

## THE MECHANICAL ENGINEER'S REFERENCE BOOK.

For Machine and Boiler Construction. In Two Parts. Part I. GENERAL 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 . **£3 3s.**

PART I.—MEASURES.—CIRCUMFERENCES AND AREAS, &c., SQUARES, CUBES, FOURTH POWERS.—SQUARE AND CUBE ROOTS.—SURFACE OF TUBES.—RECIPROCALS.—LOGARITHMS. — MENSURATION. — SPECIFIC GRAVITIES AND WEIGHTS.—WORK AND POWER. — HEAT. — COMBUSTION. — EXPANSION AND CONTRACTION. — EXPANSION OF GASES.—STEAM.— STATIC FORCES.— GRAVITATION AND ATTRACTION.—MOTION AND COMPUTATION OF RESULTING FORCES.—ACCUMULATED WORK.—CENTRE AND RADIUS OF GYRATION.—MOMENT OF INERTIA.—CENTRE OF OSCILLATION.—ELECTRICITY.—STRENGTH OF MATERIALS.—ELASTICITY.—TEST SHEETS OF METALS.—FRICTION.—TRANSMISSION OF POWER.—FLOW OF LIQUIDS.—FLOW OF GASES.—AIR PUMPS, SURFACE CONDENSERS, &c.—SPEED OF STEAMSHIPS.—PROPELLERS.—CUTTING TOOLS.—FLANGES.—COPPER SHEETS AND TUBES.—SCREWS, NUTS, BOLT HEADS, &c.—VARIOUS RECIPES AND MISCELLANEOUS MATTER.—WITH DIAGRAMS FOR VALVE-GEAR, BELTING AND ROPES, DISCHARGE AND SUCTION PIPES, SCREW PROPELLERS, AND COPPER PIPES.

PART II.—TREATING OF POWER OF BOILERS.— USEFUL 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 SPEEDS 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.

With Appendix describing a Recent Engine with Tube Igniter. By T. M. GOODEVE, M.A. Crown 8vo, cloth . . . . . . . . . **2/6**

"Like all Mr. Goodeve's writings, the present is no exception in point of general excellence It is a valuable little volume."—*Mechanical 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* **8/6**

## A TREATISE ON STEAM BOILERS.

Their Strength, Construction, and Economical Working. By R. WILSON, C.E. Fifth Edition. 12mo, cloth . . . . . . . . . **6/0**

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

"The author shows himself perfect master of his subject, and we heartily 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.C.E. 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 HAEDER, 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 . . . . . . . . . . . . . . **9/0**

"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. Crown 8vo, cloth . . . . . . . . . . . . **3/6**

"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.
[*Just 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 1902.

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 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. [*Just Published. Net* **25/0**

"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."—*Journal 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."—*Builder.*

"We accord the work unqualified praise. The information is given in a plain, straightforward manner, and bears throughout evidence of the intimate practical acquaintance of the author with every phase of commercial engineering."—*Mechanical World.*

## AERIAL OR WIRE-ROPE TRAMWAYS.

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

"This is in its way an excellent volume. Without going into the minutiæ 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 hitherto received much attention from those qualified to deal with it in a satisfactory manner."—*Mechanical 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 486 Illustrations. Crown 8vo, cloth . . . *Net* **7/6**

"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."—*Builder.*

"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, Pattern Shop, Foundry, Fitting, Turning, Smiths', and Boiler Shops, &c. Comprising upwards of 6,000 Definitions. Edited by J. G. HORNER, A.M.I.M.E. Third Edition, Revised. Crown 8vo, cloth . . . . . *Net* **7/6**

"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 . . . **6/0**

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

## FIRES, FIRE-ENGINES, AND FIRE BRIGADES.

With a History of Fire-Engines, their Construction, Use, and Management; Foreign Fire Systems; Hints on Fire-Brigades, &c By CHARLES F. T. YOUNG, C.E. 8vo, cloth . . . . . . . . . **£1 4s.**

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

## AËRIAL NAVIGATION.

A Practical Handbcok on the Construction of Dirigible Balloons, Aëıostats, Aërop'anes, and Aëremotors. By FREDERICK WALKER, C.E., Associate Member of the Aëronautic Institute. With 104 Illustrations. Large Crown 8vo, cloth. [*Just Published. Net.* **7/6**

## STONE-WORKING MACHINERY.

A Manual dealing with the Rapid and Economical Conversion of Stone. With Hints on the Arrangement and Management of Stone Works. By M. POWIS BALE, M.I.M.E. Second Edition, enlarged. Crown 8vo, cloth . . **9/0**

"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."—*Industries.*

## 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."—*Engineering.*

"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."—*Engineer.*

## 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."—*Mechanical World.*

"It is a complete compendium of all the details of the screw-cutting lathe; in fact a *multum-in-parvo* 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, FORMULÆ, and MEMORANDA. Waistcoat-pocket size, limp leather. [*Just Published.* **1/6**

"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 waistcoat-pocket 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 dimensions 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 so 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."—*Mechanical World*

## THE ENGINEER'S YEAR BOOK FOR 1902.

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.* **8/0**

"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 Engineer.*

"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."—*Scotsman.*

"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 Herald.*

## THE PORTABLE ENGINE.

A Practical Manual on its Construction and Management. For the use of Owners and Users of Steam Engines generally. By WILLIAM DYSON WANSBROUGH. Crown 8vo, cloth . . . . . . . . . **3/6**

"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 HOARE, 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."—*English 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 formulæ again."—*Marine Engineer.*

## THE SAFE USE OF STEAM.

Containing Rules for Unprofessional Steam Users. By an ENGINEER. Seventh Edition. Sewed . . . . . . . . . . . . **6D.**

"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 WEATHERBURN, 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.—CHIMNEY.—WEATHER BOARD AND AWNING.—INTERNAL DISSENSIONS.—ENGINE DRIVERS, &c.

"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 1896. 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 . . . . . . **4/6**

"Mr. Reynolds has supplied a want, and has supplied it well. We can confidently 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."—*Athenæum.*

## 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 Mechanic.*

"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."—*Iron.*

## CONTINUOUS RAILWAY BRAKES.

A Practical Treatise on the several Systems in Use in the United Kingdom: their Construction and Performance. With copious Illustrations and numerous Tables. By MICHAEL REYNOLDS. 8vo, cloth . . . . . . **9/0**

"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.

A Practical Manual or Engineers in Charge ot Stationary Engines. By MICHAEL REYNOLDS. Sixth Edition. Crown 8vo, cloth . . . **4/6**

"The author is thoroughly acquainted with his subjects, and his advice on the various points treated is clear and practical. . . . He has produced a manual which is an exceedingly useful one for the class for whom it is specially intended."—*Engineering.*

"Our author leaves no stone unturned. He is determined that his readers shall not only know something about the stationary engine, but all about it."—*Engineer.*

## ENGINE-DRIVING LIFE.

Stirring Adventure and Incidents in the Lives ot 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 REYNOLDS. 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**

"Mr. Mackay's volume is clearly and concisely written, admirably arranged, and freely illustrated. The book is exactly what has been long wanted. We recommend it to all interested in the subject. It is sure to have a wide sale."—*Railway News.*

## TUNNELLING.

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

## 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 (1895) 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.'"—*Architect.*

## THE WATER SUPPLY OF TOWNS AND THE CONSTRUCTION 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**

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—WATER TOWERS—STAND PIPES.—XV. THE CONNECTION OF SETTLING RESERVOIRS, FILTER BEDS AND SERVICE RESERVOIRS.—XVI. 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.

APPENDIX I. By PROF. JOHN MILNE, R.S.—CONSIDERATIONS CONCERNING THE PROBABLE EFFECTS OF EARTHQUAKES ON WATER-WORKS, AND THE SPECIAL PRECAUTIONS 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 illustrated. . . . 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."—*Saturda 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 half-bound in morocco . . . . . . . . . *Net* **£6 6s.**

List of Contents.

I. Historical Sketch of some of the means that have been adopted for the Supply of Water to Cities and Towns.—II. Water and the Foreign Matter usually associated with it.—III. Rainfall and Evaporation.—IV. Springs and the Water-bearing Formations of various Districts.—V. Measurement and Estimation of the Flow of Water.—VI. On the Selection of the Source of Supply.—VII. Wells.—VIII. Reservoirs.—IX. The Purification of Water.—X. Pumps.—XI. Pumping Machinery.—XII. Conduits.—XIII. Distribution of Water.—XIV. Meters, Service Pipes, and House Fittings.—XV. The Law of Economy of Water-works.—XVI. Constant and Intermittent Supply.—XVII. Description of Plates.—Appendices, giving Tables of Rates of Supply, Velocities, &c., &c., together with Specifications of several Works illustrated, among which will be found: Aberdeen, Bideford, Canterbury, Dundee, Halifax, Lambeth, 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 treatises."—*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. [*Just Published.* **5/0**

"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."—*Builder.*

"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 Sliding Surfaces.—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 Turbines.—Design of Turbines.—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 . . . . . . **16/0**

"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 . **7/6**

"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.

A Handbook for Engineers, Landed Proprietors, and others interested in Works of Reclamation. By ALEXANDER BEAZELEY, M.Inst. C.E. With Illustrations. 8vo, cloth. [*Just Published. Net* **10/6**

"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 of 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 . . . . . . . . . . . . **7/6**

"We recommend all interested in harbour works—and, indeed, those concerned in the improvements 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 and the Office, intended also as a Text-book for Students. By JOHN WHITELAW, Jun., A.M. Inst. C.E., Author of "Points and Crossings." With about 260 Illustrations. Demy 8vo, cloth. [*Just Published. Net* **10/6**

## 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 **7/6**; or, on THIN PAPER, leather, gilt edges, for pocket use. . . . . . . . . . . **12/6**

"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.

For Reference in Surveying, Levelling, and Setting-out; and in Route Surveys of Travellers by Land and Sea. With Tables, Illustrations, and Records. By LOWIS D'A. JACKSON, A.M.I.C.E. 8vo, cloth . . . . . **12/6**

"A valuable *vade-mecum* for the surveyor. We recommend this book as containing an admirable supplement to the teaching of the accomplished surveyor."—*Athenæum.*

"The author brings to his work a fortunate union of theory and practical experience which, aided by a clear and lucid style of writing, renders the book a very useful one."—*Builder.*

## SURVEYING WITH THE TACHEOMETER.

A practical Manual for the use of Civil and Military Engineers and Surveyors. Including 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 use of Theodolite for Traverse Surveying and plotting the work with minute accuracy by means of Straight Edge and Set Square only; Levelling with the Theodolite, Setting-out Curves with and without the Theodolite, Earthwork Tables, &c. By W. DAVIS HASKOLL, C.E. With numerous Woodcuts. Fourth Edition, Enlarged. Crown 8vo, cloth . . . . . . **12/0**

"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."—*Athenæum.*

## LAND AND MARINE SURVEYING.

In Reference to the Preparation of Plans for Roads and Railways; Canals, Rivers, Towns' Water Supplies; Docks and Harbours. With Description and Use of Surveying Instruments. By W. DAVIS HASKOLL, C.E. Second Edition, Revised, with Additions. Large crown 8vo, cloth . . . **9/0**

"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.

Showing its Application to Purposes of Railway and Civil Engineering in the Construction of Roads; with Mr. TELFORD'S Rules for the same. By FREDERICK W. SIMMS, F.G.S., M. Inst. C.E. Eighth Edition, with the addition of LAW'S Practical Examples for Setting-out Railway Curves, and TRAUTWINE'S Field Practice of Laying-out Circular Curves. With 7 Plates and numerous Woodcuts, 8vo, cloth . . . . . . . . . . **8/6**

*** TRAUTWINE on CURVES may be had separate . . . . . **5/0**

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

"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."—*Engineering.*

## 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, Formulæ, 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 additions 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. [*Just Published.* **3/6**

"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."—*Athenæum.*

## 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 a Sheet mounted in cloth case. [*Just Published.* **3/6**

## EARTHWORK TABLES.

Showing the Contents in Cubic Yards of Embankments, Cuttings, &c., of Heights or Depths up to an average of 80 feet. By JOSEPH BROADBENT, C.E., and FRANCIS CAMPIN, C.E. Crown 8vo, cloth . . . . . . **5/0**

"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."—*Athenæum.*

## A MANUAL ON EARTHWORK.

By ALEX. J. S. GRAHAM, C.E. With numerous Diagrams. Second Edition. 18mo, cloth . . . . . . . . . . . . . . . **2/6**

## 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 observations on the form of arch, the rules for ordering the stone, and the construction of the templates, will be found of considerable use. We commend the book to the engineering profession."—*Building 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 115 Double Plates (20 of which now first appear in this edition), and numerous Additions to the Text. In 2 vols., imp. 4to, half-bound in morocco . . . . . . . . . . . . . **£6 16s. 6d.**

"A very valuable contribution to the standard literature of civil engineering. In addition to elevations, plans, and sections, large scale details are given, which very much enhance the instructive worth of those illustrations."—*Civil Engineer and Architect's Journal.*

"Mr. Humber's stately volumes, lately issued—in which the most important bridges erected 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.*

## 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. Royal 8vo, cloth . . . . . . . . . . . . . **12/0**

"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."—*Building News.*

## THE CONSTRUCTION OF OBLIQUE ARCHES

(A Practical Treatise on). By JOHN HART. Third Edition, with Plates. Imperial 8vo, cloth . . . . . . . . . . . . **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."—*Athenæum.*

## WEIGHTS OF WROUGHT IRON & STEEL GIRDERS.

A Graphic Table for Facilitating the Computation of the Weights of Wrought Iron and Steel Girders, &c., for Parliamentary and other Estimates. By J. H. WATSON BUCK, M. Inst. C.E. On a Sheet . . . . **2/6**

## PRACTICAL GEOMETRY.

For the Architect, Engineer, and Mechanic. Giving Rules or the Delineation and Application of various Geometrical Lines, Figures, and Curves. By E. W. TARN, M.A., Architect. 8vo, cloth . . . . . . . **9/0**

"No book with the same objects in view has ever been published in which the clearness of the rules laid down and the illustrative diagrams have been so satisfactory."—*Scotsman.*

## THE GEOMETRY OF COMPASSES.

Or, Problems Resolved by the mere Description of Circles and the Use of Coloured Diagrams and Symbols. By OLIVER BYRNE. Coloured Plates. Crown 8vo, cloth . . . . . . . . . . . . . **3/6**

## HANDY BOOK FOR THE CALCULATION OF STRAINS

In Girders and Similar Structures and their Strength. Consisting of Formulæ and Corresponding Diagrams, with numerous details for Practical Application, &c. By WILLIAM HUMBER, A. M. Inst. C.E., &c. Fifth Edition. Crown 8vo, with nearly 100 Woodcuts and 3 Plates, cloth . . . **7/6**

"The formulæ are neatly expressed, and the diagrams good."—*Athenæum.*

"We heartily commend this really *handy* book to our engineer and architect readers."—*English Mechanic.*

## 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. **4/6**

"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.

With Practical Remarks on Iron Construction. By F. W. SHEILDS, M.I.C.E. 8vo, cloth . . . . . . . . . . . . . . . **5/0**

## 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 WM. HUMBER, A. M. Inst. C.E. 8vo, cloth . . . . . . . . . . . **18/0**

"Valuable alike 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 Treatise on Railway Accidents, their Cause and Prevention; with a Description of Modern Appliances and Systems. By CLEMENT E. STRETTON, C.E., Vice-President and Consulting Engineer, Amalgamated Society of Railway Servants. With Illustrations and Coloured Plates. Third Edition, Enlarged. Crown 8vo, cloth . . . . . . . . . . **3/6**

"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.

By JOHN KEILY, C.E., late of the Indian Public Works Department. Crown 8vo, cloth . . . . . . . . . . . . . . **3/6**

"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."—*Builder.*

## THE PROGRESS OF MODERN ENGINEERING.

Complete in Four Volumes, imperial 4to, half-morocco, price **£12 12s.**
Each volume sold separately, as follows:—

FIRST SERIES, Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, &c. By WILLIAM HUMBER, A. M. Inst. C.E., &c. Imp. 4to, with 36 Double Plates, drawn to a large scale, Photographic Portrait of John Hawkshaw, C.E., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . **£3 3s.**

LIST OF THE PLATES AND DIAGRAMS.

VICTORIA STATION AND ROOF, L. B. & S. C. R. (8 PLATES); SOUTHPORT PIER (2 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, AVON (3 PLATES); UNDERGROUND RAILWAY (3 PLATES).

## HUMBER'S MODERN ENGINEERING.

SECOND SERIES. Imp. 4to, with 3 Double Plates, Photographic Portrait of Robert Stephenson, C.E., M.P., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . . . . . . **£3 3s.**

LIST OF THE PLATES AND DIAGRAMS.

BIRKENHEAD DOCKS, LOW WATER BASIN (15 PLATES); CHARING CROSS STATION ROOF, C. C. RAILWAY (3 PLATES); DIGSWELL VIADUCT, GREAT NORTHERN RAILWAY; ROBBERY WOOD VIADUCT, GREAT NORTHERN RAILWAY; IRON PERMANENT WAY; CLYDACH VIADUCT, MERTHYR, TREDEGAR, AND ABERGAVENNY RAILWAY; EBBW 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 (4 PLATES).

## HUMBER'S MODERN ENGINEERING.

THIRD SERIES. Imp. 4to, with 40 Double Plates, Photographic Portrait of J. R. M'Clean, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . . . . . . . . **£3 3s.**

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 MARSH LANE, NORTH WOOLWICH RAILWAY, AND BOW AND BARKING RAILWAY JUNCTION; OUTFALL SEWER, BRIDGE OVER BOW AND BARKING RAILWAY (3 PLATES); OUTFALL SEWER, BRIDGE OVER EAST LONDON WATER-WORKS' FEEDER (2 PLATES); OUTFALL SEWER RESERVOIR (2 PLATES); OUTFALL SEWER, TUMBLING BAY AND OUTLET; OUTFALL SEWER, PENSTOCKS. *South Side.*—OUTFALL SEWER, BERMONDSEY BRANCH (2 PLATES); OUTFALL SEWER, RESERVOIR AND OUTLET (4 PLATES); OUTFALL SEWER, FILTH HOIST; SECTIONS OF SEWERS NORTH AND SOUTH SIDES).

THAMES EMBANKMENT.—SECTION OF RIVER WALL; STEAMBOAT PIER, WESTMINSTER (2 PLATES); LANDING STAIRS BETWEEN CHARING CROSS AND WATERLOO BRIDGES; YORK GATE (2 PLATES); OVERFLOW AND OUTLET AT SAVOY STREET SEWER (3 PLATES); STEAMBOAT PIER, WATERLOO BRIDGE (3 PLATES); JUNCTION OF SEWERS, PLANS AND SECTIONS; GULLIES, PLANS AND SECTIONS; ROLLING STOCK; GRANITE 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 . . . . . . . . . **£3 3s.**

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 (2 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, CORNWALL RAILWAY (2 PLATES); WROUGHT-IRON CYLINDER FOR DIVING BELL MILLWALL DOCKS (6 PLATES); MILROY'S PATENT EXCAVATOR; METROPOLITAN DISTRICT RAILWAY (6 PLATES); HARBOURS, PORTS, 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**

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 OF SHIP'S HULL.—STABILITY CURVES AND METACENTRES.—SEA AND SHALLOW-WATER WAVES.—ROLLING 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 OF SHAFTING, PILLARS, WHEELS, &c. —HYDRAULIC DATA, &c.—CONIC SECTIONS, CATENARIAN CURVES.—MECHANICAL POWERS, 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 VESSELS.—SHIPS' FITTINGS AND TESTS.—SEASONING PRESERVING TIMBER.—MEASUREMENT OF TIMBER.—ALLOYS, PAINTS, VARNISHES.—DATA FOR STOWAGE.—ADMIRALTY TRANSPORT REGULATIONS.—RULES FOR HORSE-POWER, SCREW PROPELLERS, &c.—PERCENTAGES FOR BUTT STRAPS, &c.—PARTICULARS OF YACHTS.—MASTING AND RIGGING VESSELS.—DISTANCES OF FOREIGN PORTS.—TONNAGE TABLES.—VOCABULARY OF FRENCH AND ENGLISH TERMS.—ENGLISH WEIGHTS AND MEASURES.—FOREIGN WEIGHTS AND MEASURES.—DECIMAL EQUIVALENTS.—FOREIGN MONEY.—DISCOUNT AND WAGES TABLES.—USEFUL NUMBERS AND READY RECKONERS.—TABLES OF CIRCULAR MEASURES.—TABLES OF AREAS OF AND CIRCUMFERENCES OF CIRCLES.—TABLES OF AREAS OF SEGMENTS OF CIRCLES.—TABLES OF SQUARES AND CUBES AND ROOTS OF NUMBERS.—TABLES OF LOGARITHMS OF NUMBERS.—TABLES OF HYPERBOLIC LOGARITHMS.—TABLES OF NATURAL SINES, TANGENTS, &c.—TABLES OF LOGARITHMIC SINES, TANGENTS, &c.

"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."—*Nautical 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 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 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 8vo, 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."—*Engineer.*

## 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, Shipowners, 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 . **1/6**

"Contains much valuable information for the class for whom it is intended, especially in the chapters on the management of boilers and engines."—*Nautical Magazine.*

## 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.

Consisting of THE SAILOR'S SEA-BOOK, by JAMES GREENWOOD and W. H. ROSSER; together with the exquisite Mathematical and Nautical Tables for the Working of the Problems, by HENRY LAW, C.E., and Professor J. R. YOUNG. Illustrated. 12mo, strongly half-bound . . . . . . **7/0**

## THE ART AND SCIENCE OF SAILMAKING.

By SAMUEL B. SADLER, Practical Sailmaker, late in the employment of Messrs. Ratsey and Lapthorne, of Cowes and Gosport. With Plates and other Illustrations. Small 4to, cloth . . . . . . . . . **12/6**

"This extremely practical work gives a complete education in all the branches of the manufacture, cutting out, roping, seaming, and goring. It is copiously illustrated, and will form a first-rate text-book and guide."—*Portsmouth 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, cloth, bevelled boards . . . . . . . . . . . . **£2 2s.**

"It contains a vast amount of valuable information. Nothing seems to be wanting to make it a complete and standard work of reference on the subject."—*Nautical 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 8vo, 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 standpoint 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."—*Mining Journal.*

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

## PROSPECTING FOR GOLD.

A Handbook of Information and Hints for Prospectors based on Personal Experience. By DANIEL 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**

"This book thoroughly deserves its title of a 'Practical Treatise.' The whole process of gold milling, from the breaking of the quartz to the assay of the bullion, is described in clear and orderly narrative 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 Journal.*

## THE CYANIDE PROCESS OF GOLD EXTRACTION.

Including its Practical Application on the Witwatersrand Gold Fields and elsewhere. By M. EISSLER, M.E. With Diagrams and Working Drawings. Third Edition, Revised and Enlarged. 8vo, cloth . . . *Net* **7/6**

"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 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 eminently practical data, which should be in the possession of those interested in mining."—*Mining Journal.*

## 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 Journal.*

"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. . **4/6**

"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."—*Engineer.*

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

## 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 . . . . . . . . . . . . . **10/6**

"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."—*Mining Journal.*

"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."—*Glasgow 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* **12/6**

## 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."—*Athenæum.*

## 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, 600 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 the woodcuts and plates are good."—*Athenæum.*

"From cover to cover the work exhibits all the same characteristics which excite the confidence and attract the attention 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."—*Mining 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 ROBERT HUNT, F.R.S., late Keeper of Mining Records. Upwards of 950 pp., with 230 Illustrations. Second Edition, Revised. Super-royal 8vo, cloth **£2 2s.**

"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."—*Athenæum.*

## 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."—*Athenæum.*

## 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 . . **16/0**

## 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.—PUMP VALVES.—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 . . . . . . . . . . . . **£1 5s.**

SUMMARY OF CONTENTS:—GEOLOGY.—SEARCH FOR COAL.—MINERAL LEASES AND OTHER HOLDINGS.—SHAFT SINKING.—FITTING UP THE SHAFT AND SURFACE ARRANGEMENTS.—STEAM BOILERS AND THEIR FITTINGS.—TIMBERING AND WALLING.—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.—SAFETY LAMPS AND FIREDAMP DETECTORS.—SUNDRY AND INCIDENTAL OPERATIONS AND APPLIANCES.—COLLIERY EXPLOSIONS.—MISCELLANEOUS QUESTIONS AND ANSWERS.—*Appendix:* SUMMARY OF REPORT OF H.M. COMMISSIONERS ON ACCIDENTS IN MINES.

"Mr. Pamely has not only given us a comprehensive reference book of 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 machines 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 28 Plates and other Illustrations, including Underground Photographs. Medium 8vo, cloth. [*Just Published.* **15/0**

"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 photographs are an attractive feature of the work, being very lifelike and necessarily true representations of the scenes they depict."—*Colliery Guardian.*

"Mr. Bulman and Mr. Redmayne, who are both experienced Colliery Managers of great literary ability, are to be congratulated on having supplied an authoritative work dealing with a side of the subject of coal mining which has hitherto received but scant treatment. The authors elucidate their text by 119 woodcuts and 28 plates, 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 Journal.*

## 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 8vo, 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 VAPOUR 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. With Ten Collotype Plates and other Illustrations. Demy 8vo, cloth. [*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 . . . . . . . . . . . . **2/6**

"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**

# ELECTRICITY, ELECTRICAL 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 8vo, 780 pp., fully Illustrated, including Maps and Folding Plates. *Net* £3 3s.

"There are few, if any, persons more fitted to write a treatise on submarine telegraphy than 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."—*Athenæum.*

## DYNAMO ELECTRIC MACHINERY: its CONSTRUCTION, 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 8vo. 260 pages, with 184 Illustrations. [*Just 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.*

"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 Installation Management. By J. W. URQUHART. With numerous Illustrations. Third Edition, Revised. Crown 8vo, cloth . . . . . . . . 5/0

"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 and concise manner."—*Electrical Review.*

"A *vade-mecum* of the salient facts connected with the science of electric lighting."—*Electrician.*

## DYNAMO CONSTRUCTION.

A Practical Handbook for the Use of Engineer-Constructors and Electricians-in-Charge. Embracing Framework Building, Field Magnet and Armature Winding and Grouping, Compounding, &c. By J. W. URQUHART. Second Edition, Enlarged. Crown 8vo, cloth . . . . . . . . 7/6

"Mr. Urquhart'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 readers 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. Net* **7/6**

## 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. **4/6**

"An example which deserves to be taken as a model by other authors. The subject is treated in a manner which any intelligent man 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. —*Architect.*

## 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 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 Electricians, and Seagoing Engineers-in-Charge. By J. W. URQUHART, C.E. Second Edition, Revised and Extended. 326 pp., with 88 Illustrations, Crown 8vo, cloth . . **7/6**

"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 . **10/6**

## 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.

By H. M. NOAD, F.R.S. Cheaper Edition. 650 pp., with 470 Illustrations Crown 8vo, cloth . . . . . . . . . . . . . . **9/0**

# 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 necessary to prepare students for the various examinations in building construction."—*Building News.*

"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."—*Journal 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., &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.* **7/6**

"Mr. Purchase's 'Practical Masonry' 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 treatise on the subject, the author himself having commenced as an operative mason, and afterwards acted as foreman mason on many large and important buildings prior to the attainment of his present position. It should be found of general utility to architectural students and others, as well as to those to whom it is specially addressed."—*Journal of the Royal Institute of British Architects.*

## MODERN PLUMBING, STEAM AND HOT WATER HEATING.

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. [*Just Published. Net* **21/-**

## HEATING BY HOT WATER.

With Information and Suggestions on the best Methods of Heating Public, Private and Horticultural Buildings. By WALTER JONES. Second Edition. With 96 Illustrations, crown 8vo, cloth . . . . . . . *Net* **2/6**

"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 . . . . . . . . . . . . . . . **7/6**

"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, crown 8vo, cloth . . . . . . . . . . . . . . **4/0**

"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."—*Architect.*

"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 . . **21/0**

## 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."—*Builder.*

## A HANDY BOOK OF VILLA ARCHITECTURE.

Being a Series of Designs for Villa Residences in various Styles. With Outline Specifications and Estimates. By C. WICKES, Architect. 61 Plates, 4to, half-morocco, gilt edges . . . . . . . . **£1 11s. 6d.**

"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.

Being a Text-book of Useful Information for Architects, Engineers, Surveyors, Contractors, Clerks of Works, &c., &c. By FREDERICK ROGERS, Architect. Third Edition. Crown 8vo, cloth . . . . . . . . . . **3/6**

## ARCHITECTURAL PERSPECTIVE.

The whole Course and Operations of the Draughtsman in Drawing a Large House in Linear Perspective. Illustrated by 43 Folding Plates. By F. O. FERGUSON. Second Edition, Enlarged. 8vo, boards . . . . **3/6**

"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. Journal*

## PRACTICAL RULES ON DRAWING.

For the Operative Builder and Young Student in Architecture. By GEORGE PYNE. 14 Plates, 4to, boards . . . . . . . . . . **7/6**

## 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. [*Just Published.* **7/6**

"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. BEATON. Ninth Edition. Waistcoat-pocket size, gilt edges . . . . . . . . . . . . . . . **1/6**

"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, cloth . . . . . . . . . . . . . . . . **15/0**

"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 Waterworks 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.

By WILLIAM HUMBER, A.M. Inst. C.E., and M.Inst. M.E. Imp. 4to, half-bound morocco. (See page 11.) . . . . . . . *Net* **£6 6s.**

## THE WATER SUPPLY OF TOWNS AND THE CONSTRUCTION OF WATER-WORKS.

By PROFESSOR W. K. BURTON, A.M. Inst. C.E. Second Edition, Revised and Extended. Royal 8vo, cloth. (See page 10.) . . . . . **25/0**

## 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 . . **2/6**

## 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.
[*Just 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.

A Text-book to the Practice of the Art of Ventilating Buildings. By W. P. BUCHAN, R.P. Crown 8vo, cloth . . . . . . . . . **3/6**

## 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. [*Just 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. With 61 Plates, Portrait of the Author, and several Woodcuts. In One large Vol., 4to, cloth . . . . . . . . . . . . . **25/0**

"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.

Its Rise, Progress, and Construction. With Hints on the Management of Saw Mills and the Economical Conversion of Timber. Illustrated with Examples of Recent Designs by leading English, French, and American Engineers. By M. POWIS BALE, A.M.Inst.C.E., M.I.M.E. Second Edition, Revised, with large Additions, large crown 8vo, 440 pp., cloth . . . . . **9/0**

"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 ASHPITEL, F.S.A. Together with Practical Rules on Drawing, by GEORGE PYNE. With 74 Plates, 4to, cloth . . . . . . . . **£1 1s.**

## 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 . . **2/6**

"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 aid 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**

## 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 . . . . . . . . . . . **3/6**

"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.

Containing New and Copious Tables of the Reduced Weight and Measurement of Deals and Battens, of all sizes, from One to a Thousand Pieces, and the relative Price that each size bears per Lineal Foot to any given Price per Petersburgh Standard Hundred; the Price per Cube Foot of Square Timber to any given Price per Load of 50 Feet, &c., &c. By William Dowsing. Fourth Edition, Revised and Corrected. Crown 8vo, cloth . . . **3/0**

"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 . **3/6**

"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 . . . . . . . . . . **3/6**

"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 building 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, Revised. Crown 8vo, cloth. [*Just Published.* **3/6**

Summary of Contents: — Prefatory Remarks. — Objects of Planting.—Choice of a Forester.—Choice of Soil and Site.—Laying Out of Land for Plantations.—Preparation of the Ground for Planting.—Drainage.—Planting.—Distances and Distribution of Trees in Plantations.—Trees and Ground Game.—Attention after Planting.—Thinning of Plantations — Pruning of Forest Trees.—Realization.—Methods of Sale.—Measurement of Timber.—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 information of a useful and practical character on the planting and subsequent treatment of trees."—*Illustrated Carpenter 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 . . . . **10/0**

## 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 intermediate Expenses, Freight, Insurance, &c.; together with copious Information for the Retailer and Builder. Third Edition. 12mo, cloth . . **2/0**

# 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. 6d.**

LIST OF PLATES:—1. VARIOUS TOOLS REQUIRED FOR WOOD PAINTING.—2, 3. WALNUT; PRELIMINARY STAGES OF GRAINING AND FINISHED SPECIMEN.—4. TOOLS USED FOR MARBLE PAINTING AND METHOD OF MANIPULATION.—5, 6. ST. REMI MARBLE; EARLIER OPERATIONS AND FINISHED SPECIMEN. — 7. METHODS OF SKETCHING DIFFERENT GRAINS, KNOTS, &c.—8, 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 BIRD'S-EYE MAPLE; PRELIMINARY STAGES AND FINISHED SPECIMEN.—16. METHODS OF SKETCHING THE DIFFERENT SPECIES OF WHITE MARBLE.—17, 18. WHITE MARBLE; PRELIMINARY STAGES OF PROCESS AND FINISHED SPECIMEN.—19. MAHOGANY; SPECIMENS OF VARIOUS GRAINS AND METHODS OF MANIPULATION.—20, 21. MAHOGANY; EARLIER STAGES AND FINISHED SPECIMEN.—22, 23, 24. SIENNA MARBLE; VARIETIES OF GRAIN, PRELIMINARY STAGES AND FINISHED SPECIMEN.—25, 26, 27. JUNIPER WOOD; METHODS OF PRODUCING GRAIN, &c.; PRELIMINARY STAGES AND FINISHED SPECIMEN.—28, 29, 30. VERT DE MER MARBLE; VARIETIES OF GRAIN AND METHODS OF WORKING, UNFINISHED AND FINISHED SPECIMENS.—31, 32, 33. OAK; VARIETIES OF GRAIN, TOOLS EMPLOYED AND METHODS OF MANIPULATION, PRELIMINARY STAGES AND FINISHED SPECIMEN.—34, 35, 36. WAULSORT MARBLE; VARIETIES OF GRAIN, UNFINISHED AND FINISHED SPECIMENS.

"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.*

"A comprehensive guide to the art. The explanations of the processes, the manipulation 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 work."—*The Architect.*

## ELEMENTARY DECORATION.

A Guide to the Simpler Forms of Everyday Art. Together with PRACTICAL HOUSE DECORATION. By JAMES W. FACEY. With numerous Illustrations. In One Vol., strongly half-bound . . . . . . . **5/0**

## 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."—*Building News.*

## MARBLE DECORATION

And the Terminology of British and Foreign Marbles. A Handbook for Students. By GEORGE H. BLAGROVE, Author of "Shoring and its Application," &c. With 28 Illustrations. Crown 8vo, cloth . . . . . **3/6**

"This most useful and much wanted handbook should be in the hands of every architect and builder."—*Building World.*

"A carefully and usefully written treatise; the work is essentially practical."—*Scotsman.*

# DELAMOTTE'S WORKS ON ALPHABETS AND ILLUMINATION.

## ORNAMENTAL ALPHABETS, ANCIENT & MEDIÆVAL.

From the Eighth Century, with Numerals; including Gothic, Church-Text, large and small, German, Italian, Arabesque, Initials for Illumination, Monograms, Crosses, &c., &c., for the use of Architectural and Engineering Draughtsmen, Missal Painters, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c., &c. Collected and Engraved by F. Delamotte, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, ornamental boards . . . . . . . . . . . . 2/6

"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."—*Athenæum.*

## 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. Delamotte, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, ornamental boards . 2/6

"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."—*Standard.*

## MEDIÆVAL ALPHABETS AND INITIALS FOR ILLUMINATORS.

By F. G. Delamotte. Containing 21 Plates and Illuminated Title, printed in Gold and Colours. With an Introduction by J. Willis Brooks. Fourth and Cheaper Edition. Small 4to, ornamental boards . . . . . 4/0

"A volume in which the letters of the alphabet come forth glorified in gilding and all the colours of the prism interwoven and intertwined and intermingled."—*Sun.*

## 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 . . . . . . . . 6/0

"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."—*Athenæum.*

## THE EMBROIDERER'S BOOK OF DESIGN.

Containing Initials, Emblems, Cyphers, Monograms, Ornamental Borders, Ecclesiastical Devices, Mediæval and Modern Alphabets, and National Emblems. Collected by F. Delamotte, and printed n Colours. Oblong royal 8vo, ornamental wrapper . . . . . . . . . . . . 1/6

"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."—*Athenæum.*

## 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 . . . . . . . . . . . . 5/0

*** *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.

Chapters on the Origin and Construction of the Heavens. By J. E. GORE, F.R.A.S., Author of "Star Groups," &c. Illustrated by 6 Stellar Photographs and 12 Plates. Demy 8vo, cloth . . . . . . . . . . **16/0**

"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 to 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.

A Student's Guide to the Constellations. By J. ELLARD GORE, F.R.A.S., M.R.I.A., &c., Author of "The Visible Universe," "The Scenery of the Heavens," &c. With 30 Maps. Small 4to, cloth . . . . . . **5/0**

"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. **2/6**

"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."—*Athenæum.*

## 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 . . . . . . . . . . . . **18/0**

"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."—*Educational Times.*

## 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 8vo, cloth . . . . . . . . . . . . . . . . . **7/6**

"A most valuable storehouse of conchological and geological information."—*Science Gossip.*

## THE TWIN RECORDS OF CREATION.

Or, Geology and Genesis, their Perfect Harmony and Wonderful Concord. By G. W. V. LE VAUX. 8vo, cloth . . . . . . . . . . **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 Rock.*

## HANDBOOK OF MECHANICS.

By Dr. LARDNER. Enlarged and re-written by BENJAMIN LOEWY, F.R.A.S. 378 Illustrations. Post 8vo, cloth . . . . . . . . . . **6/0**

"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 life."—*Mining Journal.*

## 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.

By Dr. LARDNER. Edited and re-written by BENJAMIN LOEWY, F.R.A.S., &c. 117 Illustrations. Post 8vo, cloth . . . . . . . . . . **6/0**

"The style is always clear and precise, and conveys instruction without leaving any cloudiness or lurking doubts behind."—*Engineering.*

## HANDBOOK OF OPTICS.

By Dr. LARDNER. New Edition. Edited by T. OLVER HARDING, B.A. Lond. With 298 Illustrations. Small 8vo, 448 pp., cloth . . . . . . **5/0**

"Written by one of the ablest English scientific writers, beautifully and elaborately illustrated." —*Mechanics' Magazine.*

## 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."—*Athenæum.*

"We 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 Journal 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 handsomely bound in half-morocco . . . . . . **£1 11s. 6d.**

"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.** 5*s.*
**The Microscope.** 2*s.* cloth.
**Popular Geology.** 2*s.* 6*d.* cloth.
**Popular Physics.** 2*s.* 6*d.* cloth.
**Steam and its Uses.** 2*s.* cloth.
**Popular Astronomy.** 4*s.* 6*d.* cloth.
**The Bee and White Ants.** 2*s.* cloth.
**The Electric Telegraph.** 1*s.* 6*d.*

## NATURAL PHILOSOPHY FOR SCHOOLS.

By Dr. LARDNER. Fcap. 8vo . . . . . . . . . . . . **3/6**

"A very convenient class book for junior students in private schools."—*British Quarterly Review.*

## 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**

"One 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. [*Just Published.* **10/6**

"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."—*Builder.*

"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. With 66 Illustrations. Crown 8vo, cloth. [*Just Published.* **7/6**

## 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. [*Just Published. Net* **10/6**

"In this work the author has rendered no small service to a numerous body of practical men. . . . 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."—*Builder.*

"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 gun-cotton, 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.

A 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 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 . . **9/0**

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. 390 pp. of Text. With 232 Illustrations and Working Drawings, Second Edition, with Additions. Super-royal 8vo, cloth . . **£1 10s.**

"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."—*Athenæum.*

"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 News.*

## 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 8vo, 530 pp., cloth. [*Just Published.* **12/6**

"May be consulted with advantage by the student who is preparing himself for examinational tests, while the scientific brewer will find in it a *résumé* 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."—*Brewers' Journal.*

"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."—*Brewers' Guardian.*

"Although the requirements 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. **2/6**

"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.

Containing Tables, Rules, and Memoranda for Revenue Officers, Brewers, Spirit Merchants, &c. By J. B. MANT, Inland Revenue. Second Edition, Revised. 18mo, leather . . . . . . . . . . . . **4/0**

"This handy and useful book is adapted to the requirements of the Inland Revenue Department, and will be a favourite book of reference."—*Civilian.*

"Should be in the hands of every practical brewer."—*Brewers' 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. [*Just Published. Net* **25/0**

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 DRYING OR FIRING OF THE LEAF.—MACHINES FOR NON-AUTOMATIC DRYING OR FIRING OF THE LEAF.—DRYING OR FIRING MACHINES.—BREAKING OR CUTTING, AND SORTING MACHINES.—PACKING 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 Journal.*

"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."—*Journal Society of Arts.*

## FLOUR MANUFACTURE.

A Treatise on Milling Science and Practice. By FRIEDRICH KICK, Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the Second Enlarged and Revised Edition with Supplement. By H. H. P. POWLES, Assoc. Memb. Institution of Civil Engineers. Nearly 400 pp. Illustrated with 28 Folding Plates, and 167 Woodcuts. Royal 8vo, cloth . . . . . . **£1 5s.**

"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 idiom."—*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 . . **7/6**

"A distinct advance in the literature of cotton manufacture."—*Machinery.*

"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-TAYLER, 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 Agglutinants 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. Crown 8vo, cloth. [*Just Published.* **2/0**

"We have pleasure in speaking favourably of this volume. So far as we have had experience, which is not inconsiderable, this manual is trustworthy."—*Athenæum.*

"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 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 an art 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 literature."—*Nature.*

## 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 paper-makers 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 Wood Fibre, with a Description of the Machinery and Appliances used. To which are added Details of Processes for Recovering Soda from Waste Liquors. By ALEXANDER WATT, Author of "The Art of Soap-Making." With Illustrations. Crown 8vo, cloth . . . . . . . . . . . **7/6**

"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. [*Just Published.* **3/6**

## THE ART OF LEATHER MANUFACTURE.

Being a Practical Handbook, in which the Operations of Tanning, Currying, and Leather Dressing are fully Described, and the Principles of Tanning Explained, and many Recent Processes Introduced; as also Methods for the Estimation of Tannin, and a Description of the Arts of Glue Boiling, Gut Dressing, &c. By ALEXANDER WATT, Author of "Soap-Making," &c. Fourth Edition. Crown 8vo, cloth . . . . . . . **9/0**

"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."—*Chemical Review.*

## 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 Shoe-Maker*. 12mo, cloth. . . . . . . . . . . **2/0**

## WOOD ENGRAVING.

A Practical and Easy Introduction to the Study of the Art. By W. N. BROWN. 12mo, cloth . . . . . . . . . . . . . . . **1/6**

"The book is clear and complete, and will be useful to any one wanting to understand the first elements of the beautiful art of wood engraving."—*Graphic.*

## MODERN HOROLOGY, IN THEORY AND PRACTICE.

Translated from the French of CLAUDIUS SAUNIER, ex-Director of the School of Horology at Macon, by JULIEN TRIPPLIN, F.R.A.S., Besancon Watch Manufacturer, and EDWARD RIGG, M.A., Assayer in the Royal Mint. With Seventy-eight Woodcuts and Twenty-two Coloured Copper Plates. Second Edition. Super-royal 8vo, cloth, **£2 2s.**; half-calf . . . **£2 10s.**

"There is no horological 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 Journal.*

"The latest, the most complete, and the most reliable of those literary productions to which continental watchmakers are indebted for the mechanical superiority over their English brethren —in fact, the Book of Books, is M. Saunier's 'Treatise.'"—*Watchmaker, Jeweller, and Silversmith.*

## 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 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 handbook intended for the use of a workman. Should be found in every workshop."—*Watch and Clockmaker.*

## 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."—*Engineer.*

## ELECTRO-METALLURGY.

Practically Treated. By ALEXANDER WATT. Tenth Edition, including the most recent Processes. 12mo, cloth . . . . . . . . . **3/6**

"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.

A Practical Treatise for Masters and Workmen, Compiled from the Experience of Thirty Years' Workshop Practice. By GEORGE E. GEE, Author of "The Goldsmith's Handbook," &c. Crown 8vo, cloth . . . . . . **7/6**

"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. [*Just Published.* **5/0**

"An excellent practical manual."—*Engineering.*
"An excellent work, giving the newest information."—*Horological Journal.*

## ELECTROTYPING.

The Reproduction and Multiplication of Printing Surfaces and Works of Art by the Electro-Deposition of Metals. By J. W. URQUHART, C.E. Crown 8vo, cloth . . . . . . . . . . . . . . . . . **5/0**

"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 Journal.*

## SILVERSMITH'S HANDBOOK.

By GEORGE E. GEE, Jeweller, &c. Third Edition, with numerous Illustrations. 12mo, cloth . . . . . . . . **3/0**

"The chief merit of the work is its practical character. . . . The workers in the trade will speedily 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.

For Hotels, Restaurants, and the Trade in general, adapted also for Family Use. By R. WELLS, Author of "The Bread and Biscuit Baker." Crown 8vo, cloth . . . . . . . . . . . . . **2/0**

"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 129 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

And the Manipulation of Rubber. A Practical Treatise on the Manufacture of Indiarubber Hand Stamps, Small Articles of Indiarubber, The Hektograph, Special Inks, Cements, and Allied Subjects. By T. O'CONOR SLOANE, A.M., Ph.D. With numerous Illustrations. Square 8vo, cloth. . . . **5/0**

# 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 KNOWLEDGE *of the several* CRAFTS. *In describing the processes employed, and the manipulation of material, workshop terms are used; workshop practice is fully explained; and the text is freely illustrated with drawings of modern tools, appliances, and processes.*

---

## THE METAL TURNER'S HANDYBOOK.

A Practical Manual for Workers at the Foot-Lathe. With over 100 Illustrations. . . . . . . . . . . . . . . . 1/0

"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. 1/0

"We recommend the book to young turners and amateurs. A multitude of workmen have 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 . . . . . . . . . . . . . . . 1/0

"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 . . . . . . . . . 1/0

"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. . . . . . . . . . . 1/0

"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 . . . . . . . . . . . . . . . 1/0

"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.*

## THE WOODWORKER'S HANDYBOOK OF MANUAL 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 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."—*Schoolmaster.*

"Helpful to workmen of all ages and degrees of experience."—*Daily Chronicle.*

"Practical, sensible, and remarkably cheap."—*Journal of Education.*

"Concise, 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 Journal.*

"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 Edition, Carefully Revised Throughout. Crown 8vo, cloth.
[*Just Published.* **4/6**

"Whoever wishes to correspond in all the languages mentioned by Mr. Baker cannot 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."—*Athenæum.*

"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.* **7/6**

"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 crown 8vo, cloth . . . . . . . . . . . . **12/6**

"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 . . . . . . . . . . **10/6**

"Mr. Dowling's Tables are well put together as a ready reckoner for the conversion of one system into the other."—*Athenæum.*

## THE IRON AND METAL TRADES' COMPANION.

For Expeditiously Ascertaining the Value of any Goods bought or sold by Weight, from 1s. per cwt. to 112s. per cwt., and from one farthing per pound to one shilling per pound. By THOMAS DOWNIE. 396 pp., leather . . **9/0**

"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."—*Railway 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 $\frac{1}{128}$th of a Penny to 20s. 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 of tons, 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."—*Glasgow 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 1*d.* to 168*s.* per cwt., and containing 186,000 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 . . . . . . **£1 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."—*Sheffield Independent.*

## THE DISCOUNT GUIDE.

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 1¼ to 90 per cent., Tables of Discount from 1¼ to 98¾ per cent., and Tables of Commission, &c., from ⅛ to 10 per cent. By HENRY HARBEN, Accountant. New Edition, Corrected. Demy 8vo, half-bound . **£1 5s.**

"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."—*British 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 advancing by One Shilling from 4*s.* to 55*s.* per week. By THOS. GARBUTT, Accountant. Square crown 8vo, half-bound . . . . . . . **6/0**

## 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 ¼ 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 . . . . . . . **£1 5s.**

## 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 up to Present Requirements, 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. 6d.**

SUMMARY OF CONTENTS.

BOOK I. ON THE VARIETIES, BREEDING, REARING, FATTENING AND MANAGEMENT OF CATTLE.
BOOK II. ON THE ECONOMY AND MANAGEMENT OF THE DAIRY.
BOOK III. ON THE BREEDING, REARING, AND MANAGEMENT OF HORSES.
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, 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 CULTIVATION 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.

"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 compeer among the many works at present in existence. . . 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."—*Athenæum.*

"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.*

## 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 Stock. Demy 8vo, 384 pp., with 79 Plates and Maps, cloth. . . **12/6**

"A really complete 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 '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 LEVELLING.—WEIGHTS AND MEASURES.—MACHINERY AND BUILDINGS.—LABOUR.—OPERATIONS.—DRAINING.—EMBANKING.—GEOLOGICAL MEMORANDA.—SOILS.—MANURES.—CROPPING.—CROPS.—ROTATIONS.—WEEDS.—FEEDING.—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. [*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 unstinted 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.* **2/6**

"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 Agriculturist.*
"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. **7/6**

"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 Gazette.*

## 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. . . . . . . **6/0**

"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., half-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 care, 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 Express.*

## 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.

With a New System of Farm Book-keeping. By SIDNEY FRANCIS. Fifth Edition. 272 pp., waistcoat-pocket size, limp leather . . . . . **1/6**

"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 Weekl Messenger.*

## THE ROTHAMSTED EXPERIMENTS AND THEIR 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 Dyer, 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.

A Guide to the Manipulation of Bees, the Production of Honey, and the General Management of the Apiary. By G. Gordon Samson. With numerous Illustrations. Crown 8vo, wrapper . . . . . . . **1/0**

## 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 . . . . . . . . **2/6**

"The volume is a capital study of a most important subject."—*Agricultural Gazette.*

## 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 . . . . . . . . . . . . . *Net* **7/6**

"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' Magazine.*

## A PLAIN GUIDE TO GOOD GARDENING.

Or, How to Grow Vegetables, Fruits, and Flowers. By S. Wood. Fourth Edition, with considerable Additions, and numerous Illustrations. Crown 8vo, cloth . . . . . . . . . . . . . . . . **3/6**

"A very good book, and one to be highly recommended as a practical guide. The practical directions are excellent."—*Athenæum.*

## MULTUM-IN-PARVO GARDENING.

Or, How to Make One Acre of Land produce £620 a year, by the Cultivation of Fruits and Vegetables; also, How to Grow Flowers in Three Glass Houses, so as to realise £176 per annum clear Profit. By Samuel Wood, Author of "Good Gardening," &c. Sixth Edition, Crown 8vo, sewed . . . **1/0**

"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.

A Practical Guide to the Cultivation and General Treatment of the Potato. By J. Pink. Crown 8vo . . . . . . . . . . . . **2/0**

## 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 ESTATES 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."—*Engineering.*

"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."—*Investors' 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 for inventories, and a guide to determine the value of interior fittings and other effects."—*Builder.*

## 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 8vo, cloth . . . . . . . . . . . . . . . . **12/6**

"The standard text-book on the topics of which it treats."—*Athenæum.*

"The work is one of general excellent character, and gives much information in a compendious and satisfactory form."—*Builder.*

"May be recommended as giving a great deal of information on the law relating to auctioneers, in a very readable form."—*Law Journal.*

"Auctioneers may be congratulated on having so pleasing a writer to minister to their special needs."—*Solicitors' Journal.*

## THE AGRICULTURAL VALUER'S ASSISTANT.

A Practical Handbook on the Valuation of Landed Estates; 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."—*Agricultural Gazette.*

"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 auctioneers in preparing valuations of all kinds."—*Kent Herald.*

## AGRICULTURAL SURVEYOR AND ESTATE AGENT'S HANDBOOK.

Of Practical Rules, Formulæ, Tables, and Data. A Comprehensive Manual for 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* **7/6**

"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."—*Scotsman.*

## 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 . . . . . . . . **4/0**

"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 . . . . . . . . . . . **5/0**

"The advice is thoroughly practical."—*Law Journal.*

"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 thoughtful 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 the Authorisation of Railways, Tramways, Gas and Water Works, &c. By L. LIVINGSTONE MACASSEY, of the Middle Temple, Barrister-at-Law, M. Inst. C.E. 8vo, cloth . . . . . . . . . . . **£1 5s.**

## 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**

## CONCILIATION & ARBITRATION in LABOUR DISPUTES.

A Historical Sketch and Brief Statement of the Present Position of the Question at Home and Abroad. By J. S. JEANS, Author of "England's Supremacy, &c." Crown 8vo, 200 pp., cloth . . . . . **2/6**

## 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 including New Acts of Parliament of 1901. Comprising the *Youthful Offenders Act, 1901*; the *Larceny Act, 1901*; the *Intoxicating Liquors Act, 1901*; the *Factory and Workshop 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 cloth.
[*Just Published.* **6/8**

*** *This Standard Work of Reference forms* A COMPLETE EPITOME OF THE LAWS OF ENGLAND, *comprising (amongst other matter)*:

THE RIGHTS AND WRONGS OF INDIVIDUALS—LANDLORD AND TENANT—VENDORS AND PURCHASERS—LEASES AND MORTGAGES—PRINCIPAL AND AGENT—PARTNERSHIP AND COMPANIES—MASTERS, SERVANTS AND WORKMEN—CONTRACTS AND AGREEMENTS—BORROWERS, LENDERS AND SURETIES—SALE AND PURCHASE OF GOODS—CHEQUES, BILLS AND NOTES—BILLS OF SALE—BANKRUPTCY—RAILWAY AND SHIPPING LAW—LIFE, FIRE, AND MARINE INSURANCE—ACCIDENT AND FIDELITY INSURANCE—CRIMINAL LAW—PARLIAMENTARY ELECTIONS—COUNTY COUNCILS—DISTRICT COUNCILS—PARISH COUNCILS—MUNICIPAL CORPORATIONS—LIBEL AND SLANDER—PUBLIC HEALTH AND NUISANCES—COPYRIGHT, PATENTS, TRADE MARKS—HUSBAND AND WIFE—DIVORCE—INFANCY—CUSTODY OF CHILDREN—TRUSTEES AND EXECUTORS—CLERGY, CHURCHWARDENS, &C.—GAME LAWS AND SPORTING—INNKEEPERS—HORSES AND DOGS—TAXES AND DEATH 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 law; and thereby to dispense, as far as possible, with professional assistance and advice. There are many wrongs and grievances which persons submit to from time to time through not knowing how or where to apply for redress; and many persons have as great a dread of a lawyer's office as of a lion's den. With this book at hand it is believed that many a* SIX-AND-EIGHTPENCE *may be saved; many a wrong redressed; many a right reclaimed; many a law suit avoided; and many an evil abated. The work has established itself as the standard legal adviser of all classes, and has also made a reputation for itself as a useful book of reference for lawyers residing at a distance from law libraries, who are glad to have at hand a work embodying recent decisions and enactments.*

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."—*Weekly 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."—*Leeds 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."—*Figaro.*

"A dictionary of legal facts well put together. The book is a very useful one."—*Spectator.*

## THE PAWNBROKER'S, FACTOR'S, AND MERCHANT'S GUIDE TO THE LAW OF LOANS AND PLEDGES.

With the Statutes and a Digest of Cases. By H. C. FOLKARD, Barrister-at-Law. Cloth . . . . . . . . . . . . . . . . **3/6**

## 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. UTTLEY, Solicitor. Fcap. 8vo, cloth . . . . . . . . . . . **3/6**

## 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 . . . . . . . . . . . . . **6D.**

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.




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 ENGINEERING by G. R. BURNELL, M.I.C.E. Seventh Edition, revised, with LARGE ADDITIONS by D. K. CLARK, M.I.C.E. . . . 6/6

**Pioneer Engineering:**
A Treatise on the Engineering Operations connected with the Settlement of Waste Lands in New Countries. By EDWARD DOBSON, M.INST.C.E. With numerous Plates. Second Edition . . . . . . . 4/6

**Iron Bridges of Moderate Span:**
Their Construction and Erection. By HAMILTON W. PENDRED. With 40 Illustrations . . . . . . . . . . . . . . 2/0

**Iron and Steel Bridges and Viaducts.**
A Practical Treatise upon their Construction for the use of Engineers, Draughtsmen, and Students. By FRANCIS CAMPIN, C.E. With numerous Illustrations . . . . . . . . . . . . . . 3/6

**Constructional Iron and Steel Work,**
As applied to Public, Private, and Domestic Buildings. By FRANCIS CAMPIN, C.E. . . . . . . . . . . . . . 3/6

**Tubular and other Iron Girder Bridges.**
Describing the Britannia and Conway Tubular Bridges. By G. DRYSDALE DEMPSEY, C.E. Fourth Edition . . . . . . . . . 2/0

**Materials and Construction:**
A Theoretical and Practical Treatise on the Strains, Designing, and Erection of Works of Construction. By FRANCIS CAMPIN, C.E. . . . 3/0

**Sanitary Work in the Smaller Towns and in Villages.**
By CHARLES SLAGG, Assoc. M.Inst.C.E. Third Edition . . 3/0

**Roads and Streets (The Construction of).**
In Two Parts: I. THE ART OF CONSTRUCTING COMMON ROADS, by H. LAW, C.E., Revised by D. K. CLARK, C.E.; II. RECENT PRACTICE: Including Pavements of Wood, Asphalte, &c. By D. K. CLARK, C.E. 4/6

**Gas Works (The Construction of),**
And the Manufacture and Distribution of Coal Gas. By S. HUGHES, C.E. Re-written by WILLIAM RICHARDS, C.E. Eighth Edition . . 5/6

**Water Works**
For the Supply of Cities and Towns. With a Description of the Principal Geological Formations of England as influencing Supplies of Water. By SAMUEL HUGHES, F.G.S., C.E. Enlarged Edition . . . . 4/0

**The Power of Water,**
As applied to drive Flour Mills, and to give motion to Turbines and other Hydrostatic Engines. By JOSEPH GLYNN, F.R.S. New Edition . 2/0

**Wells and Well-Sinking.**
By JOHN GEO. SWINDELL, A.R.I.B.A., and G. R. BURNELL, C.E. Revised Edition. With a New Appendix on the Qualities of Water. Illustrated 2/0

**The Drainage of Lands, Towns, and Buildings.**
By G. D. DEMPSEY, C.E. Revised, with large Additions on Recent Practice, by D. K. CLARK, M.I.C.E. Third Edition . . . 4/6

**The Blasting and Quarrying of Stone,**
For Building and other Purposes. With Remarks on the Blowing up of Bridges. By Gen. Sir J. BURGOYNE, K.C.B. . . . . . . 1/6

**Foundations and Concrete Works.**
With Practical Remarks on Footings, Planking, Sand, Concrete, Béton, Pile-driving, Caissons, and Cofferdams. By E. DOBSON, M.R.I.B.A. Eighth Edition . . . . . . . . . . . . . . 1/6

**Pneumatics,**
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.**
For Students and Practical Use. By T. BAKER, C.E. Eighteenth Edition, Revised and Extended by F. E. DIXON, A.M. Inst. C.E., Professional Associate of the Institution of Surveyors. With numerous Illustrations and two Lithographic Plates . . . . . . . [*Just published* 2/0

**Mensuration and Measuring.**
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. . . . . . . . . . . 1/6

## *MINING AND METALLURGY*

**Mining Calculations,**
For the use of Students Preparing for the Examinations for Colliery Managers' Certificates, comprising numerous Rules and Examples in Arithmetic, Algebra, and Mensuration. By T. A. O'DONAHUE, M.E., First-Class Certificated Colliery Manager. [*Just published*. 3/6

**Mineralogy,**
Rudiments of. By A. RAMSAY, F.G.S. Fourth Edition, revised and enlarged. Woodcuts and Plates . . . . . . . . . . 3/6

**Coal and Coal Mining,**
A Rudimentary Treatise on. By the late Sir WARINGTON W. SMYTH, F.R.S. Eighth Edition, revised by T. FORSTER BROWN . . . 3/6

**Metallurgy of Iron.**
Containing Methods of Assay, Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. With numerous Illustrations. Sixth Edition, revised and enlarged . . . . 5/0

**The Mineral Surveyor and Valuer's Complete Guide.**
By W. LINTERN. Fourth Edition, with an Appendix on Magnetic and Angular Surveying . . . . . . . . . . . 3/6

**Slate and Slate Quarrying:**
Scientific, Practical, and Commercial. By D. C. DAVIES, F.G.S. With numerous Illustrations and Folding Plates. Fourth Edition . . 3/0

**A First Book of Mining and Quarrying,**
With the Sciences connected therewith, for Primary Schools and Self Instruction. By J. H. COLLINS, F.G.S. Second Edition . . . 1/6

**Subterraneous Surveying,**
With and without the Magnetic Needle. By T. FENWICK and T. BAKER, C.E. Illustrated . . . . . . . . . . . . . 2/6

**Mining Tools.**
Manual of. By WILLIAM MORGANS, Lecturer on Practical Mining at the Bristol School of Mines . . . . . . . . . . 2/6

**Mining Tools, Atlas**
Of Engravings to Illustrate the above, containing 235 Illustrations of Mining Tools, drawn to Scale. 4to . . . . . . . . . 4/6

**Physical Geology,**
Partly based on Major-General PORTLOCK'S "Rudiments of Geology." By RALPH TATE, A.L.S., &c. Woodcuts. . . . . . . 2/0

**Historical Geology,**
Partly based on Major-General PORTLOCK'S "Rudiments." By RALPH TATE, A.L.S., &c. Woodcuts . . . . . . . . . 2/6

**Geology, Physical and Historical.**
Consisting of "Physical Geology," which sets forth the Leading Principles of the Science; and "Historical Geology," which treats of the Mineral and Organic Conditions of the Earth at each successive epoch. By RALPH TATE, F.G.S. . . . . . . . . . . . 4/6

## *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

**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 Great Eastern Railway. Third Edition . . . . . . 2/0

**Fuel, Its Combustion and Economy.**
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

**The Boilermaker's Assistant**
In Drawing, Templating, and Calculating Boiler Work, &c. By J. COURTNEY, 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 Riveters. By JOHN COURTNEY. Edited by D. K. CLARK, M.I.C.E. Fourth Edition . . . . . . . . . 4/0

*** *The last two Works in One Volume, half-bound, entitled* "THE BOILER-MAKER'S READY-RECKONER AND ASSISTANT." By J. COURTNEY and D. K. CLARK. *Price* 7/0.

**Steam Boilers:**
Their Construction and Management. By R. ARMSTRONG, C.E. Illustrated 1/6

**Steam and Machinery Management.**
A Guide to the Arrangement and Economical Management of Machinery. By M. POWIS BALE, M.Inst.M.E. . . . . . . . . 2/6

**Steam 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 Practical Men. By T. BAKER, C.E. . . . . . . . . . 1/6

**The Steam Engine.**
By Dr. LARDNER. Illustrated . . . . . . . . . . . 1/6

**Locomotive Engines,**
By G. D. DEMPSEY, C.E. With large Additions treating of the Modern Locomotive, by D. K. CLARK, M.Inst.C.E. . . . . . . 3/0

**Locomotive Engine-Driving.**
A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS. Tenth Edition. 3*s*. 6*d*. limp; cloth boards. 4/6

**Stationary Engine-Driving.**
A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS. Sixth Edition. 3*s*. 6*d*. limp; cloth boards . 4/6

**The Smithy and Forge.**
Including the Farrier's Art and Coach Smithing. By W. J. E. CRANE. Fourth Edition . . . . . . . . . . . . . 2/6

**Modern Workshop Practice,**
As applied to Marine, Land, and Locomotive Engines, Floating Docks, Dredging Machines, Bridges, Ship-building, &c. By J. G. WINTON. Fourth Edition, Illustrated . . . . . . . . . . . 3/6

**Mechanical Engineering.**
Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of the Steam Engine, &c. By FRANCIS CAMPIN, C.E. Third Edition . . . . . 2/6

**Details 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 . . . . . . . . 1/6

**Power in Motion:**
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. . . . . . . 2/6

**Practical Mechanism,**
And Machine Tools. By T. BAKER, C.E. With Remarks on Tools and Machinery, by J. NASMYTH, C.E. . . . . . . . . . 2/6

**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. . . . . . . . 1/6

---

## *NAVIGATION, SHIPBUILDING, ETC.*

**The Sailor's Sea Book:**
A Rudimentary Treatise on Navigation. By JAMES GREENWOOD, B.A. With numerous Woodcuts and Coloured Plates. New and enlarged Edition. By W. H. ROSSER . . . . . . . . . . 2/6

**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

**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. R. YOUNG. New Edition . . . . . . . . . . . 4/0

**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

**Sails and Sail-Making.**
With Draughting, and the Centre of Effort of the Sails. By ROBERT KIPPING, N.A. . . . . . . . . . . . . . . 2/6

**Marine Engines and Steam Vessels.**
By R. MURRAY, C.E. Eighth Edition, thoroughly revised, with Additions by the Author and by GEORGE CARLISLE, C.E. . . . . 4/6

**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 . . . . . . . . . . . . . . . . 1/6

## ARCHITECTURE AND THE BUILDING ARTS.

**Constructional Iron and Steel Work,**
As applied to Public, Private, and Domestic Buildings. By FRANCIS CAMPIN, C.E. . . . . . . . . . . . . . 3/6

**Building Estates:**
A Treatise on the Development, Sale, Purchase, and Management of Building Land. By F. MAITLAND. Third Edition . . . . . . 2/0

**The Science of Building:**
An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A. Lond. Fourth Edition . . . . . . . 3/6

**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 GRIMTHORPE). Second Edition . . . . . . . . . . . 4/6

**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.**
By C. BRUCE ALLEN. Eleventh Edition, with Chapter on Economic Cottages for Allotments, by E. E. ALLEN, C.E. . . . . . . 2/0

**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 ADAM HAMMOND. With 68 Woodcuts 1/6

**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,**
Rudimentary Treatise on the Manufacture of; containing an Outline of the Principles of Brickmaking. By E. DOBSON, M.R.I.B.A. Additions by C. TOMLINSON, F.R.S. Illustrated . . . . . . . . . 3/0

**The Practical Brick and Tile Book.**
Comprising: BRICK AND TILE MAKING, by E. DOBSON, M.INST.C.E.; Practical BRICKLAYING, by A. HAMMOND; BRICK-CUTTING AND SETTING, by A. HAMMOND. 550 pp. with 270 Illustratious, half-bound . . 6/0

**Carpentry and Joinery—**
THE ELEMENTARY PRINCIPLES OF CARPENTRY. 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 . . . . . . 6/0

**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 . . . . . . . 2/6

**Roof Carpentry:**
Practical Lessons in the Framing of Wood Roofs. For the Use of Working Carpenters. By GEO. COLLINGS . . . . . . . . 2/0

**The Construction of Roofs of Wood and Iron;**
Deduced chiefly from the Works of Robison, Tredgold, and Humber. By 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 . . . . . . . 1/6

**The Timber Importer's, Timber Merchant's, and Builder's Standard Guide.**
By R. E. GRANDY . . . . . . . . . . . . . 2/0

**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 BUCHAN. Eighth Edition, Re-written and Enlarged, with 500 Illustrations . 3/6

**Ventilation:**
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 . . 2/0

**Limes, Cements, Mortars, Concretes, Mastics, Plastering, &c.**
By G. R. BURNELL C.E. Fifteenth Edition . . . . . 1/6

**Masonry and Stone-Cutting.**
The Principles of Masonic Projection and their application to Construction By EDWARD DOBSON, M.R.I.B.A. . . . . . . . . 2/6

**Arches, Piers, Buttresses, &c.:**
Experimental Essays on the Principles of Construction. By W. BLAND. 1/6

**Quantities and Measurements,**
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. HORTON. Sixth Edition . . . . . . . . . . . 4/0

*** *The above, strongly bound in leather, price* 5/0.

**Light:**
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

**Hints to Young Architects.**
By GEORGE WIGHTWICK, Architect. Sixth Edition, revised and enlarged by G. HUSKISSON GUILLAUME, Architect . . . . . . . 3/6

**Architecture—Orders:**
The Orders and their Æsthetic Principles. By W. H. LEEDS. Illustrated. 1/6

**Architecture—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 . . . . . . . . . . . 2/0

*** ORDERS AND STYLES OF ARCHITECTURE, *in One Vol.,* 3/6.

**Architecture—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 . . . . . . . 2/6

*** *The three preceding Works in One handsome Vol., half bound, entitled* "MODERN ARCHITECTURE," *price* 6/0.

**Perspective for Beginners.**
Adapted to Young Students and Amateurs in Architecture, Painting, &c. By GEORGE PYNE . . . . . . . . . . . . 2/0

**Architectural Modelling in Paper.**
By T. A. RICHARDSON. With Illustrations, engraved by O. JEWITT 1/6

**Glass 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

**Vitruvius—The Architecture of.**
In Ten Books. Translated from the Latin by JOSEPH GWILT, F.S.A., F.R.A.S. With 23 Plates . . . . . . . . . . 5/0

*N.B.—This is the only Edition of* VITRUVIUS *procurable at a moderate price.*

**Grecian 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 1/0

*** *The two preceding Works in One handsome Vol., half bound, entitled* "ANCIENT ARCHITECTURE," *price* 6/0.

# *INDUSTRIAL AND USEFUL ARTS.*

**Cements, Pastes, Glues, and Gums.**
A Guide to the Manufacture and Application of Agglutinants. With 900 Recipes and Formulæ. By H. C. STANDAGE . . . . . . 2/0

**Clocks and Watches, and Bells,**
A Rudimentary Treatise on. By Sir EDMUND BECKETT, Q.C. (Lord GRIMTHORPE). Seventh Edition. . . . . . . . . . 4/6

**Electro-Metallurgy,**
Practically Treated. By ALEXANDER WATT. Tenth Edition, enlarged and revised including the most Recent Processes . . . . . 3/6

**The Goldsmith's Handbook.**
Containing full Instructions in the Art of Alloying, Melting, Reducing, Colouring, Collecting and Refining, Recovery of Waste, Solders, Enamels, &c., &c. By GEORGE E. GEE. Fifth Edition . . . . . . 3/0

**The Silversmith's Handbook,**
On the same plan as the GOLDSMITH'S HANDBOOK. By G. E. GEE. 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

**French Polishing and Enamelling.**
A Practical Work of Instruction, including numerous Recipes for making Polishes, Varnishes, Glaze-Lacquers, &c. By R. BITMEAD . . 1/6

**Practical Organ Building.**
By W. E. DICKSON, M.A. Second Edition, Revised, with Additions 2/6

**Coach-Building:**
A Practical Treatise. By JAMES W. BURGESS. With 57 Illustrations 2/6

**The Cabinet-Maker's Guide**
To the Entire Construction of Cabinet-Work. By R. BITMEAD . 2/6

**The Brass Founder's Manual:**
Instructions for Modelling, Pattern Making, &c. By W. GRAHAM . 2/0

**The Sheet-Metal Worker's Guide.**
A Practical Handbook for Tinsmiths, Coppersmiths, Zincworkers, &c., with 46 Diagrams. By W. J. E. CRANE. Third Edition, revised . . 1/6

**Sewing Machinery:**
Its Construction, History, &c. With full Technical Directions for Adjusting, &c. By J. W. URQUHART, C.E. . . . . . . . 2/0

**Gas Fitting:**
A Practical Handbook. By JOHN BLACK. New Edition . . 2/6

**Construction 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 . . . . . . . . . . . 3/6

**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 BEDFORD LENO. With numerous Illustrations. Fourth Edition 2/0

**Mechanical Dentistry:**
A Practical Treatise on the Construction of the Various Kinds of Artificial Dentures. By CHARLES HUNTER. Fourth Edition . . . 3/0

**Wood Engraving:**
A Practical and Easy Introduction to the Art. By W. N. BROWN . 1/9

**Laundry Management.**
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 . . . . . . . . . 1/6

**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 . . . . . . . . 2/0

**Barn Implements and Machines:**
Treating of the Application of Power and Machines used in the Threshing-barn, Stockyard, Dairy, &c. By Prof. J. SCOTT. With 123 Illustrations. 2/0

**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

**Agricultural Surveying:**
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. Half-bound . . . . 12/0

**Outlines of Farm Management.**
Treating of the General Work of the Farm; Stock; Contract Work; Labour, &c. By R. SCOTT BURN . . . . . . . . . 2/6

**Outlines of Landed Estates Management.**
Treating of the Varieties of Lands, Methods of Farming, Setting-out of Farms, Roads, Fences, Gates, 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. . . . . . . . . . . . **2/0**

**The Hay and Straw Measurer.**
New Tables for the Use of Auctioneers, Valuers, Farmers, Hay and Straw Dealers, &c. By JOHN STEELE . . . . . . . . . **2/0**

**Meat Production.**
A Manual for Producers, Distributors, and Consumers of Butchers' Meat. By JOHN EWART . . . . . . . . . . . . **2/6**

**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 . . . . . . . . . . . . **1/6**

**Cottage Gardening:**
Or Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. **1/6**

**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 . . . . . . . . . . . . . **3/6**

**The Tree Planter and Plant Propagator:**
With numerous Illustrations of Grafting, Layering, Budding, Implements, Houses, Pits, &c. By SAMUEL WOOD . . . . . . . **2/0**

**The Tree Pruner:**
A Practical Manual on the Pruning of Fruit Trees, Shrubs, Climbers, and Flowering Plants. With numerous Illustrations. By SAMUEL WOOD **1/6**

*** *The above Two Vols. in One, handsomely half-bound, price* **3/6.**

**The Art of Grafting and Budding.**
By CHARLES BALTET. With Illustrations . . . . . **2/6**

## 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. HEATHER, M.A. With 14 Plates . . . . . . . . . . . **2/0**

**Practical Plane Geometry:**
Giving the Simplest Modes of Constructing Figures contained in one Plane and Geometrical Construction of the Ground. By J. F. HEATHER, M.A. With 215 Woodcuts . . . . . . . . . . . **2/0**

**Analytical Geometry and Conic Sections,**
A Rudimentary Treatise on. By JAMES HANN. A New Edition, re-written and enlarged by Professor J. R. YOUNG . . . . . **2/0**

**Euclid (The Elements of).**
With many Additional Propositions and Explanatory Notes; to which is prefixed an Introductory Essay on Logic. By HENRY LAW, C.E. . **2/6**

*** *Sold also separately, viz:—*

**Euclid.** The First Three Books. By HENRY LAW, C.E. . . . . **1/6**

**Euclid.** 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. DOWLING, C.E. . . . . . . . . . . . . **1/0**

*** *Or with "The Elements of Plane Trigonometry," in One Volume,* **2/6**

**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 . . . . . . . . . . . . . . **1/6**

**Commercial Book-keeping.**
With Commercial Phrases and Forms in English, French, Italian, and German. By JAMES HADDON, M.A. . . . . . . . . **1/6**

**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. HIPSLEY . . . . . . . . . . **1/6**

**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 . . . . . 2/0

**** In ordering the above, be careful to say "Original Edition," or give the number in the Series (32), to distinguish it from the Enlarged Edition in 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 and 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 . . . . . . . . . . . . 1/6

**Surveying and Astronomical Instruments.**
Including—I. Instruments used for Determining the Geometrical Features of a portion of Ground. II. Instruments employed in Astronomical Observations. By J. F. HEATHER, M.A. Illustrated. . . . 1/6

**** 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. F. HEATHER, M.A. Enlarged Edition, for the most part entirely re-written. The Three Parts as above, in One thick Volume. . . . . 4/6

**The Slide Rule, and How to Use It.**
Containing full, easy, and simple Instructions to perform all Business Calculations with unexampled rapidity and accuracy. By CHARLES HOARE, C.E. With a Slide Rule, in tuck of cover. Seventh Edition . . 2/6

**Logarithms.**
With Mathematical Tables for Trigonometrical, Astronomical, and Nautical 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 Mercantile and State Purposes. By FEDOR THOMAN, Paris. Fourth Edition . 4/0

**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. R. YOUNG. New Edition . . . . . . . . . . . 4/0

**Mathematics,**
As applied to the Constructive Arts. By FRANCIS CAMPIN, C.E., &c. Third Edition . . . . . . . . . . . . . . 3/0

**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. . . . 2/0

**Statics and Dynamics,**
The Principles and Practice of. Embracing also a clear development of Hydrostatics, Hydrodynamics, and Central Forces. By T. BAKER, C.E. Fourth Edition . . . . . . . . . . . . . 1/6

## 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 DARYL, 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 . . . . . . . . . . . 2/6

**Pianoforte,**
The Art of Playing the. With numerous Exercises and Lessons. By CHARLES CHILD SPENCER . . . . . . . . . . 1/6

**The House Manager.**
A Guide to Housekeeping, Cookery, Pickling and Preserving, Household Work, Dairy Management, Cellarage of Wines, Home-brewing and Wine-making, 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 1/0

**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 . . . . . . . . [*Just Published* 1/6

**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. H. 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 GORMAN. Twenty-seventh Edition, carefully revised by C. NORRIS . . 2/6

**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. . . . . . . . . . . . . . . 3/6
*Complete with the* GRAMMAR, 5/6.

**Composition and Punctuation,**
Familiarly Explained for those who have neglected the Study of Grammar. By JUSTIN BRENAN. 18th Edition. . . . . . . . . . 1/6

**French Grammar.**
With Complete and Concise Rules on the Genders of French Nouns. By G. L. STRAUSS, Ph.D. . . . . . . . . . . . 1/6

**English-French Dictionary.**
Comprising a large number of Terms used in Engineering, Mining, &c. By ALFRED ELWES . . . . . . . . . . . 2/0

**French Dictionary.**
In two Parts—I. French-English. II. English-French, complete in One Vol. . . . . . . . . . . . . . . 3/0
*** *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 . . . . . . . . 1/6

**German Triglot Dictionary.**
By N. E. S. A. HAMILTON. Part I. 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. . . . . . . . . . . 7/6

**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 . . . . . . . . . . . . . . 4/0
*** *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.**
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. Third Edition, revised . . . . . . . . . . 5/0
*** *Or with the* GRAMMAR, 7/0.

**Animal Physics,**
Handbook of. By DIONYSIUS LARDNER, D.C.L. With 520 Illustrations. In One Vol. (732 pages), cloth boards . . . . . . . . 7/6
*** *Sold also in Two Parts, as follows:—*
ANIMAL PHYSICS. By Dr. LARDNER. Part I., Chapters I.—VII. 4/0
ANIMAL PHYSICS. By Dr. LARDNER. Part II., Chapters VIII.—XVIII. 3/0

BRADBURY, AGNEW & CO., LD., PRINTERS, LONDON AND TONBRIDGE.