ENGINEERING ESTIMATES

COSTS AND ACCOUNTS


UNIVERSITY OF CALIFORNIA
ANDREW
SMITH
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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

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Capio Lumen

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PREFACE.

So far as the author of this work is aware, there is no previous publication which attempts either to cover the ground which is here traversed, or to attain the object he has in view.

Briefly, the ground covered is represented by that part (by far the most important) of the commercial work of an engineering establishment which centres in the preparation of estimates. The object in view, primarily, is to place a general acquaintance, at least, with commercial engineering within the reach of young men receiving a practical training in engineering shops and drawing offices, so many of whom are often placed at serious disadvantage later on in their lives for want of commercial knowledge.

The need of a book dealing with the subjects which are herein treated has long been recognised; and whilst it is not to be supposed that the present work can entirely and in every detail meet that want, the author hopes it may be found sufficiently comprehensive to be practically useful in many quarters. At all events, he can say that there was a time in his own experience when, being called upon unexpectedly to discharge important managerial duties, such a book as the present would have been of immense service to him.

Attention has been confined as closely as possible to matters actually bearing on the purpose in view; and only such incidental digressions have been introduced as appeared likely to afford suggestions which might be useful in commercial negociations. No attempt has been made (indeed, none would have been possible within reasonable limits) to deal either with designing on the one hand, or general book-keeping on the other. Numerous works on both subjects are already available.

Whilst specially written for the younger men already mentioned, the author hopes and believes that the present publication—and more particularly the sections dealing with indirect expenses and the preparation of costs—will prove of interest and use to many principals, managers, and others who are already engaged in directing the commercial work of engineering establishments.

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ENGINEERING ESTIMATES, COSTS, AND ACCOUNTS.

CHAPTER I.

INTRODUCTORY.

It is a common complaint, and one which from time to time finds vigorous expression in our technical journals, that young men supposed to be learning their profession in mechanical engineering establishments rarely receive any systematic instruction in estimating, or even have afforded them opportunities of acquiring the knowledge necessary to enable them to prepare a formal tender or to give a simple quotation.

As a rule, there is no part of the work of an engineering establishment about which it is so difficult to obtain information as that dealing with the preparation of estimates. This circumstance undoubtedly constitutes a serious defect in our methods of training young engineers. It is, however, futile to suppose that employers will lay themselves out to remedy this defect.

For reasons which all can appreciate, most employers keep everything connected with the methods and rates they adopt in preparing their estimates to themselves and a few confidential officials. It is, moreover, quite true that one may become a skilful engineer and may discharge successfully all the duties expected of a skilled mechanic without knowing anything about the preparation of estimates or how the commercial business of an engineering establishment must be managed.

At the same time, a young man who enters an engineering establishment, not merely to be a pattern maker or a turner or a fitter, but to learn a business, aims, if he is worth anything at all, to become something more than a simple journeyman or tradesman. He hopes to fill, sooner or later, some responsible managerial position; but it is obvious that his qualifications for such positions would be immensely increased if, in addition to the technical knowledge and practical skill he acquires in his progress through the shops, he added a knowledge of commercial engineering, and particularly of the preparation of estimates.

For want of this commercial knowledge on his part, he is very likely to see some coveted post pass into the possession of one who has had no practical training whatever, but has been brought up entirely in the offices.

It is the primary object of this work to remedy, as far as may be possible by such means, the defect previously mentioned, and to convey to young men connected with mechanical engineering who possess a healthy ambition to rise in their profession, a general acquaintance with commercial management, and especially with the preparation of estimates.

It is intended, first, to consider the general principles by which we have to be guided and the conditions which commonly control us in the preparation of estimates; next to review the different classes of material and labour with which we have to deal and the prices at which these may be rated; then to examine in detail the cost of manufacturing, and the prices at which they are sold, of that large class of articles which constitute general millwright work, passing on to deal in like manner with certain representative classes of machinery, engines and boilers.

Finally, the organisation and routine of the cost-keeping department of an engineering establishment will be explained and illustrated by specimen rulings of the principal books employed.

It is not, of course, pretended that the methods which will be set forth and the rates that will be used in this work are of universal adoption. Every establishment has its own special methods and arrangements. What will be attempted is to explain the lines as it were along which the business of estimating and the commercial management of an establishment proceeds, and to illustrate the work by practical examples, so as to enable any intelligent young man to adapt himself readily to the methods and arrangements peculiar to any establishment in which he may be placed.

General Principles.

There are certain obvious reflections, applicable to all businesses, which it is necessary to have in view. Capital is invested in a manufacturing industry with the primary object of earning a profit for its owners. A profit can only be made in one way—by selling the productions of the business for a larger sum than the gross cost of manufacturing and delivering them to the buyers. The amount of profit made is determined by three elements—cost of the raw material, cost of manufacturing, and the selling prices of the finished articles.

A modification in any one of these elements will have its effect on the profit (or loss) that will be made in any case. The prices, however, at which the productions of any manufacturing industry are sold, are rarely, if ever, quite arbitrary—determined solely by the will of the manufacturer. They are determined, first, by the demand that exists for that particular kind of manufactures; and secondly, by the competition of the makers, actual or prospective. It is true that the manufacturers of a particular kind of articles—tube and file makers and the makers of certain classes of iron and steel, for example—may combine together and agree not to sell their productions under certain prices. It is, however, the competition amongst themselves which compels them to take this course, and prospective competition which prevents them fixing the rates higher. Competition always tends to equalise the selling prices of the same class of articles in the same market, and thus to set up what may be called a "normal" price for that class of articles.

Equally, the prices which must be paid for the raw material required by any manufacturing establishment, are also determined by the demand on the part of the manufacturers and the competition amongst the owners or producers of the raw material. Consequently, both the price which he must pay for his raw material and the price which he can get for his finished productions are largely determined by influences over which the manufacturer has comparatively little control. Hence we learn the immense importance of the second element mentioned above—cost of manufacturing—in relation to the profit that can be made in any establishment. Upon the way in which the manufacturing processes are organised and directed, the profit will largely depend.

What has just been said will be found strictly applicable to the business of a manufacturing engineer. We may consider engineering productions under two heads — General and Specialties.

Considerations determining Tenders.

Leaving the latter out of view for a moment, and having regard only to the former, suppose the case of an engineer who proposes to tender for some such work—a quantity of shafting and gearing, for example. What are the considerations by which he will be influenced in determining the amount of his tender? In the first place, he must know what the necessary materials will cost him to buy, and will exercise his knowledge of the markets in finding out the lowest prices at which he can buy material of the requisite quality. Secondly, he will consider how he can convert the material in the raw or half-manufactured condition in which he will receive it, into the condition required by the customer, at the lowest possible cost in labour and expenses.

He will clearly wish to fix a price that will leave him a reasonable profit at least. Engineers, like many other manufacturers, are sometimes obliged to work at cost price, and even under. When trade is very bad and orders scarce, it may be better for an engineer to take a contract at cost price, in order to keep his establishment together and in working order, than to be without it. Of course, such a policy will only be adopted when absolutely unavoidable, and cannot be long pursued. Again, an engineer beginning business will often be content to work for very little profit for a time, in order to make a connection. But, of course, as a general thing, the price which an engineer quotes for any work will be one that will leave him some reasonable profit. His leading idea will, indeed, be to make as large a profit as he can. He will, however, probably know that invitations have been sent to other firms to tender for the same work; he will thus be in competition, and must consider his price accordingly. He will, therefore, be anxious to obtain any information he can as to the nature and extent of the competition he has to meet. Small circumstances—the presence of a representative of a rival house in his district—some reference in the specification to a peculiarity of construction known to be specially recommended by another firm, will often convey to a shrewd man of business much information as to the competition he must take into account. He will try to avoid two extremes—a very low and a very high quotation. A very low price, would no doubt, secure him the order, but, even if such a price leaves a margin of profit, it is unpleasant to reflect when an order has been secured, that a much higher price might have been obtained. On the other hand, a very high price would not only lose the particular order in view, but might deter the enquirer from asking for tenders on future occasions.

It may be that the competition is purely local and that our engineer enjoys a first-class reputation for the way in which he does his work. In this case he may think himself able to add something to what may be considered the normal price of the work, on account of his reputation. On the other hand, he may know that his reputation is not very good—or it may be to make—in which case he will probably quote something under the normal price, thus discounting his disadvantages with a view to tempt his customer. Again, the work may be for his district and his competitors at a distance. In this case, if his works are modern or as good as his competitors, he may have a slight advantage, and may think himself able to add a little to his tender in consequence. At the same time he will be careful how he tries to avail himself of such an advantage, because his competitors may do what he might be quite willing to do himself if in their circumstances—that is, to sink extra carriage and other expenses, or a large part of them, and thus keep their quotations down.

Detailed and General Specifications.

Our engineer will be placed under one of two very different conditions. Either he, in common with his competitors, will have received a complete detailed specification, with plans, of the work to be done, or he will merely have received a general description of what the intending purchaser wishes to accomplish. In the former case he will simply have to get out his quantities and workmanship in accordance with the specification and plan, affix his rates, and obtain his total; in the latter he will have to prepare his own plan and specification. In the first case he will know that the lowest tender will probably be the one which will be accepted. This is nearly always so with the contracts of railway companies and other public bodies—at any rate when tenders are specially invited, and not publicly advertised. Such bodies usually issue very detailed specifications, and when they invite tenders only ask firms in whom they have confidence. It is, therefore, a matter of indifference to them, in all respects save that of price, which tender is accepted, and consequently they take the lowest. Very small differences in amount are in such cases sufficient to win or lose important contracts. In one instance in the author's experience a difference of £3 only in a considerable tender for locomotive boilers lost his firm the order. This being so, our engineer will aim to quote a price which will be just sufficient, and no more, below all the other tenders to secure him the order; provided, of course, that such price will leave him the minimum of profit for which he is willing to work.

In the second case price may not be the only condition that will determine who secures the order. Under this condition there will be opportunities for our engineer to exercise both his mechanical ingenuity and his commercial tact—the former in devising the best or most economical method of accomplishing the object in view; and the latter in preparing the specification and in persuading the intending buyer that what the specification proposes is the best, and worth the amount of the tender.

It will thus be seen that there are many considerations which may influence a manufacturing engineer in determining the amount of his tender for any proposed work. Considerations of a similar nature will also influence him when charging a customer for work that has been done without reference to any formal tender. In the proper application of such considerations lies the highest art of business.

It does not, however, usually fall to the lot of the submanager or the estimate clerk to make this practical application. Their duty is generally fulfilled by preparing an estimate in accordance with the rules or custom of the establishment, leaving it to the chief manager or principal himself to practically apply such considerations as have just been pointed out, by reducing or increasing the total amount of the estimate so prepared. At the same time it will be well for younger men to endeavour to take the broadest possible views of their business, and to note carefully the considerations that influence their seniors in different cases as they arise, and the degree of success that attends the application of those considerations.

Specialties.

The prices of specialties are also largely determined by such considerations as those to which we have referred. It by no means follows that a manufacturer will be independent of competition, and can afford to disregard the elementary conditions of ordinary business because he makes specialties which are patented inventions. This indeed is very rarely the case — only in some exceptional instances, where the inventions are both unique and of great importance. In the great majority of patented specialties the manufacturer is quite as much under the control of competition, as any other. The maker of a patent pump, for example, must determine his price largely by the prices asked by other makers for their pumps, even although his may possess some advantages over most other kinds. The users of pumps will pay a reasonable price for improvements, but will put up with the inconveniences of inferior pumps rather than pay an excessive price for a better one.

A very high price for any specialty will always operate in two ways to the disadvantage of the maker—it will restrict the sale, and will stimulate inventors to produce a cheaper apparatus. Hence prudence would clearly dictate a reasonable moderation in fixing the price at which even a valuable patented invention is to be offered to the public.

A specialty, however, need not be a patented invention. An engineer may determine, by giving particular attention to one class of ordinary work, to make a specialty of its manufacture. For instance, he may decide to make a specialty of the manufacture of shafting, or of wheels, or some type of boiler or engine. His object may be to get special prices for his productions, on account of the superior merits they possess, owing to the particular attention he gives to that kind of work: or it may be, by means of special tools, by purchasing the raw material, manufacturing it and selling the finished article in large quantities, so to reduce the cost of manufacture below what may be considered the normal cost of that particular kind of work as to enable him to make a larger profit than usual out of such work at ordinary rates, or even to sell under the usual prices.

CHAPTER II.

ESTIMATES TECHNICALLY CONSIDERED.

HAVING now briefly indicated certain guiding principles or considerations affecting the preparation of estimates, we may pass on to consider our subject more in detail.

Engineering estimates may be considered from two points of view, or may be said to possess a twofold character—a technical and a commercial. Technically considered, the preparation of an estimate consists in the calculation of the weights or quantities of material, and in estimating the amount of labour, skilled and common, that will be required to complete a proposed piece of work: whilst the commercial function consists in determining the rates at which the various kinds of material and labour shall be priced in the estimate, in apportioning the proper sums for manufacturing expenses and profit, and in deciding the final amount of the tender. In other words, the technical function deals with quantities, and the commercial with prices.

In small establishments both technical and commercial duties are often performed by the same person; but in large works the technical part of an estimate is in most cases performed by one person—generally a draughtsman, with the assistance of the foreman; and the commercial part is dealt with by another—an estimate clerk under the direction of the manager, or by the manager himself.

The technical preparation of an estimate naturally divides itself into two parts—namely: 1st, material; 2nd, labour or workmanship.

Material. The materials with which we have to deal are principally the following:

Cast Iron.—In its ordinary condition we meet with cast iron in nearly every estimate, as it enters more or less into most engineering productions, being especially employed whenever the qualities of stiffness or rigidity or resistance to compression are required, or adherence to a shape which cannot be readily forged is necessary : hence, used for the cylinders and framing of engines, for the framework of nearly every class of machinery, for wheels and pulleys, columns, beams, wall boxes and brackets, and innumerable other objects. Occasionally also we meet with it in the special conditions of malleable and chilled castings, the former being largely used for parts of machines which are required to be as light and strong as possible, but which cannot be made of wrought iron on account of cost or unsuitable shape; and the latter being employed wherever it is necessary to have great surface hardness to resist abrasion or indentation, as in the roller paths or rollers of swing bridges, the rolls of certain classes of mills, and in other cases.

Wrought or "Malleable" Iron.—In the shape of forgings for crank-shafts, cranks, connecting and piston rods of engines, axles, and heavy shafting ; in the shape of round bars for common shafting, spindles, small pump rods, tie rods and bolts ; and in the shape of tees, angles and plates for boilers, bridges and roofs.

Steel Castings.—Now being used in daily increasing quantities in cases where formerly common cast iron, malleable cast iron, or wrought iron would have been employed.

Mild Steel.—Which, in the forms of forgings, bars, angles and plates, is now largely used where quite recently the superior classes of wrought iron were employed, and is even displacing wrought iron for many ordinary purposes.

Copper.—In the form of round bars for special pump rods, for bolts to be used in positions where iron is not admissible, and in the form of sheets for special boilers, kiers, or stills, and steam and other pipes on board ship.

Brass, Gun Metal, Phosphor Bronze and other Alloys.—Principally in the shape of castings for bearings, bushes, glands, valves, taps, pump and plunger liners, and pumps for use with acid liquors or other special purposes.

Lead.—Occasionally in the shape of castings, and frequently as sheet lead for lining tanks and other vessels for chemical works and other purposes.

Timber.—Yellow pine and Honduras mahogany or baywood for patterns; beech and hornbeam for the cogs of mortice wheels and for special purposes—for example, the beetles of beetling engines; oak for the jibs of cranes and for water wheels; pitch pine for certain classes of machines—the fulling or wash-mills used in the finishing of high-class cotton and linen fabrics, for instance: willow for lining grooved pulleys, and for friction straps or breaks; lignum vitæ for bearings; sycamore, teak, and mahogany for callender rollers, and occasionally other timbers.

Other Materials.—Tin, leather, indiarubber, asbestos, cements, ropes, &c., in addition to numerous articles which are bought in a finished condition, occur more or less frequently.

Calculation of Quantities.

The first step in the preparation of an estimate, assuming a sufficient plan and specification to be before us, is to calculate or "take out," to use the drawing office phrase, the weights or quantities of the materials that will be required for the proposed work. To enable him to do this, the student must be possessed of certain elementary knowledge which it does not fall within our province to convey. He must understand arithmetic, including both vulgar and decimal fractions; he must have a sufficient knowledge of mensuration to enable him to calculate the areas of triangles, rectangles, simple polygons, circles and common segments, and the volumes or cubical contents of the simpler solids—prisms, cylinders and spheres. He must understand mechanical drawing sufficiently to enable him to "read" perfectly any ordinary plan. He must also know, or, what will do as well so far as this point is concerned, know where to find quickly, the weights per unit volumes or quantities of such materials as those we have just mentioned—for example, the weight of a cubic inch of cast iron.

All properly-equipped engineering offices contain books of tables from which these particulars as to weights can be obtained, probably the book most frequently consulted being "The Pocket Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers" by G. L. Molesworth, or as it is briefly and familiarly styled in the drawing office, "Molesworth." This or some similar book is indeed indispensable to anyone who has to prepare engineering estimates. The tables which have to be most frequently referred to are the following:—

Areas and Circumferences of Circles.
Strength and Weight of Materials.
Weight of Flat Bar Iron.
" " Round and Square Bar Iron.
" " Angle and T Iron.
" " Sheet Metals.
" " Plates.
" " Cast-iron Pipes.

The student should, therefore, familiarise himself with the arrangement of the above tables; and it would be well if he would commit to memory at least the following parts: the weights per cubic inch of cast iron, wrought iron, steel and brass; the weights per lineal foot of round bar iron from ½in. up to 6in. diameter, and the weights per superficial foot of iron and steel plates from ¼in. to 1in. in thickness. The weights per cubic inch of average qualities of the four metals mentioned must, indeed, be firmly fixed in the mind. They are:—

Cast Iron	0·260lb.
Wrought Iron	0·280 "
Steel	0·288 "
Brass	0·300 "

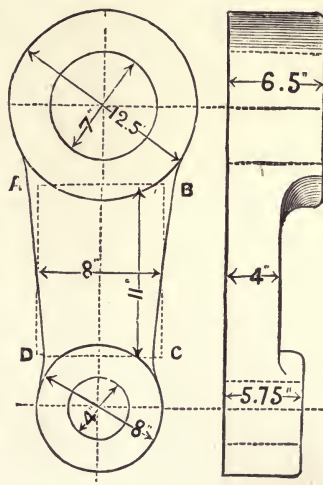
One or two simple examples will serve sufficiently well to illustrate the nature of the work involved in the taking out of quantities.

1. Let it be required to find the weight of a cast-iron plate 2ft. square by 1½in. thick. The number of cubic inches in such a plate will be 24 × 24 × 1·5 (the length, breadth and thickness of the plate in inches) or 864 cubic inches. This number multiplied by 0·26, the weight of one cubic inch of cast iron of average density, will give the weight of the plate in pounds, namely, 224·64—practically 2 cwt.

2. Let it be required to find the weight of a wrought-iron bar 10ft. long and 2in. in diameter. The length of this bar in inches multiplied by the area of the transverse section in inches will give the total number of cubic inches in the bar—377—with sufficient exactness for our purpose. This number multiplied by 0·28, the weight of a cubic inch of wrought iron, gives the weight of the bar in lbs.—105. In practice this

process of calculation would rarely be gone through. The table of "Weights of round bar iron" in "Molesworth" would be referred to, and it would be seen that the weight of a lineal foot of 2-in. round bar of iron is 10·49lb.; 10ft. would consequently be practically 105lb. as above. Similarly, suppose we want the weight of a steel plate (say for a boiler flue) 9ft. long by 3ft. wide and ½in. thick. We learn from "Molesworth"—Table of weights of plates—that the weight of a superficial foot of ½-in. steel plate is 20·8lb.; and as there are 27 superficial feet in the plate supposed, the weight required is simply 27 multiplied by 20·8, or slightly over 5cwt.

3. Suppose we require the weight of a wrought-iron crank, as shown in the annexed illustration. It is obvious that we cannot find the weight of this crank at one calculation. We must imagine the crank to be split up into several parts, and must find the weight of each part separately. We may take the crank-shaft end first. Here we have a cylinder 12·5in. in diameter by 6·5in. long; but the cylinder is not solid—it has a hole through it 7in. in diameter. Therefore, for the number of cubic inches in the cylindrical part of the shaft end of the crank we have—the area of 12·5 × 6·5 less the area of 7 × 6·5, equal to 547 cubic inches. The crank-pin end of the crank must be taken in a similar manner. There is now the web of the crank to be calculated. The face of this web presents an irregular figure having two straight sides not parallel and two unequal curved sides. The exact superficies of this face can be determined without difficulty by joining the corresponding ends of the straight sides by other straight lines, finding the superficies of the surface so arranged and then deducting the segments of the circles contained within the four straight lines. For all practical purposes, however, it will be sufficient to consider the face of the web as a rectangle, as shown by the dotted lines. The cubic inches in the web will



therefore equal 11 × 8 × 4, or 352. Adding all together, we have—Shaft end of crank, 547 cubic inches; pin end of crank, 217 cubic inches; web, 352 cubic inches; total 1116—equal to 312 lb., or, making an allowance for the fillets at the back of the crank, say 315lb. as the weight of the crank when finished to the dimensions marked.

It would be easy, but it is quite unnecessary, to multiply examples at this stage. Simple as are the illustrations which have just been given, most of the calculations involved in the taking out of quantities in mechanical engineering may be resolved into problems equally simple. The most complicated mechanical design admits of being divided, in imagination, into a number of simple parts in the same way as we have just divided the crank, and the probable total weight of the structure estimated in a similar manner.

It is important to remember, when calculating weights from plans or specifications, that the dimensions given are invariably finished dimensions, and therefore the article, if it has to be "machined" in any way, will require to be cast or forged, as the case may be, larger, in order that it may, when finished, be of the required size. It is especially important to remember this when dealing with heavy engine forgings, large iron castings, and all brass or gun-metal castings.

Rough and Finished Sizes.

The allowances which have to be made for "machining" vary according to the nature of the work, and vary also in different establishments; some firms, by paying special attention to the moulding of their castings, or by the use of very accurate tools, can work with very small allowances. For turning up rolled steel or iron bars into polished shafts an allowance of $\frac{1}{16}$ in. full in the diameter ought to be sufficient up to 3 in. diameter; larger sizes will require from $\frac{1}{8}$ to $\frac{1}{4}$ in. Much larger allowances —$\frac{1}{4}$ in. to $\frac{3}{4}$ in.—have to be made in the case of hammered bars, such bars never being so regular and true as rolled bars; and still more must be allowed on heavy engine forgings and shafts with large bosses. An allowance of 1 inch all over in the diameters would not be too much in the case of an ordinary engine crank-shaft which is to be turned up to, say, 6 in. in diameter in the journals; and larger allowances would be necessary for larger shafts.

It need scarcely be mentioned that an engine crank will come from the forge solid, without any holes for the crank-shaft or pin, and that this would also be the case with the ends of a connecting-rod. Hence, in calculating the weight of a forging of a crank to be finished to the dimensions shown in the preceding illustration, we should have to treat the cylindrical ends as solid, and make an allowance of $\frac{1}{4}$ in. in every direction. The weight of such a forging would consequently be about 460 lbs.

It may be mentioned that it is the usual practice for engineers when ordering their heavy forgings to give merely the finished dimensions, leaving it to the forge people to make the allowances they think necessary; and as forgings are generally sold by weight, it is not an unusual thing for a forge manager, in his anxiety to allow plenty, to allow rather too much.

On the flat parts (which have to be machined) of iron castings, it will generally be sufficient for the purposes of an estimate to make an allowance of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. The latter allowance should also be sufficient for most curved surfaces in cast iron, where fairly good castings can be depended upon, though more has to be made in the case of large pulleys.

In the course of the examples which will be given further on, the reader will have opportunities of noting allowances made in different cases. In addition to the weights of the various metals to be used, it will be necessary, when new patterns have to be made, to estimate the quantity of timber that will be required. This is expressed in cubic feet when the patterns are massive, and in superficial feet of boards of various thickness when the patterns are framed. Other quantities have also from time to time to be calculated or estimated—the number of bolts and nuts, when these are of small sizes; the weight of jointing materials; the weight of paint when much painting has to be done; and so on.

In passing, it may be mentioned it is a great advantage to be able to make rough calculations mentally of the weights of various engineering objects. It is easy to remember that a

Mental Calculations.

cubic inch of cast iron weighs slightly over $\frac{1}{4}$ lb. —$\frac{1}{4}$ lb. and $\frac{1}{100}$ lb. Therefore, to find the weight of any number of cubic inches of cast iron, all that is necessary is to divide by four and add 1 lb. for every 100 cubic inches, the total being the weight in pounds. Similarly, a cubic inch of wrought iron weighs $\frac{1}{4}$ lb. and $\frac{8}{100}$ lb. Again, the area of a circle is approximately $\frac{3}{4}$ and $\frac{1}{30}$th of the square of the diameter. For example, the square of 10 is 100; three fourths of 100 is 75; $\frac{1}{30}$th of 100 is a little over 3, which, added to 75, makes 78—a total that is within half-an-inch of the exact area of a circle of 10 diameter. An acquaintance with details of this kind will often prove of great use to the student.

Estimation of Workmanship.

We come now to consider briefly the estimation of workmanship. This is necessarily a much more difficult matter than the mere calculation of weights—it is largely a matter of experience and judgment. Few tasks, indeed, are less matters of rule and calculation, and more matters of special knowledge, reasoning, and judgment, than the estimation of workmanship.

The conditions upon which this question of workmanship depends are not only numerous, but are liable to great and not infrequent variation. The power and accuracy of the machine tools employed; the quality of the steel used for the cutting tools; the quality of the files used, and the completeness and efficiency of other hand tools and appliances which are at the command of the workmen; the facilities provided by means of cranes, pulley blocks and other apparatus for the handling of material; the character and amount of the assistance provided in the shape of common labour; the general organisation of the shop; the intelligence and energy of the foreman; the character of the workmen themselves—all these, and often other elements, enter into this question of workmanship and determine the amount of time that will be required to perform a specified work.

Hence, the knowledge gained by experience in one place, or at one period, requires to be carefully checked when it has to be applied in another place, or after any considerable lapse of time. Hence, also, all we can do here is to show how the task of filling in the workmanship of an estimate may be gone about, point out how reason and judgment have to be exercised, and indicate some general rules applicable to certain classes of work; leaving it to the student to extend his knowledge by a study of the examples which will presently be given, and of work that may come under his own observation.

The classes of engineering labour with which we have mostly to deal are the following: Draughtsmen and pattern-makers; turners, planers, slotters, drillers, and other machinists; fitters and millwrights; and smiths. In ordinary millwright and similar work it is not considered necessary to set out moulder's time in estimates. This is obviously not required when the castings are to be bought from outside. In such cases the person whose business it is to price the estimate will know how much per cwt. he will be charged for any particular class of castings by his founders; and if there is anything special in the castings that are contemplated, he will ask the founders for a special quotation.

Neither is the moulder's time set out, as a rule, in establishments which have a foundry of their own. The work of the foundry is of so regular a character, and so much a matter of repetition, the labour varies so nearly in each class of castings, according to the weight, that it is a simple matter to fix rates which will in each class of castings cover all expenses. Hence all the particulars which the person who prices the estimate requires, as a rule, are the weight and class of casting. In special instances, however, it may be required to set out the moulder's time, particularly in the case of large and important loam castings of a character new to the establishment.

It is also generally unnecessary in ordinary smith's work to detail the smith's time; but in any work of a special or exceptional nature the smith's time will have to be estimated.

Neither is it necessary, except in special cases, to detail the amount of common labour likely to be required in any given case. The general assistance of labourers throughout the shop as also the services of crane-men, engine-drivers, tool-smiths carters, storekeepers, foremen and others, will be covered in the rates that will be put down in the estimate, or by some percentage or other charge.

In preparing estimates for boiler work, particularly boiler repairs and alterations, it is desirable to set out full particulars as to the extent to which certain machine tools, furnaces, &c., will be used. A squad of men engaged upon some important boiler repairs will, whilst making their preparations in the shop, use, more or less, according to the nature of the work, a large furnace, one or more smith's fires, a set of rolls, a shearing and punching machine, drilling machines and so on. Jobbing boiler work is of so variable a character that it would be almost impossible to cover fairly the use of the furnaces, rolls, etc., by the rates charged for the men's time; hence the desirability of estimating, more or less in detail, the time these special appliances will be used in any particular case.

In estimating the workmanship on any engineering object there is then generally to be considered: the preparation of the drawings, the preparation of the patterns in the case of castings, the moulder's time or the time of the smith and his strikers or hammermen in special cases, the machining of the article, the fitter's time finishing in the shop and erecting at the destination.

In ordinary work it is not usual to detail the amount of drawing and pattern-making that will be required for each individual object; it is usually sufficient to make a general estimate of the drawing and pattern-making required for the whole contract and set it out at the end of the estimate.

Again, an estimate draughtsman, in considering the pattern-making likely to be required, always ascertains whether there are not in the stores some patterns which, either with or without alteration, may be made to fall in for the work required. For special fixings, of course, patterns must be made up specially and the time for them set out more or less in detail in an estimate; but the ordinary patterns of pulleys, pedestals, hangers, wall brackets, columns, pipes, etc., which are found in the stores of established engineering works, can generally be altered within certain limits to suit the requirements of ordinary cases. For instance, a column pattern may be lengthened or shortened, may have a square base or a round base put upon it, may have one or more brackets attached to its side, and so on. Hence the pattern-making that will be required in the case of a contract can very often be conveniently summed up at the end of the estimate thus:—"Alteration of patterns, so much time."

For machining the plainer kinds of work it is possible to indicate some rules of a general character, which may help the student and, particularly, suggest to him how he may prepare rules for his own guidance in any establishment in which he may be placed. The time for turning plain flat belt pulleys of from 24in. diameter and 6in. face and upwards should not exceed one hour and a quarter for every superficial foot of finished surface. Pulleys with rounded faces should be done at not more than one hour and a half per superficial foot. Smaller sizes will require from one and a half to two and a half hours per superficial foot. These allowances will generally cover the time of boring the centres; but there will be to add the slotting of the key-beds, and, in the case of split pulleys, the time of a fitter splitting and bolting, the latter being one hour's work of a fitter for small-sized pulleys up to half-a-day's work for large sizes. In the case of large and important pulleys, cast in halves, there will also be the planing of the joints to be included.

For turning plain rolled shafting bars of moderate diameters, half-an-hour per superficial foot of finished surface should be sufficient; and for plain hammered shafts, with solid flange couplings, one hour per superficial foot.

For forged shafts, with bosses, one hour and a half to two hours and a half must be allowed. Stationary engine crank-shafts, with the usual fly-wheel boss and sunk journals, say of 9 in. diameter, require about two or two and a quarter hours per superficial foot for turning, and a little longer time must be allowed for smaller sizes, much of course depending upon the style of the forging itself—that is, whether nicely or roughly forged, with a moderate or with an excessive allowance.

Plain piston rods, which require to be very highly polished, require about three hours per superficial foot for turning.

As planing machines are not driven so fast as lathes, and are not so continuous in their action, work done upon them requires more time per superficial foot than work done in lathes. Large key-beds on plain crank-shafts will usually be found to take from four and a half hours to six hours per superficial foot, including the time occupied in changing the position of the shaft on the planer table. A large continuous surface will be done in from three to five hours per superficial foot, according to the degree of finish which it is desired to give in the machine.

The work done, however, in planing and shaping machines is so irregular in character that it is impossible to lay down rules of anything like general application. This latter remark applies with equal force to almost every kind of fitter's and millwright's work. It must also be borne in mind that the rates just indicated for turning must be approximate—they will vary in different establishments and in the same establishment from time to time.

It is not expected of a draughtsman or other person who is preparing an estimate that he should be able, entirely unassisted, to determine the workmanship that must probably be expended. There are two sources of information to which he can most properly apply for information: First, the time records or cost accounts of previous work; and secondly the foremen of the different departments.

If we have to estimate the time that will be required to perform a certain work and we have at hand a record of the time actually expended on some previous occasion on a somewhat similar piece of work, obviously that record will constitute the best guide we can possibly have. We have nothing to do but to consider how far, if at all, it is necessary to modify the particulars contained in the record. A reference to past experience, whenever it can be made, is exceedingly valuable. Suppose we are preparing an estimate for a crank-shaft pedestal —say of 12 in. diameter. We have not made so large a pedestal before, but we have made 10 in. pedestals of similar construction. Clearly it will be a great advantage to have before us the particulars of the time actually expended on the 10 in. pedestals. The larger one will certainly take more time—it cannot take less—and by a careful comparison of the two designs it will be possible to make a very reliable deduction from the account of the one what will be required for the other.

When there are no previous records available, the foremen should be consulted in all cases of importance—the foremen are the men best able in any establishment to estimate workmanship. Indeed, it is hardly possible to consult the foremen too much on questions of workmanship. Their interest in the work of the establishment will thereby be quickened and their sense of responsibility increased. A foreman who is consulted respecting the time likely to be required for any particular job will generally take care that his estimate is, at least, not exceeded.

CHAPTER III.

ESTIMATES COMMERCIALLY CONSIDERED.

THE technical part of an estimate being completed—the weights and quantities calculated, the workmanship estimated and the whole set out with the necessary detail and in proper order on the estimate sheets, there remains the commercial part of the work to be done.

In performing this, either of two methods may be adopted. In the one, the object in view is to ascertain the probable cost of the proposed work to the *manufacturing engineer.* The material, therefore, is rated at the prices which he will actually pay for it, and against the various items of workmanship are set the amounts of the wages that will be actually paid. The total so obtained will represent the probable cost of the proposed work in direct materials and workmanship. To this total must be added a certain percentage—properly a percentage on the wages of the skilled labour, as will be explained further on—which percentage is intended to cover such a proportion of the working expenses of the establishment, including rents, rates, gas, common labour, management, etc., as may be supposed to be fairly chargeable to such a contract as the one in view.

The total now obtained will represent the *gross cost* of the proposed work to the *manufacturing engineer*, and there remains only to add the amount of profit which the engineer desires to receive from the contract.

This is undoubtedly the most perfect method of preparing an estimate, whether for small or large contracts ; and possesses many recommendations. It enables the engineer to see at a glance the lowest sum, with all possible exactness, which he can accept without loss. An estimate so prepared can be most readily compared with the actual cost of the work when completed, assuming, of course, that proper cost accounts are kept.

The other method is, however, easier, and is more generally adopted. In this method, the materials and workmanship are simply priced at certain standard rates, which rates are supposed to cover not merely the cost of the materials and workmanship, but also the working expenses of the establishment and profit. The total so obtained is an estimate of the cost of the proposed work, not to the *manufacturing engineer*, but to the intending *buyer*. It gives at once a selling price for the work in view, but furnishes no indication as to what the work will actually cost to the engineer.

This method of preparing an estimate is distinctly empirical, and has as many disadvantages as the first and more scientific method has recommendations. Unless an engineer knows as nearly as possible what a contract will actually cost him, it is evident that he cannot decide upon the sum he will ask for the work with anything like the confidence he ought to be able to feel—he can merely hope that the rates in the estimate are, on the one hand, high enough to cover the cost, and on the other hand not so high as to put his tender out of the running.

We shall give examples of estimates prepared in accordance with the first and more exact method; but as the second and rough and ready plan is so generally adopted, we shall deal with it first, and shall endeavour to give the reader a general view of the rates charged for the ordinary classes of engineering material and workmanship when preparing estimates in accordance with this second method. Of course it will be understood that these rates vary in different districts. Indeed, in no two establishments, even in the same district, will they be the same as a whole, although it is no uncommon thing for the manufacturing engineers of a district to agree to a certain minimum for certain classes of work. The rates charged will also vary from time to time, according to the prices of the raw materials and the rates of wages paid to engineering workmen.

Basis Rates—Material. The examples that will be given, are mostly taken from a period during which the prices of certain representative classes of material and labour ruled about as follows, namely :—

	Per Ton. £	s.	d.
G. M. B. Scotch pig iron	2	4	0
Middlesbro' No. 3 pig iron	1	16	0
Ordinary marked Staffordshire bars	7	10	0
"Best Best" Staffordshire boiler plates	8	5	0
Ingot copper—good quality	60	0	0

Carriage, which must be added to the above, ran about 6*s.* per ton on Scotch pigs and 14*s.* per ton on Staffordshire bars and plates. The pig iron actually used in the foundry in question was a somewhat superior Scotch quality, costing, with carriage, usually about £2 16*s.* per ton during the period named.

LABOUR.

	s	d.		s.	d.
Pattern makers	30	0	to	32	0
Ironmoulders	34	0	„	38	0
Smiths	30	0	„	36	0
Turners	30	0	„	34	0
Fitters and millwrights	28	0	„	32	0
General Labourers	14	0	„	19	0

Per week of 54 hours.

Rates for Iron Castings.

There are three general classes of iron castings—loam castings, dry-sand castings, and green-sand castings. The latter are moulded from full patterns in the common foundry sand in its damp or "green" condition; dry-sand castings are moulded in a similar way usually, but in a slightly different kind of sand, and the mould is afterwards dried in a stove; whilst loam castings are built up about a mere skeleton pattern, or "swept" up by boards cut to such outlines that their revolution about certain centres forms the shape of the desired casting.

What may be called the framework of a loam mould is a substantial erection of brick. This brickwork is lined or faced with loam, to which the moulder gives the required shape and finish with his trowels and other tools, aided by his outline boards and by working drawings. The mould is finally dried in a stove, or by having coke fires built in or about it.

The price at which any cast ng will be charged to a customer, or rated in an estimate, depends upon the amount of labour required to mould the casting in proportion to its weight. Loam castings are consequently the most expensive productions of the iron foundry.

A casting will be made in loam, either because it is impossible to mould it in green sand, or because the risk of losing the casting would be very great, owing to its size or intricacy; or because, only one or a very limited number of castings being required, the expense of making a pattern would greatly outweigh the extra cost as compared with green-sand moulding.

Consequently loam castings are nearly always of a special character, and are rated at special prices, according to the labour they require. In the following list of some representative loam castings the prices given are those at which the castings were charged to buyers or rated in estimates.

	cwt.	qr.	lb.	Per cwt. s.	d.
Horizontal Corliss engine cylinder, 24 in. × 54 in.	44	0	0	23	0
Cover for ditto	9	2	21	18	0
Beam engine cylinder	60	0	0	16	0
Horizontal engine cylinder	9	2	0	26	0
Sole plate or framing for ditto	17	0	0	24	0
29-in. piston block	9	1	0	16	0
22-in. "	6	3	0	16	0
Hydraulic press cylinder	36	0	14	14	0
" "	19	0	0	16	0
Clay pug mill cylinder	20	1	4	14	0
Fixing for bottom of upright shaft	44	0	0	15	0
Yarn boiler in two parts	50	0	0	15	0
"	43	0	0	14	6
"	28	0	0	16	6
Mangle bowl, 90 × 18 in.	30	2	0	16	0
Marine engine condenser	83	0	0	14	6
" " side frame or column	28	2	7	14	6
" " circulating pump	20	1	14	19	0
" " air pump	13	1	0	22	0
" " bilge pump	2	0	0	26	0
" " cylinder	80	0	0	17	0
" " " cover	14	1	0	14	0
" " sole plate	82	0	0	13	6
" " piston block	13	0	14	14	0
" " junk ring	3	2	14	14	0
" " slide valve	4	3	6	18	0
Stern tube	28	2	0	13	0
Propeller boss or centre	20	0	0	13	0
" blade	12	1	0	18	0

The cost of preparing the loam boards is not included in above rates. The marine castings mentioned were sold to another engineering firm, and were subject to a discount of $7\frac{1}{2}$ per cent.

In all properly managed works, a separate cost is kept of *each* loam casting, and the prices determined by adding a percentage to the gross cost. The percentage added is commonly about one third. In exceptional cases—for instance, where great risk of making a bad casting is incurred, the proportion may be higher—up to two thirds. Some detailed costs of loam castings will be given further on.

Coming now to green-sand castings, we have the following classes:—

SPUR WHEELS FROM ORDINARY PATTERNS.

	Per cwt. s.	d.		s.	d.
Weight each under 7 lb.	16	0	to	18	0
" " 7 to 28 lb.	13	0	"	16	0
" " 28 to 112 lb.	12	0	"	15	0
" " 1 to 5 cwt.	10	0	"	13	0
" " 5 cwt. and upwards	9	0	"	12	0

It is a common practice to make a distinction between spur and bevil wheels, and to charge bevils (and also worm wheels), 1*s.* to 2*s.* per cwt. more than spurs; also to charge mortise wheel castings 1*s.* to 2*s.* per cwt. more than plain wheels, whether spur or bevil. Wheels cast to split are also charged extra—generally 2*s.* per cwt. for small wheels, and 1*s.* to 1*s.* 6*d.* for large wheels. Thus a split bevil wheel of 3 cwt. would be rated from 13*s.* 6*d.* to 17*s.* per cwt.

MACHINE MOULDED SPUR WHEELS.

	Each.				
	s.	*d.*		*s.*	*d.*
Weight each 28 to 56 lb.	12	0	to	16	0
„ „ 56 to 112 lb.	14	0	„	20	0
	Per cwt.				
„ „ 1 to 5 cwt.	15	0	„	18	0
„ „ 5 to 10 cwt.	14	0	„	17	0
„ „ 10 to 20 cwt.	13	0	„	16	0
„ „ 20 cwt. and upwards	10	6	„	13	6

Bevil and mortise wheels usually 2*s* per cwt. extra.

Wheels flanged to pitch line, 1*s.* 6*d.* or 2*s* per cwt. extra.

Wheels cast to split 1*s.* 6*d.* or 2*s.* per cwt. extra.

Hence on a bevil mortise there would be an extra charge of 4*s.* per cwt.—2*s.* for the bevil and 2*s.* for the mortise, and so on with other variations. In wheels to be split, wrought-iron splitting plates are often used, and are charged extra along with the bolts at 4½*d.* to 6*d.* per lb.

When two or more castings off the same wheel pattern are ordered at the same time a reduction of 1*s.* or 2*s.* in the rate per cwt. should be made.

A brief reference to the difference between ordinary and machine moulded wheels may, perhaps, be desirable. Formerly nearly every toothed wheel used in mechanical engineering was made from a complete pattern, the principal exceptions being large engine fly-wheels and the gearing of water-wheels, these being moulded from large segment patterns, cast in pieces, and the segments subsequently bolted together. The cost of making a wheel pattern, seeing that every cog had to be cut out of wood, was, therefore, very heavy. Now, however, the wheel-moulding machine enables us to mould almost any kind and size of wheel with a pattern of two teeth only, the entire rim being completed by moulding a tooth at a time, the block pattern being moved round on a fixed centre by successive steps to enable this to be done. The arms of the wheels are usually formed by cores made in separate core boxes.

The time required to mould a wheel by machine is longer than would be required to mould a similar wheel from a full-sized pattern, hence the weight per cwt. for a machine-moulded wheel is necessarily higher than for a similar common one. This extra rate, however, is more than counterbalanced by the saving in the cost of pattern-making, whilst the casting is much better, as a rule, than any which could be made from a complete pattern, especially if the pattern had been used a few times, or had been in store for any lengthy period.

Generally, the rates we are now giving for castings are exclusive of the cost of preparing or altering patterns, though they would usually be allowed to cover the mere use of stock patterns, but one or two firms who lay themselves out specially for making machine-moulded wheels would supply castings of wheels of any ordinary size or pitch at about the rates named, including every expense connected with the preparation of patterns.

BELT PULLEY CASTINGS.

Generally 9*s*. to 15*s*. per cwt. The following is a fair scale for ordinary straight or curved arm pulleys of moderate widths relatively to the diameters, namely :—

	Per cwt. s. d.		s. d.
Weight each under 1 cwt.	11 0	to	14 0
„ „ 1 cwt. to 5 cwt.	10 0	„	13 0
„ „ 5 cwt. to 10 cwt.	9 0	„	12 0
„ „ 10 cwt. to 20 cwt.	8 6	„	12 0

Cast to split, 1*s*. 6*d*. to 2*s*. 6*d*. extra per cwt.
Flanged on one or both sides, 1*s*. 6*d*. to 2*s*. 6*d*. extra per cwt.

Larger pulleys would usually have the rims swept up in loam, and would be rated as loam castings—at from 10*s*. to 14*s*. per cwt.

ROPE PULLEY CASTINGS.

These generally have the rims swept up in loam :—

	Per cwt. s. d.		s. d.
Weight each under 2 cwt.	16 0	to	26 0
„ „ 2 cwt. to 5 cwt.	14 0	„	20 0
„ „ 5 cwt. to 10 cwt.	12 0	„	16 0
„ „ 10 cwt and upwards	11 0	„	15 0

FLY-WHEEL CASTINGS.

Wheels with plain rims, moulded whole, and with the centres divided in the sand to allow for contraction :—

	Per cwt. s. d.		s. d.
Weight each 1 ton to 3 tons	8 0	to	12 0
„ „ 3 tons and upwards	7 0	„	10 [illegible]

Geared fly-wheel castings of above weights, from segment patterns, 1*s.* 6*d.* to 2*s.* 6*d.* per cwt. extra.

Wheels with plain rims cast in halves or in segments for planing.

	Per cwt. s. d.		s. d.
Weight per wheel, 3 to 10 tons	9 6	to	11 6
" " 10 to 20 tons	9 6	"	11 0
" " 20 tons and upwards	8 6	"	9 6

Rope fly-wheels in halves or segments :—

	Per cwt. s. d.		s. d.
Weight per wheel, 3 to 10 tons	12 0	to	14 0
" " 10 to 20 tons	11 0	"	13 0
" " 20 tons and upwards	10 0	"	12 0

COLUMNS, BEAMS AND GIRDERS.

Plain heavy columns and beams for buildings, of weights say from 15 cwt. each up to 40 cwt., will range from 9*s.* down to 6*s.* per cwt., according to quantity required. Moderately light columns, with brackets cast on to carry pedestals, for weaving sheds, from 9*s.* down to 6*s.* 6*d.* per cwt.

CAST-IRON PIPES.

	Per cwt. s. d.		s. d.
Plain straight-flanged pipes	7 0	to	10 0
Plain straight-flanged bends	9 0	"	12 0
Straight spigot and faucet pipes	6 6	"	8 6
Plain spigot and faucet bends	7 0	"	9 6

If with single branches about 2*s.* per cwt. extra.

Many general founders and engineers now buy spigot and faucet pipes from Scotch and other houses who make specialties of their manufacture, and retail them instead of making such pipes themselves. They can be bought for about £4 5*s.* per ton and upwards. The special makers of these common pipes are, however, now so well-known that a millowner who required any considerable quantity would apply to these special makers. Hence general founders and engineers do comparatively little now in this class of work, being called upon indeed for little more than special or odd lengths.

Cast-iron hangers, brackets and pedestals, 9*s.* to 14*s.* per cwt. according to weight and character.

Wall boxes, 8*s.* to 12*s.* per cwt.

ORDINARY LOOM AND OTHER MACHINE CASTINGS.

	Per cwt. s. d.		s. d.
1 to 7 lb.	13 0	to	15 0
7 " 14 lb.	12 0	"	14 0
14 " 28 lb.	11 0	"	13 0
28 " 112 lb.	9 6	"	11 6
1 cwt. to 5 cwt.	8 0	"	10 6

WHEEL AND PINION CASTINGS FOR LOOMS, ETC.

	Per cwt.
	s. d. s. d.
1 to 3 lb.	16 6 to 18 0
3 " 7 lb.	15 0 " 17 0
7 " 14 lb.	14 0 " 16 0
14 " 28 lb.	13 0 " 15 0

FIRE BARS.

Common, such as can be moulded on their edges, 5*s.* 6*d.* to 7*s.* per cwt.; 6*s.* 6*d.* is a common rate. Such bars are usually moulded by apprentices at the rate of four or six in a box at a time. Very light bars, and such as require to be moulded on their sides, must be charged higher, 7*s.* 6*d.* to 9*s.* 6*d.* per cwt. Side bars and bearers, 7*s.* 6*d.* to 9*s.* 6*d.* per cwt.

When a tender is given for castings only, from a customer's own patterns—say to a millowner, or to an engineer who does not make his own castings—it is a common practice to quote all-round or overhead prices for the different classes of castings (except loam castings). Such all-round rates run from 10*s.* to 12*s.* for ordinary wheel castings, and from 8*s.* to 11*s.* for ordinary mill "uses."

Wrought Iron and Mild Steel.

Common wrought bar iron, costing from £6 to £7 per ton delivered into the yard, will be rated at from 9*s.* to 13*s.* 6*d.* per cwt. Good marked bars, costing the engineer between £8 and £10 per ton, and used largely for bolts, small forgings, etc., will be put down at from 12*s.* to 18*s.* 8*d.* per cwt. Small quantities should be charged 2*d.* or 2½*d.* per lb.

It is to be remembered that in cutting up bar iron there is necessarily considerable waste, which cannot be covered except by charging rates which may appear high relatively to the cost of the iron in large quantities. Moreover, it is a distinct convenience to the public he serves for the manufacturing engineer to keep in store a reasonable supply of such iron as is in frequent demand for numerous purposes, and the manufacturing engineer is entitled to be paid for providing this convenience.

Hammered scrap bars and forgings, costing from £11 to £20 per ton, will be charged from 20*s.* to 35*s.* per cwt.; and Bowling or Low Moor bar iron at 28*s.* to 38*s.* per cwt., or 3¼*d.* to 4*d.* per lb. Mild steel, however, as previously mentioned, is now being largely used where formerly Bowling, Low Moor, or Farnley iron was employed; and as mild steel bars of good quality can be bought at from 10*s*. to 16*s*. per cwt., they would be rated at a little over the prices usually charged for good marked iron bars, or from 18*s*. to 30*s*. per cwt., according to weight.

Heavy, plain mild steel crank-shaft forgings, which cost from 20*s*. to 28*s*. per cwt., may be rated at from 32*s*. to 40*s*. per cwt., and mild steel piston rods at about the same. Generally such forgings are rated at from 30 to 70 per cent. on the prices which, the manufacturing engineer has to pay for them. Several detailed examples of jobs involving crank-shafts, etc., will be given further on.

Wrought iron and mild steel in the forms of plates, angles, etc. will be dealt with fully in the section on boiler work.

Brass and Gun-Metal.

The prices at which brass and gun-metal castings are rated vary very much, as engineers and brass founders have very different ideas as to what may be considered good qualities of brass or gun-metal. The following range of prices, however, will cover the rates charged by manufacturing engineers to their clients in most districts:—

	Per lb. s. d.		Per lb. s. d.
Good yellow metal	0 9	to	0 11
Good common brass	0 10	,,	1 0
Good bush or gun-metal	0 11	,,	1 2
Bell metal	1 2	,,	1 6
Phosphor bronze and other special alloys, up to ..	– –		2 0

Scrap Metal.

In the case of heavy brass castings which are to be bored or turned or otherwise machined, an allowance should be made in any estimate which is required to be made up carefully, for the brass borings or cuttings that will result from the machining operation. These cuttings are valuable, and will be used again in the brass foundry. They may be rated at from 3*d*. to 5*d*. per lb., according to the quality of the metal used. The borings or turnings that result from the machining of iron or steel, whilst worth collecting—as they can be sold at from 20*s*. to 30*s*. per ton for use by chemical manufacturers, wrought-iron makers, and others—are not sufficiently valuable to be taken into account in an estimate.

A manufacturing engineer is often required by the terms of a specification to take old material about to be replaced by new in part payment for the new work. Apart from estimates, engineers—especially if they have their own iron or brass foundries—are expected by their regular customers to take old material in part payment of the ordinary accounts. The rates at which old material may be credited in an estimate or in an account, under such circumstances, may be taken at about the following—viz.:

	Per cwt.			
	s.	*d.*	*s.*	*d.*
Good heavy cast iron (mill fixings, etc.)	2	3 to	2	9
Good light cast iron	1	9 ,,	2	0
Good heavy wrought iron (shafting, bolts, etc.)	2	3 ,,	2	9
Good light wrought iron (sheet iron, etc.)	–	–	1	0
Burnt fire bars	–	–	1	0
	Per lb.			
Good bush metal	0	5 to	0	6½
Common brass	0	3½ ,,	0	4½

Engineers who have their own foundries are often glad to take scrap iron from old mills in exchange for goods, as the iron from old establishments is usually of very good quality.

Pine timber used for patterns will be rated at from 5*d.* to 7*d.* per superficial foot per inch in thickness. Seasoned hornbeam and beech, which are largely used for cogging wheels, are usually

Timber.

rated from 6*d.* to 9*d.* per superficial foot for every inch in thickness. They cost in the plank from 2*d.* to 3*d.* per inch, green, but have to be seasoned for a long time, and there is frequently considerable waste.

In addition to the three great classes of materials—cast iron, wrought iron and mild steel, and brass in its various forms—which have been passed rapidly under review, there are numer-

Sundries.

ous "sundries" which more or less frequently present themselves in estimates of proposed work and in accounts for work completed.

Some of these sundries are, in a greater or less degree, specialties, and are bought in a finished condition from their manufacturers. To this class belong steam and vacuum gauges, sight-feed lubricators, steam traps, reducing valves, brass valves and taps generally, centrifugal and other special pumps, fans and blowers, injectors, etc.

The prices at which such articles can be rated are in most cases fixed by the list prices of the manufacturers, the latter allowing the engineer who has to include the articles in his tender or account a trade commission, which varies from 5 or 10 to 50 per cent. off the list prices. This trade commission will usually be as much profit as the engineer desires, or at any rate as much as he is able to make on the mere retailing of the article, hence the prices put down in estimates and accounts for these special sundries are generally the list prices of the manufacturer.

In large engineering works, one or more brass finishers are sometimes kept, and the brass valves and taps largely made on the premises; but even in such cases, the prices fixed for the articles will usually be about the same as the list prices of the regular brass goods manufacturers.

In their proper place we shall give some examples of the cost of brass and other valves.

In addition to such special sundries as those just mentioned, there are many common sundries which the manufacturing engineer buys practically ready for use. The following is a list of some of those which most frequently occur, with the rates at which they may be usually charged in the small or odd quantities in which they generally present themselves.

Bolts and Nuts, black, ordinary lengths, square heads, hexagon nuts, handmade.

Size	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	inch.
Charge ...	$2\frac{1}{2}$*d.*	3*d.*	$3\frac{1}{2}$*d.*	4*d.*	5*d.*	6*d.*	each.

If in sufficient quantities to be charged by weight, then about

8*d.*, 7*d.*, 6*d.*, $5\frac{1}{2}$*d.*, 5*d.*, 4*d.* per lb.

For special bolts made in the engineer's own place, the following is a fair scale for sizes from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. diameter :—

Weight per bolt and nut.

Under 2lb.	5*d.* per lb.
2lb. to 7lb.	$4\frac{1}{2}$*d.* „
7lb. to 14lb.	4*d.* „
14lb. to 28lb.	$3\frac{1}{2}$*d.* „
28lb. and upwards	$3\frac{1}{2}$*d.* to $2\frac{3}{4}$*d.*

Common Set Screws.—About the same as bolts and nuts; and common *Coach Screws* about a fourth less than the prices given in the first table above for bolts.

Files.—Charge odd files at maker's list prices; if supplied in considerable numbers then at, say, a fifth under the list. The list prices are subject to a discount of 50 or 60 per cent. to engineers.

Wrought-iron Steam and Water Pipes and Fittings.—Charge cut lengths of tubes and single bends and other fittings at the tube-maker's list prices. For uncut—that is, complete lengths of tubes—and for fittings in any considerable quantity, a reduction of about a third should be made from the list rates. The list prices are subject to a considerable discount to engineers—about 70 per cent.

Sheet Indiarubber.—Charge generally at maker's list prices. These prices vary from 2*s.* 6*d.* to 8*s.* per lb., according to quality and thickness, the thinnest being the dearest per lb. in every quality. The maker's prices are subject to a discount of 33⅓ per cent. to engineers. Small odd pieces of grey rubber of fair quality, say about 4*s.* 6*d.* list price, should not be rated at less than 4*d.* per oz., as the cutting gives rise to considerable waste.

Indiarubber Valves, costing from 3*s.* 6*d.* to 5*s.* 6*d.* in the grey quality, and up to 7*s.* 9*d.* in the red quality, less the discount, should be rated at the full prices.

Asbestos Sheet, costing 1*s.* 6*d.* to 2*s.* per lb., charge at 2*s.* to 3*s.* 6*d.*

Asbestos Cement, costing 1*s.* 6*d.* or 1*s.* 9*d*, per lb., charge at 2*s.* to 2*s.* 9*d.*

Vulcan Cement, costing 15*s.* per cwt., charge at 2½*d.* or 3*d.* per lb.

Red Lead Cement, charge about 5*d.* per lb.

White Lead, charge about 4*d.* per lb.

Iron Borings, sifted for jointing purposes, charge 6*s.* or 8*s.* per cwt.

Sal Ammoniac, charge 1*s.* per lb.

Brass Gauze, for jointing purposes, costing say 7*d.* per superficial foot, charge 1*s.* or 1*s.* 2*d.* per foot.

Lead, sheet, charge 3*d.* per lb.; wire 8*d.* to 1*s.* per lb.

Rope Yarn, hemp, charge about 10*d.*, and flax (costing 1*s.* 2*d.* per lb.), charge 1*s.* 9*d.* or 2*s.* Flax Gaskets, charge usually about 2*s.* 6*d.* per lb.

Tuck's Packing, costing say 1*s.* 8*d.* net, charge about 2*s.* 6*d.* per lb.

Sheet Tin, generally about 6*d.* per sheet.

Emery Cloth, 1*d.* per sheet.

Tallow, when costing about 30*s.* per cwt., charge 6*d.* per lb.

Candles, charge 7*d.* or 8*d.* per lb.

Red Oxide Paint, costing about 18*s.* per cwt., charge 4*d.* or 5*d.* per lb.

Raw Oil, Boiled Oil and Turpentine, costing from 2*s.* to 2*s.* 6*d.* per gallon, charge 6*d.* or 8*d.* per pint.

Grinding Sand, costing 2*s.* per stone (14 lb.), charge 3*d.* or 4*d.* per lb.

Pump Leathers, for hydraulic press pumps, charge—

$\frac{3}{4}$	1	$1\frac{1}{2}$	2 inches.
9*d.*	1*s.*	1*s.* 6*d.*	2*s.* each.

Neck Leathers, for hydraulic press cylinders, charge about—

4	5	6	8	10	12	16 inches.
6*s.*	7*s.* 6*d.*	9*s.*	11*s.*	12*s.* 6*d.*	15*s.*	17*s.* 6*d.*

The measurements given are the inner diameters of the leathers, corresponding to the diameters of the press rams.

Hydraulic Tubing, iron, costing 4½*d.* to 9*d.* per lineal foot net, charge 10*d.* to 1*s.* 3*d.* per foot.

Copper Hydraulic Tubing, costing 11*d.* or 1*s.* per lb, charge 1*s.* 6*d.* or 2*s.* for short lengths. Hydraulic couplings, costing 5*d.* each, charge 9*d.* or 10*d.*

Piston Springs are mostly bought by engineers from one or other of the few firms who make specialties of their manufacture. Good steel coil springs can be bought at the following rates:—

Under 24 inches diameter	...	...	3*s.* 6*d.* per inch.
24 in. to 40 in. „	...	...	4*s.* „
40 „ 50 „ „	...	...	4*s.* 6*d.* „

less a discount of about 35 per cent. It will be sufficient to rate such springs at the full list prices; the discount allows a sufficient margin for profit.

Other specialties and sundries will from time to time present themselves, the prices of which will have to be determined as they arise. The expression, "list prices," has more than once been used. It should be one of the first objects of anyone entrusted with the pricing of estimates or accounts to make a collection of price lists of such articles as files, tubes, indiarubber, etc, and put them into convenient form for ready reference.

Workmanship.

The rates put down for workmanship in estimates prepared on the system we have now in view (that is, in estimates priced at profit rates), vary principally according to the indirect expenditure necessary to enable the different classes of workmen to perform their work.

This indirect expenditure, as will be more fully explained presently, is, relatively to the actual wages paid, low in the case of draughtsmen, rather more in the case of pattern-makers, higher still for fitters and millwrights, and highest of all in the case of smiths and machinists. Hence the time of a draughtsman, earning say 10*d.* per hour, would probably not be rated at more than 1*s.* 6*d.*, whereas the time of a turner, earning say 7½*d.* per hour, would be rated at from 1*s.* 6*d.* up to 3*s.* per hour.

The following list of profit rates for workmanship will cover all the classes of labour which appear in estimates, except in exceptional cases :—

Draughtsmen, 1*s.* 6*d.* to 2*s.* 6*d.* per hour, including all materials used by draughtsmen.

Pattern-Makers, 10*d.* to 1*s.* 4*d.* per hour, including the use of hand-tools, circular or band saws, small planing machines, and other appliances of the pattern shop, and also the general assistance of the pattern-makers' labourers.

Fitters and Millwrights working in the shop, 10*d.* to 1*s.* 3*d.* per hour, including the use of files and other hand-tools, the general appliances of the shop, and the general assistance of the fitting shop labourers. Fitters and millwrights working outside the shop are usually rated about 10*d.* per hour, including the use of hand-tools. Files, however, when taken new out of store for outside work, should be charged to the customer when the work is not done under contract; though it is not usual to have any special entry in an estimate for files. Leading hands working outside, and acting more or less in the capacity of foremen, will be rated at from 1*s.* to 1*s.* 6*d.* per hour.

It is necessary to bear in mind that workmen, when working outside the shop, are invariably paid a certain sum, called generally "allowance" or "diet money," in addition to their wages; and this sum must, of course, be charged to a customer or covered in an estimate. The sum actually paid for "allowance" without any addition is the amount usually charged—profit is not sought on the workmen's allowance. It is usual for all the principal employers of a district to agree to a certain definite scale of rates for allowance to be paid to the men when working outside the shop. The allowance is generally at the rate of 1*s.* to 1*s.* 6*d.* per working day, when engaged within a certain limited distance from the works, and 1*s.* 6*d.* to 2*s.* when beyond that distance, with an addition at the rate of one penny per hour for all overtime.

It is also necessary to remember, when any work to be done outside the usual working hours is to be included in an estimate, that one hour of overtime is reckoned in the men's wages as an hour and a quarter or an hour and a half of common time; and that work done on Sunday, Christmas day, and Good Friday is paid for at double the ordinary day rates, or counted as double time.

Machinists. *Turners*—At small lathe, 1s. 6d. to 1s. 9d. per hour.
„ At large lathes, 2s. to 3s. 6d. per hour.
Planers—At small machines, 1s. 6d. to 2s. per hour.
„ At large machines, 2s. 6d. to 5s. per hour.
Slotters—At small machines, 1s. 3d. to 1s. 6d. per hour.
„ At large machines, 1s. 9d. to 2s. 6d. per hour.
Milling and Shaping Machine Men—Same as slotters.
Drillers—At small machines, 1s. 2d. to 1s. 6d. per hour.
„ At large machines, 1s. 9d. to 2s. 3d. per hour.
Screwers—About same as Drillers.
Grinders—1s. 6d. to 2s. 3d. per hour.

The above rates for machinists will include the general assistance of shop labour, preparation of ordinary tools, etc.; but where, as is sometimes necessary, a special labourer is attached to a machine, the rate will have to be increased by from 5*d.* to 7*d.* per hour. In rating machinists and machine tools, regard must be paid to the nature of the work itself, as well as to the machine in which the work is to be done. It may sometimes happen that a small and unimportant piece of work will be done in a large machine, but it would scarcely be judicious in such a case to charge the large machine rate. On the other hand, a heavy piece of work may at times, by means of special contrivances, and by the exercise of extra care, be done in a small machine; and in such a case, the work may be fairly charged at the rate of a large machine. Again, it is a common thing for a slotter, a planer, or a screwer, to look after two machines of different sizes. Hence, in one job, such a workman's time may be rated low, but in another case the same man may be rated high.

Steam Engines.—A contract occasionally includes machine work which must be done at night or outside the usual working hours; whilst accounts for breakdown affairs very frequently include machine work done at night. A charge must in such cases be made for the engine running specially for the work in question. The charge may vary from 3*s.* 6*d.* to 6*s.* 6*d.* per hour, a fair average being 5*s.* per hour for a short period, and

4*s.* for a lengthy period, including the attendance of the engine driver.

Cylinder Re-boring.—Tenders have not infrequently to be given for re-boring engine cylinders in their places. This work usually necessitates a good turner leaving his lathe idle in the shop whilst he re-bores the cylinder, and involves the use of boring bars and tackle which, having regard to the fact that they are only occasionally employed, are costly appliances. The rates for such work consequently range high—from 7*s.* 6*d.* to 20*s.* per hour, according to the size of the cylinder that is to be re-bored. In the case of a cylinder, say, 36 or 40 inches diameter, the rate should be from 10*s.* to 15*s.* per hour. These rates are, of course, only charged for the time of the turner out at the place; but, in addition, the cost of making any special preparation in the shop must be covered.

Smiths.—Smith and one striker or hammerman and fire, 2*s.* to 2*s.* 6*d.* per hour. A smith and two strikers and fire, 3*s.* to 4*s.* per hour. These rates will usually be held to cover the use of a general steam hammer—that is, of a hammer used perhaps by two or three smiths. It is, however, necessary occasionally to charge specially for the use of a steam hammer; the rate in such cases may be from 3*s.* to 5*s.* per hour, including the hammerman or boy.

Labourers.—Labourers, who are paid wages varying from 13*s.* to 19*s.* per week may usually be rated at from 4½*d.* to 7*d.* per hour. As previously mentioned, however, the rates for skilled labour, which have already been given, will in most establishments cover the assistance of the general shop labourers. Hence common labourers' time will rarely appear in an estimate to be priced at these *profit* rates—only indeed when some common labour will be specially employed.

Rates for boilermakers and their tools will be given in the section on boiler making.

In addition to material and workmanship in the shop, estimates have generally to include the cost of delivering the material at the site where it is to be erected, or at some convenient railway station or port, and very frequently also the cost of erection. Where the site is local, there is nothing more than the cartage and the men's time and allowance whilst erecting, to be considered; but

Freight, Erection, &c.

when the site is at a distance, the railway carriage or freight must be covered, also the travelling time and expenses of the workmen who will be sent to erect, and probably the time and expenses of a draughtsman or foreman going to take working dimensions, or to superintend the erection, or both. It is usual to put down for carriage and expenses merely the sums that will actually be paid.

It may be added that, as a rule, engineers do not provide the common labour required whilst any work is being erected, but merely the skilled labour—common labour and the necessary scaffolding being provided by the person for whom the work is being done. In the case of work for public companies, however, common labour, scaffolding and every other appliance have often to be provided by the engineer.

In estimates for work that is likely to be exceptionally difficult, or in connection with which there will be unusual risks, it is customary to add something to the total amount of the ordinary elements of the estimate, on account of these contingencies. This, however, must always be done with discretion, as such addition may easily overweight a tender.

We have now reviewed those classes of material and labour with which we have most frequently to deal in the preparation of estimates.

The most natural avenue by which a young engineer may pass from the strictly practical work of the shops to take a part in the commercial management of an establishment lies through the estimate office or department; and we have therefore endeavoured to give, as shortly as possible, a general introduction to the whole work of estimating. We shall now give one or two examples of estimates prepared on the profit-priced system, in order to illustrate the form in which such estimates may be most conveniently set out.

CHAPTER IV.

GENERAL EXAMPLES.

THE most convenient size of paper on which to set out the particulars of an estimate is foolscap, ruled with weight, rate and money columns, as shown below.

EXAMPLE No. 1.—INQUIRY: Price for 11 cast-iron columns, length 9 ft., diameter at bottom 7 in., tapering to 6 in. at the top, with square bases and with heads prepared for wooden beams, and fitted with leaf ornaments. Metal to average ⅝ in. in thickness, all as per tracing, etc.

Tender for cast-iron columns for A.B. as per inquiry dated ———, to be delivered at ———:—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	11 cast-iron columns, about 9 ft. long, 7 in. to 6 in. diameter, with bases and heads as per tracing, etc.	50 0 0	7 0	17 10 0
	11 sets cast-iron ornaments	5 0 0	12 0	3 0 0
	Drilling for iron ornaments, 3 days		12 0	1 16 0
	Fitting and riveting iron ornaments, 8 days ..		10 6	4 4 0
	Altering and preparing patterns, 6 days ..		10 6	3 3 0
	Cartage, 2s. per ton			0 6 0
	Quote £30 net.			29 19 0

EXAMPLE No. 2.—INQUIRY: Price for pedestal, 5½ in. bore by 7½ in. long, with extra-long sole.

Tender for 5½ in. by 7½ in. pedestal, with double brasses for C. D. :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	1 cast-iron block and cap	1 2 0	10 6	0 15 9
	2 gun-metal brushes	0 0 36	1 3	2 5 0
	2 bolts and 4 nuts	0 0 6½	0 7	0 3 10
	Boring and facing, ¾ day		16 0	0 12 0
	Drilling oil hole, 1 hour			0 1 6
	Fitting brasses and cap, 2¼ days		10 6	1 3 8
	Altering pattern, ½ day		10 6	0 5 3
	Quote £5 10s. net.			5 7 0

EXAMPLE No. 3.—INQUIRY: Price for light shafting, with hangers, pedestals, pulleys, etc., as per specification.

Tender for shafting, etc., for :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	93 ft. 1¾ in. plain shafting, turned and polished, finished weight	6 3 14	0 3½	11 4 7
	3 cast-iron flanged couplings, bored, faced, slotted and drilled, etc., finished weight ..	1 0 14	0 5½	2 17 9
	9 finished bolts and nuts for do.		2 0	0 18 0
	6 keys, ground		1 6	0 9 0
	5 hangers and caps with single brass 1¾ in. bore		15 0	3 15 0
	2 pillar brackets with caps and single brasses, 1¾ in.		15 0	1 10 0
	2 pedestals with single brasses		15 0	1 10 0
	8 cast-iron pulleys, 16 in. diameter by 13 in. wide, bored, turned and slotted		32 6	13 0 0
	8 keys, ground..		1 6	0 12 0
	Alteration of pattern, 1 day			0 10 6
	Keying couplings on shafts, 1 day			0 10 6
	Quote £36, less 2½ per cent., delivered (local) ready for erection.			36 17 4

EXAMPLE No. 4.—INQUIRY: Price for pair of mitre wheels, with 42 and 41 cogs, 2¼ in. pitch and 5½ in. face.

Tender for mitre wheels, with etc. for :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	1 cast-iron mitre wheel, 42 by 2¼ by 5½; 1 cast-iron mitre wheel, 41 by 2¼ by 5½ (from full stock patterns)	6 0 0	14 0	4 4 0
	Boring 42-wheel to gauge, ½ day		16 0	0 8 0
	Slotting 1 key bed in 42-wheel and 4 in 41-wheel, ½ day		12 0	0 6 0
	Quote £4 18s. net.			4 18 0

EXAMPLE No. 5.—INQUIRY: Price for two cast-iron belt pulleys, each 36 in. diameter by 7 in. wide, and with a flange at one side; both split and bolted.

Tender for single flanged pulleys, 36 in. by 7 in., for :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	2 cast-iron pulleys, 36 in by 7 in., cast to split, each with a flange at one side	4 2 14	11 0	2 11 0
	Turning and boring ditto, 2½ days		16 0	2 0 0
	Splitting and bolting, 1 day			0 10 0
	8 ¾-in. bolts and nuts		0 5	0 3 4
	Stock pattern, ¾ day		10 6	0 7 11
	Quote £5 10s. net.			5 12 3

EXAMPLE No. 6.—INQUIRY: Price for four cast-iron rope pulleys, each 3 ft. in diameter, with 3 grooves for 5-in. ropes, all split, bolted, bored to gauges, and turned in grooves.

Tender: Four cast-iron rope pulleys for :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	4 cast-iron rope pulleys, each 3 ft., 3 5-in. rope grooves, cast to split	19 3 0	16 0	15 16 0
	16 1¼-in. bolts and nuts	0 2 6	0 5	1 5 10
	Turning and boring, 10 days		16 0	8 0 0
	Splitting, bolting and balancing, 4 days.. ..		10 6	2 2 0
	Preparing patterns, 2½ days		10 6	1 6 3
				28 10 1
	Estimated finished weight	17 0 0	33 6	28 9 6

Quote £28 10s. less 2½ per cent.

EXAMPLE No. 7.—INQUIRY: Price for two crank-shaft pedestals, with adjustable brasses, 11 in. bore by 20 in. long.

Tender for crank-shaft pedestals for :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	2 Cast-iron blocks and caps	54 0 0	9 0	24 6 0
	8 Best gun-metal brasses	11 7 6	1 3	73 10 0
	4 Wrought-iron wedges	3 0 22	0 2½	3 14 7
	12 Wrought-iron adjusting screws and nuts, 17 in. by 1 in.	0 2 8	0 5	1 6 8
	8 cap bolts, nuts, guards, and set screws—bolts 17 in. by 1¼ in.	1 3 8	0 4	3 8 0
	Planing blocks and caps, brasses and wedges, 12 days		20 0	12 0 0
	Slotting inside of blocks, 4 days		18 0	3 12 0
	Fitting at brasses, wedges, and caps, 20 days ..		10 6	10 10 0
	Boring and facing, 5 days		20 0	5 0 0
	Drilling oil holes, 1 day			0 13 6
	Turning bolts and nuts, 6 days		16 0	4 16 0
	Alteration of stock patterns, 4 days		10 6	2 2 0
				144 18 9
	Cr., say 120 lb. gun-metal borings..	1 0 8	0 3½	1 15 0
	Quote £140 net.			143 3 9

EXAMPLE No. 8.—INQUIRY: Price of new piston rod and cost of fitting same to old piston and replacing latter.

Tender for piston-rod for :—

Date.		cwt. qr. lb.	s. d.	£ s. d.
	1 mild steel piston rod about 7·2 in. long, to finish 3½ in. diameter, with taper boss to fit piston—forged weight	2 1 14	34 0	4 0 9
	3 wrought-iron cotters	0 1 0	0 6	0 14 0
	Turning and finishing rod, 2½ days		16 0	1 10 0
	Drilling cotter holes in piston rod, 1 day ..			0 12 0
	Boring and turning old gland bush and neck bush of cylinder cover, and boring and facing old crosshead, 2 days		16 0	1 12 0
	Fitters taking old rod out of piston, fitting new rod in piston and crosshead with new cotters, and refitting bushes, 5 days		10 6	2 12 6
	Engineer out at place, taking out old piston, etc., bringing same to shop, and re-erecting all, 3½ days		8 3	1 8 11
	Man's allowance, 6s.; Railway fares, 6s. ..			0 12 0
				13 8 2
	Contingencies			1 11 10
	Quote £15 net, all necessary assistance at place to be given us.			15 0 0

The examples just given will serve for the purpose immediately in view. Most of these examples will sufficiently explain themselves, but it may be well to refer particularly to one or two points. In example No. 3, it will be observed that the workmanship is not given in detail, but that the articles are priced at certain finished rates—the weights given being finished weights. This is a very convenient method of preparing estimates of this character for regular classes of work.

In most establishments standard rates per pound, per foot or per article, for such work as that indicated in this example, are on record, and can be used in pricing such estimates, thus saving time both in the drawing and general offices. It is, however, of the utmost importance that these standard rates should be carefully checked from actual costs, from time to time. It may also be added that the work in this example, being of a light character, is such as could be easily done by small engineering shops; and many such establishments, buying cheaply and working cheaply, would quote for such a contract from 10 to 20 per cent. less than the amount given.

Referring to example No. 6, firms accustomed to the manufacture of rope pulleys would not, except in very special cases, go through the detailed process of estimating as shown in this example, but would merely calculate the finished weight of the pulleys, and price it at their standard rate per cwt. for this size and kind of pulley. A table of weights and prices for rope pulleys will shortly be given.

It will be noticed that the pulleys are described as "cast to split." A firm, however, wishing to make a very fine job of such pulleys would cast each half separately, plane the joints where the two halves go together, drill the bolt holes and turn the bolts so as to exactly fit the holes. This would add from 25*s*. to 30*s*. each to the price of the pulleys, though firms who lay themselves out specially for the manufacture of rope pulleys would make those named in this example somewhat cheaper in either case. The size of the rope—that is 5 in.—is, of course, the girth or circumference of the rope, and not the diameter.

Example No. 8, it will be seen, is an estimate partly for new work and partly for repairs. The practice of asking quotations for repairs has greatly increased of late years. The case illustrated in this example is not much out of the way, but sometimes very unreasonable requests for repair quotations are made by millowners and others to engineers.

Nearly all estimates are more or less problematical, but an estimate for repairs must necessarily be particularly so; hence engineers endeavour to avoid as far as they can giving tenders for repair work. Even in such a comparatively simple case as that of this example, it was quite likely that, owing to some circumstance which could not possibly be recognised at the time the estimate was made, more time would be occupied in connection with the engine (a beam engine) than the amount put down. Consequently, as will be noted, a sum, small in fact, but large relatively to the whole work, was put down to cover any contingency of such a character.

Difficulties in connection with quotations for repairs and renewals can sometimes be very conveniently got over by undertaking that the work shall not exceed a certain sum, and that if the cost comes out less the advantage shall be given to the person for whom the work is to be done. Such an arrangement fairly entered into gives all that a millowner or other proprietor can reasonably expect, whilst it keeps the engineer reasonably safe.

It may be useful in, concluding this portion of our task, to illustrate how a tender for such work as example No. 9 may be written out. The tender would usually run :—

"Messrs. ———. Gentlemen,—We propose to supply you with one new mild steel piston rod, turned and finished all over, to suit your piston; take old rod out of piston, fit new one to piston and old crosshead with new cotters to be provided by us; also to rebore present gland and neck bushes of cylinder cover, and rebore and face up old crosshead to receive new rod; also to send an engineer out to your place to take out piston and cover ready to be brought to our shop, and to replace all ready for work for the sum of £15 0 0 (fifteen pounds) net; all carting to be done by you, and all the necessary assistance of labourers and scaffolding at your place to be provided by you.

"We shall esteem your order and remain,

"Yours truly,

———"

CHAPTER V.

INDIRECT EXPENSES.

BEFORE passing on to deal with estimates of the probable cost of work to the manufacturing engineer, and also with the actual cost of work completed, it is necessary to explain the meaning and import of the phrase "Indirect Expenses," which will frequently occur. The preparation of estimates and the recording or charging up of actual costs are, of course, two distinct and independent operations; but it is impossible to deal with the former without also, more or less, dealing with the latter. The costs of an establishment ought at once to check the estimates of the past and form a guide to the preparation of those in the present and future.

Elements of Cost.

The cost of any article may be considered, for our purpose, as made up of three elements—the cost of the materials contained in it, the cost of labour directly expended on it, and the general expenses of the establishment. The latter element comprises rent, rates, insurance, interest, depreciation and maintenance, managers' salaries, office expenses, the wages of firemen, enginemen, and common labourers employed generally about the place, cartage, coal, water, gas, oil, and the thousand and one sundries which are required to keep an engineering establishment in motion. The presence of the first two elements in any piece of machinery is, of course, obvious. The presence of the third may not appear so obvious, and would seem sometimes to be overlooked or very much underrated, but it is just as real.

Before any piece of machinery can be produced, there must have been a previous expenditure or liability incurred, on account of rent, motive power, tools, and so on. No one would think of presenting an annual balance-sheet without including the rent, rates, and other charges of a like nature. But an annual balance-sheet, so far as the expenditure is concerned, and taking stock into account, is neither more nor less than a statement of the cost of all the work produced during the year; and as the whole is the sum of all its parts, it follows that every article produced during the year, down to the smallest screw, has had to bear a share of the general expenses of the establishment. Hence it is desirable that every estimate of probable, or statement of actual, cost, should contain as a distinct item this element of general or indirect expense; and not only because an estimate of cost cannot otherwise be considered complete, but because when so prepared, the actual profit that may be expected, or that has been earned, or the loss that has been incurred, may be seen at a glance, which cannot be done either when this element is omitted, or when the estimate is made up at rates intended to cover profit as well as indirect expenses.

The question now presents itself—How is the proper amount of this element of indirect expenses, with reference to any particular piece of work, to be ascertained? It will be obvious that this element can only be included in a cost or estimate by a method of average or percentage. To ascertain the proportion, all the items constituting the general expenses of an establishment—that is to say, every item of expenditure which has not been charged *directly* against some particular job for a buyer or for stock—for a given period, generally a year, must be collected together and the sum total ascertained. This sum will constitute a certain proportion to the remainder of the expenditure. To take an illustration—the total expenditure, excluding expenditure on new tools, &c., charged to capital account, in a certain period, of a general engineering establishment having its own iron and brass foundries and smiths' shops, &c., amounted to a little over £30,000, made up as follows:—

Determining Indirect Expenses.

	£
Material charged direct to the jobs completed during the period or in progress at the end	9,800
Wages ditto	11,583
Other expenditure—Rent, rates, insurance, interest, coal, office expenses, managers' salaries, repairs, &c.	9,190
	£30,573

Here it will be seen that the general expenses constituted 30 per cent. of the total expenditure. But another question now arises—Whether should the percentage for indirect expenses be determined with reference to the material alone, the direct wages alone, or both combined? This is to a certain extent a matter of indifference, and must be determined by the nature of the business; but for a general engineering establishment, the safest and most accurate method is to determine the proportion with reference to the *direct wages* alone, with certain exceptions to be shortly mentioned, and that for the following reasons:—The cost of the material of engineering productions —iron, copper, &c.—is liable to greater and more frequent fluctuations than the cost of labour, and these fluctuations may and do occur without affecting to any serious extent the general working expenses of an establishment—the only item liable to be much affected being that of interest on capital. The quantity and value of the material used for different jobs vary immensely; but it is clear that an article requiring little material but a large amount of skilled labour will cost more for indirect expenses than one containing much material but little labour. Altogether it will be found that the indirect expenses of an establishment will maintain a more constant relation to the skilled labour employed than to the material contained in the articles manufactured. Of course, certain items of the indirect expenses, such as rent, rates, and insurance, vary little from year to year; but the amount of gas, oil, cleaning waste, tool steel, files, &c., consumed will vary with the number of skilled workmen employed; as will also the amount of wages paid for common labour engaged to give assistance throughout the works generally. Lastly, it is the skilled labour which earns the profit, and, therefore, the skilled labour would appear to be the most natural basis upon which to calculate the indirect expenses.

In the illustration just given, it will be seen that the proportion of indirect expenses to direct wages was practically 80 per cent. It is not, however, sufficient to determine the proportion merely in the gross; the proportion must be determined for each separate department.

Departmental Expenses.

An enquiry for price, or an order, may be merely for castings from the customers' own patterns; it is therefore necessary to know the indirect expenses of the foundry. The enquiry may be for castings to sketches, and patterns will have to be made; it is therefore necessary to know the indirect expenses of the pattern shop. Again, a piece of work may require the services of every department, but each in a different degree. In order to ascertain the proportions for each department, the general or indirect working expenses have to be analysed and classed under two groups—those which are *special* to each department and those which are *common* to all. The latter will at once suggest themselves. They consist chiefly of managers' salaries, office expenses, rent, rates, insurance, interest, gas, &c. In cases where a department is located in a separate building, the rent, rates, insurance and some other items on account of that building, can of course be charged direct to that department; but otherwise every desirable object is secured by simply distributing these common expenses over the various departments in proportion to the wages paid in each. It is sometimes contended that the two classes of indirect expenses should be shown separately in an estimate or a statement of cost; that there should first be set out the *special* departmental expenses and then a separate percentage to cover the *general* indirect expenses. This, however, means unnecessary trouble and complication. Every useful purpose is gained if the total departmental expenses, in any case, are determined by adding to the *special* indirect expenses, a proportion of the *general* expenses ascertained in the manner we have indicated. The indirect expenses special to each department may be briefly considered.

Drawing Office.

The indirect working expenses special to the drawing office are comparatively small, and consist chiefly of drawing materials and stationery, and of a not inconsiderable portion of the wages of apprentices (where these are paid) and tracers. Of course in the drawing office, as in every other department, every hour of time which can be so charged ought to be charged against the jobs in hand, and the major portion of the wages of the drawing office will be disposed of in this way. But after all has been done, there will generally remain a considerable portion of the wages of juniors, and possibly, also, of the head draughtsman, which must be included in the indirect expenses of the department.

Pattern Shop.

The indirect expenses special to this department consist principally of timber, nails, glue, sandpaper, repairs and renewals of machine saws and other machine tools, repairs of building and fittings, the wages of foremen, and of one or two labourers employed to "fetch and carry" generally. Sometimes the attempt is made to charge direct the timber used for each job. This may be done in special cases and where a good system of store-keeping exists; but, as a rule, the attempt involves more trouble than the results are worth, whilst every practical purpose is attained by treating the timber as one item of the departmental indirect expenses. In some works the drawing office and pattern shop are treated as one department; and, indeed, it is quite sufficient to treat them so, except in very large establishments.

The foundries constitute the obvious exception to the rule that expenses should be calculated on direct wages. It is still true in the foundries, as elsewhere, that it is the skilled labour which earns the profit, but the manufacturing processes in the foundries are extremely simple when compared with those in other departments. The iron foundry, for example, turns out only one class of article—iron castings. It costs just the same to melt a ton of iron, whether the metal be intended for light and difficult castings, which have required a large amount of labour to mould them, or for plain and heavy castings. The other general expenses of the foundry will also be usually proportionate to the weight of the castings produced. Hence, it is most convenient to reduce all the indirect expenses of the iron foundry, and for certain purposes all the expenditure of every kind, to a rate per cwt. of dressed castings.

Iron Foundry.

The indirect expenses special to the iron foundry comprise foremen's wages, the wages of furnace and bank-men and common labourers, coke, limestone, brick, fireclay, sand, blacking, brushes, bellows, chaplets, core irons, iron rods, hay for cores, steam power for fans, loss of iron, &c.; the wages of one or two workmen, who either wholly or in part work for the foundry—a joiner, smith (making core irons), fitter (repairing boxes), and various sums for repairs, renewal of utensils, &c. In some cases the indirect expenses of the loam department of the foundry are kept separate from those of the green-sand side, but generally it will be sufficient to find the rate per cwt. of dressed castings which will cover all the general expenses of the foundry as a whole, merely keeping the wages of skilled labour of each branch separate. The following summaries will serve as illustrations:—

SUMMARY OF IRON FOUNDRY EXPENDITURE FOR 27 WEEKS, ENDING ———— ——

	T.	C.	Q.
Output of loam and dry-sand castings	138	16	0
„ green-sand	654	12	0
Total output of dressed castings	793	8	0

	£	s.	d.	£	s.	d.		Cost per Ton of Dressed Castings. £	s.	d.
Cost of iron				2,231	8	8	=	2	16	3
Cost of melting—										
Wages	135	3	4							
Coke, &c.	341	6	8							
				476	10	0	=	0	12	0
Cost of fettling or dressing, inclusive				268	11	5	=	0	6	9
Sundry wages charged against iron foundry, including foreman, smith, fitters and general labourers				421	18	2	=	0	10	7¾
				3,398	8	3	=	4	5	8
General expenses—Rent, rates, management, &c.				959	3	4	=	1	4	2
Cost, exclusive of direct labour				£4,357	11	7	=	5	9	10

From this statement it will be seen that every cwt. of castings costs in metal, departmental and general expenses common to the foundry as a whole, as nearly as possible 5*s.* 6*d.* The costs when the skilled labour and the common labour special to each department of the foundry are included, will appear from the following:—

LOAM AND DRY-SAND DEPARTMENT.

	T.	C.	Q.	£	s.	d.		Cost per Ton. £	s.	d.
Dressed Castings	138	16	0	763	3	4	=	5	9	10
Common labour, special to loam shop				265	15	0	=	1	18	3½
				1,028	18	4	=	7	8	1½
Moulders' Wages				682	8	7½	=	4	18	4
Total Cost				£1,711	6	11½	=	12	6	5½

GREEN-SAND DEPARTMENT.

	T.	C.	Q.	£	s.	d.		£	s.	d.
Dressed castings	654	12	0	3,594	8	3	=	5	9	10
Coremakers				70	9	0	=	0	2	1½
Common labour special to department				377	13	0	=	0	11	6½
				4,042	10	3	=	6	3	6
Moulders' wages				840	1	5	=	1	5	8
Total cost				£4,882	11	8	=	7	9	2

Thus, the total cost per cwt. of loam and dry-sand castings, all round, was slightly over 12*s.* 3*d.*, and of green-sand castings slightly under 7*s.* 6*d.* To determine the cost of any particular casting during any period to which the above summaries might be considered applicable, we have merely to rate the metal at £7 8*s.* 1½*d.* per ton (say 7*s.* 6*d.* per cwt.) if a loam-casting, and £6 3*s.* 6¼*d.* per ton (say 6*s.* 3*d.* per cwt.) if a green-sand casting, and add the moulders' wages for the casting in question. It may be added that several of the items in the above summaries, particularly "sundry wages," "general expenses," and the items of labour, both skilled and common, in the loam department, are rather high. There was no piece-work in the loam department and very little on the green-sand side. The rates shown by the above summaries are, however, absolutely "total"—they include every expense of manufacture without exception.

The departmental expenses of the brass foundry are very similar to those of the iron foundry, there being some special—crucibles for example. In this department, owing to the comparatively small proportion which the cost of labour of all kinds bears to the cost of the metals used, it is not considered necessary, except in special cases, to have the skilled labour returned against each order number, as ought always to be done in the iron foundry. It is sufficient to reduce all the expenses, including skilled labour, to a rate per lb. of dressed castings. This rate will usually run in an ordinary engineering establishment, from twopence to threepence per pound weight. The rate ought not to exceed the latter figure, and in jobbing foundries, which work for the trade, it is not infrequently brought down to a fraction over a penny. Though it is generally sufficient to allow the skilled labour to be covered by an all-round rate per pound, distinctions have, however, to be made in the brass foundry, arising from the different qualities and characters of the alloys used in making the castings, which alloys vary much according to the purposes for which the castings have to be used.

Brass Foundry.

These different alloys will range themselves, generally, under the following heads:—yellow metal, good common brass, gun-metal, bell-metal, anti-friction metals, and solders. There will also be special alloys—such as those in which phosphor-bronze or phosphor-tin largely enter—used from time to time. The cost of the different mixtures may be determined most conveniently, and with sufficient accuracy for all practical purposes, by a simple calculation based upon the proportions of the metals used by the foreman to form the alloys. Thus, suppose we wish to know the cost of "good common brass." This will probably consist of 16 parts copper, $1\frac{1}{2}$ of tin, $1\frac{1}{2}$ of zinc, and a little lead, which may be neglected—and the calculation will stand thus :—

		£	s.	d.
16 lb. copper	@ $6\frac{1}{2}$*d.* =	0	8	8
$1\frac{1}{2}$ lb. tin	@ $10\frac{1}{2}$*d.* =	0	1	$3\frac{3}{4}$
$1\frac{1}{2}$ lb. zinc	@ 2*d.* =	0	0	3
19 lb. "good common brass"	@ $6\frac{1}{2}$*d.* =	0	10	$2\frac{3}{4}$

The importance of making the distinction referred to will be evident if we compare the above with the cost of either a hard gun-metal or a yellow brass such as is largely used for taps and valves. The two latter would probably stand thus :—

HARD GUN-METAL.

		£	s.	d.
16 lb. copper	@ $6\frac{1}{2}$*d.* =	0	8	8
3 lb. tin	@ $10\frac{1}{2}$*d.* =	0	2	$7\frac{1}{2}$
1 lb. hard gun-metal	@ $7\frac{1}{2}$*d.* =	0	11	$3\frac{1}{2}$

YELLOW BRASS.

		£	s.	d.
16 lb. copper	@ $6\frac{1}{2}$*d.* =	0	8	8
8 lb. zinc	@ 2*d.* =	0	1	4
24 lb. yellow brass	@ 5*d.* =	0	10	0

The total costs of these different mixtures would therefore stand about as follows :—

Yellow brass	7*d.* to 8*d.* per lb.
Good common brass	$8\frac{1}{2}$*d.* to $9\frac{1}{2}$*d.* "
Hard gun-metal	$9\frac{1}{4}$*d.* to $10\frac{1}{4}$*d.* "

being made up of 5*d.* per lb., for metal in the case of the yellow brass for example, and 2*d.* to 3*d.* per lb. for moulding, melting, loss of metal, crucibles, sundries, and repairs, and a proportion of the general expenses for rent, rates, management, &c. In all properly organised works, weekly or fortnightly statements showing the cost of the castings under all the important heads are prepared.

Smiths' Shop.

The indirect expenses special to the Smiths' Shop are principally coal, waste of material, iron and steel used to repair and keep in order the smiths' tools, steam-power for fans or blowers and hammers, repairs and renewals of hearths, wages of smiths repairing and renewing tools, foreman's wages, &c. There is usually very little common labour, strictly so-called, in the smiths' shop, as the helpers, strikers, or hammermen, as they are variously named, are all more or less skilled men; and as each smith has his own striker or strikers, who work for him and for no one else, and as he cannot as a rule work without them, the wages of both smith and strikers can be added together and treated as one. The wages of the steam-hammer men or boys should also be dealt with on a similar plan, and be distributed over the different smiths who use the steam-hammer. Thus, say a leading smith earning 38*s.* per week returns 9 hours against a job. Instead of merely charging 9 hours at 38*s.* per week, there will be charged 9 hours at probably 77*s.*, made up as follows:—

				£	*s.*	*d.*
1 smith	9 hours	@ 38s.	=	0	6	4
1 striker	9 "	@ 18s.	=	0	3	0
1 "	9 "	@ 17s.	=	0	2	10
1 steam-hammer boy	4½ "	@ 8s.	=	0	0	8
				0	12	10

equal to 9 hours at 1*s.* 5*d.* per hour, or 77*s.* per week. Notwithstanding the fact that nearly all the labour in the smiths' shop may be thus charged direct, the percentage to cover indirect expenses is almost invariably high.

Machine or Turning Shop.

The indirect expenses special to this department are the heaviest of all. They comprise—steam-power, oil, oil-cans' cleaning waste, tool steel, hammers, leather belts, laces, grindstones, emery, emery paper, emery wheels, smiths' charges dressing tools, a half or other proportion of the craneman's wages (an overhead traveller being now found in most large shops), repairs of machine tools, repairs and renewals of utensils, labourers' wages, and the wages of foremen. The items of rent, interest on capital, &c., are necessarily also heavy. Whilst in average works it will usually be sufficient to determine the indirect expenses of the machine shop as a whole, in large works or where very large and costly machine tools are in use, it may be advisable to divide the machine shop into two, or even more, sections, placing the large tools by themselves in the one and the ordinary too's in the other, and to determine the percentage for each section. This may be done very conveniently and with sufficient accuracy, as a general thing, by dividing the total indirect expenses of the machine shop into two parts proportionate to the cost of the machine tools in each section. At the same time, it is not at all difficult where anything like proper book-keeping exists to keep the working expenses of each section separate, and as the power consumed by each section can also be either ascertained by engine indications, or very closely estimated, a very large proportion of the indirect expenses of each section can be ascertained absolutely, leaving only general items—rent, management, &c.—to be determined by calculation based upon the cost of the tools.

The fitting department is generally in the same building as the machine department; but the indirect expenses of the one can easily be kept distinct from the other. The special expenses of the fitting shop comprise—files (a heavy item), hammers, chisel steel, cleaning waste or cloths, oils and cans, grindstones, repairs and renewals of numerous utensils—stocks and dies, ratchet braces, &c.—a proportion of the craneman's wages, labourers' wages, very often a large portion of the junior apprentices' wages, and the wages of foremen. Owing, however, to the sum total of fitters' and millwrights' wages, which can be charged direct, being usually large, the percentage for indirect expenses is generally comparatively small. It is necessary when any considerable staff of fitters is regularly employed on outdoor work to determine a separate percentage for them; otherwise the percentage, when applied to the wages expended in the shop, will be too small, and when applied to outside work, too large. This will be obvious when it is borne in mind that light and shelter, the assistance of labourers, the use of scaffolding, and numerous sundries are generally provided by the customer for whom the men are working outside.

Fitting or Erecting Shop.

The percentage on direct wages to cover all indirect expenses, both departmental and general, in a general engineering establishment should not exceed the higher rates given in the following scale, whilst they will not often fall below the lower rates:—

Drawing office	25	to	33⅓	per cent.
Pattern shop..	50	to	75	„
Drawing office and pattern shop when treated as one ..	33⅓	to	50	„
Smiths' shop	75	to	100	„
Machine shop	100	to	150	„
Fitting shop	40	to	50	„
Fitters outside	15	to	25	„

That is to say, if a job has required an expenditure of £4 for drawings and patterns treated as one department, it must be charged with from 26*s.* 8*d.* to 40*s.* more to cover the indirect expenses that will have been incurred on its account, and so on with the other departments.

A remark that applies to every department, and that is sufficiently obvious, is that these percentages will be higher when there is little doing than when business is good. In the former condition of things, not only will the rent, office expenses, and many other items be practically the same as in the latter, but many of the workmen who have to be retained will be obliged to charge a not inconsiderable proportion of their time against their shop, instead of against customers.

From what has now been said, it will be obvious that whilst it is of the utmost importance to cover in every estimate, and to include in every statement of cost, the indirect charges of the establishment, the sum put down cannot, in any case, be other than an estimate, and will therefore differ, and ought to be shown separate, from the material and labour which, in the case of a cost, will be actual returns. The proportion or percentage may be accurately determined at the close of any period from the accounts of that period. A proportion so determined may be, and as a rule will be, used during the succeeding period; but whether it will be accurate or not will depend upon the amount of work done in it, and cannot be certainly known until its close.

We have thus dwelt at some length upon the question of general or indirect expenses, because it is of the utmost consequence that anyone who wishes to prepare estimates should have an adequate conception of the importance of these general expenses as an element in the cost of everything produced; and, also, some idea of the relative values of this element in the different departments of an ordinary engineering establishment.

CHAPTER VI.

MILLWRIGHT WORK—MILL FIXINGS, PEDESTALS, ETC.

WE shall now deal with the cost of manufacturing and with the usual selling prices of general millwright work. The large class of articles comprised in the term "millwright work" may very well be styled the "common objects" of the general engineers' establishment. They are required more frequently and in greater numbers than any other of the productions of the mechanical engineer, being necessary, more or less, to every manufacturing industry in which steam or other motive power is employed.

The machinery of a spinning mill, by which the actual manufacturing operation is performed, differs immensely from that of a weaving factory, whilst that of a weaving factory differs in an equal or greater degree from the machinery of a flour mill; but all these establishments must contain shafting, bearings or pedestals in which the shafting may revolve, fixings to carry the pedestals, and also wheels or pulleys to convey motion to the machines. The machinery of *conversion* in two works may differ enormously, but the machinery of *transmission* will be found to possess many, if not all, its features in common.

It is no doubt true that there are now many engineering establishments which have little or nothing to do directly with general millwright work. Undoubtedly mechanical engineering, like most other industries, has been enormously modified during the past half-century by the great development of the principle of the division of labour which has taken place in that time. There are now many engineering works which are simply factories for the production of some particular class of machinery. Nevertheless there is no department of mechanical engineering in which a young man may be placed in which he will not find a knowledge of the construction and cost of machinery of transmission of value to him, if not actually indispensable. It is not, therefore, necessary to offer any apology for dealing in some detail with this branch of our subject.

These may be conveniently considered under two heads—special, and standard or ordinary fixings. Nearly every mill,

Mill Fixings.

factory, or other manufacturing establishment using steam or water-power requires at one time or other a number of special cast-iron fixings to carry some portion of the machinery of transmission in some peculiar or special situation. For these fixings special patterns have usually to be made, and as these patterns are generally of no use as stock or standard patterns, their cost in each instance must be entered against the special casting, and covered by the price charged in the account or estimate. The cost of moulding these fixings—which are very often loam castings, or, if they are done in green sand, are unusually difficult—must also be taken separately, as should also any workmanship upon the casting itself.

EXAMPLE No. 9.—Estimate of cast-iron footstand, with bell-metal bush and steel step for upright shaft, for .... (Profit rates).

Date.			Cwts. qrs. lbs.	s. d.	£ s. d.
	1 cast-iron stand, in loam		44 2 0	15 0	33 7 6
	1 „ door		1 1 14	11 0	0 15 2
	1 wrought-iron plate		1 6	0 3½	0 9 11
	1 steel step		40	1 6	3 0 0
	1 bell-metal step		36	1 5	2 11 0
	2 steel pins, forged			1 6	0 3 0
	4 bolts and nuts		5½	0 6	0 2 9
	12 studs and nuts			0 6	0 6 0
	Turner at stand	7 hours		3 0	1 1 0
	„ steps, &c.	30 „		2 0	3 0 0
	Planer	10 „		3 0	1 10 0
	Driller (large machine)	10 „		2 0	1 0 0
	Fitters	35 „		1 4	2 6 8
	Grinder	4½ „		2 0	0 9 0
	Patterns (extra timber)	85 „		1 6	6 7 6
	Drawings	35 „		2 0	3 10 0
	Less 2½ per cent. discount				59 19 6

EXAMPLE No. 9A.—Statement of cost of preceding cast-iron stand.

£ s. d.			s. d.	£ s. d.
	1 cast-iron stand, in loam	43 3 0	7 6	16 10 2
	Moulders' wages			10 5 9
	1 cast-iron door	1 2 0	6 3	0 9 5
	Moulders' wages			0 0 9
	1 wrought-iron plate, from boiler shop ..	2 0	18 0	0 9 0
	1 compressed steel step, per Whitworth ..	3 3	1 0	1 19 0
	1 bell-metal step (special)	2 11	1 0	1 15 0
	4 bolts and nuts (stock)	5½	0 4	0 1 10
	12 studs and nuts (stock)		0 2½	0 2 6
	2 steel pins	1½	0 2	0 0 3
	Workmanship—			
0 0 9	Smiths at pins. Wages paid			0 0 9
	Turners, 40 hours „			1 6 8
	Planers, 12 „ „			0 6 5
	Drillers, 12 „ „			0 4 11
2 18 7	Grinders, 3½ „ „			0 1 1
0 10 9	Fitters, 40 „ „			1 1 6
1 9 7	Patterns, 75 „ „			1 19 5
0 6 2	Drawings, 35 „ „			1 4 8
	Cost in materials and wages			37 19 0
5 5 10	Indirect expenses			5 5 10
	Gross cost			43 4 11
	Profit (35 per cent.)			15 4 7
	Amount in estimate, £59 19*s.* 6*d.*, less 2½ per cent...			58 9 6

In the above statements we give first an estimate, at profit rates, for a special fixing, and, secondly, the actual cost of the fixing when completed ready for erection. The rates in the estimate were slightly over the usual profit rates of the establishment, as the work was for a very particular customer, and would have to be most carefully done. In the "cost," the rates put opposite the iron castings cover not merely the cost of the metal, but every indirect expense properly belonging to the ironfounder, as previously explained. The sums in the left hand money column represent the indirect expenses for the different classes of labour against which the amounts are set, supposed to be chargeable to the job.

These expenses are here calculated on the following scale—viz., machinists, 150 per cent.; fitters, 50 per cent.; pattern makers, 75 per cent.; smiths, 100 per cent.; and draughtsmen, 25 per cent. on the actual wages paid. The four items of machinists' wages amount to £1 19*s.* 1*d.*, and 150 per cent. on this sum equals £2 18*s.* 7*d.* It will be noted that the profit in this example amounted to about 35 per cent. on the gross cost of the fixing; though if the cost of the principal casting be compared with the sum put down for it in the estimate, it will be seen that the profit on the casting alone was only about 25 per cent on the cost—certainly not more than ought to be obtained on special and risky castings of this nature. Whilst the statement of cost is in this example set out in detail, costs of such work may be much more briefly summarised (the principal items being collected from different books) where proper accounts are kept, as will be explained in due course. One or two other detailed costs of special fixings may be given.

Example No. 10.—Summary of cost of 1 special wall box, prepared to carry crank shaft pedestal at lower part and pedestal for first motion upright shaft above, for—

£ s. d.			s. d.	£ s. d.
	1 casting, in loam	104 1 7	7 6	39 2 4
	Moulders' wages			13 4 6
2 9 9	Pattern makers (wages paid)			3 6 4
	Extra timber (special return)			0 16 0
2 9 9	Cost in materials and labour			56 9 2
	Expenses (other than foundry)			2 9 9
				58 18 11
	Profit (33 per cent. nearly)			19 5 9
	Tender was 15s. per cwt. net.			78 4 8

Example No. 11.—Summary of cost of cast-iron sole plates, prepared for stands to carry 6 in. pedestal, for—

£ s. d.			s. d.	£ s. d.
	3 castings (green sand)	80 1 0	6 3	25 1 7
	Moulders' wages			1 4 4
1 3 8	Pattern makers' wages			1 11 6
	Planers' wages			0 11 2
1 7 3	Drillers' "			0 7 0
0 1 3	Fitters' "			0 2 5
	Cost in materials and wages			28 18 0
2 12 2	Expenses (other than foundry)			2 12 2
				31 10 2

The castings in last example stood in the estimate as follows:

			s. d.	£ s. d.
3 sole plates		82 0 0	8 6	34 17 0
Planing	2 days		20 0	2 0 0
Drilling	2 "		16 0	1 12 0
Fitting	½ "		10 6	0 5 3
Patterns	6 "		12 0	3 12 0
				42 6 3
Less 2½ per cent. discount				1 1 2
				41 5 1
Cost as above				31 10 2
Profit, equal nearly to 31 per cent. on cost				9 14 11

It must not be supposed that profits equal to those shown in the two last examples are always to be obtained. Larger profits will not often be obtained where there is competition; and lower rates must frequently be taken, especially where the castings form part of a considerable contract. Many other detailed examples of special fixings might be given, but the following list will serve to supplement sufficiently what has already been adduced.

Sundry Fixings.

SPECIAL CAST-IRON MILL FIXINGS.

	Weight.			Profit Rates per cwt. for Castings only.	
				s.	d.
1 Stand for upright (loam)	65	0	4	14	0
Pattern making extra, 7 days @ 12s.					
1 Wall fixing (loam)	19	2	4	16	0
Pattern making extra, 4½ days, @ 10s. 6d.					
1 Foundation plate for upright (loam)	85	0	0	13	0
Pattern making extra, 9 days @ 10s. 6d.					
1 Box casting, sole, 5 ft. 8 in. × 3 ft. 10 in.; top, 3 ft. 8 in. × 3 ft. 8 in.; depth, 16 in.	32	0	0	10	0
1 Box casting, sole, 11 ft. × 2 ft. 10 in.; top, 10 ft. × 2 ft. 10 in.; depth, 3 ft.	66	0	0	10	0
1 Box casting, sole, 10 ft. × 2 ft. 9 in.; top, 10 ft. × 3 ft.; depth, 15 in.	61	0	0	10	0
(The above three castings were moulded in green sand, but had loam cores.)					
Pattern making extra, 30 days @ 10s. 6d.					
2 Special pilasters, each 7 ft. 6 in. high × 12 in. wide	18	0	0	9	0
Pattern making extra, 3 days @ 12s.					
(These box castings and pilasters were all in connection with an engine house.)					
1 Channel Beam, 9 ft. long (green sand)	6	2	0	9	0
Pattern making, 2 days @ 10s. 6d. extra.					
2 Beams, each 19 ft. 6 in. by 16 in. deep; bottom flange, 6 in. × 1¼ in.; top, 4 in. by ⅞ in.; web, ⅞ in.	30	0	0	8	0
Pattern making, 6 days @ 10s. 6d. extra.					
2 Fixings for top of beams	6	0	0	9	0
Pattern making, 4 days @ 10s. 6d. extra.					
2 Beams, each 11 ft. long × 16 in. deep	19	0	0	8	0
1 Bridge to go between	6	0	0	9	0
Pattern making on beams and bridge, 6 days @ 10s. 6d.					
2 Beams, each 11 ft. long × 14 in. deep	16	0	0	8	0
1 Bridge to go between	4	2	0	9	0
Pattern making on both, 6½ days @ 10s. 6d. extra.					
1 Wall fixing, prepared for 4 in. pedestal	13	0	0	9	0
Pattern making, 4½ days @ 10s. 6d. extra					
2 Plate Washers	8	0	0	7	0
Pattern making, ½ day @ 10s. 6d. extra.					
4 Fluted columns, each 6 ft. 8 in. by 7 in. diameter	16	0	0	9	0
Altering stock pattern to suit, 2 days @ 10s. 6d. extra.					
18 Plain columns, each 5 ft. 10 in. long × 5 in. diameter, and ⅝ in. thick	40	0	0	9	0
Altering stock pattern, 1 day @ 10s. 6d. extra.					
9 Columns, 12 ft. high over all, with flanged bases, and with heads prepared to carry rolled iron beams and to receive pedestal brackets	99	0	0	7	6
Pattern making—putting head to stock pattern, etc., 4 days @ 12s. extra.					
10 Foundation plates (open sand)	40	1	0	6	6
Pattern making, ½ day at 12s. extra.					
The above are all profit rates.					

Special Bolts and Nuts.

In connection with these special fixings, special bolts and nuts are often required. It may be well to give one or two examples.

EXAMPLE No. 12.—Cost of 14 1½-in. cotter bolts and nuts, for—

£ s. d.				s. d.	£ s. d.
	14 1½-in. bolts, 28 nuts and 14 cotters, forged weight (Staffordshire "Crown" iron).. ..		7 2 0	8 6	3 3 9
0 17 1	Smith's and striker's wages ..	20 hours		46 0	0 17 1
	Screwing and tapping	9½ ,,		23 0	0 4 1
0 7 3	Grinder (dressing cotters, etc.) ..	2 ,,		20 0	0 0 9
	Materials and wages				4 5 8
1 4 4	Expenses				1 4 4
	Gross cost				5 10 0

Equal to 1·57*d.* per lb.

These bolts, etc., stood in the estimate at 2¼*d.* per lb. The price of such bolts generally runs from this rate up to 3*d.* per lb., according to the weight per bolt. The lighter the weight per bolt the higher the price per lb.

EXAMPLE No. 13.—Cost of 8 2¼-in. bolts, 15 in. long, with square necks and with two nuts each. Nuts and points of bolts faced.

£ s. d.				s. d.	£ s. d.
	8 bolts and 16 nuts, forged weight		2 0 0	8 6	0 17 0
0 8 6	Smith's and helper's wages ..	10 hours		46 0	0 8 6
	Screwing and tapping wages ..	9 ,,		23 0	0 3 10
0 10 3	Turning nuts and points of bolts in lathe (apprentice)	16 ,,		10 0	0 3 0
	Materials and wages				1 12 4
0 18 9	Expenses				0 18 9
	Gross cost				2 11 1

Equal to 2·78*d.* per lb.

The estimate for the above stood thus :—

				s. d.	£ s. d.
	8 bolts and 16 nuts, 2¼ in. × 15 in.		2 0 7	0 3	2 15 9
	Facing nuts and points	12 hours		1 6	0 18 0
					3 13 9

Equal to 3·8 per lb.

EXAMPLE No. 14.—Cost of 36 rag-end bolts, 6 in. × by ⅝ in., with nuts.

£ s. d.				s. d.	£ s. d.
	36 bolts and nuts, 6 in. × ⅝ in.		0 1 6	8 6	0 2 8
0 1 8	Smith's wages	2 hours		46 0	0 1 8
0 1 9	Screwing and tapping	3½ ,,		18 0	0 1 2
					0 5 6
0 3 5	Expenses				0 3 5
					0 8 11

Equal to 3·14*d.* per lb. Taken in estimate at 5*d.* per lb.

Special bolts of a similar character to those which have just been used as examples, made in a general engineering establishment, will not often cost less than the rates here shown. It may be incidentally remarked that home-made bolts and nuts of standard sizes cost usually much more than similar bolts and nuts could be bought for from the regular manufacturers. A bolt maker is, however, necessary to a large engineering shop; and, as he cannot always be engaged on special bolts, it pays to let him fill up his time making standard sizes.

Wall Boxes.

Most general engineering establishments gradually accumulate a stock of patterns of wall boxes which are used from time to time for different jobs, and thus become standard patterns. The list below may be taken as fairly representative. It is very often the case, however, that a stock pattern of a wall box has to be altered to suit different thicknesses of walls, and in other details. It is a simple matter to do this—strips being fixed on when the pattern is to be made wider; and, if the casting is required narrower than the pattern, the moulder can with a little care "stop off" the superfluous width in the sand. The bridge in the box to carry the pedestal generally admits of adjustment to a certain extent. The cost of altering the stock patterns must, of course, be covered in any estimate. The cost of wall boxes, as castings, may usually be taken as about the average or all-round cost of the castings turned out of a general engineering foundry. It is rare that any machining has to be done on a wall box—a little chipping or filing by the fitter when placing the pedestal being all that is necessary.

TABLE No. 1.—List of wall boxes.

	Dimensions.	Weight.	Rate per Cwt. Profit Prices.
	3 ft. 6 in. × 3 ft. 6 in. × 2 ft. 5 in. deep, for 9 in. pedestal ..	20 0 0	7s. to 9s.
	New pattern would require from 3 to 5 days.		
	3 ft. 0 in. × 3 ft. 0 in. × 2 ft. 5 in. deep, for 6½ in. pedestal ..	15 0 0	7s. to 9s.
	New pattern would require from 3 to 5 days.		
	3 ft. 0 in. × 3 ft. 0 in. × 1 ft. 6 in. deep, for 5½ in. pedestal ..	11 0 0	7s. to 9s.
	New pattern would require from 2½ to 4 days.		
	2 ft. 0 in. × 2 ft. 0 in. × 2 ft. 0 in. deep, for 4½ in. pedestal ..	8 0 0	7s. to 10s.
	New pattern would require from 2 to 3½ days.		
	2 ft. 6 in. × 2 ft. 6 in. × 1 ft. 6 in. deep, for 4 in. pedestal ..	8 0 0	7s. to 10s.
	2 0 × 2 0 × 1 2 " 4 " ..	5 0 0	8s. to 10s.
	2 0 × 2 0 × 1 0 " 4 " ..	4 1 0	8s. to 10s.
	2 0 × 2 0 × 0 9 " 4 " ..	3 1 14	8s. to 10s.
	2 0 × 2 0 × 1 6 " 3½ " ..	6 3 0	8s. to 10s.
	1 6 × 1 2 × 1 2 " 3 " ..	2 3 0	8s. to 10s.
	1 6 × 1 6 × 1 0 " 3 " ..	2 1 14	8s. to 10s.
	1 6 × 1 6 × 0 9 " 3 " ..	1 3 0	9s. to 12s.
	1 4 × 1 4 × 1 2 " 2½ " ..	2 0 14	8s. to 10s.
	1 4 × 1 4 × 1 0 " 2¼ " ..	1 3 0	9s. to 12s.
	1 4 × 1 4 × 1 0 " 2 " ..	1 3 0	9s. to 12s.
	1 4 × 1 4 × 0 9 " 2 " ..	1 1 14	9s. to 12s.

The "depth" given in the above table is the distance through the wall box from front to back, and corresponds with the thickness of the wall.

The above prices would cover the use of stock patterns, but not the cost of any alterations or adjustments that might be necessary. These alterations would have to be covered by a special charge.

In a general contract, however, containing a number of wall boxes, it will generally be sufficient, to cover all alterations and preparations, to add from one to three shillings per cwt. to the above rates.

The wall box patterns given in the above table were mostly made at different times to suit the requirements of different customers, and without reference to any particular scale.

The following would constitute a fair price list for plain wall boxes for ordinary walls, the prices being subject to say 2½ per cent. discount in a month; delivery F.O.B. (free on board), or F.O.R. (free on rails) in maker's own town.

TABLE NO. 2.—Price list of wall boxes.

Size of Pedestal.	Size of Box.	Thickness of Wall.	Approximate Weight.	Price per Box.
				£ s. d.
1¾ or 2 in.	12 in. square.	9 in.	1 0 0	0 16 0
2¼ in.	15 "	9	1 1 14	1 2 0
3	16 "	9	1 2 0	1 5 0
3½	16 "	9	1 2 0	1 5 0
4	18 "	9	1 3 0	1 10 0
4	18 "	13½	2 2 14	2 0 0
4½	18 "	9	1 3 0	1 10 0
4½	18 "	13½	2 2 14	2 0 0
5	20 "	13½	3 3 0	2 10 0
5½	24 "	13½	4 3 14	3 10 0
6	27 "	13½	6 0 0	4 4 0

10 per cent. extra for bolts and nuts and joggle keys to hold pedestal, and for pine packings. Most firms would supply single wall boxes at above rates, and quantities at 10 per cent. less.

Hangers and Brackets.

Both these fixings are for the purpose of carrying shafting. The term "Hanger" is applied generally to all fixings for this purpose which are bolted to beams overhead, and thus as it were "hang" from above. The term "Bracket" is applied to all fixings for this purpose which are bolted to the sides of walls or columns.

Both hangers and brackets may be divided into two general classes—viz, those which have brasses fitted actually or directly in them, and thus form in themselves the bearings for the shafting; and those which have separate pedestals bolted or otherwise fitted on them. The former are cheaper than the latter—*i.e.*, the pedestal brackets or hangers are cheaper than independent brackets or hangers with separate pedestals—but they are not so good. It is difficult to put a number of them correctly in line when erecting; they are more difficult to adjust, should adjustment become necessary owing to the settling of the walls of the house or to any other cause; and they are troublesome when any renewal of bushes becomes necessary.

Following are a few examples of costs, and also tables of weights and prices. The hangers given in the examples and tables are of the ordinary "sling" type, in which there are two flanges to bolt to the overhead beams; though both weights and prices may be taken as practically applicable also to the plain boot-shaped style in which there is only one flange to bolt to the beam.

Example No. 15.—Cost of hanger with single brass and iron cap. Depth to centre of bearing, 14 in.; bore, 1¾ in.

£ s. d.				s. d.	£ s. d.
	Cast iron		0 1 16	8 0	0 3 2
	Brass		2¼	0 10	0 1 11
	2 ½-in. bolts			0 3	0 0 6
0 1 3	Drilling	2 hours		24 0	0 0 11
	Fitter	1 "		30 0	0 0 7
0 0 11	Apprentice fitter	7½ "		9 0	0 1 3
	Materials and wages				0 8 4
0 2 2	Expenses				0 2 2
	Gross cost				0 10 6

Charged 17*s.*

Example No. 16.—Cost of 2 pedestal hangers with single brasses. Depth to centre of bearing, 18 in.; bore, 2¾ in.

£ s. d.				s. d.	£ s. d.
	Cast iron		1 0 10	8 0	0 8 9
	Brass		10	0 10	0 8 4
	4 bolts and nuts, ⅝ in.			0 4	0 1 4
0 2 8	Driller	4 hours		24 0	0 1 9
	Fitter	12 "		28 0	0 6 3
0 3 10	Pattern maker (Getting out and repairing stock pattern)	3 "		26 0	0 1 5
	Materials and wages				1 7 10
0 6 6	Expenses				0 6 6
	Gross cost				1 14 4

Charged 27*s.* 6*d.* each.

EXAMPLE No. 17.—Cost of pedestal hanger with double brasses. Depth to centre of bearing, 24 in.; bore 1¾ in.

£ s. d.				s. d.	£ s. d.
	Cast iron		1 1 0	8 0	0 10 0
	Brass		9	0 10	0 7 6
	2 bolts and nuts, ⅝ in.			0 4	0 0 8
0 1 8	Driller	2½ hours		24 0	0 1 1
	Fitter	10 "		28 0	0 5 2
0 3 5	Pattern maker at stock pattern ..	3 "		30 0	0 1 8
	Materials and wages				1 6 1
0 4 1	Expenses				0 4 1
	Gross cost				1 10 2

Charged 45s.

EXAMPLE No. 18.—Cost of pedestal hanger with single brass. Depth, 18 in.; bore, 4 in.

£ s. d.				s. d.	£ s. d.
	Cast iron		1 3 14	8 0	0 15 0
	Brass		11½	0 10	0 9 7
	2 bolts and nu's, ¾ in.			0 6	0 1 0
0 4 0	Driller, boring	6 hours		24 0	0 2 8
	Fitter	9 "		28 0	0 4 8
0 3 5	Altering pattern. Pattern maker	4 "		28 0	0 2 1
	Materials and wages				1 15 0
0 7 5	Expenses..				0 7 5
	Gross cost				2 2 5

Charged 70s.

It should be mentioned that the hangers given in the four last examples were made simply in the quantities there given—that is, singly in all except one instance—to odd orders. Therefore the costs are higher than would be the case in the event of a large number of one size being made at a time; and the prices at which the hangers are charged are also proportionately higher than would be charged for considerable numbers.

TABLE No. 3.—Table of pedestal hangers (single brasses) and plain hangers.

Bore.	Depth.	Cast Iron.	Brass.	Gross Cost (approximate).	Price of Pedestal Hanger.	Price of Plain Hanger.
				£ s. d.	£ s. d.	£ s. d.
1½ in.	14 in.	0 1 16	2¼ lb.	0 10 6	0 15 0	0 7 6
1¾ "	14 "	0 1 16	2¼ "	0 10 6	0 16 0	0 9 0
2 "	18 "	0 2 14	2¾ "	0 13 0	0 19 0	0 10 6
2¼ "	18 "	0 2 14	3½ "	0 14 6	1 2 6	0 12 6
2½ "	18 "	0 3 0	3½ "	0 16 6	1 5 0	0 15 0
2¾ "	18 "	0 3 0	5 "	0 19 0	1 7 6	0 17 6
3 "	18 "	1 0 0	6¼ "	1 4 0	1 15 0	0 19 0
3½ "	24 "	1 2 0	9 "	1 13 0	2 10 0	1 4 0
4 "	24 "	1 3 14	11½ "	2 0 0	3 0 0	1 10 0
4½ "	24 "	2 1 0	14 "	2 8 0	3 10 0	1 16 0

If with double brasses (a brass top and bottom), 20 per cent.

extra; 15 per cent. extra on prices of plain hangers for pine packing, bolts and nuts to hold pedestal, and joggle keys.

By "plain hanger" in the last column of the above table is meant a hanger prepared to have a separate pedestal bolted to it. The weight of such a hanger would be slightly over the weight of cast iron in the pedestal hanger of corresponding size, but may be considered as practically the same. Most engineering firms would supply pedestal hangers at the rates given in the above table in small quantities at a time, and in large numbers at from 10 to 25 per cent. less. A single pedestal hanger should not cost more to make than the sum opposite each size, and the cost should come out considerably less when a dozen or more are made at once.

The costs and prices of pedestal wall brackets—that is, of brackets which form in themselves the bearings for the shaft, may be taken at about 10 per cent. more than hangers—the distance from the wall to the centre of the shaft in the one case not being more than the depth from the beams to the centre of the shaft in the other. The price of plain brackets—that is brackets which are intended to have separate pedestals bolted to them—may be taken at from 20 to 25 per cent. more than plain hangers. The only difference is that there is usually from a fifth to a third more cast-iron in the bracket than in the hanger of corresponding size. Pillar bracket pedestals are simply pedestals intended to be bolted to the sides of pillars or columns. In the case of wall brackets and hangers, the centre of the shaft must be at a considerable distance from the wall or beams, so that there will be sufficient clearance for the pulleys or wheels which are intended to go on the shaft. But a shaft may be carried quite close to a column, as there will be, in the space between two columns, ample clearance for all pulleys. Hence pillar bracket pedestals have not so much cast-iron in them as wall brackets or hangers, and may, indeed, almost be regarded as ordinary pedestals. If 10 per cent. be added to the prices of plain pedestals which follow, this will generally be sufficient to cover the extra cost of pillar bracket pedestals of corresponding dimensions.

These different terms are all used to describe the same class of fixing. These fixings are of many different designs and of all sizes, from the massive pedestal for the crank-shaft of the

Pedestals, Plummer-Blocks, Seats, Bearings.

engine or for the water-wheel axle, down to the neat little bearing resting on a neat bracket fixed by screws to the wall of his workshop, in which the shafting of the watch manufacturer revolves. As the pedestal or plummer-block is undoubtedly the most important of all mill fixings, we give detailed examples of most ordinary sizes.

EXAMPLE No. 19.—Cost of cast-iron pedestal with double brasses, 8½ in. bore by 12 in. long; planed on sole and top, and with jaws slotted to receive brasses.

£ s. d.			s. d.	£ s. d.
	Cast iron	8 0 14	6 3	2 10 10
	Moulders' wages			0 8 4
	Brass	1 0 9	0 10	6 4 2
	4 bolts with nuts and guards	1 0 14	8 0	0 9 0
0 5 1	Smith's and helper's wages ... 6 hours		46 0	0 5 1
	Planer .. .. 40 ,,		28 0	1 0 9
	Slotter .. .. 22 ,,		20 0	0 8 2
	Driller .. .. 3 ,,		20 0	0 1 1
	Turner .. .. 19 ,,		34 0	0 12 0
	Apprentice turner at bolts, etc. .. 6 ,,		10 0	0 1 1
3 6 8	Screwer .. .. 3½ ,,		20 0	0 1 4
	Fitters .. .. 66½ ,,			1 15 11
1 0 2	Pattern maker preparing stock pattern 7½ ,,			0 4 4
	Materials and wages			14 2 1
4 11 11	Expenses			4 11 11
	Gross cost			18 14 0

The following is a copy of the entry in the sales book and also a copy of the invoice for the above pedestal, which was not made under contract, but ordered without a tender being required:

			s. d.	£ s. d.
June.......	Block and cap for 8½ × 12 in. pedestal ..	8 0 14	10 6	4 5 4
	2 best gun-metal steps	1 1 9	1 2	8 13 10
	4 bolts and nuts and guards	1 10 14	0 4½	2 7 3
	Planing sole and top of block and underside of cap, slotting jaws, filing and fitting brasses, boring brasses and facing ends of bolts, etc., and preparing patterns (use of patterns included)			12 13 7
				28 0 0

To make complete new patterns for a pedestal of above dimensions would take from 10 to 14 days of a pattern maker. The pedestal given in the above example had more workmanship than is usually required for ordinary shafting pedestals put upon it. It was, indeed, a crank-shaft pedestal, though used for a first motion shaft in this instance; and the instructions were to make a very good job of it. The following examples represent more the character of ordinary shafting pedestals.

From these it will be seen that pedestals as large as the one in the last example can be made much lighter and less expensive. At the same time the following may be considered of high-class character for ordinary purposes.

EXAMPLE No. 20.—Cost of pedestal with double brasses, 9 in. bore by 14 in. long.

			s. d.	£ s. d.
Cast iron		6 3 8	7 3	2 9 6
Brass		1 1 0	0 10	5 16 8
Bolts and nuts forged		0 2 0	0 3	0 14 0
Planer	13 hours		28 0	0 6 9
Turner	24 "		34 0	0 15 1
Apprentice turner at bolts, etc. ..	12 "		10 0	0 2 3
Grinder at bolts	4 "		20 0	0 1 6
Driller	2 "		20 0	0 0 9
Fitters	72 "			1 18 8
Materials and wages				12 5 2
Expenses				2 18 10
Gross cost				15 4 0

Charged £23.

EXAMPLES NOS. 21 AND 22.—Cost of pedestal with double brasses.

8 in. bore by 12 in. long. 7 in. by 12 in.

			s. d.	£ s. d.			s. d.	£ s. d.
Cast iron		5 1 7	7 3	1 18 7	—	4 2 0	7 3	1 12 8
Brass		3 23	0 10	4 9 2	..	99	0 10	4 2 6
Bolts and nuts, forged ..		1 12	0 3	0 10 0	..	19	0 4	0 6 4
Planer ..	10 hours		28 0	0 5 2	7 hours		28 0	0 3 8
Turner ..	20 "		34 0	0 12 7	15 "		34 0	0 9 5
" at bolts,&c.	9 "		28 0	0 4 8	5 "		28 0	0 2 1
Grinder ..	2 "		20 0	0 0 9	2 "		20 0	0 0 9
Driller ..	2 "		20 0	0 0 9	2 "		20 0	0 0 9
Fitters ..	60 "			1 11 6	50 "			1 6 0
Materials and wages..				9 13 2	..			8 4 2
Expenses				2 11 8	..			1 18 9
Gross cost				12 4 10	..			10 2 11

Charged £17 10s. Charged £15 10s.

EXAMPLE No. 23.—Cost of pedestal with double brasses, 6 in. by 10 in. long.

			s. d.	£ s. d.
Cast iron		3 0 0	7 6	1 2 6
Brass		70	0 10	2 18 4
Bolts and nuts		15	0 4	0 5 0
Planer	6 hours		28 0	0 3 1
Turner	9 "		34 0	0 5 8
" at bolts	4 "		10 0	0 0 9
Grinder	2 "		20 0	0 0 9
Driller	2 "		20 0	0 0 9
Fitters	40 "			1 1 6
Materials and wages				5 18 4
Expenses				1 7 3
Gross cost				7 5 7

Charged £10 10s.

EXAMPLES NOS. 24 AND 25.—Cost of pedestal with double brasses.

5 in. bore by 10 in. long. 4½ in. by 9 in.

		s. d.	£ s. d.			s. d.	£ s. d.
Cast iron	1 3 14	7 6	0 14 1	..	1 2 9	7 6	0 11 11
Brass	47	0 10	1 19 2	..	35½	0 10	1 9 7
Bolts and nuts	10	0 4	0 3 4	..	10½	0 4	0 3 8
Planer .. .. 3 hrs.		28 0	0 1 7	3 hours		28 0	0 1 7
Drillers(boring,&c.)10 „		20 0	0 3 9	8 „		20 0	0 3 0
Turner, at bolts, &c. 6 „		10 0	0 1 1	..			
Grinder .. .. 2 „		20 0	0 0 9	2 „		20 0	0 0 9
Fitters .. .. 30 „			0 14 5	22 „			0 10 9
Materials and wages..			3 18 2	..			3 1 3
Expenses			0 18 0	..			0 13 4
Gross cost			4 16 2	..			3 14 7

Charged £6 10s. Charged £5 5s.

EXAMPLES NOS. 26 AND 27.—Cost of pedestal with double brasses.

4 in. by 8 in. 3½ in. by 7 in.

		s. d.	£ s. d.			s. d.	£ s. d.
Cast iron	1 0 0	8 0	0 8 0	..	0 2 21	8 0	0 5 6
Brass	27	0 10	1 2 6	..	17	0 10	0 14 2
Bolts and nuts	7	0 4	0 2 4	..	5	0 4	0 1 8
Planer .. 2 hours		28 0	0 1 1	..			
Driller .. 7 „		20 0	0 2 7	5 hours		20 0	0 1 10
Grinder .. 1 „		20 0	0 0 5	1 „		20 0	0 0 5
Fitter .. 15 „			0 7 6	10 „			0 5 2
Materials and wages..			2 4 5	..			1 8 9
Expenses			0 9 10	..			0 6 0
Gross cost			2 14 3	..			1 14 9

Charged £3 10s. Charged £2 10s.

EXAMPLES NOS. 28 and 29.—Cost of pedestal with double brasses.

3 in. by 6 in. long. 2½ in. by 5 in. long.

		s. d.	£ s. d.		s. d.	£ s. d.
Cast iron	0 2 0	8 0	0 4 0	0 1 12	8 0	0 3 3
Brass	13½	0 10	0 11 3	9	0 10	0 7 6
Bolts and Nuts..	4	0 4	0 1 4	3½	0 4	0 1 2
Driller .. .. 3½ hours		20 0	0 1 4		20 0	0 1 8
Grinder .. .. 1 „		20 0	0 0 5		20 0	0 0 5
Fitter .. .. 9 „			0 4 6			0 3 3
Materials and wages ..			1 2 10			0 17 3
Expenses			0 4 11			0 3 9
Gross cost			1 7 9			1 1 0

Charged £2. Charged £1 7s. 6d.

EXAMPLES Nos. 30 and 31.—Cost of pedestal with double brasses.

2 in. by 4. in. long. 1½ in. by 3½ in. long.

		s. d.	£ s. d.		s. d.	£ s. d.
Cast iron	0 0 22	8 0	0 1 7	0 0 9	8 0	0 0 8
Brass	6	0 10	0 5 0	4	0 10	0 3 4
Bolts and nuts			0 1 0			0 0 8
Driller .. .. 2 hours		20 0	0 0 9		20 0	0 0 9
Grinder .. .. 1 „		20 0	0 0 5		20 0	0 0 3
Fitter .. .. 4 „			0 2 0			0 1 5
Materials and wages ..			0 10 9			0 7 1
Expenses			0 2 9			0 2 6
Gross cost			0 13 6			0 9 7

Charged 18s. 6d. Charged 15s.

All the above examples of pedestals are taken from actual experience, and are the costs of pedestals made either singly or in lots of not more than two or three at a time. In most of the cases slight alterations in the patterns were necessary, but the cost of this item has been left out, as it is so variable. The brasses in all these instances will be found on the heavy side—pedestals often being made with brasses from 25 to 50 per cent. lighter. The cost of pedestals with single brasses—that is, with one brass let into the block, and with merely a cast-iron shell cap above—may be taken at about one-fifth, or twenty per cent. less than the costs shown for the double brass pedestals. The principal saving is in the brass.

All the pedestals given in these examples were of the ordinary plain type, with soles having double tails; the bolts being used merely for securing the cap to the block, and not also, as is the case sometimes, for the purpose of attaching the pedestal to the fixing. The cost of side pedestals, with correspondingly weighty brasses, would be about the same.

The selling prices given in the above examples would frequently be allowed to include—in the larger sizes at least—pine packing when required, joggle keys and the bolts and nuts to attach the pedestal to the fixing, unless the bolts were of extra length or of some special character. Many firms would charge lower prices than those given in the above examples, even with the costs about the same; but these prices are not at all out of the way for odd pedestals, more particularly if a departure from the stock pattern has been made, as something must be allowed for the use of the engineer's patterns.

A firm intending to make a specialty of pedestals, and to issue or advertise a price list, would endeavour to fix their weights and prices at about the figures given in the table on the other side.

The selling prices given in the table would be exclusive of any oil cups, bolts for securing the pedestals to the fixings, or of wood packings. In preparing a list of this kind intended for public use, it is necessary to keep in mind that the selling price must be sufficient to cover not only a cash discount of $2\frac{1}{2}$ or 5 per cent. to the buyer, when the buyer is the user also, but must be sufficient to cover a still larger discount—10 to 15 per cent.—to merchants, agents, and other distributors.

Pedestals can be bought at lower prices than those given in the "selling price" column in the table; but in the writer's opinion it is not possible to sell pedestals profitably at lower rates than those just given, and at the same time to do justice to the user in the matter of workmanship and quality and weight of brass.

TABLE No. 4.—Price list of pedestals, with double brasses.

Size.	Weight of Iron.	Brass.	Approximate Gross Cost.	Selling Price.
			£ s. d.	£ s. d.
1¼ in. × 3 in.	0 0 9	2¾ lb.	0 6 8	0 9 0
1¾ „ × 3½ „	0 0 16	3½ „	0 7 0	0 10 0
2 „ × 4 „	0 0 20	4¼ „	0 7 6	0 11 6
2¼ „ × 4½ „	0 1 0	5½ „	0 9 6	0 14 6
2½ „ × 5 „	0 1 4	6½ „	0 12 0	0 17 6
3 „ × 6 „	0 1 20	9 „	0 18 6	1 7 6
3½ „ × 7 „	0 2 4	13 „	1 7 0	1 17 6
4 „ × 8 „	0 3 0	20 „	1 18 0	2 15 0
4½ „ × 8½ „	1 1 0	26 „	2 10 0	3 12 0
5 „ × 9 „	1 2 14	35 „	3 5 0	4 5 0
5½ „ × 9½ „	1 3 0	42 „	3 19 0	5 0 0
6 „ × 10 „	2 1 0	50 „	4 15 0	6 0 9

With single brasses, 15 per cent. less.

It is, perhaps, unnecessary to add that pedestals of reasonable quality can only be made at the costs given above, by being made in quantities, and either on piece-work or on a systematic plan.

CHAPTER VII.

MILLWRIGHT WORK, contd.—SHAFTING AND COUPLINGS.

MILL and general shafting is now made principally from the following materials:—

Hammered Scrap Forgings.—Used for heavy upright and other shafts, especially such as have large bosses to receive wheels. These forgings cost the manufacturing engineer from £11 to £20 per ton in the condition in which they leave the hammer, according to the size and the number and shape of the bosses—£14 to £16 per ton being ordinary rates.

Siemens and Bessemer Steel Forgings.—Used for same purposes as the hammered scrap, and costing from £20 to £30 per ton.

Bowling and Low Moor Iron Forgings.—Now but little used comparatively, the cheaper—but, if properly made, equally reliable—mild steels being used instead.

Many engineering establishments have their heavy forged shafts rough-turned at the forge, especially if time is important or the carriage considerable. The advantage of having the shaft thus rough-turned is that it enables the forge-master to ascertain with tolerable certainty whether or not the forging is sound; and if it is not, to rectify the defect if slight, or to make a new forging, if necessary, without loss of time. Nothing is more tantalising in an engineering shop than to get in a heavy forging, centre it in the lathe, possibly get it half or nearly wholly turned, and then to find it is defective and must be rejected and returned to the forge. A rough-turned forging, of course, costs the engineer rather more per ton than if he takes it from the hammer—from £2 to £6 extra, according to character.

It is customary for the manufacturing engineer, before ordering his heavy shaft forgings, to submit outline tracings of the shafts he requires to the forge or forges which he favours, and to invite quotations upon those tracings.

Most shafts of five inches diameter and upwards, and also lighter shafts if they have large or numerous bosses, are made from simple forgings, that is, they are not passed through the rolls. Lighter shafting, however, and not infrequently 5-inch and 6-inch shafting if plain, is made from rolled bars as follows :—

Bowling or Low Moor Iron Rolled Bars.—Used occasionally for special work ; cost from £16 to £26 per ton at the works.

Siemens and Bessemer Steel Bars.—Cost from about £6 10*s.* for the lowest Bessemer, to £20 per ton for the best Siemens. The Siemens or Siemens-Martin steel is generally considered to be better and more reliable than the Bessemer.

The new steel made by the basic or Thomas-Gilchrist process is now beginning to be offered in bars at very low prices, even under £5 per ton. It is not, however, perfectly reliable as yet, and is usually rather hard ; but it will no doubt be improved and come into very general use, as it can be produced at a lower cost than other steels.

Kirkstall Rolled Bars.—Very good, cost from £7 to £12 per ton. It may be noted that, in addition to the plain rolled bars for turning, the Kirkstall Forge also produce a special kind of rolled bars called "planished" bars, which are intended to be used without being turned at all. They are undoubtedly very good bars, have a fine skin, and are perfectly true—they are finally "trued up" by special machinery. These planished or patent rolled bars cost generally about £14 per ton.

Staffordshire, Scotch, and other Rolled Iron Bars.—These are very largely used for plain shafting, and cost from £6 to £12 per ton, according to sizes and quality. Excellent South Staffordshire bars, in every way suitable for shafting, can be bought in ordinary sizes at £7 10*s.* or £8 per ton at the works. These prices will buy "marked" bars, that is, bars branded with the marks of particular and well-known makers, and which have become recognised as guarantees of quality, as distinguished from the common bars of any and every maker.

It may be added that it ought to be considered a *sine quâ non* in all iron or steel for shafting that it should be mild, soft, and tough. If hard, it will be liable to be brittle, and therefore unreliable, whilst (what is of equal consequence in a commercial sense) it will take extra time to turn it in the lathe.

It may be useful, more especially to some of our younger readers, to mention a few of the leading makers of shaft forgings and bars.

Among the best known establishments from which manufacturing engineers buy their heavy shaft forgings may be mentioned the following, viz.:—The Bolton Iron and Steel Co., Ld., Bolton; Sir Joseph Whitworth and Co., Ld., Manchester; Sir W. Armstrong, Mitchell, and Co., Ld., Newcastle-on-Tyne; Steel Company of Scotland, Glasgow; The Ince Forge Co., Wigan; J. and W. Beardmore, Parkhead, Glasgow; Lancefield Forge Co., Glasgow; Mersey Forge Co., Ld., Liverpool; Landore Siemens Steel Co., Ld., Swansea; Portland Forge Co., Kilmarnock; Vickers, Don Works, Sheffield; Cammell and Co., Ld., Sheffield; John Brown and Co., Ld., Sheffield.

Makers of Forgings and Bars.

The following are well-known makers of rolled bars for shafting, viz.:—The Bowling Iron Co., Bradford, Yorks: The Lowmoor Iron Co. (Hird, Dawson, and Hardy), Bradford, Yorks; the Farnley Iron Co., near Leeds; the Kirkstall Forge Co., near Leeds; the Bolton Iron and Steel Co., Ld., Bolton; the Landore Siemens Steel Co., Ld., Swansea; the Steel Company of Scotland, Glasgow; the Weardale Coal and Iron Co., Ld., Spennymoor, Yorks; J. and W. Beardmore, Parkhead, Glasgow; Pearson and Knowles Co, Ld., Warrington; and in the Staffordshire district, John Bagnall and Sons, Ld., West Bromwich; the Earl of Dudley (E. Fisher Smith, agent), near Dudley; N. Hingley and Sons (Netherton Crown Brand), near Dudley; William Barrows and Sons, Tipton; Shelton Bar Iron Co., Stoke-on-Trent; Coalbrookdale Iron Co., Ld., Coalbrookdale.

It may be mentioned that whilst manufacturing engineers and makers of iron are more and more dealing directly with one another, to the advantage of both parties, a large amount of business in bar iron is still transacted through the medium of iron merchants and agents.

The cost of a line of shafting is affected to a very considerable extent by the kind of coupling adopted to connect the different lengths together. The best coupling, considered simply as a method of connecting two shafts together, is undoubtedly the solid flange coupling. It is, however, expensive, and involves the use of split pulleys or wheels; and though it is to be preferred for heavy shafts, the cast-iron flange coupling is in every way suitable for ordinary line shafting.

Couplings.

The solid flange coupling, as its name implies, is formed by forging a flange on the end of each shaft to be coupled; the cast-iron flange coupling is formed by keying a cast-iron flange on the end of each shaft to be coupled. The shafts are connected by bolts passing through the two flanges. The two flanges constitute the coupling.

The following are a few examples of estimates and costs:—

EXAMPLE No. 32.—Estimate for tender for 2 mild steel shafts, 9 in. diameter on body, each with one coupling flange and one boss. (Profit rates.)

				s. d.	£ s. d.
	One 9-in. steel shaft, forged weight		30 0 0	33 0	49 10 0
	One 9-in. " " "		34 0 0	34 0	59 1 6
	Turning and polishing both shafts all over	12 days		20 0	12 0 0
	Boring 8 holes in each flange ..	1½ "		16 0	1 4 0
	Planing 8 keybeds	2½ "		18 0	2 5 0
	Fitter (cutting of centres, &c.)	1 "		10 6	0 10 6
	8 1½-in. bolts and nuts (forged) ..	.. ..	50	0 3½	0 14 7
	Turning and fitting bolts ..	2 days		14 0	1 8 0
					126 13 7

Tender, £126 0s. 0d. (less 2½ per cent. discount).

The cost of the foregoing was as follows, viz.:—

£ s. d.				s. d.	£ s. d.
	One 9-in. mild steel shaft		30 3 0	25 0	38 8 9
	One 9-in. " "		35 2 0	26 0	46 0 0
	Turner at shafts	116 hours		34 0	3 13 1
	Planer	27 "		28 0	0 14 0
6 18 5	Driller	14 "		20 0	0 5 2
0 2 0	Fitter..	7 "		30 0	0 3 11
	8 1½-in. forged bolts and nuts ..	.. ..	52	8 0	0 3 9
0 3 10	Smiths and helpers	4½ "		46 0	0 3 10
0 6 8	Turner at bolts	24 "		10 0	0 4 5
	Materials and wages				89 16 11
7 10 11	Expenses				7 10 11
	Gross cost				97 7 10

Finished weights of shafts, 26 cwt. 2 qrs. 9 lbs. and 29 cwt. 2 qrs. 7 lbs.

It may be noticed that in last example, the time of the turner on the bolts, counted in hours, is considerably more in the actual cost than the time put down in the estimate. This discrepancy, in this instance, is accounted for by the fact that whilst the time in the estimate is that which it was supposed an ordinary journeyman would take to do the work, the work was actually done by one of the older apprentices.

Example No. 33.—Cost of 6 hammered scrap-iron shafts with bosses, collars, and solid flanges for coupling.

£ s. d.				s. d.	£ s. d.
	2 shafts, ea. 17ft. 6in. long × 6½in. diam. on body		48 0 14	15 0	36 1 11
	2 ,, 18 0 ,, × 6 ,, ,,		44 1 7	15 0	33 4 8
	2 ,, 18 0 ,, × 5½ ,, ,,		39 3 0	15 0	29 16 3
	26 bolts and nuts, 6 in. × 1¼ in.		0 3 24	8 0	0 7 9
	Turners at shafts	260 hours			7 9 3
	Planers	53 ,,		28 0	1 7 6
	Drillers	56 ,,		20 0	1 0 9
16 9 8	Turners at bolts	60 ,,			1 2 3
0 4 3	Fitters	17 ,,			0 8 6
0 7 8	Smiths and helpers at bolts ..	9 ,,		46 0	0 7 8
	Materials and wages				111 6 6
17 1 7	Expenses				17 1 7
	Gross cost				128 8 1

The estimate for these shafts at profit rates stood as follows :—

				s. d.	£ s. d.
	2 hammered scrap shafts, 6½ in.		47 0 0	20 0	47 0 0
	2 ,, ,, 6 ,, ...		44 0 0	20 0	44 0 0
	2 ,, ,, 5½ ,, ...		40 0 0	20 0	40 0 0
	Turning	27 days		16 0	21 12 0
	Planing	6 ,,		16 0	4 16 0
	Drilling	6 ,,		12 0	3 12 0
	26 bolts and nuts		1 0 0	0 3	1 8 0
	Turning bolts and nuts	6½ .		12 0	3 18 0
					166 6 0

Tender, £166 6*s*. 0*d*. nett.

The rates given in the above estimate were fully 10 per cent. under those usually put down in the establishment where this work was done, as it was desired in this instance to put in a (comparatively) low tender. These rates would, however, be considered good in many establishments. It will be noted that the forgings were in two out of the three lots slightly heavier than was estimated, but, as previously mentioned, this is a circumstance very liable to occur. It will also be observed that the profit price down for the forgings is exactly 33⅓ per cent. on the price actually paid for them. It was, however, expected that 16*s*. per cwt. would have to be paid for the forgings, and 25 per cent. was therefore the percentage counted upon in the estimate.

A much higher percentage, as already stated, is often taken on such shafts, as there is a certain amount of risk in connection with them. That is to say, a shaft of this character may, after a considerable amount of workmanship has been put upon it in the engineers' shop, turn out to be defective, and have to be returned to the forge. In such an event all good forges will replace the defective forging without expense to the engineer, but will not pay the latter for the time and money he has expended upon the bad forging before the defect was discovered. Forgings are usually supplied to engineers upon a kind of tacit understanding to the effect that the maker will take every reasonable care—exercise "due diligence"—to secure a sound forging; but if, after all, a defect appears when the shaft or other article is being finished, the engineer must share the loss incurred to the extent of the value of the workmanship that has been expended in his shop, whilst the forge-master takes the other, and usually larger, share of the loss, represented by the replacing of the forging by a new one. Hence it will be seen that if a "reed" is discovered as a shaft is receiving its finishing cut, the engineer may lose the whole of his profit on the forging; and, therefore, a considerable percentage is justifiable. At the same time 25 per cent. is a very common percentage on heavy forgings, and one with which many manufacturing engineers are well satisfied.

EXAMPLE No. 34.—Estimate for 197 lineal feet of 4½-in. shafting, plain, with 10 cast-iron flange couplings. (Profit rates.)

					s.	d.	£	s.	d.
11 rolled bars, allowing ⅛ in. diameter for turning		103	0	0	15	0	77	5	0
Turning	16 days				16	0	12	16	0
Planing keybeds for couplings..	3½ ,,				16	0	2	16	0
10 cast-iron flange couplings, each in two halves		16	2	0	10	0	8	5	0
Turning and boring ditto ..	17½ days				16	0	14	0	0
Drilling bolt holes	7 ,,				12	0	4	4	0
Slotting keybeds	1½ ,,				12	0	0	18	0
50 bolts and nuts, 4½ × 1 in., forged and screwed		1	1	0	0	4	2	6	8
Turning ditto	12 days				14	0	8	8	0
40 wrought-iron keys, 7 × 1⅛ × ⅝ in.		0	2	0	0	6	1	8	0
Grinder dressing ditto	1 day						0	15	0
Keying couplings on shaft ..	6 days				9	6	2	17	0
							135	18	8

Tender £135 (less 2½ per cent. discount).

The cost of the above came out as follows: the cost of the shafting being separated as accurately as possible from that of the couplings.

Cost of 4½-in. shafting and couplings :—

£ s. d.				s. d.	£ s. d.
	Shafting—				
	11 rolled bars, 4⅝ in.		100 3 0	10 9	54 3 1
	Turners	164 hours			4 15 2
8 9 3	Planers	34 „		28 0	0 17 8
	Materials and wages				59 15 11
8 9 3	Expenses				8 9 3
	Gross cost				68 5 2
	Finished weight, cwt. 93 2 0				
	Couplings, bolts and keys—				
	20 iron castings		16 1 0	6 3	5 1 7
	Moulders' wages				0 15 4
	Turners	160 hours			4 8 11
	Drillers	76 „		20 0	1 8 2
9 6 6	Slotter	10 „		23 0	0 7 3
	50 bolts and nuts, forged weight		1 0 20	8 0	0 9 6
0 11 1	Smith and helper	13 hours		46 0	0 11 1
	Screwer	9 „		20 0	0 3 4
	Turner	60 „		26 0	1 8 11
2 13 4	Apprentice turner at nuts ..	20 „		9 0	0 3 4
	40 wrought-iron keys		0 2 0	8 0	0 4 0
0 8 6	Smith and helper	10 hours		46 0	0 8 6
0 11 2	Grinder	20 „		20 0	0 7 5
0 13 5	Fitters keying couplings on ..	64 „			1 10 10
	Materials and wages				17 8 2
14 4 0	Expenses				14 4 0
	Gross cost				31 12 2

SUMMARY A.

Amount of Tender, less discount		£131 12 6
Gross cost of shafting	£68 5 2	
„ couplings	31 12 2	99 17 4
Profit		£31 15 2

SUMMARY B.

	Per Lineal Foot, Shafting only.	Per lb. Finished, Shafting only.	Couplings with Bolts, and Keying on.
Cost	0 7 0	1·57*d.*	£3 3 5
Selling price	0 9 6	2·13*d.*	4 6 2

EXAMPLE No. 35.—Cost of 8 lines of wrought-iron shafting, 3 in. diameter, each line 40 ft. long, in two lengths, joined by solid flange couplings, with turned bolts and nuts.

£ s. d.				s. d.	£ s. d.
	16 rolled bars, and coupling ends for same ..		89 0 0	0 6	42 5 6
11 8 0	Smiths and assistants forging couplings and welding to bars	176 hours		70 0	11 8 0
	Turners	363 „			10 14 4
17 11 6	Drillers	54 „		20 0	1 0 0
	32 ¾-in. bolts and nuts		0 2 14	8 0	0 5 0
0 7 8	Smith and assistant	9 hours		46 0	0 7 8
	Screwer	6 „		18 0	0 2 0
	Turner	29 „		28 0	0 15 0
1 9 10	Apprentice turner at nuts and heads	26 „		6 0	0 2 11
0 1 11	Fitters	8 „			0 3 10
	Materials and wages				67 4 3
30 18 11	Expenses				30 18 11
	Gross cost				98 3 2

Finished weight—76 cwt. 1 qr. 4 lb. = 2·77*d.* per lb. = 25*s.* per cwt.
Total length—320 ft. = 6*s.* 2*d.* per foot.

The estimated weight of the above lot of shafting was 75 cwt. 3 qrs. The price was £130, being the estimated weight calculated at $3\frac{1}{4}d.$ per lb., with 5 per cent. extra for packing for shipment.

EXAMPLE No. 36.—Cost of 8 lines of wrought-iron shafting, $2\frac{5}{8}$ in. diameter, each line 40 ft. long, in two lengths, joined by solid flange couplings, with turned bolts and nuts.

£ s. d.				s. d.	£ s. d.
	16 rolled bars, and coupling ends for same ..		47 0 14	9 6	22 7 8
6 3 2	Smiths and assistants	95 hours		70 0	6 3 2
	Turners	296 „			8 1 2
13 2 10	Drillers	38 „		20 0	0 14 1
	24 $\frac{5}{8}$-in. bolts and nuts		0 0 20	8 0	0 1 6
0 3 10	Smith and assistant	$4\frac{1}{2}$ hours		46 0	0 3 10
	Screwer	2 „		18 0	0 0 8
0 6 3	Turner	27 „		7 0	0 3 6
0 1 10	Fitters	7 „		28 0	0 3 8
	Materials and wages				37 19 3
19 17 11	Expenses				19 17 11
	Total cost..				57 17 2

Finished weight—37 cwt. 2 qrs. 8 lbs.=3·3*d.* per lb.
Total length—320 ft.=3*s.* $7\frac{1}{4}d.$ per foot.

Tender £73 15*s.*, being the estimated weight (38 cwt.) calculated at 4*d.* per lb., with 5 per cent. extra for packing for shipment.

It may be desirable to explain, with reference to both the two last examples, though the examples really carry this explanation on the face of them, that the flanges to form the couplings were forged on the ends of short pieces of bars in the smiths' shop of the establishment; the short pieces with the flanges at the ends being subsequently welded to the plain rolled bars as bought from the makers. This is the practice generally followed in works where the smiths' shop possesses a steam hammer.

It will be obvious that in preparing the specification of the rolled bars for shafting of this kind for the bar makers, allowance must be made for the coupling ends. Thus, in the two last examples the bars were ordered 17 ft. 3 in. in length, and if there had been flanges at both ends of each shaft the length of the rolled bars would have been correspondingly shorter. For the coupling ends themselves iron was taken out of stock.

Let us now see what the difference in cost would probably have been if the 3-in. shafting in Example No. 35 had had plain cast-iron flange couplings instead of the solid forged flanges.

EXAMPLE No. 37.—Estimated cost of 8 lines of wrought-iron shafting, 3 in. in diameter, each line 40 feet long, in two lengths, joined by cast-iron flange couplings, with turned bolts.

£ s. d.				s. d.	£ s. d.
	16 plain rolled bars, 3⅛ in. × 20 ft.		76 2 0	10 6	40 3 3
	Turning	200 hours		30 0	5 11 2
8 16 8	Planing or slot-drilling keybeds ..	16 ,,		20 0	0 5 11
	8 cast-iron couplings in halves		11 2 0	7 6	4 6 3
	Turning and boring	90 hours		30 0	2 10 0
	Drilling	30 ,,		20 0	0 11 1
4 15 8	Slotting	8 ,,		18 0	0 2 8
	16 keys			0 6	0 8 0
	32 ⅞-in. bolts and nuts, turned, etc.			1 9	2 16 0
0 7 10	Fitters keying on	30 hours		28 0	0 15 7
	Materials and wages				57 9 11
14 0 2	Expenses				14 0 2
	Gross cost				71 10 1

Equal to nearly 4*s.* 6*d.* per lineal foot, against 6*s.* 2*d.* for the solid flanged shafting.

It will be seen from above that the gross cost of the material is slightly higher than in No. 35, though the weight of the material is practically the same in both cases. A higher price per cwt. had to be paid for the bars in No. 37 than in No. 35, owing to their greater length. This slight disadvantage on the side of the plain shafting with cast-iron couplings is, of course, much more than counterbalanced by the cost of forging, and the extra turners' time in the case of the shafting with solid flange couplings. Although the total length of the shafting is the same in each case, much more time is required to finish the solid flange shafting than is needed for the plain bars and cast-iron couplings.

The cost of the shafting and couplings, as distinguished from each other in the last example, and the probable selling price are shown in the following summary:—

SUMMARY C.

	Per Lineal Foot, Shafting only	Per lb. Finished Weight, Shafting only.	Couplings and Bolts.
Cost ..	£0 3 5	1·74*d.*	£2 1 6
Selling Price ..	0 5 0	2·5*d.*	2 15 0

The cast-iron couplings in the examples given were all polished all over, and had in the one half a recess turned out to fit a corresponding projection left on the other half. Some firms offer, and there are people content to take, these couplings roughly turned and with plain faces. These, of course, are much cheaper, but certainly not so good.

Examples such as the following are of almost daily occurrence in a general engineering shop.

EXAMPLE No. 38.—Summary of cost of 53 ft. of 2½-in. wrought-iron shafting, in four lengths, with three cast-iron flange couplings.

£ s. d.			s. d.	£ s. d.
	4 Kirkstall K. M. bars, 14 ft. × 2⅝ in., from stock	8 3 23	9 0	4 0 8
	9 ⅝-in. bolts and nuts	0 0 7	9 0	0 0 7
	6 wrought-iron keys	0 0 6	9 0	0 0 6
0 2 5	Smith's wages (bolts and keys)			0 2 5
	3 cast-iron couplings	1 1 26	6 3	0 9 2
	Moulders' wages			0 1 8
	Turners' wages .. .. .. 50 hours			1 6 11
	Apprentice turner .. .. .. 18 "		7 0	0 2 4
	Driller .. .. 5 "		18 0	0 1 8
	Planer .. .. 2 "		28 0	0 1 1
	Slotter .. .. 2½ "		18 0	0 0 10
	Grinder (at keys) .. .. .. 1½ "		20 0	0 0 7
2 10 2	Fitters .. .. 15½ "			0 7 5
0 3 9	Draughtsman .. .. .. 2 "		40 0	0 1 6
	Materials and wages			6 17 4
2 16 4	Expenses			2 16 4
	Gross cost			9 13 8

Total net finished weight, 8 cwts. 3 qrs. 27 lb.

EXAMPLE No. 39.—Summary of cost of 1 wrought-iron shaft, 4 in. by 6 ft. 11 in. long, with 1 boss 5¼ in. diameter by 12 in.

£ s. d.			s. d.	£ s. d.
	1 rolled bar with boss forged on..	3 1 0	10 0	1 12 6
0 7 9	Smith and helper .. .. .. 6 hours		70 0	0 7 9
0 9 3	Turner.. .. .. 11 "		30 0	0 6 2
0 0 4	Draughtsman..			0 1 2
	Materials and wages			2 7 7
0 17 4	Expenses..			0 17 4
	Gross cost			3 4 11

The last two examples were not made under contract; the orders were given without previous enquiry as to price. The entries in the sales book were substantially as follows, viz.:—

EXAMPLE No. 38.

			s. d.	£ s. d.
June 30	SMITH AND JONES, Blanktown.			
	53 ft. of 2½-in. wrought-iron shafting in four lengths, turned and polished all over, and with keybeds cut for couplings		3 9	9 18 9
	3 cast-iron flange couplings, turned and polished, keyed on shafts and fitted with turned bolts and nuts		35 0	5 5 0
				15 3 9

Subject to 2½ per cent. for cash on July 10.

In some houses the entry would have been made in the following manner:—

			s. d.	£ s. d.
June 30	SMITH AND JONES.			
	4 rolled iron bars, from stock, to make 53 ft. of 2½-in. shafting	8 3 23	14 0	6 5 4
	9 ⅝-in. bolts and nuts, forged		0 7	0 5 3
	6 wrought-iron keys		0 7	0 3 6
	3 cast-iron couplings, in halves	1 1 26	11 0	0 16 4
	Turning and polishing shafting and cutting key-beds, turning and boring couplings, drilling for bolts and slotting key-beds, turning and fitting bolts, keying couplings on shafts and facing in lathe			7 10 10
				15 1 3

Less 2½ per cent. discount.

Again, other firms would charge the customer simply in the following fashion:—

			s. d.	£ s. d.
June 30	SMITH AND JONES.			
	53 ft. of polished wrought-iron shafting, with cast-iron flanged couplings, turned and polished, keyed on and fitted with turned bolts	8 3 27	0 3½	14 13 9
				14 13 9

EXAMPLE No. 39.

			s. d.	£ s. d.
June 30	THOMAS BROWN.			
	1 wrought-iron shaft, 4 in. diameter on body × 6 ft. 11 in. long over all, with 1 forged boss 5¼ in. × 12 in. long	3 1 0	0 3	4 11 0
	Turning and polishing do., all over .. .			1 0 0
				5 11 0

From the examples which have been given it will be seen that plain wrought-iron shafting, not including couplings, can be made in a general engineering shop to sell at about the following rates, and to leave a good margin of profit, viz.:—18*s.* per cwt. for 4 in. shafting, and 23*s.* per cwt. for 2½ in., and proportionately for other sizes. But, by making suitable arrangements—preparing special tools, putting men on piece work, and so on—such shafting can be turned out profitably at considerably lower rates. Polished wrought-iron shafting, said to be perfectly true and straight, is, indeed, offered in ordinary sizes as low as 12*s.* per cwt. Shafting at this price either cannot be very good or cannot leave much profit; but it is easy to see how tolerably good shafting can be turned out about this figure.

Rolled bars to 3 in. can be bought at under £6 10*s.* per ton at the works; plain shafting can be finished with proper arrangements at the rate of two superficial feet per hour, or even more, and 100 per cent. on the wages paid ought to be sufficient to cover general expenses in an establishment, or portion of an establishment, specially laid out for this class of work.

Therefore, the cost of 3-in. shafting, made under such conditions, would stand about as follows, viz. :—

Example No. 40.—Estimated cost of 55 ft. of 3-in. plain wrought-iron shafting, in 4 lengths.

			s. *d.*	£ *s.* *d.*
4 rolled bars, 14 ft. × 3⅜ in.	12	3 14	6 6	4 3 8
Turning ditto .. .. say 24 hours			30 0	0 13 4
General expenses, say 100 per cent. on wages				0 13 4
Gross cost				£5 10 4

As this cost is equal to 9*s.* 6*d.* per cwt. on the finished weight, 12*s.* per cwt. would leave a margin of slightly over 25 per cent. on the cost—a margin sufficient, indeed, in an establishment kept constantly employed on shafting, to allow a rather better quality of iron to be used. Any good general engineering establishment may, indeed, with suitable arrangements, make plain shafting from cheap bars to sell at from 12*s.* to 14*s.* per cwt., if orders for large quantities at a time can be secured. Everything in matters of this kind depends upon organization, and upon giving to the workmen the stimulus which is usually supplied by piece-work rates.

In connection with plain shafting having removable couplings, collars or rings with set screws are very frequently required, for the purpose of preventing the shafting from moving laterally in its bearings, and for keeping loose pulleys in position on the shafting. These collars are usually made of wrought iron, and are bored to slide along the shaft, turned and polished all over on the outside, drilled and tapped, and fitted with set screws. They can be bought finished from certain firms, but they are usually made in the shop, as they constitute very suitable work for apprentice turners.

Loose Collars.

The following two examples show the time occupied in making these collars, when made, as they very often are, in twos or threes at a time; and also the prices calculated at profit rates :—

EXAMPLE No. 41.—Two loose collars and set screws for 3-in. shaft.

		lbs.	s.	d.	£	s.	d.
Forgings		16	0	2	0	2	8
Smith ..	1½ hour		2	0	0	3	0
App. turner	7½ "		0	10	0	6	3
Driller ..	½ "		1	2	0	0	7
App. fitter	1 "		0	4	0	0	4
					0	12	10

Selling price, 6*s.* 6*d.* each.

EXAMPLE No. 42.—Two loose collars and set screws for 3½-in. shaft.

		lbs.	s.	d.	£	s.	d.
Forgings		20	0	2	0	3	4
Smith ..	1½ hour		2	0	0	3	0
App. turner	9 "		0	10	0	7	6
Driller ..	½ "		1	2	0	0	7
App. fitter	1 "		0	4	0	0	4
					0	14	9

Selling price, 7*s.* 6*d.* each.

When made in quantities, say of a dozen at a time, for stock, as they ought always to be, the time per collar comes out considerably less. A complete list of prices will be found in a subsequent table.

CHAPTER VIII.

MILLWRIGHT WORK (continued).—OVERHEAD RATES AND MILLWRIGHT WORK AS A SPECIALTY.

LARGE contracts for fitting up mills or factories with the necessary machinery of transmission are not infrequently made at certain rates per cwt. or per lb. of the material actually supplied.

Overhead Rates.

This system is somewhat liable to be abused. It presents a strong temptation to many firms to quote very low rates for the purpose of securing the contract, and then to compensate themselves by putting more weight than is at all necessary into any parts of the work which admit of such manipulation. It is not always easy for even the best firms to resist this temptation, especially when dealing with a certain class of people.

At the same time, this method of contracting is a very safe one for the buyer; that is to say, the buyer may depend upon getting full weight in all the parts of his machinery. It is, moreover, a method which permits changes to be made in the original designs, during the progress of the work, without raising troublesome questions as to the amounts of extras, and altogether is a very simple and convenient plan.

The rates asked under such contracts vary very considerably amongst engineering firms, according to the value which different houses set upon the character of their work, but the following figures may be taken as representing about the general range for such portions of machinery of transmission as have just been passed in review—the prices of pig iron and copper, etc., and the rates of wages mentioned previously being kept in mind.

Overhead Rates for Mill Fixings, Shafting, &c.

	s.	d.		s.	d.	
Wall boxes and fixings (green sand castings only)	13	0	to	15	0	per cwt.
Cast iron in hangers and pedestals	14	0	,,	18	8	,,
Brass in ,, ,, ...	1	3	,,	1	8	per lb.
Bolts and nuts in hangers and pedestals	0	5	,,	0	8	,,
Bolts and nuts (general)	0	3	,,	0	5	,,
Cotter bolts and nuts	0	2¾	,,	0	3½	,,
Coach screws	0	3	,,	0	4	,,
Rolled wrought-iron shafting, with cast-iron couplings, bolts, keys, and collars weighed in and including forging ordinary bosses	24	0	,,	30	0	per cwt.
Ditto, with solid flange couplings	27	0	,,	35	0	
Hammered scrap-iron ,, ...	36	0	,,	50	0	

The rates quoted for hangers and pedestals are sometimes rates per cwt., inclusive of brasses and bolts. In such cases the rates run about as follows, viz :—

Hangers	24s. to 30s. per cwt.
Pedestals	35s. „ 50s. „

The general rates just given will be entirely inclusive, in cases where the mill or factory in which the machinery is to be erected is anywhere in the neighbourhood of the engineering works. That is to say, the rates will include the cost of taking the necessary working dimensions, preparing working drawings and patterns, and the cost of skilled labour erecting—the necessary scaffolding and common labour being provided by the buyer. It is scarcely necessary to mention that these rates only apply to comparatively large general contracts; small jobbing orders would not pay at these prices.

There are many firms who, more or less, make a specialty of certain portions of millwright work. That is to say, they have laid out their establishments, or a portion at least, specially for the production of mill fixings, shafting, etc. In some cases they have put down special tools, prepared special designs, adopted certain standard dimensions to which they adhere, introduced piece work largely, and generally made such arrangements as they considered suitable for turning out these articles in large quantities as cheaply as possible.

Millwright Specialties.

There are few general engineering firms who have not felt the competition of these "specialty houses," as they may be conveniently termed; and those who are wise in their generation have prepared themselves, as far as possible, to meet this competition.

In the following table are given three different sets of prices, marked, respectively, A, B and C. A and B are the rates of "specialty houses"—A being about the lowest and B the highest with which the writer is acquainted—whilst the rates opposite C are those at which these articles can, in the writer's opinion, be made to sell at a fair margin of profit, by most general engineering establishments, by proper arrangements and with the appliances usually available in such works.

TABLE NO. 5.—SUMMARY OF PRICES.

Diameter in Inches.		1½	1¾	2	2¼	2½	2¾	3	3½	4	4½	5	5½	6
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d	s. d.
Pedestals with single brasses (length of C about twice the bore) .. .. .. each	A	5 6	9 0	10 0	11 0	12 6	16 0	20 0	30 0	42 0	—	—	—	—
	B	—	—	—	—	—	—	—	—	—	—	—	—	—
	C	7 6	8 6	10 0	12 0	15 0	19 0	23 0	31 0	45 0	—	—	—	—
Pedestals with double brasses (length of C about twice the bore) .. .. .. each	A	5 0	7 0	9 0	11 0	14 0	17 6	22 0	35 0	48 0	58 0	70 0	83 0	95 0
	B	8 0	10 0	12 0	15 0	18 0	23 0	28 0	40 0	60 0	80 0	90 0	105 0	130 0
	C	9 0	10 0	11 6	14 6	17 6	22 6	27 6	37 6	55 0	72 0	85 0	100 0	120 0
Plain hangers — depth, 14 to 24 in. .. .. .. each	A	7 6	9 0	10 6	12 6	15 0	17 6	19 0	24 0	30 0	36 0	50 0	60 0	70 0
	B	20 0	20 0	20 0	30 0	30 0	30 0	30 0	40 0	40 0	60 0	60 0	80 0	80 0
	C	10 0	10 0	10 0	20 0	20 0	20 0	25 0	30 0	35 0	40 0	55 0	70 0	70 0
Pedestal hangers, with single brasses .. .. .. each	A	10 0	12 0	16 0	20 0	25 0	30 0	35 0	40 0	55 0	65 0	—	—	—
	B	—	—	—	—	—	—	—	—	—	—	—	—	—
	C	15 0	16 0	19 0	22 6	25 0	27 0	35 0	50 0	60 0	70 0	85 0	100 0	115 0
Pedestal hangers, with double brasses .. .. .. each	A	12 0	14 0	18 0	23 0	30 0	35 0	45 0	—	—	—	—	—	—
	B	15 0	20 0	25 0	32 0	40 0	45 0	55 0	—	—	—	—	—	—
	C	18 0	20 0	24 0	27 6	31 0	36 0	45 0	60 0	75 0	85 0	100 0	115 0	130 0
Polished wrought-iron shafting, exclusive of couplings or collars .. .. .. per foot	A	1 6	1 9	2 0	2 6	3 0	3 6	4 0	5 0	6 6	—	—	—	—
	B	2 0	2 6	3 3	3 9	4 3	5 0	5 9	8 0	10 6	14 0	19 0	25 0	30 0
	C	2 0	2 6	3 0	3 3	3 9	4 6	5 0	7 0	9 0	10 9	15 0	20 0	25 0
Cast-iron flange couplings, turned, bored, fitted with turned bolts, and with keys and keyed-on shaft ea.	A	8 0	10 0	12 0	15 0	18 0	21 0	25 0	35 0	50 0	70 0	90 0	—	—
	B	20 0	24 0	26 6	30 0	36 0	42 0	48 0	60 0	75 0	90 0	105 0	120 0	130 0
	C	16 6	20 0	25 0	30 0	35 0	40 0	45 0	60 0	75 0	90 0	100 0	110 0	120 0
Polished wrought-iron loose collars, with steel set screws each	A	1 6	1 9	2 0	2 3	2 6	2 9	3 0	4 0	6 0	—	—	—	—
	B	3 0	3 6	4 0	5 0	5 6	6 3	7 0	9 0	12 0	15 0	18 0	20 0	24 0
	C	2 0	2 9	3 0	3 6	4 0	5 0	6 6	7 6	10 0	12 6	15 0	20 0	25 0

CHAPTER IX.

MILLWRIGHT WORK, continued.—CAST-IRON BELT PULLEYS.

BELT pulleys of ordinary dimensions are usually moulded from full patterns in green sand. The patterns themselves, except in some small sizes, are almost invariably of cast iron, as it is obvious that, owing to the slight structure of a pulley, a wooden pattern would immediately lose its proper shape after being once used. In making the pattern, the centre, or boss, and the arms are made in wood, but the rim in all the larger sizes, at least, is usually swept up in loam, the casting being subsequently turned up in the lathe, and carefully dressed all over. Of course, double contraction is allowed when a cast-iron pulley pattern is being prepared. These patterns are necessarily somewhat expensive, and in large establishments considerable capital is sunk in the stock of pulley patterns.

Pulley Patterns.

This outlay of capital on pulley patterns is, however, quite unavoidable. It would be out of the question to attempt to charge a customer for making a pattern for some ordinary size of pulley, except in very rare cases. A buyer would not incur such a charge, as he knows that if one firm has not a pattern of the size he requires, or that can be modified to suit, another house will. He has, therefore, only to inquire of two or three houses, and he will find what he wants, provided, of course, that the pulley he requires is of ordinary dimensions. Hence an engineering firm wishing to do business in pulleys must be prepared to make patterns of ordinary sizes on their own account.

If a number of pulleys of the one size are ordered at once, the cost of the pattern may be immediately covered. If only one pulley is required, the cost of the pattern will almost certainly not be covered by the profit on the transaction; and the manufacturing engineer has simply to be content to take the pulley pattern into his stock and put it on his list, in the expectation that sooner or later he will be able to make use of it again, and thus be fully recouped in due time.

Of course, the price charged for a finished pulley must include a reasonable amount for the use of the engineer's pattern; whilst any alterations or modifications of the pattern made specially to suit the buyer's requirement, must also be charged for specially or sufficiently covered in the price put down for the finished pulley.

Pulley patterns only admit of modification within certain not very wide limits. The centre or boss can be modified more freely than any other part, as it is a simple matter to make the bore or eye of the pulley larger or smaller than the size for which the pattern was originally designed. If the pulley was originally designed to go on, say, a 3-in. shaft, all that is required to make it suitable for any smaller size is for the moulder to put in a smaller core. If the pulley is required to go on a larger shaft than one of 3 in., the centre or boss of the pattern can be lined up by the pattern-maker to the required extent.

Modifying Sizes.

A slight variation is possible in the finished diameter of the pulley by lining up the rim of the pattern. By lining up on the outside the pulley may be finished to a quarter or even half-an-inch larger than the original diameter. In such a case the rim of the pulley will be turned out on the inside a little for the sake of appearance, leaving merely a belt of the full thickness at the centre where the arms join the rim. By lining up on the inside of the rim of the pattern, the pulley may be finished to a quarter or half-an-inch less in diameter than the original size. In the matter of width, a skilful moulder can increase this an inch or two in an ordinary size, by "drawing" the pattern in the sand without any alteration of the pattern; whilst if the finished pulley is required narrower than the pattern, the casting is just made of the full size and the superfluous width cut off by the turner, when finishing the pulley.

Hence it will often occur that there is a very great discrepancy between the weight of the casting and the finished weight of the pulley. In the cost or account, the full weight of the casting as made must, of course, be put down, notwithstanding that a large proportion, it may be, had to be cut to waste.

A full pattern would not be made for a very large pulley, or one of some exceptional character. The rim would simply be swept up in loam, although the centre and arms might be moulded in green sand from full patterns.

The same pattern will usually serve for both solid and split pulleys, but it requires to be specially prepared if the pulley is to be split.

Splitting and Bolting.

It is usually sufficient to split the casting of a pulley just as it comes from the foundry, then to bolt the two halves together, and afterwards to pass the pulley on to the turner.

In some very special cases, pulleys are cast in halves, the two halves planed on their faces (that is, where the two halves go together), the holes for the bolts drilled, and the halves connected with turned bolts carefully fitted into their holes.

The splitting and bolting of an ordinary pulley, or the planing of the faces in special cases, are, of course, all done previously to the turning up of the rim.

Very small split pulleys often appear, relatively, very costly, owing to the fact that the two halves cannot be bolted in the usual way, but have to be connected by dowels and cottars, which are frequently very troublesome to put in.

Large or heavy pulleys which are not required to be put on the shaft in halves, are, nevertheless, frequently split in the centre by having two or three flat cores inserted in the mould. This is done to relieve the strains which are liable to be set up by unequal contraction. The centre is afterwards hooped with wrought iron—the rings being put on hot. This, of course, means extra expense.

Belt pulleys have their rims finished either flat, or curved more or less convex, the latter kind being variously styled "crown," "round," "rounding," "curved," or "convex faced."

Flat and Curved Rims.

Where the belt from a pulley is to drive on to fast and loose pulleys, the pulley will have a flat rim; but where the belt will always run in the one plane—that is, will not require to be shifted from side to side—the pulley will have a rounded face.

The cost of pulleys with round faces is, of course, higher than the cost of equal-sized pulleys with flat faces; and the cost of pulleys which are split and bolted is higher than the cost of solid pulleys of the same dimensions.

There are consequently two elements of extra cost which frequently arise and must be charged to the buyer, when incurred, either specially as extras, or in the price charged for the pulley as a whole—viz., first, the extra cost of splitting and bolting or making the pulley in halves; and, second, the extra cost of rounding the face. Very often both these extras occur in the same pulley

Extra Charges.

Other extra charges arise when pulleys have flanges cast on one or both sides; when they are made of extra strength; and when some departure from the ordinary or standard type or dimensions is desired.

A question frequently discussed by engineers is whether pulleys ought to have straight or curved arms. Both types have their advocates; but the curved arm would now appear to be most generally recognised as the right thing. So far, however, as the cost of making pulleys is concerned, the question of curved versus straight arms is of little importance. The only difference in cost arises in the pattern-making—the straight arm naturally costs a little less to make at this initial stage than the curved arm.

Straight or Curved Arms.

A cast-iron belt pulley is so elementary a structure, and the workmanship on it of so simple and straightforward a character, that there would hardly appear room for much difference to occur between the cost of manufacturing a pulley of a given size in one establishment and the cost in another. Nevertheless, very considerable differences are found, arising partly from differences in the character of the metal used in the foundry, but still more from the greater care and thoroughness with which pulleys are finished in one shop, as compared with the way in which such work is done in another.

Manufacture.

In a general engineering establishment there is but little chance, as a rule, of effecting any particular economy in the cost of manufacturing pulleys, owing to the great variety of sizes and conditions in and under which they have to be made. The only occasions on which any special economy can be effected, are when a large number of pulleys of one size are ordered at a time, as in the case of the pulleys for the line shafting of a weaving shed. Arrangements can then be made for turning two or three pulleys at a time in the same lathe, and a very considerable saving of time may be thus gained.

In machine shops the conditions are much more constantly favourable to economy. In such works, very large numbers of pulleys, mostly of small sizes, are required, and the cost of their manufacture may be brought very low. Handy labourers are, in many cases, put at the lathes, and are paid so much per dozen pulleys bored or turned, or both.

Prices.

For convenience in quoting prices for pulleys, or charging up accounts, most establishments either arrange a complete graduated price list, or adopt some scale or rule by which to calculate the price of any given pulley. The two most common bases of calculation are the weight of the finished pulley in pounds, and the area of the face of the pulley in square inches. There can be no doubt that the latter basis is decidedly the more scientific of the two, and is the best on every ground, except, perhaps, from the point of view of those who believe in putting in plenty of weight into machinery which is to be sold by the pound or ton.

Whichever basis of calculation is adopted, it will be most convenient to regard every pulley, first of all, as being solid (not split) and flat faced, and then to add extras to the price so found, for splitting and bolting, for rounding the face, or for flanging, by a pre-determined percentage. It will also be desirable to graduate the rates per pound or per superficial inch, to some extent, according to the size of the pulley. A rate that would be quite fair for a pulley 8 in. diameter by 4 in. wide, would be too high for one 48 in. diameter by 12 in. wide. Two or three comprehensive divisions, as in the scale which follows, will generally be sufficient.

Where pulleys are priced according to weight, the average rate per pound in some establishments is put as low as $2\frac{3}{4}d.$, whilst in others it is put at $3\frac{3}{4}d.$ A mean between these two extremes ought to represent a fair rate at which most houses should be willing to work. Where the price is calculated according to the finished face of the pulley, the average rate for solid, flat-faced pulleys is, in some places, put as low as three-eighths of a penny per superficial inch, whilst in others it is put at three-fourths of a penny per superficial inch.

The table given after the following examples exhibits a convenient scale and fair rates on the superficial basis of calculation. A complete price list of all ordinary sizes is, however, to be preferred as more convenient, though the preparation of such a price list is decidedly tedious.

Following are a few examples of costs and prices, with reference to which it should be mentioned that the pulleys were made from the stock patterns of a general engineering establishment; that is to say, from patterns which were not made all at one time, in accordance with one general design, but were made as required, over a period of many years, and contained in consequence more than one modification of design, according to the ideas that happened to prevail in the drawing office at different periods. The weights, therefore, are not so strictly proportionate as they might be made.

Example No. 43.—Cost of cast-iron pulley, 66 in. diameter by 15 in. wide, made extra strong and with heavy rim, so as to serve as a fly-wheel, split, bolted, and with one key-bed slotted and turned convex on face.

£ s. d.				s. d.	£ s. d.
	Cast iron		13 0 0	6 3	4 1 3
	Moulders' wages				0 8 4
	Bolts and nuts		1 9	9 0	0 3 0
0 3 3	Smiths' wages				0 3 3
	Turner—Wages paid	24¼ hours			0 15 9
1 4 6	Slotter „	1½ „			0 0 7
0 4 7	Fitter—Splitting and bolting ..	16½ „			0 9 1
0 11 5	Pattern makers—Strengthening stock pattern	26 „			0 15 2
	Materials and wages				6 16 5
2 3 9	Expenses				2 3 9
	Gross cost				9 0 2

Charged £14, less 2½ per cent.

This example is introduced as illustrating one of the numerous "special cases" which arise in engineering practice. It will be seen that an ordinary belt pulley pattern was taken, strengthened and made sufficiently heavy for the purpose in view. It will be observed that although this pulley was split, it had a key-bed cut in it. It is not usual for pulleys which are split and bolted to have keys also; a pulley which is bolted in halves hard upon a shaft will usually hold sufficiently by friction only. Sometimes, however, when a heavy power is to pass through a split pulley, a key is fitted as well to make assurance doubly sure.

EXAMPLE NO. 44.—Cost of cast-iron pulley, 80 in. diameter by 11 in. wide, split and bolted, bored 8 in. diameter and turned convex on face.

£ s. d.				s. d.	£ s. d.
	Cast iron		9 2 11	6 3	3 0 0
	Moulders' wages				0 12 5
	Bolts and nuts (stock)		12½	0 3½	0 3 8
1 0 6	Turner—Wages paid	20½ hours			0 13 8
0 2 7	Fitter ,, ...	10 ,,			0 5 2
0 8 5	Pattern makers—Enlarging centre and strengthening arms, &c.	21 ,,			0 11 2
	Materials and wages				5 6 1
1 11 6	Expenses				1 11 6
	Gross cost				6 17 7

Charged £11 11*s.* 10*d.*, less 2½ per cent., being equal to 1*d.* per superficial inch of the rim, or 2⅝*d.* per lb. weight; the finished weight being 8 cwt. 2 qr. 4 lb., including the bolts.

The price per superficial inch for the pulley in last example may appear high, but a pulley of this diameter cannot be considered of ordinary dimensions, besides which the width of the rim relatively to the diameter is small, hence a comparatively high rate is to be expected.

EXAMPLE NO. 45.—Cost of one pair fast and loose pulleys 62½ in. diameter by 9 in. wide, loose pulleys bushed with brass, both split and bolted, and joints of loose pulley planed. Rims swept up in loam.

£ s. d.				s. d.	£ s. d.
	Cast iron (rims in loam)		10 1 7	7 6	3 17 4
	Moulders' wages				1 9 6
	Bolts and nuts		40	9 0	0 3 4
0 3 1	Smiths' wages				0 3 1
	Brass..		21	0 10	0 17 6
	Turners—Wages paid	41⅞ hours			1 6 10
	Planers ,, ...	2 ,,			0 0 11
2 2 9	Drillers ,, ...	2 ,,			0 0 9
0 3 10	Fitters ,, ...	14 ,,			0 7 7
0 13 5	Pattern makers—Wages paid ..	33 ,,			0 17 11
0 0 5	Draughtsman ,, ..	1½ ,,			0 1 6
	Materials and wages				9 6 3
3 3 6	Expenses				3 3 6
	Gross cost				12 9 9

Charged £16 13*s.*, less 2½ per cent. discount.

This is another example of a "special case." The pulleys, it will be seen, are treated entirely as loam castings; the rims having been swept up in loam, it was considered that sufficient loam shop expenses had been incurred to justify the metal being put down at the loam shop rate.

It is generally considered objectionable to make a loose pulley in halves, and this should not be done where it can be avoided. In this case, however, a solid pulley could not have been got on the shaft without taking down a portion of a building, at very considerable cost and much inconvenience.

EXAMPLE No. 46.—Cost of cast-iron pulley 41 in. diameter by 11 in. wide, split and bolted and turned convex on rim.

£ s. d.			s. d.	£ s. d.
	Cast iron	2 3 14	6 3	0 18 0
	Moulders' wages			0 4 2
	Bolts and nuts (stock)	0 0 11	0 3½	0 3 3
0 15 0	Turner—Wages paid .. .. 16½ hours			0 10 0
0 1 1	Fitter " .. .. .. 4 "			0 2 1
0 2 1	Pattern maker—Wages paid .. 5 "			0 2 9
	Materials and wages			2 0 3
0 18 2	Expenses			0 18 2
	Gross cost			2 18 5

Charged £4 9s., 2½ per cent., being equal to ¾d. per superficial inch of the rim, or 4d. per lb. weight finished—the finished weight, including bolts, being 2 cwt. 1 qr. 12 lb.

EXAMPLE No. 47.—Cost of 2 cast-iron pulleys, 36 in. by 7 in., each with flange on one side, split and bolted, and turned convex on rim.

£ s. d.			s. d.	£ s. d.
	Cast iron	4 2 14	6 3	1 8 11
	Moulders' wages			0 9 5
	Bolts and nuts (stock)	16	0 3½	0 4 8
0 16 6	Turner—Wages paid .. .. 20 hours			0 11 0
0 2 6	Fitter " .. .. .. 9 "			0 5 0
0 2 0	Pattern maker at flange, etc. .. 5 "			0 2 7
	Materials and wages			3 1 7
1 1 0	Expenses			1 1 0
	Gross cost			4 2 7

Charged £5 15s., less 2½ per cent., being equal to ⅝d. per superficial inch of rim, counting the surface of both sides of the flange, which was 1½ in. deep—both sides of the flange being turned. A tender was given for the above flanged pulleys, the price being based upon the following estimate, calculated at profit rates, viz.:—

Estimate for 2 pulleys, etc., profit rates.

			s. d.	£ s. d.
	2 pulley castings	4 3 0	12 0	2 17 0
	Bolts and nuts	16	0 5	0 6 8
	Turner .. .. 2¼ days		16 0	1 16 0
	Fitter .. .. 1 day		10 6	0 10 6
	Pattern maker at flanging, etc. .. ¾ "		12 0	0 9 0
	Quote £5 15s., less 2½ per cent.			5 19 2

EXAMPLE No. 48.—Cost of cast-iron pulley, 34 in. by 4 in., solid, turned convex on face, one key-bed slotted.

£ s. d.			s. d.	£ s. d.
	Cast iron	1 3 14	6 3	0 11 9
	Moulders' wages			0 1 11
	Turner—Wages paid .. .. 5 hours			0 2 11
0 5 0	Slotter " " .. .. 1 hour			0 0 5
0 0 11	Pattern maker .. .. .. 2 hours			0 1 3
	Materials and wages			0 18 3
0 5 11	Expenses			0 5 11
	Gross cost			1 4 2

Charged £1 12s., less 2½ per cent., being equal to ⅞d. per superficial inch of rim, and rather less than 2¼d. per lb. finished weight, the latter being 1 cwt. 2 qr. 12 lb.

EXAMPLE No. 49.—Cost of 4 cast-iron pulleys, each 32 in. by 8 in., split and bolted, and turned round on face.

£ s. d.			s. d.	£ s. d.
	Cast iron	7 0 26	6 3	2 5 3
	Moulders' wages			0 12 5
	16 bolts and nuts, ⅞ in., stock		0 4	0 4 0
	Turners—Wages paid .. .. 28 hours			0 16 4
1 5 9	Driller " " .. .. 2 "			0 0 10
0 3 2	Fitters " " .. .. 12 "			0 6 3
0 2 8	Pattern maker " .. .. 6 "			0 3 6
	Materials and wages			4 8 7
1 11 7	Expenses			1 11 7
	Gross cost			6 0 2

Charged £2 10s. each, less 2½ per cent., being equal to ¾d. per superficial inch of rim, and rather more than 3½d. per lb. of the finished weight, latter being 6 cwt. 0 qr. 7 lb.

EXAMPLE No. 50.—Cost of 7 cast-iron pulleys, each 30 in. by 8 in., split and bolted, and turned round on face.

£ s. d.			s. d.	£ s. d.
	Cast iron	11 1 9	6 3	3 10 0
	Moulders' wages			1 1 11
	28 bolts and nuts, ⅞ in., stock		0 4	0 9 4
	Turners—Wages paid .. .. 43 hours			1 5 1
1 19 11	Drillers " " .. .. 3½ "			0 1 6
0 5 8	Fitters " " .. .. 21 "			0 11 4
0 3 0	Pattern maker, preparing stock pattern 7 "			0 4 1
	Materials and wages			7 3 3
2 8 7	Expenses			2 8 7
	Gross cost			9 11 10

Charged £2 7s. each, less 2½ per cent., being equal to ¾d. per superficial inch of rim, and 3¾d. per lb. weight, latter being 9 cwt. 2 qrs. 7 lb. total.

EXAMPLE No. 51.—Cost of 3 cast-iron pulleys, 26 in. by 5 in., split and bolted and turned convex on face, eye bored 2¾ in. diameter.

£ s. d.			s. d.	£ s. d.
	Cast iron	3 0 5	6 3	0 19 0
	Moulders' wagers			0 5 8
	12 bolts and nuts, stock		0 2	0 2 0
0 13 2	Turners—Wages paid .. .. 16½ hours			0 8 9
0 2 4	Fitters " " .. .. 9 "			0 4 8
0 0 11	Pattern makers " .. .. 2 "			0 1 2
	Materials and wages			2 1 3
0 16 5	Expenses			0 16 5
	Gross cost			2 17 8

Charged 30s. each, equal to ⅞d. per superficial inch of rim, and about 4d. per lb. of finished weight, latter being 2 cwt. 1 qr. 2 lb. for the three pulleys.

EXAMPLE No. 52.—Cost of 1 cast-iron pulley, 24 in. by 5 in., solid, turned round on face and bored 3½ in. diameter.

£ s. d.			s. d.	£ s. d.
	Cast iron	1 0 25	6 3	0 7 9
	Moulders' wages			0 1 6
	Turners—Wages paid .. .. 5½ hours			0 3 3
0 5 6	Slotter " " .. .. 1 "			0 0 5
0 0 8	Pattern maker " .. .. 1½ "			0 0 11
	Materials and wages			0 13 10
0 6 2	Expenses			0 6 2
	Gross cost			1 0 0

Charged 25s., being equal to a little over ¾d. per superficial inch.

EXAMPLE No. 53.—Cost of 1 cast-iron pulley, 24 in. by 12 in., solid, turned flat on face and bored $3\frac{3}{4}$ in. diameter.

£ s. d.				s. d.	£ s. d.
	Cast iron		1 1 0	6 3	0 7 10
	Moulders' wages				0 1 11
	Turners—Wages paid	8 hours			0 4 5
0 7 3	Slotter " "	1 "			0 0 5
0 1 4	Pattern maker "	3 "			0 1 9
	Materials and wages				0 16 4
0 8 7	Expenses				0 8 7
	Gross cost				1 4 11

Charged 39*s*., being equal to a fraction over $\frac{1}{2}d$. per superficial inch of rim.

The two last examples are useful as illustrating the high cost of a narrow pulley as compared with the cost of a wide one of the same diameter. It will be seen that although the narrow pulley was charged over $\frac{3}{4}d$. per inch (really too low a rate for so narrow a rounded pulley), the percentage of profit on the cost was less than half that shown in the case of the wider pulley, notwithstanding that the latter was charged considerably less per inch.

Of course this is accounted for to some extent by the circumstance that the narrow pulley had a rounded face and the wide one a flat face; but still more by the facts that the weight of the casting relatively to the width is necessarily greater in a narrow than in a wide pulley, and that, as the time occupied in preparing to turn and bore a narrow pulley is practically the same as for a wide one, the cost of turning, and indeed of all other elements of workmanship, relatively to the width, is greater in a narrow pulley than in a wide one. There was, however, in the particular case of this narrow pulley this additional circumstance (which often occurs, as already mentioned), that a considerable proportion of the metal was cut to waste, the pattern being some inches wider than the specified width of the pulley. Of course the superfluous width of a casting is, in such cases, cut off at once before the actual turning up of the rim commences, but it nevertheless means an additional amount of turner's time quite appreciable in so small a job, apart from the value of the metal thrown away. The wider the pulley the lower may be the price per superficial inch of the rim up to the point when it becomes necessary to use two castings to make the pulley required.

EXAMPLE No. 54.—Cost of 50 cast-iron pulleys, 16 in. by 8 in., split and bolted, bored $2\frac{3}{4}$ in., and turned flat on face and balanced.

£ s. d.			s. d.	£ s. d.
	Cast iron	39 0 14	6 3	12 4 7
	Moulders' wages			3 9 11
	200 $\frac{3}{4}$-in. bolts and nuts, iron	1 2 0	9 0	0 13 6
0 10 0	Smith and helper—Wages paid .. 12 hours			0 10 0
	Turners " " .. 177 "			4 17 4
7 14 6	Screwer " " .. 17 "			0 5 8
1 9 5	Fitters " " .. 114 "			2 18 10
0 8 3	Pattern makers, overhauling and preparing two stock patterns—wages paid .. 20 hours			0 11 0
	Materials and wages			25 10 10
10 2 2	Expenses			10 2 2
	Gross cost			35 13 0

Charged 20s. each, being equal to a fraction under $\frac{5}{8}d.$ per superficial inch of rim.

EXAMPLE No. 55.—Cost of 30 cast-iron pulleys, 14 in. diameter × 12 in., split and bolted, bored $2\frac{3}{4}$ in., and turned flat on face and balanced.

£ s. d.			s. d.	£ s. d.
	Cast-iron	19 1 21	6 3	6 1 7
	Moulders' wages			2 12 6
	120 $\frac{5}{8}$-in. bolts and nuts—stock		0 $2\frac{1}{4}$	1 5 0
4 10 9	Turners—Wages paid .. .. 110 hours			3 0 6
0 10 6	Fitters " " .. .. 56 "			1 0 11
0 0 11	Pattern makers " .. .. $1\frac{1}{2}$ "			0 1 2
	Materials and wages			14 1 8
5 2 2	Expenses			5 2 2
	Gross cost			19 3 10

Charged 20s. each, being equal to $\frac{7}{16}d.$ per superficial inch of rim.

The pulleys illustrated by the two last examples are two very common sizes, being often required in large numbers for spinning mills and weaving sheds. They are consequently sometimes offered at very low prices by firms who have them very cheaply made by piece work. The writer has known 14 by 12 pulleys supplied at 11*s.* 6*d.* each. The pulleys were decidedly light, very rough castings, and roughly finished. Very common prices for this size of pulley are from 14*s.* to 16*s.* 6*d.* each.

It may be asked: "What does it matter whether a pulley is rough or not so long as it will do its work?" There are, however, still people who like to have the satisfaction of knowing that everything they have is good, whether it is absolutely essential to be so or not, and who are willing to pay a fair price for that satisfaction. Lower prices might have been taken than those mentioned in the two last examples and still left a profit, but the prices given were, in both cases, readily paid, as very good jobs were made of the pulleys. Single pulleys of these dimensions would, of course, be charged at a much higher rate—20 to 30 per cent. higher.

EXAMPLE No. 56.—Cost of 1 cast-iron pulley 12½ in. × 4 in. wide, solid, rounded on face and bored 1⅝ in.

£ s. d.				s. d.	£ s. d.
	Cast-iron		0 1 11	6 3	0 2 3
	Moulders' wages				0 0 7
	Turner—Wages paid	4 hours			0 2 2
0 3 11	Slotter " "	1 "			0 0 5
	Pattern maker—lining up				
0 0 11	12 in. pattern	2 hours			0 1 2
	Materials and wages				0 6 7
0 3 5	Expenses				0 4 10
	Gross cost				0 11 5

Charged 15s., being equal to a fraction over 1½*d.* per superficial inch.

EXAMPLE No. 57.—Cost of 1 cast-iron pulley, 7 in. diameter × 6 in. wide, split, turned round on face and bored 2 in.

£ s. d.				s. d.	£ s. d.
	Cast-iron		0 1 26	6 3	0 3 1
	Moulders' wages			9 0	0 1 3
	Iron for dowells and cotters		0 0 8	0 9	0 0 8
0 1 9	Smiths' wages	2 hours			0 1 9
0 3 0	Turner—Wages	3½ "			0 2 0
0 1 1	Fitter "	4 "			0 2 1
0 3 2	Pattern maker—widening and preparing stock pattern for splitting	8 "			0 4 2
	Materials and wages				0 15 0
0 9 0	Expenses				0 9 0
	Gross cost				1 4 0

Charged 25s., being equal to nearly 2½*d.* per superficial inch—obviously a very costly pulley, as indeed small pulleys of this kind generally are. It will be noted that the pulley was practically charged at cost price in this case.

The examples which have now been given will have sufficiently illustrated the variation in the costs and selling prices of cast-iron pulleys, according to the three determining elements—viz., kind, size, and quantity made at one time.

It will be noted that the split and rounded pulleys were charged at from ¾*d.* to 1*d.* per superficial inch of the rims. Most general engineering establishments can make such pulleys to sell at these rates and to leave a good profit, whilst many works would supply them for less. As previously mentioned, however, it is generally most convenient, in determining the price of a pulley, to treat it as being solid (not split) and with a flat face, and to arrive at the price, if split or rounded, by percentages.

The following diagram exhibits what the writer considers a fair scale of rates—that is to say, rates at which a general engineering establishment can supply pulleys and at once give good value to the buyer and earn a reasonable profit.

SCALE OF RATES FOR CAST-IRON PULLEYS, SOLID (NOT SPLIT), WITH FLAT TURNED FACES, CENTRES BORED, AND ONE KEY BED SLOTTED. NO KEYS INCLUDED.

Diameter in Inches.	Width of Face.						
	3	4	5	6	9	13	18
6 to 9	Special	1*d.*	1*d.*	1*d.*	$\frac{3}{4}$*d.*	Special	Special
9 to 20	Special	1*d.*	$\frac{7}{8}$*d.*	$\frac{3}{4}$*d.*	$\frac{5}{8}$*d.*	$\frac{5}{8}$*d.*	$\frac{3}{4}$*d.*
20 to 60	Special	1*d.*	$\frac{7}{8}$*d.*	$\frac{3}{4}$*d.*	$\frac{5}{8}$*d.*	$\frac{5}{8}$*d.*	$\frac{3}{4}$*d.*
60 to 72	Special	1*d.*	1*d.*	$\frac{7}{8}$*d.*	$\frac{3}{4}$*d.*	$\frac{3}{4}$*d.*	$\frac{3}{4}$*d.*
72 to 84	Special	1*d.*	1*d.*	1*d.*	$\frac{7}{8}$*d.*	$\frac{3}{4}$*d.*	$\frac{3}{4}$*d.*

The above rates are per superficial inch of finished face.
Extra for turning round on face = 5 per cent.
" " splitting and bolting—including bolts = 4*s.* and 10 per cent.
" " flanging on one side = 10 per cent.
" " " " both sides = 15 per cent.

STANDARD SIZES.—Any diameter advancing by 1 in. at a time from 6 in. to 20 in.; by 2 in. at a time from 20 in. to 30 in.; by 3 in. at a time from 30 in. to 60 in.; and by 6 in. at a time from 60 in. to 84 in. Any width of face advancing by 1 in. at a time from 3 in. to 18 in. Intermediate sizes to be charged same as the next highest standard size. Larger sizes special.

Of course a scale on a plan of this kind may be "shaded" to any required degree, but the above is quite sufficient for all practical purposes, and indeed many people would consider this scale "shaded" more than is necessary. According to this scale a solid, flat-faced pulley 18 × 6 would be rated at $\frac{3}{4}$*d.* per inch, one 18 × 9 at $\frac{5}{8}$*d.* per inch and so on with the extras added when incurred. For example, the price of a pulley 20 × 6—split, bolted, turned round on face and bored would be found as follows:—

	£	s.	d.
20 × 6 pulley at $\frac{3}{4}$*d.* per superficial inch	1	3	8
Extra for rounding face at 5 per cent.	0	1	3
" " splitting and bolting at 10 per cent.	0	2	5
And	0	4	0
	1	11	4

The prices determined by this scale would allow a discouut of 5 per cent. for single pulleys to ordinary users, and a discount of 10 per cent to merchants or to users ordering a large number of pulleys at a time. Many firms would be satisfied with a scale ranging from $\frac{1}{16}$ to $\frac{1}{8}$ less than the one above as their basis. There are, however, objections to a scale of this character, and it is no doubt better to prepare a complete detailed list of prices, after the manner of the following table, which contains two lists which may be taken as fairly representative of the rates charged by firms which make a specialty of this kind of work.

PRICE LIST OF CAST-IRON PULLEYS.

Finished Diameter.	BREADTH OF FACE IN INCHES. 4	6	8	10	12	15	18
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
6 .. .. .. A	6·0	8·0	10·0				
B	7·6	8·6	10·0				
9 .. .. .. A	7·0	9·0	11·0				
B	8·6	10·6	12·6				
12 .. .. .. A	10·0	12·0	14·0	18·0			
B	11·6	13·6	15·0	18·6			
15 .. .. .. A	12·0	14·0	16·0	20·0	26·0		
B	13·6	16·0	18·6	22·6	28·0		
18 .. .. .. A	14·0	16·0	20·0	24·0	29·0	38·0	
B	16·6	19·0	23·0	28·0	32·6	42·0	
21 .. .. .. A	17·0	20·0	24·0	29·0	34·0	46·0	58·0
B	19·0	22·6	26·6	32·6	37·0	50·0	64·0
24 .. .. .. A	19·0	23·0	27·0	32·0	38·0	50·0	60·0
B	21·6	25·6	30·0	37·0	43·0	59·0	72·0
27 .. .. .. A	22·0	26·0	32·0	37·0	44·0	60·0	72·0
B	23·6	28·6	35·0	42·0	48·6	68·0	82·0
30 .. .. .. A	24·0	30·0	37·0	42·0	49·0	70.0	82·0
B	26·6	33·0	39·0	48·0	54·0	76·0	90·0
36 .. .. .. A	28·0	36·0	46·0	54·0	64·0	88·0	100·0
B	31·6	41·0	49·0	60·0	71·0	96·0	110·0
42 .. .. .. A	39·0	43·0	55·0	64·0	80·0	104·0	120·0
B	35·0	48·0	59·6	70·0	86·0	116·0	135·0
48 .. .. .. A	46·0	52·0	64·0	81·0	100·0	121·0	145·0
B	42·0	56·0	72·0	91·0	112·0	132·0	155·0
60 .. .. .. A	60·0	77·0	95·0	118·0	138·0	152·0	200·0
B	54·0	80·0	97.6	135·0	150.0	168·0	200·0
84 .. .. .. A	100·0	135·0	150·0	175·0	195·0	225·0	300·0
B	80·0	115·0	148·0	195·0	215·0	245·0	300·0

Extras for rounding face .. .. .. A 5 per cent., B 10 per cent.
" splitting, etc. .. .. .. A 15 per cent. and 3*s.* each.
B 10 per cent. and 5*s.* each.
Discounts from 5 to 10 per cent.

During recent years wrought-iron pulleys have been very largely introduced, and have seriously affected the business of general engineers so far as pulleys are concerned. They undoubtedly have many recommendations, though it may be questioned whether, if the merits of each of the two classes of pulleys were carefully added up, the balance would be found so very decidedly on the side of wrought iron as against carefully designed and well made cast-iron pulleys; whilst for heavy work at least the latter unquestionably have the advantage.

Wrought Iron Pulleys.

At present, wrought-iron pulleys are almost solely made by a few firms who hold patents for certain features of construction;

and hence general engineers who are called upon to supply wrought-iron pulleys, either to their regular customers who take a fancy that way, or as part of some contract, simply buy the pulleys from one or other of the special makers, and content themselves with the trade discount allowed by them.

There is, however, no reason, apart from questions of patent right, why general engineers should not design and make wrought-iron pulleys themselves profitably, provided only that their works are fairly well equipped and especially if the works include a boiler shop.

CHAPTER X.

MILLWRIGHT WORK, continued.—ROPE PULLEYS.

Development of Rope Driving.

THE application of ropes to the purpose of transmitting heavy powers, as in the main drives of modern cotton mills and other works, if we have regard not merely to the novelty of the application but also to its advantages and extent, must be considered one of the most remarkable developments which has been made in mechanical engineering during the present generation. Doubtless a rope or cord of some kind was the very earliest form of driving band employed; and engineers have long been familiar with the use of ropes for certain special purposes, as in hoisting gear for example, and for transmitting light powers across considerable spaces, but rope driving in the sense in which the phrase is now generally employed may be said to have been practically invented within the past twenty-five years.

When Sir William Fairbairn wrote his "Treatise on Mills and Millwork" he dismissed the subject of rope driving with a merely casual reference; but certainly no one would now think of writing a treatise on mills and millwork without devoting a considerable section to main driving by ropes, no matter how partial he might be either to gearing or flat belts.

It is safe to say that the next quarter of a century will see a still greater extension of rope driving than has taken place in the past. There will of course always remain conditions under which either flat belts or wheels will have unquestionable advantages over any other method of conveying power and will therefore be used. It must also be admitted that a rope drive is sometimes very costly, that it takes up considerable space, and may involve a certain loss of power. Nevertheless, two considerations alone—the ease and smoothness of a rope drive, and the facility with which it lends itself to high speeds, both of engine and machinery, will be in innumerable cases sufficient to determine owners of power in its favour. And certainly it is something to be thankful for, when so much in mechanical engineering is almost unavoidably both ugly and noisy, that so graceful and quiet a method of transmitting heavy powers, as we see in a well-arranged rope drive, possesses so many practical advantages and daily finds people willing to pay for it.

However, it is not so much with the merits, practical or æsthetic, of rope driving that we are here mostly concerned, but with its manufacture and cost.

Conditions Favourable to Rope Drives.

At the same time it is desirable to briefly indicate the considerations, at once practical and commercial, which must in any given case determine whether a rope drive shall be adopted or not. They are principally:—First, can the prime mover be arranged with its shaft parallel to the principal line shafts of the mill or other works?

Secondly, can direct access be obtained from the fly-wheel to the principal line shafts to be driven?

Thirdly, can a section of the house be built off, so as to form a space enclosed from the rooms in which the manufacturing operations are carried on, to constitute the race for the ropes? This consideration is important, in view of the communication of fire from one floor to another in houses containing a number of floors. It is obvious that where ropes simply drive through openings in the floors, these openings, as in the case of an unenclosed hoist, offer the most perfect facility for the communication of fire from one floor to another.

Fourthly, will the prime mover and the machinery to be driven run at high speeds? Rope driving is generally unsuitable where the prime mover is a water-wheel or a beam engine, though perfectly suitable for horizontal turbines driving high speed machines.

Lastly, can sufficient space be allowed to provide a liberal number of ropes for the power to be transmitted? This consideration is of the utmost importance. A rope drive is distinctly unsuited for any case where, owing to structural difficulties or cost, ample space cannot be allowed. When a certain number of ropes are only just sufficient at the speed at which they are running for the power to be transmitted, they must either be stretched very tight and thus set up excessive friction in the journals, or there will be considerable slip, rapid wear of the ropes, and loss of power. A liberal margin in the number of ropes with reference to the speed and power is absolutely essential to a successful rope drive on any considerable scale.

Where the queries which have just been put can all be answered in the affirmative we have the best possible conditions for a rope drive. Hence the peculiar suitability of modern cotton and woollen mills for rope drives, also, in a less degree, modern flour mills. A weaving shed does not offer quite so favourable a field for rope driving. The number of shafts to be driven, with reference to the total power, is so great that it is usually out of the question to drive all, or even a large proportion, direct from the engine fly-wheel; whilst the shafts are too close together to allow one to be driven from another advantageously. Hence the best practice is to drive by ropes direct on to one or more main shafts running the entire length of the house, and to drive the cross shafts from which the looms are driven by bevil gear from the main shafts.

Class of Ropes.

The ropes used for rope driving are usually of hemp or cotton, and range from one to two inches in diameter. They are, however, described by their girth, or circumference, as often as by their diameter. The price, of course, varies, but fine Manilla hemp ropes, suitable for driving purposes, may be bought at about 46*s.* per cwt. In ordering the ropes for any particular drive, a considerable length—nine to ten feet—must be allowed for the splicing. The ropes are sometimes used plain, but more frequently they are thoroughly smeared with some preparation of tallow and plumbago. Saturation in molten paraffin wax is recommended for increasing the flexibility and prolonging the life of ropes used for driving purposes.

Moulding Rope Pulleys.

Single groove rope pulleys of standard sizes may be moulded in green sand from full patterns made in halves, that is, cut as it were right through the bottom of the groove transversely to the axis. The making of the pattern in halves in this manner is rendered necessary by the obvious impossibility of removing a whole pattern from the moulding box or flask after the sand has been rammed into the groove.

Pulleys with more than a single groove but of moderate sizes may have the rims swept up in loam, using a board cut to form the grooves, and the arms and centre formed by sand cores. Large pulleys and pulleys with many grooves are invariably moulded entirely in loam. There is no reason, however, why rope pulleys of moderate dimensions should not be moulded in green sand from small segmental patterns on the same principle as wheels are moulded in the wheel-moulding machine.

Like common pulleys, rope pulleys may be either solid or split. It is a convenience to make pulleys larger than about 8 ft. in diameter in halves in any case; whilst rope fly-wheels are almost necessarily made in smaller segments.

Following are a few representative examples of costs and estimates, and tables of weights and prices.

EXAMPLE No. 58.—Cost of 4 cast-iron rope pulleys, each 24 in. in diameter, with two grooves turned for 3½-in. ropes, pulleys cast in halves, joints planed, centres bored to gauge, and pulleys balanced.

£ s. d.				s. d.	£ s. d.
	Cast iron (loam rims)		5 1 4	7 6	2 0 4
	Moulders' wages	30 hours			0 18 9
	16 bolts and 32 nuts		0 0 25	9 0	0 2 0
0 1 8	Smiths' wages				0 1 8
	Planer—Wages paid	22 hours			0 5 8
	Turner "	37 "			0 18 1
1 16 11	Screwer "	2½ "			0 0 10
	Fitter "	6 "			0 3 3
0 3 7	Apprentice ditto (balancing, &c.)	21 "			0 3 10
0 7 9	Pattern makers—Wages paid ..	30 "			0 10 4
	Materials and wages				5 4 9
2 9 11	Expenses				2 9 11
	Gross cost				7 14 8

Charged as follows in the Sales Book, viz.:—

			s. d.	£ s. d.
June 20.	4 cast-iron rope pulleys, each 24 in. diameter, with two grooves, cast in halves, joints planed, halves bolted with ⅝-inch bolts and double nuts, grooves turned and polished for 3½-inch ropes, centres bored to gauge, pulleys carefully balanced, and including a proportion of cost of special patterns		60 0	12 0 0

One or two points in the above should be noted. It will be seen that the wages paid to the planer are very small in comparison to the number of hours, the explanation being that the man worked two small machines, and had both going at the time he did this work. The number of hours returned against the pulleys is the number that the planer had them in hand, but he was working on another job during the same time. We touch here a question with which we shall have to deal when treating of cost accounts. Suffice it to say now that the sum set opposite the time in this case was fixed by the cost clerk, who kept in view the other work that the planer was doing at the same time.

The sum opposite pattern makers will also appear small. Examination showed that a considerable amount of the work had been done by an apprentice in his last year.

Having reference to the amount of work done in this case by apprentices, the charge made for the pulleys must be considered very moderate. For it must be mentioned that a manufacturing engineer is fully entitled to derive all the advantage he can from his apprentices. It does not follow that because a job costs less than usual, owing to the fact that apprentices have done a large part of it, it should be charged less than what may be considered the normal price to the buyer. The engineer is entitled to what benefit he can get under such circumstances; besides, it is nothing but ordinary prudence to charge the normal price in these cases. The order may be repeated at a time when apprentices cannot be utilised; but if a job be charged low at one time it will be very difficult to get a higher rate on a future occasion, there having been no rise of prices in material or labour generally in the interval to account for the difference.

Example No. 59.—Cost of 4 rope pulleys, 30 in. diameter (solid), each with two grooves for 3½ in. ropes, turned, bored, slotted and balanced.

£ s. d.				s. d.	£ s. d.
	Cast iron (loam rims) .. }		8 1 0	7 6	3 1 11
	Moulders' wages	24 hours			0 16 4
	Turners—Wages paid	38½ "			1 1 2
1 18 0	Slotter "	9 "			0 4 2
0 3 1	Fitters "	12 "			0 6 2
0 3 9	Pattern makers—Wages paid ..	8 "			0 5 0
	Materials and wages				5 14 9
2 4 10	Expenses				2 4 10
	Gross cost				7 19 7

Charged £11 15s., less 2½ per cent., being equal to 35s. per cwt. of the finished weight, latter being 6 cwt. 3 qr.

Example No. 60.—Cost of one 48 in. and one 36 in. rope pulley, each with two grooves for 1½-in. (or 4-in.) ropes, turned, bored, slotted and balanced.

£ s. d.				s. d.	£ s. d.
	Cast iron		3 1 1	7 6	1 4 5
	"		2 1 26	7 6	0 18 8
	Moulders' wages	18 hours			0 11 3
	Turners—Wages paid	30 "			0 13 2
1 9 0	Slotter "	2½ "			0 1 2
0 1 11	Fitter "	7 "			0 3 10
0 5 3	Pattern makers—Wages paid ..	12 "			0 7 0
	Materials and wages				4 4 6
1 16 2	Expenses				1 16 2
	Gross cost				6 0 8

Finished weights, 2 cwt. 3 qr. 10 lb., and 2 cwt. 0 qr. 10 lb. Charged £8 13*s*., less 2½ per cent., being at the rate of 35*s*. per cwt.

Example No. 61.—Cost of two rope pulleys, 39 in. in diameter, and two 36 in., each for three 5-in. ropes, all cast in halves, planed, bolted, bored and turned up in grooves and balanced. Bolts turned and bolt holes drilled.

£ s. d.				s. d.	£ s. d.
	Cast iron		22 0 14	7 6	8 6 0
	Moulders' wages	50 hours			1 16 4
	8 bolts and nuts, 8 in. by 1¼ in. 8 " " 5 in. by 1¼ in.	.. ..	0 2 12	9 0	0 5 6
0 5 1	Smiths' wages				0 5 1
	Driller	17 hours			0 7 9
	Turners at pulleys	81 "			2 7 3
	" at bolts	21 "			0 9 7
6 4 0	Planer	35 "			0 18 1
0 7 6	Fitters	29 "			0 14 11
0 8 9	Pattern makers	20 "			0 11 8
0 1 1	Draughtsmen	5 "			0 4 2
	Material and wages				16 6 4
7 6 5	Expenses				7 6 5
	Gross cost				23 12 9

Finished weight, 18 cwt. 1 qr. 21 lb. Estimated finished weight, 17 cwt. 2 qr. Tender, £30 12*s*. 6*d*., less 2½ per cent., being at the rate of 35*s*. per cwt. of the estimated finished weight.

The castings in last example were somewhat heavier than they ought to have been, and the time machining was greater in consequence than ought to have been necessary. At the same time, there can be no doubt that the weight was slightly under-estimated when the tender was prepared. The estimated weight, finished, was 17 cwt. 2 qr. It no doubt ought to have been 18 cwt. 2 qr., and this would have made the tender £32 7*s*. 6*d*., instead of £30 12*s*. 6*d*. The profit would consequently have been at the rate of nearly 35 per cent. on the gross cost, instead of at the rate of a trifle under 30 per cent. However, there is frequently an element of consolation in cases of this kind where work has been under-estimated. Instead of dwelling upon the apparent loss of the 35*s*., we may reflect that if the tender had been this amount higher, the order itself might have been lost.

EXAMPLE No. 62.—Cost of one rope pulley 60 in. diameter, by 4 grooves, for 5¼-in. ropes, cast in halves, joints planed, bolt holes drilled, bolts turned and pulley balanced :—

£ s. d.				s. d.	£ s. d.
	Cast iron		15 0 0	7 6	5 12 6
	Moulders' wages	34 hours			1 1 3
	4 1-in. bolts and 4 ¾-in. bolts and nuts		0 1 0	9 0	0 2 3
0 1 1	Smiths' wages..	1½ hours			0 1 1
	Turner (pulley)—Wages paid ..	28 "			0 18 8
	" (bolts) " " ..	5 "			0 2 7
	Slotter (facing joints of the two halves) —Wages paid	11 "			0 4 11
	Driller	9 "			0 3 4
2 5 0	Screwer	1½ "			0 0 6
0 3 10	Fitter—Bolting and balancing ..	14 "			0 7 8
0 14 0	Pattern makers	33 "			0 18 8
0 1 0	Draughtsman	4 "			0 4 0
	Materials and wages				9 17
3 4 11	Expenses				3 4 11
	Gross cost				13 2 4

Finished weight, 13 cwt. 14 lb. Cost per cwt. £1. Charged £17, less 2½ per cent., being at the rate of £1 6*s*. per cwt. of the finished weight.

It will be noticed that the two halves of this pulley had the joints faced in the slotting machine. Work of this kind is usually more conveniently done in a good slotting machine than on a planer, and at a somewhat less cost, as a rule, in wages.

EXAMPLE No. 63.—Cost of one rope pulley 72 in. diameter, by 5 grooves, for 5¼ in. ropes, and one pulley 50 in. diameter, same grooves, both cast in halves, joints planed, bolt holes drilled, bolts turned and pulleys balanced :—

£ s. d.				s. d.	£ s. d.
	Cast iron (72 pulley)..		19 2 21	7 6	7 7 8
	" (50 ")..		13 0 21	7 6	4 18 11
	Moulders' wages	85 hours			2 16 8
	16 bolts and nuts and pins		0 3 0	9 0	0 6 9
	1 key (for 72 pulley)		0 0 3	9 0	0 0 3
	2 forgings for balance weights		0 0 12	9 0	0 1 0
0 8 0	Smiths' wages..	8½ hours			0 8 0
	Turners (pulleys)—Wages paid ..	77 "			2 8 6
	" (bolts) " " ..	24 "			0 12 5
	Planer " " ..	24 "			0 12 5
	Slotter " " ..	10½ "			0 4 5
	Drillers " " ..	41½ "			0 14 7
7 3 2	Grinder (key and balance weights)	8½ "			0 3 1
0 7 3	Fitters—Wages paid..	37½ "			0 14 5
1 13 8	Pattern makers "	87 "			2 11 7
0 2 3	Draughtsman "	9 "			0 9 0
	Material and wages				24 9 8
9 19 4	Expenses				9 19 4
	Gross cost				34 9 0

Finished weight, 26 cwt. 2 qr. Cost per cwt. £1 3*s*. 4*d*. Charged £41 5*s*., being at the rate of £1 7*s*. 6*d*. per cwt. on an estimated finished weight of 30 cwt.

The workmanship generally, but more particularly the items of pattern makers, drillers, and fitters, as shown in above statement of cost, must be considered rather excessive. The rate of profit on the gross cost is, in consequence, comparatively low, being, when the usual discount is deducted from the price, only about 15 per cent. There is, however, to be kept in view the fact that in addition to this profit the engineer has obtained payment for the patterns, which he retains. In this instance the patterns, which would consist of loam boards for moulding the rims, and boxes for forming the arms and centres, were probably entirely new. It would be a mistake to put too much value on such patterns, as the chances of using them again without extensive alterations are usually not very great.

EXAMPLE No. 64.—Cost of rope pulleys, as follows, viz. :—

One 64 inches diameter	by 12 grooves.
One 52 „ „	„ 12 „
One 62 „ „	„ 6 „
One 48 „ „	„ 6 „
Two 52 „ „	„ 3 „

All for 5¼-in. ropes (2½-in. pitch of grooves), solid, centres bored and slotted, grooves turned and pulleys balanced and fitted with wrought-iron keys.

£ s. d.				s. d.	£ s. d.
	Cast iron—64 in. pulley		35 3 14		
	„ 52 „		29 1 0		
	„ 62 „		18 2 7		
	„ 48 „		14 0 0		
	„ 52 „		8 3 0		
	„ 52 „		8 2 7	7 6	43 2 6
	Moulders' wages	320 hours			10 0 9
	6 W. I. keys		0 1 4	9 0	0 2 7
0 10 1	Smiths' wages..	11 hours			0 10 1
	Turners—Wages paid	298 „			9 6 3
	Slotter „ „	34 „			0 14 2
15 9 5	Grinder—(keys) „	14 „			0 5 10
0 6 4	Fitters „ „	23 „			0 12 7
2 0 0	Pattern makers	99 „			2 14 5
0 3 6	Draughtsmen	12 „			0 14 0
	Material and wages				68 3 2
18 9 4	Expenses				18 9 4
	Gross cost				86 12 6

Total finished weight, 99 cwt. 3 qr. 14 lb. Average cost per cwt. 17*s.* 4*d.* Charged £106 16*s.* net, in accordance with tender based on estimate, as follows:—

Estimated weights and prices of above rope pulleys for—

Actual Finished Weight.		Estimated Finished Weight.	Rate per cwt.	£ s. d.
32 0 14	One rope pulley, 64 in. diameter, by 12 grooves, for 5¼-in. ropes, bored, turned and key bedded	34 0 0	20 0	34 0 0
25 2 0	One ditto, 52 in. diameter	26 0 0	20 0	26 0 0
16 1 7	One ditto, 62 in. × 6 grooves	16 0 0	21 0	16 16 0
11 3 7	One ditto, 48 in. × 6 „	12 0 0	22 0	13 4 0
14 0 14	Two ditto, 52 in. × 3 „	14 0 0	24 0	16 16 0
99 3 14				106 16 0

EXAMPLE No. 65.—Cost of one rope pulley 96 in. in diameter, by 7 grooves, for 5½-in. ropes, rim solid, centre split and hooped with wrought-iron hoops. Also one pulley 60 in. diameter, with 3 grooves, and one 50 in. diameter, with 4 grooves, both solid, and to work with 96 in. pulley, all bored, turned, slotted and fitted with keys.

£ s. d.				s. d.	£ s. d.
	Cast-iron (96 pulley)		38 3 0		
	„ (60 pulley)		10 2 12		
	„ (50 pulley)		10 1 26	7 6	22 8 8
	Moulders' wages	166 hours			5 3 10
	Wrought-iron for hoops		0 3 4	9 0	0 7 1
	Wrought-iron for keys		0 0 22	9 0	0 1 9
0 11 6	Smiths' wages	12½ hours			0 11 6
	Turners (pulleys and hoops)—Wages paid	138 „			4 6 3
	Turners (preparing two mandrils to gauges supplied)	8 „			0 4 5
	Planer (preparing two mandrils to gauges supplied)	3½ „			0 1 9
	Slotter	15 „			0 6 11
7 11 11	Grinder	3 „			0 1 3
0 14 5	Fitters (hooping and keying on)..	61 „			1 8 9
1 5 7	Pattern makers	62 „			1 14 1
0 2 11	Draughtsman	5 „			0 5 10
	Materials and wages				37 2 1
10 6 4	Expenses				10 6 4
	Gross cost				47 8 5

Total finished weight, 52 cwt. 0 qr. 26 lb. Average cost per cwt., 18*s.* 4*d.* Charged £61 net, in accordance with tender based on estimate at profit rates, as follows—viz.:—

ESTIMATED WEIGHTS AND PRICES OF ABOVE ROPE PULLEYS.

Actual Finished Weights.			Estimated Finished Weights.	Rate per Cwt. s. d.	£ s. d.
34 1 0	1 rope pulley, 96 in. diameter × 7 grooves, for 5½-in. ropes, rim solid, centre split, bored, turned and slotted		33 0 0	20 0	33 0 0
	2 W. I. hoops, extra		0 3 0	0 5	1 15 0
	Turning and boring hoops ..	¾ day		16 0	0 12 0
	Fitters hooping	3 days		10 6	1 11 6
	Smith and fire	½ day		20 0	0 10 0
9 0 22	1 rope pulley, 60 in. × 3 grooves		9 0 0	23 0	10 7 0
8 3 4	1 rope pulley, 50 in. × 4 grooves		8 2 14	23 0	9 15 5
	Turner at two mandrils	1 day		16 0	0 16 0
	Planer at two mandrils	½ „		18 0	0 9 0
	3 W. I. keys		0 0 21	0 6	0 10 6
	Fitters keying pulleys on mandrils	3 days		10 6	1 11 6
52 0 26					60 17 11

Quoted £61 net, delivered free on rails (makers' town).

These pulleys were for existing shafts in a mill at some distance, and were to be keyed on mandrils in the makers' works to save time when erecting. It was known that existing mandrils could, with some slight alterations, be utilised, otherwise, of course, the charge for preparing the mandrils would have been greater. Gauges were supplied by the mill-owner.

The examples which have now been given will sufficiently illustrate the character of the work which presents itself in a general engineering establishment in connection with rope pulleys. It will be seen that the cost of the pulleys in these examples ranges from about 34*s*. per cwt. to a little over 17*s*. per cwt., whilst the selling prices range from 40*s*. to 20*s*. per cwt. The cost of the castings alone runs from 11*s*. to 9*s*. per cwt. Rope pulley castings can be bought by engineering firms who have no foundry of their own from founders at from about 12*s*. per cwt. for the lightest loam rim castings to 9*s*. for heavy castings, all patterns, boards or core boxes being provided by the buying firm.

One or two houses, who make specialties of mill castings, will supply engineers with ordinary rope pulley castings ready for the lathe, to specification, and including all preparation of patterns, at about the following rates, viz. :—

Pulleys under 5 cwt.	16s. to 20s.
Pulleys of 5 cwt. and under 10 cwt.	14s.
Pulleys of 10 cwt. „ 20 cwt.	13s.
Pulleys of 20 cwt. „ 40 cwt.	12s.

Extra for casting in halves for planing, about 2s. per cwt.

Rope pulleys above 8 ft. in diameter are rarely required. Rope fly-wheels are, of course, made much larger than this, but these will be dealt with in connection with engines.

It will be noticed that, with one or two exceptions, the examples just given deal with pulleys in pairs or sets. It is rare for only one rope pulley to be ordered at a time. Single belt pulleys are frequently ordered with a general engineering house, the pulleys being required to drive direct on to machines with which pulleys are provided; but as ropes are principally used to convey motion from one line shaft to another, or from the engine to the line shafts, and rarely for driving direct on to machines, at least two pulleys are generally required at a time.

In example No. 65, three pulleys constituted the set, the power being taken off the 96 in. pulley by three ropes on to the 60 in. pulley at one side, and by four ropes on to the 50 in. pulley at the other side.

As with belt pulleys, a list of prices for convenience when quoting is almost indispensable to any house intending to do much in rope pulleys. We append a list giving prices and approximate finished weights for the most common sizes. For the sake of comparison, the prices of a second house are also given, but it must be understood that the weights only apply to the prices opposite the A's, exact particulars of the weights corresponding to the prices opposite the B's not being available :—

Table of prices and approximate finished weights for grooved pulleys for 5¼-in. ropes (pitch of grooves 2½ in.), pulleys solid. Prices include boring, turning, and slotting key-bed.

Number of Grooves.		Diameter in Feet. 4	5	6	7	8
1	Cwts. A B	2¼ £2 15s. £5 0s.	3¼ £4 0s. £6 10s.	4½ £5 10s. £8 0s.	6 £7 10s. £10 0s.	7½ £9 10s. £13 0s.
2	Cwts. A B	4½ £5 10s. £6 10s.	6¼ £7 15s. £8 0s.	8 £10 0s. £10 0s.	13 £12 10s. £13 0s.	12 £15 0s. £16 0s.
3	Cwts. A B	6 £6 15s. £8 0s.	9 £10 0s. £10 0s.	11 £12 0s. £13 0s.	13½ £15 0s. £16 0s.	16 £18 0s. £20 0s.
4	Cwts. A B	8 £8 15s. £10 0s.	11 £12 0s. £12 0s.	14 £15 10s. £16 0s.	17½ £19 0s. £20 0s.	20 £22 0s. £24 0s.
5	Cwts. A B	10 £11 0s. £11 5s.	13 £13 15s. £14 0s.	16½ £17 10s. £18 10s.	20½ £21 10s. £22 15s.	24 £25 0s. £27 0s.
6	Cwts. A B	12 £12 10s. £13 0s.	15 £15 0s. £16 0s.	20 £20 0s. £21 0s.	24 £24 0s. £25 10s.	28 £28 0s. £30 0s.
7	Cwts. A B	14 £14 0s. £15 0s.	17 £17 0s. £18 10s.	23 £23 0s. £24 0s.	28 £28 0s. £29 10s.	33 £33 0s. £34 10s.
8	Cwts. A B	16 £16 0s. £17 0s.	19 £19 0s. £21 0s.	25½ £25 10s. £27 0s.	31 £31 0s. £33 0s.	37 £37 0s. £39 0s.
9	Cwts. A B	18 £18 0s. £19 10s.	22 £22 0s. £24 0s.	28 £28 0s. £31 10s.	35 £35 0s. £36 10s.	41 £41 0s. £44 10s.
10	Cwts. A B	20 £20 0s. £22 0s.	25 £25 0s. £27 0s.	31 £31 0s. £34 10s.	38 £38 0s. £40 0s.	45 £45 0s. £50 0s.
11	Cwts. A B	22½	28½ £28 10s.	34½ £33 0s.	42 £41 0s.	49 £49 0s. ......
12	Cwts. A B	25	32 £32 0s.	38 £37 0s.	46 £45 0s.	54 £54 0s. ......

Extras, if cast in halves, planed and bolted, and including bolts, from 50 per cent. on smaller sizes, down to 15 per cent. on the larger sizes, on the above rates.

The above rates may be taken as subject to the usual discounts, ranging from 2½ per cent. in ordinary cases to users, to 10 per cent. in special cases, or to engineers intending to sell again.

CHAPTER XI.

MILLWRIGHT WORK, continued.—TOOTHED GEARING.

UP to a comparatively recent date toothed wheels were almost universally employed as the first, and in innumerable cases as the only, distributors of the power of prime movers. Of late years, however, and principally under the influence of the demand for higher speeds, the position formerly occupied almost exclusively by toothed wheels has been in a constantly increasing measure filled by ropes and wide belts.

Wheels versus Pulleys.

We have previously referred to Fairbairn's "Mills and Mill-work," a work which will, of course, long remain an engineering text-book. It is interesting to observe the complacency with which the distinguished author regarded the fact that toothed gearing was, at the time he wrote, so universally employed in the great manufacturing districts of the North of England. Wide belts were then beginning to be used in London and the South, but the great engineer entertained no doubt that the North was right in holding steadily to toothed gearing. We now see that in this matter of power distribution, as in so many others, the country has to a very large extent followed the lead of London.

It is still more singular to observe how a great advance in mechanical science and skill, which has been made at one stage of manufacturing operations, as evidenced by the higher speeds at which modern machinery of conversion is driven, has been concurrent with, and in a very large measure has compelled the adoption of, what must be considered less scientific and exact methods of distributing power.

Two of the principal objects which the scientific millwright has in view are: First, to secure an exact and constant velocity ratio between the prime mover and the machinery to be driven; and secondly, to reduce the friction on his journals to a minimum. It cannot be questioned that, theoretically always, and practically also, when they are properly designed and carefully made, toothed wheels are better calculated to secure the two objects named than either belts or ropes. Hence, in resorting so largely to the latter in these days for distributing power, we are not adopting the most exact and scientific means that would appear to be available. It would thus seem that the machine maker had distinctly outrun the millwright.

Notwithstanding, however, the popularity of ropes and belts at the present time, toothed gearing is likely for a long period yet to constitute one of the most important sections of a general engineer's business, although it may not bulk quite so largely in it as in some former days. Certain heavy classes of machinery—rolling mills, for example—must almost necessarily be driven by gearing; a large proportion of the shafting in most manufactories is still most conveniently and advantageously driven by wheels; whilst, apart from entirely new installations, large numbers of wheels are required for those renewals, alterations, and extensions of existing establishments which form so large a proportion of the work which passes through a general engineering shop.

Moreover, it is by no means certain that gearing will not recover some of the ground which it must be held to have lost of late years in the estimation of power consumers. The adoption of more perfect forms of teeth, and especially of various modifications of stepped teeth, as in the now well-known types of helical wheels, and the use of the wheel-moulding machine, enable wheels to be made to-day which are quite suitable for speeds which would have been thought preposterous not many years ago ; whilst a more general resort to cast steel as the material for wheels will no doubt permit a still further advance.

Toothed wheels present themselves in an engineering establishment in a considerable number of different forms and modifications. We have, first, the general division of spur wheels, bevel wheels, screw and worm wheels. All these may be either solid, cast to split, or cast in halves. Spur and bevel wheels, again, may be entirely of metal, or may be mortice wheels — that is, have wooden cogs; and may either have plain open teeth

Varieties of Wheels.

or have the teeth flanged or shrouded. The shrouding may be the full depth of the teeth, or carried only to the pitch line.

Again, wheels may be put into use literally as they come from the dressing or fettling shop, as in some cases of very low speeds, or, on the other hand, they may be bored, slotted, turned up in the lathe on the face and ends of the teeth, and have the teeth accurately "pitched and trimmed" either by hand or by machine, and finally be carefully balanced, as ought to be the case with all wheels intended to run at high speeds.

There are at least four distinct methods in which wheels may be made:—

Methods of Manufacture.

Firstly, a casting may be made with a solid or blank rim, and teeth be cut out by a milling machine having special cutters, and provided with dividing apparatus for the purpose. This method is as yet rarely used for any but comparatively small wheels.

Secondly, the wheel may be moulded from a full pattern.

Thirdly, the wheel may be made by having the rim moulded from a small segmental pattern by the aid of the moulding machine, the centre and arms being formed by dry sand covers.

Fourthly, the wheel may be made in segments, the rim segments being either moulded from a full pattern or by machine, and the segments subsequently built up to form the complete wheel.

Large geared engine flywheels are generally made in the latter manner. In whatever way the wheels may be made, the castings are invariably greensand castings.

The introduction of the wheel-moulding machine undoubtedly constitutes the most important advance which has been made in connection with the manufacture of wheels. It is safe to say that by far the larger proportion of new wheels now made for mill gearing are made by the aid of the machine.

Machine-Moulded Wheels.

Whilst several wheel-moulding machines are now offered, they are all the same in principle, the essential features being a radial arm to which can be attached the block pattern for the teeth at the proper distance from the centre, and which admits of being very accurately turned round upon its centre; means for withdrawing the block pattern from the sand after the tooth (or teeth in some cases) has been moulded, and for returning the pattern preparatory to moulding further teeth ; and accurate dividing apparatus.

The use of the machine not only effects a considerable saving in the cost of making patterns, but secures a greater degree of accuracy in the castings themselves than can be obtained when full patterns are employed. This advantage obtains even as compared with castings made from new full patterns, and of course very much more decisively in the case of wheels moulded from patterns which have been used once or twice or stored for a considerable time. A third advantage, by no means unimportant, is the saving effected in the space required for the storage of wheel patterns. Hence a wheel-moulding machine of some kind has become indispensable to any firm wishing to command any considerable business in mill gearing.

The following are a few typical examples of costs and estimates of toothed gearing :—

Example No. 66.—Cost of two machine-moulded spur wheels, each with 53 teeth, 1⅝ in. pitch by 3½ in. face, turned on face and ends of teeth, bored and key-seat slotted. New pattern for machine :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	2 castings		3 2 10	6 3	1 2 6
	Moulder's wages	22 hours			0 14 8
	Turner — Wages paid	20 "			0 11 6
0 18 11	Slotter " "	2 "			0 0 11
	Pattern maker " "	23½ "			0 13 7
0 11 5	Apprentice do. " "	11 "			0 1 8
	Material and wages				3 4 10
1 10 4	Expenses				1 10 4
	Gross cost				4 15 2

From the above the following appears :—

Cost of castings only	£1 17s. 2d.	10s. 4d. per cwt.
Cost of castings, including patterns	£3 3s. 10d.	17s. 6d. per cwt.

The wheels were charged as follows :—

		cwt. qr. lb.	s. d.	£ s. d.
	2 machine-moulded spur wheels, each, etc.	3 2 10	19 0	3 8 2
	Turning on face and ends of teeth, boring eyes, and slotting one key-bed in each wheel			2 0 0
				5 8 2

Less 2½ per cent.

It will thus be seen that the charge made for the castings only just covered their cost, including patterns. As far as the castings were concerned, the maker had to be satisfied with the patterns for his profit. If only one casting had been required, the cost of the patterns would not have been covered at the rate charged in above statement for the castings. Hence, either a special charge would have had to be made to cover cost of patterns, or the value of the latter would have had to be considered as an equivalent.

The remarks made upon the question of charging for patterns, when dealing with belt pulleys, now apply with equal force in the matter of wheels. A manufacturing engineer who wishes to make or keep a business in wheels must be prepared to make patterns on his own account, except in special cases. That is to say, millowners and other buyers of wheels are now quite familiar, through the medium of printed price lists and the advertisements of specialty houses, with the prices at which machine-made wheels can be bought from such houses, and will not, therefore, as a rule, allow a general engineer to charge them higher rates.

In the above example, and, indeed, in most of the following examples, the cost of patterns stands high. The patterns were all made by hand, the teeth being carefully dovetailed into the block and not merely cut out of the solid—the entire patterns being thoroughly well made, as they were intended to be kept for future use and included in the wheel list of the establishment.

The cost of patterns, however, as indicated in these examples, might be very considerably reduced by proper arrangements.

Example No. 66 may be compared with the following :—

EXAMPLE No. 67.—Cost of one spur wheel with 68 teeth, 1⅝ in. pitch by 3½ in. wide, and one pinion with 16 teeth, to work with above wheel, both bored and slotted :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	Cast-iron wheel		2 0 10		
	" " pinion		0 1 14	6 3	0 15 8
	Moulder's wages	9½ hours			0 5 7
	Turner..	8¾ "			0 5 1
0 9 0	Slotter..	2 "			0 0 11
1 8 10	Patternmakers (new wheel pattern only)	71 "			1 18 5
	Material and wages				3 5 8
1 17 10	Expenses				1 17 10
	Gross cost				5 3 6

Cost for castings only, £1 1s 3d. = 8s. 7d. per cwt.

In this instance the cost of the castings only, without reference to the patterns, was £1 1s. 3*d*., or 8*s*. 7*d*. per cwt ; being, therefore, 16 per cent. less than the cost per cent. of the castings only in the preceding example. The two examples, whilst not identical, offer a fair comparison.

Charged as follows, viz :—

	cwt. qr. lb.	s. d.	£ s. d
1 cast-iron spur wheel, 68 × 1⅝ × 3½ in. wide	2 0 10	12 0	1 5 1
1 pinion with 16 teeth for ditto	0 1 14	14 0	0 5 3
Boring wheel and pinion, slotting key-bed in each and including net cost of preparing new wheel pattern—latter to remain ours..			4 4 5
			5 14 9

Less 2½ per cent.

This was a case where wheels and pinions as above were very frequently required. The wheel pattern had become unfit for use, and it became necessary to make a new one—either a full pattern or a segment for the moulding machine. As the customer required the castings often, he preferred to pay the cost of a new full pattern in order that he might get the castings at 12*s*. per cwt., rather than pay 15*s*. or 18*s*. per cwt. for machine-moulded wheels and nothing specially for patterns.

In the account, 18*s*. was reckoned for the boring and slotting of the wheel and pinion, the amount for the pattern being merely the gross cost, as shown in above statement—no profit being charged on the pattern in consideration of the fact that it remained the property of the engineer, and of the regular business which the latter received in connection with it.

EXAMPLE No. 68.—Cost of 7 pairs of bevel wheels and pinions, 2 ft. 4½ in. × 60 × 1½ × 3½ face and 1 ft. 7½ in. × 40 × 1½ × 3½ face, machine made, wheels split and bolted, pinions solid, all bored and slotted :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cast iron—7 wheels	10 3 0		
	" " 7 pinions	7 0 0	6 3	5 10 11
	Moulders' wages .. .. .. 105 hours			3 5 8
	14 bolts and nuts, 4 in. × 1 in. / 14 " " 4 in. × 1¼ in. } stock ..	0 3 7	0 3	1 2 9
	Turners—Wages paid .. .. 32 hours			0 18 8
1 16 3	Slotter " " .. .. 12½ "			0 5 6
0 4 1	Fitters " " .. .. 15¾ "			0 8 2
0 18 4	Pattern makers " .. .. 44½ "			1 4 5
	Material and wages			12 16 1
2 18 8	Expenses			2 18 8
	Gross cost			15 14 9

Cost of castings only .. .. £8 16*s*. 7*d*. .. 9*s*. 8*d*. per cwt.
Cost of castings and patterns .. .. .. £10 19*s*. 4*d*. .. 11*s*. 9*d* per cwt.

Charged as follows:

		cwt. qr. lb.	s. d.	£ s. d.
	7 machine-moulded bevel wheels, 60 etc. ..	10 3 0	18 0	9 13 6
	7 " " pinions, 40, etc.	7 0 0	20 0	7 0 0
	28 bolts and nuts	0 0 91	0 5	1 17 11
	Boring and slotting all, and splitting and bolting wheels			4 12 5
				23 3 10

Less 2½ per cent.

It will be seen from above that when a number of castings off the one pattern are made at a time, such rates for the castings as those shown in this example pay very well, even including the cost of the patterns.

It should be added that in the establishment where these wheels were made, cast iron splitting plates were generally used. Some makers use wrought iron plates and charge extra for them along with the bolts.

EXAMPLE No. 69.—Cost of one pair of machine-made mitre wheels, 2 ft. 6 in. by 42 and 2 ft. 5⅝ in. by 41 by 2½-in. pitch and 5½-in. face; 42 wheel bored to gauge and with one key-bed slotted; 4 key-beds slotted in 41 wheel:—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	Cast iron		6 0 0	6 3	1 17 6
	Moulders' wages	26 hours			0 16 9
	Turner—Wages paid	4 "			0 2 3
0 6 5	Slotter "	4½ "			0 2 0
1 2 3	Pattern maker, at new patterns for machine	54 "			1 9 8
	Materials and wages				4 8 2
1 8 8	Expenses				1 8 8
	Gross cost..				5 16 10

Cost for castings only.. .. .. .. £2 14*s*. 3*d*. = 9*s*. 0*d*. per cwt.
" " and patterns .. .. £5 6*s*. 2*d*. = 17*s*. 6*d*. "
Charged 19*s*. per cwt. for the castings and 15*s*. for the boring and slotting. Total, £6 9*s*., less 2½ per cent.

As in No. 66, it will be seen that the above job only just paid when taken as a whole. Of course, any subsequent castings off the same patterns would pay very well if rated (as they would be) from 16*s*. to 19*s*. per cwt. It should be added that in the above case, the wheels being mitres and differing in size by one tooth only, whilst a separate block pattern was made for moulding the rim of each, the one core box, with slight modifications, was used for forming the arms of both.

EXAMPLE No. 70.—Cost of one pair of machine-made mitre wheels, 60 and 59 by 2½ in. by 6-in. face, both bored and slotted :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	Cast iron		7 1 0		
	„		6 3 14	6 3	4 4 9
	Moulders' wages	48 hours			1 10 0
	Turner—Wages paid	10½ „			0 6 3
0 11 9	Slotter „	3½ „			0 1 7
1 3 11	Pattern makers, at new patterns for machine..	58 „			1 11 10
	Materials and wages				7 14 5
1 15 8	Expenses				1 15 8
	Gross cost				9 10 1

Cost for castings only.. .. .. .. £5 14s. 9d. = 8s. 1d. per cwt.
„ „ and patterns .. .. £8 10s. 6d. = 12s. 1d. „
Charged £13 5s. 2d., being at the rate of 17s. per cwt. for the castings, with £1 5s. for boring and slotting.

This job, it will be seen, paid very well, although only one pair of wheels was supplied. In connection with this example, it may be pointed out that the cost of the patterns was very little more than in Example No. 69, although the wheels were more than twice as heavy. This is, of course, only what would be expected, seeing that the patterns for the rim would have the same number of teeth in both cases. If only a single wheel had been required, the cost would have been about 14*s.* 6*d.* per cwt., including patterns. Hence, single machine-made wheels of 6 cwt. or over will generally cover the cost of patterns, when charged at about the rates given.

EXAMPLE No. 71.—Cost of one mitre wheel, 4 ft. 9⅝ in. diameter by 56 by 3¼ by 9-in. face, and two 4 ft. 9 in. by 55 by 3¼ by 9-in. face, flanged to pitch-line, all machine-made, all turned on ends and face of cogs and on flanges, centres bored, and key-bed slotted in each :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	3 castings		53 2 21	6 3	16 15 7
	Moulders' wages	112 hours			3 9 0
	Turners—Wages paid	44½ „			1 6 0
2 3 5	Slotter „ „	6½ „			0 2 11
2 3 9	Pattern makers, at new patterns for machine	98 „			2 18 4
	Materials and wages				24 11 10
4 7 2	Expenses				4 7 2
	Gross cost				28 19 0

Cost for castings only.. .. .. .. £20 4s. 7d. = 7s. 6d. per cwt.
„ „ and patterns .. .. £25 6s. 0d. = 9s. 6d. „

It will be obvious that, if only two instead of three wheels had been ordered, the cost for the pair, including patterns, would have been about £18 12*s.* or 10*s.* 4*d.* per cwt., as the pattern-making would have been the same.

The above wheels were charged as follows:—

		cwt. qr. lb.	s. d.	£ s. d.
	1 machine-made mitre wheel, 4 ft. 9¾ in. and 56 teeth; and 2 ditto 4 ft. 9 in. and 55 teeth, by 3¼-in. pitch and 9-in. face; all flanged to pitch lines	53 2 21	15 0	40 5 3
	Turning teeth on ends and face, turning flanges, boring centres and slotting key-bed in each			5 0 0
				45 5 3

Less 2½ per cent.

It is, of course, unnecessary to remind any of our readers of the reason why, in pairs of mitre wheels, one wheel is invariably made with a tooth more than the other, as in all the three last examples. The introduction of this extra cog—the "hunting-cog" or tooth—necessitates a separate pattern for each wheel of the pair when full patterns are used, and a separate block tooth pattern for each wheel, when the wheel-moulding machine is used; but there is no question that the advantages secured—the equalising of the wear of the teeth and the consequent smoothness of running—fully justify this extra cost.

Example No. 72.—Cost of one machine-made spur wheel, 53 cogs, 4½-in. pitch by 12-in. face, and one pinion, with 42 cogs to suit above wheel, both made of extra strong cold blast iron mixture; four key-ways slotted in each, and both hung on shafts in shop with new keys:—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	1 casting—wheel		36 2 0		
	1 " pinion		30 3 0	8 3	27 14 10
	Moulders' wages	144 hours			4 3 0
	8 W. I. keys		1 1 14	9 0	0 12 5
0 17 6	Smiths' wages	19 hours			0 17 6
	Slotter—Wages paid..	14 "			0 6 3
0 13 11	Grinder (at keys)—wages paid ..	9 "			0 3 0
0 9 8	Fitters—Wages paid	37 "			0 19 3
2 19 11	Pattern makers, at new patterns for machine	134 "			3 19 0
	Materials and wages				38 15 3
5 1 0	Expenses				5 1 0
	Gross cost				43 16 3

Cost for castings only .. .. £31 17*s.* 10*d.* = 9*s.* 6*d.* per cwt.
" " and patterns .. .. £38 16*s.* 9*d.* = 11*s.* 6*d.* "

An estimate of probable cost was made up for above. This estimate came out £41; 25 per cent. was added, and the tender given in at £53 6*s.*, less 2½ per cent. It will be noted that 2*s.* per cwt. was added to the ordinary rate put down in the cost, on account of the extra quality of iron used in the mixture of which the wheels were cast.

EXAMPLE No. 73.—Cost of one machine-moulded spur wheel, 9 ft. 10¾ in. diameter; 108 cogs, 3½-in. pitch by 10-in. face, cast in halves, joints planed and bolted, centre bored and slotted :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	2 castings		47 2 0	7 6	17 16 3
	Moulders' wages	131 hours			3 10 11
	16 bolts and nuts		0 3 12	9 0	0 7 9
0 3 9	Smiths' wages	9½ hours			0 3 9
	Turner—Wages paid	18 "			0 11 3
	Slotter at joints and key-way—Wages paid..	26 "			0 1[illegible] 5
2 6 9	Turner at bolts—Wages paid ..	34 "			0 [illegible] 6
0 4 5	Fitters " " ..	17 "			0 8 9
2 0 10	Pattern makers " " ..	95 "			2 14 5
	Materials and wages				26 13 0
4 15 9	Expenses				4 15 9
	Gross cost				31 8 9

Cost for castings only .. .. £21 7*s.* 2*d.* = 9*s.* per cwt.
" " and patterns .. .. £26 2*s.* 5*d.* = 11*s.* "
Charged £41, less 2½ per cent., being at the rate of 14*s.* per cwt. for the casting, 4*d.* per lb. for the bolts as forgings, and a sum of £3 6*s.* for the turning, planing and bolting, etc.

The general foundry expenses connected with large machine-moulded wheels being to so large an extent similar to those incurred in connection with ordinary loam castings, it becomes desirable to treat such wheels as loam castings. Hence the wheel in this example is put down at loam-casting rate.

It may be observed that there is nothing specially put down in these examples for expenses or charges in connection with the wheel-moulding machine. What special charges were incurred in connection with the machine were simply included in the general foundry expenses; but, of course, where a large business is done in machine-moulded wheels, it is desirable to open a separate account for expenses in connection with the moulding machines.

EXAMPLE No. 74.—Cost of one cast-iron spur wheel, 9 ft. 5¾ in. diameter, 84 cogs, 4½-in. pitch by 12-in. face, cast in two halves from full pattern, joints faced and bolted, and four key-beds slotted in centre :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	2 castings		55 1 0	6 3	17 5 4
	Moulders' wages	51 hours			1 14 9
	16 bolts and nuts		0 3 9	9 0	0 7 6
0 4 3	Smiths' wages	5¼ hours			0 4 3
	Slotter at joints and key-ways ..	26½ "			0 11 8
1 11 3	Turners at bolts	17 "			0 9 2
0 6 3	Fitters	23 "			0 12 6
	Materials and wages				21 5 2
2 1 9	Expenses				2 1 9
	Gross cost				23 6 11

Cost for castings only, £19 0*s.* 1*d.* = 6*s.* 11*d.* per cwt. Charged £31 7*s.*, less 2½ per cent., being at the rate of 9*s.* per cwt. for the casting, 4*d.* per lb. for the bolts, and £4 19*s.* for the planing and bolting, etc.

The wheel in above example was made from a stock pattern. To have made a new full pattern for the half of this wheel would have taken about 30 days of a pattern maker, and would, therefore, have cost about £12 10*s.* in wages and expenses, or about 4*s.* 6*d.* per cwt.

We shall conclude this section with a few examples of mortise wheels and a list of rates for cogging.

Example No. 75.—Cost of one bevel mortise wheel with 54 cogs, $1\frac{5}{8}$-in. pitch by $4\frac{1}{2}$-in. face, bored, turned, slotted, and cogged with best seasoned beech:—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	Cast iron		2 1 7	6 3	0 14 6
	Moulders' wages	$5\frac{1}{2}$ hours			0 3 6
	Beech	22 ft. by $1\frac{1}{2}$ in.		0 $7\frac{1}{2}$	0 13 2
	Wire for pins		0 0 $3\frac{1}{2}$		0 0 7
	Turner—Wages paid	10 hours			0 5 10
	Driller „	$2\frac{1}{2}$ „			0 0 11
0 10 9	Slotter „	1 „			0 0 5
	Millwrights „	43 „			1 0 9
0 13 11	Apprentice do. „	58 „			0 7 1
0 2 11	Pattern maker, altering stock pattern	7 „			0 3 10
	Materials and wages				3 10 7
1 7 7	Expenses				1 7 7
	Gross cost				4 18 2

Charged as follows in sales book, viz.:—

		cwt. qr. lb.	s. d.	£ s. d.
	1 cast-iron bevel mortise wheel	2 1 7	14 0	1 12 5
	Boring and slotting centre, turning and drilling rim for cogging, altering pattern and cogging with best seasoned beech			5 2 7
				6 15 0

Less $2\frac{1}{2}$ per cent.

The amount included in above charge of £5 2*s.* 7*d.* for cogging alone was £3 16*s.* 6*d.*, being at the rate of 1*s.* 5*d.* per cog; of course, including the timber.

It will be observed that the timber in above example is rated as costing 5*d.* per superficial foot per inch of thickness. The actual rates per foot per inch paid for the timber were $2\frac{1}{2}$*d.* to 3*d.*, but this was for the timber in the green state, though in plank, and the timber had, therefore, to be seasoned. It was consequently reckoned that interest on capital, rent, maintenance of racks and stores, handling and loss of timber, brought the cost up to 5*d.* per foot per inch by the time the timber came to be used.

It is probably not necessary to say that the amount of timber returned against a wheel in any particular case is the superficies of the plank used for the wheel. There is, of course, considerable waste in cutting up the plank, and the amount of timber returned at one time against a wheel may be very different to the amount returned at another time against the same wheel. On one occasion planks may be found which cut up very neatly for the job, but on the next the planks may not fall in so well, and consequently there will be much more waste in the latter than in the former case.

Example No. 75 may be compared with the following cost of re-cogging a wheel of the same size and kind.

EXAMPLE No. 76.—Cost of re-cogging bevel mortise wheel of 54 cogs, $1\frac{5}{8}$-in. pitch by $4\frac{1}{2}$-in. wide :—

£ s. d.				s. d.	£ s. d.
	Beech, 19 ft. × $1\frac{1}{2}$ in.			0 $7\frac{1}{2}$	0 11 11
0 2 9	Turners' wages	3 hours			0 1 10
0 11 8	Millwrights and apprentices ..	81 „			1 3 3
	Materials and wages				1 17 0
0 14 7	Expenses				0 14 7
	Gross cost				2 11 7

Charged £3 16*s*. 6*d*., less $2\frac{1}{2}$ per cent, being at the rate of 1*s*. 5*d*. per cog.

It will be noticed that in the cost of the new wheel there is returned 10 hours of a turner, and in the cost of re-cogging 3 hours of a turner. In the new wheel there was the following turner's work :—viz., boring the centre, turning up the rim preparatory to putting in the cogs, and turning up the cogs on face and ends after they had been put in the wheel, but before they were shaped. In the re-cogging there was, of course, only the last item of turner's work required, and this item appears in every case of re-cogging. There were other items of workmanship in the new wheel which do not, of course, appear at all in the re-cogging.

It should be added that in all these examples of mortise wheels the final shaping of the teeth was done by hand, though they were cut out of the plank, shanked and drilled by circular saw and lathe.

It will be seen also that the percentage for indirect expenses put down in these examples for millwrights' cogging is just the same as for ordinary fitters. The millwrights when cogging used machine tools to a certain extent, but it was considered that this was fully balanced by savings in other expenses as compared with general fitters, and that all desirable ends were secured by treating millwrights and fitters as constituting one department.

EXAMPLE No. 77.—Estimated price of 1 mortise wheel, 2 ft. 1⅜ in. diameter, with 40 cogs 2-in. pitch and 5½-in. face, and 1 iron wheel 2 ft. ⅜ in. diameter, and 39 cogs to work with mortise, both bored and slotted, mortise cogged with best beech and iron wheel pitched and trimmed. (Profit rates):—

			cwt. qr. lb.	s. d.	£ s. d.
	1 mortise wheel		2 2 0	12 0	1 10 0
	Boring and turning	1½ day		13 6	1 0 3
	Drilling	2 hours		11 3	0 2 6
	Slotting	1 hour		11 3	0 1 3
	Cogging with beech		40 cogs at	1 9	3 10 0
	1 iron mitre wheel		2 0 14	12 0	1 5 6
	Boring and turning	1¼ day		13 6	0 16 11
	Slotting	1 hour			0 1 3
	Pitching and trimming both sides	6½ days		9 0	2 18 6
	Getting out stock patterns ..	¼ day		10 6	0 2 8
					11 8 10

Quote £11 10s., less 2½ per cent.

The cost of above pair of mitre wheels turned out as follows, which it will be seen was as near the estimate as to time as need be desired :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	1 mortise wheel		2 2 7		
	1 iron mitre wheel		2 1 0	6 3	1 10 1
	Moulders' wages	10½ hours			0 6 2
	Beech for cogging, 18 ft. × 1⅜ in.	.. ..		0 8½	0 12 9
	Iron wire for pins				0 0 8
	Turner—Wages paid	23 hours			0 11 5
	Driller "	2¼ "			0 0 10
0 19 3	Slotter " .. .	1¼ "			0 0 7
	Millwrights (cogging mortise)—Wages paid	40 "			0 19 10
	Apprentice do.—Wages paid ..	25 "			0 3 0
0 16 7	Millwrights (pitching and trimming)—Wages paid	64 "			1 10 4
0 2 2	Pattern-makers at full stock patterns—Wages paid				0 2 11
	Materials and wages				5 18 7
1 18 0	Expenses				1 18 0
	Gross cost				7 16 7

The pitching and trimming of the teeth of the iron wheel were done entirely by hand, as was all the shaping of the mortise wheels in these examples. It is true that several machines have of late years been introduced for the shaping of mortise, and the trimming of metal, cogs. Some of these have been entirely complete and independent in themselves, whilst others have been designed to be worked in conjunction with a lathe. It cannot be said, however, that any has come into general use. This is, no doubt, partly owing to the relative decline in the demand for toothed gearing in the face of the superior recommendations of belts and ropes for so many modern drives. Owing to this decline, invention has been rather sluggish in regard to gear-cutting machines, and many engineers, who might have purchased one or another of the machines which have been brought out, have hesitated, and preferred to depend upon the old-fashioned methods. Hence a very large proportion of mortise wheel cutting and of the trimming of metal wheels is still done by hand.

EXAMPLE No. 78.—Cost of 16 bevel mortise wheels, 4 ft. 6 in. diameter, with 80 cogs, $2\frac{1}{8}$-in. pitch and $5\frac{1}{4}$ in. wide, split and bolted, bored and slotted, turned on rim, cogged with beech, and keyed on shafts in shop.

£. s. d.			cwt. qr. lb.	s. d.	£ s. d.
	16 castings		116 0 0	6 3	36 5 0
	Moulders' wages	141 hours			4 8 1
	96 bolts and nuts, $1\frac{3}{4}$ in. × 5 in. and $1\frac{1}{4}$ in. × 5 in.		5 0 0	9 0	2 5 0
	16 W. I. keys		0 2 15	9 0	0 5 8
1 2 1	Smiths' wages				1 2 1
	Beech for cogging, 304 ft. × $1\frac{3}{4}$ in.			0 $8\frac{3}{4}$	11 1 7
	„ „ 208 ft. × $1\frac{1}{2}$ in.			0 $7\frac{1}{2}$	6 10 0
	Pins		0 3 12	12 0	0 10 4
	Turners—Wages paid	306 hours			9 0 2
	Drillers „	69 „			1 5 10
	Slotter „	27 „			0 12 0
16 14 9	Grinder at keys—Wages paid ..	14 „			0 5 2
	Fitters (splitting, bolting and keying) —Wages paid	197 „			5 1 9
	Millwrights (cogging)—Wages paid,	1440 „			33 0 4
20 16 1	Apprentice „ „	560 „			3 10 0
2 5 6	Pattern makers (making new full pattern)—Wages paid.. ..	104 „			3 0 8
	Materials and wages				118 3 8
40 18 5	Expenses				40 18 5
	Gross cost				159 2 1

Equal to £9 19*s*. per wheel.

The above wheels were charged £209 14*s*. net, in accordance with a tender based upon an estimate at profit rates, the full detailed particulars of which it is not necessary to give. It will suffice to say that the castings were reckoned at 9*s*. 6*d*. per cwt., the bolts and nuts at 3*d*. per lb., and the cogging at 1*s*. $9\frac{1}{2}$*d*. per cog.

An equal number of iron pinions to work with above were supplied at the same time. The pinions had 33 teeth each, weighed on an average 2 cwt. 14 lbs.; were rated at 12*s.* per cwt.; were made from a new full pattern, against which 80 hours were returned; and were pitched and trimmed on both sides of the teeth at an expenditure in time of 44 hours of a millwright per wheel. The amount in the estimate for the pinions was £72, equal to £4 10*s.* per pinion.

EXAMPLE No. 79.—Cost of one machine-moulded spur mortise pinion 7 ft. 0⅛ in. diameter, with 69 cogs, 4-in. pitch by 14-in. face, cast in one piece to split through arms, bored, slotted, and turned on face and sides of rim.

£ s. *d.*			cwt. qr. lb.	*s.* *d.*	£ *s.* *d.*
	1 casting		73 1 0	7 6	27 9 5
	Moulders' wages	140 hours			3 18 10
	12 2¼-in. and 1¾-in. bolts and nuts (extra quality)		2 2 0	14 0	1 15 0
0 11 0	Smiths' wages	13 hours			0 11 0
	Beech for cogging, 80 ft. × 3 in.			1 3	5 0 0
	" " 50 ft. × 2½ in.			1 0½	2 12 1
	W. I. pins		0 0 30	0 1¼	0 3 2
	Turners—Wages paid	64 "			2 1 4
	Slotter "	7 "			0 3 1
3 18 9	Driller "	19¼ "			0 8 1
	Fitters "	26 "			0 14 2
	Millwrights "	300 "			7 4 0
4 7 5	Apprentice do. "	84 "			0 16 8
3 11 10	Pattern maker (new pattern for machine)	107 "			4 15 9
	Materials and wages				57 12 7
12 9 0	Expenses				12 9 0
	Gross cost				70 1 7

Charged £95 net, in accordance with estimate made up at profit rates, in which the weights &c., were approximately as above, the casting being rated at 13*s.* 6*d.* per cwt., the bolts at 3*d.* per lb., the turning at 18*s.* per day, and the cogging at 10*s.* 6*d.* per cog. An alternative tender for the wheel cast in halves, and with the joints planed, bolt-holes drilled, and bolts turned, was also given at £105 net.

Re-cogging.

The re-cogging of wheels constitutes an important part of the gearing business of an engineering establishment; but the general range of re-cogging costs will have been sufficiently indicated by the examples of new wheels just given. Re-cogging in any case simply means the same millwright's time, or, perhaps, 10 per cent. more on account of knocking the old cogs out; the same amount of timber, and from a third to a half of the turner's time, as in the case of a new wheel.

The following table, however, summarises a number of cases of re-cogging, which may be taken as fairly representative, and will sufficiently indicate the variations which occur in this class of work:—

TABLE OF TIMBER AND TIME RE-COGGING WHEELS.

Kind of Wheel.	Dimensions.	Timber used.	Millwrights' Time.	Apprentice Millwright.	Turner.
		ft. in. in.	Hours.	Hours.	Hours.
Bevel	43 × 1¾ × 4	13 0 × 1½	34	31	2
"	60 × 1⅞ × 4½	13 0 × 1¼	49½	—	4
"	43 × 2 × 5	20 0 × 1¾	40	25	4½
"	40 × 2 × 5	16 0 × 1⅝	48	—	4½
"	58 × 2 × 5	30 0 × 1½	102	—	5
"	28 × 2¼ × 6	24 0 × 1¾	52	4	2
"	79 × 2¼ × 6	49 0 × 1⅝	100½	38	4
"	60 × 2½ × 5	40 0 × 1¾	125	10	4
"	66 × 2½ × 8½	68 0 × 2	113	26	4½
Spur	82 × 2¾ × 7½	56 0 × 2	181	12	8½
"	44 × 2⅞ × 8	46 0 × 2	76	—	4
"	81 × 3 × 9	82 0 × 2	346	25	10
"	78 × 3 × 9	81 0 × 2¼	204	27	8
Bevel	50 × 3⅛ × 8	75 0 × 2½	138	37	7½
Spur	60 × 3½ × 12	110 0 × 2½	260	39	6
"	41 × 4 × 13	77 0 × 3	170	50	10

The following is a table of charging prices for re-cogging, which should cover all expenses, allow thoroughly-seasoned timber to be used, the work to be done carefully, and leave a fair margin of profit:—

TABLE OF PRICES FOR RE-COGGING (HANDWORK).

Price per Cog.

Breadth of Face.	4	5	6	7	8	9	10	11	12	13	14
Pitch.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1¼	1 2	1 3	—	—	—	—	—	—	—	—	—
1½	1 3	1 4	—	—	—	—	—	—	—	—	—
1⅝	1 4	1 5	1 6	—	—	—	—	—	—	—	—
1¾	1 5	1 6	1 8	1 10	—	—	—	—	—	—	—
1⅞	1 6	1 7	1 9	2 0	—	—	—	—	—	—	—
2	1 9	1 11	2 2	2 6	2 10	—	—	—	—	—	—
2¼	2 0	2 2	2 5	2 10	3 4	—	—	—	—	—	—
2½	—	2 4	2 8	3 2	3 9	—	—	—	—	—	—
2¾	—	—	3 0	3 6	4 0	—	—	—	—	—	—
3	—	—	—	4 0	4 6	5 0	5 6	—	—	—	—
3¼	—	—	—	4 4	4 9	5 3	5 9	—	—	—	—
3½	—	—	—	5 0	5 6	6 2	7 0	—	—	—	—
3¾	—	—	—	—	6 3	6 9	8 0	9 0	—	—	—
4	—	—	—	—	6 6	7 2	8 0	8 9	9 9	10 6	—

Subject to usual terms to millowners. Some firms would charge from 10 to 20 per cent. less than above rates.

CHAPTER XII.

MILLWRIGHT WORK, continued.—GENERAL CONTRACTS.

WE have now reviewed and illustrated by examples, in sufficient detail, all those large classes of productions which go to constitute millwright work. General estimates and contracts for millwright work simply consist of combinations, of course in ever-varying proportions, of those productions which we have now examined; but it may be desirable, before passing on to deal with machines and engines, to give two examples of general estimates of millwright work.

The first shall be an estimate for work in connection with a flour-mill extension, and the second for work in connection with a spinning-mill extension.

The former will be made up at profit rates, in accordance with the method most generally adopted, because of its convenience, and the latter will be an estimate made up in accordance with the more scientific and useful method, which seeks to set out the probable actual cost of the work in view to the manufacturing engineer. It will be seen that the latter method involves rather more labour than the former, both actual in the preparation of the estimate itself and retrospective, as much careful analysing and tabulating must be done before the percentages and some of the other rates can be determined. The information which this method conveys to the practical man of business is, however, worth very much more than the extra trouble necessitated. Of course it is quite easy to determine what the selling price of any particular part of the estimate will be. The percentage added to the whole for profit, if added to any particular item (with its corresponding charge for indirect expenses if an item for labour) will, of course, give the proposed selling price for that item.

EXAMPLE No. 80.

September ——, 188—

SPECIFICATION OF FIXINGS, SHAFTING, GEARING, ETC., REQUIRED IN CONNECTION WITH 16 PROPOSED NEW PAIRS OF MILLSTONES FOR

MESSRS. ________________

	cwt. qr. lb.	s. d.	£ s. d.
1 wall box, 3 ft. 6 in. by 3 ft. 6 in. by 2 ft. 5 in. deep, with bridge for 9 in. pedestal	20 0 0	8 0	8 0 0
2 wall boxes, 3 ft. by 3 ft. by 2 ft. 5 in., with bridges for 6½ in. pedestals	30 0 0	9 0	13 10 0
8 pedestals, 6½ in. by 12 in. long		110 0	44 0 0
6 „ 6 in. by 12 in. „		100 0	30 0 0
6 „ 5½ in. by 12 in. „		90 0	27 0 0
(All with shell caps and single brasses.)			
40 tail bolts and nuts	1 3 14	0 3	2 12 6
2 hammered scrap-iron shafts, each 17 ft. 8 in. by 6½ in. diameter, with bosses and collars Forged weight	48 0 0	20 0	48 0 0
2 ditto, each 18 ft. by 6 in.	44 0 0	20 0	44 0 0
2 ditto, each 18 ft. by 5½ in., with solid flange couplings	40 0 0	20 0	40 0 0
Turning shafts all over .. .. 27 days		16 0	21 12 0
Planing key-beds .. .. .. 6 „		16 0	4 16 0
Drilling bolt-holes in flanges .. 6 „		12 0	3 12 0
26 bolts and nuts, 6 in. by 1¼ in., for coupling..	1 0 0	0 3	1 8 0
Turning and fitting bolts .. .. 6½ days		12 0	3 18 0
1 machine-made spur wheel, 7 ft. 2½ in. by 78 by 3½ by 9	31 0 0	13 0	20 3 0
2 ditto pinions, 4 ft. 9½ in. by 52 by 3½ by 9 ..	40 0 0	13 6	27 0 0
Slotting four key-beds in each .. 1½ day		14 0	1 1 0
12 wrought-iron keys, 12 by 2¼ by 1⅛	0 3 17	0 6	2 10 6
4 wrought-iron hoops for 78 cog wheels ..	1 3 0	0 4½	3 13 6
Keying three wheels on shaft .. 6 days		9 0	2 14 0
Smith (shrinking on hoops) .. 1 day			1 0 0
16 bevel mortise wheels, 4 ft. 6 in. by 80 by 2⅝ by 5¼, split and bolted	116 0 0	12 0	69 12 0
64 bolts and nuts, 5 by 1¼ } 32 „ „ 5 by 1⅛ }	5 0 0	0 3	7 0 0
Splitting and bolting .. .. 14 days		9 0	6 6 0
Boring centres and turning rims 28 „		15 0	21 0 0
Slotting key-bed in each .. .. 3 „		14 0	2 2 0
Cogging with seasoned beech 1280 cogs ..		2 0	128 0 0
16 wrought-iron keys, 8 by 2 by 1	0 2 15	0 6	1 15 6
Grinding ditto .. .. .. 1½ day		16 0	1 0 4
Keying all wheels on shafts .. 8 days		9 0	3 12 0
2 pairs of fluted cast-iron columns for first-shaft bearings, 6 ft. 8 in. by 7 in. diameter..	16 0 0	9 0	7 4 0
2 cast-iron bridges for ditto	4 2 0	9 0	2 0 6
8 bolts and nuts, 4 in. by ⅞ in.	0 0 14	0 4	0 4 8
8 coach screws for tops of columns .. .. } 8 rag end bolts for bottom .. .. .. }	0 0 21	0 4	0 7 0
Fitting and bolting .. .. .. 2 days		9 0	0 18 0
18 cast-iron columns, 5 ft. 10 in. by 5 in. by ⅝ in. thick, to carry platforms	40 0 0	9 0	18 0 0
36 coach screws, 5 in. by ⅝ in. .. .. .. } 36 rag end bolts, 6 in. by ⅝ in. .. .. .. }	0 1 18	0 5	0 19 2
Pattern-making on above			
Wall boxes and pedestals.. .. 6 days		10 0	3 0 0
Columns .. .. 1 day		10 0	0 10 0
Mortise wheel, new full pattern 12 days } Spur wheel and pinions, patterns for machine }	Included in prices.		
Carriage and freight, say	24½ tons	40 0	49 0 0
Erection of above—two millwrights only—all assistance to be provided by mill-owners 80 days		9 0	36 0 0
Travelling time and expenses			4 10 0
Draughtsmen (making working drawings, tracings, etc.) .. .. .. 6 days		12 0	3 12 0
			£717 3 8

Net amount of tender, £717 3*s*. 8*d*. Order entered at £700 net.

The rates in above specification were in several respects somewhat below those usually asked in the establishment in question. They are, however, very fair rates, and such as most engineering firms would be willing to accept. The rate put down for the erection was intended to include the men's allowance; and it will be seen that it was not considered necessary to add anything specially for contingencies.

Example No. 81.

February _____, 18____.

ESTIMATED COST OF FIXINGS, PEDESTALS, SHAFTING, PULLEYS, ETC., REQUIRED FOR PROPOSED EXTENSION AT ____________________ MILL.

Messrs. ____________________

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	16 hangers, 13½ in. from beam to centre of shaft, for 4½-in. pedestals	23 0 0	7 6	8 12 6
	64 gibhead bolts and nuts, 5 by 1⅛	1 3 4	0 2½	1 17 6
	1 C. I. channel beam, 9 ft. long	6 2 0	6 9	2 6 11
	8 bolts and nuts, 4½ in. by ⅞ in.	0 0 12	0 2½	0 6 6
	2 C. I. beams, 19 ft. 6 in. by 16 in. deep	30 0 0	6 9	10 2 6
	1 C. I. bridge for ditto..	2 2 0	7 6	0 18 9
	4 bolts and nuts, 3½ in. by ⅞ in.	0 0 6	0 2½	0 1 3
0 1 10	Fitting and bolting .. .. ¾ day		4 10	0 3 8
	2 C. I. fixings to go on top of fireproof beams ..	6 0 0	7 6	2 5 0
	8 bolts and nuts, 4 in. by ⅞ in.	0 0 12	0 2½	0 2 6
	2 C. I. cross beams, 11 ft. by 16 in...	19 0 0	6 9	6 8 3
	1 C. I. bridge between ditto..	6 0 0	7 6	2 5 0
	12 bolts and nuts, 4 in. by 1 in. and 4½ in. by ⅞ in.	0 0 20	0 2½	0 4 2
	1 wall box, 2 ft. by 2 ft. by 2 ft., for 4½ in. pedestal	8 0 0	7 6	3 0 0
0 2 5	Fitting and bolting beams .. .. .. 1 day		4 10	0 4 10
	1 wall box, 3 ft. by 3 ft. by 1 ft. 6 in., for 5½-in. pedestal	11 0 0	7 6	4 2 6
	22 pedestals, 4½ in. by 6¾ in. long, with double brasses, oil dish at each side with lubricating rings, cap bolts long enough for fixing ..		50 0	55 0 0
	2 C. I. pedestals and caps, 5½ in. by 14 in. ..	6 0 18	7 6	2 6 3
	4 brasses for ditto	1 1 8	0 10	6 3 4
	4 cap bolts, 12 in. by 1⅛ in.	0 0 20	0 2½	0 4 2
	4 tail bolts, 6 in. by 1¼ in.	0 0 17	0 2½	0 3 7
0 12 6	Boring and facing .. .. .. 2 days		5 0	0 10 0
0 14 6	Fitting .. .. 6 „		4 10	1 9 0
0 1 0	Drilling .. .. 2 hours		3 0	0 0 8
	11 lengths of 4½ in. wrought-iron shafting, about 197 ft. in all, all plain except one boss on one length (⅛ in. in diam. allowed for turning) ..	100 0 0	10 9	53 15 0
	Turning ditto .. .. 13 days		5 0	3 5 0
6 3 9	Planing key-beds .. .. .. 3¾ „		4 8	0 17 6
0 5 10	Forging one boss .. .. .. ½ „		11 8	0 5 10
	11 C. I. face couplings in 22 pieces	16 2 0	7 6	6 3 9
	55 bolts and nuts, 4½ in. by 1 in.	1 1 16	0 2½	1 12 6
	44 W. I. keys, two in each half coupling, 7 in. by 1⅛ in. by ⅝ in...	0 2 6	0 4	1 0 8
	Boring and turning couplings .. 19¼ days		5 0	4 16 3
	Drilling bolt holes .. .. .. 8¼ „		3 4	1 7 6
	Turning bolts .. .. 13¾ „		4 8	3 4 2
14 9 5	Slotting key-beds .. .. .. 1½ „		3 4	0 5 0
0 14 6	Keying on couplings .. .. .. 6 „		4 10	1 9 0
	1 hammered scrap-iron shaft, 7 ft. 6 in. long over all, with boss 3 ft. 6 in. by 6½ in., two bearings 5½ by 14, and coupling end 4½	7 0 14	16 0	5 14 0
23 5 9	Carried forward			192 15 0

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
23 5 9	Brought forward			192 15 0
	Turning ditto all over .. .. .. 2½ days		5 0	0 12 6
1 1 2	Planing key-beds .. .. .. 3 hours		4 8	0 1 7
	2 C. I. beams at carding room, 11 ft. by 16 in. ..	19 0 0	6 9	6 8 3
	1 bridge between ditto	6 0 0	7 6	2 5 0
	12 bolts and nuts	0 0 20	0 2½	0 4 2
0 2 5	Fitting and bolting .. .. 1 day		4 1	0 4 10
	1 wall box, 3 ft. by 3 ft. by 1 ft. 6 in., with bridge for 5½ pedestal	11 0 0	7 6	4 2 6
	2 pedestals, 5½ in. by 14 in., as before			12 5 0
	1 hammered scrap shaft, 10 ft. long over all, boss 6 ft. by 6½ in., two bearings 5½, one end left for welding	9 2 14	16 0	7 14 0
1 0 8	Turning ditto all over .. .. .. 2¾ days		5 0	0 13 9
0 2 5	Planing key-bed .. .. .. 3 hours		4 8	0 1 7
	1 piece H. S. shaft, 4 ft. by 3 in.	0 3 12	16 0	0 13 9
0 3 11	Welding ditto .. .. 3 hours		11 8	0 3 11
0 3 9	Turning ditto .. .. ½ day		5 0	0 2 6
	1 C. I. flanged coupling in two parts, 3-in. bore ..	1 3 0	7 6	0 13 2
	4 bolts and nuts, 3½ in. by ⅞ in.	0 0 7	0 2½	0 1 6
	2 keys, 6 in. by ⅞ in. by ½ in.	0 0 2	0 4	0 0 8
	Boring and turning coupling .. 1½ day		5 0	0 7 6
	Drilling holes .. .. ½ "		3 4	0 1 8
	Turning bolts .. .. ¾ "		4 8	0 3 0
0 19 8	Slotting key-beds .. .. .. 1 hour		3 4	0 0 5
0 1 3	Keying on coupling .. .. .. ½ day		4 10	0 2 5
	2 C. I. beams, 11 ft. by 14 in. deep	16 0 0	6 9	5 8 0
	1 C. I. bridge for ditto	4 2 0	7 6	1 13 9
	8 bolts and nuts, 4½ in. by ⅞ in.	0 0 12	0 2½	0 2 6
0 1 10	Fitting and bolting .. .. .. ¾ day		4 10	0 3 8
	1 wall box, 2 ft. by 2 ft. by 1 ft. 6 in., for 3½ in. pedestal	7 0 0	7 6	2 12 6
	2 C. I. pedestals and caps, 3½ in. by 11 in. ..	2 1 16	7 6	0 18 0
	4 brasses for ditto	0 1 24	0 10	2 3 4
	4 cap bolts and 4 tail bolts	0 0 15	0 2½	0 3 2
	Boring and facing .. .. .. 1 day		5 0	0 5 0
0 8 9	Drilling .. .. ¼ "		3 4	0 0 10
0 8 6	Fitting and bolting .. .. .. 3½ days		4 10	0 16 11
	2 pedestal hangers, 3-in. bore, with single brasses		24 0	2 8 0
	1 ditto, 3½ in.		33 0	1 13 0
	1 rope pulley, 64 in. diameter by 12 grooves, 2½-in. pitch, 5¼-in. ropes, bored, turned and slotted. Finished weight	31 2 0	16 0	25 4 0
	1 ditto, 52 by 12 grooves	25 2 0	16 0	15 8 0
	1 ditto, 62 by 6 "	16 0 0	16 0	12 16 0
	1 ditto, 48 by 6 "	12 0 0	16 0	9 12 0
	2 ditto, 52 by 3 "	14 0 0	16 0	11 4 0
	6 W. I. keys	0 1 0	0 4	0 9 7
0 14 6	Keying pulleys on shaft in shop .. 6 days		4 10	1 9 0
	Pattern making—			
	4½ hanger and pedestal .. .. 9 "			
	Channel beam .. .. 2 "			
	Beams, bridges and fixings .. 32½ "			
	Wall boxes and pedestals .. .. 14½ "			
	Couplings .. .. 1 day			
	Hangers .. .. 1 "			
11 5 0	Total .. .. 60 days		5 0	15 0 0
	Taking working dimensions and making drawings .. .. 12 days		6 8	4 0 0
1 0 0				
6 0 10	Erecting all at mill (local) .. .. 50 " (Cartage included.)		4 10	12 1 8
	All builder's work to be done by millowner, and all scaffolding and common labour to be provided by him.			
	Estimated cost, materials, &c.			355 11 7
47 0 5	Expenses			47 0 5
	Total estimated cost			402 12 0
	Add 25 per cent.			100 13 0
				503 5 0

Quoted £500, less 2½ per cent.

Many engineers would add a smaller percentage for profit, especially if they could place reasonable dependence upon the estimate of the gross cost. The method in which such estimates as above are prepared will be sufficiently obvious. The general plans having been prepared—it may be roughly, but in sufficient detail for the purpose—the estimate draughtsman goes carefully over them and writes out on his sheets every item that will be required, calculating weights and filling in other necessary particulars. The sheets are then handed in to the estimate clerk to be priced.

In quoting prices for work, such as illustrated in the last two examples, it is generally advisable to send a separate specification setting out the proposed work, and a separate letter or tender giving the price. The former can then, during the progress of the work, if ordered, or at any time, be handed about amongst foremen or others, without the price being observed; and as a rule neither the engineer who sells nor the millowner who buys cares to have prices too publicly displayed. The specification, after setting out all the principal items, should conclude with a general paragraph somewhat as follows, viz.:—

All the necessary bolts and nuts will be supplied by us.

The whole of the work specified above to be delivered at your mill [if local] and erected ready for starting; it being understood that you will do all masons' or joiners' work, and provide our men with the necessary assistance of labourers and scaffolding. The ropes for the pulleys to be also supplied, and put on by you. (Signature)................................

The tender would then simply be a letter somewhat as follows, viz.:—

To Messrs.................................

Gentlemen,—We propose to supply you with fixings, shafting, rope pulleys, etc., for your new extension, all in accordance with specification and outline plan [when supplied] enclosed, for the sum of £500 (Five hundred pounds), less 2½ per cent., payable upon completion of the work. We shall be obliged by your order, which shall have our best attention.—Your respectfully,

....

When very complete plans are prepared and tracings from them are submitted, the detailed specification may be omitted and reference made in the formal tender merely to "enclosed tracing."

CHAPTER XIII.

MISCELLANEOUS PRODUCTIONS.

HAVING now discussed, as fully as is necessary for our purpose, the millwright section of the business of a general engineering establishment, we shall treat briefly of the miscellaneous productions of such an establishment before passing on to deal with steam engines.

Specialisation.

Those economic forces with which we associate the terms "division of labour," "competition," and so on, are constantly leading engineering as well as other manufacturers to devote themselves more and more to special branches of their businesses, and to the establishment of new houses for the manufacture of very limited classes of productions, and in many cases for the manufacture of only one kind of appliance.

The manufacture of machinery for preparing, spinning, and weaving textile materials has, of course, long constituted a separate branch of mechanical engineering; but even this is now subdivided into numerous departments. There are a few large establishments which still undertake to supply machinery for nearly every operation in connection with the preparing, spinning, and weaving of every textile material; but for one such house there are dozens which devote themselves principally to machinery for one class of textile material, or to machinery for one or two operations only in connection with one or two materials.

The production of wood-working machinery, flour-milling machinery, iron-rolling machinery, machine tools, sugar machinery, gold mining machinery and other classes, are also now firmly constituted special departments of mechanical engineering, mostly carried on specially, though occasionally as portions of general engineering businesses.

Subdivision, however, by no means stops merely with the concentration in the hands of a few special firms of the manufacture of machinery for a particular industry. We have specialists for nearly every kind of engineering productions, including such as are used in common by different industries—for pumps, hoists, cranes, hydraulic presses, weigh-bridges, steam valves, taps, and so on. So much, indeed, is this the case, that the first question anyone who requires any mechanical appliance nowadays asks himself is, "Who makes a specialty of it?" The assumption, of course, is that an article will be obtained at a less price from a house which makes a specialty of it than from one where the article is only made incidentally, as it were.

It is, however, by no means a universal rule that an article will be bought for less from a specialty than from a general house. The former may be able to make it more cheaply; but it is well to keep in mind that a specialty house requires a very extended market, and to secure such market must incur expenses for travellers, agencies, or some form of advertising, for keeping up a stock and on other special accounts, which a general engineering establishment, depending principally upon a local connection, does not incur.

Neither does it follow that an article obtained from a specialty house will be better than one of a similar class obtained from a general establishment. On the contrary, specialty houses are usually under influences which are calculated to make their productions inferior to those of a good general engineering establishment. In the former, the desire to produce as cheaply as possible, and especially to make the cost of an article at one time less than on former occasions, is particularly strong, and very often leads to a reduction of material below what is necessary for securing reasonable durability; whilst piece-work, unless most rigidly supervised, will lead to hasty, and consequently imperfect, workmanship.

However, we are not particularly concerned here either with the advantages and disadvantages, or the causes of this specialisation of mechanical industry. What we are concerned with is the effect of this tendency to specialisation upon those general engineering businesses which are to be found in every industrial centre.

Effect on General Businesses.

That it has had a very decided effect upon these businesses no one will question. It has limited, and is constantly tending to limit, the number of productions which can be profitably manufactured in a general engineering establishment. Formerly, anyone who required a mechanical appliance turned, as a matter of course, to local engineering firms. But now he will consult a directory or the advertising pages of an engineering journal, and send to the end of the kingdom or beyond for quotations.

Nevertheless, there are still many productions of a general character which may be manufactured profitably in a general engineering establishment possessed of fair resources. Amongst these may be reckoned cast-iron tanks and cisterns, iron doors, pumps for general purposes, cranes, hoists, weigh-bridges, railway turn-tables, hydraulic and other presses, mortar mills, clay machinery, millstone frames and gearing, some brewers' and distillers' plant (as mashtuns and backs), some bleaching and finishing machinery (as yarn and cloth boilers or kiers, wash-mills, mangles and calenders), flax scutching apparatus (in certain districts), and so on. It will be obvious that many of these would, if required, lend themselves readily to the development of a specialty business.

It would take too long, and is not necessary for our purposes, to deal with all these productions in detail; but we shall endeavour to give the student a general acquaintance, at least, with the costs and prices of some which may be considered of a representative character, commencing with an example of a plain cast iron tank for holding water. Most manufacturing establishments where steam power is employed require one or more large tanks; whilst engineers are also frequently called upon to quote for such tanks for hospitals, asylums, workhouses, prisons, and other public institutions, either in connection with the arrangements for extinguishing fire, for supplying the steam boiler or boilers, or for the general water supply of the establishment.

Cast Iron Tanks.

EXAMPLE No. 82.—Estimated price for a cast-iron tank 10 ft. long by 8 ft. wide by 3 ft. 6 in. deep for...........(Profit rates.)

		cwt. qr. lb.	s. d.	£ s. d.
	4 flanged plates for bottom, 5 ft. by 4 ft. by $\frac{9}{16}$ thick 4 ditto for sides, 5 ft. by 3 ft. 6 in. by ½ in. .. 4 ditto for ends, 4 ft. by 3 ft. 6 in. by ½ in. ..	47 0 0	10 0	23 10 0
	164 bolts and nuts, 2¾ in. by ⅝ in. for joints ..	0 3 0	0 3¼	1 2 9
	1 W. I. stay, 10 ft. by ⅞ in. diameter			
	2 ditto, 8 ft. by ⅞ in. diameter	0 1 15	0 4	0 14 4
	6 bolts and nuts for ditto, 3½ ft. by ⅝ in. ..	0 0 7	0 5	0 2 11
	Cement putty for joints	1 0 0	0 4	1 17 4
	Fitting tank together in shop .. 3 days		9 0	1 7 0
	Preparing patterns .. .. .. 4 „		10 6	2 2 0
	Paint and painting—2 coats red oxide			0 15 0
				31 11 4

Delivery free on rails; erection not to be included. Quoted £31 10*s.*, less 2½ per cent.

This tender, it will be seen, is equal to rather more than 12*s.* 10*d.* per cwt., on the gross weight of the tank. This is a moderate price, though in some establishments the rate would be at least £1 per ton less. The cost of this tank came out as follows, viz. :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	12 castings	48 0 14	6 9	16 4 10
	Moulders' wages .. .. .. 63 hours			1 18 11
	Bolts and nuts	0 3 14	18 0	0 15 9
	Wrought-iron for stays	0 2 0	10 0	0 5 0
0 3 3	Smith, forging ends .. .. 3½ hours			0 3 3
	Cement, prepared	1 0 0	0 2½	1 3 4
0 8 5	Fitters .. .. 32½ hours			0 16 10
0 16 8	Pattern-makers .. .. .. 38 „			1 2 2
0 3 3	Painter .. .. 18 „			0 6 6
	Materials and wages			22 16 7
1 11 7	Expenses			1 11 7
	Gross cost			4 8 2

Net selling price, £30 15*s.* 7*d.*; gross cost, £24 8*s.* 2*d.*; profit, £6 7*s.* 5*d.*—equal to 25 per cent. on gross cost.

A much smaller rate of profit has, however, frequently to be taken in work of this kind, which is obviously plain, involves little risk, and includes little skilled labour.

Occasionally, where a cast-iron water tank is to occupy a conspicuous position on a building, attempts, more or less (generally less) successful, are made to give an ornamental character to the tank by casting a design of some kind upon the front of the plates, or by casting the plates themselves with curved tops and bottoms. Of course, such tanks are much more expensive than plain ones, as in the above example. Their price may run up to £20 per ton.

EXAMPLE No. 83.—Estimated price for 5 plain single iron doors and frames, 6 ft. by 3 ft. in clear. (Profit rates.)

		cwt. qr. lb.	s. d.	£ s. d.
	5 cast-iron frames, 5 in. by 1⅛-in. section, and with joggles for building into walls and projections for hinges cast on	16 1 0	9 6	7 14 5
	5 wrought-iron plates, 6 ft. 1 in. by 3 ft. 1 in. by $\frac{5}{16}$	10 2 0	12 0	6 6 0
	10 cast-iron hinges	1 0 0	10 6	0 10 6
	10 sets of screws		0 5	0 4 2
	Rivets for hinges	0 0 10	0 5	0 4 2
	5 strong wrought-iron latches and keepers ..		6 0	1 10 0
	Drilling holes .. .. .. 2½ days		3 6	1 13 9
	Fitting .. .. 7 „		10 0	3 10 0
	Pattern-making—preparing stock-pattern .. .. ⅜ day		10 6	0 7 11
	Boiler makers, levelling plates at boiler-shop .. .. 1 „			1 0 0
				23 0 11

Equal to £4 12s. per door. Quoted £4 15s., less 2½ per cent. per door. Order accepted at £4 4s. net. Cost as follows:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Castings (frames and hinges)	17 2 7	6 9	5 18 7
	Moulders' wages .. .. .. 40 hours			1 0 4
	5 wrought-iron (ship) plates	10 1 0	7 3	3 14 4
	10 set pins	0 0 7	9 0	0 0 7
0 1 5	Smiths, at ditto .. .. .. 1½ hour			0 1 5
	5 latches, per account		3 10	0 19 2
	Rivets „ „	0 0 10	0 2	8
	Boiler makers' charge, levelling			17 6
0 16 6	Driller .. .. 25 hours			0 11 0
0 16 2	Fitters .. .. 68 „			1 12 4
0 4 3	Pattern maker .. .. 9 „			0 5 8
	Materials and wages			15 2 7
1 18 4	Expenses			1 18 4
	Gross cost			17 0 11

Net price paid, £21; gross cost, £17 0s. 11*d.*, profit, £3 19s. 1*d.*

EXAMPLE No. 84.—Summary of cost of 14 pairs of single iron doors (two doors back to back), 6 ft. 7 in. by 2 ft. 7 in. in the clear, doors panelled by having flat bars riveted on one side, delivered and fitted up at place (local).

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	28 castings (frames)	72 2 4	6 3	22 19 7
	56 „ (hinges)	5 1 0	6 3	1 12 10
	Moulders' wages			4 13 0
	28 wrought-iron plates	64 1 4	7 3	23 6 1
	Wrought iron for panelling	24 1 0	7 3	8 9 10
	„ „ straps (to tie frames through wall) and pins for hinges .	4 3 0	8 0	1 18 0
	Rivets	3 0	16 0	0 12 0
	28 thumb latches		3 9	5 5 0
	Paid boiler-makers for levelling..			2 14 0
3 5 5	Smiths—Wages paid			3 5 5
9 18 0	Machinists „			6 12 0
6 2 0	Fitters „			12 4 0
1 1 6	„ „ (at place)			4 6 0
0 4 9	Pattern makers—Wages paid at stock patterns			0 6 4
	Materials and wages			98 4 1
20 11 3	Expenses			20 11 8
	Gross cost			118 15 9

Equal to £8 10s. nearly per pair of doors.

Tender, £9 12*s*. 6*d*. per pair net. The latter rate is really a low one for iron doors of this kind well made. £10 10*s*. would have been a very fair price. At the same time, there is no doubt that some little saving might have been effected by careful arrangement and supervision in the workmanship. It may be added that it is unwise to include erection of such doors in the price if it can be avoided, as so much depends upon the builders.

EXAMPLE No. 85.—Cost of 10 double iron doors for hoist openings, 8 ft. by 4 ft. in clear, with panelled fronts, sliding bolts, and 1 Chubb lock to each double door.

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	10 frames and mouldings	129 0 0	7 0	45 3 0
	20 wrought-iron plates	26 3 0	7 3	9 13 11
	Wrought iron in panels, pins, hinges, bolts, rivets, &c.	26 1 0		9 4 0
	10 Chubb locks		6 9	3 7 6
	Boiler-maker's charge			6 14 0
7 2 6	Smiths and helpers..			7 2 6
12 5 6	Machinists			8 3 10
4 0 9	Fitters			9 1 6
0 9 10	Pattern-makers at stock patterns			0 13 1
0 12 9	Draughtsmen			2 11 0
	Material and wages			101 14 4
24 11 4	Expenses			24 11 4
	Gross cost			126 5 8

Equal to £12 10s. 6*d*. per door. Charged £15 per door, less 2½ per cent.

The doors in the last example were a particularly good job, the frames being planed across the face, the edges of the doors planed and most accurately fitted to the frames; the sliding bolts were specially forged and turned, and the whole very carefully done to please a fastidious customer.

We have given an example of each of the three kinds of iron doors in general use, as doors of one or the other kind are in regular demand, sometimes in considerable numbers, in all manufacturing districts. They are, moreover, amongst the few things of which no one as yet appears to have attempted to make a specialty.

CHAPTER XIV.

MISCELLANEOUS PRODUCTIONS, continued.—PUMPS.

BEING required in connection with nearly every manufacturing industry, and in large numbers in connection with some—presenting no special difficulties in the matter of designing, and requiring only very ordinary plant for their production—pumps form an attractive object of manufacture to most engineers, and are within the capacity of most general engineering establishments, at any rate, so far as the common sizes of the ordinary types of pumps are concerned.

We have in consequence numerous makers of pumps, many of whom profess to make a specialty of this branch of engineering productions. Nor can it be questioned that in some instances the pumps of the advertising makers really do possess special features of more or less merit; though in a number of cases the specialty, so far as the design is concerned, consists in some trifling and not always advantageous departure from some well-known standard type. In other instances, again, no special features whatever are set forth—a low price being relied upon for securing business.

Notwithstanding the numerous advertising and special makers of pumps, most large general engineering establishments find it worth while to keep patterns of certain common sizes of some one or other type of pump suitable for general use.

In good establishments these patterns will generally be, and always ought to be, of extra strong design, for if a user goes to a local general engineer for a pump it will, as a rule, be because he thinks he will get a stronger and better made article than he will obtain from the ordinary run of makers, and will be prepared to pay a somewhat higher price in consequence.

Common Types.

There are two types of pumps, at least, of which most large establishments have patterns, viz., the common single-acting plunger pump, which is still frequently used for feeding boilers and for forcing moderate volumes of water considerable heights; and the plain barrel pump, with plunger of the piston type having cup leathers, or some form of metallic packing in the best makes. The latter is generally designed so that it may be made up, in any of the standard sizes, as a single or double-acting pump. The former type is usually made in sizes from 1½ to 3in. diameter of the plunger, and the latter from 3 to 12 in. diameter of the barrel.

Plunger Pumps.

The following example illustrates the cost of a plain plunger pump.

EXAMPLE No. 86.—Cost of one 2 in. plunger pump (4½ in. stroke), all of cast iron, with strong square base, plunger turned, end slotted and drilled for connecting to pump rod, neck and stuffing box of barrel bored, gland bored and turned, valve seats bored, valves turned, top of valve chest faced, cover turned, and flanges of suction and discharge faced :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings	1 0 7	6 3	0 6 8
	Moulders—Wages paid			0 4 10
	2 gland and 4 cover bolts—stock		0 3	0 1 6
	Packing for gland			0 1 4
1 2 8	Machinists—Wages paid			0 15 1
0 2 10	Fitters			0 5 8
	Materials and wages			1 15 1
1 5 6	Expenses			1 5 6
	Gross cost			3 0 7

Charged £4 15s., less 2½ per cent.

Methods of Driving.

The above cost and charge include only the pump, and do not cover any driving apparatus. Various methods of driving these pumps are adopted, the most common being either a disc on the end of a shaft, with a pin and pump-rod connected direct to the head of the plunger, or an eccentric on a shaft similarly connected to the plunger. The latter was adopted in the case of the pump of which the cost is given above. The eccentric block was keyed on a 3-in. shaft making 38 revolutions per minute.

Very frequently these pumps have brass plungers and valves, and sometimes are entirely of brass. In the above case, if the plunger and valves had been of brass the cost would have been about 20*s*. higher, and if the pump had been entirely of brass it would have stood about 90*s*. higher. An air vessel of cast iron would have added about 15*s*. to the cost as given in the statement.

It will be observed that there is no charge for patterns in above statement. A set of patterns for such a pump would cost from 60*s*. to 80*s*., according to the design of the valve chest.

The following table exhibits a fair scale of prices for pumps of this type, and of the most usual sizes:

PRICE LIST OF PLUNGER PUMPS.

Diameter of plunger Inches	1¼	1½	2	2½	3
Cast iron	£4 0 0	£4 5 0	£4 15 9	£6 15 9	£9 0 0
Air vessel, extra	0 18 0	1 2 6	1 5 0	1 15 0	2 0 0
Brass plunger and valves ..	5 0 0	5 10 0	6 5 0	8 0 0	10 0 0
All brass	6 6 0	7 15 0	10 5 0	12 0 0	15 0 0

Many of the cheaper class of houses would put these prices from 10 to 20 per cent. less.

Barrel Pumps. The following examples will illustrate the cost of pumps of the second type mentioned—that is, the ordinary barrel type.

EXAMPLE No. 87.—Cost of one 3-in. vertical double-acting barrel pump (12-in. stroke), cast-iron barrel, valve chests, covers, and connecting branches, cast-iron bucket with cup leathers, wrought-iron pump and forked connecting rod, brass valves and seats, and cast-iron bow guide for pump-rod :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings	5 0 14	6 3	1 12 1
	Moulders' wages			0 13 1
	Brass castings—4 valves and 4 seats, and 3 pairs brushes for connecting rod	16	0 10	0 13 4
	Wrought iron in rod, guard, crosshead, etc..	3 4	10 0	0 7 10
	Cup leathers and sundry bolts, etc.—stores..			0 4 3
0 13 9	Smiths—Wages paid			0 13 9
2 8 0	Machinists "			1 12 0
0 5 7	Fitters "			0 11 2
	Materials and wages			6 7 6
3 7 4	Expenses			3 7 4
	Gross cost			9 14 10

Price charged for pump as above, and not including any driving gear, air vessel, suction or discharge pipe, £15, less 2½ per cent.

Methods of Driving. As in the case of plunger pumps, many different methods of driving vertical barrel pumps are adopted. Sometimes the pump is driven by a disc plate and pin at the end of a short piece of shafting carried on brackets attached to a wall, and receiving motion from some main or other shaft.

A compact, self-contained driving arrangement for a single or double-barrelled pump is formed by a stout cast-iron column with a broad base, or a separate base, to which the pump can be attached, and having the gear for driving at the top. The driving gear will usually consist of a short shaft with a broad pulley to receive the motion from a pair of fast and loose pulleys, and having a small geared wheel at the end working into a larger wheel so as to bring down the speed to a suitable rate for the pump. The large wheel will have a pin to which the connecting rod can be attached. Such a driving arrangement admits of being duplicated to work two pumps, one on each side of the column, and is probably the cheapest self-contained driving arrangement that can be devised for one or two barrels. The column may be utilised as an air-vessel where desired.

A better self-contained arrangement is formed by two **A**-frames with a crank-shaft, which may either be driven direct by a belt or through the medium of gearing, where it is necessary to reduce the speed. The **A**-frames form bearings both for the crank-shaft and for the axle on which the pulley and small driving-wheel are placed. The pump in Example No. 87 was driven in this manner, the cost of the entire driving gear being as follows, viz. :—

Cost of A-frames and driving gear for 3-in. single-barrel double-acting pump :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings, A-frames, base, caps, spur-wheel and pinion, and pulley	7 2 0	6 3	2 6 11
	Moulders' wages			0 13 4
	8 brass bushes	14	0 10	0 11 8
	Wrought iron in single-throw crank-shaft, pulley shaft, pin, tie bars, etc...	3 7		0 12 0
0 10 6	Smiths' wages			0 10 6
1 9 6	Machinists			0 19 8
0 8 0	Fitters			0 16 0
	Materials and wages			6 10 1
2 8 0	Expenses			2 8 0
	Gross cost			8 18 1

Charged £12 10s., less 2½ per cent., making total charge for pump, framing and driving gear £27 10s., less 2½ per cent. If the pump had had the barrel lined with brass, the additional cost would have been about 60s., and the pump might have been charged, say, £4 or £5 higher. A set of patterns for pump in last example would cost about £5, whilst patterns for the framing and gearing would have cost about an equal sum, not including the pulley, for which some regular stock pattern would no doubt be available

EXAMPLE No. 88.—Cost of 6-in. single-barrel double-acting pump, with cast-iron barrel, valve chests, covers, bow guide, connecting branches and bracket, wrought-iron pump rod crosshead and forked connecting rod, etc., brass valves, seat, bushes for connecting rod and guide for pump rod (stroke of pump 15 in.).

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings ..	10 2 21	6 3	3 6 10
	Moulders' wages			1 0 6
	Brass castings	46	0 10	1 18 4
	Wrought iron..	1 3 0		0 19 0
	Leathers and sundries—stores			0 11 0
1 4 6	Smiths—Wages paid			1 4 6
5 1 9	Machinists			3 7 10
0 16 0	Fitters ..			1 12 0
	Materials and wages			14 0 0
7 2 3	Expenses			7 2 3
	Gross cost			21 2 3

Charged £30, less 2½ per cent., for pump only as above. With brass-lined barrel, bucket and muntz metal rod, charged £10 extra—the actual extra weight of brass and muntz metal being 158 lb. The extra cost for independent framing and driving gear for above pump, similar to that described for the 3-in. pump, of which the cost has already been given, would be about £17, and pump as given in above cost, together with framing, would be charged about £55.

Barrel pumps of the kind we are now dealing with are frequently combined in sets of two or three, and arranged to be driven by a double-throw or three-throw crank-shaft. The cost of a pair of pumps, so far as the pumps alone are concerned, would be practically double the cost of a single one, and a set of three practically treble.

For determining the probable cost with framing, if the cost of a single barrel pump be doubled in the case of a pair, and a third be added to the cost of the framing and gear for a single pump, and if the cost of the pump be trebled in case of a three-throw arrangement, and a half be added to the cost of framing and gear for a single pump, a reliable approximation will be obtained. For example: Probable cost of pair of 3-in. double-acting vertical pumps with framing and driving gear—Cost of single pump doubled, £9 14*s.* 10*d.* and £9 14*s.* 10*d.*, equal £19 9*s.* 8*d.*; framing, etc., for single pump, £8 18*s.* 1*d.*, plus one-third, equal £11 17*s.* 6*d.*; total £31 7*s.* 2*d.* Such a pair of pumps would be charged from £40 to £47, complete.

Pumps of this kind may be arranged as well pumps, the pumps proper being placed in the well and connected with the framing and gearing at the top by long rods, and are applicable to numerous other purposes. The following table gives a fair scale of prices for the most usual sizes.

PRICES OF VERTICAL DOUBLE-ACTING LIFT AND FORCE PUMPS.

Diameter of barrel .. .. Inches	3	4	5	6	8
Stroke	12	12	12	15	18
Price of pump only	£15	£18 10	£24	£30	£42
Price of pump and driving gear with A-framing	£27 10	£32	£40	£50	£65
Extra with brass-lined barrel, brass bucket and rod	£6	£7 5	£8 10	£10	£20
Capacity of gallons per hour	1,300	2,500	3,750	6,000	12,000

The pump referred to in Example 86 belongs to the class of simple-force pumps; those in Examples 87 and 88 to the class of combined lift and force pumps; but the patterns of the latter admit of being utilised for the construction of simple lift pumps, by substituting for the solid pump buckets, buckets with valves, and by modifying the valve chests; although simple lift pumps constructed from these patterns would be considerably heavier and more costly than pumps of corresponding size made from patterns specially prepared as simple lift pumps.

Steam Pumps.

Pumps of the classes we have just discussed, whilst they may often be used with advantage, and are still constantly required for many purposes, are not so much in demand now as in former years. Their places are being taken by centrifugal pumps, and still more by steam pumps of the donkey and other direct steam-driven types.

Few general engineers attempt to make centrifugal pumps. Their field of usefulness is not so wide as that of the vertical barrel pump, although in certain circumstances, as for lifting very large volumes of water short heights—as in the drainage of low lands—they are probably the most efficient of all pumps.

Steam pumps—that is, direct-driven pumps—are, however, in such regular demand, and suitable for such an immense variety of circumstances, that it is almost certain to be worth while to go into their manufacture in any well-equipped general establishment.

We shall give one or two costs of pumps of this class by way of illustration.

Donkey Pumps.

The following is a summary of the cost of a donkey pump of the ordinary type, but of strong design, suitable for high pressure, quick speed, and heavy duty.

EXAMPLE No. 89.—Cost of 1 double-acting donkey pump with steam cylinder 7 in. diameter, pump 3½ in. diameter, stroke 7 in.

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron casting (dry sand), steam cylinder and framing and pump	6 1 14	7 6	2 6 10
	Moulders' wages			4 1 0
	Iron castings (green sand)	3 0 14	6 3	0 19 7
	Moulders' wages			0 6 4
	Brass castings	100	0 10	4 3 4
	Wrought iron in rods, spindle, collars, etc. ..	1 0 7	12 0	0 12 9
0 14 5	Smiths' wages			0 14 5
	1 1½-in. steam valve			0 11 9
	2 "Ramsbottom" rings			0 8 6
	Drain taps, oil cups, etc., per stores . .			0 14 4
9 3 0	Machinists—Wages paid			6 2 0
3 2 2	Fitters " "			6 4 3
	Materials and wages			27 5 1
12 19 7	Expenses			12 19 7
	Gross cost			40 4 8

Charged £50, less 2½ per cent., as in table below.

The above was the cost of one pump made by itself. Where half-a-dozen or more can be made at a time, the cost in wages per pump can usually be considerably reduced. Patterns are not included in above—they cost for this size, including drawings, £16 5*s.*—material, wages and expenses. The pump in this example formed one of the following range :—

TABLE OF DONKEY PUMP PRICES, CAPACITIES, ETC.

Diam. steam cylinder	Inches	4½	7	8	10
" water "	"	2½	3½	5	7
Length of Stroke	"	6	7	9	10
Strokes per minute	.. ..	115	100	80	60
Diam. steam pipe	Inches	1¼	1½	1½	2
" exhaust pipe	"	1½	2	2	2½
" suction pipe	"	2½	3	4	4½
" delivery pipe	"	2¼	2½	3½	4½
Gallons per hour	.. ..	1,400	2,850	5,900	9,700
Approximate weight	.. ..	8 cwt.	11 cwt.	14 cwt.	18 cwt.
Price	.. ..	£40	£50	£65	£80

The pumps in above list have brass buckets, liners, valves, and seats, and pump glands and muntz metal rods. The capacities given are supposed to be those which may be obtained when working with say 80lb. steam pressure and against a pressure of about 80lb.

Direct Acting Steam Pumps.

From the ordinary donkey pump we pass by a natural transition to the newer types of direct-acting steam pumps which now receive so large a share of the favour of pump users. In the donkey pump a direct connection is made between the piston of the engine and the pump rod, and a donkey pump therefore represents a distinct advance, so far as the reduction of working parts and simplification are concerned, as compared with any pump in which a belt drive or gearing is employed. Still, in a donkey pump, what is practically a complete steam engine with connecting rod, crank-shaft, eccentric and fly-wheel, and sometimes a governor, is employed to drive the pump.

In those pumps to which the term "direct-acting steam pump" is now applied simplification and reduction of parts is carried a step further, the connecting-rod, crank-shaft, fly-wheel and other parts being dispensed with. There are two general types of direct-acting steam pumps now in common use. In the one the valves of the steam cylinder are actuated by levers or tappets connected with the piston and pump rod; in the other there are no external levers whatever, the valve controlling the admission and eduction of steam being actuated by supplementary pistons contained in the valve-chest or forming a part of the main piston.

The Worthington pump, which is a duplex pump, the motion of one piston being utilised to control the admission and eduction of steam in the other cylinder reciprocally, may be taken as representative of the first type, and the well-known "Special" and "Universal" pumps of the second type. The latter type occupies rather less space than the former, but probably has no other special advantage—it must indeed be considered as the more complicated type.

Whilst special economy in the matter of steam consumption can hardly be claimed for the direct-acting pumps, they have sufficient advantages to entirely outweigh any little extravagance in this regard, being, as they are, extremely convenient, requiring little space and no very heavy foundations, and suitable for almost every purpose for which a pump is required, from the feeding of a boiler to the putting out of a fire. Consequently, a very large business is done in them, and a business which is no doubt profitable to the large makers.

The pumps are now made in an immense variety of sizes, and in several modifications for special purposes, by the special makers; and the prices, at least of English-made pumps, have of late been put very low—doubtless under the stress, to a certain extent, of the competition of American-made pumps, which, however, are still sold at comparatively high rates. Notwithstanding this, these direct-acting pumps are still well worth the attention of manufacturing engineers who can either lay themselves out to make them on the factory system in competition with the makers who now occupy the field, or can depend upon a local or special connection for regular, though not necessarily numerous, orders.

The following is the summary of the cost of a direct-acting pump with external levers for working the steam valve, designed for sale under the latter circumstances.

Example No. 90.—Summary of cost of 1 direct-acting steam pump, having 1 steam cylinder and 1 double-acting pump—pump barrel 6 in. diameter, steam cylinder 10 in. diameter, stroke 15 in.—brass-lined barrel, brass bucket, brass glands and muntz metal pump rod.

		cwt. qr. lb.		£ s. d.
	Material, including moulders' wages and all sundries	14 2 0		27 12 0
	Wages—Machinists, fitter and smiths			11 10 0
	Expenses			10 4 0
	Gross cost			49 6 0

This pump was intended to work up to a capacity of about 9000 gallons per hour, against a pressure of 100 lb. to the square inch, at a speed of 50 strokes per minute, corresponding to a piston speed of 125 ft. per minute. Of course, the pump would admit of being worked at a still higher rate if required. It is one of the advantages of direct-driven pumps that the quantity of water thrown can be regulated within such wide limits. The above pump was intended to be sold at from £60 to £65. The cost of the drawings and patterns stood at £21. A saving in the cost of manufacture, as stated above, to from £5 to £10 was expected to be made in future cases.

CHAPTER XV.

MISCELLANEOUS PRODUCTIONS, continued.—HOISTING MACHINERY.

THERE are at least three classes of hoisting machinery usually made in most large general engineering establishments, viz., crab winches, jib cranes and mill or warehouse hoists. It is safe to say that crab winches are rarely made in such establishments as cheaply as they can be bought from one or two special makers; but apart from the fact that most large firms who have much erecting to do prefer to make winches for the sake of being sure that they have strong and substantial apparatus for their own requirements, winches constitute very suitable and convenient work for apprentices and junior hands at slack times.

Crab Winches.

Hence they are very generally made, though perhaps not with much consideration for their own intrinsic value as profit-earning productions. Two sizes at least are usually made—one to lift up to one ton direct, and up to five tons with the assistance of two and three sheave pulley blocks; and one to lift two and a half tons direct, and up to twelve with blocks. Larger sizes, to lift up to four or five tons direct, are also occasionally made. The best are made so that they may be worked either single or double purchase, and so that the load may be lowered by means of the brake, without the handles revolving.

The following summary gives costs and prices of two—perhaps the most common—sizes.

EXAMPLES Nos. 91 and 92.—Costs and prices of crab winches (single or double purchase at will; with plain lever brakes, and with brass bushes in bearings) :—

	To lift with Blocks—2 and 3 Sheaves.	
	5 Tons. £ s. d.	12 Tons. £ s. d.
Material—including moulders' wages	3 18 6	6 1 6
Wages paid	1 9 7	2 6 0
Expenses	1 4 11	1 18 4
Gross cost	6 13 0	10 5 10
Charged	7 10 0	12 0 0
Weight	7 cwt.	10 cwt.

The smaller sizes may be bought from some houses at from £6 to £7 10s., and the larger at from £9 5s. to £11, including brakes and brass bushes in bearings. Single-purchase winches of the smaller size can be bought for from £4 15s. to £6 10s. For the larger size a double-purchase winch would always be used. There is nothing included in above costs for patterns.

In the establishment where the above were made no other sizes were manufactured; but anyone wishing to make a regular business in crab winches would require to make a range of sizes, somewhat as indicated in the following table, which also gives the highest and lowest prices with which the writer is acquainted. The lower rates can only allow a very moderate margin for profit, for a good article—the higher will allow both a reasonable margin and very good work.

PRICE LIST OF CRAB WINCHES.

Single Purchase.

To lift with 2 and 3 Sheave Blocks.	Prices.	Extra for Brake.	Brass Bushes.
1 Ton	£3 0 0	About 15 0	From 12s. 6d. to 25s.
2 "	£2 5 0 to 4 5 0	10 0 to 20 0	
3 "	2 9 0 " 5 0 0	12 0 " 22 0	
4 "	2 18 0 " 4 17 6	12 0 " 22 0	
5 "	3 9 0 " 5 15 0	12 0 " 22 0	
6 "	4 8 0 " 7 0 0	16 0 " 25 0	
9 "	5 6 0 " 8 0 0	18 0 " 25 0	

PRICE LIST OF CRAB WINCHES.

Double Purchase.

To lift with 2 and 3 Sheave Blocks.	Prices.	Extra for Brake.	Brass Brushes.
4 Tons	£3 10 0 to £7 0 0	10 0 to 25 0	18 0 to 27 6
5 "	4 0 0 " 5 10 0	12 0 " 25 0	18 0 " 27 6
6 "	5 0 0 " 8 0 0	17 0 " 25 0	20 0 " 27 6
9 "	6 0 0 " 10 0 0	17 0 " 25 0	22 0 " 35 0
12 "	7 5 0 " 9 5 0	18 0 " 25 0	22 0 " 35 0
15 "	9 8 0 " 12 10 0	20 0 " 25 0	31 0 " 40 0
18 "	11 16 0 " 16 0 0	28 0 , 40 0	40 0 ..
20 "	16 0 0 ..	40 0 ..	42 0 ..
24 "	.. 19 0 0	.. 60 0	.. 40 0

A simple form of crane in regular demand for warehouse purposes is formed by combining a common crab winch placed inside the warehouse with a wrought-iron jib frame placed outside the warehouse, and provided with grooved pulleys for the chain to pass over. The best form has a complete triangular frame of wrought-iron, with the jib curved a little towards the crane post and suspension bar, strengthened by one or more circular stiffening rings placed in the space formed by the three sides of the triangle and riveted to all three sides. The bottom and top of the crane posts have pivots which rest in sockets in cast-iron brackets attached to the wall.

Warehouse Cranes.

The crane is usually placed by the side of the top warehouse door, a small pair of guide pulleys being placed on the top wall bracket to guide the chain through the wall, and another guide pulley being placed inside the wall to guide the chain down to the winch.

On the opposite page are notes of costs and prices of two very common sizes of this type of crane. To the figures given in the examples must be added the costs of crab winches of suitable power, bringing the prices of the cranes complete except chain, which is usually charged so much per foot, up to £17 and £23 10*s*. respectively, the two winches referred to in Examples Nos. 91 and 92 being those included. The chain usually supplied is $\frac{1}{2}$ in. in the small size, and $\frac{5}{8}$ in. in the larger, being B B short link tested crane chain and charged 11*d*. and 1*s*. 1*d*. per foot respectively.

EXAMPLES Nos. 93 and 94.—Costs and prices of wrought-iron jib cranes, frequently called warehouse cranes :—

To lift	1 ton.	2 tons.
Height of crane post	5 ft.	5 ft. 6 in.
Radius of jib	4 ft.	4 ft. 6 in.
	£ s. d.	£ s. d.
Material—Wrought-iron frame, cast-iron brackets, and wall plate, cast-iron guide pulleys, wrought-iron pins, wall bolts, cast-iron ball, etc.	2 18 6	3 6 0
Workmanship	2 2 0	2 18 0
Expenses	2 6 4	3 6 6
Gross cost	7 10	9 10 6
Charged	9 10 0	11 10 0
Prices of other makers	9 0 0	10 0 0

A cheaper form of crane, in which the crane post is dispensed with (the wall being allowed to form the post), is sometimes supplied; but there can be no doubt that the type described above is a much more substantial arrangement.

Engineers who have a connection with docks and harbour boards, railway companies, and other public bodies find a moderate and fairly profitable business, as a rule, in connection with the ordinary hand wharf crane. This may be briefly described as consisting of a stout central crane post of cast iron, partially sunk in the ground in the best types and connected with single or double foundation plates (usually a casting with six or eight radiating arms). The crane-post has a framing of cast iron carrying the winding gear swung upon it in such a manner that it may be turned completely round. To the lower part of the gearing frame a jib, generally of oak, is attached, the head of the jib being connected with the head of the gearing frame by wrought-iron suspension bars. Sometimes the jib is made of iron in the form of a hollow casting; but good sound oak is mostly preferred, and is no doubt better. The timber offers very great resistance to compression and is more elastic than iron. Its great elasticity is, of course, a valuable feature, enabling it to withstand better than metal the sudden and frequent shocks which it receives. The type will be quite familiar, being found on wharves, railway sidings and goods platforms, contractors', ironfounders' and engineers' yards, and in numerous other situations. The crane is to be obtained in sizes from a half to ten tons lifting capacity, the most common size being the three ton. We append summaries of costs of three sizes.

Wharf Cranes.

EXAMPLES Nos. 95, 96 and 97.—Costs and prices of hand wharf cranes (single and double purchase):—

To lift	3 tons	5 tons	10 tons
Radius	13 ft.	14 ft.	15 ft.
Approximate weight	54 cwt.	92 cwt.	180 cwt.
	£ s. d.	£ s. d.	£ s. d.
Cost of materials, including foundation bolts and plates, oak jib, sufficient length of BB tested short link crane chain to reach the ground level, single-sheave chain pulley with hook, brass bushes in bearings, brake, etc., and including moulders' wages	29 14 0	50 11 8	97 10 0
Other wages paid	7 14 6	11 16 4	21 14 0
Expenses	8 15 0	13 0 6	24 6 8
Gross cost	46 3 6	75 8 6	143 10 8
Charged	60 0 0	95 0 0	185 0 0
Prices of other makers for comparison	48 0 0 to 65 0 0	85 0 0 to 105 0 0	160 0 0 to 210 0 0

Patterns are not included in above. The patterns for the three ton size cost in wages, material and expenses practically £20. The crane posts were in all the sizes loam castings, though there is no reason whatever why the pillars of the small size at least should not be cast in green sand.

It should be understood that the costs are in each case the costs of cranes made singly at odd times, and in an establishment where no special efforts were made to cultivate a business in cranes. The weights might be reduced probably ten or fifteen per cent. in the three ton size, and about five per cent. in the two larger sizes, whilst savings in the time and consequently in the expenses might also be made.

The ordinary warehouse hoist is another hoisting appliance which lies in the way of most general engineering shops of moderate capacity, or at least of such as are situated in towns.

Warehouse Hoist.

This hoist in its simplest form consists of a stout timber cage sheeted on two or three sides and strengthened by wrought-iron tie bolts at each corner and at other points, arranged to slide freely up and down the well of the hoist between two or four guides attached to the wall. One or two ropes attached to the top of the cage pass over a grooved pulley or pulleys at the top of the hoist, and are connected with a balance weight of cast iron arranged to slide in a recess in the wall. The cage is raised or lowered by means of one open and one crossed belt, which drive the pulleys through the medium of a screw and screw wheel. A brake is attached, being carried, together with the whole of the driving gear, on a cast-iron frame fixed at the highest point of the hoist. Passing through the cage are ropes, by which the hoist can be worked from the inside of the cage, as well as from the outside. Provision is also generally made by which the cage will be automatically stopped when it reaches the highest point to which it is intended to go; and refinements in the shape of safety clips or catches, by which the cage will be prevented from falling if the rope breaks, are also sometimes provided, although the screw and screw wheel constitute a sufficient element of security in all ordinary cases where they are employed.

Following are summaries of the costs of three common sizes of such hoists.

EXAMPLES NOS. 98, 99 and 100.—Costs and prices of warehouse lifts or hoists:—

To lift	10 cwt.	20 cwt.	30 cwt.
Size of cage	54 in. × 42 in. × 72 in. high, in clear.	60 in × 48 in. × 76 in. high, in clear.	60 in. × 60 in. × 76 in. high, in clear.
Gross weight	29 cwt.	33 cwt.	42 cwt.
	£ s. d.	£ s. d.	£ s. d.
Cost of material, including moulders' wages, and ropes	20 5 0	24 9 7	30 2 11
Smiths' wages	2 15 7	3 5 0	4 12 6
Machinists' „	2 14 1	3 16 0	5 8 0
Fitters' „ (in shop)	4 13 10	6 15 5	8 14 3
Joiners and pattern-makers' wages.	3 10 0	3 12 1	4 18 0
Draughtsmen's wages	2 1 0	2 17 4	2 16 0
Fitters' (erecting) „	1 14 0	1 16 1	3 2 0
Material and wages	37 19 6	46 11 6	59 13 8
Expenses	12 17 0	16 4 1	21 16 8
Gross cost	50 16 6	62 15 7	81 10 4
Price charged	65 0 0	80 0 0	110 0 0

While the above figures included ropes, they did not include either belts or guides for the cage. A drawing was handed in each case to the buyer, showing how the guides for the cage and the beams at the head of the lift were to be fixed, and all this work was done by the builder. The two smaller sizes had two guides only—one at each side; the largest size had a guide at each corner. All the cages were sheeted with pine on three sides, as well as on the bottom and top. The framework of the cages was of oak. The erection was in each case local. Of course, had it been at a distance, there would have been some additional expense on account of travelling time and expenses, etc.

It must not be supposed that the amounts opposite "Joiners' and pattern-makers" covered the whole cost of the patterns in wages. Most of the pattern-makers' wages, strictly-speaking, were simply on account of alterations of stock patterns, the remainder and all the joiners' time being on the cages. These hoists—or, to be more accurate, lifts, seeing that the actuating power is placed at the top—have almost always to be made up specially, and the design modified as compared with any previous cases. Hence, there will always be found in the cost a (comparatively) large item for draughtsmen's wages incurred in taking working dimensions, making general design, and so on.

CHAPTER XVI.

MISCELLANEOUS PRODUCTIONS, continued.—HYDRAULIC PRESSES AND PUMPS.

It is now close upon a hundred years since Joseph Bramah gave his great invention to the world, and, in the natural exaltation of the moment, claimed for it the distinction of a new mechanical power. Bramah was doubtless a little extravagant in his claims, but even his enthusiastic imagination could hardly have conceived how many and how varied would be the applications of his invention. A mere catalogue of the purposes to which the hydrostatic—or, to use the popular and commercial term the hydraulic—press has been applied would fill many pages, whilst there are now numerous industries in which the press is simply indispensable.

Joseph Bramah.

We may divide hydraulic presses into two or three great classes.

First will come those which are used for compressing or packing material into a comparatively small bulk for convenience of handling during shipment, and for the saving of space (and consequently of charges for freight or carriage) during transit by sea or land. Under this head we may range the ordinary warehouse press now so largely used in this and all textile manufacturing countries, for packing piece goods of nearly every description, together with all the modifications made specially for baling cotton, wool, skins, esparto grass, flax, hemp, hay, straw, and

Types of Presses.

other substances, most of which are, of course, made for use abroad.

Secondly may be placed those presses which are used for expressing liquids or semi-liquids from fibrous, granular and pulpy or paste-like substances, under which head come presses used for expressing water from saturated yarns, particularly linen and other heavy yarns (now being to some extent displaced by centrifugal drying machines or hydro-extractors), together with tallow, stearine and paraffin presses, and presses for expressing the oil from olives and other fruits, linseed, cotton and rape seed, and other substances.

In addition to these two great classes, there are a number of types of presses—for example, forging or moulding presses, printers' presses, and presses used in the manufacture of certain kinds of tobacco—each of which might be held to constitute a class by itself.

Manufacture.

A good deal of mystery is sometimes, and certainly quite unnecessarily, attempted to be associated with the manufacture of hydraulic presses, more especially in connection with the proportioning of the cylinder and in connection with the mixtures of iron used for cylinder and ram. Of course, an apparatus, some parts of which are intended to work under a pressure of one or perhaps ten tons to the square inch, and to exert a total pressure of from fifty to a thousand tons, must be well designed and made from good material, but at the same time there is nothing in either of these conditions which need deter any fairly well-equipped establishment from entering upon the manufacture of these presses. Most large shops, in textile manufacturing places at least, already make them.

Warehouse or Packing Press.

The ordinary warehouse or packing press may be considered the most representative. This is made in many sizes, from 5 in. diameter of ram up to 12 in., and with a rise of from 15 in. to 120 in. Probably the two most useful sizes are the two which are the subjects of the summaries on the opposite page. It will be noticed that in these two examples, although both the cylinders and the rams are loam castings, the former are rated rather higher than the latter. This arises from the fact that a superior mixture of metal was used for the cylinders, of course with the object of securing in the highest degree the two qualities essential in such cylinders—great strength and soundness.

EXAMPLE No. 101.—Summary of cost of 6 hydraulic presses, with rams 8 in. diameter, having a rise of 27 in.; platen, or table, 48 in. by 38 in.; height from top of platen when down to underside of head of press, 72 in.

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	6 cylinders (loam)	140 0 0	8 6	59 10 0
	6 rams (loam)	38 3 0	7 6	14 10 8
	Moulders' wages			18 16 0
	Greensand castings	379 1 0	6 3	118 10 4
	Moulders' wages			15 18 10
	24 wrought-iron columns, with collars forged at each end, 48 nuts, etc.—columns 3½ in. finished diameter	86 3 14	9 0	39 1 11
10 4 0	Smiths' wages			10 4 0
	Brass castings	24	0 10	1 0 0
	6 neck leathers (stores)		6 0	1 16 0
27 6 9	Machinists' wages			18 4 6
4 18 0	Fitters' "			9 16 0
0 6 2	Pattern makers' wages (getting out stock patterns)			0 8 3
	Materials and wages			307 16 6
42 14 11	Expenses			42 14 11
	Gross cost			350 11 5

Sum in contract for above 6 presses, £450 net. Usual price per press, £85.

The above size of press was designed to work up to three tons per square inch in the cylinder, giving, therefore, a total pressure of 150 tons. Pumps are not included in above.

EXAMPLE No. 102.—Summary of cost of 1 hydraulic press, with ram 10 in. diameter, having a rise of 36 in.; platen or table, 64 in. by 48 in.; height from top of platen when down to underside of head of press, 90 in.

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cylinder (loam)	36 3 0	8 6	15 12 5
	Ram (loam)	10 2 0	7 6	3 18 9
	Moulders' wages			4 14 0
	Greensand castings	108 0 0	6 3	33 15 0
	Moulders' wages			4 3 0
	Columns (3½ in.), etc.	16 2 0	9 0	7 8 6
2 3 7	Smiths' wages			2 3 7
	Brass castings	9	0 10	0 7 6
	Neck leather, etc. (stores)			0 18 4
7 4 6	Machinists' wages			4 16 4
0 19 11	Fitters			1 19 10
0 9 0	Pattern makers (getting out stock patterns and repairing same)			0 12 0
	Materials and wages			80 9 3
10 17 0	Expenses			10 17 0
	Gross cost			91 6 3

Charged £130 net for press alone, as above.

This press was intended to work with a pressure of two and a-half tons per square inch in the cylinder, giving a total pressure, therefore, of close upon 200 tons. It may be pointed out that a variation in the height of a press may easily be made at a trifling additional expense when the height is increased, and without additional expense when the height is reduced—the columns merely require lengthening or shortening. An increase in the rise of the ram may also be made, within certain limits, at a moderate additional cost, as the cylinder and ram merely require to be made longer; all the other parts of the press may remain the same. An increase in the size of the table, or platen, means new patterns for platen, sill or base, and the top of the press, and, consequently, considerable extra cost—practically, in fact, a new size of press altogether.

Modifications of Size.

For both the two sizes of presses given above a similar set of pumps was usually supplied. The pumps were of the ordinary type for hand power, with cast-iron cistern, brass barrels, valves, and plungers, and wrought-iron levers. Each set had two pumps, one 2 in. in diameter, and one 1 in. in diameter—the large pump being, of course, used for quickly filling up the cylinder, and the small one for putting on the extreme pressure. The pumps cost about £20 per set, including the usual expenses, and were charged £30.

Press Pumps.

The usual quotation for an 8 in. press, with set of double pumps, the necessary connections between press and pumps, and including delivery and erection (local), was £120, and for a 10 in. press and pumps, etc., £165—the foundations for the presses being, of course, prepared by the buyer.

In cases where steam or gas power is available, pumps constructed so that they may be driven by power, instead of by hand, are frequently supplied. A set of double pumps as described above, with power drive attachment, and provision for working by hand also, when necessary, cost £42, and was charged £60. Pumps for power drive only are frequently made with both plungers of equal size (1 in. diameter generally), the press cylinder being filled up with sufficient rapidity when the pumps are driven by power, without the use of the large-sized plunger. Power pumps with three plungers for serving a number of presses are occasionally required.

The following table exhibits a range of sizes of plain hydraulic presses, from which most ordinary requirements may be filled :—

Diameter of ram	Inches	6	8	10	12
Rise of ram	„	24	27	36	48
Pressure per sq. in. in cylinder	Tons	3	3	2½	2
Total power	„	84	150	190	226
Clear height with platen down	Inches	60	72	90	100
Size of platen..	„	46 × 36	48 × 38	64 × 48	90 × 56
Price of press only		£70	£85	£130	£220
Set of hand pumps extra		£25	£30	£30	£30
Do. power pumps		£60	£60	£60	£60
Approximate total weight	Tons	4	5½	8½	12½

Press Repairs.

The ram of any hydraulic press in constant use will wear, and in course of time will require to be renewed. Quotations, definite or approximate, are not infrequently asked for for such a renewal, and the other work at the press which is always necessitated by the renewal. The following is a copy of an estimate for such a case :—

EXAMPLE No. 103.—Estimated price of 8 in. hydraulic press repairs for __________________. (Profit rates.)

			cwt. qr. lb.	s. d.	£ s. d.
	1 new ram		7 0 0	14 0	4 18 0
	Turning ditto..	2 days		20 0	2 0 0
	Drilling and fitting pin	½ day		15 0	0 7 6
	Re-boring present cylinder ..	1½ days		25 0	2 5 0
	„ „ platen	1 day		25 0	1 5 0
	Taking out present cylinder and ram, replacing same, and putting in new ram, leaving press ready for work:—				
	Fitter	3 days		12 0	1 16 0
	Labourer	3 „		4 6	0 13 6
	1 new neck leather				0 13 0
					13 18 0

Quoted £14 net, and ordered at this price.

One small point in above should, perhaps, have special reference. It will be seen that a labourer's time outside is specially included—the press being at a warehouse only, suitable labour for assisting a mechanic was not attainable there, and had, therefore, to be sent from the engineers' shop.

CHAPTER XVII.

MISCELLANEOUS PRODUCTIONS, continued.—BLEACHING MACHINERY.

MUCH of the machinery used in the bleaching, printing, and finishing of textile material—particularly cotton and linen—is of a heavy description; some, indeed—the larger-sized calenders and mangles, for example—being of a very massive character. Consequently, such machinery lies very decidedly in the way of good general engineering shops situated in those districts where it is used. Most large general establishments, indeed, situated in districts where much bleaching is done, have a connection more or less intimate and complete with the bleachworks, and will actually manufacture some classes of the machinery or plant required in bleaching, although few, if any, may produce every kind of machinery used in this and its allied industries.

Great changes have, however, been made during recent years in many of the processes connected with bleaching and finishing; and some old-established engineering houses who formerly had practical monopolies in regard to certain classes of bleaching plant have found themselves cut out by younger and more enterprising firms, who have either introduced novelties of their own or have taken up and developed ideas or processes suggested by practical bleachers. Much of the machinery, therefore, which the older firms formerly supplied, and could still make better than anyone else, is now obsolete.

We cannot dwell upon this class of machinery, but may adduce the following few examples by way of illustrating its character and possibilities in the way of manufacturing profits.

It may be premised that there is rarely much opportunity in this class of machinery for the introduction of piecework, or for effecting economy in manufacture by making in quantities. Such machinery is almost invariably made up specially to definite orders; and modifications of design to satisfy some special requirement or some whim on the part of the buyer are frequently required.

It will be seen that in none of the following examples is the cost of complete new patterns included. Complete patterns for the mangles would be expensive; but the cost of patterns for the kiers would not be serious, as the kiers themselves are made from very simple loam boards. The costs per cwt. of the principal castings in examples Nos. 104 and 105 are practically 9*s*. 9*d*. and 11*s*. respectively.

EXAMPLE No. 104.—Cost of one yarn boiler (also styled "kier" and "kieve"), 6 ft. 6 in. diameter across top, 6 ft. 3 in. diameter at bottom, and 6 ft. deep, with inlet and run-off branch cast on bottom, and fitted with perforated false bottom, central stand or vomit pipe, and wrought-iron cover or lid, with spreader on underside, safety valves on top, and provided with wrought-iron hinge and holding-down bolts and nuts with handles:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Boiler (loam casting)	43 0 0	7 6	16 2 6
	Moulders' wages			4 16 8
	Green-sand castings	12 0 0	6 3	3 15 0
	Moulders' wages			0 18 0
	Brass castings	6	0 10	0 5 0
	Wrought iron in bolts, handle-nuts, hinge and holding-down straps, etc.	1 2 14		0 17 10
	Rivets	10	0 2	0 1 8
1 13 1	Smiths' wages, including riveting, straps, etc. on lid or cover			1 13 1
	1 boiler cover, per boiler-shop account ..	5 2 0		8 6 0
1 3 3	Machinists—Wages paid			0 15 6
0 15 3	Fitters „			1 10 5
0 8 3	Pattern makers „ (stock patterns) ..			0 11 0
	Materials and wages	62 1 2		39 12 8
3 19 10	Expenses..			3 19 10
	Gross cost			43 12 6

Charged £60 net, no pipes or valves external to the boiler or kier proper being included.

Kiers or boilers practically the same as described above constitute an essential element of a bleaching plant, whether for yarn or cloth. Larger kiers, when made in cast iron, are usually made in two parts, the upper one being simply a large hollow truncated cone, with a flange top and bottom, the bottom part being in the shape of a large deep dish, flanged at the top to join to the upper part. The upper half of such a kier is sometimes called a "crib." The following summary shows the cost of a kier of this kind.

EXAMPLE No. 105.—Summary of cost of boiling pot or kier 7 ft. diameter at top inside, tapered to 6 ft. 6 in. at false bottom, in two parts—crib or upper part 3 ft. 3 in. deep, bottom 3 ft. 6 in. deep, with wrought-iron cover and accessories, as in Example No. 104:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Crib casting (loam)	19 0 0	7 6	7 2 6
	Bottom ,, ,, ...	34 1 0	7 6	12 16 11
	Moulders' wages			9 2 0
	Greensand castings	11 2 0	6 3	3 11 11
	Moulders' wages			0 19 1
	12 wrought-iron straps, 2 hinges, 12 hinged bolts and lever nuts, 2 eye bolts, 30 joint bolts and nuts and other wrought-iron ..	1 3 21		1 2 9
	Rivets	14	0 2	0 2 4
2 8 10	Smiths' wages			2 8 10
	Wrought-iron cover, 7 ft. 6 in. diam. of plate, ¼ in. thick, per boiler-shop account	6 1 0	30 0	9 7 6
2 3 2	Machinists' wages			1 8 9
1 2 10	Fitters' wages			2 5 8
0 6 0	Pattern-makers—stock patterns			0 8 0
	Materials and wages	73 0 7		50 16 3
6 0 10	Expenses			6 0 10
	Gross cost			56 17 1

Charged £75 net for a single kier; charged £72 10*s.* net per kier for 6 kiers. These prices being at the engineer's shop, no cartage or erection or any accessories external to the kier being included.

It will be noticed that the kiers referred to in the two last examples had each a lid or cover, covering the whole of the top, the hinge being placed at the edge of the kier. As these covers are necessarily too heavy to be conveniently raised by hand, a small winch is usually provided for the purpose, the winch being generally attached to a wall. The price charged for a wall winch in connection with the above kiers was £7 or £7 10*s.* The material to be boiled may be most conveniently put into and taken out of such pots, or kiers, as those in the above examples, by being first placed in a large net and then lifted into the pot by a crane, the net being hung on to a wrought-iron cross attached to the end of the crane chain. A crane for the purpose, and having a timber (memel) pillar, jib and stay, screw wheel gearing, chain and sheaves, was usually charged £45 to £55, with £5 extra for wrought-iron cross. A suitable net was charged from £6 10*s.* to £8. In some cases kiers are required with open tops—that is, without lids; whilst, again, wrought-iron kiers for boiling under high steam pressure, with closed tops provided with large manholes (two usually), to allow the goods to be put in and taken out, are not infrequently wanted.

Winches for Kiers.

Example No. 106.—Cost of 1 starch mangle with 2 sycamore bowls, 50 in. face, 20 in. and 16 in. diameter, 1 brass bowl, 50 in. face and 10 in. diameter, brass plate spreader, compound levers (top and bottom), coupling rods and adjusting screw boxes, wrought-iron top-setting screws and hand-wheels, strong cast-iron side frames and brass bearings, etc.; driving gear, consisting of spur wheel on end of bottom roller axle, pinion and pair of fast and loose pulleys, 18 in. by 4 in., on axle 4 ft. long, with cast-iron stands, and 2 2-in. pedestals with double brasses. Speed arranged to deliver cloth at 60 yards per minute:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings (green sand)—			
	2 side frames	10 3 0	6 3	3 7 2
	Sundries	7 0 0	6 3	2 3 9
	Moulders' wages			1 10 4
	Brass roller, 1 in. thick on body	5 1 0	0 10	24 10 0
	Brass bushes, spreader, etc.	1 0 8	0 10	5 0 0
	Wrought iron	7 2 0	10 0	3 15 0
3 19 10	Smiths' wages			3 19 10
	2 sycamore rollers		35 0	3 10 0
	Set screws, etc.—per stores			0 9 0
10 19 0	Machinists' wages			7 6 0
1 13 4	Fitters' wages			3 6 8
0 18 5	Pattern-makers' wages—alterations of stock patterns, new spreader pattern, etc.			1 4 6
	Materials and wages	31 2 8		60 2 3
17 10 7	Expenses			17 10 7
	Gross cost			77 12 10

Charged £98 net, delivered (local), and £2 10s. extra for erecting, the cost of which is not included in above. No trough included—this being provided by buyer.

Example No. 107.—Cost of 1 mangle, similar to the one described in last example, but with 2 sycamore rollers, each 20 in. diameter by 63 in. long, and 1 brass roller, 10 in. diameter by 63 in. long, with cast-iron core:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings (greensand)—			
	2 side frames	11 3 0	6 3	3 13 5
	1 roller	4 3 0	6 3	1 9 8
	Sundries	6 1 0	6 3	1 19 1
	Moulders' wages			1 18 10
	Brass bowl and spreader	6 2 14	0 10	30 18 4
	Brass plates, blocks, etc.	3 10	0 10	3 18 4
	2 sycamore bowls			5 10 0
	Wrought iron	7 3 4	10 0	3 17 11
5 0 4	Smiths' wages			5 0 4
	Bolts, etc.—per stores			0 8 2
14 11 0	Machinists' wages			9 14 0
3 9 0	Fitters' wages			6 18 0
0 15 3	Pattern-makers—getting out, repairing and strengthening stock patterns			1 0 4
0 5 5	Draughtsmen			1 1 8
	Materials and wages			77 8 1
24 1 0	Expenses			24 1 0
	Gross cost			101 9 1

Charged £150, less 5 per cent. commission, and including packing for shipment and delivery free on rails (local). Packing cost £3 4s., which must be added to above to make total cost. No trough included. Drawings for making this of timber at destination were supplied. No driving gear included.

The replacing of mangle and calender bowls constitutes an important element of the work in connection with bleaching and finishing, which is done in those engineering shops where machinery for the purposes named is made. The following examples will sufficiently illustrate this kind of work:—

Mangle Bowls.

EXAMPLE No. 108.—Cost of two sycamore bowls, each 50 in. face by 20 in. diameter, with wrought-iron axles 2½ in. diameter at ends, collars, filling rings and wedges:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	2 sycamore sticks		35 0	3 10 0
	Wrought iron	3 0 21	10 0	1 11 11
0 14 4	Smiths' wages			0 14 4
1 9 8	Machinists (turner, 36 hours)			0 19 9
0 2 6	Fitter (9 hours)			0 5 0
	Materials and wages			7 1 0
2 6 6	Expenses			2 6 6
	Gross cost			9 7 6

Charged £13 10s. net.

Frequently an old bowl is sent in to be replaced by a new one, and to have as many of the old parts as can be, used again. Following is copy for an entry of a job of this kind.

EXAMPLE No. 109.—Charge for replacing old sycamore mangle bowl with new bowl—old parts used again. Size about same as in No. 108:—

		cwt. qr. lb.	s. d.	£ s. d.
	1 new sycamore bowl			3 0 0
	Piercing old axle	1 14	0 4	0 14 0
	2 new wrought-iron collars and 8 new wedges	27	0 5	0 11 3
	Taking out old axle, etc., boring new bowl, fitting in repaired axle, turning grooves for old filling rings, and turning up bowl and axle ends and collars (about 16 hours of a turner and 8 of a fitter or millwright) ..			1 17 6
				6 2 9

Less 2½ per cent. monthly.

EXAMPLE No. 110.—Summary of cost of cast-iron calender bowl, 4 ft. face by 12 in. diameter, with wrought-iron axle:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cast-iron bowl (loam)	8 2 0	7 6	3 0 0
	Moulders' wages			0 18 4
	Wrought iron in axle and keys	1 1 21	10 6	0 15 1
0 7 0	Smiths' wages			0 7 0
1 10 3	Machinists (turner 36 and planer 1 hour) ..			1 0 2
0 3 11	Fitters (14½ hours)			0 7 10
0 3 6	Pattern-makers (8 hours)			0 4 8
0 0 9	Draughtsman			0 3 0
	Materials and wages			6 16 1
2 5 5	Expenses			2 5 5
	Gross cost			9 1 6

Charged £13 net.

EXAMPLE No. 111.—Estimated price of cast-iron mangle bowl, 90 in. face by 18 in. diameter, with wrought-iron axle 10 ft. long over all, 3½ in. diameter in body, with two bosses 5 in. diameter. (Profit rates):—

		cwt. qr. lb.	s. d.	£ s. d.
	1 cast-iron bowl in loam (extra hard mixture)	30 0 0	12 6	18 15 0
	1 wrought-iron axle	3 2 0	28 0	4 18 0
	2 wrought-iron keys	0 0 5	1 0	0 5 0
	Boring and turning bowl and axle 9½ days		20 0	9 0 0
	Planing key-bed in axle .. .. .. ½ day		16 0	0 8 0
	Cutting key-beds in bowl and keying on axle .. .. 2 days		10 0	1 0 0
	Pattern making .. .. 1 day		12 0	0 12 0
				34 18 0

Quoted at £35 net. Order placed with another house at about 10 per cent. less.

EXAMPLE No. 112.—Summary of cost of three mahogany calender bowls, each 44 in. face by 16 in. diameter, with wrought-iron axles:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	1 mahogany log, 18 ft. × 17 in. (being at the rate of 1s. per superficial foot per inch thick)		17 0	15 6 0
	Wrought iron in axles, hoops, wedges and collars	5 3 14	10 0	2 18 9
2 8 2	Smiths' wages			2 8 2
5 18 6	Machinists' wages..			3 19 0
0 6 1	Fitters' wages			0 12 1
0 0 11	Draughtsman			0 3 6
	Material and wages			25 7 6
8 13 8	Expenses			8 13 8
	Gross cost			34 1 2

Charged £45, less 2½ per cent.

EXAMPLE No. 113.—Summary of cost of one brass spread roller, 5 ft. 6½ in. face by 6 in. diameter, with wrought-iron axle:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Brass casting	2 3 8	0 10	13 3 4
	Wrought-iron axle	0 2 14	10 0	0 6 3
0 2 1	Smiths' wages			0 2 1
2 4 6	Machinists' wages			1 9 8
0 1 8	Fitters' wages			0 3 3
0 2 0	Pattern makers' wages			0 2 8
	Material and wages			15 7 3
2 10 3	Expenses			2 10 3
	Gross cost			17 17 6

Charged £25 net.

Modern Calender.

It may be interesting in this connection to give the amounts of the tenders made for a "3-bowl calender, having two bowls of cast iron, covered with rubber and 42 in. face by 18 in. diameter; one bowl of brass, 42 in. face by 9 in. diameter, with the usual compound levers, entering rails, batching gear, and cast-iron framing, with brass side-plates, etc." Four tenders were sent in—two English, one

Scotch, and one Irish. They were respectively as follow—£200, £210 (with a lighter alternative arrangement of framing at £185), £225, £215. Side gearing for driving extra, varying from £22 to £35. All at works or free on rails in maker's town.

EXAMPLE No. 114.—Summary of cost of two double beam beetling engines, with sycamore beams 10 ft. 6 in. face by 18 in. diameter, beech beetles, cast-iron wipers, and framing, and with single traversing gear for each machine :—

£ s. d.				£ s. d.
	Materials			82 4 0
4 13 0	Smiths' wages			4 13 0
32 1 0	Machinists, millwrights, fitters, etc.			41 6 0
	Material and wages			128 3 0
36 14 0	Expenses			36 14 0
	Gross cost			164 17 0

Price £220 net, packing and delivery on rails in maker's town £7 extra. Sometimes charged about 5 per cent. less.

New beetling beams for above, with wrought-iron gudgeons, rings and wedges, etc., turned and finished complete, were usually charged from £10 10*s.* to £12. The sycamore logs, roughly squared to finish to size given above, cost from £4 10*s.* to £5. Extra beetles of seasoned beech about 6 ft. long by 4½ in. by 4 in., in the rough, were usually charged about 30*s.* per dozen.

CHAPTER XVIII.

MISCELLANEOUS PRODUCTIONS, continued.—BRICK-MAKING MACHINERY AND MORTAR MILLS.

It cannot be contended that brick-making machinery has realised the expectations formed of it some years ago, either with reference to the quality of the brick produced or with reference to the cost of manufacture, as compared with hand-made bricks. There is still unquestionably much room for improvement in the construction of brick-making machinery alike with the view of producing a more perfect brick than is usually made now, and in saving time in drying and expense in handling. Notwithstanding, however, the admitted imperfection of brick-making machinery, there is quite sufficient demand for such machinery, both at home and abroad, to justify a good and well-equipped general engineering establishment in devoting some time to its study, and even in sinking some capital in patterns, with a view to cultivating a business in machinery of this class.

Arrangement and Capacity of Plants.

In its simplest form, a brick-making plant consists of a pug mill with two mouthpieces and two cutting tables. An elementary plant of this character is not infrequently required for use with horse-power, and to make 5,000 to 7,000 bricks per day of ten hours. Of course such a plant means that the clay as got from the ground is in a fit condition to be put into the pug direct, and also assumes that the clay will be fed into the pug by hand.

What may be considered a complete plant will include, apart from motive power, a clay-crushing roller mill, which may either have a single or a double pair of rollers, or five rollers; a pug mill with mouthpiece; a pair of cutting tables; hauling gear and clay wagons for hauling the clay out of the pit direct up to a platform on a level with the top of the rollers; and a brick pressing machine for giving a more compact structure, more exact shape, and better-finished appearance to bricks required for facing and other special purposes. Plants of this character are required for producing from 10,000 to 25,000 or 30,000 bricks per day of ten hours.

Sometimes an edge roller mill, similar to a mortar mill, is substituted for the horizontal roller mill for the preliminary grinding or crushing of the clay. Mixing pans and screens are also sometimes required; whilst a complete plant will usually include dies for making perforated, hollow, and other special bricks, pipes, and tiles. We append notes of the costs and selling prices of a plant capable of making 30,000 bricks per day.

It may be well to note that all the machines in the following four examples are on the heavy side. The weights would admit of appreciable reduction without serious detriment to the efficiency of the machinery. It is, of course, true that machinery of this character must be very strong, as the work is, under the most favourable circumstances, very heavy; whilst the occurrence of a particularly hard or stony lot of clay may at any moment put enormous strain upon the framing, bearings and gearing. It is, therefore, far better to err by putting in too much weight than in the other way. Still, in the following examples there is no doubt a rather excessive margin.

In the case of the cutting tables (No. 117), there is also, no doubt, room for some economy of workmanship, and the same remark applies to the pug mill (No. 116). The workmanship in the other two examples is probably about right, and would not admit of any appreciable reduction without doing injustice to the machinery. A wise buyer will appreciate good and sound workmanship even in rough machinery of this kind, as such workmanship means the consumption of less power, a greater output, fewer repairs and less loss of time.

EXAMPLE No. 115.—Summary of cost of one 5-roller clay crushing and grinding mill:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Loam castings (rollers)	169 2 0	7 6	63 11 3
	Moulders' wages			4 17 6
	Green-sand castings	74 1 14	6 3	23 4 11
	Moulders' wages			3 9 4
	Hammered scrap axles	16 0 0	16 0	12 16 0
	Wrought iron (sundries)	6 1 7	9 0	2 16 10
	B. boiler plate for scrapers	2 0 0	12 0	1 4 0
	Brass castings	3 0 4½	0 10	14 3 9
	Beech and pine packings			0 8 4
	Sundries (bolts, washers, etc.—per stores) ..			0 12 0
6 2 0	Smiths' wages paid			6 2 0
16 1 6	Machinists' „			10 14 4
5 1 10	Fitters' „			10 3 7
	Material and wages	271 0 25		154 3 10
27 5 4	Expenses			27 5 4
	Gross cost			181 9 2

EXAMPLE No. 116.—Summary of cost of one vertical pug mill, with double mouthpieces, one set brass dies, for plain perforated bricks, and lubricating boxes, etc., to work with above mill:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Loam castings (cylinder and bracket)	28 1 21	7 6	10 13 3
	Moulders' wages			4 1 10
	Green-sand castings	39 1 0	6 3	12 5 4
	Moulders' wages			2 0 9
	Hammered scrap shaft	8 3 21	16 0	7 3 0
	Steel footstep (Whitworth)	0 2 15	35 0	1 2 2
	Wrought iron	7 3 0	9 0	3 9 9
	Brass castings	2 0 14	0 10	9 18 4
	Sundries—per stores			0 4 9
5 4 8	Smiths' wages			5 4 8
8 12 5	Machinists' wages			5 14 11
6 7 11	Fitters' „			12 15 11
	Material and wages	87 0 15		74 14 8
20 5 0	Expenses			20 5 0
	Gross cost			94 19 8

EXAMPLE No. 117.—Summary of cost of two receiving tables, with cutting-off gear, for above pug:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Green-sand castings..	2 14	6 3	0 3 11
	Moulders—Wages paid			0 2 1
	Wrought iron	4 0 0	9 0	1 16 0
	Wrought iron in angles and plates	6 0 21	9 0	2 15 8
	Brass castings	31	0 10	1 5 10
	Pins for rollers			0 6 6
	Cloth, nails, pet cocks, etc.—per stores ..			0 6 8
	Tin cylinders, per account			0 5 6
5 2 10	Smiths—Wages paid			5 2 10
2 13 8	Machinists „			1 15 9
2 15 10	Fitters „			5 11 8
	Material and wages	11 0 10		19 12 5
10 12 4	Expenses			10 12 4
	Gross cost			30 4 9

EXAMPLE No. 118.—Summary of cost of hauling gear to work with above—no wagons included:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Green-sand castings..	24 2 0	6 3	7 13 2
	Moulders' wages			1 8 4
	Wrought iron	4 3 7	9 0	2 3 4
	Hammered scrap	4 3 7	16 0	3 17 0
	Brass castings	46	0 10	1 18 4
	Sundries, per stores..			1 2 0
4 4 3	Smiths' wages			4 4 3
5 19 0	Machinist			3 19 4
1 16 4	Fitters			3 12 7
	Material and wages	34 2 4		29 18 4
11 19 7	Expenses			11 19 7
	Gross cost			41 17 11

GENERAL SUMMARY.

	Weight.	Gross Cost.	Price.
	T. c. q. lb.	£ s. d.	£ s. d.
Roller mill	13 11 0 0	181 9 2	240 0 0
Pug mill	4 7 0 15	94 18 8	135 0 0
Tables	11 0 10	30 4 9	40 0 0
Hauling gear	1 14 2 4	41 17 11	65 0 0
	20 3 3 1	348 11 6	
Draughtsmen and pattern makers ..		20 4 0	
Erection wages and expenses ..		22 11 10	
Total cost, exclusive of patterns		391 7 4	480 0 0

The above plant was exceptionally strong and well made. It made fully 30,000 plain perforated bricks in ten hours from a strong coarse clay, having probably rather more than an average percentage of stones. On a more favourable clay, and with proper arrangements for carrying off, it would, no doubt, work up to a higher capacity still.

Having regard to the weight of the plant and its capacity, the price named in above summary cannot be considered excessive. The price included erection (local) though cartage was done at the buyer's cost. The cost does not include the driving gear to connect the mills with the engine. This item will, of course, vary according to the arrangements of the site. The extra price of the driving gear in the above case was £165. A complete set of patterns for above would cost from £60 to £70.

The above plant would be described as a complete "four-process" plant—that is to say, the clay is hauled to the head of the mill, crushed and ground in the rollers, pugged, and made into bricks in one continuous operation. Had the hauling gear been omitted, the plant would only have been a "three-process." A simple pug mill with mouthpieces and tables constitutes a "two-process" or "double-process" plant.

Below are general summaries of two smaller plants than the one of which particulars are given above :—

EXAMPLE No. 119.—Brick-making plant for 20,000 bricks per day of 10 hours:—

	Weight.	Gross Cost.	Price.
	T. c. q. lb.	£ s. d.	£ s. d.
Roller mill (4 rolls)	8 13 2 0	150 8 0	200 0 0
Pug mill (vertical)	3 0 0 0	71 10 8	100 0 0
Tables	7 3 0	14 9 4	20 0 0
Hauling gear	1 1 2 0	27 4 6	40 0 0
	12 2 3 0	263 12 6	360 0 0

EXAMPLE No. 120.—Brick-making plant for 15,000 bricks per day of 10 hours :—

	Weight.	Gross Cost.	Price.
	T. c. q. lb.	£ s. d.	£ s. d.
Roller mill (4 rolls)	6 2 2 0	108 4 6	145 0 0
Pug mill (vertical)	1 14 0 0	44 2 0	66 0 0
Tables	7 1 0	13 10 0	20 0 0
Hauling gear	19 3 0	29 0 0	38 0 0
	9 3 2 0	194 16 6	269 0 0

Nothing is included in either of above summaries, either for any special alteration of patterns or for erection.

It may be well, in this connection, to add the following summaries of the costs, etc., of edge roller mills or mortar mills. These mills are occasionally used in connection with brick-making, both for dry and wet grinding ; but, of course, have a very much wider field of usefulness. They are, consequently, made by many general engineers who do not make brick machinery.

Mortar Mills.

These mills may be obtained in sizes from 5 ft. diameter of the revolving pan to 9 ft. diameter, and in two designs—one with the driving gear below the pan and one with the gear above. The former is the less costly arrangement, and for all practical purposes is as good as the latter. All the mills in the following summary are under-driven.

The following three sizes are probably the most useful and the sizes most frequently required.

EXAMPLE No. 121.—Summary of costs, etc., of mortar mills:—

Diameter of pan	6 ft. 6 in.	7 ft. 6 in.	9 ft. 0 in.
Diameter of rollers	3 ft. 0 in.	3 ft. 6 in.	4 ft. 0 in.
Width of rollers	1 ft. 0 in.	1 ft. 2 in.	1 ft. 8 in.
Weight of rollers, each	18 cwt.	24 cwt.	30 cwt.
Gross weight	4 tons 15 cwt.	8 tons.	10 tons.
	£ s. d.	£ s. d.	£ s. d.
Cost of materials	45 2 0	71 0 0	86 14 0
Cost of wages	6 16 0	8 14 4	10 3 0
Expenses	7 2 4	8 13 8	11 1 0
Gross cost	59 0 4	88 8 0	107 18 0
Selling price	80 0 0	105 0 0	135 0 0
Prices of other makers	55 0 0 to 90 0 0	85 0 0 to 105 0 0	110 0 0 to 160 0 0

When required with pans perforated in the bottom for dry grinding, an addition of from 5 to 10 per cent. will be made to above prices. Patterns are not included in above particulars. The gross weights given might be safely reduced about 10 per cent.

It is unnecessary to add that all the above mills are for use in connection with steam or water power. Smaller mills for driving by horses or cattle are required both for home and abroad, but come more under the head of agricultural machinery.

CHAPTER XIX.

MISCELLANEOUS PRODUCTIONS, continued.—VALVES AND COCKS.

THE manufacture of valves and cocks is a branch of mechanical engineering which is probably now more specialised than any other, there being numerous houses, many of high standing, who devote themselves almost exclusively to this business. Two circumstances have principally contributed to bring about this condition; first, the immense demand which exists for valves and taps, and other steam and water fittings; and, secondly, the moderate character of the plant and the comparatively small amount of capital required to conduct a business in these productions.

Probably the larger part of steam and water fittings required by general engineering establishments are purchased by them from the special makers. Particularly is this the case with the smaller class of fittings—water gauges for boilers, oil and tallow cups, and the smaller brass valves and taps, for example. At the same time, most large establishments prefer to make the heavier valves and cocks they require themselves. They have the tools, must keep men who can be put to work of this kind when necessary, and usually have a range of patterns sufficient for all ordinary requirements. Further, a large part of the work in connection with valves and cocks is very suitable for the older apprentices and junior journeymen.

Some large houses, having their own brass foundries, find it an advantage to keep one or two brass finishers also, and are thus able to make for themselves nearly all they require, even the smaller class of valves and taps and other fittings—except, of course, patented or very special articles. It will, however, very rarely be the case for brass valves and taps of standard types to be produced in a general engineering establishment anything like so cheaply as they might be bought from some of the special makers.

It may be, and no doubt is the fact, that a very large proportion of the brass goods offered by some of the special makers is of very inferior metal, light in design, and roughly finished ; but what has just been stated with reference to relative cost of production will apply when the comparison is made with the manufactures of first-class houses.

The following examples may be taken as fairly representative of the class of work we are now considering, so far as it is done in general engineering establishments, though of course they must not be taken as exhaustive.

EXAMPLE No. 122.—Cost of three 2½-in. steam stop valves (frequently called Mather and Platt valves), with cast-iron bodies, covers, hand-wheels and bridges, and brass valves, seats and spindles, flanges faced and turned :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cast-iron	2 1 20	6 3	0 15 4
	Moulders' wages	27	4 10	0 2 10
	Brass			1 2 6
	Bolts and nuts—per store			0 5 2
1 9 6	Machinists' wages (turner, 21 hours; apprentice ditto, 26; slotter, 3; driller, 7)			0 19 8
0 3 5	Fitters' wages..			0 6 10
	Material and wages			3 12 4
1 12 11	Expenses			1 12 11
	Gross cost			5 5 3

Charged £7 10s., less 2½ per cent. for the three. Valves of this size can be bought at as low as 29s., less 15 per cent. discount. The best special makers will, however, ask from 35s. to 45s., less from 15 to 20 per cent. discount to engineers.

EXAMPLE No. 123.—Cost of one 5-in. valve, as above :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cast iron	2 0 21	6 3	0 13 8
	Moulders' wages			0 3 0
	Brass	20½	0 10	0 17 1
	Bolts, etc.—per stores			0 2 3
1 1 2	Machinists (turner, 19 hours; apprentice do., 8; driller, 4)			0 14 1
0 3 6	Fitters			0 7 0
	Material and wages			2 17 1
1 4 8	Expenses			1 4 8
	Gross cost			4 1 9

Charged £5 10s., less 2½ per cent. Special makers' prices for this size range from £4 to £5 5s., less trade discount.

It will, of course, be obvious that when a general engineer makes up a single valve as above, he places himself at a disadvantage as compared with the specialty houses when the comparison is with the standard patterns of the latter, seeing that such houses usually make their valves by the dozen, and by piece-work.

Under piece-work arrangements the total sum paid for finishing a valve such as above would probably not exceed 12*s.* 6*d.*; the iron castings would be bought from some general founder at 8*s.* per cwt. or under, whilst the brass would cost from 9*d.* to 10*d.* per lb.; and the general expenses would be put at probably 30 or 50 per cent. less than in our example. Where, however, a departure from the standard dimensions has to be made for a single valve, the specialty house has not such a decided advantage over the general engineer.

The following was a case in point, the valve having special-sized flanges and being exceptionally short between the two flanges. The price charged was less than the amount of a quotation received for the valve from a good specialty house.

EXAMPLE No. 124.—Cost of one 7-in. steam stop valve, generally as in two last examples:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cast-iron	2 1 7	6 3	0 14 5
	Moulders' wages			0 4 1
	Brass	35	0 10	1 9 2
	Bolts, etc.—per stores			0 3 4
1 8 6	Machinists (turner, 25 hours; slotter, 5; drillers, 5)			0 19 0
0 4 4	Fitters (journeyman, 5 hours; apprentice fitters, 32)			0 8 8
0 3 0	Pattern makers (altering patterns)			0 4 0
	Material and wages			4 2 8
1 15 10	Expenses			1 15 10
	Gross cost			5 18 6

Charged £8 net. Ordinary prices for this size standard patterns run from £6 to £8, less trade discounts.

The above examples relate solely to the ordinary type of steam stop valve, having the centres of the two flanges in the one straight line. The type used for connecting steam pipes to boilers, and having the flange at the discharge side at right angles to the flange at the inlet side, known as "Kingston" valves, and as "Junction" valves are usually a little more costly, but may be taken

Junction Valves.

as practically the same. It is unnecessary, therefore, to give any detailed examples of this type.

EXAMPLES NOS. 125 and 126.—Costs of 2½-in. and 3-in. brass blow-off cocks, plain stuffing-boxes and glands :—

	2½ in.	3 in.
Brass castings	43 lb.	56 lb.
Finished weights	37½ „	49½ „
	£ s. d.	£ s. d.
Cost castings	1 15 10	2 6 8
Machinists' wages	0 8 3	0 11 5
Fitters' wages	0 7 4	0 7 1
Material and wages	2 11 5	3 5 2
Expenses	0 16 1	1 0 0
Gross cost	3 7 6	4 5 2
Price charged	4 10 0	5 10 0

The simpler type of cock in which the stuffing-box and gland are dispensed with, variously styled "plain plug cock," "self-packing cock," etc., costs about one-third less than above; whilst the type now largely used by the best firms, in which there is a kind of double or compound gland, which permits the upper stuffing-box of the cock to be re-packed under pressure, costs about a third more.

EXAMPLE NO. 127.—Cost of two 3-in. plain stopper or self-packing cocks, with cast-iron barrels, flanged at each end, and brass plugs or stoppers :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Iron castings	3 0	6 3	0 4 8
	Moulders' wages			0 2 0
	Brass castings	33	0 10	1 7 6
0 19 5	Machinists' wages (turner, 21 hrs.; driller, 2)			0 12 11
0 5 6	Fitters' wages.. .. .. .. 21 hours			0 10 11
	Material and wages			2 18 0
1 4 11	Expenses			1 4 11
	Gross cost			4 2 11

Charged £3 each, less 2½ per cent.

Numerous changes may be, and are in most large shops, rung upon the type of cock referred to in the above example, to meet the demands which arise from time to time in connection with bleach, dye, and print works, and other establishments where large volumes of liquids have to be dealt with. A cock of this type may be required all brass or all iron ; with one flange and one spigot end ; with one flange and one bent or nose end ; with one spigot and one faucet end ; or with two faucet ends, and so on.

Modifications of Patterns.

An engineer's patterns and core boxes for cocks of this type generally admit of modification, within certain wide limits, to meet such requirements as those indicated, as in the following case, where a double flange cock was converted into a spigot and faucet cock.

EXAMPLE No. 128.—Cost of one 6-in. spigot and faucet cock, all cast iron, faucet bored and spigot turned on rim :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	Cast iron ..		2 0 7	6 3	0 12 11
	Moulders' wages ..				0 4 2
0 16 11	Turners' wages ..	19 hours			0 11 3
0 2 4	Fitters' wages ..	9 "			0 4 8
0 6 11	Pattern makers' wages ..	17 "			0 9 3
	Material and wages ..				2 2 3
1 6 2	Expenses ..				1 6 2
	Gross cost ..				3 8 5

Charged £5, less 2½ per cent., including alteration of pattern.

EXAMPLE No. 129.—Cost of one 2-in. boiler feed valve, cast-iron body or shell, brass valve, seat and spindle (two flanges, one at right angles to the other) :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Cast iron ..	1 26	6 3	0 3 1
	Moulders' wages ..			0 1 8
	Brass castings ..	6½	0 10	0 5 3
	Bolts and studs—per stores ..			0 1 2
0 13 3	Machinists' wages ..			0 8 10
0 2 4	Fitters' wages ..			0 4 8
	Material and wages ..			1 4 8
0 15 7	Expenses ..			0 15 7
	Gross cost ..			2 0 3

Charged £2 15s., less 2½ per cent.

Quantities. Valves such as above should never be made up singly, except in special cases. Wherever there is sufficient demand to justify the making or keeping up of patterns, it will always pay to make standard valves in quantities of not less than half-a-dozen at a time.

On occasions when merely half-a-dozen feed valves, as in the last example, were made up at a time, the workmanship per valve was reduced fully one-third, as compared with the example, the gross cost per valve as put into the store standing usually about £1 10*s*. 6*d*. Making up in larger numbers and the adoption of piece-work would have effected still greater economy in manufacture.

The following tables show the weights, time of brass finisher

Brass Wheel Valves.

occupied in finishing, gross cost (expenses being reckoned as 100 per cent. of the wages) and selling prices of plain brass wheel valves and plain brass plug cocks, as made in the brass finishing department of a general engineering shop :

BRASS WHEEL VALVES (FEMALE ENDS).

Size.	Brass Castings.	Time finishing.	Gross cost.	Usual Selling Price.
			s. d.	*s. d.*
¾ in.	3¼ lb.	2¼ hours.	5 3	7 6
1 in.	4¾ lb.	3½ "	7 10	10 6
1¼ in.	8 lb.	5 "	12 2	15 6
1½ in.	9 lb.	6 "	14 0	18 0
2 in.	11 lb.	9 "	19 0	25 0

BRASS PLUG COCKS.

Size.	Brass Castings.	Time finishing.	Gross Cost.	Selling Price.
			s. d.	*s. d.*
½ in.	1¾ lb.	1½ hours.	3 1	5 9
¾ in.	2¾ lb.	2 "	4 6	7 0
1 in.	4 lb.	3 "	6 8	9 6
1¼ in.	7 lb.	4½ "	11 2	14 0
1½ in.	8½ lb.	6 "	13 8	17 6

None of the scales shown in the above tables can be considered perfect. That is to say, anyone designing a new and complete set of patterns would arrange to have the weights, and consequently the selling prices, better graduated. However, for work of this kind done in a general engineering shop, in ordinary day's time, and in quantities rarely exceeding half-a-dozen or a dozen valves or taps at a time, the results shown in the above tables (which, of course, varied somewhat from time to time) cannot be considered unsatisfactory.

Better arrangements in the matter of tools and fixings for the lathe would, no doubt, have enabled some time to be economised; whilst in the special brass shops, where piece-work is adopted, very much less is paid in wages for the workmanship on these articles. In the valves, for example, from 1*s.* for the ¾ in. size to 3*s.* for the 2 in. size would be considered good rates to pay for finishing.

On the other hand, it not infrequently happens where brass-work of the kind we are now considering is done in a general engineering shop, that one or two valves or cocks have to be finished by themselves; and in such cases the time finishing will be from a third to a half more than the amounts given in the tables, the result being that these articles are sometimes sold for less than they cost. Valves and taps of fair quality and finish can be bought by engineers at fully a third less than the selling prices given in the above tables.

Tables of Standard Sizes.

The following tables exhibit the rates charged in a general engineering shop for the valves, etc., specified, all the articles being made in the shop, most of them being probably heavier than necessary, and all carefully finished:—

Stop Valves (M. and P. Valves), Brass Valves, Seats and Spindles, Cast-Iron Bridges for Outside Screws.	£ s. d.	Junction (or Kingston) Valves for Boilers, otherwise same as the Stop Valves.	£ s. d.
2 in.	1 15 0		
2½ in.	2 0 0		
3 in.	2 10 0	3 in.	3 0 0
4 in.	3 15 0	4 in.	4 0 0
5 in.	5 0 0	5 in.	5 10 0
6 in.	6 0 0	6 in.	7 0 0
7 in.	8 0 0	7 in.	8 10 0
8 in.	10 0 0	8 in.	10 10 0
10 in.	15 0 0	10 in.	16 10 0

Feed Valves (Angle Pattern), Brass Valves, Seats and Spindles.	£ s. d.	Brass Packed Blow-off Cocks, Straight Pattern.	£ s. d.	Brass Self-Packing Blow-off Cocks (Angle-inverted Plug Pattern).	£ s. d.
2 in.	2 15 0	2 in.	2 15 0	2 in.	2 10 0
2½ in.	3 5 0	2½ in.	3 15 0	2½ in.	3 5 0
3 in.	3 10 0	3 in.	4 15 0	3 in.	4 5 0

Single Lever Safety Valves.	£ s. d.	Double Lever Safety Valves.	£ s. d.
		3 in.	5 10 0
3 in.	3 10 0	4 in.	7 0 0
4 in.	5 10 0	5 in.	9 0 0
5 in.	7 0 0	6 in.	12 0 0

Brass Water Gauge Cocks.	Per Set—£ s. d.	Brass Try Cocks (Polished).	Each—£ s. d.
		½ in.	0 10 0
⅝-in. glass	2 5 0	⅝ in.	0 12 6
¾-in. "	2 15 0	¾ in.	0 15 6

For brass wheel valves and plain brass plug taps or cocks see tables already given.

CHAPTER XX.

PRIME MOVERS.

THE prime movers at present in practical use are the following, viz., steam engines, waterwheels, turbines, windmills, gas engines, hydraulic engines (so-called), and hot-air engines.

Of these only three—steam engines, waterwheels, and windmills—come within the scope of general engineering shops; the others remain in the hands of certain special makers, and are, besides, mostly of very limited application.

Windmills.

Windmills only come within the sphere of establishments situated in certain districts, as in the Midland and Southern Counties of England, or of houses who export to certain countries abroad, and will not be dealt with here, as the writer has no experience of their manufacture.

Water-wheels.

Waterwheels come within the scope of a larger number of firms. Most old-established houses in the great manufacturing districts of the kingdom have experience of their manufacture; and whilst few new wheels are now made, the renewal of buckets, segments, bearings, and axles, and other repairs, constitutes in some districts by no means an unimportant item of business.

Steam Engines.

Steam engines, however, naturally constitute the class of prime movers which claims special attention here. It is no doubt true, as we are reminded from time to time by very high authorities, that the steam engine will some day be entirely discarded in favour of more direct methods of utilising heat; and it is unquestionably the fact that the gas engine (which probably foreshadows the type of heat engine of the future) has already displaced the steam engine for certain purposes, as well as occupied fields which the steam engine very likely never could have entered. Nevertheless, the steam engine is still the prime mover of manufacturers, and will probably remain so for more than one generation.

Innumerable types of steam engines are now made, with all of which it would, of course, be impossible to deal within the limits at our disposal, apart altogether from the question of experience. We can only select certain representative types, and deal generally with them.

Types of Steam Engines.

The types of engine now most favoured for manufacturing purposes are: The horizontal direct-acting engine, the beam engine, and, to a small extent, the inverted direct-acting engine or the marine type. The latter is only very occasionally adopted, and appears to be only supplied by engineers who have a marine as well as a general connection. This type occupies comparatively small ground space, and may be, therefore, well adapted in some very exceptional circumstances; but it is doubtful whether this advantage, such as it is, is not gained at the expense of qualities of more importance in manufacturing industries—steadiness and smoothness of running, for example. This type is, however, extremely well adapted for small high-speed engines.

Comparatively few beam engines are now made for manufacturing uses. This type possesses the great recommendation of being subject to little and very regular wear and tear, and is the most durable type and the most economical in the matter of maintenance yet made. It may also, of course, be made, within the limits for which it is suitable, as economical in fuel consumption as any other—indeed, up to recently the most economical engines working on land were beam engines. For the purpose for which James Watt first made engines—that is, the pumping of water—the beam engine is still the most convenient and economical, and therefore easily holds its own. This type does not, however, lend itself to the high speeds now required in manufacturing industries quite so readily as the horizontal direct-acting engine, which is the type now most favoured and most generally adopted in these industries.

The horizontal engine is itself made in numerous modifications. We have, first, the single-cylinder engine, which may be either condensing or non-condensing. Secondly, engines with a pair of cylinders of equal size placed side by side, and with the piston rods coupled up to the same crank-shaft. This arrangement is commonly—though, perhaps, rather loosely—described as a "pair of engines," and may also be either condensing or non-condensing, though, of course, invariably the former in the larger sizes. Thirdly, engines with a pair of cylinders of unequal diameters placed side by side, with the piston rods connected with the same crank-shaft, and working compound. This is the arrangement generally indicated by the term "compound engine," and is also what is very commonly meant by the expression, "pair of compound engines." Fourthly, we have engines with two cylinders of unequal diameters, placed one behind the other, with a piston rod passing through both cylinders, and working compound, this being the arrangement indicated by the term, "compound tandem engine." Fifthly, we have engines with two sets of cylinders, each set arranged tandem, working compound, placed side by side and connected to the same crank-shaft, this being the arrangement understood to be described by the expression, "pair of compound tandem engines." Other modifications are also in existence, but the five just described are the most important and those in most general use.

Type as affecting cost.

The cost, and therefore the selling price, of an engine of any type admissible for manufacturing uses and for a given power, will be largely affected by the following conditions, viz. :—Speed of piston, pressure of steam, character of valves, valve gear and its auxiliaries; construction of cylinder—that is, whether steam jacketed or not; class of fly-wheel, whether plain, geared, turned up for belt or for ropes; and, of course, the general conditions of the quality of material employed and the character of the workmanship and finish.

It will be obvious that an engine which is to run at a high speed may, for a given power, have its parts made lighter than one which is to run at a slow speed; also, that one which is to work with a high pressure of steam may be made with a smaller cylinder than one which is to work under steam of a low pressure; also, that an engine with a common slide valve having a fixed and invariable cut-off, and with the admission of steam controlled merely by the governor acting upon a common throttle valve, may be made for less money than an engine with valves, say, of the Corliss type, worked by gear constructed to give a variable cut-off according to the load, and controlled direct by the governor.

The modifying influence of the other conditions mentioned upon the cost of an engine will be equally apparent.

A question which very naturally presents itself the moment we enter upon the consideration of the costs and prices of steam engines, is the following, viz., Is there any standard or rule by which engines are measured for commercial purposes?

Standard of Measurement.

The importance, and indeed, necessity of exact standards of measurement have long been recognised in every branch of science and industry. Nor are engineers at all wanting in regard to the exactness and completeness with which they can measure and express the actual power that is at any moment being exerted by their engines. It would, therefore, be very reasonable to suppose that, for commercial purposes, for calculating prices, for selling or buying so important an appliance as a steam engine, manufacturing engineers would possess equally complete and exact standards or rules of measurement. This, however, is not the case. There is at present no standard or rule of measurement for commercial purposes of anything like universal or even general use—engines being described very largely according to the ideas or whims of their respective makers.

At one time there did exist a universal standard of measurement, but that was when there was only one firm of steam-engine makers—Boulton and Watt.

At present there are used numerous formulæ, to all of which the misleading expression, "nominal horse-power," is applied, and in addition there is used as a standard for calculating prices the probable indicated horse power of an engine.

It furnishes a striking illustration of the extent to which Watt impressed his individuality upon the steam engine, that not only is the steam engine, structurally considered, to all intents and purposes the same to-day as he left it, but a distinctly crude standard of measurement which he devised is now in one form almost universally employed for practical purposes, and in another also largely for commercial purposes, although it never can now be used for the latter without qualification, expressed or implied, and always vague.

One of the standards mentioned—nominal horse-power—is now falling into disuse, engines being described, more especially in the larger sizes, simply by their leading dimensions, or by the actual horse-power for which they are constructed or will indicate under a certain pressure of steam. It is, however, necessary to understand what the term implies, as it is still used, more especially in the price lists of makers of the smaller classes of engines.

Nominal Horse-power.

Briefly, "nominal horse-power" is a descriptive measurement of an engine which is usually intended to convey an idea of its size, on the assumption that its size will be a measure of its value without reference to the power which it will actually give out.

Originally, and as still sometimes used, the formula for determining the n.h.p. was the area of the cylinder in inches, multiplied by 220, as the piston speed, and 7 as the mean effective pressure, and divided by 33,000. These figures gave approximately the indicated horse-power of Watt's time, and powers thus determined became associated with certain sizes of engines.

Afterwards, when higher pressure steam began to be used expansively, and higher speeds were adopted, these figures no longer gave approximately the actual horse-power, but as the power determined by them had become associated with certain sizes of engines, it appears to have been considered necessary to retain them, and to use the term "nominal" to distinguish the power they gave from the actual horse-power.

The above formula is equivalent to 21·5 square inches of piston per horse-power; also to the diameter squared divided by 27; and both these formulæ were, and are still, used for simplicity. Subsequently a modification of the formula, into which the length of the stroke enters as one term, was introduced, and at present the most generally-accepted formula is the diameter in inches, squared, multiplied by the cube root of the stroke in feet and divided by some figure supposed to be a constant, but which in fact appears to be anything between

30 and 60 for condensing engines, and 10 and 25 for non-condensing engines, according to the fancy of makers.

Summarising these formulæ, and taking a condensing engine of 36-in. cylinder and 72-in. stroke, it will be seen that they give the n.h.p. as follows:—

$$\frac{1018 \text{ (area of cylinder)} \times 220 \times 7}{33{,}000} = 47 \cdot 5 \text{ n.h.p.}$$

$$\frac{1018}{21 \cdot 5} = 47 \cdot 3 \text{ n.h.p.}$$

$$\frac{36^2}{27} = 48 \cdot 0 \text{ n.h.p.}$$

$$\frac{36^2 \times \sqrt[3]{6}}{48} = 49 \cdot 5 \text{ n.h.p.}$$

Such an engine would be described by some makers as a 40, and by others as a 50 nominal horse engine. The following list gives the sizes of some condensing engines, with the n.h.p. by which they are described by several makers:—

Diam. of Cylinder. Inches.	Length of Stroke. Inches.	N.H.P.
24	42	16 to 20
25	42	18 „ 20
28	60	25 „ 30
30	60	30 „ 35
36	60	40 „ 45
36	74	45 „ 50
46	82	80 „ 90

The difficulty with regard to n.h.p. is twofold. In the first place there is no definite principle generally recognised upon which to base the formula for determining it. Hence hardly any two makers use exactly the same formula. Secondly, almost equal diversity exists as to the number of times over the nominal horse-power to which engines may be worked. A number of makers may be found who agree approximately in the descriptions they give of their engines in so far as what they call the nominal horse-power is concerned, as in the list of engines given above; but, at the same time, very great diversities will be found. For example, one maker calls his 24-in. by 42-in. condensing engine a 20 nominal horse engine; another calls his 24-in. by 48-in. (only 6 inches longer in the stroke than the former it will be observed) a 50 nominal horse engine; whilst another describes his 24-in. by 48-in. as a 60 nominal horse engine. The piston speeds given by all the three are practically the same.

Again, whilst probably the majority of makers use different figures for determining the nominal horse-power of non-condensing to those they use for condensing engines, some makers allow no distinction and use the same formula and figures for both. Formerly it was not uncommon to find an engineer who had unsuccessfully tendered for an engine, attribute his failure to having understated the nominal horse-power of his engine, or understated the number of times the nominal horse-power up to which his engine might be worked, and who would, in consequence, resolve to be less scrupulous in future and to use higher descriptive rates without altering his sizes. Hence, whilst any reasonable formula for determining nominal horse-power may be very useful in an engineering office, where it is consistently employed for the purposes of ready calculation as to prices, there is none of any value for the purposes of general comparison.

Ratios nominal to indicated Horse-power.

Obviously, the ratio between the nominal horse-power of an engine and the actual power up to which it may be worked will depend upon the way in which the former is determined. If we take as the nominal horse-power for condensing engines 22 square inches of piston area, or what will generally amount approximately to the same thing,

$$\frac{(\text{diameter piston in inches})^2 \times \sqrt[3]{\text{stroke in feet}}}{46},$$ and for

non-condensing engines, 11 square inches of piston area or

$$\frac{(\text{diameter piston in inches})^2 \times \sqrt{\text{stroke in feet}}}{19}$$ — formulæ

which will be found to agree approximately with the practice of probably most of the best makers—then we shall find that as a general thing the indicated horse-power up to which modern engines are worked will be about the following, viz.:—

Non-condensing engines, three to five times the nominal horse-power.
Simple condensing engines, five to eight times the nominal horse-power.
Compound condensing engines, four to seven times the nominal horse-power.

In calculating nominal horse-power, the area, or the squares, of all the cylinders which go to constitute the complete engines must, of course, be added together.

The sole use of the nominal horse standard of measurement, where it is employed at all, is as a basis for commercial calculations. The cost or price of any engine, per nominal horse-power, will, of course, depend upon the formula used for determining the nominal horse-power, and will be modified by the conditions already mentioned. Taking the formulæ last given, viz:—

Prices per N.H.P.

$$\frac{(\text{diameter})^2 \times \sqrt[3]{\text{stroke}}}{46} \text{ and } \frac{(\text{diameter})^2 \times \sqrt[3]{\text{stroke}}}{19}$$ — selling prices will range about as follows, viz.:—

Non-condensing Engines.

Horizontal non-condensing engines, with plain slide-valves, governors, equilibrium throttle valves, plain fly-wheels, and all usual mountings:—

From 2 to 5	n.h.p.,	£22 to £17	per n.h.p.
From 5 to 15	,,	£20 to £14 10*s*.	per n.h.p.
From 15 to 50	,,	£14 10*s*. to £10 10*s*.	per n.h.p.

The higher rates given for the larger sizes would, with most makers, be allowed to cover some simple form of variable expansion valve gear which would admit of adjustment by hand whilst the engine was in motion; the turning up of the rim of the fly-wheel to make it suitable for carrying a belt, and the construction of the cylinders with steam jackets. For Corliss valves and automatic cut-off gear, from £4 10*s*. to £3 10*s*. extra per nominal horse-power should be required; and for fly-wheels turned up for ropes about £1 or £1 5*s*. extra per nominal horse-power. The weights per nominal horse-power would vary from 16 cwt. down to 6 cwt. The above rates apply to good strong engines, such as would be made in a first-class general engineering shop (see list of engines following).

Some special houses offer lighter classes of engines in a number of small sizes to run at high speeds, the weights of which range from 3 to 2½ cwt. per nominal horse-power, and the prices from £12 10*s*. to £9 per nominal horse-power. Coupled engines, or pairs of above type, that is—engines with two cylinders of equal diameter placed side by side and coupled to the same crank-shaft, would by some makers be charged at the same rate per nominal horse-power, as they are, of course, practically two complete engines. Others would, however, rate them about 5 per cent. less per nominal horse-power.

Horizontal simple condensing engines, with plain slide-valves, governors, and equilibrium throttle valves, plain fly-wheels and horizontal air pumps worked from back prolongation of piston rods in the smaller sizes, and in the large sizes, vertical or diagonal air pumps worked from crossheads or from back prolongation of piston rods:—

Condensing Engines.

From 10 to 20 n.h.p., £35 to £25 per n.h.p.
20 n.h.p. and upwards, £32 10*s.* to £20 per n.h.p.

If with variable and automatic expansion valves and gear, say of the gridiron type, working at the back of plain slide-valves; or with Corliss valves, and automatic gear, from £7 10*s.* to £5 per nominal horse-power extra. If with rope fly-wheels from £3 to £2 per nominal horse-power extra. Weights would range from about 12 cwt. per nominal horse-power in the smaller sizes to 25 cwt. in the larger. Pairs of engines (two cylinders, side by side, coupled to same crank-shaft), about 10 per cent. less per nominal horse-power.

Compound Engines.

Horizontal compound condensing engines (cylinders side by side) with plain or geared fly-wheels, plain slide-valves on low-pressure cylinders, gridiron cut-off slide-valves or Corliss valves with automatic gear controlled direct by governors on high-pressure cylinders, and with plain (not steam-jacketed) receivers between high and low-pressure cylinders, from £30 to £22 10*s.* per nominal horse-power. Steam-jacketing both cylinders and also receiver would add from £1 10*s.* to £1 per nominal horse-power. Rope fly-wheels from £3 to £2 per nominal horse-power.

Horizontal tandem compound engines, otherwise as above, from £28 to £20 per nominal horse-power.

Simple condensing beam engines, with wrought-iron connecting rods, plain or geared fly-wheels and cast-iron beams, from £36 to £22 per n.h.p., according to character of valves and gear and size of engine. The higher rate would now cover equilibrium, conical or double-beat valves, or Corliss valves with automatic gear. This rate might also in some cases be allowed to cover wrought-iron beams instead of cast-iron beams. For engines as above, in pairs, about 10 per cent. less per n.h.p.

As already intimated, nominal horse-power as a standard of measurement is not so much used now as formerly; many of the best houses rarely employ it in their calculations, but prefer to rate their engines at so much per the actual indicated horse-power up to which they are constructed to drive. The rates per indicated horse-power for horizontal non-condensing engines range from £7 down to £4 in the smaller sizes, and from £6 down to £3 in the larger sizes. For horizontal simple condensing engines, the rates range from £7 down to £3; for horizontal compound engines, from £8 down to £4; and for horizontal compound tandem engines, down to as low as £3 10*s.* For beam engines, the rates range from £10 down to £5 per indicated horse-power, and to about 10 per cent. less for engines in pairs or coupled.

Indicated Horse-power.

From the figures just given it will be seen that very great variations exist in the prices quoted for steam engines. These differences are determined partly by the class or type of engine, partly by the style or finish in which it is got up, partly by the material employed, and partly by the different values which different houses set upon their productions, or the amount of profit for which they are willing to work.

Fair Rates.

Good plain horizontal non-condensing engines can be made in a general engineering establishment to indicate, say, up to 80 or 100 h.p., and to leave a reasonable margin of profit at from £4 10*s.* to £3 10*s.* per i.h.p.; and high-class non-condensing engines of this type, with Corliss valves and automatic gear, and with fly-wheels turned up for belts or ropes, at from £5 10*s.* to £4 10*s.* per i.h.p. Good strong horizontal condensing engines with compound slide-valves (gridiron cut off valves on back of plain slides) and automatic gear, to indicate up to, say, 150 h.p., can be made at from £5 to £4 per i.h.p.; with rope fly-wheels from £5 10*s.* to £4 10*s.*; and with Corliss valves, steam jacketed cylinders, and rope fly-wheels at £7 to £6 per i.h.p. Good strong horizontal compound condensing engines, with Corliss valves and automatic gear on high-pressure cylinder at least, and to indicate up to 200 i.h.p., can be made at from £6 10*s.* to £5 5*s.* per i.h.p., and larger sizes up to, say, 400 i.h.p., at from £4 10*s.* to £4; or, including steam jacketing throughout and rope fly-wheel, at from £5 to £4 10*s.*

Good plain beam engines, in pairs, to indicate up to 400 i.h.p., and with automatic valve gear, can also be made at from £6 10s. down to £5, whilst an extra 10s. or 15s. would permit a high-class job to be made.

These rates will cover delivery and erection locally, and all the usual mountings and accessories, but not, of course, any builder's work. Some makers would include steam pipes from boilers to the engine; but others would charge these extra at a rate per cwt. erected—say from 12s. to 16s. per cwt. The rates per i.h.p. just given would allow the engines to be constructed so as to develop their specified powers with a reasonable weight of steam—say, not exceeding, in the compound engines, a consumption of $2\frac{1}{4}$ or $2\frac{1}{2}$ lb. of good coal per i.h.p. per hour, provided, of course, that the boiler efficiency is reasonable.

Modes of Estimating.

When making up a formal estimate of the cost or price of an engine of a type more or less new to the establishment, it is convenient to take a plain or simple type which has already been made as the basis of calculation, and to add sums to cover the probable extra cost of the departures proposed to be made from the plain type used as the basis; and this, of course, whether the nominal or the indicated horse-power be used as the standard of measurement, thus,

Example No. 130.—Estimated price of one horizontal, non-condensing, high-pressure steam engine, with cylinder $14\frac{1}{2}$-in. diameter by 36-in. stroke, spring coil piston, Corliss valves and automatic gear for admission valves controlled direct from governor, rope fly-wheel 10 ft. 6 in. in diameter, with grooves for five ropes and to weigh about $3\frac{1}{2}$ tons. Engine to indicate 60 h.p. at 65 revolutions per minute with 80 lb. steam pressure in boiler. Profit rates:—

	£ s. d.	£ s. d.
Basis type. Horizontal engine with plain slide-valve, equilibrium throttle valve, high-speed governor and plain fly-wheel, 60 i.h.p. at	4 5 0	255 0 0
Extra for Corliss valves with eccentric drive for exhaust-valves and automatic gear for steam-valves connected direct with governor	—	60 0 0
Extra for rope fly-wheel, say $3\frac{1}{2}$ tons, at	8 0 0	28 0 0
		343 0 0
Say 60 i.h.p., at	5 10 0	330 0 0

Steam and exhaust pipes extra at 16s. per cwt. erected (local).
Quoted net accordingly, and order secured.

We now supplement the general rates for steam engines which have already been given, by the following notes of the actual costs and selling prices of a number of engines, most of which may be considered as of a representative character.

The engines in all the examples were strong and well and carefully made. Probably the weights were in most cases on the heavy side—in one or two instances decidedly so. It is safe to say the workmanship might, in every instance, have been reduced by better organisation and direction.

EXAMPLE No. 131.—Horizontal, high-pressure, non-condensing engines, with metallic-packed pistons, steel piston-rods, crank-shafts and crank-pins, hammered scrap-iron connecting rods, plain slide-valves, quick-speed governors, equilibrium throttle valves, plain fly-wheels, boiler feed-pumps, steam stop-valves, lubricators and other mountings, strong cast-iron bed-plate, and foundation bolts complete; cylinders lagged with felt and polished wood. Delivered and erected locally :—

Size of cylinder..	6 × 12	9 × 18	12 × 24
Nominal h.p.	2	5	10
Indicated h.p.	9	16	35
Steam pressure	80 lb.	80 lb.	80 lb.
Revolutions per minute	150	100	80
Gross weight	21 cwt.	46 cwt.	80 cwt.
„ cost	£42	£84	£136
Price (patterns stock)	£60	£105	£165

The above costs are the costs of engines made up singly. Anyone, however, laying himself out to make engines of this class on a proper system, and making, say, half-a-dozen of the small size at a time, and two or three of the larger sizes, could cheapen the actual cost of manufacture, as compared with the above figures, considerably, and thus secure a larger profit, or reduce the prices. In order to compete with engines of this class as made and sold to-day by good specialty houses, the prices would have to be within the figures as shown in the following table, viz. :—

Size of cylinder	5 × 10	6 × 12	8 × 16	9 × 18	10 × 20	12 × 24	15 × 30
Weight of engine .. .. cwt.	7½	10	18	29	38	40	85
„ fly-wheel .. .. „	4	6	10	13	16	24	40
Price .. .. £	35	40	65	80	110	135	200
Extra for foundation bolts .. £	2 0	2 0	2 10	4 0	5 0	6 0	9 0
„ feed pump.. .. £	4 0	4 0	5 0	6 10	8 0	10 0	15 0
„ variable expansion gear £	—	—	—	15 0	17 0	19 0	30 0

There is no doubt that good, fairly strong, and well-made engines can be made profitably to sell at the above rates by anyone whose connection is such that he can depend on regular orders, or who will lay himself out to make such a connection. The prices given would allow a discount of 2½ per cent. to users where delivery and erection are charged extra, or the usual commission and discount to merchants for re-sale, say 7½ per cent. or not more than 10 per cent. altogether for prompt cash.

Example No. 132.—Horizontal, high-pressure, non-condensing engine, with cylinder 12 in. by 21 in. stroke, same as No. 131, but with spur fly-wheel. Strong and well-made engine :—

Size of cylinder	12 × 21
Called n.h.p.	10
Intended for i.h.p.	35 to 40
Revolutions per minute	100
Gross weight	87 cwt.
Cost of materials	£51 0 0
„ wages, including £4 for erection	43 0 0
„ expenses	39 14 0
Gross cost (patterns stock)	133 14 0
Price	165 0 0
„ per i.h.p., reckoned as 40	4 2 6

Considering the weight of above engine, and the fact that it was really very well and carefully made, the price charged is very moderate.

It will be seen that the profit is 23 per cent. on the gross cost, which cannot be considered excessive, as something must be allowed for the use of the patterns. The term "patterns stock" simply means that existing patterns were used. Hence the wages included only a small amount of pattern maker's time for getting out, repairing and making slight modifications.

Example No. 133.—Horizontal, high-pressure, non-condensing engine, with cylinder 12 in. by 26 in. stroke, with steel coil piston, steel piston-rod, crank-shaft and crank-pin, hammered scrap-iron connecting-rod and cross-head, Corliss valves, separate eccentric for exhaust and steam valves, latter with trip gear controlled direct by governor, quick-speed governor (Porter type), fly-wheel 8 ft. 6 in. diameter, turned up for five ropes; cylinder lagged with felt and polished mahogany with brass bands, all usual mountings. A good, high-class engine :—

Size of cylinder	12 × 24
Nominal h.p.	10
To work up to i.h.p.	60
Gross weight—engine only	52 cwt.
Cost—materials	£70 10 0
„ wages, including erection	72 0 0
„ expenses	58 0 0
Gross cost—engine	200 10 0
Weight fly-wheel	50 cwt.
Gross cost ditto	£31 0 0
Total cost, excluding patterns	231 10 0
Price charged	280 0 0
„ per i.h.p.	4 15 0
Gross cost of patterns and drawings	53 16 0

It will be seen that the price charged just about covered the total cost, including patterns and drawings; but as the patterns, etc., were considered to be fully worth to the establishment the amount which stands opposite to them in the above summary, and as the above cost was of the first engine made from the patterns, and it was anticipated that savings could be effected in future engines from the same patterns, the total result was not considered unsatisfactory.

EXAMPLE No. 134.—Horizontal, non-condensing, 14 by 30, with compound slide-valves, adjustable by hand (separate valves for steam and exhaust, and separate eccentrics), rope fly-wheel 10 ft. 6 in. diameter, for four ropes; plain governor and equilibrium throttle valve, cylinder lagged, all mountings, etc. :—

Size of cylinder	14 × 30
Nominal horse-power	14
Approximate i.h.p.	60
Gross weight	142 cwt
„ cost, including erection	£208 0 0
Price „ „	260 0 0
„ per i.h.p...	4 6 8

Some alterations of patterns, amounting to about £10 total cost, are included in the cost given above.

EXAMPLE No. 135.—Horizontal, non-condensing, 15 in. by 3 ft., with Corliss valves and automatic cut-off gear for steam valves, controlled direct by quick-speed governor, separate eccentrics for steam and exhaust valves, rope fly-wheel 10 ft. 6 in., for five ropes; cylinder lagged with felt and polished mahogany, steam-valve and all usual mountings :—

Size of cylinder	15 × 3 ft.
Nominal horse-power	17
Approximate i.h.p.	75
Revolutions per minute	75
Gross weight—engine only..	92 cwts.
„ cost (excluding patterns)	£223 0 0
Weight fly-wheel	78 cwts
Gross cost „	£52 0 0
Total cost engine and fly-wheel (excluding patterns)	275 0 0
Price	350 0 0
„ per i.h.p...	4 13 6
Gross cost patterns and drawings	58 16 0

It will be seen that the above did not leave any large margin as profit when the cost of the patterns is included in the total amount; but it will be clear that if the same price is obtained for other engines from these patterns, they will pay fairly well, apart from the possibility of making the engines for less than the amount which appears opposite total cost in above summary.

All the engines, of which the particulars are given above, were, it will be seen, constructed to work as non-condensing engines. Any one, however, from No. 132 to No. 135, might very conveniently be converted into a condensing engine by having a horizontal condenser and air-pump placed at the back of the cylinder so as to be worked by a prolongation of the piston-rod. The

Condensers and Pumps.

costs of suitable condensers and pumps, and the extra prices which might reasonably be charged for them, would run about as follows :—

	Approximate costs.	Extra prices.
Examples Nos. 132 and 133 ...	£65	£90
„ No. 134	74	100
„ No. 135	78	105

Cheaper condensers might be made, but the above figures would permit the condensers and connections to be well made, so as to be in keeping with the engines. The approximate costs given would not cover entirely new and complete patterns, so that something would have to be added on this account in the case of the first manufactured.

EXAMPLE No. 136.—Horizontal, condensing, steel coil piston, mild steel piston rod, crank-shaft and pin, plain slide valve, plain governor, equilibrium throttle valve, plain fly-wheel, cylinder lagged as before, steam stop valve and usual mountings. Air-pump vertical below engine level, and worked from back prolongation of piston. Good plain job :—

	Size of cylinder	18 × 36
	Nominal horse-power	10
	Approximate i.h.p.	70
	Gross weight, engine only	8¼ tons
	Weight of fly-wheel	3 „
	Gross cost, exclusive of patterns, but including erection	£301 12 0
	Price	365 0 0
	„ per i.h.p.	5 4 3

The above cost was considered too high, and should have been at least 10 per cent. less.

EXAMPLE No. 137.—Horizontal, condensing, 18in. × 36in. steel coil piston, steel piston rod, crank-shaft and pin, hammered scrap crank, connecting rod and crosshead, slide valves with gridiron cut-off valves at back, latter worked by trip gear driven by horizontal shaft and connected direct to quick-speed governor; condenser and air-pump under engine level, and worked off back prolongation of piston-rod, rope fly-wheel, 12 ft. diameter for six ropes. Good, strong, high-class job :—

	Size of cylinder	18 × 36
	Revolutions per minute	70
	Nominal horse-power	10
	Approximate i.h.p.	80
	Gross weight, engine only	9 tons 14 cwt.
	„ cost ditto, including about £40 on account of alterations of patterns, and including erection	£344 0 0
	Weight of fly-wheel	4 tons 6 cwt.
	Cost of ditto	£61 4 0
	Price of engine complete	450 0 0
	„ per i.h.p.	5 12 6

The above engine was considerably heavier than was necessary, and might have been made lighter to the extent of 5 to 7½ per cent. without disadvantage to the engine and with advantage to the makers. Other quotations for the above ranged from £390 to £500.

EXAMPLE No. 138.—Horizontal, condensing engine, cylinder 20in. × 36in. spring coil piston, slide valves with gridiron cut-off valves and automatic gear, etc., generally same as last, but with plain fly-wheel :—

Size of cylinder	20 × 36
Nominal horse-power, called	15
Intended for i.h.p.	90
Gross weight, engine only	9 tons 5 cwt.
„ cost ditto, including £43 on alteration of patterns	£345 0 0
Weight of fly-wheel	3½ tons
Gross cost of ditto	£37 5 0
Total cost of engine and fly-wheel	382 5 0
Price	450 0 0
„ per i.h.p.	5 0 0

EXAMPLE No. 139.—Horizontal, condensing engine, 20in. × 36in. spring coil piston, Corliss valves and automatic gear for steam valves, condenser, mountings, etc., as before ; cylinder steam-jacketed ; spur fly-wheel :—

Size of cylinder	24 × 48
Nominal horse-power	20
Intended for i.h.p.	150
Revolutions per minute	55
Gross weight, engine only	20 tons
„ „ fly-wheel	9 „
„ cost, engine	£664 10 0
„ „ patterns and drawings	102 0 0
„ „ fly-wheel	106 5 0
Total	872 15 0
Price	950 0 0
„ per i.h.p.	6 6 8

EXAMPLE No. 140.—Horizontal, compound, condensing engine, with cylinders 12 in. and 21 in. by 36 in., Corliss valves and automatic gear on high-pressure cylinder, plain slide valves on low-pressure cylinder, plain fly-wheel about 12 ft. diameter, receiver between cylinders ; condenser and mountings, etc., as before :—

Size of cylinders	12 and 21 × 36
Nominal horse-power	20
To work to i.h.p.	70
Revolutions per minute	68
Weight of fly-wheel	3½ tons.
Gross cost of engine	£432 0 0
Price	515 0 0
„ per i.h.p.	7 7 2

EXAMPLE No. 141.—Horizontal, compound, condensing engine, Corliss valves on both cylinders ; both cylinders steam-jacketed ; fly-wheel, spur 16 ft. diameter and about 10 tons weight ; condenser, mountings, etc., as before :—

Size of cylinders	16 and 30 × 48
Nominal horse-power	40
To work up to i.h.p.	200
Revolutions per minute	56
Weight of fly-wheel	10 tons.
Gross cost of engine	£960 0 0
„ „ fly-wheel	130 0 0
Total cost	1,090 0 0
Price	1,260 0 0
„ per i.h.p.	6 6 0

The above cost included nearly £100 on account of patterns, which it would not be necessary to expend in the event of another pair of engines being made from the same patterns.

EXAMPLE No. 142.—Horizontal, compound, condensing, Corliss valves on both cylinders, receiver between cylinders, all steam-jacketed, rope fly-wheel 22 ft diameter and about 20 tons weight :—

Sizes of cylinders	21 and 38 × 60
Nominal horse-power	75
To work up to i.h.p.	400
Revolutions per minute	55
Gross cost	£1,780 0 0
Price	2,000 0 0
„ per i.h.p.	5 0 0

As in the last example, the cost of above included a considerable sum—about £190—on account of patterns.

EXAMPLE No. 143.—Horizontal, compound, tandem, condensing, Corliss valves on high-pressure cylinder and slide valves on low-pressure cylinder, rope fly-wheel about 26 tons weight ; no steam jacketing :—

Sizes of cylinders	24 and 40 × 60
Nominal horse-power	80
To work up to i.h.p.	500
Gross cost	£1,600 0 0
Price	1,875 0 0
„ per i.h.p.	3 15 0

A comparatively small sum—about £60—appears in above cost on account of patterns and plans. The price must be considered low for a good job.

EXAMPLE No. 144.—Beam, condensing engine, gun-metal equilibrium tappet valves worked by trip gear controlled direct from governor, cast-iron beam (extra strong cold blast iron mixture), wrought-iron connecting rod, steel crank-shaft, crank-pin and piston rod, all usual pumps and mountings, rope fly-wheel about 10 tons weight :—

Size of cylinder	30 × 60
Nominal horse-power	35
To work up to i.h.p.	175
Boiler pressure	40 lb.
Revolutions per minute	35
Gross cost, including £26 on account of plans and patterns	£860 0 0
Price	1,150 0 0
„ per i.h.p.	6 11 6

The amount mentioned for plans and patterns in above only covers the cost of the ordinary plans required in connection with every new engine, and the cost of overhauling patterns, making sundry repairs upon them and small alterations. Practically, no new patterns or designs were required in this case.

EXAMPLE NO. 145.—Pair of beam, condensing engines, gun-metal equilibrium tappet valves, automatic gear, controlled direct by governor, cast-iron beams, hammered scrap connecting rods, crank-shaft and cranks, etc., usual mountings and connections, spur fly-wheel about 20 ft. diameter and 25 tons weight:—

Size of cylinders	36×72
Nominal horse-power	100
To work up to i.h.p.	400
Boiler pressure	60 lb.
Revolutions per minute	30
Gross cost, including usual plans and preparation of stock patterns	£1,966 0 0
Price	2,400 0 0
„ per i.h.p.	6 0 0

Other tenders for the above pair of engines ranged from £1,900 to £2,650.

In all the preceding examples of engines the cost given includes erection locally (where the erection was not actually local, the cost has been reduced to what it would have been in such event for the sake of equal comparison). One or two superior labourers were usually sent by the engineers with their tradesmen to erect, but the general common labour was provided by the buyers. No pinions or pulleys on first-motion shafts are included.

It will be seen that in those cases where new or practically new patterns had to be made, the margin of profit is very small, and it may be taken as a general thing that prices where new patterns have to be made will not do more than merely cover their cost in the case of the first engine made—that is to say, the patterns in such cases will have to be taken as the profit. Indeed, it will not infrequently happen that more than one engine will have to be made and sold before the cost of the patterns and drawings is entirely recovered, except in the case of special designs, the prices of which ought, of course, to cover all expenses and leave a fair profit.

Engine Repairs—Breakdowns.

The renewal of parts of steam engines and general overhauls constitute a most important part of the business of a general engineering establishment, and it is therefore desirable to give one or two examples of such work before passing from this section of our subject. Breakdown jobs are usually the most profitable that enter an engineer's shop. The order, as a rule, is given to the engine builder, because he is naturally in the best position for doing the work quickly (at least if locally situated), without inquiry as to cost, or, at most, with merely a general inquiry as to probable cost of any particular part which may require renewal;

the instructions generally being practically "Restore our engine as quickly as you can, work night and day whilst you are at it, and do the best you can for us."

Nor can anyone blame an engineer for charging his highest rates in cases of engine or other breakdowns. Such work always demands extra care and attention on the part of the principal, or his managers and foremen; interrupts and suspends for a time other work, probably with the result of giving offence to other customers; and generally disorganises the business of the establishment, and not infrequently, especially if a heavy job involving much overtime, demoralises the men for many days. It is, in most cases, a distinct advantage to a millowner or other proprietor to have his engine restored to working order in the least possible time, and he can therefore reasonably be charged an adequate sum for the use of the appliances, ability, and knowledge which the engineer devotes for the time being to the attainment of the object in view.

It may be added that in many a case the breakdown of an engine is directly due to the fact that the establishment served by it is particularly busy, and that in consequence a heavy duty was being taken out of the engine at the moment it gave way. A manufacturing engineer, when making up his account for a breakdown job, may, of course, be trusted to fully appreciate such a circumstance.

Engine breakdowns are, however, steadily becoming less frequent comparatively, as the old types of beam engines, with their cast-iron connecting-rods and beams, are being replaced by the modern horizontal engine, in which all moving parts subjected to much strain, except the fly-wheel, are constructed of wrought iron or mild steel. With all their many excellent qualities, the older beam engines were unquestionably of a type calculated to provide good breakdown jobs to manufacturing engineers. The breaking of either connecting-rod or beam usually meant the breaking of both, and the knocking out of the cylinder bottom in addition. Hence these older engines have provided many good accounts to engine makers for replacing the cast-iron connecting-rods and beams by rods and beams of wrought iron. The modern horizontal engine, apart from quality of material, is undoubtedly of a stronger type, structurally considered.

The following copy of an account for a small breakdown repair will illustrate a suitable form in which to make up and present an account in such cases. We also append summary of the cost of this job.

EXAMPLE No. 146.—Account for an engine breakdown repair (beam engine):—

		cwt. qr. lb.	s. d.	£ s. d.
188.. May.	1 Cast-iron walking beam of an extra strong cold-blast mixture of iron	22 0 0	16 0	17 12 0
	3 new steel keys, forged	7	1 0	0 7 0
	Boring beam for centres, cutting key-beds, skimming up and polishing old centres in lathe, driving and keying centres in beam and preparing pattern of latter			17 8 6
	2 main centre pedestal blocks and caps ..	5 3 12	11 0	3 4 5
	4 gun-metal bushes for ditto	98	1 4	6 10 8
	4 bolts, nuts, and guards	80	0 6	2 0 0
	Planing soles, sides, and jaws of blocks; planing and fitting bushes, and boring, facing, and filleting latter..			12 6 3
	2 brass bushes for cylinder cover	18½	1 4	1 2 10
	Turning, boring, and fitting ditto			0 19 4
	1 wrought-iron hoop for cylinder cover ..	20	0 4	0 6 8
	Turning up cover in lathe, shrinking on hoop, and turning up latter			1 4 2
	Overhauling air-pump bucket, and straightening and cleaning up pump rod in lathe ..			1 14 6
	1 cast-iron discharge valve	1 0 14	11 0	0 12 5
	1 cast-iron guard	20	11 0	0 2 0
	Boring, facing, and fitting ditto, and preparing patterns			2 9 9
	3 ⅜-in. steel studs finished..		3 0	0 6 0
	1 new piston, 34 in. diameter, with cast-iron block, junk rings and packing rings, turned, faced, and accurately scraped, and fitted with steel coil spring complete			37 0 0
	2 steel cotters, forged and ground	11	1 2	0 12 10
	Straightening and skimming up old piston rod, and fitting and cottering same to piston before receiving order for new rod			1 12 0
	1 new mild steel piston rod, 7 ft. 6 in. × 3 in. ..	2 1 0	36 0	4 1 0
	1 forged cotter and clutch..	2½	1 4	0 3 4
	Turning new rod, drilling and cutting cotter holes and fitting to piston and clutch ..			4 6 6
	Extra for shop engine working at night (36 hours at 4s.)			7 4 0
	Turner out at your mill with engine and boring tools, reboring your cylinder .. 7 days		30 0	10 10 0
	Expenses and allowance paid			0 13 9
	Getting out and preparing boring tools in shop			1 19 0
	Less 2½ per cent. for cash on			136 8 11

SUMMARY OF COST OF ABOVE JOB.

	cwt. qr. lb.	s. d.	£ s. d.
Loam castings—piston	12 0 14	7 6	4 10 11
Moulders' wages			0 17 4
Green-sand castings—extra metal;	29 0 18	8 3	11 18 7
Moulders' wages			1 16 6
Forgings	3 2 12		2 1 4
Smiths' wages			1 16 0
Brass castings	116½	0 10	4 16 11
Sundries (coil spring at 4s. per inch, less 35 per cent., etc.)			5 14 0
Wages paid			26 2 8
„ extra labourers			3 1 0
Material and wages			62 15 3
Expenses..			22 12 0
Gross cost			85 7 3

In addition to foregoing, there was an account for men out at the mill putting up the new parts, but it is not necessary to set out the particulars—the time was charged at the ordinary rates.

It will be seen that, after the discount is deducted, the price charged for the work represents a profit of fifty-five per cent. on the gross cost. This rate in such a small case cannot be considered excessive, as the work demanded nearly as much attention on the part of the management as a much larger job would have done.

It may be pointed out that in this instance, although it was the beam which gave way, the fracture was detected in time to prevent any serious crash. Advantage was taken of the stoppage to make the other repairs indicated in the account as they were needed.

Estimates for Renewals.

Estimates or tenders are not infrequently called for for renewing parts of engines, and whilst all engineers will, and properly so, demur to giving tenders for general repairs, yet as the workmanship in connection with the renewal of a definite part can usually be pretty closely estimated, there is no objection to giving quotations for such renewals.

EXAMPLE NO. 147.—Estimated price for renewing set of 9 in. equilibrium valves for beam engine for.................................. (Profit rates):—

	cwt. qr. lb.	*s. d.*	£ *s. d.*
4 9-in. equilibrium valves, with seats, spindles, nuts, and thimbles, all best brass	440	1 2	25 13 4
16 ½-in. steel set screws for seats, turned and chased		1 6	1 4 0
4 steel taper pins and keys		1 6	0 6 0
Turning, boring, chasing and finishing valves, seats, spindles and nuts.. .. 18 days		16 0	14 8 0
Drilling .. .. ½ day		12 0	0 6 0
Re-chasing two old covers.. .. ¾ "		16 0	0 12 0
Fitters at socket ends, keying and marking off 2 days		10 0	1 0 0
Pattern makers—altering patterns 6 "		10 6	3 3 0
Draughtsman—taking dimensions and drawing .. .. 2 days		12 6	1 5 0
Turner—making gauges .. .. 1 day		16 0	0 16 0
Fitters—taking out old valves and putting in new, including overtime .. 6 days		10 0	3 0 0
			51 13 4

Quoted £50 net, and order taken at this figure.

The cost of the above turned out to be £38 7*s.* 10*d.*, the estimated time proving to be very nearly as above. The time turning up the valves was a little more than estimated, and the time erecting a little less. The castings came out a few pounds heavier.

EXAMPLE No. 148.—Estimated prices of 1 mild steel crank shaft and 2 crank-shaft pedestals for ditto for..................... (Profit rates):—

		cwt. qr. lb.	s. d.	£ s. d.
	1 mild steel crank-shaft 10 ft. 9 in. long over all, with centre boss 16 by 23, crank bosses 12 by 10, bearings 11 by 21. Forged weight ..	51 0 0	30 0	76 10 0
	Turner at shaft .. .. .. 9 days		20 0	9 0 0
	Planer at key-beds .. .. .. 2½ „		20 0	2 10 0
	Fitter at ends of shaft .. .. 1 day		10 0	0 10 0
	Turner, re-boring one crank .. 1½ days		20 0	1 10 0
	Extra for engine, etc., working at night (about 40 hours)			6 0 0
	Net, delivered (local) ready for erection ..			96 0 0
	2 cast-iron blocks and caps for pedestals ..	53 0 0	9 0	23 17 0
	8 brass bushes	1160	1 2	67 13 8
	4 wrought-iron wedges, forged	330	0 2½	3 8 9
	12 adjusting screws and nuts, forged	65	0 5	1 7 1
	8 cap bolts, nuts and guards, forged	200	0 4	3 6 8
	Planers at blocks, caps and bushes 12 days		20 0	12 0 0
	Slotters at do. .. .. .. 4 „		16 0	3 4 0
	Turners at do. .. .. .. 5 „		20 0	5 0 0
	Turners at bolts and nuts .. .. 6 „		16 0	4 16 0
	Drillers .. .. 2 „		13 6	1 7 0
	Fitters .. .. 20 „		10 0	10 0 0
	Pattern-makers—altering stock patterns 4 „		10 6	2 2 0
	Extra for night work			6 0 0
	Net, delivered ready for erection			144 2 2

All ordered at the sum of £240, less 2½ per cent.

EXAMPLE No. 149.—Cost of 1 hammered scrap-iron crank-pin:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Hammered scrap-iron	1 2 0	14 0	1 1 0
0 17 5	Smiths—Wages paid .. .. 13 hours			0 17 4
	Turner „ .. .. 30 „			0 18 9
1 10 2	Planer „ .. .. 3 „			0 1 4
0 3 11	Fitter „ .. .. 15 „			0 7 9
0 0 8	Draughtsman „ .. .. .. 3 „			0 2 6
	Material and wages			3 8 8
2 12 1	Expenses			2 12 1
	Total cost			6 0 9

Charged £8 net.

Cases similar to the one indicated in the following example are of not infrequent occurrence in establishments situated in manufacturing districts.

EXAMPLE No. 150.—Account for mild steel crank shaft to replace broken one. No tender given:—

		cwt. qr. lb.	s. d.	£ s. d.
June, 1888	1 mild steel crank-shaft forging	79 3 14	36 0	143 15 6
	Turning and polishing ditto all over, and planing flats for flywheel keys and sunk beds for crank keys, cutting off both ends of broken shaft with cranks on, boring, slotting and driving ends of shaft out of cranks, and truing up cranks in lathe			30 9 9
	Extra for engine working at night			9 10 0
	(Subject to 2½ per cent. discount.)			183 15 3

The cost of the above job, as far as the part included in the above extract is concerned, was as follows, viz. :—

£ s. d.			cwt. qr. lb.	s. d.	£ s. d.
	1 forging		79 3 14	25 0	99 16 11
	Turners	158 hours			4 18 9
	Planer	50 "			1 2 1
9 17 9	Slotter (cutting old shafts, etc.) ..	35 "			0 13 0
0 18 4	Fitters (old cranks, etc.)	70 "			1 16 9
0 3 11	Draughtsman	20 "			0 15 6
2 9 0	Extra labour at night, including engineman ..				4 18 0
	Material and wages				114 1 0
13 9 0	Expenses..				13 9 0
	Gross cost				127 10 0

The renewal of pistons is another important element of the section of an engineer's work which we are now reviewing. A crank-shaft, connecting-rod, crank or crank-pin, will as a rule only require renewal in the event of a breakdown (if made of good material in the first instance) or in the event of a flaw in the forging showing itself in course of time. A piston will require renewal, sooner or later, owing to mere wear and tear. Frequently, though not always, the renewal will be accompanied by the re-boring of the cylinder. Whilst a new piston, however, does not necessitate the re-boring of the cylinder, the re-boring of the cylinder invariably necessitates a new piston.

Pistons.

Tenders are frequently required for new pistons, but an estimate clerk or draughtsman is rarely called upon to make up an estimate for a new piston in detail. Every establishment where much engine work is done has its own scale of prices for pistons, based upon former costs and upon the experience of the establishment as to what prices are to be obtained in ordinary competition.

The following table may be taken as showing the range of prices for good pistons with steel coil springs. The rates given are per inch of the diameter :—

TABLE OF PRICES OF PISTONS WITH STEEL COIL SPRINGS.

Diameter.	Price per Inch.		
	s. d.		s. d.
12 inches to 20 inches.	16 0	to	18 0
20 " 30 "	18 0	"	20 0
30 " 40 "	19 0	"	21 0
40 " 50 "	20 0	"	22 0
50 " 60 "	22 0	"	24 0

For pistons below about 12 in. diameter plain flat springs are most generally used. The above rates will also apply to air and other pump buckets when of iron. Brass buckets are, of course, much dearer.

It is a common and wise practice when it is suspected that a cylinder will, before long, require re-boring or a piston renewing, to have either or both examined some little time before the approach of a season of the year at which it will be convenient to have the one done or the other put in. If it is decided that a new piston will be required, the order is usually placed so that the piston may be made under ordinary working conditions, and be ready when wanted.

We append one or two examples of costs of pistons.

EXAMPLE No. 151.—Cost of piston 18 in. diameter, with steel coil spring:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Loam castings—block, junk and packing rings	3 2 14	7 6	1 7 2
	Green-sand ditto	9	6 3	0 0 7
	Moulders' Wages			0 10 11
	10 ⅝-in. bolts and nuts	14	10 0	0 1 3
0 1 2	Smiths—Wages paid			0 1 2
	Steel coil spring and carriage			2 2 6
	Turners—Wages paid .. .. 50 hours			1 9 7
	Driller ,, ... 9 ,,			0 3 0
2 12 2	Apprentice turner (at bolts) Wages paid .. .. 13 ,,			0 2 2
0 11 1	Fitters' Wages .. .. .. 46 ,,			1 2 2
0 1 11	Pattern Makers' (at stock patterns) Wages .. .. 4 ,,			0 2 6
	Material and Wages			7 3 0
3 6 4	Expenses..			3 6 4
	Gross cost			10 9 4

Charged £16 4*s.* net, or 18*s.* 0*d.* per inch diameter.

EXAMPLE No. 152.—Cost of one piston, 24 in. diameter, with steel coil spring:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Loam castings	7 1 7	7 6	2 14 10
	Green-sand ditto	11	6 3	0 0 7
	Moulders' wages			1 6 0
	Brass	1		0 0 10
	Bolts, nuts and hoop	20	10 0	0 1 10
	Steel coil spring			3 4 0
0 4 10	Smiths—Wages paid			0 4 10
	Turners ,, ... 61 hours			1 16 1
2 18 5	Drillers ,, ... 7 ,,			0 2 10
1 3 8	Fitters ,, ... 86 ,,			2 1 6
	Apprentice—Wages paid .. .. 35 ,,			0 5 10
0 2 9	Pattern makers (stock patterns) .. 8 ,,			0 3 10
0 0 10	Draughtsman			0 1 8
	Material and Wages			12 4 8
4 10 6	Expenses			4 10 6
	Gross cost			16 15 2

Charged £24, less 2½ per cent., or 20*s.* per inch diameter

EXAMPLE No. 153.—Cost of one piston, 34 in. diameter, with steel coil spring :—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Loam castings	14 2 18	7 6	5 10 0
	Green-sand ditto	14	6 3	0 0 10
	Moulders' Wages			2 6 3
	Brass	1		0 0 10
	Bolts, nuts and hoop	26	10 0	0 2 2
0 4 10	Smiths' wages			0 4 10
	Steel coil spring			4 10 0
	Carriage on ditto			0 4 4
	Turners—Wages paid .. .. 78 hours			2 8 9
	Apprentice do. (bolts, etc.) Wages paid 14 "			0 4 6
4 14 11	Driller .. .. " " 24 "			0 10 0
	Fitters .. .. " " 93 "			2 6 1
1 8 0	Apprentice ditto .. " " 39 "			0 9 11
0 5 6	Pattern makers (alterations only) " 11 "			0 7 4
	Material and wages			19 5 10
6 13 3	Expenses			6 13 3
	Gross cost			25 19 1

Charged £35 14s. net or 21s. per inch diameter.

It will be understood that the costs of pistons just given do not include the making of complete patterns or boards, but merely general alterations and adjustments. The cost of complete boards, etc., for pistons is not, however, very much where the castings are made in loam.

Tenders and Specifications.

It may be well, before leaving this section of our subject, to give an example of a specification of an engine, as sent out, accompanied by a tender, by an engineering establishment.

Many tenders for engines are merely letters, simply describing the leading features and giving the leading sizes of the engine, and stating price. Most people, however, who are contemplating the purchase of an engine of moderately large dimensions like to receive a more detailed description of any engine offered to them, and most engineers prefer to give a detailed specification, with the twofold object in view of thoroughly impressing the buyer with all the meritorious features of the engine offered, and of preventing misunderstandings. Hence it is desirable for the student to have an idea how to draft such a specification.

Some large firms who have complete engineering staffs draw up specifications of their own when requiring engines, and invite tenders upon those specifications. Many public bodies, also, as, for example, water or sewage authorities, when requiring pumping engines, follow a similar practice, or, perhaps, have specifications drawn up for them by professional consulting engineers.

The specification is most conveniently written on foolscap paper, having a wide margin, in which the headings of the paragraphs may be written; thus,

Part Copy of Engine Specification.

SPECIFICATION OF HORIZONTAL HIGH-PRESSURE CONDENSING STEAM ENGINE, TO INDICATE 180 HORSE-POWER AT 60 REVOLUTIONS PER MINUTE, AND WITH 80 LB. STEAM PRESSURE, FOR MESSRS. ....

CYLINDER.—The engine proposed will have a cylinder 24 in. in diameter for a stroke of 4 ft., with valve-chests for Corliss valves cast on, and made from an extra strong mixture of cast iron. The cylinder will be jacketed for steam by having a liner or inner shell, also made of an extra strong and hard mixture of metal, accurately fitted in the outer shell, and will be accurately bored, bell-mouthed and faced, and be provided with covers for cylinder proper, and for valve-chests, all turned and polished. Both cylinder covers will have brass-bushed stuffing boxes and glands, and the valve-chest covers will also be bushed with brass. The cylinder will also be lagged with hair-felt and polished mahogany staves, belted with polished brass bands.

PISTON.—The piston will have block, junk-ring and double packing rings, carefully bored, turned, faced and scraped, and provided with a steel coil spring.

VALVES AND GEAR.—The valves will be of the Corliss type, two for steam and two for exhaust. The steam valves will be worked by our patent releasing gear, actuated by eccentric on the crank-shaft, and controlled direct from the governor, so as to give an automatic and variable cut-off proportionate to the load. The gear will have suitable dashpots for steadying the motion of the valves. The exhaust valves will be worked by separate eccentric and rod.

PISTON-ROD, CONNECTING-ROD, etc.—The piston-rod will be of mild steel, turned and polished all over, and will be prolonged through the back of the cylinder for the purpose of driving the air and force pumps. The cross-head, connecting-rod and crank will be of the best hammered scrap iron. The connecting-rod will have the necessary straps, gibs and cotters, and will be bushed with the best brass. The crank-pin will be of the best mild steel.

CRANK-SHAFT.—The crank-shaft will be of the best mild steel, with journals of extra length and ample diameter.

FLY-WHEEL.—The engine will have a spur fly-wheel 15 ft. in diameter, with teeth 3-in. pitch by 9-in. face, and will be about 10 tons in weight. The wheel will be machine moulded, cast in three segments, will have the joints planed, and the segments carefully bolted with strong bolts.

PUMPS AND CONDENSER.—The engine will have an air-pump, feed-pump and condenser, all arranged vertically below the level of the engine, and at the back end. The air-pump will be 18-in. by 24-in. stroke, and will have a bucket with steel coil spring. Both pumps will be worked from the back prolongation of the piston-rod. The pump-rods and levers will be of forged iron or mild steel, and will be bushed with brass where necessary. The condenser will be provided with the necessary cocks, and will have an ornamental stand for the injection for the house floor, with polished index plate and lever handle.

FRAMING AND PEDESTALS.—The engine framing will be of the Corliss type, of extra strong section, and will be planed to bed upon the foundation, planed for the cross-head slides, faced to connect to the cylinder, and will have the jaws for the crank-shaft bearing slotted. The crank-shaft bearing on the framing, and also a strong pedestal which will be provided to carry the outer end of the crank-shaft, will both be fitted with adjustable brasses of the best quality. All the necessary foundation bolts and cotters will be provided.

General.—The engine will be provided with all the necessary pressure and vacuum gauges, lubricators, tallow cups, drain and indicator cocks and other mountings; and will be throughout of the best material and workmanship. All the parts usually so finished will be polished bright.

Delivery and Erection.—The engine will be delivered and erected by us at your mill, it being understood that you will prepare the foundations to our plans, and give our men the necessary assistance of labourers and scaffolding.

(Signed) ....

Such a specification will be accompanied by a brief letter stating price for engine "according to specification enclosed." It will be obvious that the specification may be amplified to any desired extent, and filled up with details as to sizes of the various parts. All that we have desired to do is to indicate the general character and arrangement of such a specification.

CHAPTER XXI.

STEAM BOILERS.

WE shall now deal with the preparation of estimates for steam boilers and the cost of making boilers.

The manufacture of steam boilers is, of course, quite a business by itself, requiring special shops, tools and other appliances and a special class of workmen, and is largely carried on independently of any other. It is, however, probably most conveniently and economically conducted as a branch of a general engineering establishment.

Space will not permit of the treatment of this section of our subject in great detail, and we shall therefore deal simply and briefly with those classes of boilers which most commonly occur in the business of a combined engineering and boiler-making establishment.

Elements of Complete Boiler.

A complete boiler, as usually sold to a buyer, may be considered as made up of three elements, viz., first, the boiler proper, with the manhole and the seats, saddles or blocks, as they are variously termed, for the mountings, riveted thereon ; secondly, the furnace fittings ; thirdly, the steam and water mountings.

As a rule, the boiler shop of a combined establishment deals only with the first two of these elements, leaving the third to the engineering branch.

Where boiler making is carried on as an independent business, the mountings are, in the great majority of cases, bought by the boiler maker from firms who make a specialty of their manufacture. The boiler maker being allowed a discount of from 15 to 30 per cent. from the list prices of the manufacturers of the mountings, he earns a good commission for passing the mountings through his hands. Occasionally a boiler is sold without mountings, the latter being purchased by the buyer of the boiler direct from some of the special makers.

Progress of Boiler Making.

Up to within a comparatively recent date, a boiler shop was a distinctly crude and primitive establishment, in which the material used in the construction of boilers was treated in what cannot be considered as other than a barbarous fashion—the drift might indeed have been taken as emblematic of the character of the entire establishment and method of manufacture. Of recent years, however, the adoption of high-pressure steam and the use of steel plates have compelled boiler makers to adopt more scientific, reasonable and exact methods of handling their material; and a complete modern boiler shop, with plate edge planing and turning machines, multiple drills, shell-drilling machines, flanging machines, portable riveters and other mechanical appliances, must be placed amongst the most exact and scientific constructive establishments of our day.

Simplicity of Work.

At the same time the business of boiler making is still comparatively simple. We have to deal in it with comparatively few and simple materials, and comparatively few classes of workmanship, whilst the finished productions, although imposing, are simple, and present few variations of type. The preparation of estimates of the probable cost of boilers is, consequently, easy.

Preparation of Estimates.

In most large establishments, where proper records of the boilers made are kept, it will only occasionally be necessary to make up an estimate in detail. Suppose we have an inquiry for the price of a boiler of some standard type, size, and pressure. The list of boilers previously made will, very likely, contain one or more examples of boilers similar to the one for which a quotation is now required. The gross weight of the boiler and the total cost of manufacture will therefore be easily obtained from the cost books, and if the rates for material and wages are practically the same now as when the previous boilers were made, there is nothing further to do—we know the probable cost of the boiler in question, and have merely to consider whether we shall quote the same price as in the previous examples, or make some modification. If the rates for materials or wages are different to what they were on the former occasions, we have the weight of the boiler, and one or two simple calculations will enable us to make the necessary deductions or additions, as the case may be. The rates per ton at which boilers of standard types, sizes, and pressures can be manufactured in any boiler shop, and also the rates per ton for which they can be sold under ordinary conditions, ought to be as familiar to those having charge of the commercial part of the business, as the rates of wages paid to the men and the rates which have to be paid for plates.

At the same time the calculation of the weight of material required to make a boiler is so simple and so readily performed, that it is preferred by many to make such a calculation in nearly all cases. The points which require particular attention in making such a calculation are, principally, the number of rings in which the shell of the boiler will be made; the number of plates which will be used for each ring; the widths of the laps of the circular seams; the style of the longitudinal joints, whether butt-jointed or lap-jointed, and, if the latter, the width of the lap. These points will determine the sizes of the plates to be used, which must be kept within certain limits, partly to suit the tools of the establishment and partly to avoid having to pay excessive "extras" in the prices of the plates.

Other points are, whether the angle iron round the front end of the shell will be put on inside or outside (this obviously determining the size of the end plate), the angle iron at the back end being invariably put on inside; whether the end plates will be made in single solid pieces or halves, the length of the furnaces, the number of rings in the flues and the character of the joints, whether the longitudinal joints will be butted or lapped, and whether the circular joints will be lapped, flanged, or made with expansion hoops, or partly one and partly the other. And, lastly, the style of the riveting in the different parts of the boiler, whether single, or double, or treble; what pitches and what sizes of rivets will be used—a consideration of these points is obviously necessary to determine what weight of rivets will be required.

For example: We are required to quote for a Lancashire boiler, 24 ft. long and 6 ft. diameter, with furnaces and flues 2 ft. 4 in. in diameter. The shell of this boiler will probably be made in seven rings. 24 ft. divided by seven will give 3 ft. $5\frac{1}{8}$ in. as the net width of each ring without allowing for lap. As the boiler is only to work at 60 lb. pressure, the circular or transverse joints of the shell will merely be single-riveted, and if we allow $2\frac{1}{4}$ in. to each ring for lap we shall have sufficient. The width of the plates will therefore be put down at 3 ft. $7\frac{1}{2}$ in. Each ring of the shell will probably be made of three plates. The circumference of 6 ft. being 18 ft. 10 in. practically, the net length of each plate will require to be 6 ft. $3\frac{1}{2}$ in.; but as the longitudinal seams are to be double-riveted, we shall have to allow about 5 in. to each plate for lap, making the total length say, 6 ft. $8\frac{1}{2}$ in. The plates for the shell will therefore be set out in the estimate form, as follows—viz., 21 shell plates 6 ft. $8\frac{1}{2}$ in. × 3 ft. $7\frac{1}{2}$in. × $\frac{3}{8}$ in. steel = 3 tons, 11 cwt.

A table such as may be found in Molesworth's Pocket Book, of the weights per superficial foot of plates of different materials and thicknesses, would, of course, be used in calculating the weight of the plates required. The sizes of the plates for other parts of the boiler and their weights will be found in a similar manner, as will be apparent from the few examples which will shortly be given.

Materials of Boilers.

It has already been stated that the materials required by the boiler maker are comparatively few—they are principally plates, flat, tee and angle bars, and rivets. These will either be steel or iron in the case of ordinary stationary boilers (copper plates are also used in boiler construction, but only for locomotive and some special types of boilers).

Both steel and iron plates are divided into different classes and qualities; steel plates will be either Bessemer or Siemens process plates, the latter being generally considered more reliable than the former, and therefore preferred, especially for parts exposed to the direct action of the fire or for parts which have to be flanged or otherwise much worked. In iron plates we have at the head, the Bowling, Lowmoor, and Farnley plates (the well-known Yorkshire brands) which, however, are only used for special parts of boilers—the furnaces, for example, and sometimes also for the flues, especially if they have to be welded longitudinally and flanged transversely, and occasionally for Galloway tubes.

The mild Siemens steel is now largely used where Bowling or Lowmoor iron was formerly employed.

Ordinary iron plates for boilers are divided into three qualities, distinguished respectively by the brands B., BB., and BBB., meaning best; best, best; and best, best, best, or treble best; whilst in addition there are certain extra qualities, called "extra treble best," "special flanging," "charcoal" plates and other terms. These extra qualities come between the ordinary plates and the Bowling and Lowmoor, and are largely used for furnaces, flues, and Galloway tubes.

It is important to bear in mind, in preparing an estimate, that all plate makers have certain limits of thickness, length, breadth, area, and weight, within which, and within which only, their ordinary rates apply. For plates exceeding these limits, in any particular, extra rates per cwt. are charged, whilst extra rates are also charged for plates which are of any other than rectangular shape. For example: One maker's standard rate for "best" boiler plates is £7 10*s*. per ton at his works, but if a plate is over 15 ft. long it will be charged 40*s*. per ton extra, whilst if it is also over 4 ft. wide, it will be charged a further 20*s*. per ton extra. The limits adopted, and the extras charged by different makers, vary considerably. The limit for weight ranges from 4 cwt. at one works to 10 cwt. at another. The limit for length runs from 15 feet to 25 feet; and for area from 36 to 60 square feet. The limits for width and for thickness are fairly uniform amongst the principal makers, being, with regard to iron plates at least, usually 4 feet for width and from a $\frac{1}{4}$ to 1 inch inclusive for thickness. The extras charged for weight are, in some cases, simply 10*s*. per ton for every cwt. or part of a cwt. which a plate weighs above the limit. In other cases the extra begins at 20*s*. per ton and advances, as the weight of the plate increases, to 80*s*. per ton; and so on with other extras. Most steel plate makers will include all sizes required for ordinary boiler purposes in their general rates, except round plates for ends.

In the following tables we summarise the principal classes of boiler material, indicating the purposes for which they are used, and give the cost prices and the rates which may be charged when supplied in small quantities for repairs.

Prices of Materials.

SUMMARY OF MATERIAL USED IN BOILER MAKING.

Material.	Approximate Cost Price per Cwt.	Selling Rates per Cwt.	Uses.
Steel plates and angles	7*s*. 6*d*. to 12*s*.	12*s*. to 20*s*.	Furnaces, flues, and throughout.
Circles and half circles	12*s*. to 20*s*.	20*s*. to 35*s*.	Ends.
Iron plates—Lowmoor and Bowling........	18*s*. to 35*s*. (according to weight; limit without extra $2\frac{1}{2}$ cwt.)	30*s*. to 60*s*. (usually about 36*s*.)	Furnaces, flues, Galloway tubes, manholes, saddles.
Ditto angles and tees..	18*s*.	28*s*. to 36*s*.	Ends and strengthening hoops for flues.
Scotch plates — Best boiler	6*s*. 6*d*.		Gussets, furnace front plates, shells occasionally.
BB. ditto	7*s*. 6*d*.	12*s*. to 20*s*.	Shells, flues, ends.
BBB. ditto............	10*s*. 6*d*.		Shells, flues, ends, furnaces.

Above Scotch plates are usually free of extras up to 20 ft. length, 4 ft. width, 36 ft. area, and 10 cwt. each plate. Rounds and half-rounds 2*s*. per cwt. extra.

STAFFORDSHIRE AND SHROPSHIRE PLATES:			
Common	6*s*. 6*d*.		Furnace front plates.
Best boiler........	7*s*. 6*d*.	12*s*. to 20*s*.	Gusset plates, shells.
BB. ditto	8*s*. 6*d*.		Shells, flues, ends.
BBB. ditto........	10*s*. 6*d*. to 12*s*. 6*d*.		Furnaces, flues.
Special and charcoal plates	13*s*. 6*d*. to 19*s*. 6*d*.	20*s*. to 36*s*.	Flanged flues, Galloway tubes, manholes, &c.

Usually free of extras up to 15 ft. length, 4 ft. width, and 5 or 6 cwt. Rounds and half-rounds for ends 1*s*. to 2*s*. per cwt. extra.

Angles and tees— Marked Best........	8*s*. 3*d*.	12*s*.	Gussets.
,, BB.	9*s*. 6*d*.	to 16*s*.	Hoops for ends.
Rivets—Iron and steel	9*s*. to 20*s*. (usually 12*s*. to 14*s*.)	14*s*. to 36*s*.	One quality of rivets is usually used throughout.
Steel expansion hoops*	45*s*.	66*s*.	Furnaces and flues.

* These hoops cost from 40*s*. to 60*s*. each usually, according to size of flue.

To the cost prices given in above list must be added carriage or freight, which will, of course, vary according to the distance of the boiler-works from the iron-works, from a few shillings to a couple of pounds per ton. It should also be added that for certain special brands of iron plates which are sometimes specified—"Snedshill," "R. H," "Bloomfield," and others—higher rates of from one to three or four shillings per cwt. are required. It is customary, however, to submit specifications of all the plates required for a boiler or boilers to the iron makers or their agents, and to get exact quotations for them before giving the order; and it is worth while to do so, before giving in quotations for boilers, when there is time.

Prices for plates, of course, fluctuate—at times rapidly and considerably—and it is always an advantage, when much estimating for boilers has to be done, to have at hand some recent issue of a journal like *Ryland's Iron Trade Circular*, for example.

In many boiler shops certain parts—Galloway tubes, flanged flues ready for drilling or riveting, wrought-iron manholes, etc.—are bought ready-made from other establishments having special appliances for their production.

Workmanship on Boilers.

The following table shows the rates of wages paid in the shop where, and during the time when, the boilers given in the succeeding examples were made or tendered for, also the usual rates charged for the different classes of workmen inside and outside the shop, when engaged on repairs or on work for which no tender had been given:—

TABLE OF RATES FOR WORKMANSHIP.

Class of Workmen.	Wages per day of Nine Hours.	Charging Rates Inside.	Charging Rates Outside.
Platers	7*s.* 0*d.*	15*s.* 0*s.* (including fire.)	10*s.* 0*d.*
Riveters	5*s.* 9*d.*	8*s.* 0*d.*	8*s.* 0*d.*
Holders-up	3*s.* 6*d.* and 3*s.* 0*d.*	5*s.* 6*d.*	5*s.* 6*d.*
Labourers	2*s.* 6*d.*	4*s.* 6*d.*	4*s.* 6*d.*
Rivet boys	1*s.* 6*d.*	2*s.* 6*d.*	2*s.* 6d. (including use of hearth.)
Smiths	5*s.* 2*d.*	12*s.* 6*d.* (including fire.)	—
Strikers	2*s.* 10*d.*	4*s.* 6*d.*	—
Engineers or fitters	5*s.* 0*d.*	7*s.* 6*d.*	7*s.* 6*d.*

Apprentices in their last two years were usually rated as journeymen, and younger apprentices at the same rates as labourers. Of course, in addition to the rates for the men when working outside, the allowances paid to them for diet were also charged to the customer, as in the engineering department; whilst in the case of men working inside the shop, in addition to the rates as given for workmanship, the use of the boiler-makers' machine tools was also charged—punching and shearing machines being usually charged at 2*s.* per hour, a plain vertical drilling machine at 1*s.* or 1*s.* 3*d.* per hour, small rolls at 1*s.* and large rolls at 2*s.* per hour, and a hydraulic riveter at from 3*s.* to 5*s.* per hour. When work involving the use of a steam hammer was done, the hammer was charged at from 3*s.* to 4*s.* per hour, including the attendant.

The particulars as to the use of the machine tools were obtained by the time clerk from the men when collecting his returns of time spent on the different jobs in hand during each day. It is hardly necessary to say that, as a rule, the particulars as to the use of the machine tools were merely approximations; when any charge for tools was made, it was for at least half an hour.

Indirect Expenses.

The indirect working expenses of a boiler shop ought to be comparatively light. There should be very little general labour charged to the shop; whilst the jobs in hand are usually so straightforward and obvious, so little liable to become mixed, that no difficulty should be found in charging everything used—candles, oil for lamps, paint, etc., down to the smallest detail to its own proper number. Coal for the plate-heating furnaces, being usually of a special quality, may all be charged to the furnaces and covered by a special rate per hour.

The principal items of indirect expense, which will have to be covered by some percentage, will therefore be—rent, rates and taxes, maintenance of buildings and plant, renewal of utensils or loose tools, management and office expenses, firemen's wages, steam power, coal for smiths' and other fires (excluding the furnaces), and some small amount of general labour.

As in most other departments of an engineering business, it is most convenient to apportion all the indirect working expenses to the direct wages—that is, to the wages spent on work for sale. The percentage will, of course, vary in different places; in the examples we give it is put down at 40 per cent., this being the rate for all work done inside the shop. The rate reckoned for work done outside was 25 per cent. The percentage was determined with reference to the entire labour of the boiler shop—that is, no divisions into classes were considered necessary. The total average weekly wages of the boiler shop where this rate prevailed was £250. Very little piecework was done—the making of Galloway tubes and some occasional things being all that was done by piece.

Donkey Boilers. We shall now give one or two examples of estimates and costs :—

Example No. 154.—Estimated cost of 1 vertical cross tube boiler (donkey boiler) 13 ft. high, 5 ft. diameter, with furnace 7 ft. high and 4 ft. diameter at top, with 4 cross tubes, uptake 12 in. diameter. Vertical seams of shell to be double riveted. Working pressure 70 lb. Hydraulic test 140 lb.

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	3 plates, shell, ⅜ in. steel	29 0 0	11 0	15 19 0
	1 „ 6 ft. diameter, crown, ½ in. steel ..	5 1 0	12 0	3 3 0
	2 „ furnace, ½ in. steel	18 1 0	11 0	10 0 9
	1 „ 5 ft. diameter, crown ½ in. steel ..	3 2 14	12 0	2 3 6
	1 „ 2 ft. 4 in. diameter, firedoor, ½ in. steel	0 3 14	12 0	0 10 6
	1 „ uptake, ½ in. B.B.B. "Barrows" ..	4 0 7	20 0	4 1 3
	4 „ tubes, ⅜ in. B.B.B. "Barrows" ..	6 3 21	20 0	6 18 9
	2 bars, 3 by 2, B.B.	3 1 20	10 0	1 14 5
	Angle iron	0 3 21	10 0	0 9 7
	Rivets, steel	5 0 0	13 0	3 5 0
	Plate of bar iron for man and mudlids and firedoor	2 3 14	9 0	1 5 11
	Wrought iron for 6 stays	6 3 12	9 0	3 1 9
	Wrought iron for grate ring	1 2 0	9 0	0 13 6
	Boilermakers' wages (all classes)			40 0 0
16 0 0	Plate furnace, 10 hours		3 0	1 10 0
1 5 8	Boiler-shop smiths at rings, stays, etc. 8 days		8 0	3 4 0
0 7 2	Driller and helper .. .. .. 3 „		6 0	0 18 0
	Material and wages			98 18 9
17 12 10	Expenses			17 12 10
	Total cost boiler proper	88 2 11		116 11 7
	1 cast-iron stand for ashpit	5 0 0	7 0	1 15 0
	Fire bars	10 0 0	5 6	2 15 0
				121 1 7
	Add for profit 25 per cent.			30 5 5
	Price for boiler, as above			151 7 0
	Mountings (at profit rates):—			
	1 4-in. steam stop valve			4 10 0
	1 3½-in. lever safety valve			4 0 0
	1 1½-in. brass check feed valve			2 0 0
	1 1½-in. brass blow-off tap			1 15 0
	1 set gauge cocks and glasses, etc.			2 0 0
	1 5-in. steam gauge			1 12 6
	Bolts and nuts and jointing material			1 0 0
	Fitter, fitting mountings in shop..		10 0	2 10 0
	Quoted £170 net on wagon at boiler shop ..			170 14 6

The above was an estimate for a donkey boiler of somewhat special size and character, and will sufficiently illustrate the method of preparing an estimate for boilers of this type. It will be seen that whilst the net cost of the boiler proper is made up, the mountings are simply put down at profit rates. The boiler-making department bought the mountings—the valves and cocks—from the engineering department, and the steam and water gauges from outside—and had a discount of about 20 per cent. all over from the prices put down, for its profit on the mountings.

Donkey boilers of standard sizes are now largely made as stock jobs and by piece work by certain houses, and whilst some of the special makers keep up their prices, others quote very low rates. In addition, numerous special types of donkey boilers have been introduced of late years, the specialty usually lying in the form or arrangement of the tubes. Consequently comparatively few donkey boilers are now made in general boiler shops, and, unless made to special specification, they are not, in such shops, particularly profitable as a rule.

Occasionally, very large vertical cross-tube boilers are required for situations where a horizontal boiler is inadmissible, or where it is inconvenient to provide a proper brick setting and a chimney. Such boilers being, of course, departures from the ordinary sizes of donkey-boilers, fall naturally into a general boiler shop.

Cornish and Lancashire Boilers.

The principal business, however, of a modern general boiler shop lies in the manufacture of Cornish, and still more of Lancashire boilers. The Cornish boiler, with its single flue, lies intermediate between the donkey-boiler and the Lancashire type as to the duty for which it is usually intended. The Cornish boiler is supplied for moderate duties, and is consequently largely used in connection with the smaller classes of manufacturing industries. It is rarely made of a diameter exceeding 6′ 0″. For any work requiring a boiler above 5′ 6″ diameter, or representing more than 50 or 60 horse-power, a Lancashire boiler will now usually be supplied. For modern factory use either the Lancashire or "Galloway" boiler (which latter is a boiler with two furnaces opening into one large oval combustion chamber containing a large number of "Galloway" tubes) is generally adopted.

EXAMPLE No. 155.—Estimated cost of one Cornish boiler, 18 ft. 6 in. by 5 ft. diameter, with furnace and flue, 2 ft. 9 in. diameter, having one steel expansion hoop and three Galloway tubes. Working pressure, 80 lb. Test, 140 lb. Longitudinal seams, shell, lap-jointed and double-riveted. Longitudinal seams, furnace, butt-jointed and single-riveted, with covering strips inside and out. Longitudinal seams, flue, lap-jointed. Angle irons at ends, welded into solid hoops, and front one put on outside shell. Edges of all plates planed. All rivet holes drilled after plates are rolled and in position:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Shell, 12 plates, 8ft. 11in. × 3ft. 3¾in. × 7/16in., B.B.	50 0 0	10 3	25 12 6
	Furnace, 2 plates, 8 ft. 8½ in. × 3 ft. 1 in. × 3/8 in., steel	7 2 0	12 0	4 10 0
	Strips for do., 3 ft. 1 in. × 5 in. × 5/16 in., steel	2 21	12 0	0 8 3
	1 expansion hoop, Bolton steel	3 22	45 0	2 2 7
	Flue, 4 plates, 8ft. 11in. × 3ft. 2¼in. × 3/8 in., B.B.	15 0 0	10 3	7 13 9
	Ends, 1 plate, 5 ft. diameter × ½ in., B... ..	3 2 0	12 0	2 2 0
	" 1 " 5 ft. 7 in. diameter × ½ in., B. ..	4 1 20	12 0	2 13 2
	4 bars, angles, B.B.	4 1 0	9 9	2 1 5
	Plates for gusset stays, stock, B.	2 3 0	9 0	1 4 9
	Angles " " "	2 0 0	8 6	0 17 0
	Galloway tubes, 3 plates, "Weardale" ..	2 3 0	16 0	2 4 0
	Rivets, steel	5 2 0	12 0	3 6 0
	" for tubes, stock, "Bowling"	21	30 0	0 5 8
	Paint and sundries			0 15 0
10 0 0	Boiler makers' wages—all classes	5 tons	£5	25 0 0
0 8 0	" making tubes		6 6	0 19 6
	Furnace .. .. 18 hours		3 0	2 14 0
0 15 0	Plate edge planing machine .. 30 "			
0 12 6	Shell drilling machine .. .. 25 "			
	Material and wages	99 2 0		84 9 7
11 15 6	Expenses			11 15 6
	Gross cost boiler			96 5 1
	4 cast-iron branches for mountings	1 3 14	7 0	0 13 2
	Wrought iron for manhole ring, cover and crossbars, etc.	1 0 0	10 0	0 10 0
	Rivets for saddles or branches	1 21	16 0	0 7 0
0 14 0	Boiler makers' and smiths' wages			1 15 0
	Planing, drilling, etc., in engine shop			0 15 0
0 14 0	Expenses			0 14 0
	Estimated cost, boiler and saddles			100 19 3
	Add for profit, say, 25 per cent.			25 5 0
	Price for boiler, etc., as above			126 14 3
	FURNACE FITTINGS AND MOUNTINGS—PROFIT RATES.			
	Furnace front and door, wrought-iron beading, brackets and bolts			3 10 0
	Cast-iron bearers	1 3 0	10 0	0 17 6
	Fire bars	6 2 0	6 6	2 2 3
	1 4-in. steam stop valve			4 4 0
	1 4-in. lever safety valve			4 0 0
	1 fusible plug..			1 1 0
	1 2-in. feed valve, cast-iron shell			2 10 0
	1 2-in. brass blow-off cock			2 15 0
	1 cast-iron bend pipe for ditto			0 12 6
	1 5-inch steam gauge			1 12 0
	2 sets ½-in. water gauge cocks and glasses ..		35 0	3 10 0
	1 anti-priming pipe			1 4 0
	1 internal feed pipe..			0 16 0
	1 damper complete			2 15 0
	2 flue doors and frames		12 6	1 5 0
	1 floor frame and lid			1 15 0
	Bolts and jointing material			1 10 0
	Fitting mountings in shop..			1 10 0
				164 3 6
	Loading and cartage (local)			4 0 0
	Putting boiler on seat			4 0 0
	Attaching mountings at place			1 5 0
				173 8 6

Quote £174 net.

EXAMPLE NO. 156.—Estimated cost of one Lancashire boiler, 30 ft. long by 7 ft. 6 in. diameter, with furnaces and flues 3 ft. in diameter, last plate in each flue tapered to 2 ft. 7 in. in diameter, five Galloway tubes to each flue; longitudinal seams of shell, butt-jointed and double-riveted on each side joint, with covering strips inside and out; circular seams double-riveted; longitudinal seams of furnaces and flues, butt-jointed and single riveted, with strips inside and out; circular seams of furnaces and flues, all formed by steel expansion hoops; end plates, each in one piece and turned on edges and for furnaces and flues; angle iron for front, put on outside and also turned on edge to correspond with edge of plate. Edges of all plates planed; all rivet-holes drilled with plates in position. Working pressure, 100 lb.; hydraulic test, 150 lb.:—

£ s. d.		cwt. qr. lb.	s. d.	£ s. d.
	Shell plates, $\frac{1}{2}$-in., steel	142 0 0	10 0	71 0 0
	Furnace plates, $\frac{7}{16}$-in., steel	21 1 0	10 0	10 12 6
	Flue plates, $\frac{5}{8}$-in., steel	61 0 0	10 0	30 10 0
	Ends, $\frac{5}{8}$-in., steel	25 1 0	18 0	22 14 6
	Angle iron for ditto, steel	9 2 0	10 0	4 15 0
	Butt straps, steel	18 0 0	10 0	9 0 0
	Plates for gusset stays, B.	17 1 0	9 0	7 15 3
	Angles „ „ B.	20 0 0	9 0	9 0 0
	14 steel expansion hoops, Bolton	16 1 0	45 0	36 11 3
	10 Galloway tube plates, Weardale	10 0 0	14 0	7 0 0
	Rivets, steel	35 0 0	12 0	21 0 0
	Rivets for tubes, Bowling	0 3 0	30 0	1 2 6
	Paint and sundries (service bolts, etc.) ..			1 10 0
41 8 0	Boiler makers' wages	18 tons	5 15	103 10 0
1 5 4	Boiler makers at tubes (piece-work)		6 6	3 5 0
	Turning end plates and angle-iron ring, per engine-shop estimate			3 10 0
1 5 0	Plate edge planing machine .. 50 hours			
1 17 6	Shell drilling ditto .. .. .. 75 „			
	Furnace .. .. 20 „		3 0	3 0 0
	Materials and wages	376 0 0		345 16 0
45 15 10	Expenses			45 15 10
	Cost, boiler only			391 11 10
	1 wrought-iron manhole frame and cover, 1 wrought-iron mudhole ditto, and 4 wrought-iron branches, per tender (riveting included in above)			13 10 0
	Estimated gross cost boiler and saddles ..			405 1 10
	Add for profit—say, 20 per cent			81 0 4
	Price for boiler, as above			486 2 2
	FURNACE FITTINGS AND MOUNTINGS AT PROFIT RATES.			
	2 doors, with plates, brass beadings, etc., complete			10 0 0
	Brackets and bolts	0 3 14	0 4	1 12 8
	Cast-iron bearers	3 2 0	9 0	1 11 6
	Fire bars	21 0 0	6 6	6 16 6
	1 6-in. steam junction valve			7 10 0
	1 Hopkinson valve and plates			10 10 0
	1 dead-weight safety valve			9 0 0
	1 $2\frac{1}{2}$-in. check feed valve			3 0 0
	1 internal feed pipe and hangers			1 10 0
	1 stand-pipe for feed			1 5 0
	1 3-in. brass scum tap			5 10 0
	1 cast-iron stand pipe for ditto			1 5 0
	4 internal scum troughs and hangers	7 2 0	12 0	4 10 0
	1 anti-priming pipe (round)			1 15 0
	1 Bourdon steam gauge, 7 in.			2 0 0
	2 sets brass water-gauges and glasses		40 0	4 0 0
	1 brass water-level index			0 6 6
	2 fusible plugs and spare caps		30 0	3 0 0
	1 3-in. blow-off cock, brass			5 10 0
	1 cast-iron elbow pipe			0 15 0
	1 floor frame and plate			2 15 0
	2 flue doors and frames			1 5 0
	1 damper and mountings			4 0 0
	Bolts and jointing material			1 15 0
	Fitting on mountings in shop			2 0 0
				579 4 4
	Number of boilers required			3
				1737 13 0
	Deduct $2\frac{1}{2}$ per cent. for 3			43 8 6
	Quote £1,694 net on wagons at our shop ..			1694 4 6

The two examples just given, being in complete detail, sufficiently explain themselves. It will be noted that a small special sum is placed in the expenses column opposite the plate edge planer and the shell drilling machine. These machines not being used for every boiler made, it was considered necessary to fix a small additional rate for them to cover such expenses — drills, tool steel, &c.— as were special to them, although the wages of the men who worked them were included with the boiler makers.

Example No. 156 may be taken as fairly representative of a high-class Lancashire boiler, both as regards the boiler proper and its equipment. Some makers would prefer to make a boiler of this type and for so high a pressure with the longitudinal joints in the furnaces and flues welded and the circular joints flanged and with the Galloway tubes welded in, in which case some of the higher brands of iron would probably be used in preference to steel. The cost of a pair of furnaces and flues so made would be between £100 and £120, and would bring the total cost of the boiler below that of the example, as the steel expansion hoops, when used throughout, add very considerably to the cost of the boiler, though they undoubtedly make a fine job.

As already intimated, estimates for boilers are frequently made up in a much more summary fashion, as, for instance :—

Example No. 157.—Estimated cost of one Lancashire boiler 32 ft. long by 7 ft. 6 in. diameter, with furnaces and flues 3 ft. diameter, 12 Galloway tubes, 2 expansion hoops of steel, "Best" iron throughout, except furnaces, which are to be of mild steel. Working pressure, 70 lb. Hydraulic test, 120 lb.

	Tons.	£ s.	£ s. d.
1 Lancashire boiler, as above	13 0 0	11 5	146 5 0
Making ditto and expenses		5 15	74 15 0
			221 0 0
1 cast-iron manhole frame and cover			2 10 0
1 " mudhole ditto			2 10 0
4 " branches			2 10 0
			228 10 0
Add for profit, say 20 per cent.			45 14 0
			274 4 0
Mountings, etc. (these are generally detailed, and it is desirable that they should be for reference)			85 0 0
			359 4 0
Cartage, putting on seat and fixing mountings			15 10 0
			374 14 0

Quote £375 net.

Tubular Boiler.

For many situations where considerable heating surface is required, but where space or other considerations preclude the adoption of an ordinary Lancashire boiler, and particularly for shipment abroad, multitubular boilers possess many advantages. The following is an example of an estimate for a useful type of multitubular boiler:—

EXAMPLE NO. 158.—Estimated cost of one multitubular boiler, 16 ft. long by 6 ft. diameter, with two furnaces, 7 ft. long by 2 ft. 4 in. diameter; one combustion chamber, 1 ft. 9 in. long, 5 ft. 2 in. wide, and 3 ft. high; and 55 iron tubes, 7 ft. 3 in. long by 3¾ in. outside diameter, including 7 stay tubes; end plates single, front stayed with 4 gusset plates, and back with 9. Rivet holes of shell drilled after plates are rolled. Edges of plates planed; working pressure, 60 lb.; hydraulic test, 100 lbs.; longitudinal seams, shell double riveted:—

£ s. d.		cwt. qr. lbs.	s. d.	£ s. d.
	Shell, 15 plates, ⅜-in. steel	48 0 0	11 0	26 8 0
	Furnaces, 4 plates, ⅜-in. steel	15 2 0	11 0	8 10 6
	Combustion chamber, $\frac{7}{16}$-in. and ⅜-in. steel.	5 2 21	11 0	3 2 7
	1 elliptical tube plate, ⅝-in. steel	4 0 0	11 0	2 4 0
	Back end plate, 6 ft. diameter × ⅝-in. steel ..	6 2 7	11 0	3 12 3
	Front ,, 6 ft. 8 in. diameter × $\frac{7}{16}$-in. steel	5 2 0	11 0	3 0 6
	Angle iron, 3×3×½-in. ends, BBB.	5 0 0	12 0	3 0 0
	Gusset plates, B.	4 1 0	9 0	1 18 3
	Angle iron for gusset plates, B.	2 3 0	9 0	1 4 9
	Rivets, steel..	7 0 0	12 0	4 4 0
	48 plain tubes, 7 ft. 4 in.×3¾-in. outside diameter×No. 9 W. G., expanded at one end to 3⅞ in. = 352 ft., at	(18 3 12)	1 0	17 12 0
	7 stay tubes, 7 ft. 6 in.×$\frac{5}{16}$-in. thick, screwed at both ends = 51½ ft.	(2 3 8)	2 0	5 3 0
	21 nuts for tubes		1 4	1 8 0
20 0 0	Boilermakers' wages			50 0 0
0 14 0	Driller and attendant at tube plates			1 15 0
0 12 0	Shell drilling machine .. .. 25 hours			
0 10 0	Plate-edge planing machine .. 20 ,,			
	Furnace .. .. 18 ,,		3 0	2 14 0
	Paint, painting and sundries			1 5 0
	Material and wages			137 1 10
21 16 0	Expenses			21 16 0
	Gross cost boiler			158 17 10
	Wrought-iron for man and mudhole rings and plate for feed valve	3 0	10 0	0 7 6
	1 patent manhole door			1 8 0
	1 ,, mudhole door			1 1 6
	Cast-iron branches	2 0 0	7 0	0 14 0
	Rivets	1 14	16 0	0 6 0
0 15 2	Boilermakers' Wages			1 18 0
	Facing branches, per engine shop			0 15 0
0 15 2	Expenses			0 15 2
	Estimated cost boiler and saddles			166 3 0
	Add for profit 30 per cent.			49 16 9
				215 19 9
	Furnace fittings and mountings .. .			58 0 0
	Price free on rails at works, net			273 19 9

As in the case of large steam engines, tenders for new boilers are usually accompanied by specifications setting out in more or less detail the dimensions of the boilers, thickness of plates, style of riveting, and any features of construction or mounting supposed to have special merits or advantages. Most large boilermakers have printed specifications of the standard type or types of boilers which they make, the printed form having certain blank spaces left in it, where the dimensions of the various parts of a boiler may be filled in by hand, according to the requirements of any particular case. The following is a sufficiently detailed form for ordinary Lancashire boilers, viz.:—

Tenders and Specifications.

Copy of Boiler Specification.

Victoria Boiler Works, Blanktown,
Nov. , 1888.

SPECIFICATION OF NEW STEAM BOILER FOR M...
....

The boiler will be of the Lancashire type, constructed in accordance with the best modern practice, principally by the aid of patent machine tools specially designed for the various processes, so as to secure the greatest possible accuracy and soundness throughout.

SHELL.—The shell will be .... ft. long by .... diameter, and will be made in .... rings, ... plates to each ring, of .... plates .... of an inch in thickness. The longitudinal seams will be .... jointed and .... riveted, and crossed so as to avoid a continuous line of rivets. The circular seams will be .... riveted. The edges of the plates will be planed, and the rivet holes will be drilled after the plates have been rolled and put in position. Each end will be provided with a solid welded ring of angle iron for attaching to the end plates, the ring at the front end being fixed externally.

FURNACES AND FLUES.—The furnaces will be .... ft. .... in. in diameter and .... ft. .... in. long, made in .... rings, each ring of a single plate of .... and .... of an inch thick. The longitudinal seams will be .... jointed and .... riveted and placed below the fire-bed. The circular seams will be ....

The flues will be .... ft. .... in. in diameter, in .... rings, each ring of a single plate, all of .... and .... of an inch in thickness. The longitudinal seams will be .... jointed and .... riveted. The circular seams will be .... Each flue will have .... conical water circulating tubes arranged in the usual alternately vertical and diagonal manner. The last ring in each flue will be tapered to .... ft. .... in. in diameter to facilitate cleaning and inspection.

ENDS.—Each end will be made of a rolled plate of .... and .... of an inch in thickness, with the edges turned up in lathe and the holes for the flues cut out by machine and accurately finished. Each end will be sufficiently stayed to the shell by means of strong gusset plates with double angle irons.

MANHOLE, MUDHOLE AND BRANCHES.—The boiler will be provided with a .... iron manhole frame .... riveted on top of shell, and a .... iron mudhole frame on the front end plate below the furnaces, both with strong faced covers with the necessary bolts and nuts and crossbars.

.... branches of .... will be riveted to the shell to receive the mountings. All the flat flanges of the frames and branches will be turned or planed.

The boiler will have the following fittings and mountings, viz.:—

FURNACE FITTINGS.—Two wrought-iron furnace fronts with cast-iron doors having air-regulating slides, brass beadings, cast-iron dead plates, wrought-iron brackets, cast-iron bearers and set of fire bars complete.

STEAM VALVE.—One .... inch steam junction or stop valve with brass spindle, gland, valve lid and seat.

SAFETY VALVE.—One Hopkinson high-steam and low-water safety valve complete.

(And so on with the other mountings.)

PRESSURE.—The boiler will be suitable for a daily working pressure of .... lb. per sq. in., and will be proved by hydraulic pressure to .... lb. per sq. in. before leaving our works, and in the presence of your engineer or inspector.

DELIVERY, &c.—The boiler, mountings, &c., will be delivered by us free at ...., the boiler put upon its seat, and the mountings attached, for the sum of £.....................

(Signed) ....

It is probably better to give the price and terms in a separate letter.

CHAPTER XXII.

COSTS' BOOK-KEEPING.

WE shall now conclude by dealing, as fully as space will permit, with the keeping of costs. The subject has already been briefly introduced in chapter V, and it would be well if the student would re-read that chapter before going further. Great interest has of recent years been taken by those connected with the commercial work of engineering (and indeed numerous other manufacturing) establishments in the question of the best and most convenient methods of keeping costs accounts.

The days are past when a manufacturing engineer of any considerable position was content to form an idea how his business was going on by an occasional examination of his bank book and of his stocks, even with a complete stocktaking and the preparation of a balance-sheet once a year. The necessity of being able to ascertain the cost of every individual job done throughout the year, promptly upon its completion, and even of being able to follow the progress of large and important jobs in systematic costs books, week by week, is now generally recognised.

In most large engineering establishments arrangements more or less complete and reliable are now made with the view of securing these ends.

In seeking to attain these objects, the manufacturer has two important considerations in view. In the first place, he wishes to localise his profits or his losses—he wishes to know what jobs have paid him, and on which, if any, he has sustained a loss; and in the second place, he desires a safe guide by which to check his future estimates and determine his future tenders.

Object of Cost Accounts.

It will be obvious that whilst a business may upon the whole be profitable, some portions may be the very reverse; but unless a detailed system of costs be in use it will be impossible to know this, and the manufacturer may go on year after year keeping up an unprofitable department, or class of work, at the expense of other departments or classes.

Again, a business may upon the whole result in a loss, but this may be entirely due to excessive losses in certain departments or on certain classes of work. If, however, detailed costs are kept, the manufacturer can detect the weak place in a moment, and may therefore concentrate his attention upon it with a view of strengthening it; or, if this be found impossible, he knows exactly what department or class of work he must abandon.

The ordinary systems of book-keeping, whilst perfectly adapted for keeping the accounts of a manufacturer with the people from whom he buys and those to whom he sells, for exhibiting the conditions of a business as a whole at stated intervals, and for other general commercial purposes, are not adapted to the particular purpose of ascertaining and recording the costs of the individual jobs that make up the business of a general engineering establishment. Hence a special set of books must be devised, and, in large establishments a separate office should be appropriated to, and a special staff appointed, under the immediate supervision of the chief commercial manager, for the business of keeping the costs books.

Special Books Necessary.

We shall here confine ourselves to the costs books proper, and shall only touch upon such counting-house books as admit of being used in connection with the keeping of the costs. Neither shall we attempt to discuss more than incidentally the relative merits of different systems, but shall content ourselves with setting out and illustrating one system: practicable, accurate, and sufficiently complete and detailed for all ordinary purposes.

It would be easy to multiply books and forms for the keeping of costs to almost any extent; it is desirable to attain the object in view with the fewest possible books and the minimum of labour.

It is necessary to have the object to be attained clearly in view. That object is to keep a correct account of the cost of every job undertaken by the establishment, and to keep the account as closely as may be feasible concurrently with the progress of the work itself. It ought to be possible for a principal to call for particulars of the cost of any job in hand up to date, and to have a reliable statement put before him in the course of an hour, or two at the most. This will be rarely required, but should be always possible. For all ordinary purposes, it will be sufficient if the accounts of the costs of all work in hand are completed up to the end of one week or fortnight (according as wages are paid weekly or fortnightly), before the end of the next week or fortnight. Any less degree of readiness and completeness ought not to be considered satisfactory.

As was previously pointed out, the cost of any piece of machinery may be best considered as made up of three elements —viz., the cost of material used for the construction of the article; the cost of labour directly expended upon it; and a sum, most conveniently determined by a percentage upon the direct wages, to cover all the indirect expenses of the establishment.

In the writer's opinion, the percentage added for indirect expenses should cover every item of expenditure which cannot be charged direct, but which is necessary, in the case of any establishment, to the production of the article in question. This percentage should, therefore, cover management and office expenses, depreciation or maintenance, and interest on capital, as well as rent, foremen's wages, and other items of indirect but necessary expenditure. It is sometimes contended that management and office expenses and interest on capital should not be treated as elements of the cost of production. They enter, however, as elements into the cost of production, to a greater or less extent in nearly every establishment, and it is difficult to see what advantage is to be gained by treating them separately.

Before the price of an article can be fixed, something must be added to the other elements of cost on account of interest, office and management expenses, and it is, therefore, surely better, and certainly more convenient, to let these items be covered by a general percentage which has been determined with reference

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to the average volume and value of the business of an establishment, rather than to allow them to be covered by a separate rate determined by the whim or fancy of a principal at any particular moment. In some instances, as for example in the case of a firm making a specialty, advertising largely, and employing many travellers or agents, a useful purpose will be served by making a distinction between the cost of production and the cost of distribution; but it will rarely be necessary to make such a distinction in the case of a general engineering establishment.

We have already explained generally in a previous chapter the methods to be observed in ascertaining the indirect expenses of an establishment, and in apportioning these expenses properly over the different departments. The nature of these indirect expenses has also been fully dealt with. It is only necessary here to add two remarks: First, that in the scheme of cost-keeping about to be described, accounts are opened in the various costs books in the names of each department, or section of a department, and also in the name of the general indirect expenses of the establishment, and these accounts are kept exactly as the account for any order that may be in hand. That is to say, an account will be opened in the materials costs books and the wages costs books in the name of "Pattern-shop Indirect Expenses," and when the pattern-shop obtains a supply of nails or of glue for general use from the store, these items will be charged to the account in the former of the books named in the same way as a cylinder or any other item of material would be charged to the account under which it had been made; and so on with all the other departments, no matter how many there are. By thus observing the same routine and using the same books for the indirect expenses accounts as for any contract that may be in hand, the work of keeping these accounts is much simplified and labour is saved. Secondly, we remark here that an elementary rule, the strict observance of which is indispensable to the satisfactory working of any scheme of cost-keeping, is that every item of expenditure, must be charged to some account in the costs books. All expenditure for material intended for consumption or conversion in the works, or required for the maintenance of the buildings and fixed and loose plant in a proper state of repair; all expenditure for labour and management, for rent, rates, taxes, insurance, interest; all expenditure, in short, incurred for the working of the establishment, should be fully accounted for by the costs department in conjunction with the stores.

It will be better if even expenditure on capital account is also passed through the costs books. Suppose it is intended to enlarge a building or put down a new machine tool, an order ought to be entered in the order book for this extension or addition in the name of "New Buildings" or "New Fixed Plant" or "Capital Account" generally, and all expenditure in connection therewith should be dealt with in the costs books, just as in the case of an ordinary contract.

It may be added that both the costs department and the general management must carefully see that items of wages and of miscellaneous expenditure are not heedlessly charged to the working expenses accounts. "When in doubt charge to the shop" would appear to be a rule which both workmen and clerks are extremely liable to follow, either consciously or unconsciously. It will help to hold this tendency to "charge to the shop" in check if it is made a rule that nothing is to be made for the shops, either to replace a worn-out utensil or to repair a machine tool, without an order being entered in the order book.

Order Book.

The first essential element of a sound scheme of cost-keeping is an accurate and systematic method of recording orders, and distributing these orders, together with specifications sufficiently complete and detailed, amongst the various departments which will be concerned in their execution. In some establishments a number of order books are employed —one for the general offices, one for the drawing offices, and one for each of the principal departments. This method, however, involves a large amount of labour, and is inconvenient, inasmuch as the foremen must be without their order books during certain parts of the day, whilst the books are being written up in the general offices. This plan would, indeed, appear to combine the maximum of labour with the minimum of advantage; and is quite indefensible now that so many efficient methods of multiplying copies of writing are available.

A far more convenient and perfectly satisfactory method of dealing with orders is the following:—A general order book is provided and kept in the general offices. In this book every

ILLUSTRATIVE FORM NO. 1.—ORDER BOOK.

LEFT-HAND PAGE.

Date when Ordered.	Order No.	NAME AND ADDRESS OF CUSTOMER. DESCRIPTION OF ORDER.
188— Jan. 6	67	Thomas Robinson and Sons, Victoria Saw Mills, Blanktown. One horizontal high pressure non-condensing steam engine, with cylinder 9 × 18, to work at 100 revolutions per minute, and to indicate 15 h.p., with boiler pressure of 80 lbs.; metallic piston, steel rod, crank shaft and pin, hammered scrap-iron connecting rod, plain slide valve, quick speed governor, equilibrium throttle valve, plain fly-wheel turned up on rim, feed pump, stop valve, and other mountings, cast-iron bedplate, foundation bolts, &c., complete, delivered and erected as per specification.
Jan. 6	68	James Smith, Castle Street Mills. One cast-iron elbow pipe to sketch; face flanges and drill bolt holes.

order is entered as received, its consecutive number put opposite, together with any necessary references as to the estimate book, tender book, or letter book. All that is necessary in this book is for the entries to be sufficiently descriptive of the work required to be done. The arrangement of the book is shown above:—

ILLUSTRATIVE FORM NO. 1.—ORDER BOOK.

RIGHT-HAND PAGE.

Estimate Book Folio.	Specification or Tender Book Folio.	Date when delivered, and space for any remarks or notes it may be desirable to record during progress of work, or for instructions as to delivery of goods.	Folio in Sales or Day Book or No. of Delivery Docket.
9/82	8/99	Forward per G. N. R. to Blanktown Station; Robinsons will cart to mill. See letter Jan. 24th. Delivered Feb. 188— Completed Feb. 22, 188—	Docket Nos. 672 694
		Verbal order by Mr. ——— to J. T. (pattern shop foreman).	Day Book. 301

The book is of post size, giving a page of fully 15 in. in length, by 9¼ in. width. Omitting the name of the customer, but leaving space for it, and putting in the order number, an exact copy of the entry in the order book is then written out in multiple copying ink on a "Shop Order Form." A separate form is taken for each entry.

The form is a single sheet or page, nearly 16 in. by 10 in., ruled as follows:—

ILLUSTRATIVE FORM NO. 2.

O.Nº 67

Order No. 67

Issued to Drawing Office

" Shop

Order completed

Drawing Numbers.	Description of Order and Enumeration of Parts here.	This space is utilised for Remarks or Notes of Weights.

The form is copied in a copying book as a record merely, and afterwards sent into the drawing or works' manager's office. Before being sent in, however, the name of the customer is written on in pencil, merely for the information of the chief draughtsman, or works' manager. It should be made a fixed rule for all formal orders to be sent into the shops through the drawing office.

Shop Orders.

If the order is simply a casual one for some standard article or simple repair, and on the face of it enumerates all the parts that will be required, it is at once copied in a copying book, called the " Shop Orders Copy Book—D. O." (Drawing Office). Then from the back or inked side of the leaf in the copy book, as many more copies will be taken, each on a separate sheet of stout paper, as there are departments through which the work will have to pass. For example, if the order be for " One cast-iron pulley, 30 in. by 9 in. face turned convex, bored 3 in. diameter (gauge herewith), and with one key bed cut," four copies will be taken, one each for the pattern-shop foreman, the foreman moulder, the turning-shop foreman, and the storekeeper. A boy, of course, takes the copies with the aid of a strong press.

If the entry does not enumerate the parts required, the chief draughtsman sees that a complete enumeration of every part is written out on the same sheet or on continuations, with any special instructions and all necessary references to the numbers of the working drawings. This enumeration of the parts may appear a formidable task, but seeing that it has to be done by someone in some way, it is decidedly the best to have it done in the proper office at the outset. Much loss of time at subsequent stages is thus avoided. Of course, it not infrequently happens that a job must be started before all the drawings are completed, and before all the parts can be enumerated. Supplementary order forms have then to be issued.

In cases where a detailed estimate has been prepared in the drawing office, this is got back from the estimate clerk, the prices being first torn off at the side, and is utilised as the basis of the shop order sheets. Each sheet, before being sent to the foremen, has the number of the order (which is already written on it) stamped at the head in bold figures by indiarubber stamps. Each foreman has a strong guard book in which to keep his sheets. The sheets are allowed to project at the top sufficiently to enable the stamped number to be read, so that the book can be opened at any order number with perfect convenience. As soon as each foreman has finished his part of the work on any order, he initials the sheet and returns it to the drawing office; and as soon as the order is entirely completed, the original sheet received from the general office, with every original addition made in the drawing office, if any, is sent to the forwarding clerk.

Where much jobbing is done it will frequently happen that work on an order is commenced before the order is entered at all. It is difficult to prevent this entirely. Engineers of mills and others will come and give their orders verbally to foremen or managers, and the work, if urgent, must be promptly started. For such cases the foremen have "Verbal Order Forms," upon one of which they must enter the particulars of the order, with the name of the customer and of the person giving the order, and send it in to the general office to be entered, numbered, and passed through the usual course as soon as they conveniently can.

The objects sought to be attained by a complete and systematic method of distributing orders through the shops, such as the one just described, are principally two—viz., first, to ensure that nothing shall be made except under a distinct order; and, secondly, to assist in securing accurate returns of material and workmanship from the shops.

We have now to consider how these returns may be best obtained. First, as to material. It must be premised that all work is supposed to be done under an order number, and that anything made or done is to be charged against its number; except in the case of work done for the shop, in which case it will be done under an order in the name of the shop account, and must be charged against that name. It is sometimes preferred to appropriate certain numbers to the different shop accounts, and have work done for the shops returned against those numbers. There can be no particular object or advantage in adopting this plan, whilst the use of names for the shop accounts necessitates much less explanation in the case of new hands, and is less liable to cause confusion or error than numbers.

Shop Returns.

It will very often happen that other work will be returned against names—against the names of customers, instead of against order numbers, especially where much jobbing is done. This cannot be entirely avoided, and is another of those irregularities which must be tolerated, and with regard to which dependence must be placed upon the scrutiny and supervision of the costs office.

Material—Three Cases. First Case.

We have three general cases of material to deal with—first, material bought specially from outside for particular jobs; secondly, material, such as castings and forgings, manufactured in the works; and thirdly, sundries from the stores. Material or work is only ordered from outside upon a formal requisition being sent in to the general offices. The requisition is prepared and signed by one of the foremen, or by the storekeeper, or by some draughtsman in charge, and is always passed through the drawing office (or works' manager's office, which generally means the same thing), and countersigned by the chief draughtsman or manager. The requisition states the order number or name of account or department for which the material is required, and this number is entered on the order form in the "Outwards Order Book." Upon the priced invoice being received, it is at once compared generally by the outwards orders clerk with the order, and stamped with a bold rubber stamp as follows:—

ILLUSTRATIVE FORM No. 3.

REQUIRED FOR..
OUTWARDS O.B., folio..
PRICE ....
WEIGHT OR QUANTITY ....
STORES JOURNAL, folio ....
COSTS BOOK, folio ....
INVOICE BOOK, folio ....

In the first line is entered the number of the shop order, or the name of the account on behalf of which the goods were ordered. The first three lines and the last are filled up in the general offices. The invoice is then sent to the storekeeper, who certifies the receipt of the goods, and the correctness of the weight, by putting his initials in the fourth line; and if the goods were ordered for the stores, he enters the invoice in the "Stores Journal," and puts the folio or page in the fifth line.

The invoice then passes into the costs office, where, if the goods were ordered for stores, it is simply initialled in the sixth line to show that it has properly passed through the office. But if the material or work was ordered for some particular job or shop account, which will be apparent at a glance at the first line, there will be no folio, but simply the storekeeper's initials in the fifth line. The costs clerk will therefore enter the material in his "Costs Book—Materials," against the proper order number, and put the folio in the sixth line. It will thus be seen that everything received must pass through the stores and costs office, and be accounted for by the one or the other, or by both.

Storekeeper.

It may be here remarked that a good store and competent storekeeper are absolutely essential to the correct keeping of costs. It is impossible to obtain accurate and reliable returns of material used for different jobs unless the distribution of that material is carefully supervised and recorded. It will also be equally impossible to make up correct accounts of the departmental expenses. Therefore a well-organised store, under intelligent and, of course, reliable direction and control, should be one of the first objects of the proprietor or manager who desires to put his cost-keeping on a proper basis.

Second Case.

Referring now to material manufactured in the establishment—iron castings, for example. We have already explained how the foreman moulder gets his authority to make castings. In addition to the formal order sheet sent in to the foundry, the patterns when sent there from the pattern shop have, as a rule, a ticket gummed on, stating the number of the order, and the number of castings required. After the castings are fettled or dressed, they are sent to the stores weighing machine, where the storekeeper, or an assistant, receives them, weighs them, and enters them, with the number of the order for which they are required (which has usually been chalked on the castings by the foreman moulder or under his direction), upon an "Iron Foundry Returns" sheet. If the castings require workmanship to be put upon them, they are sent, accompanied by a simple docket, stating number, weight, and order number, into the turning or fitting shop. If they are to be delivered as castings to the customer, the storekeeper retains them, pending the receipt of a forwarding order from the proper quarter. The return sheets are of post size and ruled, as follows :—

ILLUSTRATIVE FORM NO. 4.

IRON FOUNDRY RETURNS.

Date________ Sheet No.______ Total Sheets______

Order No. or Name.	Number of Castings.	Description of Castings.	Cwt.	Qr.	Lb.					

The columns at the right-hand side which are left blank above are utilised for special notes or remarks, and occasionally in the costs office, for noting against particular castings the time spent in moulding them, the rate of the moulder's wages, and the total cost in wages. For example, if a casting has been made in loam, the word "loam" will be written boldly across these columns. The particulars of the time spent in moulding are frequently required by the manager or head clerk, who prices the castings in the sales book; and whilst the total cost of moulding in wages is always to be found under each order number in the "Costs Book—Summaries," and in the "Costs Book—Wages," it is frequently desirable in the case of jobbing orders to have the particulars in greater detail. In such instances, the columns on the sheets can be very conveniently used for noting the necessary details.

As soon as the sheets for the day are completed, they are copied in a press copy book in the stores office as a formal record that they were completed, and sent into the general offices, and finally into the costs office, where from them the particulars are posted by the costs clerk into the proper book under each order number or account. Returns from the brass foundry and smithy are obtained in the same manner.

It is desirable to have one man, under the supervision of the storekeeper, specially appointed to attend to the work which has just been described in connection with the shop returns sheets. In a moderately large establishment he may also attend to the giving-out of the raw material required by the foundries and smithy. In very large works, a subdivision of these duties will, of course, be necessary.

In addition to goods ordered specially for particular jobs, and which are entered in the "Costs Book" direct from the invoices; and material manufactured in the works, we have to deal with sundries supplied by the stores. Goods can only be obtained from the stores under the authority of a foreman, or of an authorised leading hand, which authority is usually conveyed to the storekeeper in the shape of a simple docket or requisition form, on which is briefly stated what is wanted, and the order for which it is required. The docket is initialled by the foreman or leading hand, and is retained by the storekeeper after the goods have been given out. At intervals, and after a sufficient length of time has elapsed to make it unlikely that any question will arise respecting the goods supplied under the authority of the dockets, the accumulated papers are destroyed.

Third Case.—Stores.

As goods are handed out of the stores, they are entered in a "Stores Waste Book," which lies conveniently near to the delivery window or counter. This "Waste Book" merely records the number, weight and description of the articles, with the order number. Two "Waste Books" are in use (for alternate days), so that one may always lie at the delivery desk, whilst the other is in the stores office. From the "Waste Books" the storekeeper compiles a "Stores Supplied" sheet for every order number or account. The compilation of these sheets is simply a "posting" operation. In some establishments, instead of posting at once on to sheets, the entries are made in a book, under the different order numbers or accounts, and copies of the accounts as they appear in this book are made from time to time for the general or costs offices. It serves every useful purpose, however, to compile the "sheets" we are now describing, and to press-copy these sheets in a copybook, which latter, of course, will be properly indexed for convenience of reference. The "stores supplied" sheets are similar to those already described in connection with the orders and the foundry returns, but are differently tinted, and are ruled as follows :—

ILLUSTRATIVE FORM NO. 5.

STORES SUPPLIED.

Order No.______

Date supplied.	Order No.	Number of Articles.	Description of Articles.	Cwt.	Qr.	Lb.	Rate.	£	s.	d.

The storekeeper is required to send in his sheets for all orders completed and all work in progress, weekly, to the general offices. He is also not infrequently called upon during the course of the week for immediate returns of orders completed, and for which priced invoices are required at once.

The sheets from the stores are, like all the other returns sheets, first copied out by hand into books which are kept in the general office. The principal use of these books is to enable the forwarding clerk to check and fill in the particulars of weights and other details into his delivery dockets or advice notes, from the originals of which the entries are made in the Day or Sales Book. In small establishments this copying of the sheets may be dispensed with, and the forwarding clerk may use the "Costs Book—Material" for filling up his delivery dockets. The sheets finally pass into the costs offices, where the particulars contained on them are entered into the "Costs Book—Material."

Costs Book—Material.

This book is a rather wide and not very deep book—each page measuring about 16 in. in width and 12 in. in depth. It is ruled as follows :—

Illustrative Form No. 6.

"COSTS BOOK—MATERIALS."

Left-hand Page.

Order No.__________ Date of Order__________

Name__________

Job__________

Date.		Number and Description of Iron Castings.	Cwt.	Qr.	Lb.	Rate.	£	s.	d.	Date.		Number and Description of Forgings — Iron or Steel.	Cwt.	Qr.	Lb.	Rate.	£	s.	d.

Right-hand Page.

Order Completed__________ Summaries Folio__________ Sales Book Folio__________

Ruling as above. (This column reserved for Brass and Copper.)	Ruling as above (This column reserved for Sundries and Stores.)

Two of these books are in constant use, one for jobbing orders and one for contracts. In the latter, orders are entered consecutively, as they come up in the returns, as much space being allotted to each as the costs clerk judges, from the nature of the order, will be required. In the jobbing book space is allotted to each regular customer, and all orders received from that customer are entered in the space reserved, each being kept separate, and entered as they come up in the returns. Jobs from casual customers are entered towards the end of the book. The two books are distinguished by having the letters J. and C., respectively, boldly stamped on the backs.

Special Castings and Forgings.

In addition to these, the principal Materials' Books, two subsidiary books, are also used, one for "Special Castings" (loam or drysand) and one for "Special Forgings." The costs of all loam, or dry-sand castings, are made up separately in the former book; the latter is used for making up the costs of forgings which it is desired to keep separate from the general body of a contract. The following will sufficiently illustrate the character and use of both books:—

Illustrative Form No. 7.

"SPECIAL CASTINGS.—COSTS BOOK."

Order No.________ C. B. M. fo.:_______ Summaries fo.:________

Name of Customer____________________

			£	s.	d.	c.	qr.	lb.		£	s.	d.
Oct.	16	1 horizontal engine cylinder ..				38	2	14	7'6	14	9	8
Oct.	4	Wages week ending	3	18	4							
"	11	" "	4	14	6							
"	18	" "	1	10	2							
			10	3	0					10	3	0
		Total cost				38	2	14	12'9	24	12	8

The particulars of the wages shown in the above example are obtained from abstract sheets, to be presently described. The first intimation that the costs clerk will have that the cylinder in question is in hand will be from his work sheets. He will, when he has made up his wages abstract sheet for the week ending October 4th, open the entry as above in the "Special Castings—Cost Book," but will, of course, have to leave the weight column and the date opposite the casting blank until the cylinder has been cast. The filling in of the weight of the cylinder will probably be the last entry he will make under this heading, preparatory to calculating the total cost of the castings.

Whilst, however, the costs of special castings and forgings are thus made up in detail in subsidiary books, they are always entered in the gross in the general Materials' Book as well, so that all essential particulars of the material supplied under any order number may be obtained on reference to one book.

Ascertaining Costs of Material, Castings, &c.

We have now explained the methods by which the costs department obtains particulars of the material obtained or made for customers under the order numbers. It is not, however, sufficient for the costs departments to be merely informed of the numbers and weights of the castings, forgings, and other parts, as such, which enter into the composition of the different jobs. It is necessary for the costs department to be also fully informed as to the quantity and character of the raw material used in the establishment for the production of the castings, forgings, and other parts, in order that they may determine such rates, for example, as the *7s. 6d.* in the illustration just given, which was the cost of loam castings under every count except moulders' wages during a certain period. The necessary particulars, so far as material is concerned, are obtained from the storekeeper. All pig iron, scrap iron, coke and limestone for the iron foundry; all copper, etc., for the brass foundry; all bar iron, coal, breeze, etc., for the smithy pass through the storekeeper's books. In the case of the iron foundry the assistant storekeeper has a book ruled as follows:—

ILLUSTRATIVE FORM NO. 8.

DELIVERIES TO CUPOLAS.

Date__________

No. 1. Scotch Pigs.			No. 3. Scotch Pigs.			No. 4. Scotch Pigs.			Hæmatite.			Common Scrap.			Light Scrap.			Coke.		
cwt.	qr.	lb.																		

We only show seven columns above. Each page of the book actually contains ten more. The above headings, being daily required, are printed ; the remaining columns have the headings left blank, so that they may be filled in by hand by the store-keeper's assistant according as they are required. As the different classes of iron are weighed over the bridge the weights are entered in the proper columns. The totals under each column are added up at the close of each day's deliveries. A page of the book is taken for each day.

From this book a monthly summary is prepared on a sheet ruled exactly like the book itself, except that it has an additional column at the left-hand side for dates. The totals of the different classes of iron supplied each day are entered in the proper columns, and the totals of the different classes supplied during the month are found by adding up the columns. If any quantity of a special brand of iron has been supplied to the furnace for a special casting, the order number under which the casting is made is noted under the entry of the weight of the iron. There is usually a small stock of pigs or other iron at the furnace bank or mouth. The weight of this can usually be estimated with sufficient accuracy, and is taken into account in the statement. That is to say, the first entries on the monthly sheet represent the stock at the furnace bank at the end of the preceding month. This is included in the addition of the columns, and then the stock at the bank when the summary is completed is deducted. The balance, of course, gives the quantity consumed during the month.

This monthly summary sheet is sent in to the costs office, and from it a monthly statement of the overhead cost of castings, as illustrated in Chapter V., page 48, is prepared and entered in a book kept for the purpose. The particulars of the metals supplied to the brass foundry are recorded in an exactly similar method to that adopted for the iron foundry.

The proper accounting for the bar iron and steel supplied to the smithy presents greater difficulties. In many establishments all bar iron and steel is simply charged to the smithy, and the price at which the material of a forging is rated in a cost is the price per cwt. paid for the bars, waste and loss being entirely covered in the percentage added for shop expenses.

Forgings.

A somewhat less summary method is certainly desirable.

The following answers for all practical purposes. The iron, etc., supplied to the smithy for the manufacture of forgings is recorded on sheets ruled as follows:—

ILLUSTRATIVE FORM NO. 9.

DELIVERIES TO SMITHY.

Date.		Order No.	Class of Iron, &c.	Special.							General.							Returned to Stock.						
Feb.	6	601	1 Bar 3 in. "Special" Steel	4	1	0	20s.	4	5	0								2	0	0	20.	2	0	0
,,	,,	Shop	2 Bars 1 in. "Crown"								0	3	0	9s.	0	6	9							

The two entries shown above will indicate the use of this sheet. All iron of ordinary character supplied to the smithy for the manufacture of general forgings is simply noted as supplied to the smithy itself, and is entered in the "general" column. The iron that appears in this column will only vary as to its cost price to very small extents—one or two shillings. Probably none of this iron will be returned to store, except in the shape of a quantity of scrap at the end of the month. The weight of this scrap will be duly noted in the "returned" column. When, however, any bars of special character are supplied to the smithy, the order number of the job for which they are required is noted (the foreman smith's requisition to the storekeeper will give the number), and the iron or steel is entered in the "special" column.

In the instance shown above it will be seen that half the bar of steel was returned, and this was considered as still worth the original price per cwt., and would consequently be taken back into the store at the full price. Only a small piece of the bar might have been returned, in which case it would only have been worth probably half-a-crown per cwt., and would have been so noted in the "returned" column.

The costs clerk, in entering up order No. 601, will come across some forging of special steel weighing about 2 cwt., and will at once turn up the "deliveries to smithy" sheet, where he will find the particulars of the bar of steel supplied to the smithy for the job. From the price recorded as the price of the bar, and from the value of the returned part, if any is entered, he will ascertain and put down the price for the material contained in the forging.

These sheets as completed are copied in a press copy-book, and at the end of the month are sent in to the costs office. They give the total weight of iron, etc., supplied to the smithy during the month, and at the same time show at a glance all the particulars required to determine the cost in material of any special cases.

All material of a general character supplied to the foundries and smithy, such as does not enter directly into the composition of the castings and forgings produced, is recorded in the general stores sheets under the heads of the different shop expenses accounts.

It will have been noticed that all material, whether in a raw condition, as for example pig iron for the foundry, or in a half manufactured condition in the form of castings or forgings for the turning or fitting shops, must pass through the stores. The strict observance of this rule will minimise error, secure regularity and economise labour.

Wages.

We come now to deal with wages, and the means to be adopted to secure that every penny paid for wages, like every penny paid for material, shall be charged against some customer, or against some shop or expenses account in the costs book.

Check Time Book.

In this connection we have the following books:—First, a "Check Time Book," in which the names and numbers of all workmen are entered under their proper departments, and in which the arrival of the men, as indicated by their checks, is noted, in accordance with the system of "time checks" adopted. This it is unnecessary to describe in detail. This book is kept by the gateman, and records the total hours made by the men in the shops.

Pay Book.

From it the names and numbers of the men, together with the total time made by each, are entered in a "Pay Book," ruled with columns for the total hours, rates of wages, gross amounts of wages, deductions, and net amounts of wages. The "Pay Book" is kept in the general office. From the "Check Time Book," also, the names and numbers of all men are entered by the costs clerks in weekly "Work Books," the rates of wages being obtained from the "Pay Book."

Work Books.

In the case of a considerable portion of the men—that is to say, all foremen, engine-drivers or firemen, furnace-men, gate-keeper, storemen, and shop labourers, the costs clerks simply take the particulars of the total time made by them, or the wages paid them where these are standing or invariable wages, from the "Check Time Book" or the "Pay Book." But in the case of all journeymen or tradesmen, apprentices and some labourers, the costs clerks obtain the particulars of the time made from the workmen themselves. These workmen will be employed on different jobs, in all probability, during the week, and it is necessary to know how much time each man or apprentice has spent on each job. For ascertaining this, a costs clerk, in some establishments, goes round, ascertains the particulars from each man, and enters them in a book which he carries with him.

Workmen's Sheets.

It is, however, better to require the workmen to record the particulars themselves, either on slates, sheets on boards, or in books. Slates are rather heavy and inconvenient to handle, and are very liable to get broken. Books very soon become extremely dirty. Probably as good a material as any is a block formed by a stout piece of common cardboard, with thirteen sheets of paper attached to it, and to one another also, by being thoroughly gummed all round their edges, except at one corner. Each sheet is large enough to contain a week's record (ten inches by eight inches is a good size), and is ruled with columns for the order number or name, the description of the job, and for each day in the week. When a sheet is filled, it is raised at the ungummed corner, and a knife slipped under, and run all round, thus detaching the sheet, and leaving a new one for a new week. The blocks are collected by a boy before breakfast each morning, and left in the costs office. They are distributed again during the forenoon.

The particulars recorded by the men are entered in the weekly "Work Books," the total time being, at the end of the week, checked by comparison with the "Pay Book." It is a rule that the amount of wages for each workman must agree in the two books before the wages are paid. The following example will illustrate the form and use of the "Work Books":—

ILLUSTRATIVE FORM NO. 10.

WORK BOOK.

Week ending 6th Dec., 188......

Workman's Number.	Workman's Name and No. of Order or Customer's Name.	Description of Job.	F.	S.	M.	T.	W.	Th.	Total Hours.	Rate Wages.	£	s.	d.
	TURNING	SHOP.											
124	William Brown.	60-in. rope wheel ..	9½	6½	9½	7			32½		0	19	3
	601	Brass gland				2½			2½		0	1	6
	Armstrong.	Valve-gear engine ..					9½		9½		0	5	7
	640	Gland cylinder ..						9	9		0	5	4
	584												
									53½	32	1	11	8
		(fitter).											
201	John Jones. Walker & Co.	Out time, per signed docket ..							54	30/	1	10	0
		Allowance									0	6	0
											1	16	0
		(labourer).											
340	Thomas Green. Shop.	.. ..							46½	13/	0	11	3

The entire wages of the establishment are dealt with in the manner indicated above. A book simply bound in a stout paper cover is used for each week. By using a book for each week, the work of posting or abstracting the wages can be carried on by one clerk without interfering with the work of entering up the books from the men's sheets. Each page of the work-book is nearly 16 in. deep by 10 in. wide. From the work-book the wages paid in all contract jobs and on account of shop or general expenses are collected, under certain classes and under the order numbers or accounts, on "Abstract Sheets," which are large sheets ruled on one side only, as in Form No. 11. No headings are printed—these being written in as required. That is to say, all the wages paid to draughtsmen on any contract job are collected together under the order number on the sheet, and the sum total found by adding up the collected items, and so on with the wages paid to pattern makers, moulders, smiths, and all other classes into which the workmen of the establishment are divided. It will be understood that all the columns on the "Abstract Sheets" are ruled alike. In the Illustrative Form No. 11, the two first sets of columns are shown different from the rest simply for convenience in introducing the figures. From these figures it will be seen that three draughtsmen worked on job No. 601 during the week covered by this sheet, that they spent altogether 51 hours on the work and received in wages on account of this job £2 3*s*. 9*d*. The particulars of wages required for the loam castings and special forging books are also obtained from the work-book or abstract sheet.

Abstract Sheets.

The totals of the wages paid to the different classes of workmen under each order number or account are then posted from the abstract sheets into the "Costs Book—Wages (C)" (contract and shop and general expenses accounts). This book is the same size as the "Costs Book—Materials," and is ruled as in Form No. 12. The sums on each horizontal line are added up as soon as the posting for each week is completed, and the total put in the "totals" column. This column, therefore, shows at a glance the amount of wages that has been paid in any week on any contract. When a job is completed, all the vertical columns are added up, all the machinists grouped together (as a rule), and the totals posted to the "Costs Book—Summaries," which will be presently described.

Costs-Book—Wages.

ILLUSTRATIVE FORM NO. 11.

WAGES ABSTRACT SHEET.

Week ending__________ ________________

Draughtsmen.				Pattern makers.																																											
601				601				Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.
10	0	19	6	5	0	5	0																																								
21	1	1	0	16	0	10	8																																								
20	0	3	3																																												
51	2	3	9	21	0	15	8																																								

ILLUSTRATIVE FORM NO. 12.

COSTS BOOK—WAGES (C).

Order No.________ Date of Order____________ Order Completed____________

Name__________________ Summaries Folio________ Sales Book Folio________

Job____

Week ending.		Draughtsmen.			Pattern makers.			Loam Moulders.			Green-sand Moulders.			Smiths.			Turners.			Planers.			Slotters and Drillers.			Other Machinists.			Fitters and Mill-wrights.			Erectors.			Labourers.			Special.			TOTALS.		
		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Dec.	6	1	2	0	2	4	1	0	8	10	0	16	0																												4	10	11
	13	2	9	0	3	8	0	1	16	0	2	0	1	0	16	6	1	4	0				0	6	2				2	11	1										14	10	10

The wages paid on jobbing orders are dealt with somewhat differently. It is quite sufficient to treat wages paid on contracts and on the different shop accounts in the general or summary manner which has just been described, but it is desirable, for the convenience of the manager or clerk whose duty it is to price jobbing work in the Day or Sales Book, to have wages paid on jobbing orders posted in greater detail. These wages are, therefore, posted direct into the "Costs Book—Wages (J)" in the manner shown in the following illustration:—

Jobbing Wages.

ILLUSTRATIVE FORM NO. 13.

COSTS BOOK—WAGES (J).

THOMAS SMITH AND CO.

Date.	Order No.	Workman.	Description of Job.	Pattern Makers.		Turners.		Fitters.			Totals.		
	702	P. M.	26-in. Pulley (2) 1s. 2d., Bush (1) 7d.	1	9								
		Turner.	26-in. Pulley (5) 3s. 1d., Bush (2) 1s. 3d. ..			4	4						
		,,	Reboring 24-in. Pulley (2) 1s. 3d.			1	3						
		,,	Cutting Shaft and turning new Journals (5) 2s. 9d.			2	9						
		,,	Old Pulleys and Wheels (4) 2s. 1d.			2	1						
		Fitters.	(4) 2s. 4d. Lining Brasses (14) 7s. 8d. ..					10	0				
				1	9	10	5	10	0		1	2	2

In addition to the three columns shown above, which are utilised for collecting the wages paid to the pattern-makers, turners and fitters, there are a number of other columns which we omit in order not to overcrowd our illustration. Altogether there are columns with printed headings for the following, and in the following order, viz., draughtsmen, pattern-makers, loam moulders, green-sand moulders, smiths, machinists, fitters and millwrights, and two blank columns.

The book is the same size as the "Contracts Costs Book," and in order to gain space for the descriptive columns, all the machinists are grouped under one heading, and the money columns are ruled for shillings and pence only. In the course of the month (the accounts for jobbing work are presented monthly) probably several orders for jobbing work will be sent in by Thomas Smith and Co., and, it may be, two cr three different orders will be running through the shops at the same time for them. It will not infrequently happen that the returns of the workmanship will be found rather mixed, but from the brief descriptions thus brought forward and collected into the "Costs Book," the manager who prices the accounts in the "Sales Book" will usually have no difficulty in appropriating the different items to the proper entries as taken from the forwarding clerk's delivery dockets, which contain, besides an enumeration of the articles supplied, a brief description of the work done upon them, which the forwarding clerk obtains from the foreman and checks by the order.

It will thus be seen that this book is designed with the double object of facilitating the charging of the jobbing accounts, and for ascertaining quickly the total wages which have been paid on account of any job done for a customer, or, at least, paid on his account during any period, it being only necessary to add up the vertical money columns and bring their totals into the final totals column for the latter purpose.

Costs Book—Summaries.

The results shown by the materials and wages costs books are finally collected into the "Costs Book—Summaries," which is a private book accessible only to the principals and confidential members of the staff.

We give an illustration of this book overleaf, selecting for examples a small contract and a small jobbing account. The letters S. B. and the figures under, refer to the folios in the Sales Book; the letters C. and J., and the figures annexed, refer to the folios in the Materials Costs Books, Contract and Jobbing, and to the corresponding Wages Costs Books. The figures in the % column indicate the percentages on the wages, which are added on account of all indirect expenses—the actual amounts of the "expenses" so calculated appear in the expenses column.

It will be readily understood that a book cf this kind, properly kept, will constitute a most valuable summary of the entire business of the establishment.

All the jobs completed in any one month are entered up consecutively in this book, so that the entries correspond with the monthly entries in the "Sales Book." Hence to determine,

ILLUSTRATIVE FORM NO. 14.

COSTS BOOK—SUMMARIES.

LEFT-HAND PAGE.

			BROWN AND JONES.
June	10	O. No. 712	Eight lines of wrought-iron shafting, 3-in. diameter, each line 40 ft. long, in 2 lengths, joined by cast-iron flange couplings, with turned bolts.
July	4	S. B. 314	Delivered f. o. r. here.
July		O. No. 780 791 S. B. 315	THOMAS SMITH AND CO. Sundries.

approximately at least, the profit that has been made in any month, it is only necessary to add up the two last columns in this book, and to subtract the one from the other. We say "approximately," because the sums which appear in the "total cost" column include an item which, in the nature of the case, is problematical—that is, the shop or indirect and general expenses.

We have now traced all the elements that go to constitute a complete cost through the different books to their final destination. The following diagram shows the relations of the books:—

MATERIALS.
Invoices. Iron Foundry Returns. Stores.
Brass " "
Smithy "
Costs Books—Materials.
(Special Castings and Forgings Books.)

WAGES.
Time Book. Pay Book. Men's Sheets.
Work Books.
(Abstract Sheets.)
Costs Books—Wages.

Costs Books—Summaries.

It only remains to add that certain items of a private character, such as managers' salaries, interest, and a few others, are furnished by the cashier in a gross sum to the chief costs clerk, when required for the purpose of completing, yearly or half-

Illustrative Form No. 14.

COSTS BOOK—SUMMARIES.

Right-hand Page.

Fol.		Weights.				Cost Materials.			Wages.			°/.	Expenses.			Total Cost.			Price.		
11	Wrought-iron ..	76	2	0	10 (	40	3	8													
	Cast-iron ..	11	2	0	6 3	3	11	11	0	16	0										
	Stores (Bolts, etc.)	0	1	18		2	16	0													
C 46	Machinists ..								9	0	8	150	13	11	0						
	Fitters								0	15	7	50	0	7	10						
		39	1	18		46	11	7	10	12	3		13	18	10	71	2	8	95	0	0
J 14	Cast-iron ..	2	0	14	6 3	0	13	4	0	3	10										
	Brass			12	10	0	10	0													
J 16	Pattern-makers								0	1	9	75	0	1	4						
	Machinists ..								0	8	4	150	0	12	6						
	Fitters								0	12	1	50	0	6	1						
						1	3	4	1	6	0		0	19	11	3	9	3	6	1	0

yearly, as the case may be, the various "expenses" accounts in the costs books.

Space will not permit us to illustrate the different shop or indirect expenses accounts. These accounts are, however, as already stated, simply treated as contracts, such items as rents and rates being dealt with as materials, and entered in the "sundries" column in the "Materials Costs Book." At the end of the year, summaries of all the indirect expenses accounts are collected together in the "Summaries Costs Book"; an abstract of all the items of indirect expenses, under their different headings, which have been included in the costs accounts of the year, is made; and a comparison instituted, by which the accuracy of the percentages which have been used during the year is tested, and the percentages to be used in the succeeding year determined.

APPENDIX.

TABLE OF ENGINEERING WAGES IN LONDON COMPARED WITH TWO OTHER ENGLISH ENGINEERING CENTRES.—OCTOBER, 1889.

	LONDON.	MANCHESTER.	NEWCASTLE-ON-TYNE.
	From	From	From
	s. d. s. d.	s. d. s. d.	s. d. s. d.
Pattern Makers	39 0 to 41 0	— 38 0	25 0 to 38 6
Iron Moulders	38 0 ,, 42 0	— 38 0	24 0 ,, 37 0
Smiths	38 0 ,, 40 0	— 34 0	25 0 ,, 37 6
Smiths' Strikers	— 24 0	— 20 0	21 0 ,, 23 0
Iron Turners	38 0 ,, 42 0	32 0 to 38 0	24 0 ,, 38 6
Planers	38 0 ,, 40 0	26 0 ,, 29 0	21 0 ,, 32 0
Drillers	— 38 0	24 0 ,, 29 0	18 0 ,, 23 0
Fitters	38 0 ,, 40 0	32 0 ,, 36 0	24 0 ,, 38 0
Millwrights	39 0 ,, 42 0	34 0 ,, 38 0	24 0 ,, 38 0
Brass Finishers	— 38 0	32 0 ,, 38 0	24 0 ,, 37 0
General Labourers	18 0 ,, 24 0	17 0 ,, 20 0	18 0 ,, 20 0

As the large engineering centres, except London, are either in the midst of, or very convenient to, iron, coal and coke producing districts, most classes of engineering material cost considerably more in London than in the other principal engineering towns. The disadvantage of London in this respect, of course, varies with the material and with the district with which the comparison is made. As a matter of fact, the special brands of Yorkshire iron, for example, cost less in London than in Glasgow or Bristol; but, upon the whole, it may be taken that the greater portion of heavy engineering raw material costs from 5 to 15 per cent. more in London than in most other large manufacturing centres.

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