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The Erection of Engineering Structures and Plant

A HANDBOOK FOR ENGINEERS ERECTORS, FOREMEN & STUDENTS

By

HARRY ATKIN, M.I.Struct.E.

Author of "Constructional Steelwork"

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AUTHOR'S PREFACE

In view of the fact that most of the important engineering concerns require the services of someone who is better educated technically than the average erector to take charge of their outside erection work—the latter usually being a solely practical man—the author has compiled this information.

It is at once admitted that no book can offer the equivalent of that actual experience which is so essential to erectors, but this one will give, in conjunction with some workshop experience, that complementary knowledge whereby the draughtsman or other technical man may tackle the job of erection on site with assurance, or at least to understand that the erecting squad are doing nothing likely to cause damage to the property entrusted to its charge, and accidents to those persons employed on the work.

It has been the author's experience to meet some really clever engineers in charge of the erection of plant who were absolutely at a loss to know how to set about the job when it came to the actual handling of the parts or the tackle. Some of them had never been away from the works previously to the job in question, and were totally ignorant of the most elementary procedure, or manner of commencing the work. An engineer in such circumstances usually finds the job weigh heavily on his mind, often to such an extent that it becomes a nightmare, because the responsibility rests entirely with him as charge engineer, however capable and willing his assistants may be.

Many firms are desirous of handing over their erection work to an engineer who is not only qualified to erect the plant and to take efficient control in a practical manner, but who is also able to make drawings for site modifications, to attend to the organisation and correspondence, to represent the firm generally, and finally to hand over the whole job when put into commission in such a manner as to gain the goodwill of their clients. By this means the firm is assured of at least a chance to quote for future schemes which may be proposed. In addition to that a man of good address and education may secure an order for the firm he represents by being acquainted with the technicalities of the commercial side.

It is useless, however, to split the responsibility between two men, and for the want of a qualified engineer the practical part is generally allocated to the practical man, and anything outside his sphere is allocated to the office trained engineer. To illustrate this point, quite recently one clever young engineer admitted to the author that he had refused an offer from his firm because he was an absolute stranger to erection work. He also regretted that there was no publication on the market whereby he could acquire some knowledge of it.

In this book the subjects dealt with are general, for such jobs as steel-framed building and large bridges are usually of the straightforward hustle type, and demand the services of a steelwork erector to supervise.

Notes on building bridges are included just to give some idea how the work is done, but it is the class of combined structural and mechanical plant that the general engineer will have to supervise, and in this class there can be no demonstrative hustle or hurry, as accuracy is of primary importance.

In the first chapter there are notes of general interest and experience, some quite elementary it is agreed, but from the author's actual experience these are quite necessary for the majority of those whom it is intended that the book should reach. To others who are somewhat accustomed to erection, their sphere of operation may be extended with more confidence than before, by being acquainted with the methods that are customary on jobs that they have not yet handled.

Special attention has been given to many details, and it is thought that opinions will not differ as to the wisdom of this.

The drawings may not be technically correct, but they are given, as are other illustrations, for the purpose of teaching both the elementary and customary terms of usage, and the methods of tackling on to the material other than by workshop practice.

The author's thanks are due to Messrs. Youngs for the use of illustrations of lifting tackle (blocks, winches, jacks, etc.), and to Messrs. Charles Churchill, Ltd., for those of pipe-fitting tools.

HARRY ATKIN.

FOUNDER'S NOTE

THE DIRECTLY USEFUL TECHNICAL SERIES requires a few words by way of introduction. Technical books of the past have arranged themselves largely under two sections: the Theoretical and the Practical. Theoretical books have been written more for the training of college students than for the supply of information to men in practice, and have been greatly filled with problems of an academic character. Practical books have often sought the other extreme, omitting the scientific basis upon which all good practice is built, whether discernible or not. The present series is intended to occupy a midway position. The information, the discussions and the problems are to be of a directly useful character, but must at the same time be wedded to that proper amount of scientific explanation which alone will satisfy the inquiring mind. We shall thus appeal to all technical people throughout the land, either students or those in actual practice.

CONTENTS

CHAPTER I

REMARKS OF GENERAL INTEREST

THERE are many jobs connected with the erection on site of a contract which include mechanical and general plant, and such a contract requires the services of a technically trained yet thoroughly practical erecting engineer. It is given to few only to be permitted to acquire such a wide range of experience whereby they can tackle almost any job in a practical manner.

The erector is usually a man whose practical experience may be relied upon to enable him to erect work quite satisfactorily, and is, one will find, a most adaptable fellow; but more often than not he lacks technical training. Maybe, since he has probably been employed at times on outside work from an early age, he has never had the opportunity to acquire such training, but to-day there is less excuse than there was a few years ago when boys had to be at their work by six a.m. Now that the hours of the works are considerably shortened, the opportunity can be taken without the fatiguing consequences.

When a youth is prevented from attending evening classes by being away from home on erection work, those responsible for his welfare should point out to him that he is gaining practical experience which is of great value; and in addition that his leisure hours can still be turned to good account by studious thought. Very often an erector is incapable of making a good rough sketch such as can be handed into the works for others to follow; and thus it becomes necessary to send a draughtsman on the site, purposely to take particulars of some modification in the work, which may—and often does—occur in these contracts.

Young engineers, especially in the drawing office frequently, have themselves to blame for their lack of practical knowledge, for with some the ground work clashes with their sense of dignity. It is a rough job at times, especially in the winter months; but the value of such experience may be a great asset later in their careers. The drawing office apprentice by virtue of his youth may, perhaps, be forgiven for looking down on the men in the works. When he is old enough to think more deeply he will discern that although the workers are all more or less dirty, they are not all labourers. Later, also, when he is better acquainted with their several crafts, and gets the opportunity to see them at work, his scorn usually turns to admiration. Many apprentices would be glad of—but do not get—the opportunity to go out amongst the dirty work, but more are afraid of the indignity that it suggests to them, and if they had the opportunity of workshop experience they would not seize hold of it.

The drawing office boy rarely gets a chance to be amongst site work, but sometimes a pupil is given the opportunity to remain outside throughout a contract, and profits considerably by the experience. It is a curious fact that premium pupils never seem afraid of the dirty jobs, and usually approach them with vigorous interest.

Erecting engineers have to learn that "lingo" by which the casual fraternity of erectors' mates, who they from time to time pick up, can understand commands uttered with a firmness that does not even hint at doubt—commands that suggest a knowledge of what ought to be, and must be. In addition to this they must be thick skinned, or fairly so, for many of these casual workers who appear on contract work, whilst being rare and useful men for the work, are sinners in every other respect. They also have to learn to be generous without being weak, and to be firm in dealing with all breaches of discipline. To be sure of their case at all times without hesitation, but they must never attempt to penalise a worker for being a few minutes late some morning, unless of course such laxity is deliberate and repeatedly occurs. In the latter case action has to be taken, because if one is allowed the privilege others will follow the lead with impunity, and attempt to justify their action by quoting this example.

If circumstances permit, some latitude can be allowed in certain directions, but this must be in consideration for work done and reward earned. For instance, it may happen that a job estimated to take the afternoon's time, of say five hours, is accomplished with a little tact in four. If so, this is a case for generous treatment, and by giving the men an extra half-hour's pay there is an inducement to further effort. The mistake of trying to squeeze another hour's work out of them should never be attempted, for it will react very severely on the speedy completion as well as on the harmonious conditions of the job. One can often hear words of encouragement from chargemen who know their work, and who can get the work done too. One old hand made use of the expression—" Let's get it done and away ! " and it never failed to get the best out of the men, for when the day's work was over it would be realised that the amount actually done was probably fifty per cent. more than most squads are in the habit of doing. The men themselves are eager to see something done, something constructed, something assuming shape which is pleasing to their eyes and satisfactory to their thinking ; the very joy of achievement brings contentment to them, no less than to the man in charge.

Many erectors are accustomed to one class of work—one particular type of erecting for one branch of engineering only. Thus we find that men accustomed to the handling of structural steel work need careful watching when employed in erecting the more delicate cast iron work, lest they forget that it is breakable and must not be bumped with hammers, or roughly handled.

The erection of simple designs in structural steelwork can with confidence be left entirely in the charge of a good practical man, for apart from the handling of the material the plumbing is not a difficult job.

The erection of new plant, either structural or mechanical, is more often than not a much simpler job than taking down work already erected. For one thing, when new work is to be erected the weight of each part can be obtained other than by guess work. It is not so with dismantling, for in many instances one has to lift the piece before finding out whether the tackle is much too heavy, or not heavy enough. This is rather a serious matter when luffing a lift from some stage or structure up aloft, or in taking down a portion of some chemical plant which has been in use, and which may happen to contain many tubes, and much sediment; therefore much thought has to be given if accidents are to be avoided by judgment instead of by luck.

One cannot erect any class of plant without tackle, or with insufficient tackle, and it should not be attempted. It is far better to be burdened with too much than not to have sufficient to eliminate all chance of accident.

The hiring of tackle may be resorted to in some instances, but is usually very expensive, and the cost of prolonged hire of lifting tackle, or of scaffolding, would soon pay for the purchase of it. There should be no scruples about paying carriage on anything that is likely to be required, as all such plant is consigned as "Contractors' Plant," and goes at a cheaper rate than the other material. There are times when borrowing has to be resorted to. This can be done locally, if not actually on site, and very often free of charge. Still, many refuse to loan tackle simply because they have in the past been put to some trouble and expense by borrowers, either returning goods in a damaged condition, or not returning them at all, leaving them to be fetched by the lender. This is not good enough—it is extremely selfish and thoughtless; if one finds firms generous enough to lend—and they will be found—one should be conscientious in the use and return of borrowed articles. Generally speaking the erecting fraternity are not mean in this respect, and it often happens that several contractors are engaged on one scheme, therefore the tackle one may be short of is likely to be included in another's kit. The loan of this will, as a rule, be freely granted.

An efficient erecting squad consists of five men, but they must be accustomed to the job. It matters not whether it be a huge girder, a thirty-ton boiler, a roof truss, or a steam engine, five are sufficient to do the job economically, and without being in each other's way. More gangs may, of course, be employed ; and odd men kept busy by such jobs as ratchet drilling, but more than five men in a squad is in most instances extravagance. In using the derrick pole this number allows, in moving, one man for each guy if necessary, whilst the foreman directs operations from the base of the pole, where he is in a position to see how it stands. Usually the operating of two guys at a time is all that is required, the other men being engaged at the foot of the pole, moving it along as the guy ropes control the top.

The greatest asset of the practical erector is ingenuity, and closely following this is confidence. Without these two valuable qualities the worry of the job is staggering. They have to be in right proportion too, for an excess of either may mean a brilliant display of folly, if not disaster. One will at times find men—good, capable men—who shudder at responsibility, and if somebody will take that burden off them they will do the job in fine style.

There are erectors and riggers, and whilst the former can do rigging, it may be that the latter cannot do erecting, although they are handy men to have on the job. Climbers in some districts are called rigger's mates, and are rated about one penny per hour above the groundsmen's rate in consideration of their use up aloft. There is one satisfactory feature regarding the payment of casual labour picked up on these erection jobs, which is that the engineer in charge is not worried by trades union restrictions in any respect. If he finds some men amongst the labourers capable of a more skilled job, he is at liberty to set them on it, and to give the correspondingly increased rate of pay. In any case there need be no fear of trouble by paying one man a little more than another in consideration of his usefulness, as the question only affects that one job, and then it is ended. The local rates of pay as a minimum basis can be obtained from any neighbouring works, or from the nearest Labour Exchange.

When the engineer goes to a job where he has to employ local labour the very first thing to do is to make his wants known. Should there be a Labour Exchange near by, the manager should be approached and be asked to single out some good men of the required skill by a certain fixed time, and these may be interrogated in a little ante room. In districts where Labour Exchanges are not handy, the village inns may be the only places to make his wants known. Still it is surprising how the news of such wants spreads, and but little difficulty is found in getting sufficient and satisfactory help. The selection of good assistants by interview is an art that is developed by experience, and one must not judge a man by active habits alone. For instance, there are many sailor men amongst the erection fraternity, and mostly their gait is a slow, swinging motion, due to years of ship deck walking on the ocean. It must not be imagined that the men are slow in their work, although they might be, but a trial will soon prove their worth. They are always good riggers and climbers if nothing more. The author's experience of seamen compels him to speak highly in their favour. There is one thing the engineer can do when selecting men. He can always employ them on trial, and warn them that if they are no good they will have to get out very quickly. He will find tartars at times, men who will try to prolong a temporary job, but such men are rare on this class of work and can soon be singled out.

A word may be said about climbing. The engineer unaccustomed to erection may feel the effects of being in an elevated position when first he attempts this, but he must not be in a hurry to either make progress at plank walking, or yet give it up altogether. The habit will come with use, and he will be surprised at the difference in the way his senses are affected within an hour: when his eyes get accustomed to looking at objects on the ground from the different angle of view, the rest is easy. He will see men walking along girders no wider than the soles of their shoes, when a slip may mean instant death, and soon he will find himself following them. The men who build structures and lay planks to walk on automatically commit to their brains the location of these, and hop from one to another just as automatically. Every one can get accustomed to climbing, not by bravado, but by progressive determination.

CHAPTER II

CRANES AND SUBSTITUTES

The Scotch Derrick-crane.—A crane for hoisting purposes is always to be preferred, and where circumstances permit a Scotch derrick (or jib) is the most useful crane to the erector on general work. They are light in construction, handy and speedy in use, and easy to erect. Their lifting capacity is high compared with their weight, but although they will cover a large radius they cannot be so readily moved along as can the single pole with the extension of the job.

Over-load.—The common types of small capacity are built of wood, the larger ones being of steel box-lattice structure. When all the parts are in good condition a fair overload may be hoisted with one of these jibs by the addition of an auxiliary guy attached to the pivot socket at the top of the stalk, the other end of the guy being secured to any available post, or to a stake in the ground.

The wood struts or guys are set at right angles to each other, and the diagramatic plan (Fig. 1) indicates the area in which the jib is at its lowest lifting capacity. The diagram also shows the auxiliary guy moved to support the crane when the jib is in that area, and the alternative position is likewise shown in dotted lines.

Anchorage.—The sole-bars are weighted with any material that is conveniently handy, old iron or bricks being the most likely stuff when on the ground; but up aloft clamping plates and bolts can be used to secure them to girders, or to a concrete floor.

Common Uses.—These jibs are common enough on buildings and similar work. They can be seen perched on the top of tall structures, on the roofs of buildings under reconstruction, and on high towers when erecting large contracts. In many of these cases the derricks are electrically controlled, the jibs on some of them being 100 ft. in length.

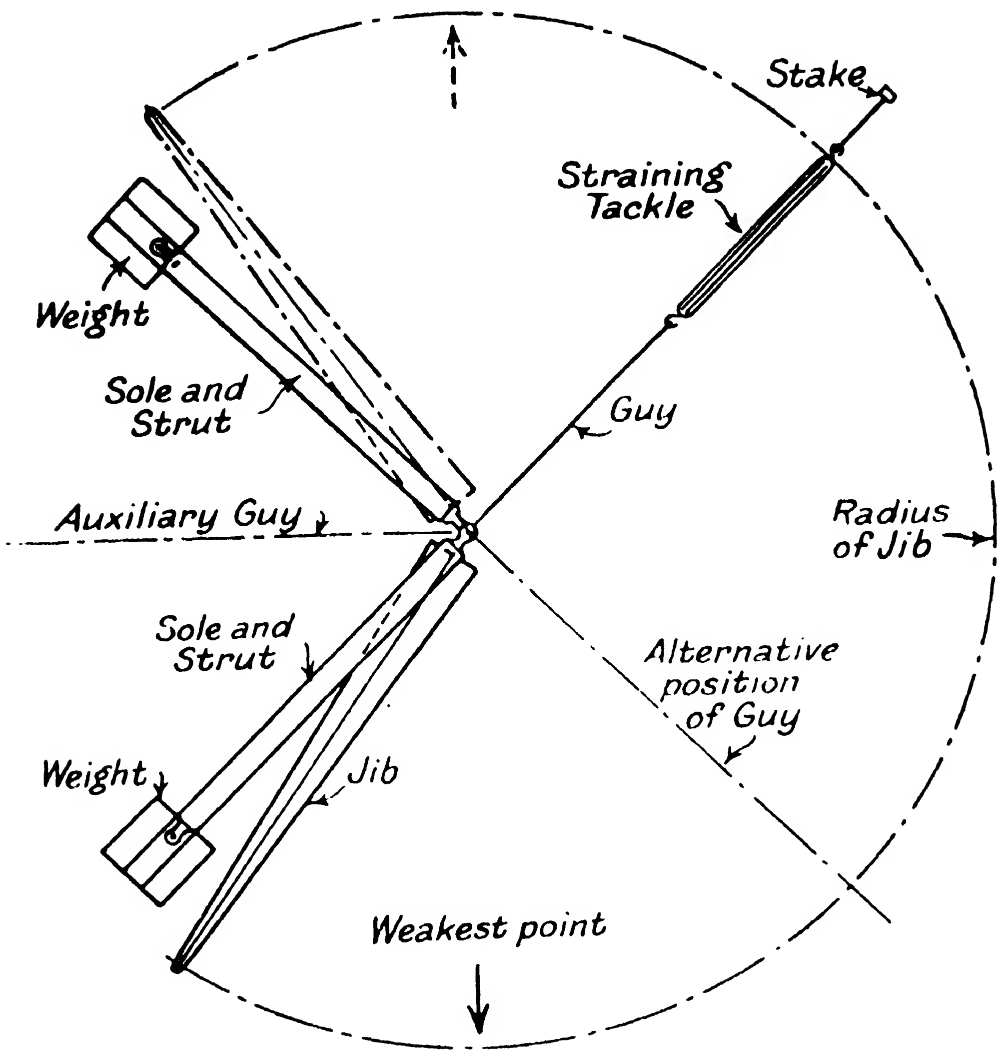


FIG. 1.—Diagramatic Plan of Scotch Jib-Crane.

Erecting.—With any but the smallest type made, some lifting tackle is necessary when it is desired to erect one of these jibs. The sole pieces are first laid in position, then with a couple of scaffold poles as sheer legs the stalk is erected and held upright, whilst the top ends of the struts are hoisted by the same temporary lifting appliance, the bottom ends being lifted or levered into position on their locking pins. The jib is then hinged to the base of the stalk, and with its guy wire hoisted up to its working height.

Types of Barrels.—The barrel for the guy wire on some of the smaller jibs is cast with its sides parallel, but on others, and on all the larger ones, the sides are tapered like a cone; this reduces the gear for hoisting the jib when it is at its greatest reach.

A Substitute.—When the nature of the job demands, an ordinary derrick pole can be made to serve as a jib, by securing the base, say in a hole in the solid earth, and by attaching a strong back guy. The side guys will not have over much weight, unless the sheer is extraordinary, and to the two guys which are to sustain the greater loads some light

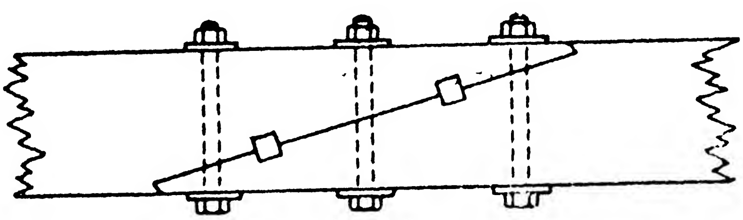


FIG. 2.—Method of Splicing a Derrick-pole.

block tackle can be attached to make luffing easy. A front guy will not be strictly necessary, but should be added for safety, to prevent any sudden jerk on the back guy from snatching over the pole. The radius of the pole will, of course, be limited, but will give a fair reach, and on a job, such as erecting a battery of economiser sections, the swinging pole is about the best proposition when a Scotch crane is not available.

The Derrick-pole.—The stick, as it is called in the jargon of the erectors, is mostly of wood, but may be of steel tube, or of lattice girder work. The wood ones are common, and are generally preferred as they lend themselves better to the advantages which have to be taken of all erection tackle. Poles are cheap and plentiful, very often many scaffold poles being on the site, and one of the latter can be requisitioned for light work. At collieries there is always a number of good long larch poles, some of which may be called into service if needed. For heavier work, the square section baulks are to be preferred when it is intended that the derricks should form a series of differing lengths. Round ones are quite as good, but square ones are better for splicing. By making the splices all to one pattern the upper and lower portions are interchangeable, thus comprising a very accommodating series. The method of splicing is illustrated in Fig. 2.

The Pole Cap.—The cap of the pole may be crowned with a flat or a dished plate disc pivoted at the centre, to which a number of ring-bolts or eye-bolts are secured. These bolts take the guy ropes. The advantage of this disc is that the pole may be revolved without having to change the guys from one anchorage to another, as would at times be necessary if they were tied to the pole. The plate disc is not popular, nor is any other contraption that adds weight to the top of the pole, the strictly necessary tackle being sufficient to make the erection of it rather a struggle, even with experienced hands on the guys.

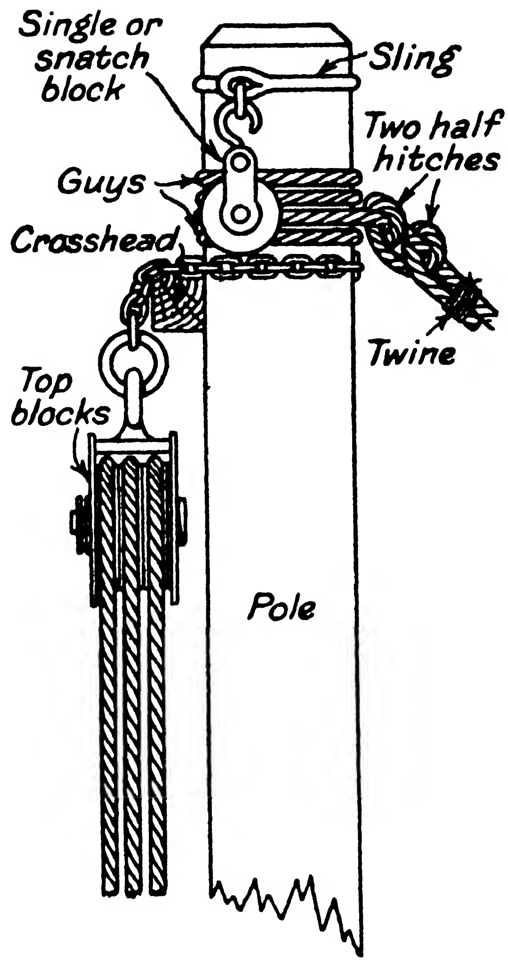


FIG. 3.—Method of Dressing a Derrick-pole (top).

The Crosshead.—Across the pole at the height decided, which may be near the top as shown in Fig. 3, or some few feet down, a crosshead is secured by nails or bolts. This crosshead is a piece of timber, say 1 ft. long by 3 in. square, and its function is to hold the blocks away from the pole, so that the rope and the wheels may work freely. Immediately above this the guys must be secured.

Dressing the Pole.—The top block is generally slung quite close to the crosshead, for an erector always aims at getting the shortest pole necessary to obtain the required height. In any case the head room is precious, and it is far better to have too much than not enough.

Guys.—Four guy ropes are customary, although three are quite sufficient when equally placed, to support the pole; with four, the manipulation of the derrick is simplified. In addition to the four guys many erectors place one as an auxiliary to use when changing the guys from one stake to another. This spare guy need not be so strong as the main ones, and if preferred it can be reeved through a single-sheaved block fixed at the top of the pole as shown in Fig. 3, one end being made fast to the base. With this auxiliary arrangement, a bosun's chair can be used to permit a man to climb the pole for fixing the tackle after it is reared. This is preferred in those cases where the weight of the tackle is too much to conveniently erect the pole fully dressed. The fifth guy is there if needed for additional control when sheering over with a lift.

The Blocks.—The guys, of course, must be attached before erecting the derrick, and it is customary, though quite optional, to do the same with the block tackle. If the blocks are fixed to the pole before lifting, they should be placed in position, block to block, and tied to the pole to prevent disarrangement. To tie them, a rope is attached to the hook of the bottom block and simply coiled round the pole a number of times in spiral form, and brought to the base. This rope is then ready for hauling down the bottom block for action. It is not strictly necessary to have the blocks together previous to erecting the pole; they may be placed in their respective positions ready for the first lift, but this is not customary because in the case of heavy rope there is so much more weight added to the pole.

The Base.—At the base of the pole, say two or three feet from the ground, a hole is bored for a bar to be inserted when it is desired to carry the pole along, or for twisting it as the case may be. This hole is not absolutely necessary, but it facilitates operations by eliminating the labour of fixing slings to do this. When the pole is to stand on soft, made ground a track of battens or plates is necessary to prevent sinking in. The bottom edges of the pole, whether the latter is a round or a square one, should be chamfered well back, to make a bite for the crowbar, and to prevent the bearing being on one sharp edge instead of on the centre of the pole.

The Snatch.—Hoisting is mostly done with a winch, the block rope being led to the barrel by a snatch block, as shown in Fig. 4, secured to the base as low as possible, and as close to the pole as it can be secured. It must not be imagined that this will have the effect of dragging the pole along, as this cannot happen when multiple sheaved blocks are being used.

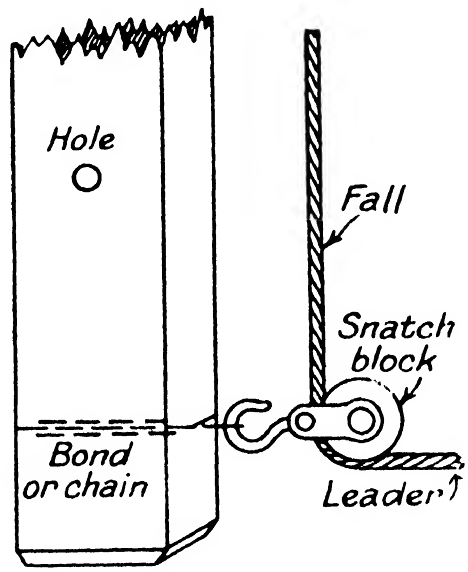


FIG. 4.—Derrick-pole: Arrangement at the base.

Erecting.—A light pole can be hoisted by hand provided that a few men are available to lift up; the erector's mates will operate the guys to heave it into a vertical position, and to secure it. A heavy pole will need a light lifting tackle either in the form of a pilot derrick or by attaching a set of light lifting blocks to some existing structure near by, and within easy reach of where the pole is to be placed for the first lift. The dressing of the derrick is the same either for light or heavy work, but for a pilot derrick three guys only need be used. However, it may happen that most of the ropes are long enough for two short guys; therefore it would be just as convenient to put four on, when the clove hitch (Fig. 29) would come in handy.

Selection and Head-room.—In the selection of a pole of suitable length, a generous allowance must be made for head-room, that is clearance above the net height to which the lift has to be landed. As a minimum, never less than twice the depth of the tackle is suggested; then the lift must be lashed as short as possible. It is a common error with many men who are not altogether regular hands at erecting to err in their judgment of head-room. They often find that the lift cannot be landed when it is hoisted as high as the tackle will allow, therefore it is wise to err on the big side. (The word lift, it must be explained, is commonly used and is quite understood in practical engineering.) Even six inches of head-room might be swallowed up by the stretching of the tackle, or in the sinking and deflection of the pole when weight is added. There must be some allowance made, too, when sheering has to be done, as this, of course, diminishes the head-room. It is good practice on heavy work when sheering is necessary to have small winches, or light tackle on the guys that have to haul the pole about, thus cutting out at least one man's time in tying and untying the knots every time a sheer has to be made. This is not always convenient, but every job has to be considered on its merits, and arrangements made accordingly.

Hoisting the Load.—The winch must be fixed in the most convenient situation, ballasted with any weighty material at hand, and staked or otherwise secured if possible. If the winch when fixed is not in right line with the pole, additional snatch blocks will be required to direct the leader on to the barrel. All four men can be at the winch when the lift is being hoisted, and after hoisting two men are sufficient to lower it into position, the others being employed in placing it.

Sheer Legs.—Sheer legs are composed of two stiff members braced together near the top at an angle of from 30 to 60 degress, to suit the particular needs of the job. They are held vertical, or at an angle, by guys placed back and front, two only being required, as shown in Fig. 5. A sling is then lashed around the brace for the suspension of the lifting tackle, the snatch-block being secured to the base of one of the legs when rope tackle is to be used with a winch.

This form of derrick is more suitable for chain blocks than is the single pole, as may be noted. The legs are convenient to use over a trench or excavation, or on the top of a flat structure for hoisting up material from below, or to an upper floor, provision being made at the guys, both back and front, for sheering.

Building contractors mostly employ sheer legs, as scaffold

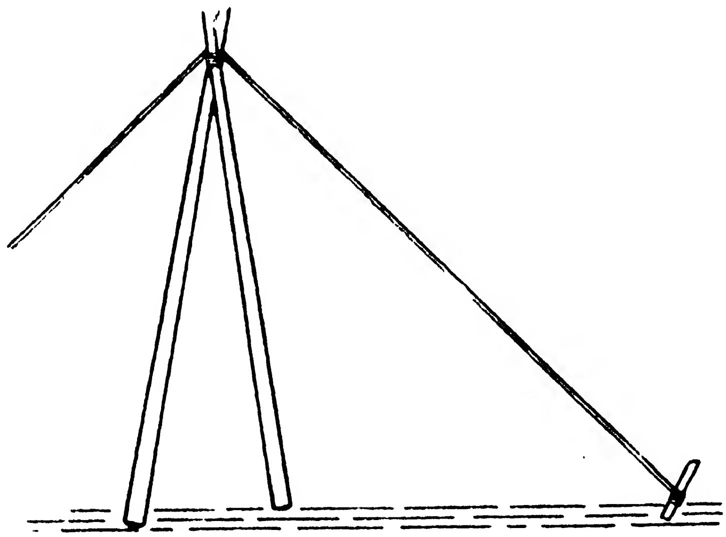


FIG. 5.—Sheer-legs.

poles are a handy means of making a set to lift upwards of a ton. (The word sheer, it might be said, is sometimes spelled shear, both are correct, but the former is the acknowledged one.)

The Tripod.—The tripod, or three-legs, is another handy form of temporary crane, especially for use with chain blocks. A set of these is admirable for lifting heavy masses of machinery that have not to be taken to a great height; examples may be seen at most locomotive depôts on the railways for hoisting engines. A readily portable set can be assembled from three lengths of steam pipe of suitable diameter, a hole being bored at the top of each for a coupling pin which will carry the shackle or D link for sustaining the lifting blocks. Complete sets of fittings in malleable iron all ready bored and screwed for capping and shoeing stock lengths of pipes—the latter having threads at both ends—are on the market. The photograph (Fig. 6) shows all the components, and when the pipes are rigged out with these fitments they are capable of sustaining a very great weight compared with their own. Stock lengths of pipes usually run up to 20 ft., and fair loads for common sizes of this length are:

2 in. pipe	.. ..	up to 1 ton
2½ in. ,,	.. ..	,, 2 tons
3 in. ,,	.. ..	,, 4 ,,
4 in. ,,	.. ..	,, 6 ,,

Fig. 6.—Tripod Fittings for W.I. Piping.

assuming that the legs are properly spread, and that sure footings on solid foundations are obtained. Short lengths of pipes may be used to make up the height, but the joints must be well socketed, with full threads, to get the necessary strength: a faulty joint may cause disaster.

A Tripod Feature.—One of the great features of the tripod made from piping, or from scaffold poles, is its use for loading and unloading lorries, when no other and better lifting tackle is to hand. The only disadvantage is with lorries that have cabs over the driver's seat, for often these cannot get out again until the load is lowered and removed from the fairway. In such cases it is wise to insist on flat horse-drawn lorries for the delivery of goods—if this is possible. If it is not, the alternative is either to back the lorry in, or remove the tripod until the driver has drawn in, then hold the lorry until the load is out of the way.

The Cathead.—The cathead is usually a baulk or a R.S.J. beam projecting from an opening high up in a building, or other structure, with lifting tackle suspended from it and operated either from below or from gearing fixed inside the

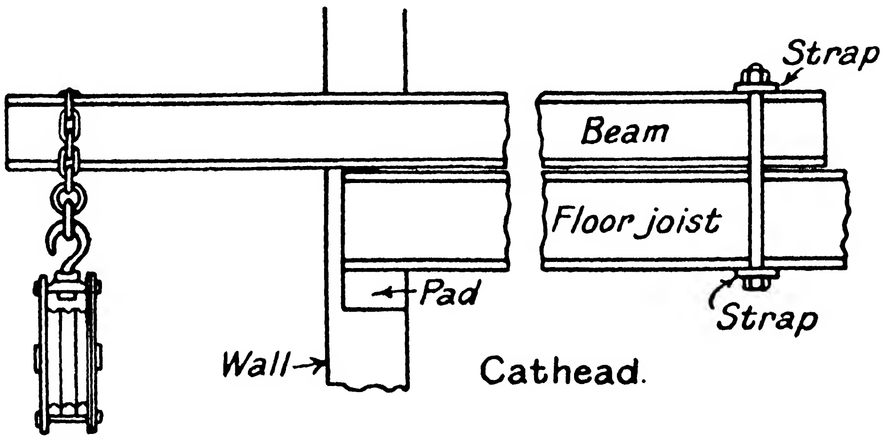


FIG. 7.—Cathead with Clamped Beam.

building. The sack-hoists to be seen on many old mills and warehouses are common forms of this crane. Fig. 7 shows one method of arranging a beam for this purpose, but every situation has to be considered on its merits, and although the principle is the same in every case, the methods of fixing and the material employed may differ greatly. In place of the bolts and straps shown, a prop in some instances might be used, or a twitch, as shown in Fig. 25. The lifting capacity of course depends mainly upon the anchorage, a stout beam or baulk can always be obtained.

The Gin-Wheel.—Builders employ the cathead for hoisting building material up aloft, and make use of two scaffold poles, sheer leg fashion for a trestle, with another pole to form a beam, as shown in Fig. 8, the anchorage being to any available security. For the rope to pass over, they use a single sheave block of special design called a " Jinny " the real name being gin-wheel or rubbish pulley. It is shown in Fig. 9, and can be purchased in a variety of sizes at a very low cost. One of these wheels has many uses in erection work, and a size of not less than say 5 in. is preferable ; still an additional snatch block will serve a dual purpose. The sheave is of cast iron, and consequently breakable, but with fair usage there is little fear of that happening.

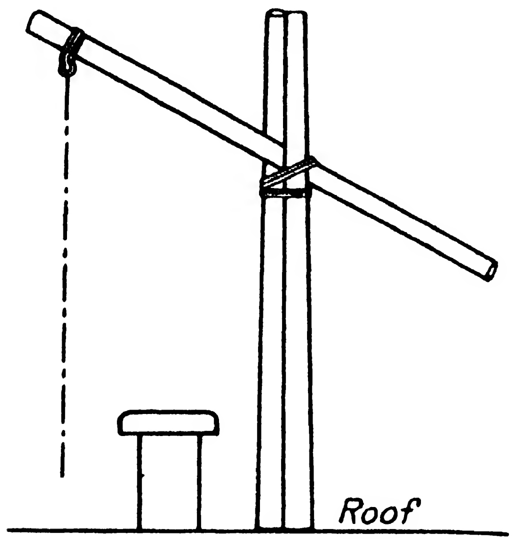


FIG. 8.—Cathead (builders' type).

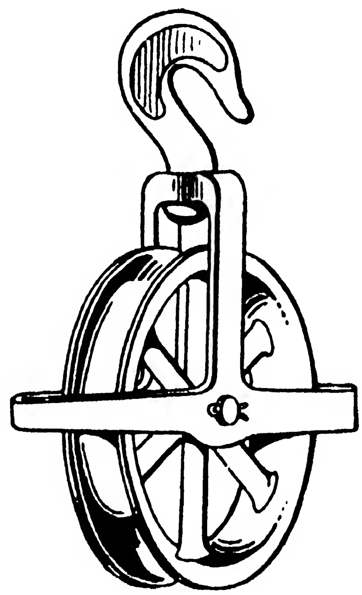


FIG. 9.—The Gin-Wheel.

The Reared Pole.—An alternative to the cathead, when a lift has not to be taken very high, is a pole reared against the building or structure, the strength being suitable for the load. With this method, as with the cathead, the load has to be luffed in as it is being lowered from the hoisting tackle. A plank reared edgewise against the wall is a common method of supporting a set of tackle for such lifts as it is suitable. Millwrights are acquainted with all such methods of obtaining lifting accommodation, and to quote a few examples—there are tie bars of roof trusses ; tall trestles with a beam across ; and a trestle, with a hole in a wall as supports for a lifting beam. All such means are of quite as much use to the erector as to the millwright, but the latter can keep some of the tackle by for the various occasions as they arise, whereas the erector has to adapt the tackle that is available.

Support from Walls.—One or more bricks removed from a wall to form a bearing for a lifting beam is a little thing that the erector does not hesitate to resort to if the job demands it, as there is generally a bricklayer handy to replace them. It may be expedient to punch a hole through a concrete floor for an eye-bolt or a sling to pass through, although this is not altogether recommended, and may not even be allowed. Still, the engineer in charge of the erection work can usually be trusted to do nothing foolish in this respect.

Lifting from Principals.—Block tackle that is slung from a beam placed across the tie bars of two principals must be used for light shifts only, unless the beam is shored up with poles firmly wedged under it to sustain the weight. When the trusses are too high, or otherwise not suitably placed for the shoring up with poles, a much greater lift than the tie bars will sustain can be suspended on a beam spanning across between two rafter backs, the tackle being secured to the beam. No trusses are intended for such use, but it is presumed, and it usually appears to be true, that all engineers know to what limits they may approach in cases of need for temporary lifting facilities.

CHAPTER III

WINCHES

The Winch.—The hoisting gear of the erector when rope blocks are used, to lift parts heavier than men can haul up by hand, is the winch, or as some erectors call it—the crab. It is essentially a crane without a jib, and is mostly used for horizontal hauling as its temporary anchorage is insufficient for anything but that, except when the load to be hoisted is very light. The first illustration (Fig. 10) is of a single purchase winch for use with soft rope, or for the small diameters in wire rope; and the second illustration (Fig. 11) is of a double purchase winch, specified for use with wire rope. The difference is mainly in the diameter of the barrel, as may be noted —the purchase relating to the gears by which the power is developed. Classification is made by the ratios of the gears.

Capacity.—There can be found on all good makes of winches a tablet indicating the maximum lift on a single line (from the barrel—as it is called), thus one may see "25 cwts." on a single purchase winch, or "5 tons" on a double purchase type. As the erector uses the rope blocks instead of a single rope in most cases, the load on the winch is correspondingly reduced, therefore the size of the winch may be comparatively small for convenience of transport, and the difference made up with blocks containing a number of sheaves.

Features.—The winches illustrated are shown without the battens to which they have to be bolted for ballasting purposes and for rolling them along the ground. They are also shown with steel plate sides, which are to be preferred to those of cast iron as the steel frames are unbreakable. Winches come in for some very rough usage at times, for they are about the most awkward piece of machinery imaginable to man-handle, especially when they need getting in or out of a railway wagon, hence the preference for the unbreakable ones. One may often see a broken cast iron side as the result of a tumble.

Gears.—The single-geared type of winch is very light in weight, is easy to move about, but is limited in its lifting capacity by reason of its high ratio. On the double-geared

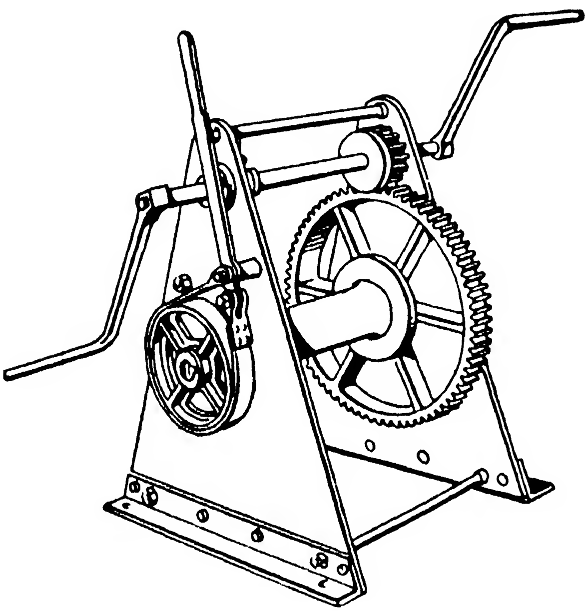


FIG. 10.—Winch, Single-geared.

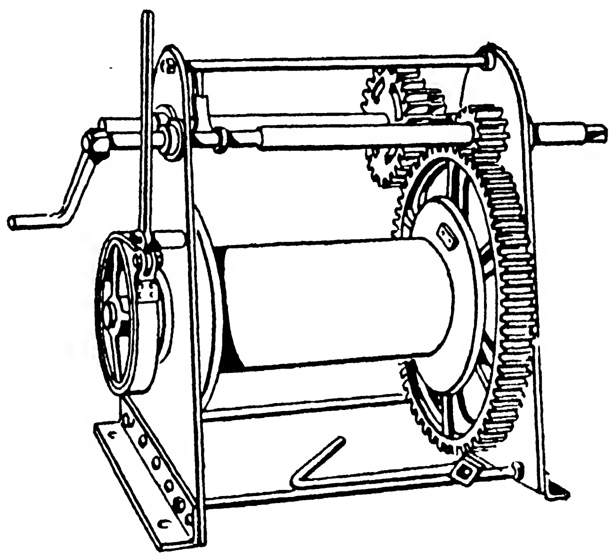


FIG. 11.—Winch, Double-geared.

type the gear is changed by sliding the lay shaft along until the required set of gear wheels are engaged: a dog clip is then inserted to keep it in position.

Most winches can be thrown out of gear to allow the barrel to revolve independently when paying out the line, or when taking in the slack. On such winches the handles can be temporarily secured to the spindle to prevent them coming off in operating, but on those that cannot be thrown out of gear the users must be cautious about the rapidly revolving handles when paying out the line—unless they are previously removed. It is a common occurrence for a man unaccustomed to the work to forget to remove the handles before commencing to pull the line from the barrel, and such an omission is the frequent cause of accident.

Fixing.—When required for action the winch is fixed in the most convenient place where it can be secured by ballasting down with bricks or scrap iron, or any other suitable material, such as 56 lb. weights, railway sleeper chairs, etc., and where stakes may be driven in front of the battens to which it is bolted. As an alternative to staking the front, the rear may be lashed to some fixed object such as a column or a structure. Assuming that the leader (the horizontal rope) is low, and as near the horizontal as it can be, little weight is required on the winch if it be well staked.

Staking the winch after it is set square with the leader will keep it in position better than lashing it back to a single column or the like, as the stakes will prevent the winch from twisting when the rope approaches either extremity of the barrel.

Winches for Guys.—Small-sized winches are adopted by structure erectors when this is possible as a means of anchorage for their guys, as the movement of the derrick is greatly facilitated thereby in cutting out the necessary tying and untying of the guys. Such winches have to be heavily weighted because, of course, there is a very considerable upwards pull with the rope at such a large angle to the surface of the ground. Needless to say, the farther the winches are from the derrick—in reason—the better.

Operations.—The winch as stated is not confined to derricking, for it can be used to draw loads along the ground, for rolling huge boilers into position, and, in any instance, where a long strong pull is required. The rope blocks may be harnessed to a load for a horizontal pull as for a vertical lift, or a single line used ; the latter will be found to be sufficiently powerful in the majority of cases when a wire rope is on the barrel. As for derricking, the winch for a pull is fixed in the most convenient place, and if the pull is not direct a snatch block is put on the line to lead it neatly on to the barrel.

Rope and Barrel.—The ratchet pawl on the barrel of the winch will decide the way the rope is to lead on to it, which should be noted when a start is made to wind the rope on to the barrel or it may have to be taken off again and rewound. The rope must be neatly led on, and the round turns always kept closely together, then there will be no trouble to get the full amount of rope on to the barrel without jar or risk. When the winch is set right no effort will be needed to lead the rope neatly, but when it is not the rope is likely to wander about the drum, and will probably build up into a ridge. When this occurs, the rope cannot be prevented from slipping into the trough it has made, the result being that the load is severely jarred, and damage may be done to the tackle thereby.

Brakes.—The makers fit a band brake to every winch, but this usually gets taken off because it is often more in the way than it is in use. No importance need be attached to the absence of a brake, as the lowering of a load by such means is not encouraged. When it is kept in good order, and is operated by a skilled hand, then a brake is very useful at times, especially when dismantling a plant. To let anyone who is unaccustomed to the use of a winch operate the brake is by no means a wise proceeding, as this band is exceptionally effective. A fierce application when a load is being lowered might snap the tackle, or even the pole, by suddenly arresting the momentum of the falling weight.

The Term "Crab."—It has been said that erectors sometimes refer to the winch as "the crab," and although it requires a good stretch of the imagination to see any resemblance to the crustaceous species, there is little doubt that its name is derived from the hoisting gear of certain lifting apparatus, as for instance the carriage of an overhead traveller or gantry crane.

CHAPTER IV

ROPE-BLOCKS

Rope-blocks.—Rope-tackle, as it is called, constitutes the most valued and useful portion of the erector's equipment. The blocks are designated single, two, three, or four sheave, according to the number of pulleys contained therein. Further classification relates to the diameter of the pulleys and the size of rope they will take ; also whether for wire rope or for the soft kind.

The single sheave is not in great demand except for the lightest luffing tackle, and usually the blocks are paired off in threes and twos, these being the most convenient for common use. The illustrations (Fig. 12) show a series of rope-blocks called the London pattern, specially made for soft rope, but they are used for wire rope because the latter is employed alternately with the former in the same blocks.

Capacity.—Blocks are selected according to the particular work they have to do, and as already stated, mostly three and two sheaves are used, it being unusual to see anything above that number on general work ; they are used certainly, but chiefly by firms who specialise in lifting and removing heavy machinery, etc. On general erection work the erector will make use of the jack, or the chain-blocks, as suits the load and conditions when these are beyond the capacity of the three and two sheave tackle. He has to adapt the tackle to the particular weight—for instance, a $\frac{3}{4}$ in. diameter manilla rope on a pair of three and two sheave blocks will lift—say 30 cwts., a matter of at least 5 cwts. on each single rope, whilst a ½ in. wire rope on the same blocks will be good enough for twice that weight. The appended table is included for reference, and relates to the London pattern blocks in common use :—

Diameter of Sheave	Inches	2½	3½	4	4¾	5	6
	M/M	63	89	101	120	137	152
Width of Groove ...	Inches	⅜	½	⅝	¾	⅞	1
1 and 1 Sheave ...	Cwts.	2	6	10	16	22	25
1 " 2 " ...	"	2¾	8	14	22	32	50
2 " 2 " ...	"	3½	10	18	27	40	62
2 " 3 " ...	"	4¼	12	22	32	46	72
3 " 3 " ...	"	5	14	25	36	52	80
3 " 4 " ...	"	5¾	16	28	39	56	86
4 " 4 " ...	"	6½	18	30	42	60	90

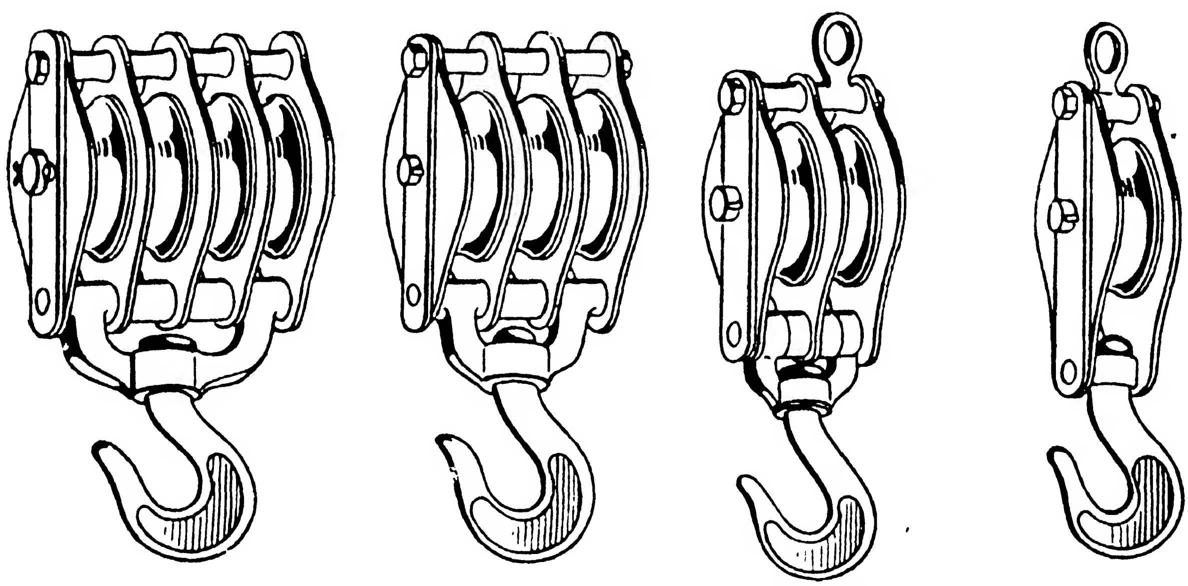


FIG. 12.—Rope-blocks (London pattern).

Rope-blocks with manilla or hemp rope are mostly used for hand hoisting; they should be connected to the winch when the lift exceeds 5 cwt.

Cost.—Rope-tackle is remarkably cheap, therefore it should be plentiful, as it is rarely idle for long periods. The light luffing tackle with ⅝ in. diameter soft rope is in common demand, especially on structural erection, or pipe contracts for power stations and chemical factories. Usually a rope of 200 ft. in length is ample for each set, and the total cost of blocks (3 and 2) and rope should not exceed £2 per set.

Length of Rope.—To calculate the length of a rope required for a 2 and 1-sheave set, take four times the height of travel and add enough for handling, or for a leader if one is needed. For a 3 and 2-sheave set allow six times the height, with the addition as for the smaller set.

Reeving the Tackle.—To reeve the blocks—say 3 and 2, first pass the end of the rope through the outer sheave of the top block, then lead it around the bottom pulley farthermost from the eye or becket, and back again to the top middle pulley; now to the other bottom pulley, and then to the top remaining one, finishing off at the eye or becket, on the bottom block which is there for the purpose.

In the case of a three-sheave block being used at the bottom (3 and 3), the finish would be at the top so the reeving would be commenced with the block having the becket attached, the rope at the finish being secured to this. If the three-sheave block is to substitute a bottom two-sheave then it must be treated as a two-sheave, leaving the middle pulley free by passing the rope around the two outer ones only, and in this reeve the becket must be on the bottom block. It is surprising what a number of mechanics and other workers in the engineering trades there are who cannot reeve a tackle without much laborious experiment, and yet it is quite simple.

For securing the rope to the becket a single knot is usually sufficient, but the end of the rope must be bound to the line with twine or soft wire, to prevent the knot coming loose. The shorter this knot is, the greater the headroom, that is—closer contact of the two blocks, which is always so precious.

Good Order.—Rope-blocks should be drawn together, block and block as it is termed, for the convenience of handling; then the fall rope should be looped around the waist of the set: this little attention keeps them tidy and prevents ravelling. If this is ignored, and the blocks are allowed to be carried about with some of the rope extended, it will often happen that the set will need reeving afresh because of the ravel. This may sound extraordinary, but it is only too true that at times the ravelled block-tackle defies the best man to undo it more quickly than he can reeve it afresh. Many hours have been spent in attempting to solve the puzzles that block-tackles have become by careless handling.

All ropes should be free from twist and neatly coiled, ready for speedy action. The dexterous handling of rope-tackle is worth much, but one often sees the coil of rope so carelessly thrown about that the bottom block cannot be hauled down until some considerable time has been spent on straightening it out.

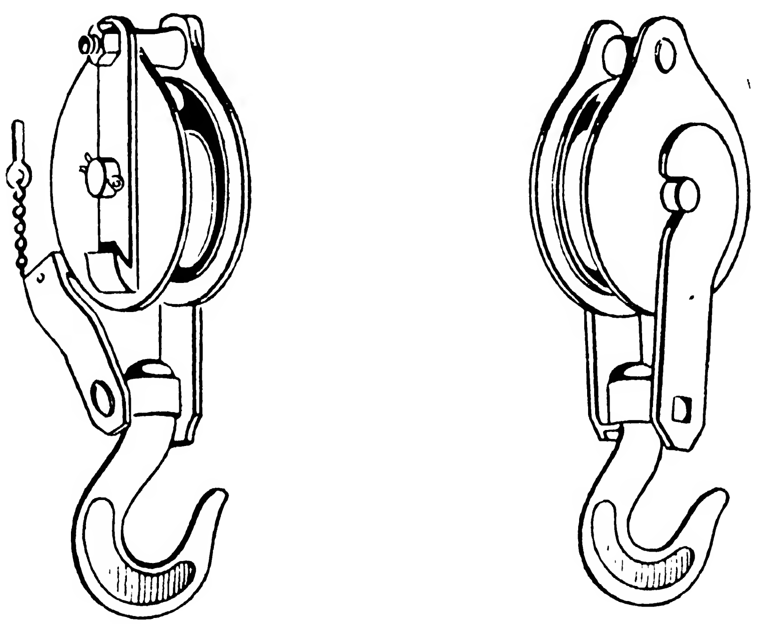


FIG. 13.—Snatch-blocks.

The Snatch-block.—The snatch-block, of which two types in common use are shown in Fig. 13, is a single-sheave block without a becket, and made for a particular purpose. As will be noted one side is broken, so to speak, and the housing for the pulley on this side is hinged to the hook-bar which allows the rope to be passed over the pulley at any desired point. The function of the snatch (as it is called) is to be a guide pulley for a haulage rope in the same way as a jockey pulley is for a belt drive. One snatch-block at least is necessary when using the winch for hoisting, as is shown in the section dealing with derricking (Fig. 4).

Standards.—Snatch-blocks, like lifting-blocks, are made in various sizes to conform to given standards, but in general erection work, any old snatch functions just as well, for there is never an excessive load placed upon these except when the lift is direct (by a single purchase).

Two or three snatch-blocks with pulleys of, say 4 in. or 5 in. diameter by $\frac{7}{8}$ in. wide, will be found sufficient to cover the range of jobs likely to be undertaken by an erector on general work.

Blocks for Wire Rope.—Blocks of the London pattern are made for use with soft vegetable rope or with chain, consequently the pulleys are much wider across the grooves than are those for wire rope. They are also made in much smaller sizes and can be obtained with pulleys so small as $2\frac{1}{2}$ in. in diameter. As the London pattern blocks are the ones mostly used by all erectors, our remarks relating to blocks for wire rope will consequently be brief.

Blocks specially made for wire rope are designed for heavy lifting and do not have pulleys less than six inches in diameter. Comparatively small pulleys are not recommended for use with wire rope ; it may be understood that the outer strands are put in tension and the inner ones in compression as the rope follows the circumference of the pulley ; when the full load occurs the latter has a tendency to flatten out by the unequal strains set up.

Pulleys for use with wire rope have v-grooves, and the specified diameter of the former is relative to the diameter of the rope that the grooves are to suit ; from that fact it will be clear that much latitude with these, so far as the diameter of the rope is concerned, is not permissible.

Block Hooks.—Blocks of both types may be obtained with either swivel hooks or rings, but a hook is much more convenient than a ring, although the latter is stronger. The hooks are of drop-forged steel stampings of excellent design and can be depended upon; one rarely sees a strained hook on modern lifting tackle.

Sheaves.—The sheaves are of cast iron of good close grained quality; brass ones may be seen in some of the London pattern blocks made for use on board ships, but cast iron is the metal commonly seen. This may appear strange, and rather an unwise selection to the engineer unacquainted with block tackle, but it is quite good practice. The sheaves of the London pattern rarely suffer damage in spite of rough usage, but, with wire rope sheaves, care must be taken that the flanges do not get chipped. It is not suggested that they are fragile, but the only damage one sees done to these is the chipping of the rims. The sketch (Fig. 14) illustrates this liability.

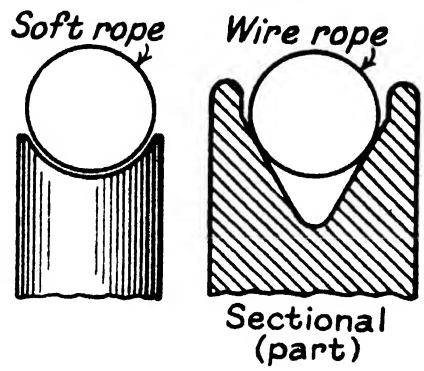


Fig. 14.—Types of Sheaves for Rope-blocks.

CHAPTER V

CHAIN-BLOCKS

The Weston Blocks.—There are several types of chain-blocks on the market; all are useful, although some are more so than others by virtue of their construction and ease of manipulation. The common Weston type known to most engineers are cheap to acquire, and are better than none at all, but little beyond that can be said in their favour for erection work. They are of the differential type, and are illustrated in Fig. 15.

The guides for the hoisting chain make any but vertical lifts most awkward and a man is required to lead the ascending chain directly in line; such assistance is not always convenient and so at times progress is slow whilst tempers are quickened. Even when hanging vertically these blocks, in most instances, require a hand to guide the chain, especially as the bottom block approaches the top one, for while hoisting is being done the loaded chain is being converted into hand chain, and the bulk is a nuisance.

The Moore Block.—On the Moore chain-blocks the guides for the hand chain are rigidly bolted to the body of the block that houses the gearing; also the hand chain is independent of the load carrying ones (a feature that is common to all the better types of blocks), and therefore the operating of them is simplified. The Moore blocks are cheap and give good service. Short in the overall, and comparatively light in weight, they are, without doubt, very popular with structural erectors; the illustration (Fig. 16) is of these blocks.

Youngs' Worm-gear Blocks.—The common worm-gear blocks are a very useful tool and are very smooth in action. They are rather a weighty set to move about and require a little more headroom than the epicycloidal types; nevertheless mechanical plant erectors usually select this type, as

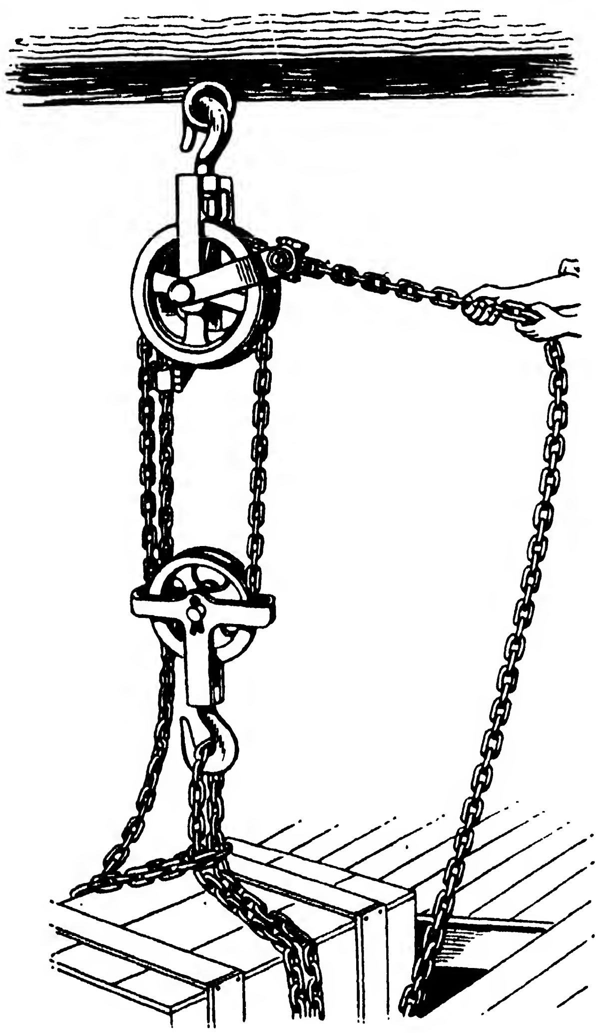


FIG. 15.—Chain-blocks, Weston type.

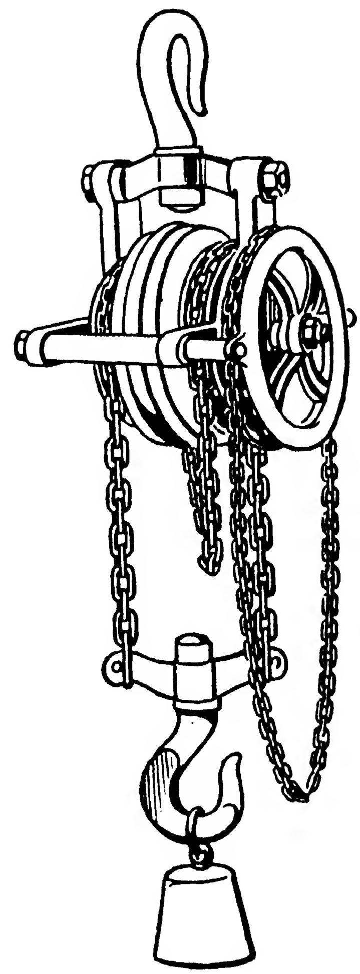


FIG. 16.—Chain-blocks, Moore's type.

the worm and wheel gearing allows of such fine adjustments in lifting and lowering.

Worm-gear blocks have more often than not a friction brake fixed to the worm-spindle, but except for very quick ratios the brake is quite unnecessary, and usually the pawl is removed because the action of the brake adds friction to the effort required to lower the load, thereby making such effort at times so great as to equal that required to hoist it.

Fig. 17 shows the heavy type for loads of one ton and above; lighter types have not the bottom block as shown, but work with a single chain that has a hook at each end. Many refer to this pattern as the Continental type because of its supposedly German origin.

The Spur-geared Blocks.—The spur-geared blocks are for some reason classed as a better lifting appliance than are other types, but it cannot be said that they are selected by erectors as the best for their purposes. The top block is heavily constructed, the gears being housed between large cheek plates which seem very much in the way at times. It can be readily understood that these blocks must have a brake attached, as the cog wheels will not, of course, sustain the weight without one.

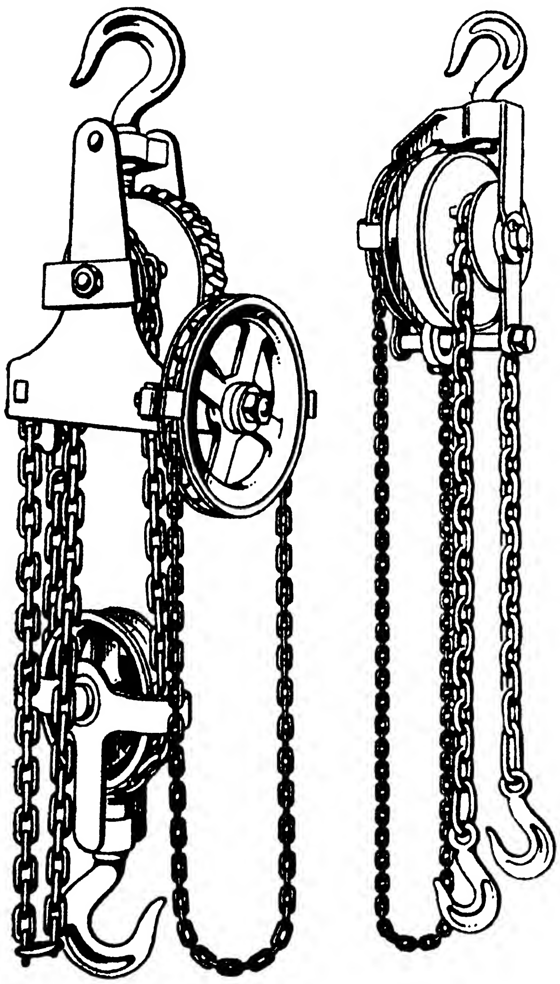


FIG. 17.—Chain-blocks, Young's Worm-geared type.
FIG. 18.—Eade's Epicycloidal type.

The spur-geared blocks are to be seen usually on run-ways and similar semi-permanent cranes, although they are portable tools. The cost of these blocks is higher than that of any other type.

Light Blocks.—In the design of some of the lighter types of blocks of which Fig. 18 is a typical illustration, the lifting chain is single and has a hook at each end. These are very convenient for light work and on many jobs much hand chain operating is eliminated, but it will be seen that a load hanging from one hook throws the blocks a little out of plumb; this condition in most instances is negligible, but it may occasionally happen to be a nuisance. However, one cannot expect to have on site the use and advantages of the blocks that are most suitable, and only when such tackle is purchased new can selection be made.

In General.—Chain-blocks on erection work may have more luffing than lifting to do on some jobs, and without doubt the epicycloidal types are to be preferred for this reason. The advantages that these blocks offer are: light in weight, compact in design, short in the overall, and ease of operation. Another feature is that the gears are all enclosed.

The worm-geared type rank next in order but, as stated, are somewhat heavy to handle, and need more headroom when a bottom block is attached; but in both this and the epicycloidal patterns the hand chain guides are bolted to the body and are quite rigid.

Hand chains should be kept clean and preferably slightly oiled but not slippery. As the chain on the Weston blocks is all in one for the load and the hand it is impossible on erection work to keep it clean, and with continued use men's hands will become sore by the grit that it brings up.

CHAPTER VI

JACKS

The Screw Jack.—There are three principal types of Jacks—the screw, the ratchet, and the hydraulic. All three are very useful for general work, but the handiest type is undoubtedly the screw or bottle-jack, for this can be short in stature yet no less powerful than the taller model; and there are few instances which will not permit of the use of the lever necessary to operate the screw. Fig. 19 is an illustration of the popular bottle jack. A similar model may be had with a ratchet attachment to the screw, so that the regular action of lifting or lowering may be continued without having to withdraw and insert the bar every quarter-turn. The only objections users raise against the ratchet operated type are the slightly increased weight of the tool—for there is, of course, a socket attached, into which the lever fits—and the bias that this socket puts upon the jack, which prevents the latter from remaining upright when free.

FIG. 19.
The Screw or Bottle Jack.

The prices of these bottle-jacks place them amongst the cheapest of tools, for a few shillings will purchase one, and no squad of erectors should be without at least two. There are many forms of the screw-jack, but it is not considered necessary to show here more than one of this class.

Haley's Jack.—There is one jack of larger build that is well worthy of mention. This is the good old Haley, and it is worked by worm-pinion and wheel. This jack may be seen in most wagon repairing and building shops, for it is eminently suited to that class of work. It has many uses in the erection of all classes of engineering work, and it possesses one advantage over the bottle types, as may be seen in Fig. 20; that is in having the foot attached to the base of the screw. This jack can be operated very quickly, and is easy in action. It is greatly appreciated for its pushing facilities, and it is remarkably cheap, especially for the service it gives. It can also be obtained with a wooden body, but such a one is necessarily more bulky than the one shown —which is of steel.

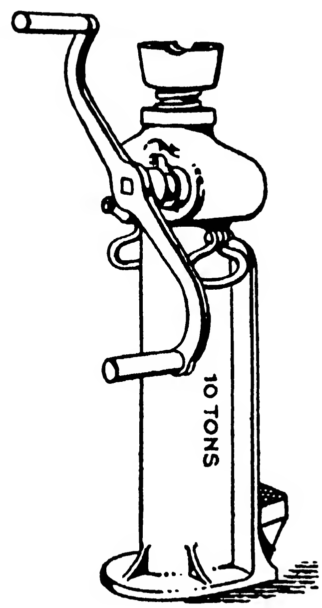


Fig. 20.
The Haley Jack.

The Ratchet-jack.—A common type of jack to be seen in garages, and largely used by the platelayers on our railways, is the ratchet jack. It is very powerful and quick in action, but space is required to operate the lever in a vertical plane, and the type is more suitable for railway permanent ways than for general work. These jacks cannot be made so small in height for anything like the same strength as the bottle type, nevertheless their value must not be under-estimated, for a couple of these will soon earn their cost on a job of considerable magnitude. The advantage the Haley jack possesses over the ratchet type is that one man can operate the former to its full lifting capacity, whereas with the latter probably two or three are needed to add their weight to bring down the lever.

The Hydraulic-jack.—The hydraulic-jacks prove useful where others fail in lifting capacity. They are constructed for heavy lifting, and are always part of the equipment of bridge-builders, boiler, and general engineers. They need a little more individual care and attention than the other types, and although many aver that they are easily put out of action, this is not so, and in such cases the blame should be on the users, not on the tools. Fig. 21 shows the tall type. These are better able to withstand more careless handling and rough usage than the shorter ones which carry the water tank and pump at the side of the ram. The tall pattern jacks can be used for pushing as well as for lifting. They are simple to operate, and after filling the upper chamber with water through a small hole for the purpose the wing-nut attached to the needle-valve is tightened before pumping commences. The ram is lowered by the slackening of the wing-nut. That is all there is in the operation.

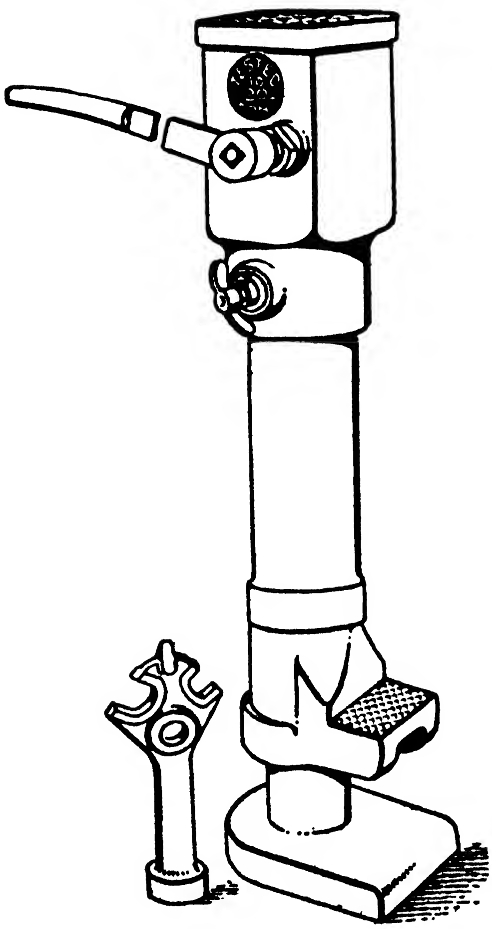


Fig. 21.—The Hydraulic-jack, Upright Model.

When the jack is not in use it should be kept upright, and with water in the chamber to prevent the leather from drying.

The Ship-jack.—Fig. 22 illustrates the shorter model of hydraulic jack called the ship-jack. Usually these are more powerful than the taller type previously described. The water tank and pump, as can be seen, are horizontally fixed to the vertical ram cylinder.

In fixing this model for action the tank must not be placed upon the same level as the cylinder base, for if this is done the deflection in the resisting body when great pressure is applied, will distribute the load along the base and will surely break the jack between the cylinder and the base.

Separate Units.—From practical experience, the author considers that the ship-jack with two separate units, as shown in Fig. 23, is a better type than the one previously described. The connection from the pump to the cylinder is by a more or less flexible copper pipe attached by unions. This method of construction eliminates all risk of damage, and the tool is in many instances far more accessible in operation. Although the adoption of this type of jack entails a little extra outlay and labour, these points are balanced by the fact that no damage can occur, and by the two parts being more portable than the composite model. The pump can also be used for testing purposes when needed.

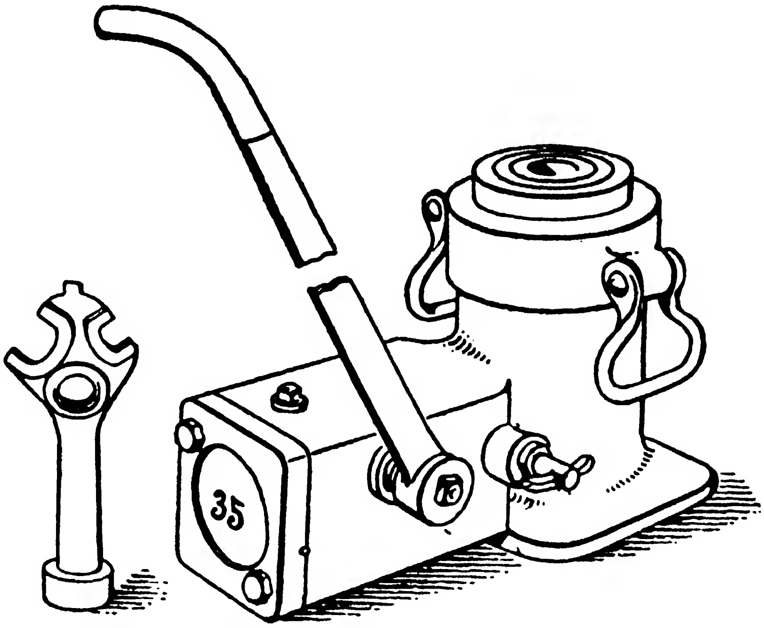


FIG. 22.—The Hydraulic-jack, Ship Model.

Hiring of Jacks.—As a rule hydraulic jacks are allocated to the care of men accustomed to using them. It is not advisable to borrow one unless with a man to operate it, for if borrowing is accomplished without a man it

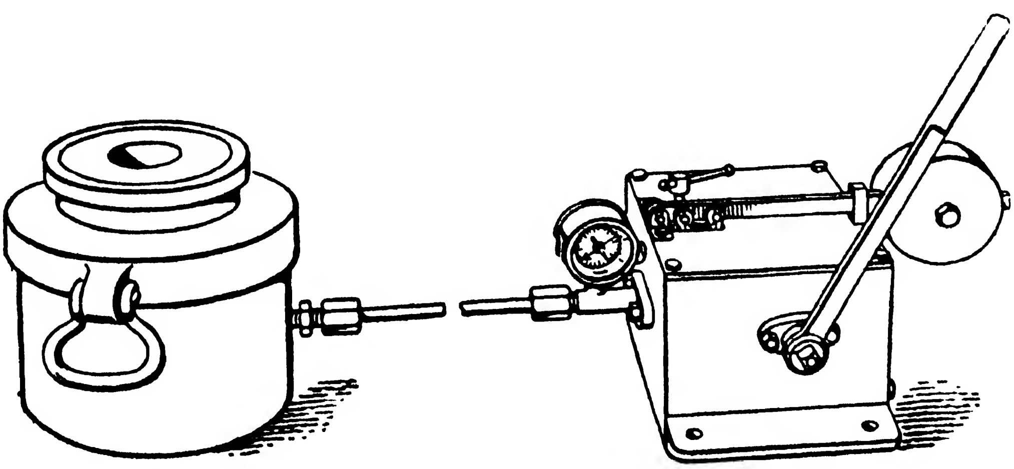


FIG. 23.—The Hydraulic-jack, Separare Units.

is more than probable that the jack will be useless. To hire one together with the services of a man to operate it may prove successful, but the cost of a few hirings will pay for a jack. Railway companies are prepared to loan jacks with attendants to responsible persons—as they will loan a crane with a man to work it—but never without an attendant.

The Loco-jack.—Some hydraulic jacks, also screw jacks, have bases with a traversing motion. These are called loco-jacks as they are used chiefly for restoring rolling stock on to the metals after it has been derailed.

The Ratchet-brace.—The ingenuity of the erector is his greatest asset, and he does not forget his ratchet-brace as a substitute for a screw-jack for light lifts in close confines. Many times has this tool been requisitioned for such purposes and always proves that it has another use than the drilling of holes.

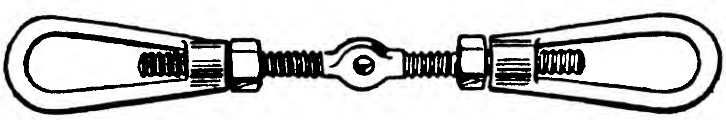


FIG. 24.—The Straining Screw.

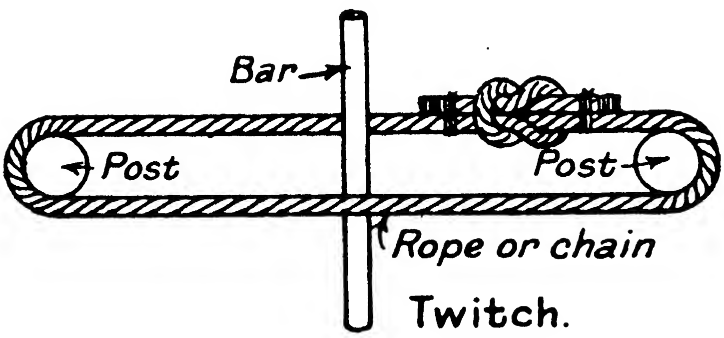


FIG. 25.—The Twitch.

The Turnbuckle.—The turnbuckle or straining screw is a jack for pulling not pushing, and for this reason it is sometimes called a union screw. Fig. 24 shows the best form of tool which consists of a right and left hand threaded screw and nuts, the latter being attached to D links or hooks. This cuts out the swivelled hook which, unless fixed with a ball thrust-washer, usually exerts a great deal of friction. These screws are to be seen connecting all railway engines and coaches, to prevent that jarring which is seen and heard with freight trains. No doubt they are known to all.

Two of these straining screws should be in the kit of every erector, for they are capable of shifting a big weight a minute fraction of an inch. They are also very convenient to use in conjunction with chains as a temporary diagonal tie with which to square up a structure in course of erection.

The Twitch.—As a substitute for the straining-screw the importance of the twitch must not be overlooked, and there are many instances where it will come in most handy. Easily attached and detached, and efficient in the majority of cases—the purpose for which it is applied is soon accomplished. The twitch can be made with a suitable piece of soft rope or wire, or with chain, according to the strength required. The sketch, Fig. 25, shows the twitch around two posts, and the arrangement is similar in other cases as in springing steel stanchions or girders into position for the fixing of wind ties or other bracings. It can also be used as a temporary bond for holding parts in a certain position.

The twitch is operated by inserting a bar of suitable size; maybe the hand-hammer shaft will accommodate the job, or a crowbar may be necessary, and by twisting the rope or chain until the tension moves the parts sufficiently. If the strain is left on the twitch for a time, the lever must be secured by a lashing (tying cord) at one or both ends.

The twitch is another instance in which the wire rope is of the greatest utility, for here again is lightness and strength.

It is here pointed out that the one disadvantage of the twitch, although it really refers to the user and not to the method, is as follows:—The bar by which the twisting is done is likely to fly from the man's hand, should he relax his hold at all when the strain is being applied, and if it does then a serious accident may occur. This should not happen with skilled men, but with unskilled labour the risk should be pointed out to them at the commencement of the job.

CHAPTER VII

ROPES

Soft Rope.—The rope mostly used for erection purposes is manilla, because this is considered the best and most suitable for all weather conditions. Hemp rope is really stronger, and when kept dry is softer, but it is rather more costly than manilla.

There are two qualities in both ; these relate to the length of fibres used in the making up, and are classed as long and short. Needless to say the longer fibres make stronger rope than the shorter ones.

There is a common jute rope which has no place in the erector's kit, so that is passed over. Cotton rope is very strong, but is too expensive for the job, and is probably more affected by the weather than the other two substances, manilla being the least affected because the fibres are of a more waterproof nature than hemp or cotton.

Rope is sold by weight at so much per lb., and although prices differ to a considerable extent, those at the best sources of supply are always the lowest. The ruling figure for manilla to-day is 7d. per lb., with hemp a little above it. The approximate weights are given in the table below :—

PURE MANILLA.

Diameter in inches.	*Ozs. per yard.*	*Lbs. per 100 feet.*
$\frac{5}{8}$ in. Average	6 ozs.	14 lbs.
$\frac{3}{4}$,, ,,	9 ,,	20 ,,
$\frac{7}{8}$,, ,,	14 ,,	28 ,,
1 ,, ,,	16 ,,	34 ,,

Scaffold Ropes.—Scaffold ropes or cords are useful for many purposes, being about $\frac{1}{2}$ in. or $\frac{5}{8}$ in. in diameter by about 15 ft. long; their cost is approximately 1s. each. Builders and contractors purchase them in coils uncut, but the lengths are marked out by the bindings for each end of every cord, which are to prevent the strands unroving.

Scaffold cords are also made in $\frac{1}{4}$-in. diameter flexible steel wire rope, with eye and thimble complete. These are not so popular as the soft ones, but are useful to erectors for purposes of light bonds or slings.

Spare Rope.—As the price of rope is so low there is not the slightest justification for starving a squad of this necessity. Plenty of rope is very convenient, and is conducive to speed in erection, therefore, it is a wise plan to have a supply at hand ready for use. A good erector will take care of his ropes right from the time they are new, and this means that he knows they are safe to work with.

Treatment.—New ropes are somewhat stiff to handle, this is to be expected, but they very soon become more flexible with use. When a new coil is opened it must be revolved as the rope is paid out, otherwise a tangled twisted mess will result. This uncoiling can be successfully managed by placing the coil on a piece of large bore pipe or a pole, supported on two bearers, and as the rope is paid out the coil is revolved. This method applies to wire rope too, as will be mentioned later.

If possible a new manilla rope should be well stretched before use, but if this is out of the question, then after the first load has been applied most probably the twist will need to be taken out, and it will pay to do this ere a second lift is attempted. From this it will be understood why a good erector cares for his ropes, for those well stretched and softened are so much better in use; but they must, however, be kept free from mutilation.

Wire Rope.—What the engineer owes to wire rope will be a debt unpaid for many years. The introduction of this of all diameters has cut out the gigantic and unwieldy chains and blocks which were common a few years ago, and it has displaced the cumbersome hempen or manilla guys that many erectors still remember. It also has the pleasing merit of being unaffected by weather conditions—a very important feature—for it was often necessary, when soft rope was used to guy erected work or the derrick pole, that a man should stand by the job all night and at week-ends, to alternately slacken the ropes as the rain tautened them, or to haul them in as the wind dried them. Unless this was attended to disaster was likely to occur; no doubt the rough winds have been blamed for damage due to some erector's neglect of this attention. One has only to study the effect of weather on the common bell tent to realise what is likely to happen to partly-erected work, or large derricks that are braced by soft guy ropes.

Other Details.—Wire rope is not so easily damaged by scoring on raw edges as the manilla, but kinks or curls must not be allowed to lie when weight is placed upon the rope. Wires are somewhat stiff to handle, still that is a detail, to which one soon gets accustomed, and, on the other hand, a ½-in. guy wire is equal to at least a 1½-in. manilla, so honours are even in this respect. Another merit that wire rope possesses over soft rope or chain is that it takes much less barrel room on the winch, and so the size of the latter has, therefore, been considerably reduced. Wire rope is sometimes called flexible cable, and its flexibility is due to its composition, which consists of a great number of fine strands of steel wire twisted around a hempen or jute core. The better qualities have more and finer strands than the cheaper ones, and they are wonderfully flexible and pliable. Each steel strand is galvanised beforehand, for the life of the rope depends upon its protection from rust; even the constant rubbing of the wires soon bares the outer strands, and rust should be counteracted by boiled linseed oil liberally applied, unless the wire is working in a greasy situation. Wires which have been in use, and coiled up and put aside should be attended to or the fine strands will rust through in a very short time, then the rope would become ragged if not actually unsafe.

Coiling Wire Ropes.—Wire rope which is used for hoisting purposes is rarely removed from the winch barrel, but guys need coiling. This cannot be done without some object to form a centre. A cask (on end) is useful, and is often available for the purpose; and if used, a few pieces of strong twine should be hung over the cask sides previous to commencing the coiling so that when the coil is completed it can easily be tied up and slipped from the cask. A very cheap turn-table as shown in Fig. 26 may easily be made, and is very useful for coiling and uncoiling any rope. It takes little portering, but apparently few will go to the trouble of making or acquiring one, preferring to struggle along anyhow instead.

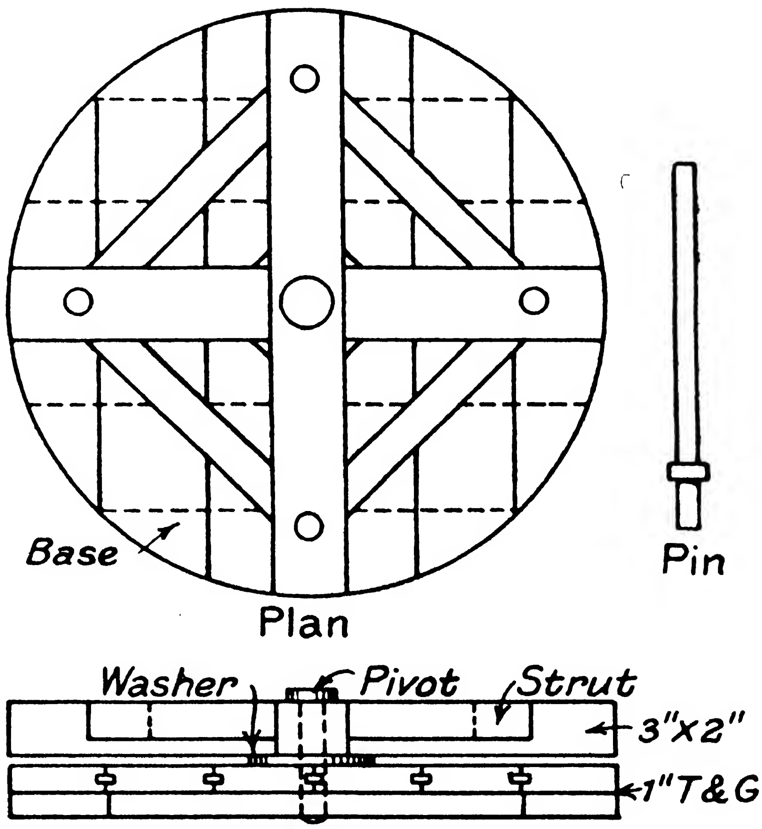


Fig. 26.—Turn-table for Coiling Ropes.

The Turn-table.—The table base is composed of two layers of 1-in. matchboard placed crosswise, and is about 2 ft. in diameter, a hole being bored in the centre for a pivot. The revolving frame is of 3 in. by 2 in. timbers forming a square about 1½ ft. across. The shoulder on at least one of the pins should be all to one side to facilitate drawing when the coil is wound. A thin washer sandwiched between the two parts will prevent excessive friction. With very heavy wire rope a turn-table is essential, but in proportion, one is equally as useful for coiling or uncoiling the lighter ones. Similar turn-tables are to be seen at all collieries and other works where much wire rope is used.

CHAPTER VIII

KNOTS

The Reefer.—Really about two knots only are customary for general erection purposes; these are the reefer and the clove hitch. To this short list can be added the common half hitch, two of which constitute the reefer knot, as may be proved by anyone interested. It is not necessary to study any beyond the two mentioned, for there is not particular application for the elaborate series often shown in publications on knots; to tie one quickly yet securely is the object to aim for. The

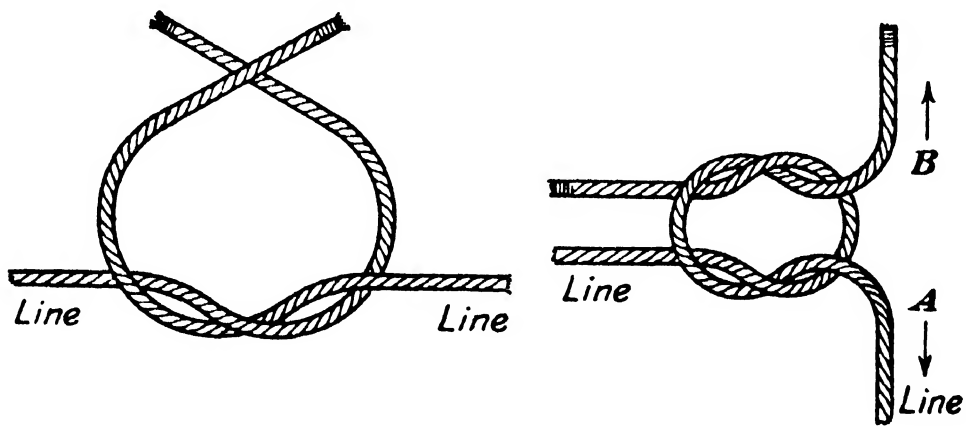


FIG. 27.—The Reefer Knot.

reefer is used for tying the ends of ropes together securely and its chief feature is that it can be quickly untied when necessary by pulling apart the line and the end that lies along it. Fig. 27 shows the reefer knot at the first pass, with the rope ends crossed ready to form the complete tie. By crossing the ends the other way, i.e., by placing the one shown in front at the back, the granny knot would result, this being the difference between the two. In Fig. 27 the reefer is shown case at least one round turn should be employed, because this takes the strain off the knot and there is little fear of it becoming drawn very tight; in addition it makes the control of the guy or whatever the rope is, so much freer for the man attending it.

The Clove-hitch.—The clove-hitch, shown in Fig. 29, is a very simple method of securing a cord around an object, and although this knot can be dispensed with it is a very useful one to know if one can be tied quickly. Although it is so simple the novice may find it very baffling at first, and until he can tie it mechanically the forming will be doubtful. Most scaffolders and riggers use the clove-hitch when cording the poles, and at times they will add the half hitch as an extra precaution. The clove-hitch is the best method for securing stiff or thick ropes, as being self-locking no knot is necessary, but the end must be bound to the lines with twine to prevent any likelihood of the hitch loosening. It is not recommended to employ the clove-hitch, as one may feel inclined to do, for securing a guy to a stake; it is very simple to slip the clove-hitch over the top of one of the latter, but the disadvantage is in releasing it again, especially if there is some strain on the line. The half-hitches are always easy to free.

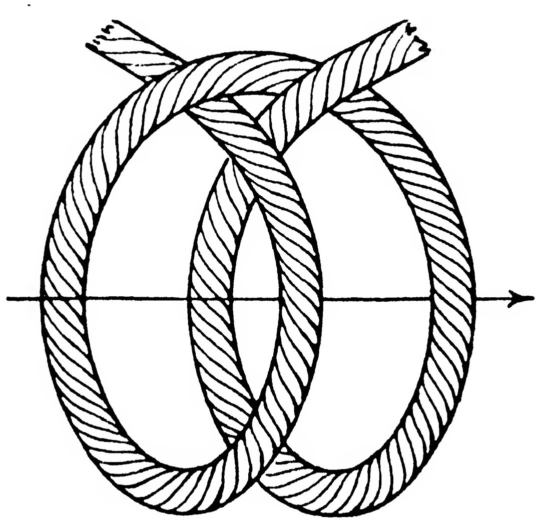


FIG. 29.—The Clove-hitch.

Securing Knots.—On the heavier ropes or on stiff ones including all wire ropes, the ends must be tied to the lines with twine after the hitches are formed. These bits of twine will prevent a knot on a stiff rope from untying itself. The idea is shown in Fig. 3 which illustrates the dressing of the derrick pole top; the two half-hitches are also to be seen securing a guy to the top of the derrick pole.

At a Post.—If when securing a rope to an object such as a column there should happen to be a quantity of spare rope, it is not necessary to carry all of it around the object; a doubled rope sufficient to allow of forming the bond and the knot is all that is needed, and the rope can be secured far more expeditiously than to coil a single line several times around the object with so much spare rope in the way.

Practice.—These knots can be practised at home with any common piece of rope or cord around a suitable post in the garden, or round a table leg in the house.

Scaffold Work.—It may be mentioned that builders' scaffolders rarely make a knot when bracing poles and putlogs. Their bonds are after the style of the clove hitch, and every round turn folds over the runner (line) that is being handled. Wood wedges are sometimes employed to key the bonds tightly, and for the purpose of driving the wedges one may see an axe carried in the scaffolder's belt.

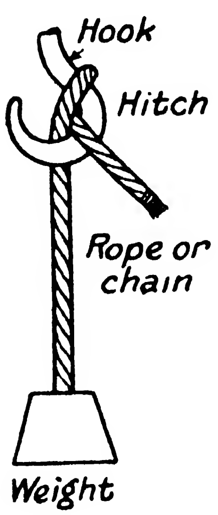


FIG. 30. The Blackwall Hitch.

The Blackwall Hitch.—The Blackwall hitch is worth knowing, and although its application is limited, it comes in very useful at times, as it can be used for hauling down the bottom block of the tackle, and for any similar purpose. It may be employed for a lift in certain circumstances, but it is not recommended unless the circumstances particularly justify it. The hitch is shown in Fig. 30, and it is made in a moment by folding the rope or sling around the back of the hook and then bringing both portions across into it, the one carrying the load being uppermost as shown, thus binding the free end. This hitch is not recommended because it is not of positive security, but is a handy hitch for jigging a lift into position or for luffing a load along the ground, where no danger could occur by a sudden freeing of the line. It can be employed with either rope or chain.

The Non-slip Knot.—One other knot is sometimes necessary for instance, in the case of a man having to ascend the derrick pole in the noose of a rope as a substitute for the bosun's chair. The simplest form of knot for this purpose is shown in Fig. 31, and it must be so tied that it cannot slip, for if it did it would be too uncomfortable to use. In forming allow as much rope as is necessary for the noose plus the tie—say about 3 ft.—then on the line form the loop A in the left hand. Next take the end of the rope in the other hand and lead it downwards into the loop A, bringing it up again under the crossed cord and over the top, finally leading into loop A again. The knot is then pulled taut and the seat is complete.

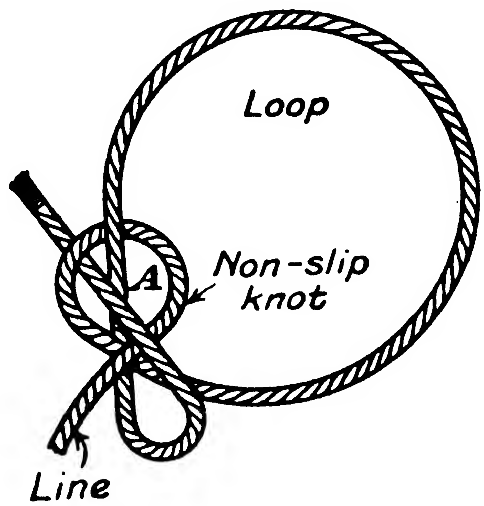


FIG. 31.
The Non-slip Loop.

This is an interesting knot, but with its rare application many cannot retain in their memories the method of forming it. It may, however, be wanted by some readers. There is a knot known to all which is a good substitute for the non-slip knot, but which is never used by erectors; it is made by placing the two cords together and forming a single knot or half-hitch on them. The knot is simple yet secure, but when drawn very tight it is difficult to undo.

CHAPTER IX

SLINGS

Slings.—Slings are indispensable to the erector, moreover he needs a variety of these to accommodate the various circumstances as they occur. Slings are made of chain, of wire rope, and of soft rope, all of which have their merits and their respective applications. The merits of the chain slings lie in their strength and their length of life, those of wire rope slings are in their strength and lightness, and those of soft rope slings in their softness.

Features.—Wire rope slings displace heavy and cumbersome chains, and can be man-handled with such comparative ease. They are much softer too for slinging cast iron parts, needing less padding to prevent fracture and damage than harsh chains, nevertheless for short slings which are so handy to use, the chain will ever be popular. One contributory cause to the latter fact is that a smith can always be found to make up a chain, but a splicer for wire rope cannot easily be found. Short slings and endless or collar chains, say of from 1½ ft. to 5 ft., composed of links of ¼ in. or ⅜ in. diameter iron are worth their weight in something more precious than the metal of which they are made. Such slings can be acquired for a few pence as they are easily made from short lengths of chain for which there is no other use, and a smith will fashion useful slings from these in a very short time.

Types of Chains.—The single leg chain or sling with a hook and ring is a very common type. Then there are the brothers, or double leg, three leg and four leg chains, according to the number of slings hanging from one large ring. The brothers are not so often seen in erection work as the single slings are, but are commonly employed in the workshops and on shunting cranes, for in such circumstances a number of them in various lengths and strengths can be kept within easy reach, or carried about on the buffers of the latter as the case may be.

Three chains are illustrated in Fig. 32, and they each have several names. The first is known as a single leg, sling or lashing chain; the second as a double leg, two leg, or brothers, and the third as a buckling chain, sling, collar chain, or bond.

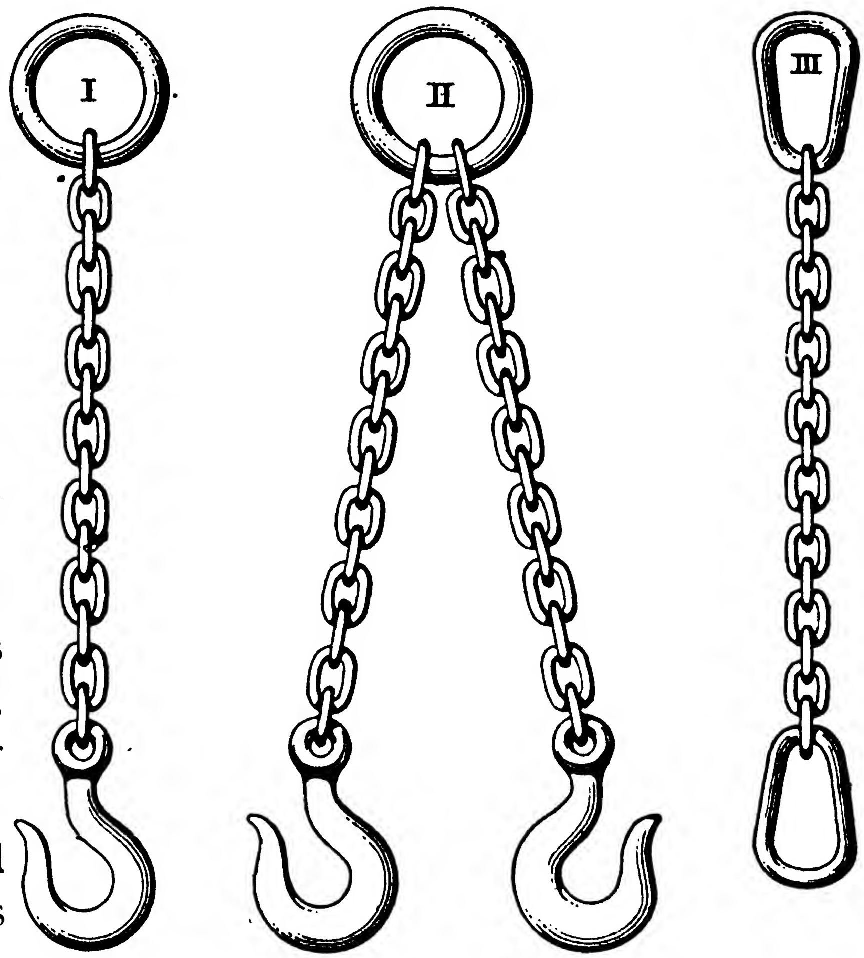


FIG. 32.—Types of Chain Slings.

Frosted Chains.—Chains need some care in frosty weather, and any sling that has been subjected to frost must be gently warmed through before use, for iron is very brittle when frosted. When chains or chain-blocks are fixed in an exposed situation, such that a fire cannot be placed near to them for thawing purposes, the frost can be removed by making a torch with some oily waste and applying this when lighted; a few minutes application will be sufficient to remove all traces of frost and consequently, all risk of breakage from that cause.

Annealing.—Chains need annealing too from time to time, and although many chains go through their life without this treatment and curiously enough never break, the process should be regularly and thoroughly performed. Apart from the scientific effect of annealing, it is a well demonstrated fact that the fibres of the iron get strained under the repeated stress of lifting, and it may easily be understood how the fire acts upon the strained fibres of the metal, restoring to them some of their original qualities; the effect is the same as applying heat to a coil spring in tension. The proper annealing of chains takes away all the brittleness due to crystallisation and makes the iron tough, but the process demands a furnace to do it thoroughly. Some good effects can be obtained in a slow fire, care being taken that the heat is limited to redness, then allowing the whole mass of chain and fire to cool off as slowly as possible. When cold the chains are better for a thorough scouring, either in the fettling machine or by wire brushing, and lastly they should be coated with boiled linseed oil.

Padding.—Large chains are very severe for the handling of heavy lifts, especially of cast iron, or of girders with flanges that are light in section; in the latter case propping and stiffening must be resorted to, whilst in the former much padding and packing is needed to prevent distortion of both chain and article. For this padding soft wood is usually employed, and any odd bits of scrap timber may be used for the purpose. The idea is to provide a bed for the irregular surface of the chain, also to prevent chipping or fracture of cast iron. The pads must be inserted as the chain is fixed and drawn taut; they may be driven in if it is more convenient to do so, but they must not be omitted in any case, in fact this padding is recommended in almost every instance when wrought or cast iron is being handled, and when chain or wire slings are being used.

Wire Slings.—Wire slings of the longer lengths are very much better than chains, as will be readily grasped, for a $\frac{3}{4}$ in. wire is very much lighter than a $\frac{3}{4}$ in. chain and yet it is quite as dependable, probably more so if the rope is good and soundly spliced. The link or hook at the end is attached to an eye (or thimble as it is often described) around which the wire is spliced. If a link or hook is not attached, then it is necessary to have one eye much larger than the other for buckling, or as an alternative, a shackle or D link must be employed to form the bond.

Wire slings are very cheap to make, but their life is short in comparison with chains, nevertheless, they quickly earn their cost by the men's time saved from the mauling of heavy chains.

Endless Slings.—Endless slings of cotton or of manilla rope are cherished by all erectors and their chief feature is in their softness for handling machinery and engine parts. It matters not whether the sling is of ½ in. diameter manilla to lift a few cwts., or of 2 in. diameter cotton rope to lift 5 or 6 tons, the erecting engineer appreciates them to the fullest extent. Precaution has to be taken that the strands do not get cut on the sharp edges of the article to be lifted, otherwise the slings become unsafe, but only negligent users will abuse these valuable pieces of tackle.

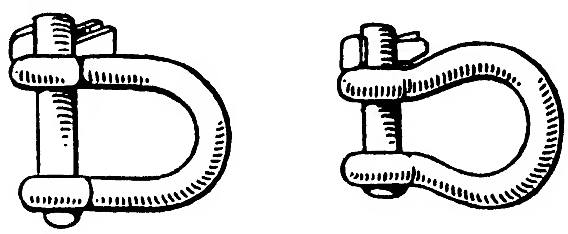


FIG. 33.
Shackles, D and Harp Shapes.

The endless sling—whether of rope, wire, or small link chain—has merits of its own in being handy for application and in gripping powers. When properly fixed it will never slip no matter to what it is lashed.

The Shackle.—The shackle or D link—is a common tool for erectors. It consists of a U-shaped piece of iron or steel, and has eyes forged at the two ends through which, as a rule, an ordinary bolt is threaded. Fig. 33 shows two popular designs in shackles.

CHAPTER X

SUNDRY TACKLE

Stakes.—Undoubtedly the best form of stake is made from the T-iron section, the angle iron being a good second. The lengths should average 4 ft. or thereabouts, as can be cut from scrap lengths of sections which accumulate in the works. Sections from $2\frac{1}{2}$ in. to 4 in. are mostly used—probably 3 in. is the best for all general purposes; and one end must be sheared to a point for driving into the ground. The irregularity of these sections give a good grip on the rope, and usually the edges are not sufficiently keen to do any damage to the fibres. Pieces of pipe, wrought iron or steel, make good stakes if capped and pointed but not unless; they are, however, very useful at times when there is nothing else to use. Even wood stakes are useful, and can be quickly knocked into shape with an axe, but for repeated use they would want capping and shoeing with metal as in the case of piles.

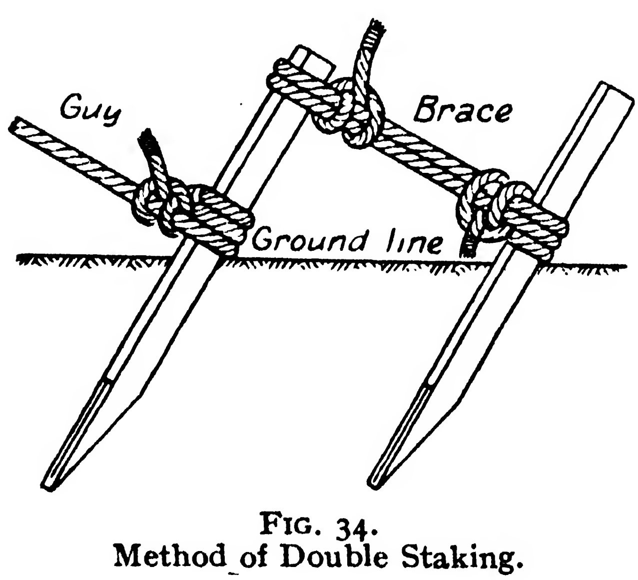


FIG. 34.
Method of Double Staking.

To have sufficient stakes, with some to spare, is good practice, for one never knows where an extra one will be needed. It may be necessary in some ground to resort to double staking, as shown in Fig. 34, and it needs no explanation here to point out the additional support that this arrangement gives to a stake that is in doubtful bond; it is self-evident and the step may be carried further to a third stake, but that is rarely necessary.

Crowbars and Levers.—Bars and levers play a very prominent part in erection. The skilled man uses a lever with a simplicity and dexterity that escapes the notice of most folks, and yet the unskilled one, whether he be an illiterate labourer or a student who has passed with honours many stages of mathematics, etc., seems to have little idea as to what is required in actual practice. The shape of the bars,

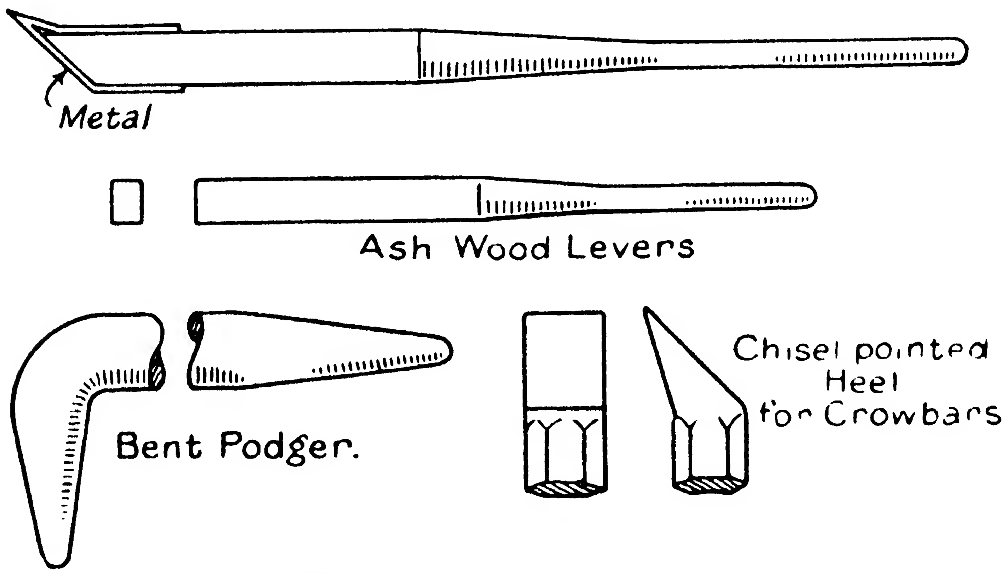


FIG. 35.—Bars and Levers.

for instance, is a mere detail which, more often than not, is neglected by those who order them to be made. The making of these is left entirely to the tool-smith, and he fashions them according to his fancy, which is no doubt the customary method as near as he can judge. The chisel-pointed end, which is heeled as shown in Fig. 35, is all that is essential for the erection of plant. Bars that have a spike or a diamond point at the other end are not preferred, in fact the point is of no use unless it is quite sharp, and then it becomes a source of danger in the hands of the users.

The chisel-point should be somewhat short and not too pronounced; the sketch in Fig. 35 gives an idea of the practical proportions.

In many instances crowbars are made far too heavy. Wrought iron ones need weight for strength, but a far better plan, and one that is cheaper in the end, is to have light cast steel ones. Chisel or similar tool steel which is anything but square in section is really very profitable for bars, and a few of these of from 4 to 5 ft. in length, and of, say, 1 in. section, will be of much greater service than great clumsy tools which the men fight shy of using. The men in the squad will cherish handy pri-ing bars, but the heavy ones are left about anywhere and are collected together only when needed.

Tommy Bars.—On short tommy bars the chisel end may be of quite as much use when flat as when heeled. Some of both designs are always useful, in fact it may be said without fear of contradiction that the tommy bar in some form does more work than any other small tool.

Podger Bars.—For structural work the podger bar is preferred to others. A blunt pointed end can be forged opposite to the chisel-pointed one, or bars of the design shown in Fig. 35 can be employed to advantage; the sketch shows the bar pointed at both ends, and one end turned at right angles to the other. This tool is most useful for handling and turning members that are holed. The bent end is suitable for lifting one side of a flat plate, and for turning angles and R.S. joists over. Made of ¾ in. diameter steel and about 20 in. long, it is a practical tool, low in cost and finds many uses.

Wood Levers.—There are two levers made of wood that are worthy of mention. These are also shown in Fig. 35, and although they are primarily intended for shunting purposes, the erector finds them very useful, especially at collieries, where they are mostly to be seen. The first one shown is about 6 ft. in length, made of straight grained ash, and is shod with a metal toe and heel in one piece. The tool is sometimes called the "toothpick."

The shorter one shown is about 4 ft. long and cut from 3 in. by 2 in. straight grained ash, with the handle roughed down to about 1½ in. diameter. Both levers are light and powerful, and give good service. The former was designed for use beneath the tyres of railway wagons, and the latter for insertion between the spokes of the wheel and the axle frame.

Levers from Piping.—The plain wrought iron pipe, of about 1½ in. diameter, is a lever that cannot be displaced from popularity. It is light and comparatively strong, but new piping is expensive to use. Generally old short lengths can be requisitioned into service for the purpose.

Plank Levers.—A few bricks and a batten of not less than 20 sq. in. in cross section will be found to offer a very handy form of leverage. A 7 in. by 2½ in. plank, say 8 to 10 ft. long, will give a good account of itself in most situations, but rather than risk breakages it should be removed and a strong angle or light R.S. joist substituted where necessary.

Rollers.—It is safe to say that rollers are required on every job, and these may be of hard wood or of metal. Wood rollers are preferred in many instances, for one thing they are not hard and slippery, and so are less likely to skid the load when on uneven ground, but they require a little more propulsion than the metal ones. Being solid they will carry a greater weight than metal pipes unless the latter are filled with concrete. Wood rollers of large diameter are selected for rolling heavy articles that have irregular surfaces, such as boilers and girders on which seams and rivet heads project, for with a little effort these projections can be made to mount the rollers, whereas with metal ones it would be foolish to try. Wood rollers, too, are lighter than metal tubes filled with concrete, and this is of primary importance for expediency in handling. Those that form part of the regular erection tackle should be capped at the ends with iron hoops, through which a number of holes, say four or more according to the diameter, are bored. These holes are for levering the load along, and with an ordinary pinch bar a good weighty piece can be either propelled or arrested as required. Fig. 36 shows the method of capping the roller.

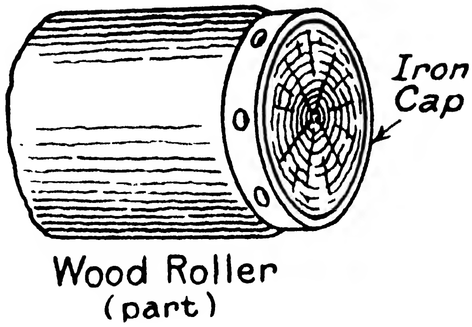


Fig. 36.—Method of Capping a Wood Roller.

Metal Rollers.—Metal rollers most commonly employed are short lengths of wrought piping, and their uses are legion. Certainly, they will not carry excessive weights, but if a sufficient number are distributed beneath the load it will be an extremely rare case if one collapses. These hard metal rollers are fine for smooth faces to roll on, but are easily scotched by small obstructions, even as small as ¼ in. in size. They should not be too small in diameter, unless the rolling path is of metal too ; on the other hand, large diameters may be awkward. To suggest a margin, pipes from 1½ in. bore to 4 in. bore are most suitable for general use.

Of course all the rollers being used at one time must be of the same bore, otherwise the progress will be interrupted. The exception to this is when only two rollers are employed, such as on articles that are long and low, but each roller must be capable of carrying the total weight without collapse, also the ground must be hard enough to prevent indentation. Girders and similar shaped members generally need only two rollers, and with this number transport is easy; also, turning about by balancing the load on one roller whilst the other is being

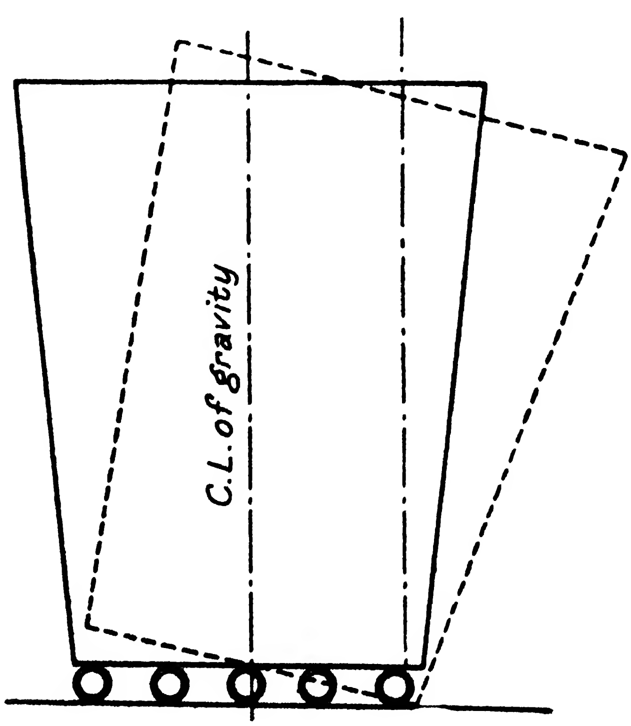


Fig. 37.—Method of Rolling Short Heavy Masses.

placed forward is a simple matter. When the article is short and somewhat bulky balancing may be out of the question, so a series of rollers must be kept well distributed beneath it, especially if the article is tall and weighty. The diagram (Fig. 37) illustrates this point.

The Cradle.—The sketch (Fig. 38) shows a timber cradle of simple design. Strong and serviceable for heavy vessels such as are common in chemical works, and for bulky articles of irregular shapes, a cradle is well worth the capital outlay. It is made of baulks of suitable strength, say 8 in. to 9 in. sq., and about 7 or 8 ft. long. The ends are seen bevelled off to give a lead on to the rollers as it reaches them. Two tie bolts firmly brace the sides, which are morticed to the sleepers.

A lighter form of cradle can be knocked together from railway sleepers, or even 3 in. battens, with similar battens to brace them together, a few long nails being quite sufficient to secure the members together for a temporary job.

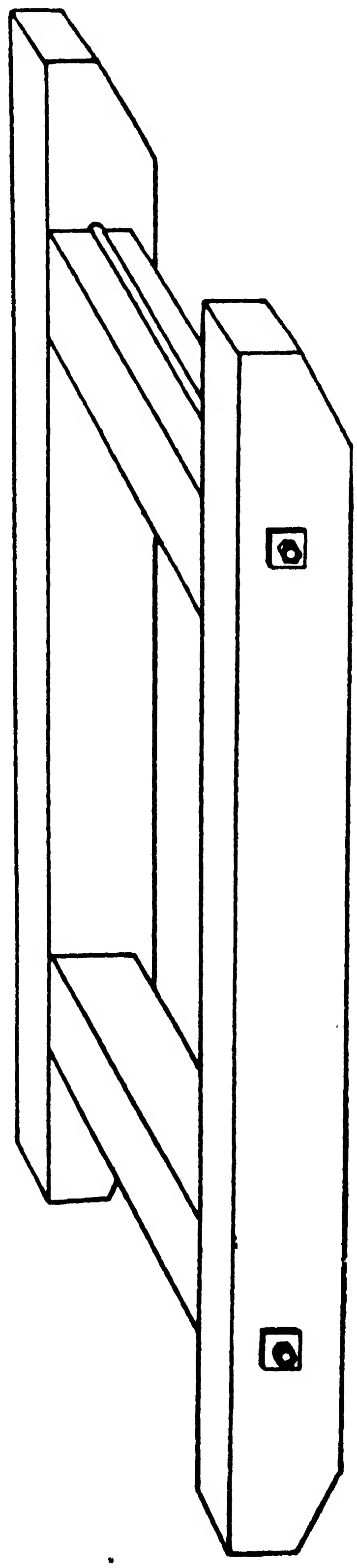


Fig. 38.—A Wooden Cradle.

Wedges.—There are many minor occasions with site work when wedging is necessary. A few good mild steel wedges of 5 in. or 6 in. long by about 2 in. wide, and tapering from 1 in. down to nothing, find many niches of usefulness. The common flat chisel steps in very often as a wedge, but this tool is mostly very precious on the job unless a means of repairing it is at hand. On the heavy structural work—bridges, for instance—large metal wedges form part of the kit. The sizes vary of course, but the average size may be given as 15 in. long by 5 in. wide, with a taper of 2 in. to nothing. When wedges are to act as a lifting jack the system of cross wedging as shown in Fig. 39 is employed, for by this means a more satisfactory lift is assured. The two wedges are driven against each other with a little lubricant on the horizontal planes, but not on the inclined one.

The popular wood wedges are made on site, a chunk of wood being sawn through on a diagonal line. Fierce ones are of little use for anything but scotches; this point needs no explanation. The smoother the faces of the wedges are the better, but when it is not convenient to plane the inclined faces, then a sheet of thin metal plate should be inserted between them to reduce the excessive friction, otherwise the wedges may splinter before they lift the weight.

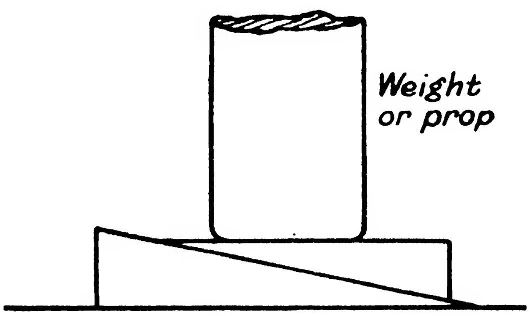


FIG. 39.
Method of Cross-wedging.

Hammers.—The hammers necessary for general erection work are of the ordinary types. Two hand-hammers are always needful, and in addition to these there should be a 7 lb. stripping or flogging hammer, and a good sledge hammer of 14 lb. or so. A further useful tool is the carpenter's hammer that has an axe edge opposite to the flat pane. Many scaffolders carry one of the latter in their belts to use as the occasion arises.

One sees, at times, hammers thrown from aloft, and more often than not the shafts are broken in consequence. This is due to shock or impact, and if it is found necessary to throw down a hammer, it should be landed on a soft bed of something.

The re-shafting of hammers is not a convenient job on site, so care should be taken of them. A few spare shafts might be included in the tool kit so that the re-shafting of broken ones can be accomplished, for hammers are indispensable tools to the erector.

Timber-dogs.—In the erection of temporary structures composed of sleepers, baulks and battens, the common method of clamping the members is by the use of timber-dogs. The illustration (Fig. 40), is of one of these. They are made of $\frac{1}{2}$ in. or $\frac{5}{8}$ in. iron or mild steel, either round or square in section, and bent at the ends as shown after being drawn out to a chisel point. Common sizes are from 9 in. to 15 in. overall, with the spiked ends from $2\frac{1}{2}$ in. to 3 in. long.

As the timbers to be clamped together lie at different angles to each other the chisel points are made to suit, the

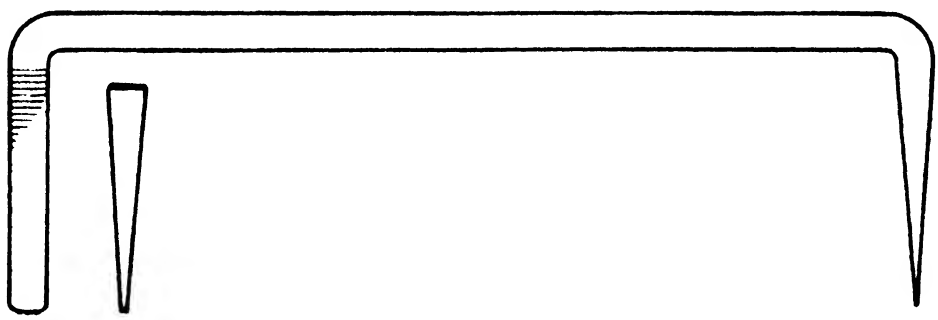


FIG. 40.—A Timber-dog.

one shown being for members placed at right angles. As the points are driven in, the wedge-shaped spike of the one end has the effect of drawing the joints together. Stock patterns are as shown in the sketch, or with the wedge points both in the same plane. Special ones are made to suit by twisting one or both ends to the desired angle.

On large contracts where wooden structures are necessary for temporary measures, thousands of these dogs are used. They are essentially contractors' tackle, and they come in handy for track-laying, shoring and staying; also for building trestles, piers, pile bridges, rafts, etc.

This form of clamping would not be employed on a trestle for such a job as shown in Fig. 67, or for any similar instance where irregular strain and oscillation would be likely to loosen the members; in such cases the baulks are either morticed or halved at the joints and securely bolted together, and fish-plated too if thought necessary. On stationary wooden structures the clamps are good enough, and they may be driven in the ends of the members as well as the sides.

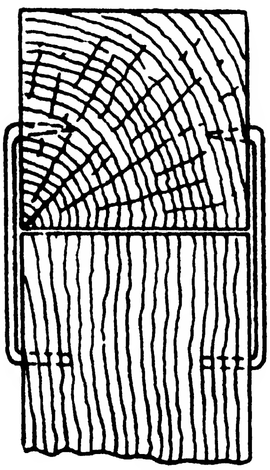


FIG. 41.
Method of Fixing Timber-dogs.

In fixing two members together as in trestle work, one dog on each side is necessary, as shown in Fig. 41, for it will be understood that a single dog will not be of much effect in such a case.

The Use of Clip-plates.—There is another instance in the application of leverage in which both the skilled worker and the technically trained student mostly fail to exercise common reasoning. This instance relates to the fixing of plate washers which are intended to do duty as clamping screws. The uses cf washer-plates, both in the works and on site, are many and they are often much more suitable and convenient than clamps even for ordinary purposes. Common fish plates from railways metals are at times requisitioned for the purpose, for they are powerful by virtue of their shape and thickness.

Now although the majority of men will readily grasp the idea of fixing clip-plates, and of placing and packing pieces in the correct position, others never seem to be able to understand how the tool performs its functions. In Fig. 42 a pair of clip-plates are shown fixed correctly for clamping—say the foot of a ratchet-stand to a R.S. joist, instead of using a screw-clamp. The shorter end of the clip must be used to grip the articles together tightly, and the bolt should be butted close to them, whilst the packing piece must be as far away as possible; the latter should be of the same thickness as the total thicknesses of the articles to be clipped.

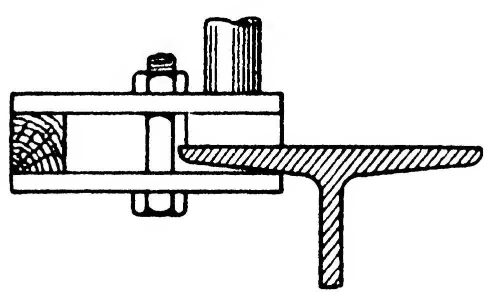
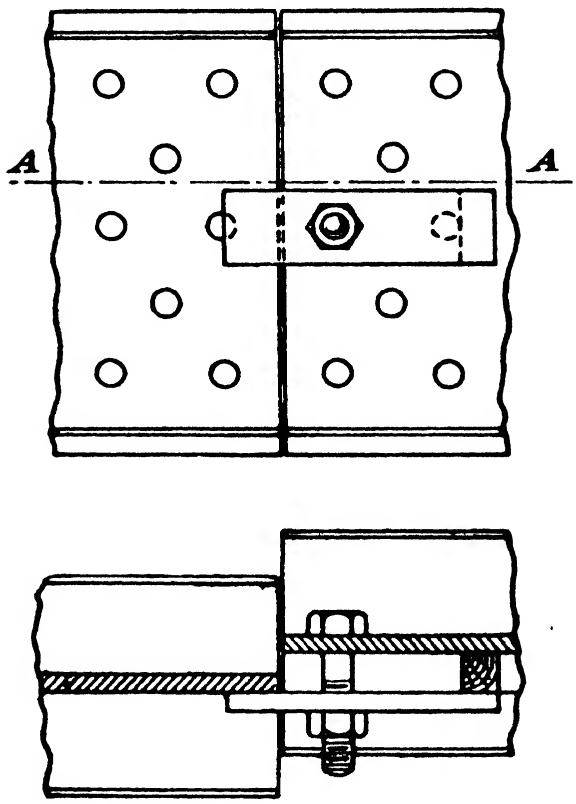


FIG. 42.
The Way to Fix Plate-Clips

When these simple conditions are in evidence there need be no doubt about obtaining the maximum compression at the clamping point, and providing the thread of the bolt is in good order this method of fixing will never allow the clip to swing round during the application of the spanner.

To place the packing piece close to the bolt as many are in the habit of doing will nullify the clamping of the articles to a very great extent, if not altogether. Packing pieces which are either too deep or too shallow are almost useless and should not be used.

Another instance of the use of a single plate is shown in Fig. 43. Here its function is to pull two R.S. joists into line when the joint covers are not available, or unsuitable, for the purpose. This illustration is just to show the way to fix the plate correctly, and there is a plan on line A.A. which clearly indicates that the bolt should be as near the point of compression, as in the previous instance. The author's actual contact with those who have had to use clip-plates is such as makes this reference essential, for all who are unaccustomed to the fixing of these err in the manner recounted.



Plan on line A.A.

FIG. 43.
Using a Single Plate-Clip.

The Pit-prop Remover.—There is a tool to be seen at all collieries which could with profit be adopted by erecting engineers. It is the grab-lock, or pit-prop remover, and is often called the Silvester, from the inventor's name. The drawing (Fig. 44) will convey the idea, and as will be noted there is a rack and lever movement, while inside the box-like body there is a spring pawl which arrests the backwards motion when the load is drawn forward, but which can be released at will. The tool is made for use with a chain, and the most convenient link is inserted in the cavity in the body after the end of the chain has been attached to the load to be moved. The 36 in. lever exerts a most powerful pull, and it is really amazing what a weight can be hauled along by one of these tools.

Probably it is due to the fact that it is especially designed for colliery and mine work that such a useful tool has escaped the notice of most erectors and erecting engineers, for there is

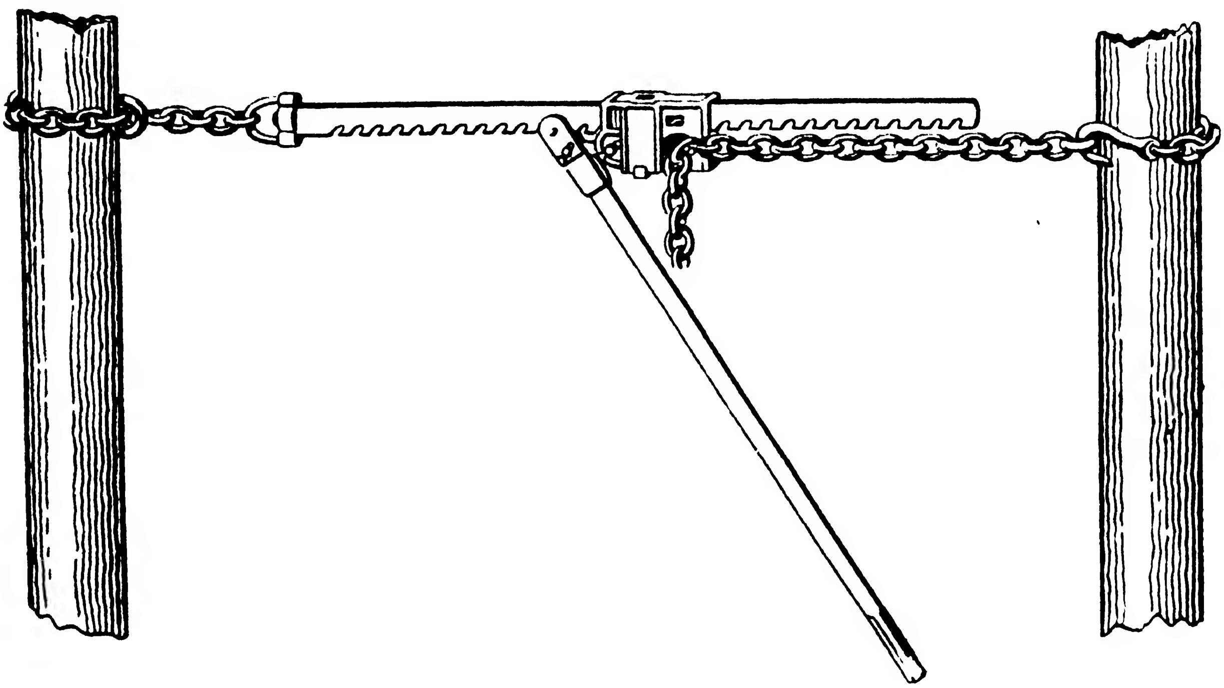


FIG. 44.—The Pit-prop Remover.

no branch of the heavy engineering industry in which the Silvester could not be profitably employed.

The tool is made of hard steel throughout and is capable of much real punishment. As stated, it has to be used with a chain attachment, but as the size of the cavity will take links of about $1\frac{1}{2}$ in. by $\frac{5}{16}$ in., there is little difficulty in obtaining a suitable one for the purpose. In addition to the enormous load that one of these tools will shift along, it has an appeal in the ease and quickness with which it can be attached and detached when suitable anchorage is within reach. The uses to which it can be put are too numerous to mention, and yet so few appear to know of its existence.

CHAPTER XI

NOTES ON FOUNDATIONS: HOLDING DOWN BOLTS, ETC.

Anchor Plates.—It often falls to the lot of the erecting engineer to order some foundation bolts for the job on which he is engaged. If this does happen consideration has to be given to their function, and also at times to the means of obtaining them quickly. Mostly there is some place near the site where they can be made, and if that is so then the only consideration is of the simplest type to use for security.

The sketch (Fig. 45), illustrates the method of fixing anchor plates under a concrete base. This is a very powerful form of anchorage, especially for tall stanchions and columns, but it is generally considered too elaborate for most jobs. The bolts may be either square or hexagon headed, but must have square necks to fit the square holes in the anchor plates, which will prevent the bolts from turning. Great care is necessary in setting this form of anchorage true to position and level, for there is no means of modifying it later. Adjustment can be made laterally so far as the holes will allow, but that is not good for the bolts, as it must throw them out of plumb, then when tightening up is attempted there is fear of a fracture across the threaded portion. When such a bolt breaks the position is hopeless, therefore it behoves the man in charge to haunt such foundations during construction.

Levels.—To emphasise the importance of keeping the level about correct, mention is here made of one job in which the anchor plates were set too low. This in itself would not have been a serious matter had not the anchors been fixed under the concrete, and it was found later when attempting to level the stanchions that the bolts would not reach through the base plates. To overcome this difficulty some special socketed extensions were turned to lengthen the bolts ;

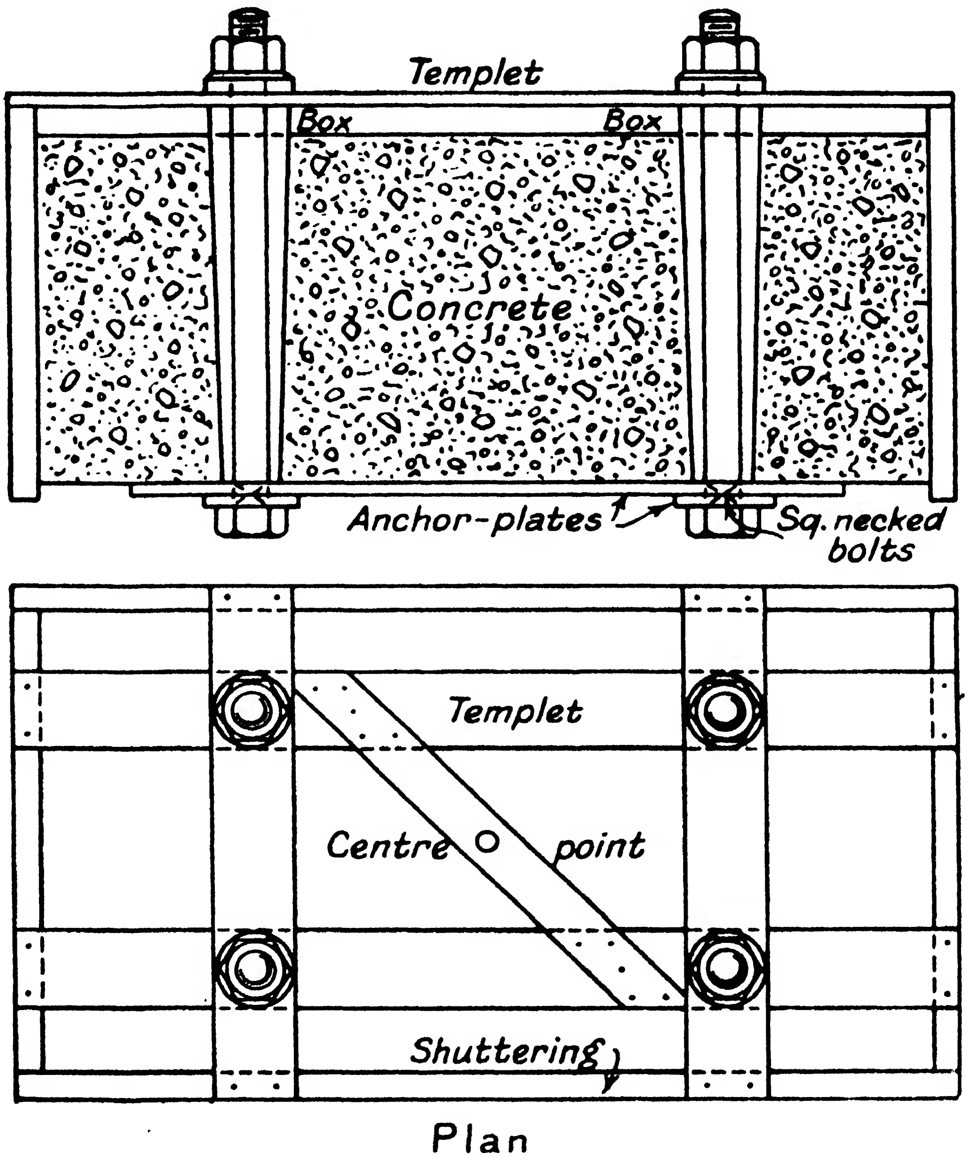


FIG. 45.—Anchorage for Tall Stanchions, etc.

and in the stanchion base plates the holes were bored out large enough to accommodate any portion of the sockets which chanced to protrude beyond the underside of the base plate.

It is customary to leave a good margin of threaded end on the bolts to overcome any sinking that may occur in the base block of concrete. The surplus—if any—may be cut off afterwards if desired, although this is not generally done.

Holding-down Bolts.—In Fig. 46 six common types of holding-down bolts are shown. A is a very cheap form of bolt, being just the plain rod looped at one end. B is also a cheap bolt; the end of the rod is split for about 1 in. back and then squared as shown. C is a style approaching the rag bolt and has a fish-tailed end; it will not have much anchoring effect unless a washer is added. D is an ordinary square-headed bolt which has a cast iron stepped pyramid (of stock pattern) threaded on to it; the head of the bolt fits loosely into the casting, but the recess in the latter will not allow it to turn. E is an ordinary bolt either square or hexagon-headed but with a square neck; the ordinary washer-plate is of suitable thickness, with a square hole in the centre to suit the neck of the bolt. F is the common rag or jagged bolt, sometimes called the Lewis bolt, and this is a real forging; the thick end may be rectangular or square in section. They are more costly to make than the other types and are not so much used to-day as they were years ago.

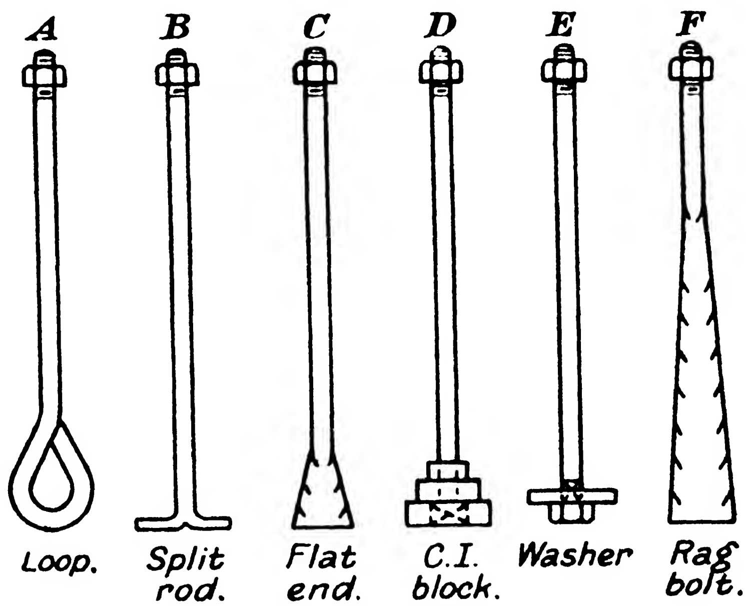


Fig. 46.—Some Holding-down Bolts.

Features.—The bolt E can be made without forging if no smith is available by screwing the head end of a rod and sandwiching the washer between two lock-nuts, or a hole in the washer may be tapped and locked with a nut; and for bolt D a short thread and a square nut will form a head for the bolt. These methods are generally cheaper than smithing when a fitting shop is handy. Really there is little to choose between the cheaper types, so selection must be based upon the particular circumstances, and to the material and means available to the engineer, when bolts are not included with the job, or when those supplied are unsuitable.

In Practice.—Practical experience has proved to the author that far too much labour has in the past been allocated to the making of anchor bolts ; when a good cement is used the cheapest possible form of holding-down bolts is quite as secure as the most elaborate one ; not only so, there is usually no need to go to the depth that some are in the habit of doing with these bolts. A big bulky base may be necessary to carry the load intended for it, but there is no doubt that the bolt, if well cemented in for 6 in., will break before it will pull out ; again, most holding-down bolts are only to function as dowels, the exception being where there is vibration of the foundations, as with engines and machinery. It seems absolute folly to be at the trouble to anchor stanchions that are to have their base plates buried beneath a concrete floor, and their exposed portions secured by upper floor girders carried along to the outer walls, and perhaps by the roof trusses too.

Grouting.—The concrete bases of all structures—this also applies to most mechanical jobs—are best left somewhat low. This allows packing to be inserted for levelling off, and facilitates the grouting in of the foundation bolts. Usually a concrete bed will sink a little after being moulded, and whilst this means a little more packing when levelling off, it is an advantage rather than otherwise.

Where the base-plate of the part being erected entirely covers the holes in the foundation, channels should be cut as runners for the grout, otherwise some difficulty may be experienced in getting the grout to the bolts ; even when the whole base is floated there remains an element of uncertainty, for in such a case one cannot know if the holes contain water. Stiff grout poured into holes will displace water that may lie therein.

Floating.—The floating of a base means that the bed-plate is surrounded by a fender of clay, or wood, or bricks, and then liquid cement is poured beneath until the level of the cement outside is higher than the underside of the bed-plate.

Packings.—Many erectors use iron wedges—only small ones—for levelling off, and these are left in, the ultimate pointing and finish covering them from sight. These wedges are quite all right in many instances, but a far simpler—and equally as good—way is to use any old bits of flat packers from the scrap heap. These can be built up to the required thickness and neatly placed under the bed-plate flush with the edge. Wedges are not at all costly to make and it may be advantageous to use them; still it is a needless expense to use them everywhere for levelling, as hundreds may be required.

Bases and Boxes.—Concrete bases must never be set on " made " earth, but must reach a good solid foundation. This remark is rather an elementary one; still there are times when an erector is required to add one or more bases for modifications on site, and perhaps he is unacquainted with earthwork details. The holes that are moulded in the concrete blocks for the holding-down bolts are mostly made to taper inwards to the bottom, as shown in A, Fig. 47. The idea behind this is that the boxes or patterns may be used again, but they are mostly broken in drawing, because the wood clings to the surface of the concrete. The moulds are generally about two-thirds of the depth of block, and although this practice of shape and depth is common everywhere, only a little thought is needed to prove to one's own reason that it is capable of great improvement. The style of box shown in B, Fig. 47, has all the merits of the other and additional ones of its own. The inward tapering (A) as previously described is eminently suited for dowelling purposes, but for anchorage it is lacking in practical appeal. When the taper of the hole is reversed, as shown in B, the hole need only be half (or less) of the depth of A, and at that will give a better anchorage.

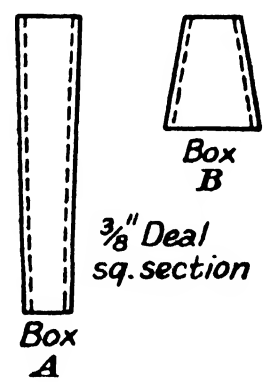


FIG. 47.
Box Moulds for Holding-down Bolts.

Its chief merit lies in the latitude allowed for it by adjusting the bed-plate, for, as will be seen from the sketch, Fig. 48, a hole with tapering sides as the A type aggravates the matter of adjustment, furthermore a hole as type B lends itself to elongation if that is necessary, whereas the A type does not, and to break away the top edge of the hole only would cant the bolt still more.

Forming Bases.—Concrete bases are sheeted around to form the mould for that portion which projects above the ground. The sheeting or shuttering is usually of timber, and it must be capable of sustaining the mass of concrete; when light battens are used, it may be necessary to shore the outsides to prevent bulging. The top edges of the sheeting are set to the required level of the base, and to these the boxes are secured by strip templets, as shown in Fig. 45. Where anchor plates are buried the bolts would be projecting through the templets, but when only the holes in the bases are required the centres of the bolts are marked on the templets. The sketch is of a simple design, but on larger bases the templets will be of a more elaborate order, although the method is the same throughout. The sheeting after being fixed should be carefully checked for position, and if this is correct there should be no doubt about the holes being in their respective places. On small bases the sheeting should be stayed to the same point of security whilst the mould is being filled, for the concreters will buffer it with their barrows. This is the cause of many irregularities in the positions of bolts and holes, which are ever a source of trouble when lining up takes place.

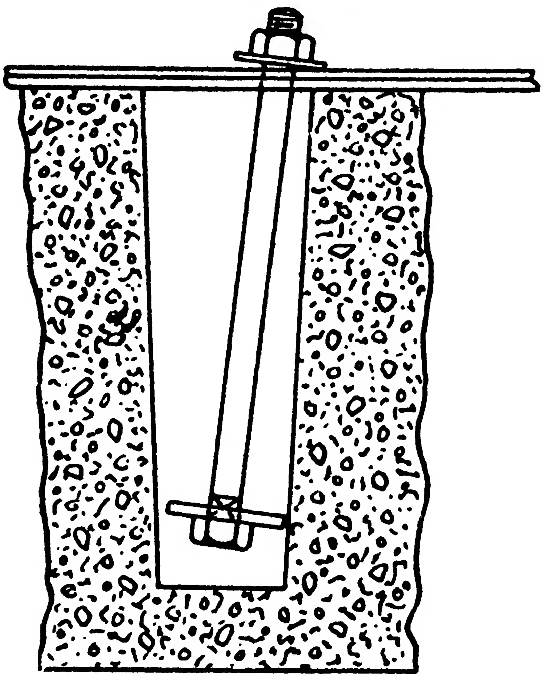
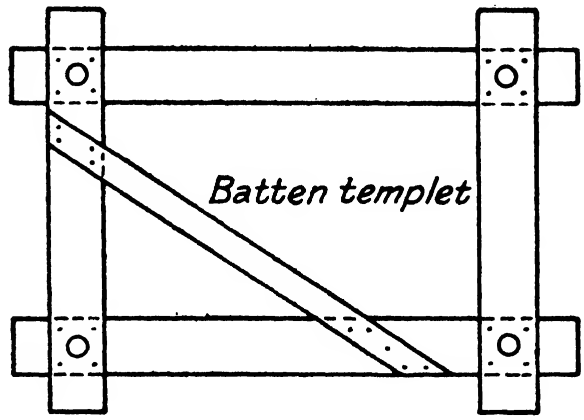
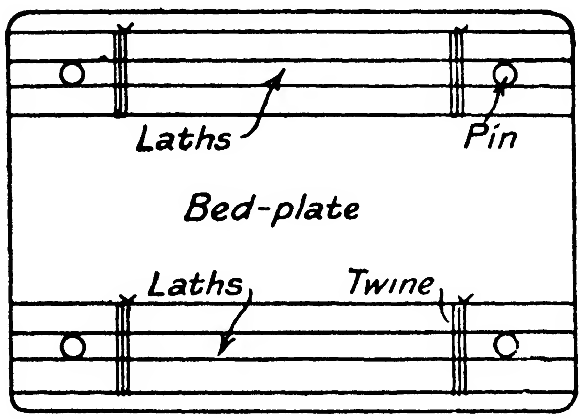


FIG. 48.—Showing fault of the Inwards Tapering Hole.

Whilst on the subject the author would point out that a very small percentage of bases are found to be in their correct positions; it would be no exaggeration to say that ninety per cent. are off the centres. It is a common failing with most builders to provide no check points, therefore when the excavation takes place the pegs are removed and the true position guessed at from the earthwork. One will occasionally meet a builder's foreman who knows what accuracy means to the erector, and then it is a pleasure to follow him up, but most erectors will tell of trouble they have over bases and foundation bolts. When the bases are correct as to centres and slightly low in levels, then erection is simplified to a very great extent, and interest in the job is not lost by annoying alterations and delay.





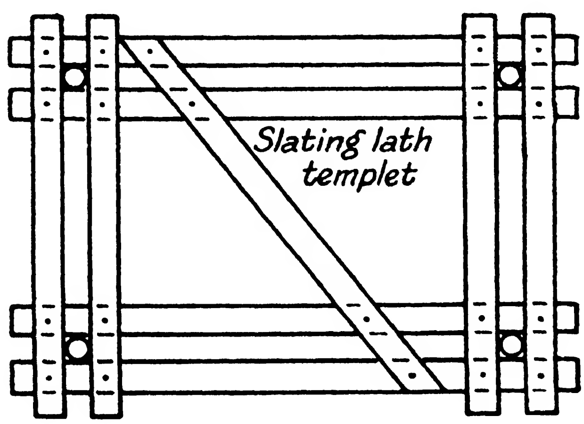


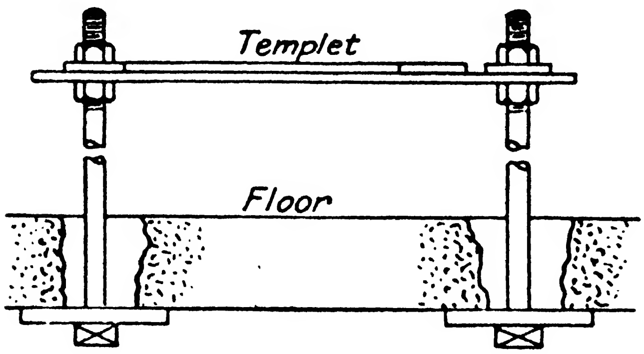
FIG. 49.
Base-plate Templet.

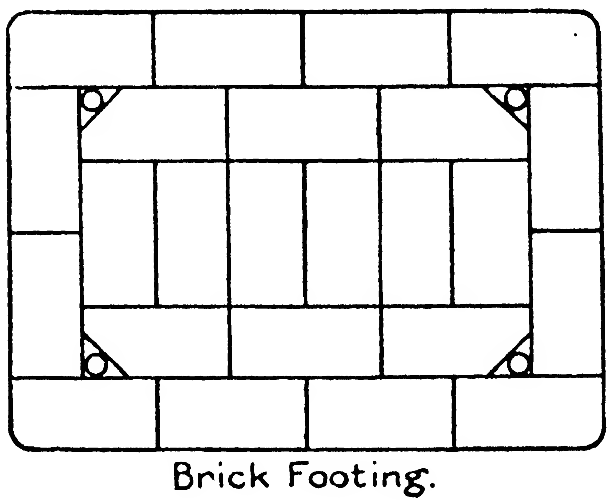
FIG. 50.
Making a Templet of Laths.

FIG. 51.
The Lath Templet Completed.

The holes in concrete blocks should be made plenty large enough: for a 1 in. bolt at least a 4 in. hole is required; 6 in. is better in most cases, for the clearance is wanted down by the washer as well as around the thread of the bolt. This rule applies to all bases whether for structural steelwork or for machinery.

Brickwork Bases.—Concrete has such a foremost place in the minds of constructional engineers to-day that many seem to forget the use of bricks for anything but wall work. It may happen that some small machine is to be erected in a factory or workshop during the week-end when the works are shut down. The mind that thinks of concrete for all bases can promise the base one week-end, and the fixed machine another, when the concrete is set. In some of our factories where food stuffs or fine chemicals are manufactured no preliminaries are allowed for fear of contamination; for the like reason no extension over the week-end can be permitted even to remove any material that will cause dust or dirt.





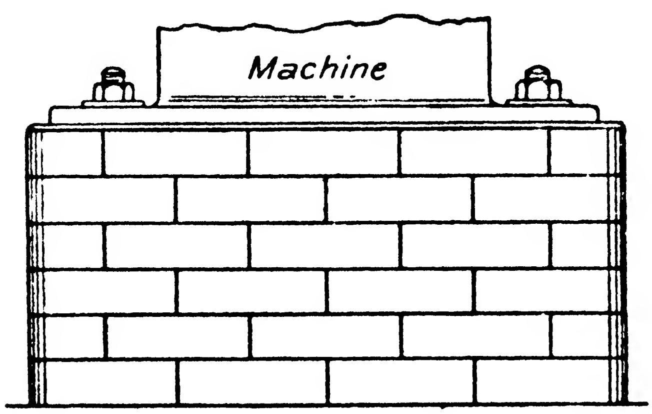


Fig. 52.
Setting Bolts in Concrete Floor.

Fig. 53.
A Brickwork Base. The Footing.

Fig. 54.
A Brickwork Base. Completed.

In fixing such machines as mixers, digesters, boiling pans, motors, etc., for which a raised bed is necessary, a brick base can be built on the concrete floor during the week-end, and the machine can be ready for action on Monday.

First a templet of the bed-plate is made from battens, as shown in Fig. 49, and if possible the holes in this templet should be marked from the actual plate. Perhaps the machine is delivered on its side, or can be turned down easily, if so a templet can be quickly knocked together from a few slating-laths, by inserting pins in the holes of the bed-plate, and to these the laths are tied with twine, as shown in Fig. 50. Then by nailing on laths crosswise, and adding a diagonal strut as shown in Fig. 51, the whole is built up in a few minutes, and is quite rigid.

Next, with the templet mark out the position of the holes on the floor, and at each position break a gap through the mat of concrete sufficiently large to thread a stout flat bar anchor-plate, as shown in Fig. 52. If desired the anchor-plates can have tapped holes into which the holding bolts can be screwed after the former are inserted. The bolts are then set to the templet and grouted in. The base of brickwork in cement can now be built around these, the footing being shown in Fig. 53. The brick-setter will keep the bolts plumb with his brickwork. Bull-nozed bricks make neat corners, and if these are on stock they should be selected.

Fig. 54 shows the base completed, and having a secure anchorage to begin with the machine can be erected on Sunday and put into commission on Monday. All that need to be left for the morning is a final try with the spanner on the nuts.

CHAPTER XII

SHAFTING: BRACKETS: BEARINGS

In General.—Although the fixing of the line-shafts on suspenders or wall brackets is a job usually allocated to a mechanic, the erecting engineer may find a difficulty in securing the services of a man who is experienced in this class of work; it therefore behoves him to know how to instruct an otherwise good mechanic in a practical manner. The job is primarily one of alignment, and when that is done correctly a few practical points in the fixing will enable the engineer who has never tackled a similar job to get everything in fine working order. The alignment is responsible for economy and efficiency, the practical points are for the elimination of maintenance costs as well as for low costs in fixing. The power consumption of line-shafts when properly erected is amazingly low, but if there is any part out of truth such consumption increases proportionately, and though the fault may not be visible to the eye it may eventually cause trouble. The remarkable flexibility of shafting and the self-aligning bearings will cover a few irregularities of the careless engineer, but the conscientious one would not allow shoddy work to pass his notice, not only with shafting but with every unit in which he is interested.

Shafts and Brackets.—When the erecting engineer is responsible also for the lay-out of the job, which at times he will be, then not only has he to supervise the erection to a satisfactory conclusion, but he, perforce, must leave behind him some evidence upon which his reputation, good or bad, is founded. To the conscientious engineer this very fact doubles his burden, for he is desirous that the result of his interest in the work shall draw forth commendatory remarks and not scathing criticism. Many people aver that an engineer in a responsible position has a comfortable job, but this is not so, in fact it is far from the truth. The engineer is a man of deeds and also of thought, if he is worthy of the name. His line shafts will be fixed and put into commission without any preliminary trial runs.

An engineer who is well learned may create the impression upon the others that his work is easy, and so it may be to him, but it has not always been, and it may not be as easy as appearances suggest. There may be a few men called engineers who are in comfortable positions which have been obtained by cleverly composed applications to directors who are unacquainted with the varied functions of plant and machinery; but responsibility cannot be shouldered by incompetence.

Fixing.—The office-trained engineer need not hesitate to accept responsibility for the erection of shafting if he has any reasoning powers at all, as he should have. He will see every point that spells success in running when the shaft is put into commission; and without any preliminary trials he should be confident that all will be satisfactory for continuous work. Firstly, the starting point must be considered, and this may be an engine or a machine. When the shafting is the first consideration, then this will sure to be parallel with some fixed object, usually a wall. If it is a wall, the position of each bracket is set out along it, not necessarily at the correct height, but say about 5 ft. from the floor. The ultimate position at the correct height is got by plumbing down from the latter, when scaffolding is erected for drilling the wall.

Wall Drilling.—In fixing the height of each bracket on the wall, it may be taken for granted that the mortar courses are good enough to work from for the drilling of the bolt holes, the adjustments being made later in fixing the brackets, or in the bearings. The bolt holes should be drilled whenever the walls will stand it, and if these are neatly done there is not the least need for grouting the bolts in afterwards. If it happens that no wall drills are available, and the only means are to cut out the brick courses, an attempt should be made to let one of the bolts in each bracket, preferably the top one, rest on the solid brickwork as shown in Fig. 55; this simplifies the hanging of brackets and the holes may be bricked up again before they are fixed. The bricks that the bolt rests upon need not be of standard size, but of a thickness to suit the desired height. Common bricks may not be procurable, but fire bricks or tiles will do just as well; and when the bolts are bricked in before the bracket is hung on to them a wood templet should be applied to keep them into the correct centres. In any case, the lower bolt, which is the more awkward to get at, should be bricked in before the bracket is placed in position.

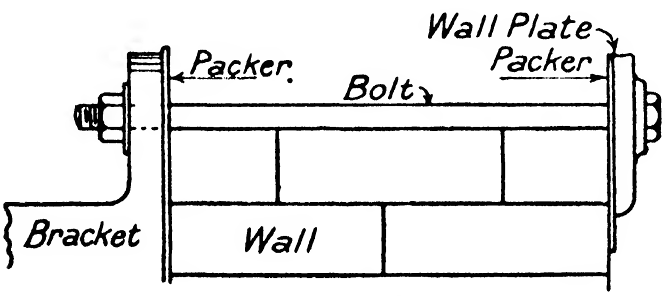


FIG. 55.—Fixing a Wall Bracket.

Packers.—Whenever brackets are fixed to a wall or to stanchions, or hangers to metal beams, it is wise to put a packer or layer of cushioning material between the faces of each. Attention is here called to the usefulness of plywood, 3 mm. in thickness, in this capacity, as it offers one of the handiest means for the purpose. A piece should be cut for every bracket and for every wall plate, the cutting being done with tin snips or with a hack saw, if a rip saw is not to hand; the bolt holes can be cut square with a wood-chisel. The insertion of this material allows of a very firm grip, as being soft it beds down over all the irregular and rough faces, thus assisting the bracket to remain firm.

There are other materials as well as ply-wood, for any soft wood will do, but the latter is more trouble to cut and handle.

Mill board is probably a better medium than plywood on very rough faces; beaver board or any similar substance is equally good. Mention is made of these various materials because there may be some of at least one sort in stock. As an expedient measure rubber insertion can be used, although its cost does not place it favourably for general adoption. Small pieces of asbestos board can be used up for the wall plates (and for bearings as is mentioned later), but rather than cut large sheets of pipe-jointing materials some wood or cardboard should be obtained.

Bolts.—In ordering bolts for wall brackets an allowance must be made beyond the customary margin to cover any irregularity in the thickness of the wall or fittings. An inch can be sawn off the bolts if necessary, but more often than not when these are ordered from a drawing they need an inch welding on. Walls often run thicker than the given dimensions; and the tables of the brackets need setting level; such points may rob the bolts of at least a few threads. In addition to these the cast iron bracket and the wall plates may take up more of the bolt than shown on the drawings. These points are such that have caused delay in forwarding actual jobs, hence their inclusion.

Brackets.—Brackets are of standard patterns, but as these are mostly bought from stock the various makes differ a little in weight and detail but not in essential features. As a rule one dimension only is stated, and that is the distance (in inches usually) from the wall to the centre of the line shaft; the other dimensions for the wall face, etc., being proportionate to the load the bracket is designed to carry. The table on the better class of bracket is slotted for the greater portion of its length, thus lateral adjustment is a simple matter; vertical adjustment being left for the bearing design and packing.

Hangers.—Suspenders or hangers are treated in a similar way to wall brackets. The line, no doubt, will be parallel to some wall, and it is only a question of accuracy in pitching out the centres of the hangers, whether of the J pattern, or of the inverted A type. No packers will be necessary for hangers bolting directly beneath a wood floor or on to wood beams, but where they connect to metal girders then it is advisable to insert packers.

Bearings.—There are many types of bearings and probably the general features of these are known to all. Each have their merits and special distinctions, all of which are centred around the price. The solid bearing or plummer block has much to recommend it for slow revolving shafts; it has to be adjusted for vertical height by packers of suitable thickness, but the adjustable patterns simplify this job out of all proportion to their extra cost. The adjustable self-aligning type should eliminate all doubt due to faulty levelling, whereby heated bearings and increased power consumption are caused; if levelling is commenced at one point—maybe there is one fixed—the job of setting the line should not take long. The fixing of a number of plummer blocks to a length of shafting is a painfully slow job, but it is a rare occasion when this type is specified for a line.

The erecting engineer will never pick up a mechanic who has so wide a range of experience, as to give him no cause to ask how something should be done, He may get a man who is accustomed to fixing shaftings, but who has had no experience of fitting the ring-oiled bearings, and although these present no difficulty, there are points to watch if needless expense is to be avoided. For instance, it may happen that the rings are solid and need threading on the shafting before a coupling is fitted; or they may be of the hinged type, needing nothing beyond careful handling when being inserted, lest broken ones accrue.

Ball-bearings.—All men know what ball-bearings are, but it can be safely said that comparatively few mechanics yet have had much experience in the fitting of them, so a few remarks here will be seasonable. It is not a difficult matter to fit a ball-bearing on to a shaft when the ring has not far to go on, but on line shafts a ring may have to be eight or even ten feet from the end; and often it is split by the time it gets into its place. The inner ring, of course, must be a moderate driving fit on the shaft; the outer ring, being already housed in the bearing, need not be dealt with here. Bright steel shafting is now drawn to such fine limits that little difficulty is encountered in fixing bearings. The ring is tried on the cleaned shaft, and if judgment decides that it will drive then it may be forced gently along. There must not be the least obstruction or burr on the shaft lest this acts as a wedge under the ring. When assured that the ring will slide smoothly along it should be placed in boiling water for a few minutes, and when it has absorbed as much heat as possible the slight expansion will facilitate the sliding along the shaft. It should be pushed on with a piece of piping of suitable bore, and under no circumstances must it be driven by tapping one side only. Fettling of the shaft beyond a rub with No. O emery cloth is not recommended, and the inner ring of the ball-race should be ground by machinery to ease this. When the bearing is in position it should be examined for cracks, and if there are no signs of these then grease can be applied to replace that which has boiled out; the ring should never be so tight on the shaft as to prevent its adjustment by gentle persuasion.

One often meets with complaints of broken ball-bearings. Now there are two probable causes, one is due to a ring being split at the time of fitting, either known or unknown to the fitter, the other is a question of lubrication. The former needs no further comment, but the latter—it may be said—is considered the fault in many cases by those who have experienced this trouble. Makers of ball-bearings do not usually put lubricators on them but pack the balls in solid lubricant in sealed housings; this, they claim, is quite sufficient and no further means of lubricating them are necessary. From practical experience the author differs with this theory, and recommends stauffers to all housings.

Solid lubricant in bearings seems to get more solid in confinement, and nothing but a hot bearing will cause the grease to reach the balls after the constant churning has resulted in it banking up at the side. Actual instances of broken ball-bearings have ceased when stauffer lubrication has been added to them.

Much against the maker's argument and assurance to the contrary, the author believes that thrust is the cause of a few broken ball-bearings. Take fans as a case in point; the action of the propeller puts a thrust endwise on the shaft, yet many makers do not consider thrust washers are essential, and most emphatically state that the ordinary ball-race is quite satisfactory. The makers certainly ought to know; but fans, to the author's actual knowledge, have given trouble over this.

Packers.—As with wall brackets, all bearings must have packings sandwiched between the hard surfaces. It is not an expensive job, and as almost any small waste piece of wood or pipe-jointing material can be used, it remains with the engineer to see that the collecting of these does not cost more than new stuff would do.

Couplings.—A line shaft that is ordered from a drawing will be delivered completely fitted with couplings of standard dimensions. The lengths will be numbered at each coupling in their respective order, and no attempt should be made to pair them otherwise, for all couplings of first-class make are machined in pairs. Certainly they are made to standard jigs, but one may find that by coupling the wrong ones a kink is made in the line.

It is not supposed that any coupling need be drawn (taken off), but if this should be required, the sketch (Fig. 56), will explain how to set about it. First get the length of shafting up to a convenient height, then with a good stout flat-bar or fish-plate, two bolts of convenient length, a small block of iron or a large nut, and a quantity of washers for the taking up of the bolts, proceed as shown. The couplings may be bumped with a lump hammer, but a block of hard wood held as a tool to soften the blow and to prevent bruises on the boss is advised. Bumping should follow the tension applied to the bolts, and in most cases the coupling will give; when as much effort as is deemed necessary fails to start it, gentle heat must be introduced, preferably by means of a blow lamp. As soon as this heat is sufficient to affect the coupling, and before it reaches the shafting, further efforts will give the desired result. The keyways and keys are parallel, and as there is no means of getting at the key to drive it, the coupling is slipped off without troubling about the key.

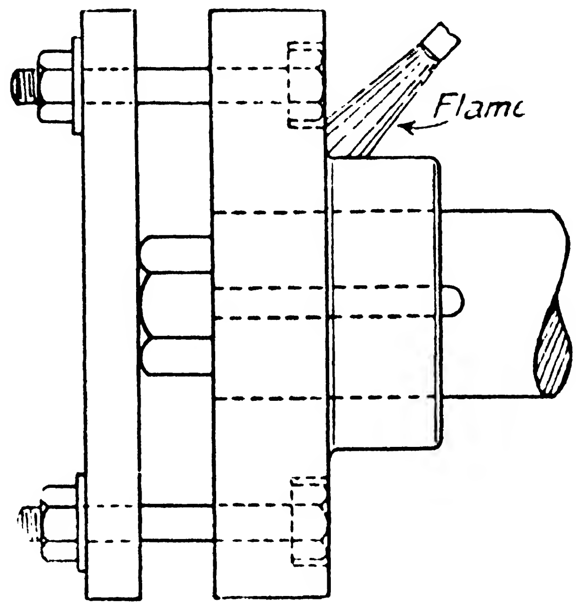


FIG. 56.
Method of Drawing a Coupling.

Fitting a Coupling.—Modern machinery has brought down the fitting of couplings to a mere question of minutes. On site it will depend upon the particular coupling as to how long the job is likely to take. First of all the end of the shaft must have all abrasions smoothed down, then it must be cleaned with No. O emery cloth. The coupling is examined and if it is quite clean both shaft and bore of the coupling should be smeared with stauffer grease or petroleum jelly (vaseline), then with a clean rag (not waste) as much as possible of the grease is wiped away from both bore and shaft, which are then tried together. If the coupling bids fair to drive on with a mallet then one may go ahead, but if it is too tight some fettling is necessary. Emery cloth is quite sufficient for reducing the end of the shaft; filing must not be resorted to because of throwing the coupling out of truth, for a small fraction here is multiplied very much in the line. When the bore of the coupling is easy on the shaft, then bushing is necessary. One must never hope to get a true line unless the shafting and the coupling are a perfect fit.

Types of Couplings.—The coupling shown in Fig. 56 is a flat faced one. With this type the concentricity depends entirely upon the bolts, therefore they are not recommended for first-class work. The better class coupling have male and female parts accurately machined, and these make the truth of the line irrespective of the bolt holes; they also have recesses for both heads and nuts of the bolts so that nothing projects.

There are other types of couplings, but the patterns mentioned are in general use. In addition to these there are a number of flexible ones on the market, and the fitting of these is exactly similar to the description given. Flexible couplings are not, as a rule adopted on line shafts.

Erecting Shafting.—To lift a length of shafting, usually a double leg sling will meet the requirements and keep the length in a straight line. Bright drawn bars are of stubborn metal and it takes a lot to spring a length of shafting, but once one gets out of truth it is useless to try to straighten it on site. There is no objection to lifting more than one length with a coupling bolted up; it is only a matter of lifting tackle, and in this case lifting blocks will have to be placed along the line to accommodate the length, and hands will be required to work them simultaneously.

Cutting Keyways and Fitting Keys.—But a generation ago there were to be seen in many works men who could cut keyways and fit keys with such remarkable precision and finish that one would ascribe the work to mechanical means. To-day there is machinery to do all this, except on site work. The erecting engineer must be very cautious in selecting his man to cut keyways and to fit keys, for much depends on them. The keyways to be cut will always be in the shafting, as the pulleys and couplings are machined at the works. The keyways in the ends of shafting for couplings are stopped short, as shown in Fig. 56, but for pulleys they usually need to be elongated somewhat to allow for inserting the key after the pulley is fixed in position. The width of the keyway can be obtained from the pulley, or the coupling, as the case may be; the standard depths being given in most handbooks. Very sharp and evenly tempered chisels, with crosscut and pointed ends, are necessary for ploughing out the bulk of the metal, and the finish is put on with scrapers.

The key is roughed out by the smith to a size which allows for reduction, and then it is fettled by the fitter, slowly but surely. This fettling is a slow job and speed has to be sacrificed to ensure a perfect fit. The fitter requires ample time, because the key has to be fitted all the way through the boss; in scamped work, the only part visible when the key is driven may be the only part that fits, and such a key would never remain fast. Smooth surfaces and a perfect fit are the two factors that ensure reliability and continuity of service.

CHAPTER XIII

PULLEYS : LUBRICATION

Pulleys.—We shall soon have the time upon us when the keyless pulley has ousted the keyed types from the market. One never could imagine a wood pulley being keyed to a shaft, yet they grip all right and never slip, so why should not metal ones hold. The utilisation of bright drawn steel for shafting has speeded up the production of design in keyless pulleys, and with the bosses turned to such fine limits, the clamping power leaves nothing for the key to do in the majority of cases.

Types.—Solid pulleys are obsolete and should be scrapped. Those with solid rims and split bosses are little better, for it may mean that a coupling has to be withdrawn to thread it on the shafting. Split pulleys (in two halves) are specified in every case nowadays, and although these cannot be fixed by one man, as can a patent pulley which is on the market, they have a merit that the patent one has not.

Patent Pulleys.—The patent pulley referred to has a steel flexible rim with only one break in it. It can be sprung open and threaded on to the shafting by one pair of hands. The only objections one can find to this design is that crown-faced pulleys are not possible, for it will be understood that to spring open a rim that is crowned would mean distortion to the part opposite the joint.

There is one great advantage with the keyless pulley which outweighs the consideration of its slight extra cost, and that is the great saving in time and labour of cutting keyways and making keys. With the keyless types the positions of the pulleys on the line need not be further thought of until the actual erection takes place, then they can be adjusted to suit, and re-adjusted if necessary in any way at any time. There are minor advantages, too, some of which may be due to modifications required on site. It has often been found necessary to fill up the keyway with solder or white metal when site alterations have resulted in a bearing

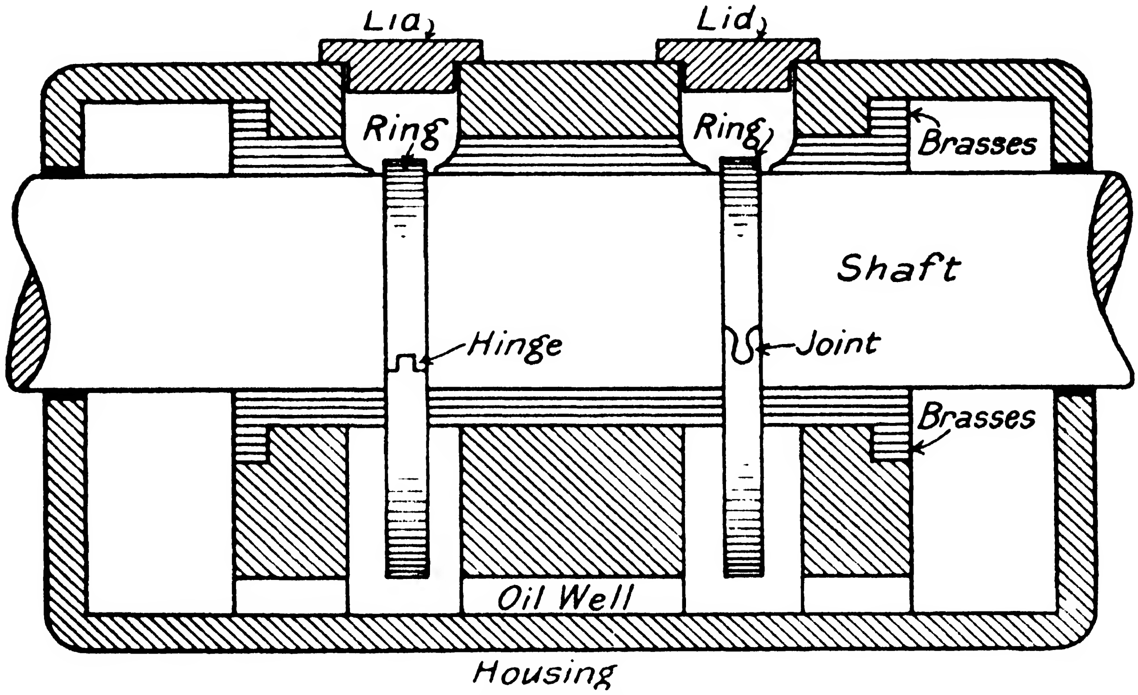


FIG. 57.—Section of Ring-Oiled Bearing.

being placed where a pulley was originally intended. Apart from all other considerations a much keywayed shaft is depreciated in value, whilst one that is free from such disfiguration retains practically its original worth.

Notes on Lubrication.—At times the erecting engineer will have points relating to lubrication to deal with. In bearings there are only two methods that effect new work, and these will be mentioned for the benefit of those who are not acquainted with them and their respective merits.

The ring-oiled bearing is universally adopted on all high speed work (other than those few shafts that are fitted with ball bearings) and on most of the slower moving shafts that are constantly at work. The sketch (Fig. 57) is to illustrate the principle, and, as will be seen, the bearing is completely housed, the brasses being supported on diaphragms above the oil well into which the rings dip. At the top of the brasses there are recesses through which the rings pass in their travel, and at these points the shaft is bared; as the shaft revolves the rings are drawn slowly round, bringing with them to the shaft a small quantity of oil which eventually finds its way into the oil grooves that are cut in the brasses. Fig. 58 is a diagram of the cross section, to make the idea clearer to all.

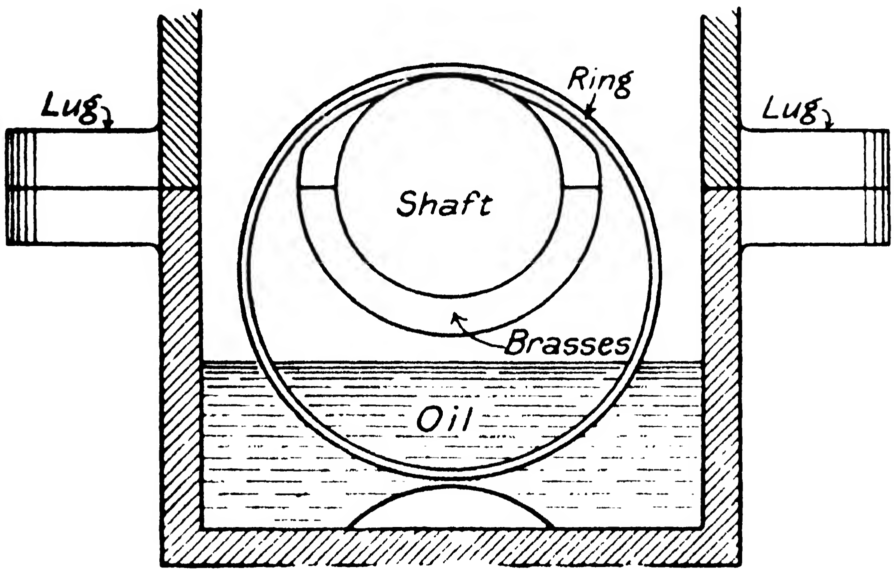


FIG. 58.—Ring-Oiled Bearing. End view.

The housing is extended beyond the brasses to form drip channels, and these are connected with the oil-well so that no oil reaches outside the bearing.

The stauffer system of lubricating is by means of solid grease forced into the bearing by either screw or spring pressure. The stauffer grease, as it is called, is mostly obtained from palm and cocoanut oil, but occasionally petroleum jelly is used. No doubt stauffers are known to all, but it may be that their merits are not; for plain bearings they have everything to recommend them, and when they are fitted any heated brasses are due to gross neglect on the part of the attendant whose duty it is to fill the cups.

There are patterns and patent types on the market to suit every condition and direction. The common type is usually fitted to the bearing cap in such a position that if an occasional turn is omitted, the heat generated by dry bearings will dissolve the grease, and this will then gravitate to the brasses in time to prevent seizure. For applications, other than the gravity flow, for constantly revolving shafts and for many isolated bearings, there is the stauffer known as the tell-tale, or spring plunger type, as shown sectionally in Fig. 59. The plunger is riveted to a steel disc which has a captive spring, and this spring can be held in compression by twisting the plunger so that the ends of the fins ride outside the cup; this is either to put the stauffer out of action, or to compress the spring whilst the cup is being filled with grease. On this type of stauffer there is a regulating screw for the throttle, so that a limit may be put on the discharge from the orifice if that be necessary.

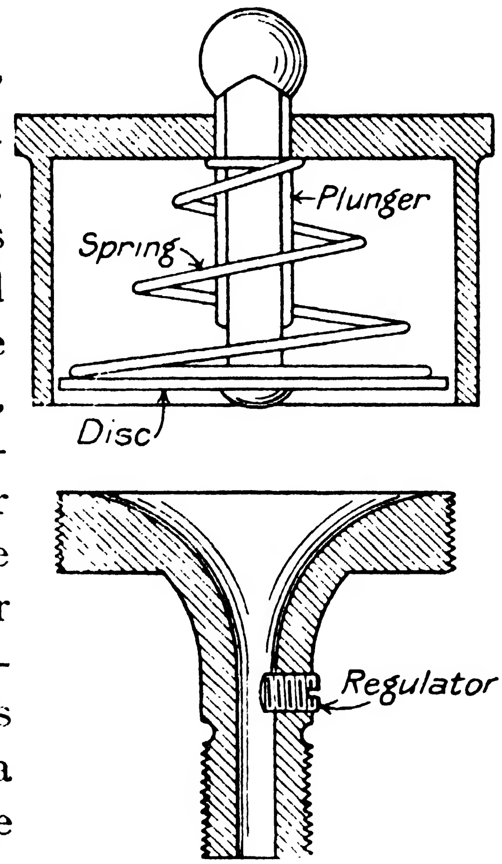


FIG. 59.
The Tell-Tale Stauffer.

For those situations where the plant is subject to excessive vibrations there is a spring lock stauffer to meet the special conditions. One of this type has a circular diaphragm, to which is secured a lock-bolt and a leaf spring, as shown in Fig. 60, and this is fixed tightly into the cup. The lock is free to move independently of the disc, but as there are notches pressed into the latter a little extra effort is necessary to compel the leaf spring to jump from one to the other. The stauffer body has a flat table, and above the orifice, as shown, are three positions for the fins on the lock-bolt, one position holds the latter as the cup is screwed on, whilst the other two give access for the lubricant to pass to the throttle.

There are in addition to these and the common patterns numerous patent types on the market, all of which function similarly, as may be seen illustrated in our engineering journals.

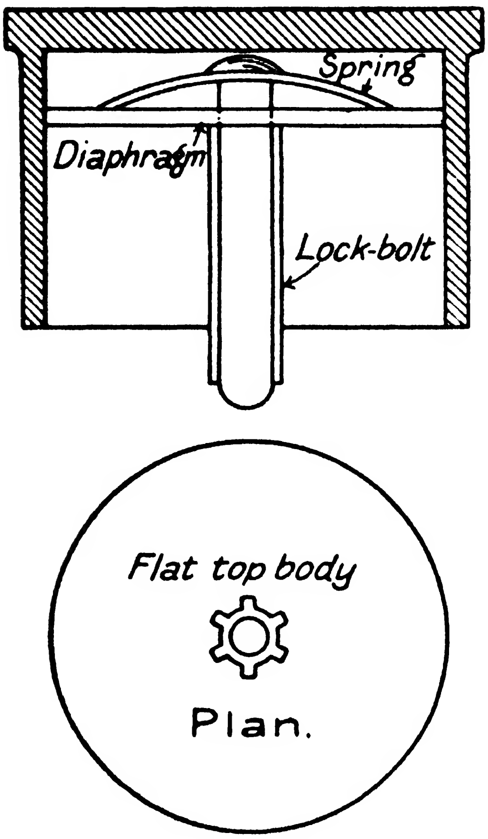


FIG. 60.
The Spring-Locked Stauffer.

Stauffers for general engineering purposes are screwed ¼ in. gas thread, which is standard. To replace a bottle lubricator it is usually only necessary to tap out the hole in the cap; at the most there is little to reamer out. There is one point to watch when fixing stauffers to bearing caps, and that is to be sure that the screwed end of the stauffer leads the grease into the top brass, for if it does not the grease may all be wasted by filling the cavity between the brass and the cap. This is likely to happen on some of the larger plummer blocks, and when the cap metal is too thick to allow the stauffer thread to reach the brass a nipple and socket must be added to make up the length.

With a few feet of ¼ in. gas pipe and a few sockets stauffers may be fitted to the most inaccessible bearings, and this will entirely eliminate the need for a man to scramble about with an oil can. For loose pulley lubrication modern practice has selected the stauffer in every case, but in many of them the stauffer is not attached to the wheel boss; it is fixed on the end of the spindle, as shown in Fig. 61.

For dusty or gritty processes the stauffer is eminently suitable, because by forcing grease through an enclosed orifice to the centre of the bearing no dust or grit can enter the latter, and as the grease exudes from the journals all the dirt is brought away with it. Really the system of lubrication by stauffers is everything that could be desired. They are cheap and simple to instal, they are clean and do not waste lubricant, they function efficiently and need no attention beyond a fill up occasionally, and a partial twist of the cup regularly as the machine or shafting demands. The only points in which the ring-oiling scores over the stauffer system are in its suitability for high speed work, and in its capacity to run for weeks with little or no attention, for so long as the rings revolve and have oil to dip into, the bearing will get it.

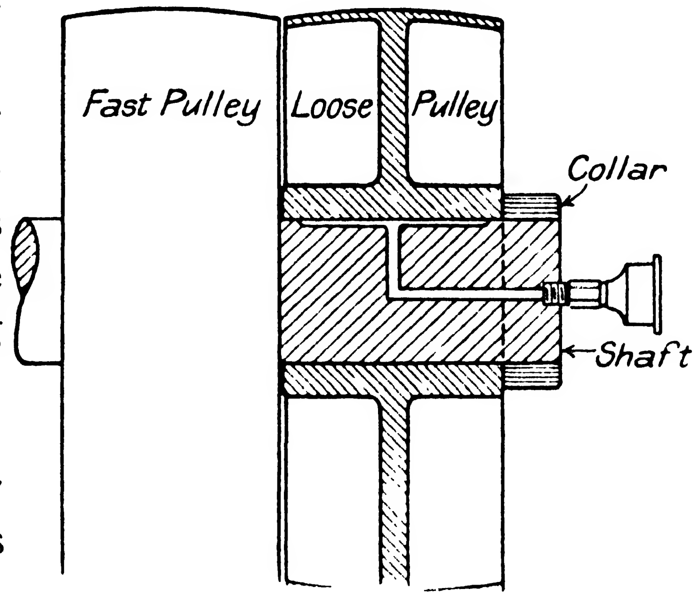


FIG. 61.—Loose Pulley Lubrication.

Stauffer grease is usually carried about in any old can or box, and is often left without a cover. This is a mistake and should not be permitted, for it means that dirt will get to the grease which will eventually find its way to the bearings, and every little bit of grit helps to score the journals. Again, a small piece of foreign matter might choke the feed pipe and so prevent the grease from reaching the bearings at all. These are minor details, admittedly, but the engineer has many thousands of such to keep his physical and mental activities ever on the alert; he has to shoulder the responsibility for thoughtless or negligent subordinates. In the long run this attention to detail is of greater importance than the high efficiency ratios, which may mean anything but economy.

CHAPTER XIV

STRUCTURAL WORK

Steel Skeletons.—At the present day the erection of steel structures for buildings is a specialised job; firms which cater for steelwork of standard designs such as these have stock tackle that is suitable for most jobs. The work of erection calls for no extraordinary ingenuity on the part of a skilled man, in fact to men accustomed to this class of work the job presents no difficulties whatever. Often a track on which a steam crane travels is laid down each bay, and with this crane—using an extended jib—the erection of stanchions, girders, and principals is quickly accomplished. There is usually nothing in the work to demand the services of a technical engineer, as the plumbing and levelling are not of a fine order except with structures including prime movers or other machinery.

A structure which is to carry the track girders for an overhead crane is usually tied at the tops of the stanchions by principals. The latter fixes the centres of the stanchions, and the wind ties on the principals set the upper part of the structure square, therefore the stanchions only require plumbing and levelling. The connection holes for securing the track girders to the brackets on the stanchions are usually elongated to facilitate lineal adjustment; in addition to this there is some lateral play, usually about 1 in. in the axles of the wheelboxes.

It will be readily understood that in the erection of this class of work, which consists chiefly of hauling and hoisting, it is profitable to employ a jib crane or at least a power driven winch. One or more of the latter, electrically operated, are usually employed whenever current is within easy reach, the motor and the winch being separate units (for the sake of portability), but both are secured to one pair of battens. Power is transmitted by a belt through suitable gearing to the winch barrel.

Method.—In the erection of a skeleton by means of a derrick-pole the track of progress is identically the same as

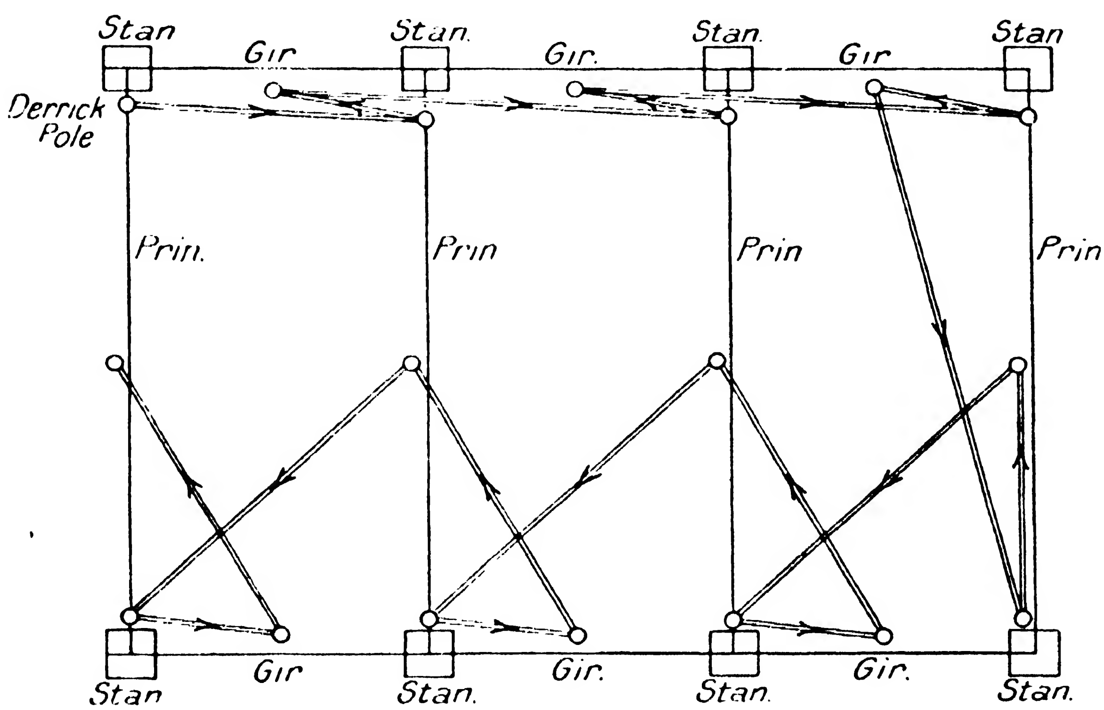


FIG 62.—Showing Progressive Order in Steel Shed Erection.

when a steam crane is used. The diagram (Fig. 62) illustrates the order of erection when stanchions, intermediate and track girders, and principals compose the skeleton frame—the lines indicating the walk of the pole in the direction of the arrows.

The first row of stanchions must be securely guyed, whether the latter are anchored or not at the base. The first principal to be erected must be guyed, but as soon as two are in position a few purlins are added to brace them together. The two principals and the two intermediate girders now form in plan a rectangle. No doubt diagonal wind ties are included in the job, so those for this rectangle are fixed to pull the latter square, and to hold it so.

In the erection of other light types of structural steelwork, which chiefly apply to colliery, chemical, and general factory work, one brain is usually good enough to supervise the whole job, but responsibility is often greater on the smaller job than on larger ones, because on the latter a combination of brains and experience makes the solving of problems so much easier. There is plenty for one man to think about if a job is any size at all. Colliery work, in particular, always includes mechanical arrangements, therefore the structures have to be lined and levelled up very truly if trouble is to be avoided later.

Small Structures.—On some small structures, where the stanchions are light and short, the inexperienced erector may feel inclined to rear these by hand. This is all right with stanchions up to about 10 ft. in length, but it is not wise to exceed that: light guys should be put on them in any case, for if the men can manage to hold the stanchions there is the girder to go across the top, and this needs a few men on a scaffold. It is not a big job to move a small pole from stanchion to stanchion, and then back again half the distance to lift the running girder into its place. More men, of course, will be needed if stanchions are to be reared by hand, so there is nothing to be gained. Apart from the latter fact there is a risk of one toppling over, due to the difficulty the men may find in balancing it when the stanchions reach the perpendicular position, for base plates may be small, and foundations may be somewhat irregular. The author has on several occasions seen hand-rearing attempted, resulting in a stanchion falling away from the men before it could be arrested; this can be understood, too, because as the stanchion top rises in the air the men have to cluster together to get a hand on it at all, and the lifting and pushing becomes uncertain; therefore, as stated, light guys should in every instance be attached, so that the member can be controlled and secured when reared.

General Points.—When a start is made to erect the structure it is assumed that sufficient rope is available for guying the parts, until so much of it is erected as to securely brace the frame. Poles may be used for propping, but all these should be lashed or otherwise made fast at the top, to prevent them falling out as the structure sways, or from being accidentally knocked out; this is a very wise precaution, and must not be ignored. It must not be forgotten, too, that hemp or manilla rope guys expand and contract, and it may happen that they have to be paid out in wet weather, or be hauled in as they stretch. Very often the guys have to be slackened when inserting intermediate girders, but that is a different matter. The chapter on Ropes deals fully with all that the subject includes, and note should be made of it.

Lifting Principals.—Principals are usually lifted by a sling lashed around the apex (or crown) plate. Now when the tie bar is of simple flat section, it will be understood that to lift the principal in this manner must put an enormous shear upon some of the bolts or rivets in the crown plate. Of course there is a limit to the span of principals which can be thus lifted without buckling, but many erectors will lift such up to 40 ft. span without supporting rafters. Tie bars consisting of angle iron sections will give the necessary support, and therefore need no further comment, but those of simple flat bar section, when on principals of 20 ft. span and over, should be stiffened. Usually a scaffold pole or an angle bar is employed for this purpose. Sometimes the scaffold pole is lashed horizontally to the struts, several feet above the tie bar and allowed to remain attached to form a support for scaffold battens which will be needed later.

Incidentally it may be pointed out that when one pole is to erect all the members, sufficient length must be allowed for it to be able to "land" the principals. For the erection of one or more long bays of steel framing it may be more expedient to use two derricks.

CHAPTER XV

COLLIERY WORK

Colliery Work.—The photographs (Figs. 63 and 64) are of two modern steel headgears above their respective pit shafts. As most of the general engineering firms undertake some work in connection with collieries, it will be opportune here briefly to describe the difference between the two types, for the benefit of those readers who are unacquainted with the actual colliery practice.

Fig. 63 shows a headgear constructed entirely of box lattice girders, and Fig. 64 illustrates a headgear of common design with its members made simply from rolled sections. The latter design is modified to contain the box-like steel plate casing which can be seen in the centre of the tower, and all around the pit brow (or bank) may also be seen a concrete casing, which together with the steel one totally enclosed the mouth of the (upcast) shaft. A word of explanation concerning the term "upcast" may here be needed.

At every colliery there are at least two shafts, to which all the mines below are connected, although it may be that only one shaft is used for winding coal. The second shaft is there in case of breakdown or accident to the machinery of the one, so that the miners can be brought up without undue delay. Assuming that there are two shafts at a colliery, and that both are used for winding coal, as shown in the photographs, the one is open around the top, and down this shaft huge volumes of air travel on their way to the workings below; the other shaft is made use of as a duct for the withdrawal of the air after it has circulated the workings and become foul.

Near the latter shaft the fan is situated, and to this the foul air is led by a channel (or drift) which is connected to the shaft just below the brow. The former shaft is called the "downcast," and the latter one the "upcast." Now to

Fig. 63.—Steel Headgear of Lattice Girders.

prevent the mine workings from being short-circuited, the air is kept from the mouth of the upcast shaft by enclosing a part of the headgear, and the pit brow with casing; air locks are included in the arrangement, the doors of which are operated only to pass men and coal tubs through.

Mine Ventilation.—The method of ventilating coal mines is a subject which may interest the reader a little further, for it may possibly happen that he will have to erect some plant at the pit bottom.

The directing of the air is carried on from the pit bottom by means of doors placed in the tub roads and tunnels, and

Fig. 64.—Steel Headgear of Rolled Sections.

by brattice cloth near the coal face, which baffle and deflect the currents to the miners at work along the coal face, until they reach the return airway, when the air is free to travel along to the upcast shaft. In the narrow stalls a circulation of fresh air is maintained by laying foul air ducts made of sheet steel along the side of the cuttings, which ducts are extended

—stove-pipe fashion—as the stalls are driven forwards: the other end of each duct being connected to the foul air main leading to the upcast shaft. The fan by which the workings are ventilated is never stopped except in case of breakdown, or maintenance of some part connected with it, or when it is necessary to open both ends of an airlock. At most pits the fan, by means of a series of shutters near to it, can be compelled to drive air down the upcast shaft; this precaution being taken to have a means of choking fire—if it should occur. There is much more engineering down below ground than many readers will imagine, and to the uninitiated engineer, a day down a coal pit is well worth the price of the garments that will be spoiled.

Clothes.—An engineer about to visit a colliery for the purpose of taking particulars at site, or for the erection of some work, must go prepared to encounter dirt—black, penetrating coal dust—and plenty of it, for it cannot be avoided. The colliery directors are at times almost indistinguishable from the miners, and whereas at most works such an undignified appearance of the directors would actually cause them a loss of prestige, no such thoughts are ever borne in colliery atmospheres. This the engineer must fully realise, as he also must that the impression he will create will be by his abilities, and not by an immaculate appearance.

Erecting Headgears.—The method of erecting headgears is similar for both large and small ones; for the former much more tackle is required, and, of course, it needs to be stronger, but the job has no extraordinary difficulties to put before an erecting engineer when the ground is clear of obstructions. In most cases it will be found that compressed air driven winches are available, and it is not a costly job to extend a pipe line to a point where it is convenient to place the winch or winches for harnessing the power.

A start is made by erecting a main leg (the main legs support most of the vertical load) and this has to be securely guyed, the back guy being placed so as not to obstruct the movement of the derrick. The accompanying sketch (Fig. 65) will convey an idea of the way to take the lifts in correct sequence to avoid unnecessary labour; the path of the derrick being clearly outlined. From the main leg (1) the derrick is walked across to the position of one front leg (2) and the latter is then lifted. The legs when erected will lie sheered over considerably, consequently the back guys must be of ample strength and of secure anchorage, because in addition to the weight of the legs the latter have to be braced. While cross bracings are being fixed the legs need to be swung about somewhat, and this action puts extra strain upon the

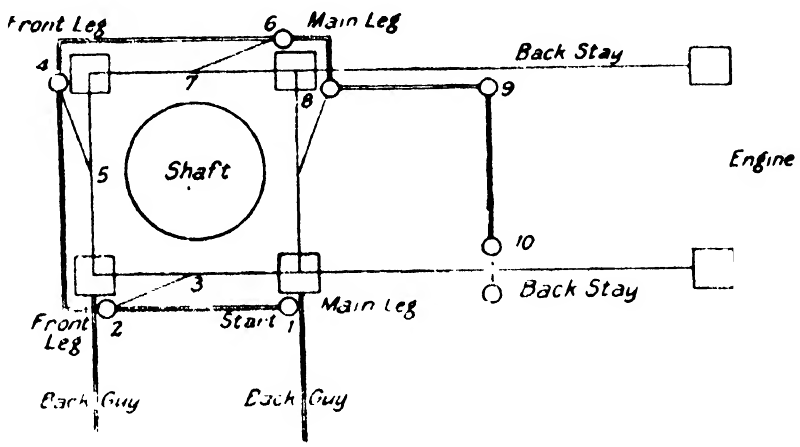


FIG. 65.—Order of Erection of Headgear.

guys. Also there is wind resistance to be taken into account which on a pit bank is, as a rule, no mean item.

By sheering over the top of the derrick the bracings (3) may be erected, and when the latter are fixed the legs then will stand without side guys, thus the path is cleared for walking the derrick along to the other front leg (4). It will be noted that the back guy at position (2) will need changing, therefore two guys should be attached to the top of that leg before erection.

The same order of progress is repeated to the second main leg when from position 8, the bracing of the structure will allow all the guys attached to it to be removed.

Points to Watch.—From the fourth leg the derrick is taken along to lift a backstay. The position 9, it will be observed, is on the inner side of the stay, so that after the erection of this one a few feet of travel will place the derrick favourably for removal after the second backstay is fixed. It can be imagined what trouble for nothing will result if the pole has to be taken right away round by not adopting this order. Regarding the two positions shown at 10 it is at the discretion of the erector as to which is convenient. There are always bracings between the backstays, and if the pole can be removed after the fixing of these, then the inner side is the one to choose. (Here is an instance of the advantage of a spliced derrick pole.)

The watching of such points similar to those which have been enumerated is a tax upon the resourcefulness of an erector; the inexperienced engineer is exhorted to study the particular situation, and to form plans beforehand of the sequence of erection. The description of headgear erection here given is in general terms; however, should the headgear be too high for the legs and stays to be lifted in one length (each member), the order still remains the same.

It is scarcely likely that an inexperienced erector will be given a job similar to either of those shown in the photographs, for those reach 100 ft. in height; the rope pulleys are 22 ft. in diameter and weigh about 10 tons each. The erection of the superstructure for changing the rope pulleys is the most harassing part, as the guys for both pole and steelwork during erection are long and consequently weighty, thus putting an extraordinary bias on the verticle pole or member, as the case may be, when the two opposing guys are handled irregularly.

Other Work.—The interest here shown in colliery work is because these jobs are such that usually an engineer from the works has charge of them; the colliery people finding all the labour and, as a rule, all the tackle too.

Most of the other structural work for colliery appliances are simple to erect, as there is nothing extraordinary either in height or weight, the chief care being in the plumbing and levelling so that the structure will be fit to receive the mechanical complement.

Checking Foundations.—A word here regarding a preliminary investigation of the site will be in season. When the erecting engineer has not been responsible for setting out and putting in the foundation bases, it is a wise plan to check these for centres, and for levels, too, if necessary, the very first thing. The surveyor or whoever is responsible for the setting out of the work perhaps has taken every care that the positions are accurately given, but the builders may not have respected the pegs ; it is an easy matter to disturb them when excavating. It is a rather common occurrence for both centres and levels to be hopelessly out, necessitating the taking down or slinging aside of those parts already erected for the bases to be made right. Take a case which interested the author, quite a small affair it is true, but one that showed ingenuity on the part of the foreman bricklayer. A heapstead was to be erected around the pit mouth which, as is customary, is situated on a bank. Two of the stanchions were to come on brick piers set on concrete mats away from the existing bank. Both piers were about three inches out of line, thus completely fouling the holding-down bolts. The attention of the foreman bricklayer was called to this error, and within one hour he confidentially reported that they had been put right. As the piers were six feet high, the author was keen to know how they had been rectified in so short a time, and was astonished to learn that each one had been jacked bodily along the concrete to the true position ; a small fillet of concrete had been added to keep them in place.

Bases and holding down bolts are dealt with in another part of the book, but incidentally all bases should be a little low, unless set exactly to the required level with a top dressing of cement.

CHAPTER XVI

BRIDGE BUILDING

Bridge Erecting.—The erection of bridges in any great detail is really beyond the scope of this book, yet it would hardly be complete without some reference to this branch of erecting. It is possible that the inexperienced engineer may have charge of the erection of a small bridge, but none of greater magnitude would ever be likely to fall to his lot. Bridge building in most cases is not a one man job, although the erection may be in charge of one man so far as operations and men are concerned. When the bridge is of some importance, it can be understood that much thought has to be given, and preparations made for the erection whilst the steelwork is being constructed in the bridge-yard, so that when delivery is made the parts can be fixed without delay.

Most of the bridges made to-day are for replacing weak ones, or for widening the road or railway, as the case may be. If the contract is for a road bridge, it may be that a temporary wooden bridge has to be built at the side of the permanent one, to accommodate the traffic whilst the work is in progress. For a bridge on a railway to be re-constructed usually means that the line has to be kept open, one part of the bridge being rebuilt whilst the old part carries the traffic. One line, of course, will need to be closed, and it may mean that the railway company will have to modify the line by inserting additional sets of points, signals, etc., to suit the occasion. When one half is fixed, the change over is made so as to carry on the traffic until the completion of the job, when all temporary work is cleared away and the new girders take the load.

The photograph (Fig. 66) shows a bridge under construction, built and erected on the old structure while the line was kept open. After the spans were completed all the supporting structure was removed.

FIG. 66.—Bridge-Building. The Broken Line.
(By courtesy of Messrs. Eastwood, Surigler & Co., Ltd.)

Arrangements.—In conjunction with the bridge-builders, the railway company attend to all matters relating to organisation. As everything appertaining to railway operation must be to schedule, of which due notice has to be given to the various railway officials, drivers, guards, etc., it can be easily realised that all details must fit in with the programme of progress, as any delay will be a costly job for the railway company—probably for the contractor, too, consequently there is a committee consisting of the best brains and experience to arrange things in the right order.

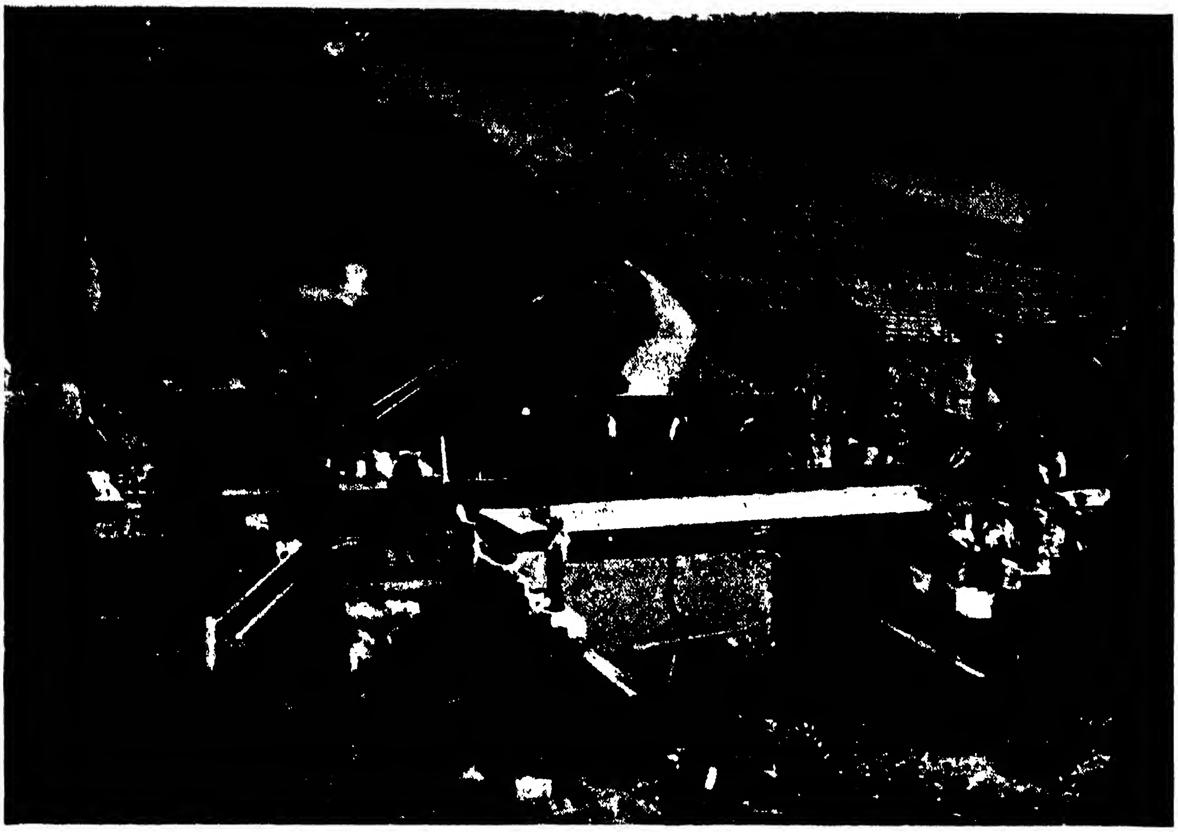


FIG. 67.—Bridge Building. A Customary Method.

FIG. 68.—Bridge Building. Ready for Pulling in.

Method.—The photograph (Fig. 67) is of a railway bridge built and erected by Messrs. De Bergue & Co., Ltd. It gives a very comprehensive idea of how some smaller bridges are erected. Usually one half is built first, and on this is laid a track for the cranes which are shunted by locos, as may be seen in the photograph.

In some cases the track is laid on a temporary structure of timber or of old girders, to commence the job; in others the span may be short enough to land the girders across with a single crane of long reach. One often hears of a bridge

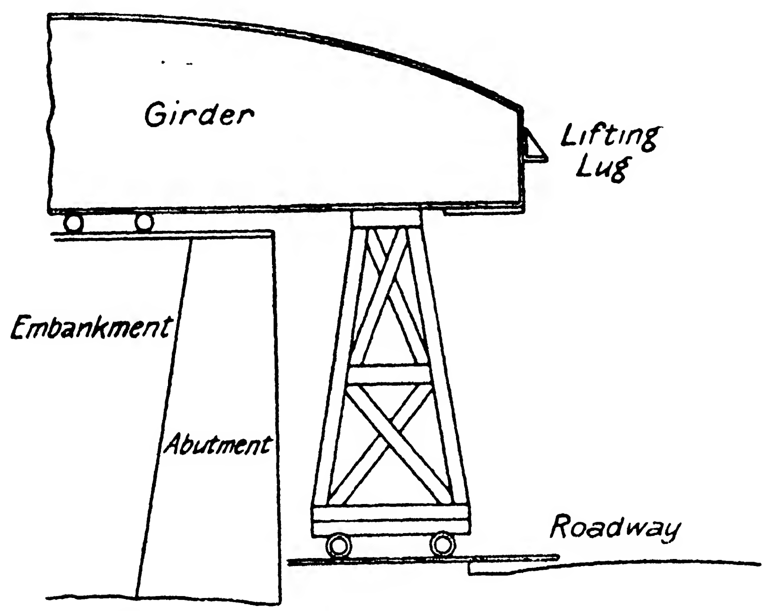


FIG. 69.—One method of Spanning a Roadway.

being built in a day. Well that is how it is done, but it is a long day, usually extending from Saturday night until the early hours of Monday morning; and it matters not what the weather is, the job must go ahead.

In cases of replacement, the method of erection depends upon the design of the bridge. Should it not be possible to build one half at a time, or to have the line closed long enough to assemble the bridge on its abutments, then the whole span is erected on a gantry at the side of the existing bridge, special runners being placed near each bearing of the main girders so that the whole bridge can be rolled into position. When all is ready on the appointed day, the two cranes are

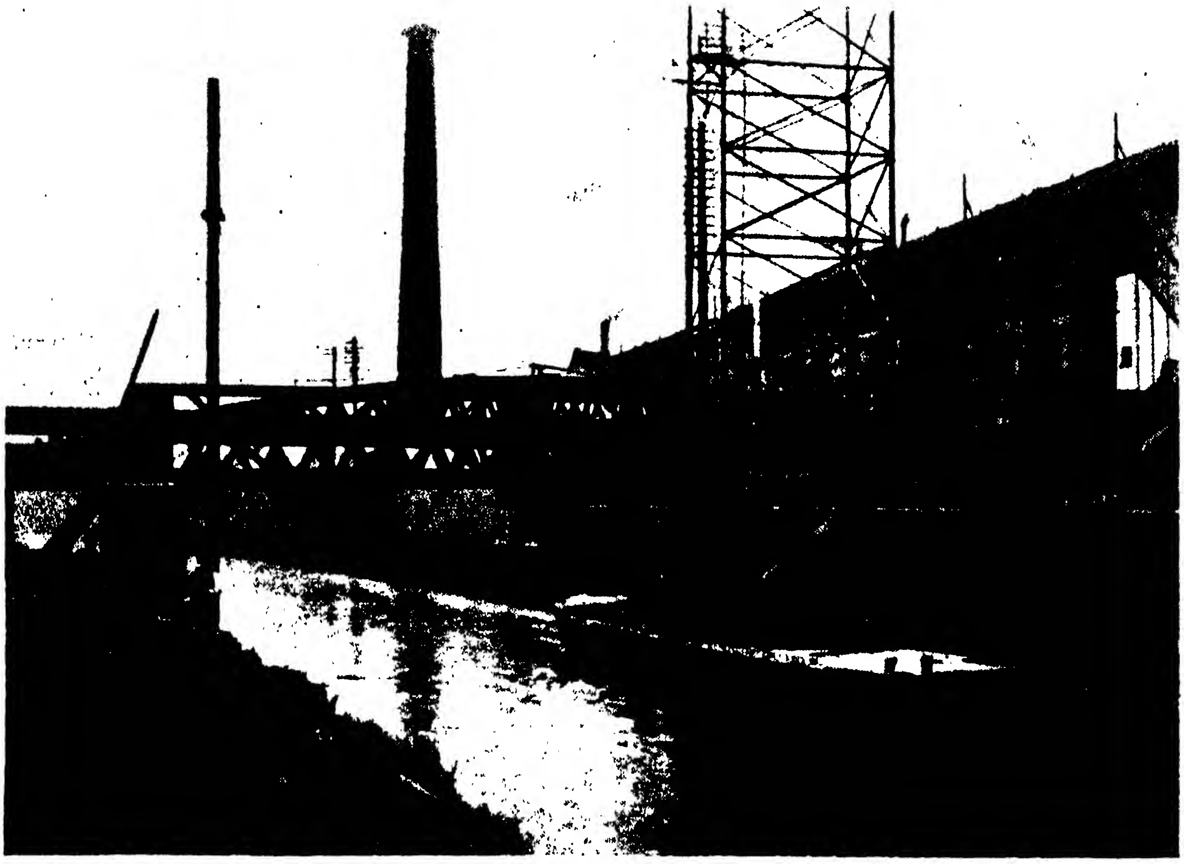


FIG. 70.—Bridging a Waterway.

FIG. 71.—Bridging a Waterway.

placed as seen in the photograph, the old bridge is dismantled piecemeal, and the new one rolled into place. Previously, of course, the masons have been at work preparing the abutments ready to receive the new bridge; when the latter is over the bearings it is lowered by hydraulic jacks fixed under special brackets on each end plate on to its seatings. In a very few minutes after the new bridge is drawn in, the permanent way is taking shape, as the platelaying squad are standing by ready to connect the lines again.

The photograph (Fig. 68) is of a road bridge built on a gantry, as previously described, the road being kept open for the traffic meanwhile. The special lifting brackets may be seen on the end plate of the girders.

Spanning a Roadway.—Bridge erecting on new roads or railway lines offer different conditions, but it must not be imagined that an extended time may be taken over the job, because the contractors forge ahead and are usually waiting to get across the new span. One method of bridging a main road with huge plated girders is shown in sketch (Fig. 69.) The line in this case was on an embankment, and across the roadway below a short piece of track was laid. On the latter a trolley with a long trestle superstructure took one end of each girder across—the track being laid in parts as needed—so that the roadway was not closed for one moment. A powerful hydraulic jack did the pushing from the other end of the girder, whilst a wire hauser and winch assisted from the opposite abutment. After the two main girders were in position the cross girders were inserted—commencement being made at one end—and the track was laid temporarily upon these, so that nothing had to be done from below.

Bridging a Water Way.—A similar idea to the one previously described is adopted when spanning a narrow waterway. The two photographs (Figs. 70 and 71) are of a bridge also built and erected by De Bergue & Co., Ltd. As in the previous case, the method is: the girders are first unloaded on the bank, each in turn is rolled, end on, until a goodly portion overhangs the barge, and then they are conveyed across. The rope blocks, by which one is being pulled across, can be seen on the towing path. The two derricks are also to be seen; these are used to upturn the girders when landed. The side view shows the barge with the trestle upon it, and the girder within reach of the landing tackle, which will place it on the piers, also to be seen in the photograph; the latter also conveys a good general impression of the way the work is done and the preparation necessary. This is a small job, but one that an erector unaccustomed to the work might some day have to tackle.

In General.—In bridge building every situation has to be considered independently, for rarely are two jobs alike; while the bridge contractors are responsible only for the bridge itself in most cases, there is always a council of experts in the background arranging for the carrying out of the various parts of the work as they are required—for example, foundations, steelwork, approaches, accommodation of traffic, etc. In the case of road bridges, too, provision has to be made for gas and water mains, and electricity and telegraph cables. If the bridge job is to be completed in quick time all these points want careful attention, both before commencement and while the work is going on.

CHAPTER XVII

STEEL CHIMNEYS

Built up Stacks.—The erecting engineer must not make up his mind that such an unusual job as the building of a steel chimney will never come his way ; it may do, and although it is an uncommon occurrence, there may come a time when one or two steel stacks are included in some contract with which he is connected. There are chimney jacks in existence, but those fellows are more accustomed to brick chimneys and steeples than to erecting steel stacks, the latter usually being done by structural erectors.

Of late years the steel stack has—to a very great extent—displaced the familiar brick chimney, although some of the steel ones are lined with a course of brickwork for a part of the way up. The very tall stack is the exception rather than the rule now, because our modern methods of inducing draughts by means of fans placed in the flues give the equivalent of the natural draughts, together with a better control of combustion. The plates are not of great weight, and the rounds vary in thickness, thus the first round to be fixed may be of $\frac{1}{2}$ in. plating, and the top round of $\frac{3}{16}$ which is all to the advantage of the builders, for the higher they get the lighter the plates are to handle.

Erecting.—The photograph (Fig. 72) is of a steel chimney, one of two being erected over a boiler plant. The caps were 120 ft. above ground level, which is perhaps the maximum height for such steel stacks. When a start is made to build one a light long derrick, or for preference a Scotch jib crane if one is at hand, is most useful for the bottom rounds, as in addition to the fixing of several rounds this affords a means of bringing the bent plates to the base ready for hoisting. By having hoisting tackle on the ground, the man below can usually get the plates to the chimney base ready for the erectors' blocks without calling for assistance.

A Plate-lifter.—Head room for the top tackle is very precious. A simple way of lifting the plates quite plumb with foreshortened tackle is by fixing a temporary angle iron lifting bar, as shown in Fig. 73. This should be supplied by the works and dispatched with the plates. The angle is bolted to two cleats as shown, and has a small eye-bolt in the centre. It also forms a stretcher-bar to hold the curved plate at its correct sweep, which makes landing so much easier than if some springing of the plate has to be done up aloft. If more head room is required than this angle affords with two short cleats, the latter may be substituted by deeper ones.

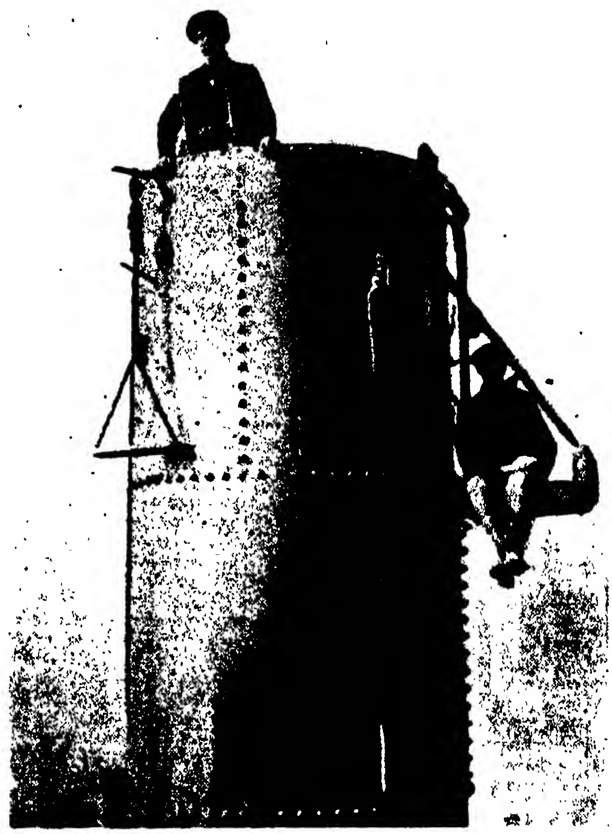


FIG. 72.—Steel Chimney Erection.

The Cage.—The outside scaffold consists of a cage which is reached by means of a bosun's chair, the latter being seen on the left of the chimney in Fig. 72. The framework of the cage is of light section angle iron braced with light flat bars for rigidity. The back, which is curved, has two grooved wheels attached to the uprights ; these grooved wheels, which are about 4 in. diameter, travel along the top edge of the plated rounds.

To keep the bottom of the cage from exerting friction against the side of the chimney, two small rollers or wheels are fixed horizontally near the deck. With a podger or a drift inserted in one of the rivet holes, the man on the cage propels himself along quite easily.

The Chair.—The bosun's chair is a plain bit of batten securely fixed (by nails) to a non-slip loop on the rope—the non-slip knot is described in that section of the book dealing with knots—the whole being suspended from a stiffly made gallows with an eye bolt for the single sheave block, as shown

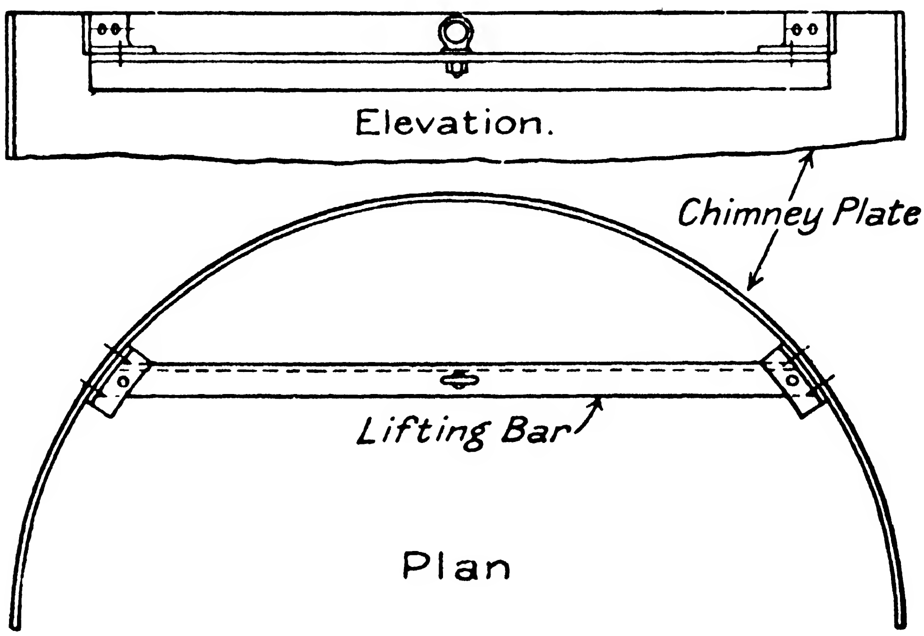


FIG. 73.—A Lifting-Bar for Curved Plates.

in Fig. 74. The gallows is made slightly acute at the bend; this gives it a better appearance than if made square, because on the thinner plates the drop is excessive by reason of the clearance in the jaw. A wire hook can be seen near the non-slip knot in Fig. 72, the ring of the hook being threaded on as the knot is being formed. This hook is for hoisting small articles, and bags of bolts and rivets.

The Inside Staging.—Around the circumferential joints inside the chimney angle iron rings (in parts) are fixed as shelves to support the brickwork, and on these the stage is laid for the erectors to work. Should the chimney be an unlined one there will be no angle iron rings to fix; in such a case four cleats and two angle iron bearers (in duplicate) will be needed to carry the stage. A short derrick pole, light and stiff, stands on the stage and is guyed to the lower rounds, or clamped to the plates.

With a light tackle on the pole each bent plate, which in the case illustrated in the photograph forms half the round, is hoisted up from below either by hand or winch, according to the weight of the plate, and landed into position. The plate is first tacked at the extremities with bolts which can be reached by hand from the inside stage, and supported at the centre by drifts placed in the rivet holes. The cage is then slung up by the tackle on to this half round; the bolting up can then be completed right away.

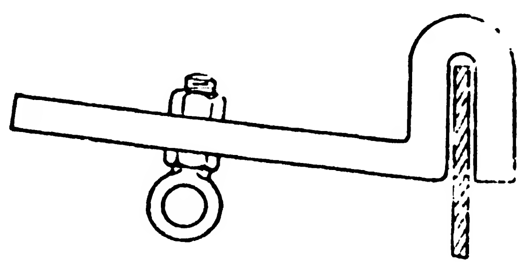


FIG. 74.
Gallows for a Pulley-Block.

Riveting.—The riveting is done from the inside where the forge stands on the staging. As the rivets are heated they are handed over to the holder-up, who sits on the cage, as seen in the photograph, with the dolly suspended above his knees. The dolly is suspended for two reasons, one is to support the weight of it, and the other is to keep it captive. When riveting the vertical seam the holder-up stands in the cage and inserts rivets up to about three or four holes from the top; these holes are left free always when assembling rounds, as by doing so the registration of the holes in the next joints is facilitated. It may be mentioned that the latter practice is adopted for the assembling of all classes of cylindrical plating.

Capping.—After the last round is fixed in position the cap ring, which is usually in two or more parts, finishes the erection of the stack. One half of the ring is bolted on and then the cage is lowered to the ground. The bosun's chair has to be transferred from the gallows to one of the eye bolts which are attached to the cap ring; or, for preference, used inside the stack—if this is possible—by being suspended from a putlog laid across the cap ring. The ring is then completed from the inside scaffold.

Completion.—It is more than probable that an iron ladder is to be attached to the stack ; the fixing of this is the next step, afterwards there remains all the tackle to be removed. The forge is lowered to the ground by the block tackle while it is still attached to the small derrick, after which everything else, men included, are lowered by a single sheave, or snatch-block, and rope. The removal of the last members of the scaffold is effected by attaching scaffold cords to these, a man then hauling them out from the ladder. On a chimney which has no ladder the task of clearing away the staging is for the coolest member of the squad, for this has to be done as the man sits astride the cap ring. After he has cleared away all he calmly awaits the return of the chair and into this he scrambles to be lowered to earth again.

Safety-belts.—There are safety-belts made of stout leather, with hip slings of rope or chain to which the attached snap links. These are available for all climbers, but the latter usually prefer to be without them, as the dangling slings seem very much in the way, also the trouble to fasten and unfasten them is usually more than the men will tolerate.

Stacks Without Ladders.—It has been mentioned that eye-bolts are fixed to the cap ring. These are for painters' use when coating the stack, which has to be done at intervals. If there is no ladder to the stack, then a single sheave pulley block with a rope threaded must be left hanging. The latter is really quite enough without a ladder, but the trouble occurs by neglecting this tackle, as usually no attention is given until it is needed for use ; then men find it unsafe and will not ascend with it. It becomes a costly job then to reach the top.

Ladders.—Of course a steel chimney should have a ladder attached, and the only probable cause of exclusion that one can imagine is by omitting it from the specification.

Naturally the suppliers will not include one if no mention is made of it in the tender.

No ladder is used on the outside of the stack during erection, as one would be more of an hindrance by fouling the ascending plates than a help. The short ladder to be seen in the photograph, projecting from the stack, is for the use of the erectors to reach the inside staging. Most steel stacks have permanent vertical ladders bolted to the plates, and as these are usually of stock lengths, say 16 ft. or more, it will be found most expedient to fix them after the plates are all in position.

When the means of ascent is by independent rungs riveted to the plates, as shown in Fig. 75, the rungs must be fixed as the stack is built up. This form of ladder is not adopted by experienced chimney makers as it is more costly to make, more trouble to fix, and is not of sound design. There can be no doubt about these independent rungs being quite secure for years after being fixed, but should rapid corrosion attack the thinner plates of the chimney the rungs would be unsafe. Apart from the initial cost, probably the fact that the men who have to scale the chimneys do not like this form of ladder has a greater influence; some of them can tell of harrowing moments when a foot has slipped over the end of a rung.

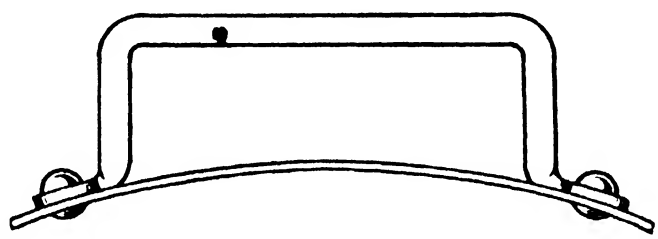


FIG. 75.—Forged Ladder-Rung.

Dismantling.—The building of steel stacks is far simpler than taking them down, although the method is the same. A larger cage is required, as the rivets being knobbed on the inside have to be cut off from the outside.

Small Diameter Stacks.—The rearing of steel chimneys of small diameters, which are riveted up before erection, is accomplished with a derrick pole. The latter must be strong and have heavy back guys to allow for the necessary sheer, owing to the bulky nature of the lift. It depends upon the height as to whether the chimney will be in one piece or two. A one-piece, or the lower part of a two-piece stack, will present no difficulty, but when it comes to the upper part of the latter some manœuvring has to be done. It would not be a difficult problem if the top part could be lifted from the top ring and simply dumped on to the lower part, but this cannot be done on tall chimneys, and so the sling has to be hitched just above the half-weight line. This throws the part a little out of plumb when hoisted, but guys are attached to the top and bottom of the part, and when the connecting ring is above its fellow one the erector climbs the ladder and secures them with a couple of bolts. The top of the stack is then thrown over into the vertical position by sheering the pole over, also with assistance on the effective guy as the load is lowered off.

CHAPTER XVIII

BOILER FIXING

Lancashire Boilers.—The transport and the fixing of Lancashire boilers is usually allocated to men accustomed to the handling of these unwieldy monsters, as special tackle is required. A brief description of how it is done will be of interest, if nothing more, to the reader. The tackle consists of a strongly built bogie, heavy baulks, four trestles (usually sections from an old flue of a Lancashire boiler), hydraulic jacks, and haulage gear for either hand or power. As a 32 ft. boiler weighs at least as many tons as it is feet in length, it follows that it needs skilled men to handle it, yet the ingenious erector need never hesitate to tackle one with proper outfit.

Haulage.—The photograph (Fig. 76) is of a boiler being hauled into position through a gateway that is only two inches wider than the boiler front. The fixing squad is seen, five men as a rule being sufficient for the purpose. The boiler has been hauled to the site by the tractor, and the latter is shown lowering it into the fire hole by means of a steel hawser, which can be observed behind the foreman who has his hand upon it. The next photograph (Fig. 77) is of the back end of the boiler. The state of the brickwork for the flues is here seen sufficiently advanced to receive the boiler; in the centre is the bottom return flue, and the spot where the foreman stands is on one of the side flues.

Tackle and Method.—When the boiler is brought along, whether by road or rail, it is first taken off its bogie

FIG. 76.—Placing a Lancashire Boiler. Front End.

FIG. 77.—Placing a Lancashire Boiler. Back End.

and lowered on to special trolleys. Each trolley is composed of a pair of strong heavy cast wheels and an axle about 5 in. square—nothing more, and these trolleys can be skewed beneath the boiler to force the latter to alter its direction while travelling along. If that is insufficient to meet the conditions, the hydraulic jack is fixed under a rivet head at one side, whilst opposed to it, in resistance to the rolling motion, a strong sprag or a piece of piping is placed, as shown in the sketch, (Fig. 78); the effect is to skid the boiler and the trolley too at that one end. A number of discs made from $\frac{3}{8}$ in. or $\frac{1}{2}$ in. steel plate are part of the equipment. The plates are

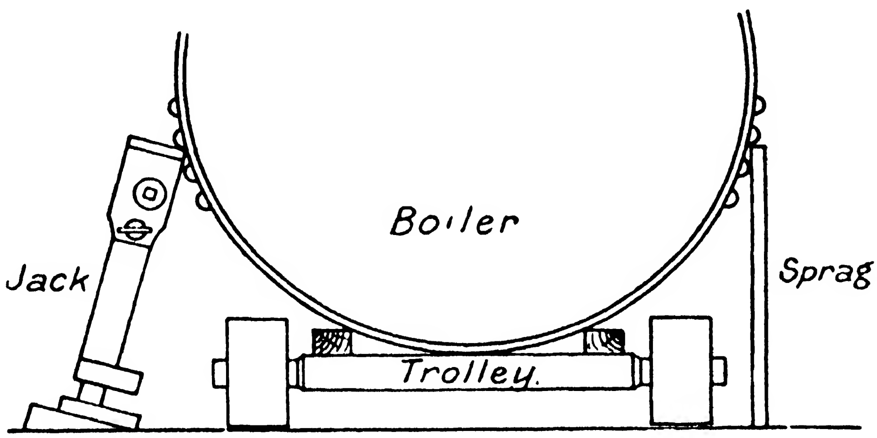


FIG. 78.—Method of Sluing a Lancashire Boiler.

about 2 ft. in diameter, and are cut circular for convenience in handling, for they can be so easily bowled along by one man as the track is needed forward, and being short they are better for following the curve in the path. The discs are laid like tiles on a roof so that the wheels of the trolleys never have to step up as they roll along, and being circular they can be more easily stepped than rectangular plates. In the photograph (Fig. 79), some of the discs can be seen, also a clear idea of the method of trolleying may be gleaned. The comparative sizes of boiler and men is well emphasised in this illustration; it is truly remarkable how soon such a small squad of men haul the giant into its place. Two hydraulic jacks, one rear and one forward, are customary, one man to each, with a little assistance on the pump lever during the heavy part. The mates attend to the track as the foreman walks around lending a hand here or there as needed. The tractor displaces the heavy winch, or other means that would be required if the former were not there, for being on the incline no liberty is allowed the boiler without an efficient control; if once it started to move there would be no arresting it until much damage was done.

Fixing.—The boiler is taken along the heavy baulks that form a bridge over the fire hole and on to its setting.

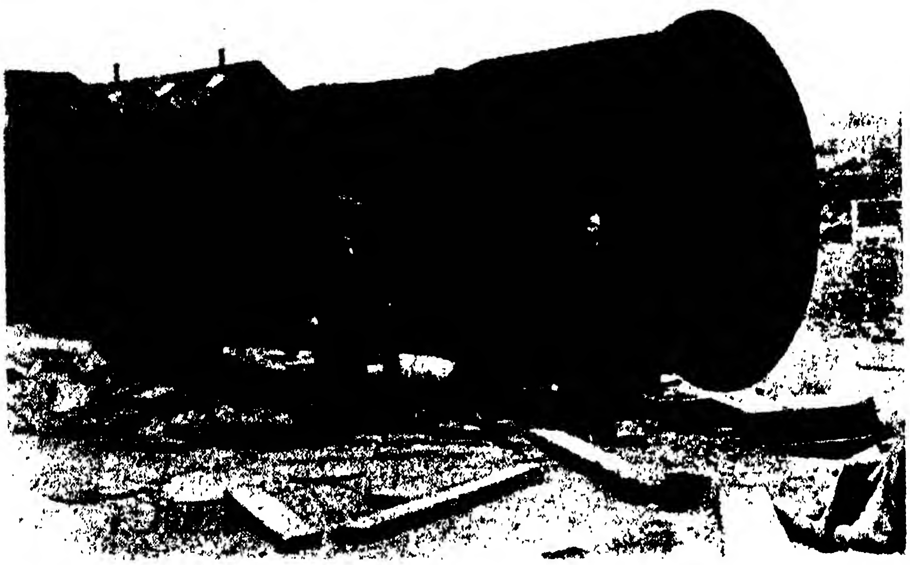


FIG. 79.—The Boiler and Some Tackle.

Then it is lowered into position and supported on temporary packers, which are capable of being withdrawn after the seating blocks are placed without disturbing anything at all. The boiler is set slightly inclined towards the fire hole, at an angle of about 1 in. in 20 ft.; this is to allow the water to drain towards the blow-off cock which is situated at the front end of the boiler, the connecting block of which can be seen in Fig. 79 near the ground.

Situations.—This is a typical boiler-fixing job, for it always seems that Lancashire boilers are to be placed in the most awkwardly designed situations. There are many simpler instances—one of which is where the boiler can be rolled broadside right from the railway wagon on to its setting, and in such a case the special trolleys would not be required.

Again, a boiler can be transported on rollers instead of trolleys, but these would need to be of ample diameter and of good wood. The haulage can be assisted with chain-blocks, or wire rope tackle and crowbars, care being taken in the scotching to prevent the boiler from rolling over sideways.

Other Boilers.—Regarding such boilers as those employed in conjunction with mechanical stokers, for the rapid conversion of water into steam, the subject contains far too much for this book. To deal with all the different types of water tube boilers, mechanical stokers, economisers, draught fans, etc., would need a volume devoted entirely to plant appertaining to steam generation.

The fixing of a Lancashire boiler has been selected because the traffic in this type is an everyday occurrence. There are numerous books dealing with all that applies to the arrangement, including all brickwork and flue settings for Lancashire boilers, except the method of handling the boiler itself, hence this small chapter.

Small Boilers.—The method of handling such boilers as the portable vertical type is similar to that of handling vessels or other lumpy articles—that is, by means of sheer legs or a set of three-legs.

CHAPTER XIX

FIXING A CIRCULATOR

The Hotchkiss Circulator.—It is a rare instance for an erecting engineer to be asked to undertake the fixing of a Hotchkiss circulator to a Lancashire boiler, but such an instance once came to the author's knowledge. It may be that some readers have never heard of this appliance, so for their benefit a brief account of it and its functions is here included.

The Hotchkiss—as it is called for short—is a vessel of globular form fitted to a Lancashire boiler for the purposes of circulating the water and removing the mud and scum, thereby preventing scale from forming on the boiler plates. The diagram (Fig. 80) will convey a clear conception of the arrangement. It will be noted that a funnel dips to the water line; the water rises up the pipe attached to this and the circulator and collects the scum from the surface in doing so. As the latter mixture passes through the body of the circulator it strikes the baffle-plate, and the mud is precipitated. The return pipe takes the water right to the bottom of the boiler, as may be observed.

Fixing.—The vessel is fixed as shown and the position is somewhere near the centre line of the boiler—as near as the top gusset will allow. The body of the vessel hangs plumb, but the pipes are cranked slightly to pass the flue or flues as the case may be. The centres of the flow and return pipes on the boiler are first obtained, and the two holes for these are burned out or cut with a cross-cut chisel.

The holes for the flanges are next marked out and drilled, the drill stand being clamped for the purpose to one of the larger hole. The holes, being on curved plates, must be very carefully drilled to make tight joints. It may be mentioned that one engineer when fixing these vessels, always tapped the holes in the shell for set-screws, thus securing the pipes inside the boiler before the outer ones were attached. The

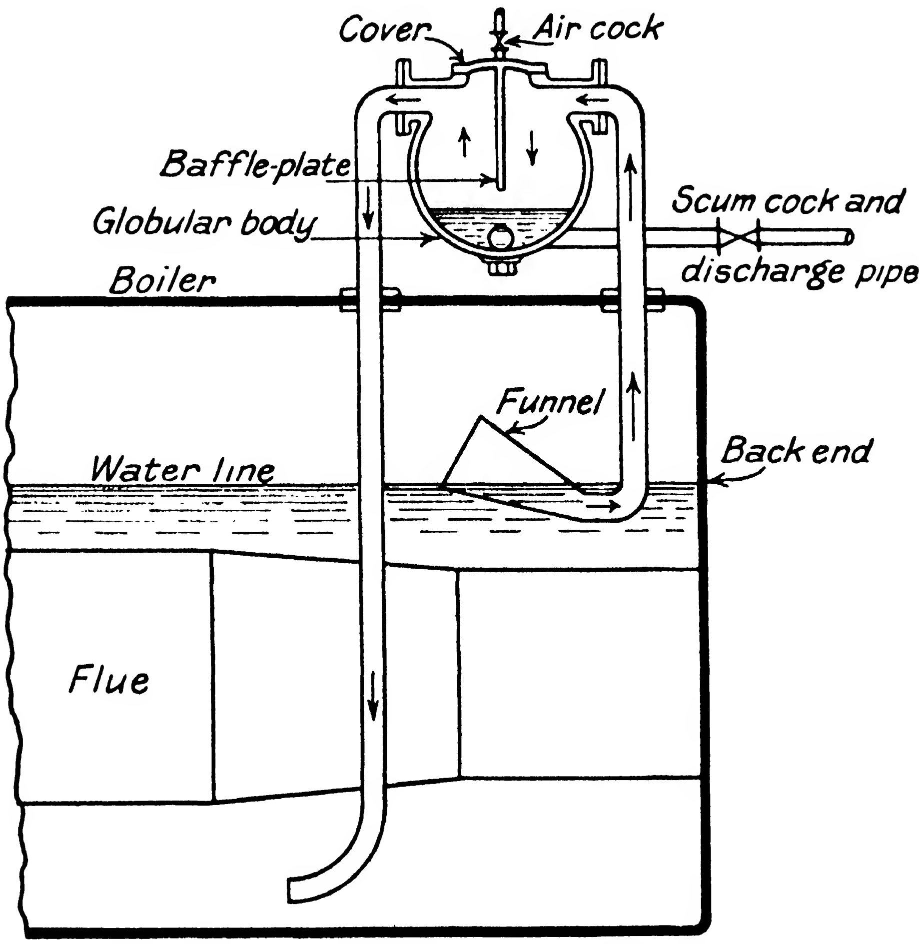


FIG. 80.—Diagram of the Hotchkiss Circulator.

hint is given for what it is worth, but the method never failed to produce sound joints, whilst the fixing was somewhat simplified thereby.

The vessel is attached to the two outer pipes—the joints being made before the connections to the boiler, as the two outer pipes support the vessel. There remains the mud discharge pipe to fix and to carry along to some convenient point where the filth can be collected.

Working.—The cover, to which the baffle plate and air cock are attached, is removed and the vessel filled with water ; the cover is then replaced and the joint made. Circulation commences with a slight rise in temperature, and will continue all the time the boiler is at work, and afterwards until the water is nearly cold. The mud discharge cock is opened periodically—say every two, four, or six hours, according to the condition of the feed water. The air cock at the top is for freeing the vessel from air, also as a blow-off for the accumulation of grease, should there be any. In the latter case, the pipe from the air cock should be connected into the mud discharge pipe.

Advantages.—It is claimed for this circulator that it improves the working conditions of the boiler to which it is fitted by preventing unequal expansion of the boiler plates and tubes at the time of lighting the fires, by quickly raising the temperature of the water below the tubes as well as above them, and by collecting and removing mud and grease which rapidly form scale. Thus fuel is saved, which is an item to be carefully considered in steam raising plants.

CHAPTER XX

ACCUMULATOR ERECTING

The Stalk.—The rearing of the cylinder which contains the ram is a case for stout sheer legs or a tripod and chain-blocks, with a couple of greased metal skids for the base to follow along as the top goes up. When erect and in position the stalk must be held upright in the tackle until secure to the base block by the holding-down bolts. The base plate of an accumulator cylinder is comparatively small in area and, whilst the stalk—which is somewhat top-heavy—may remain upright on its base, a very little bump will topple it over unless it is secured.

The Tank.—Accumulators which have ballast tanks present a little more trouble than those weighted with cast iron plates. The latter call for no special mention as the plates are in halves, and so may easily be fixed. Ballast tanks which are to contain some tons of scrap metal or other weighty material must be strongly constructed, therefore they are often more weighty than they look. A tank of say 9 ft. diameter by about 10 ft. deep will weigh perhaps three or four tons; the weight must be known when selecting the tackle.

Erecting.—One derrick pole only for lifting bulky articles is a gross failure, as may be readily understood, and when such lifts need hoisting to a comparatively great height, the sheer legs are also impossible, so recourse has to be made to two sets of lifting tackle. In the diagrams (Figs. 81 and 82) the method of tackling a bulky tank for an accumulator is illustrated, Fig. 81 showing the front view, where the two derricks are to be seen by the side of the tank which is standing in front of the stalk. The side elevation (Fig. 82) makes the method quite clear.

The tank has to be hoisted above the ram which projects from the cylinder, and as the sheer is considerable this must be taken into consideration when calculating the head-room required.

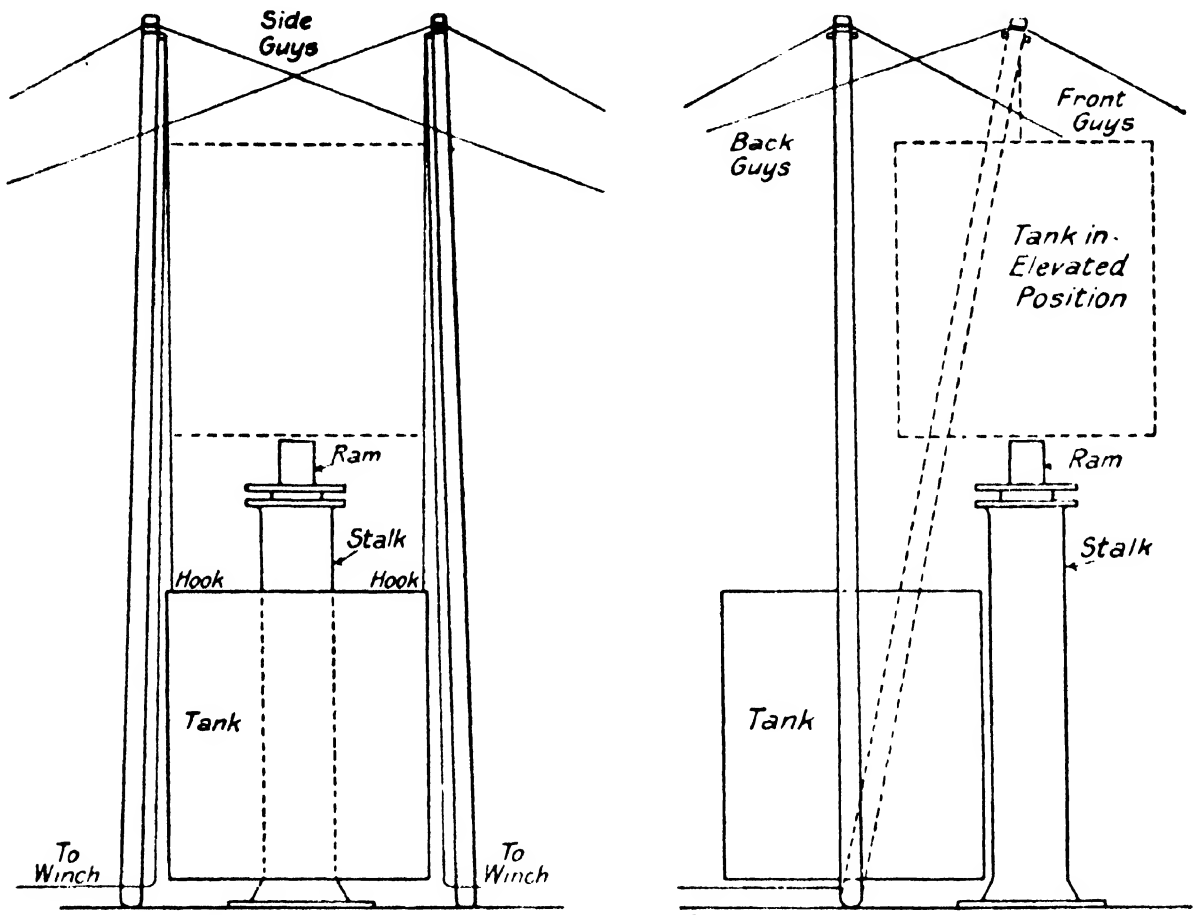


FIG. 81.—Front View. FIG. 82.—Side View.

Erecting an Accumulator Tank.

Sheering.—When a weighty tank is to be sheered the backs guys must be strong, and preferably should be attached to block-tackles, as by this method the sheering can be done so very finely. Without blocks on the back guys the outward sheer can be safely accomplished by a skilled man, but as the tube that surrounds the stalk has little clearance to pass the gland casting, great care must be taken not to allow the tank to go too far, or some difficulty will be experienced in hauling it back.

The tank may have some stays inside to which the tackle can be attached for lifting, but should there be no such means, then some holes should be drilled in the shell for a couple of strong shackles. This arrangement gives the shortest possible tackling, which means the greatest head-room. When the lifting appliances are finely arranged little difficulty will be encountered in landing the tank over the stalk.

The tank has to be lowered right down so that the suspension rods and the cap can be fixed in position, as the ram will be standing at the lowest point. Should there be a hand-test pump available—powerful enough to lift the ram, then the tank may advantageously be packed up sufficiently high for the men to work comfortably underneath it to fix the stays, and to make the joints for the pipes.

As soon as the tank is landed the tackle may be disbanded.

CHAPTER XXI

UNLOADING HEAVY VESSELS: TRANSFERRING A LIFT

THE unloading of large weighty vessels such that are common in chemical factories may call for some ingenuity on the part of the individual responsible for their erection. If it should be that a crane is established for the specific purpose then there is no problem to tackle. It is the custom with chemical manufacturers to stock spare vessels, owing to the rapid depreciation caused by the acid processes. These spares are usually unloaded and put aside out of the way.

When there is a crane that can be brought over the track good use can be made of it, even though its capacity is insufficient to lift the vessel.

The first step towards unloading, assuming that the crane be too light to lift the total weight, is to erect a stallage at the side of the track on to which the vessel can be rolled. This structure may be firmly built of sleepers or baulks, or of R.S.J.s, whichever are to hand. The intervening space between the truck and the stallage must be bridged across so that the rolling path is continuous.

As a rule the outlets on the bottom of the flat bottomed vessels make the rolling motion anything but straightforward, and it becomes necessary to use the lifting tackle, whether it consists of a crane or a jack, to pitch the rollers as the occasion demands.

There is a type of vessel largely used in chemical works which requires a little more ingenuity to remove from the truck to the stand, or to the cradle as the case may be when a sufficiently powerful crane is not available. The type referred to have dished bottoms. It was the author's experience to have many of these to unload with a "5 tons" jib crane, and as the vessels were more than eight tons each a straight lift was impossible.

The method employed to remove these awkwardly shaped vessels is well worth recording, as it was done so quickly and

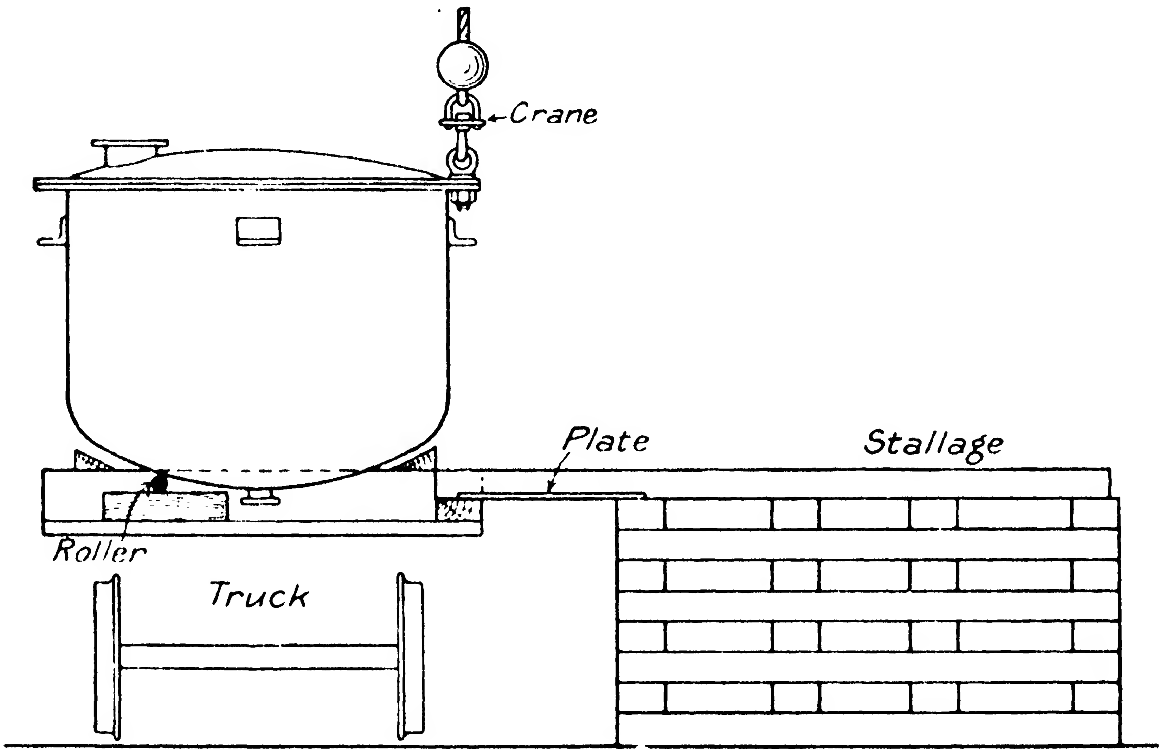


FIG. 83—Unloading a Dished-bottomed Vessel.

so simply. They were, of course, transported to the works resting on two bolsters and scotched by side baulks. The truck was drawn alongside the erected stallage, and the bridge across the gap was formed by two crossing sleepers. The side scotches were removed, and smaller scotches were substituted. At the far side, as shown in Fig. 83, a block of suitable height was placed between the two bolsters on the truck, and on this a short solid roller 2 in. in diameter was laid. The hook of the crane, was attached by means of an eye-bolt to the front side, and by gently hoisting up, the crane driver was able to propel the vessel forward towards the stallage; as he lowered off and the vessel righted itself, the block and the roller were adjusted. The action of tilting the vessel backwards brought the weight of it on to the roller and caused the forward movement by the inclination of the

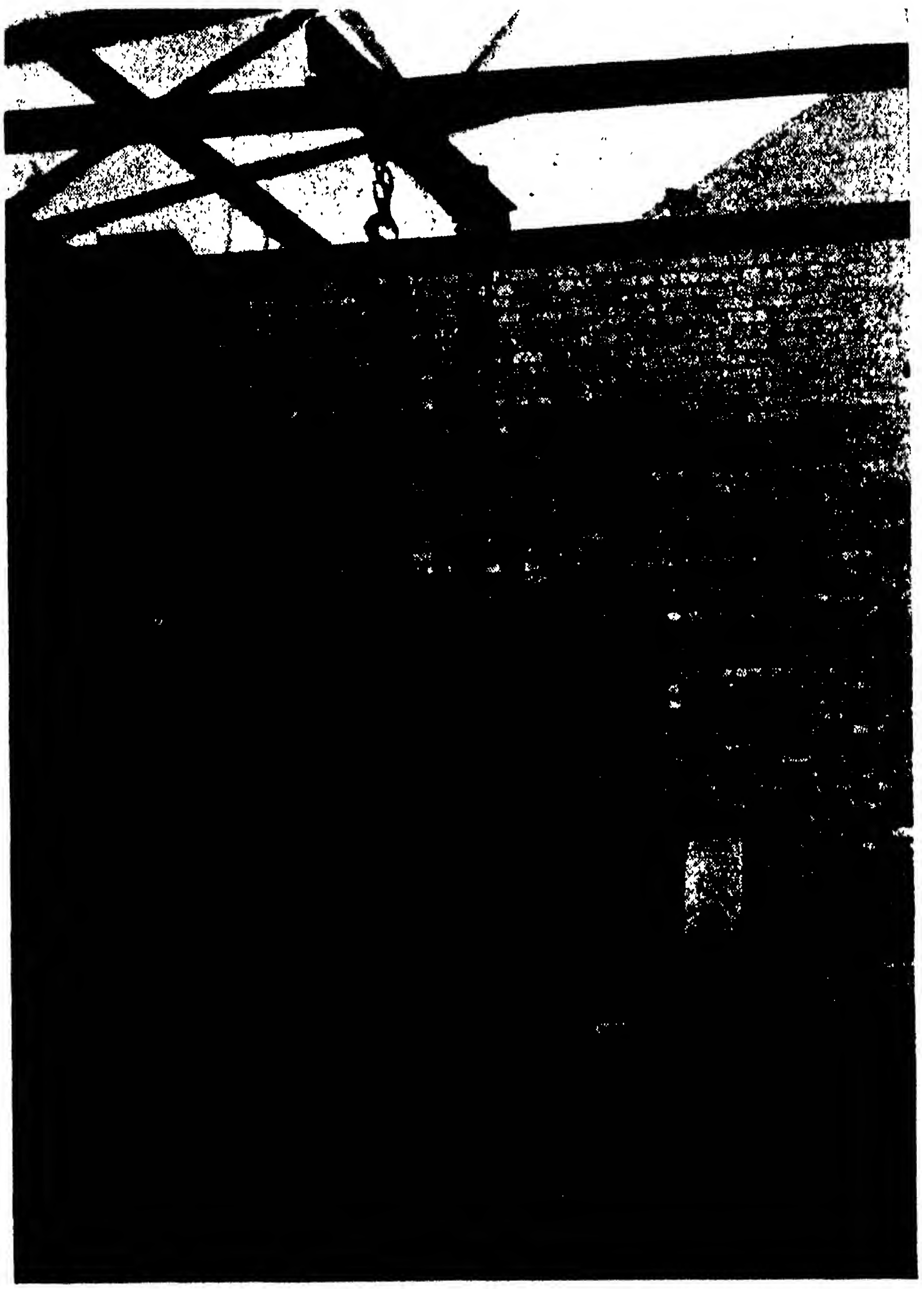


Fig. 84.—Method of Transferring a Lift.

bottom. A very slight tilt was sufficient to produce a foot of travel, a fact that may be easily verified by a glance at the sketch. The plate shown is for a continuation of the path for the roller. It would be an exaggeration to say that the forward motion of the vessel was continuous, but there is little doubt that it was nearly so.

The lowering of the vessel on to the cradle was accomplished with the same crane by taking advantage of the tilting idea. Eyebolts were placed on opposite sides of the cover, and the hook slung from one to the other as each side was lowered a little. The employment of jacks on such a vessel is an awkward and unsafe business, unless the most elaborate arrangements are devised to ensure absolute security. As previously stated, the erector's ingenuity is constantly being requisitioned, therefore the knowledge of this method of unloading vessels may suggest a means of application in some other form.

Transferring a Lift.—For the purpose of this book engine-building is not classed as erection work, as all engine-houses have lifting appliances, which are usually installed previously to the engine.

The illustration (Fig. 84) is mainly to show a method of transferring a lift which has been hoisted from the ground to its permanent position. As will be seen, two girders are placed above from wall to wall, and on these rests a lifting beam. Two sets of chain-blocks are employed—one to pick the load vertically from the ground; the other, which is directly over the centre of the bed, is to take it when hoisted well above the required height.

Should one set of chain-blocks only be available a similar method is adopted, but each part will need lowering on to a securely built stallage while the chain-blocks are moved; the part is then transferred—probably by short stages—directly over the centre.

The latter method is also employed when erecting such plant with the aid of a tripod, but with either means—the beam or the tripod—the transferring should be done in short stages, as only very little drag is permissible with such lifting tackle.

CHAPTER XXII

TOOLS AND TACKLE: LABOUR CLAUSES: BUYING

Tools and Tackle List.—An engineer or a young erector who is suddenly called upon to take charge of the erection or dismantling of some work may be asked to compile a list of the tools and tackle which he will require. The list included herein will assist him in selection, but his list may want augmenting with some additional tools, according to the nature of the job. The list given here can be taken as comprehensive of the tools and tackle commonly employed on erection work.

For Derrick Use.	*For General Use.*	
Pole.	Chain-blocks.	Hand-hammer.
Winch.	Jacks.	Chisel.
Rope-blocks.	Scaffold battens.	Spanners.
Rope (for blocks).	,, cords.	Drifts.
Ropes (for guys).	Slings.	Pinch-bars.
Snatch-blocks.	Rollers.	Plumb-bob.
Stakes.	Shackle.	Level.
Sledge-hammer.	Eyebolt.	Scotch tape.
Crowbars	Turnbuckle.	Twine.
	Long bolts.	Nails (assorted)
Ladders.	Washers.	Hand line.
	Drilling tackle.	

Contract Clauses.—It may be that a clause in the contract specifies that the clients will supply all necessary tackle for the erection of the work, perhaps all labour, or all unskilled labour, too. These clauses affect the erecting engineer, so he must be acquainted with them before taking over the work. The author here points out to the uninitiated engineer what to expect, and what to do in such circumstances.

Regarding a contract for which all necessary tackle is to be supplied by clients, the erector when he reaches the site may be surprised at the absence of tackle, or at least at such tackle that is allocated to him. A statement is made elsewhere in this book which reads: "One cannot erect any class of plant without tackle, or with insufficient tackle, and it should not be attempted," therefore it behoves the erector to insist on having suitable and sufficient tackle for the job of which he has full responsibility.

The first question that the erecting engineer on arrival may be asked is: "What tackle do you need?" and he will be wise to have his list ready and complete. He must not make an error of judgment by asking for less than he will probably require. To ask for additional tackle after he has received that which he has previously requisitioned implies lack of experience, and no clients like to think they have an inexperienced engineer in charge of erection work when they are to be charged for a skilled one.

Such erection jobs as these in which the labour and tackle are supplied by the clients are not contracts. By that is meant that no price for erection has been fixed, but than an arrangement between the suppliers and their clients has been made whereby an experienced man shall supervise the erection of the job. For this man a fixed price per day, plus travelling expenses, is to be charged on completion of the job. From these remarks it will be understood that the erecting engineer is really working for the clients, and whilst it is the duty of the latter to facilitate erection, and as economically as possible, the full responsibility is upon the former. It is the duty of the erecting engineer to foster a spirit of good will between the firm he represents and the firm by whom he is temporarily engaged.

Nevertheless sufficient tackle must be insisted upon, and no ill-will need be anticipated in doing so, in fact such insistence would rather tend to create a feeling of assurance than ill-will.

Regarding the supply of small tools which it is intended should be included in with "tackle," there might be some difficulty in obtaining a useful collection of these. The simplest way to remedy this inconvenience is for the erecting engineer to approach his firm for a kit of these, together with a tool box in which to keep them.

The question of the clause relating to the supply of labour is one that calls for a few remarks, so that the erecting engineer will know what to expect. When the clause states that the clients will supply " all necessary labour to erect," it can be taken for granted they will allocate to the job the number of men, skilled and unskilled, that he requisitions. In other words, their own men will erect the work under the supervision of the hired engineer.

Should, however, the clause say that all necessary unskilled labour will be supplied, then the hired engineer may find himself saddled with a staff of raw brawny fellows who are of little use to him, except to form what is termed a heavy gang. In such circumstances the work of the erecting engineer might be quadrupled, inasmuch as he could not trust any one of his assistants to reeve a tackle, or to tie a knot, or to use a tool—if crowbars are excepted—he himself having personally to attend to all such important details, while his squad of helpers may be looking on. Still, a situation of this character need not be tolerated for long if the management of the firm are open to reason, for by acquainting them of the advantages to be gained in having some skilled assistance, it is most unlikely that the appeal would be ignored.

Buying.—Of late years one of the most harassing and time wasting duties of the engineer has been, and is, the buying of plant and sundries. It certainly is not wise to purchase many of the necessary articles from stock without first obtaining quotations from at least three sources of supply. To give one instance of the wisdom in this remark, mention is here made of an intended purchase of wire rope for guys.

Three firms were asked to quote, and their prices per 100 ft. were 27s., 38s. and 42s., respectively. This can immediately be ascribed to the unsettled state of affairs after the war, as those who bought last bought much the cheapest. Admittedly, the merchant is sorely perplexed in attempting to keep well acquainted with current prices, but the engineer is just as much embarrassed, for the question of costs is ever within his purview. There are occasions when he will spend more time on small purchases than they are worth, but this has to be balanced by what he can save on the larger articles.

The engineer, probably more so than any other buyer, has to be a veritable encyclopædia, for in every plant and sundry there are many makes and values; there are many factors to be considered, and the greatest of these is satisfaction to all the plant affects. One often hears the remark made that the heart of a works is in its engine. This is true enough and sounds very nice, but it is a specimen of unessential verbiage. The engineer is a very material matter-of-fact individual, and the rhetoric by which some salesmen are able to wax fat has to be rigorously cut out of his vocabulary. To keep himself acquainted with all the latest improvements and inventions the engineer must listen to what the salesman has to say, and to see what he has to offer, but proof is what he seeks for amongst flowery language.

The specification for a layout must be complete in every detail, and if the engineer is not qualified to make out this, or if he has not time to devote to detail work, the best thing to do is to choose a firm of repute, state his requirements, and put his trust in their reputation to uphold their goodwill.

Buyers for the engineering trades often rank ahead of the engineer in status, yet their very exalted positions depend upon others who know what engineering supplies are. When a buyer acts independently of the engineer the latter is saddled with a lot of useless material. Take a case which disgusted the author: in this, the buyer when asked to obtain block tin for solder, acquired tin-plate instead. The error was pointed out to him, and he actually was so ignorant as to suggest that the plates could be melted down. He thought tin-plate was pure tin.

CHAPTER XXIII

PIPE-WORK: PIPES

In General.—The extension of our chemical manufacturing industry, as well as the increased uses of energy in fluid form, have stirred up a branch of engineering that was, like iron moulding, considered of little importance but a few years ago. To-day every firm, large or small, finds that pipes and pipe-fittings are essential articles in the several departments; it cannot then be wondered at that the erecting engineer occasionally has to design and supervise the installation of services of no mean order. The draughting out in detail of schemes for pipe-work in some of the large chemical and other works is almost impossible; certainly it may take much more time to obtain particulars from site, and make the drawings to show all the necessary details, than it would to do the job. In circumstances like these the erecting engineer constructs the scheme in his own mind, then imparts the practical working instructions, assisted by sketches when needed, to his foreman pipe-fitter or whoever is in charge of that section.

On very large contracts the pipe-work is let to firms who specialise in this class of work, but on the smaller jobs the cost of importing skilled pipe-fitters is usually prohibitive. If the engineer-in-charge has the necessary practical knowledge he can get the pipe-work done by his mechanics, for all such men are more or less acquainted with small bore pipes and fittings for low pressure work, if not with the more important work.

With larger pipes that cannot possibly be bent and screwed on site, it becomes necessary to make sketches for ordering these out, or for the pipe contractors to send a draughtsman for that purpose. The author's experience in erecting pipes, both cast iron and wrought steel, that have been supplied by firms whose draughtsman took his own particulars, will not allow him to speak very highly in favour of that idea ; it is to be regretted that in a great percentage of the cases the pipes supplied were faulty and needed modifying or re-making ; in some instances the draughtsmen themselves could not explain how to fix the pipes they had sketched. This can be ascribed either to the difficulty of making drawings, or to the lack of practical knowledge. Whenever the practical man has assisted in taking dimensions, the usual errors from either cause have been absent, for the man who has the responsibility of fixing the pipes takes good care that, so far as he is concerned, there shall be no mistake. Fig. 85 illustrates a typical case in cast iron pipe-work.

It must be not imagined that a pipe-fitter who is accustomed to the smaller bores—as, for instance, the fitting of heating appliances, gas-pipes, etc.—can be left serenely with the pipe-fitting on such jobs as power plants, chemical works, and high pressure ranges. Such a pipe-fitter may be a greater failure than a mechanic who has had no experience with pipe-work, and who has to be instructed in the most elementary details. Contrary to the opinions of some people pipe-fitting is a trade, it is also hard work, and demands much skill ; in addition to that, a pipe-fitter who is worthy of the name must possess a knowledge of pipes, fittings, valves, cocks, jointings, clips, steam-traps, gauges, and a host of other fitments appertaining to the craft. He must also be acquainted with the various methods of construction for high and low pressures, and for liquors and gases, to say nothing of the jobs in cast iron pipes with flanged or socketed joints, that will most probably come his way. A good pipe-fitter is worth much, and yet seldom seems to be sure of his job because of the fluctuating nature of the trade.

The feeling of the uninitiated engineer upon introduction into this branch of the science is one of amazement at the illimitable list of unfamiliar terms, and at the host of fitments with the set purposes for which they have special application.

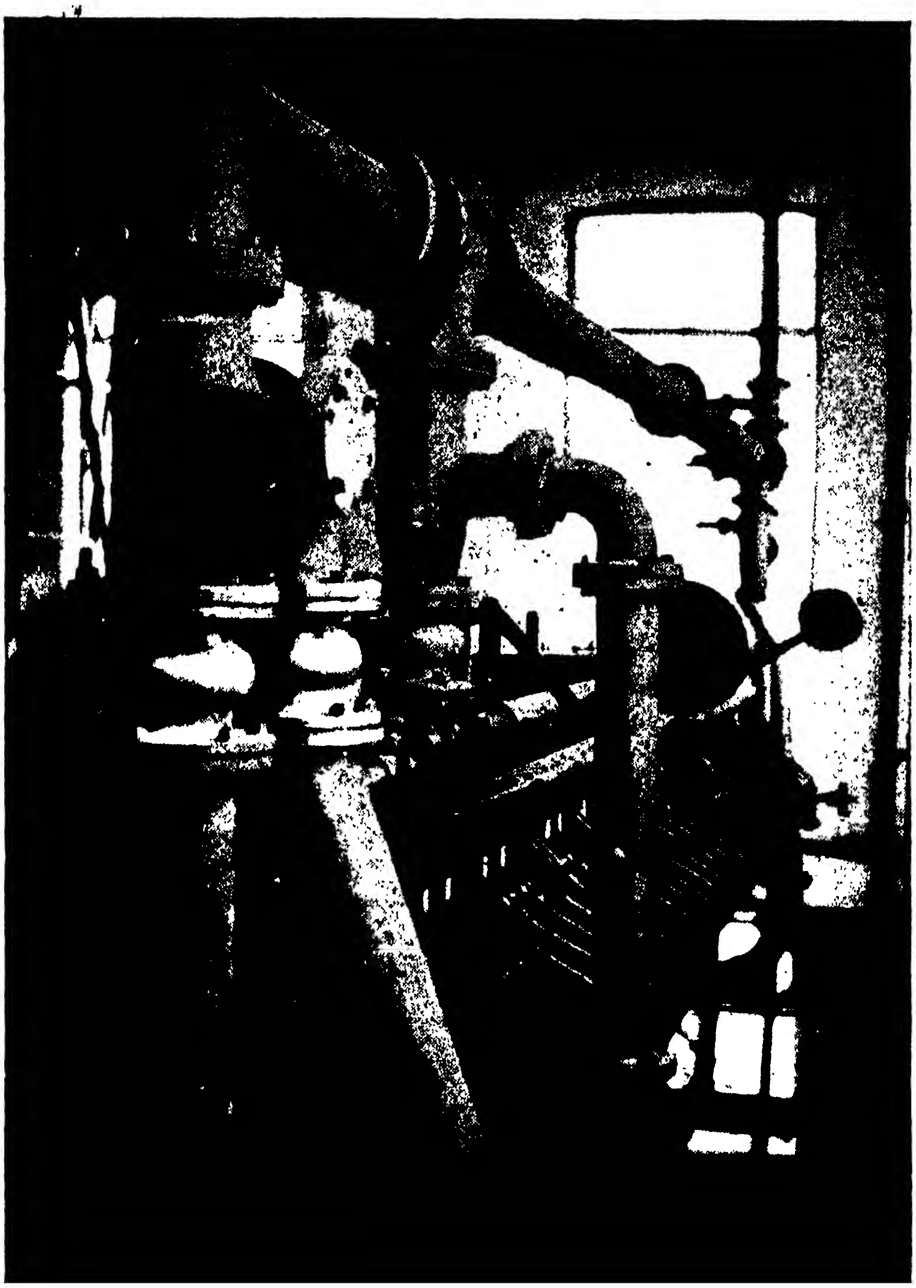


Fig. 85.—Typical Cast Iron Pipe-work.

He learns of red, blue, black and galvanized pipes; of Ts, Ys, Xs elbows, bends and offsets. He hears of valves described as Mac, globe, isolating, relief, stop-gate, check, foot, reducing, Y, blow-off, etc., and of cocks, plug, pet, bib, test, angle, glanded, two, three and four way, etc.; some screwed male or female; and some flanged and drilled to suit various standards, either on or off centres. We have only mentioned here just a few of the multitudinous parts that comprise the staggering range for the engineer's requirements in pipe-work. He may try to fathom the inner mysteries and meanings of these terms by wandering over the whole issue of published works and catalogues and yet not find enlightenment, for it is doubtful whether many could visualise the descriptions without some practical assistance. The subject is a large one and covers a wide range, but so far as space permits the various general terms, methods and practice will be dealt with here.

Steam Pipe.—Common wrought iron piping is made in several qualities, and each quality is painted by the makers to differentiate between them. The pipes that are painted red are primarily intended for fairly high pressures, and only the price prohibits their use for all purposes. They are mostly called steam pipes, and the smaller bores may be safely relied upon to withstand any pressure up to 2,000 lbs. per sq. in. But it must be steam pipe, not some cheap stuff that some get-rich-quick merchants have painted red to sell as steam pipes to buyers who try to save money by acquiring inferior goods. During the Great War when pipe was difficult to get the author adopted small bore steam pipe for some hydraulic press circuits ; this gave every satisfaction with pressures up to 2,500 lbs. per sq. in., and is probably still fulfilling the same duty to-day. It goes without saying that in normal times such practice would have been considered extremely foolish and risky, but risks had to be taken then. Nevertheless it proves conclusively the great pressure good steam pipe can sustain.

Water and Gas Pipe.—For lower pressures—up to say 100 lbs. per sq. in., the blue pipe is marketed. This class is often called water pipe, for it is mainly used for water and liquids of lower pressure than steam, and is of cheaper quality. Below this there is the black or gas pipe, unpainted and perhaps coated with boiled linseed oil. The latter piping is quite suitable for the very lowest pressures, and is mainly used for gas and for heating installations where the main factor is heat minus pressure. There is also special piping—smooth of surface—which is specified for polished handrails; this piping can be polished by grinding or buffing. Common gas pipe is largely used for factory handrailing, machinery guards and fences.

Hydraulic Pipe.—For high pressure pipe-work the piping is generally weldless steel tubing, but there is wrought iron piping for the purpose, and one will never get mistaken in this because of its thickness, which is approximately twice that of the steam pipe.

Galvanised Pipe.—The galvanised series can be had in any of the foregoing qualities, but are chiefly used for corrosive fluids, and for the better heating installations. The outside surface is galvanised for rust prevention, and a very effective means it is too, but it is often marred by the fitting. The cutting and screwing always leaves naked parts that cannot be regalvanised without going back to the baths, but the negligent pipe fitter can be prevented from skinning the zinc from those places where he applied his grips. Really all galvanising should be done after the articles are cut and shaped ready for fixing, this is a fact overlooked by many who specify galvanised pipes and fittings.

Large Pipe.—For larger bores with higher pressures and temperatures for steam ranges, power plants, water supplies, and the like steel pipe is selected, and flanged ends are always fitted to these.

CHAPTER XXIV

PIPE-FITTINGS

Pipe-fittings.—There is such a multifarious range of pipe-fittings that to illustrate them all would occupy the pages of a book devoted entirely to pipes and accessories. The accompanying sketches (Fig. 86) are given in diagrammatic form by way of explanation to the uninitiated reader so that he may grasp the functions of the fittings mentioned. They are known by the names attached, the first one being the socket or coupling, for connecting the ends of straight pipes. The Tee or T, is a socket with a branch attached, and there are many different sorts. The equal T is of course understood; the unequal ones are numerous in their styles, those shown being common examples. The method of ordering unequal Ts is as shown, and is simple to understand; this method also applies to other unequal styles, such as four way or X (cross) and Y shaped ones. The diminishing socket one cannot go wrong with. The T mentioned as an Easy tee is intended to ease the change in the direction of the flow of liquids, and is usually made of cast or malleable iron.

Pipe Elbows and Bends.—The elbows and bends need no explanation beyond stating that the former are stocked in all diminishing sizes, as are sockets, tees, etc.

Long-screw or Running-thread.—The long-screw is designed to connect two pipes or a pipe and a vessel that are fixed. It is used in conjunction with the back nut as shown, and the long thread is first screwed into one socket as far as it will go. The other end is then entered and screwed in at the expense of the long thread, the back-nut being to compensate for any likely leakage past the latter. The dotted line shown on the back-nut indicates how it is machined on the jointing face to assist in making the joint sound.

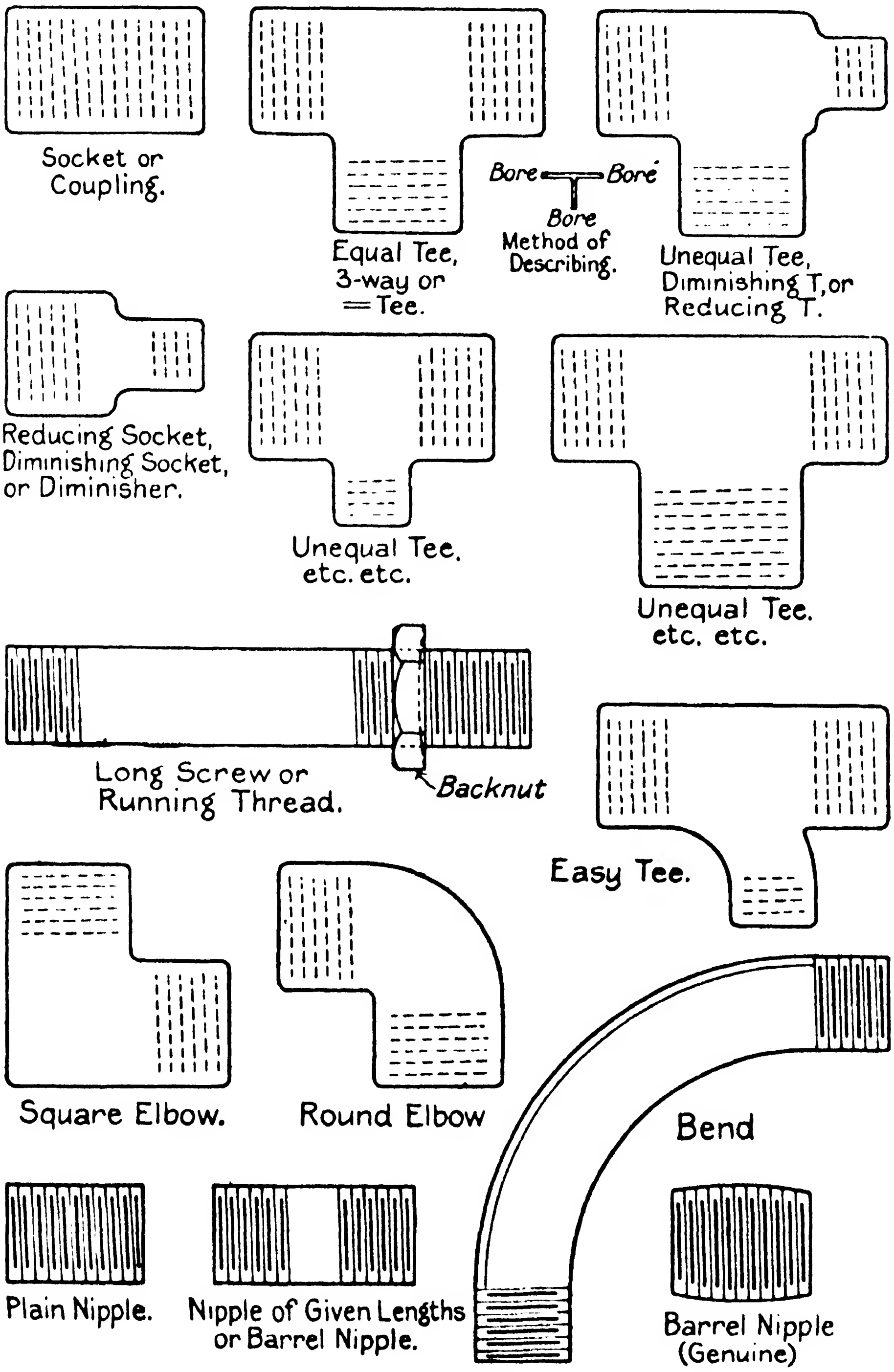


FIG. 86.—The Terms of Common Pipe-Fittings (1).

Pipe Nipples.—The plain nipple consists of a short length of pipe which is screwed the whole of its length. The sides are paralleled, consequently this class of nipple is only suitable for low pressures.

The Barrel nipple also has the thread the whole of its length, but it is shaped actually as a barrel. This nipple is commonly employed by plumbers, and it is rarely seen outside their sphere of work.

The nipple, or as it is mostly called the barrel nipple, which is really a short length of pipe threaded at both ends, is the one preferred by pipe-fitters. This class is stocked by merchants in a wide range of sizes and lengths well above those which the pipe-fitter is himself able to make with the screwing tackle that he has to use. The threads of these nipples are tapered, as are those of pipes (see pipe-screwing).

Male and Female Threads.—The diagrams (Fig. 86) show the fittings as male and female, and as will be observed all sockets, Ts and elbows are female connections, whilst the bends and nipples are male. The former have a larger bore than the latter, and this fact will have to be borne in mind by the tyro when selecting a fitting from stock. The plug and cap shown in Fig. 87 are for stopping the ends of pipes. The former is often used in general work, but the cap is not. These two also illustrate the male and female parts. The plug of course will need a socket or similar fitting to receive it; its usefulness is in plugging branches on a range that is being fixed, as will be readily understood. In passing it may be said that the blacksmith can make an effective plug from a few inches of pipe by welding the end to a point. Plugs up to 2 in. in diameter can be made this way; beyond that the acetylene-welder can make up the end with a disc of plate. It may in the latter case be more expedient to fit a flange and blank up the end, but that is a question of what fittings are available.

Temporary Carry-on.—One will not usually be able to fix up a pipe layout with the most suitable and neatest fittings, the stock at hand will decide what shall be used, at least until the proper fittings can be obtained. Pipe-fittings will accumulate everywhere, and they are always valuable stock to care for.

Hex, Nipple and Bushing.—Fig. 88 shows two other means of varying the bore of a connecting pipe. One sketch shows the bush or bushing, the other shows the hexagon nipple ; the latter can also be had equal if desired.

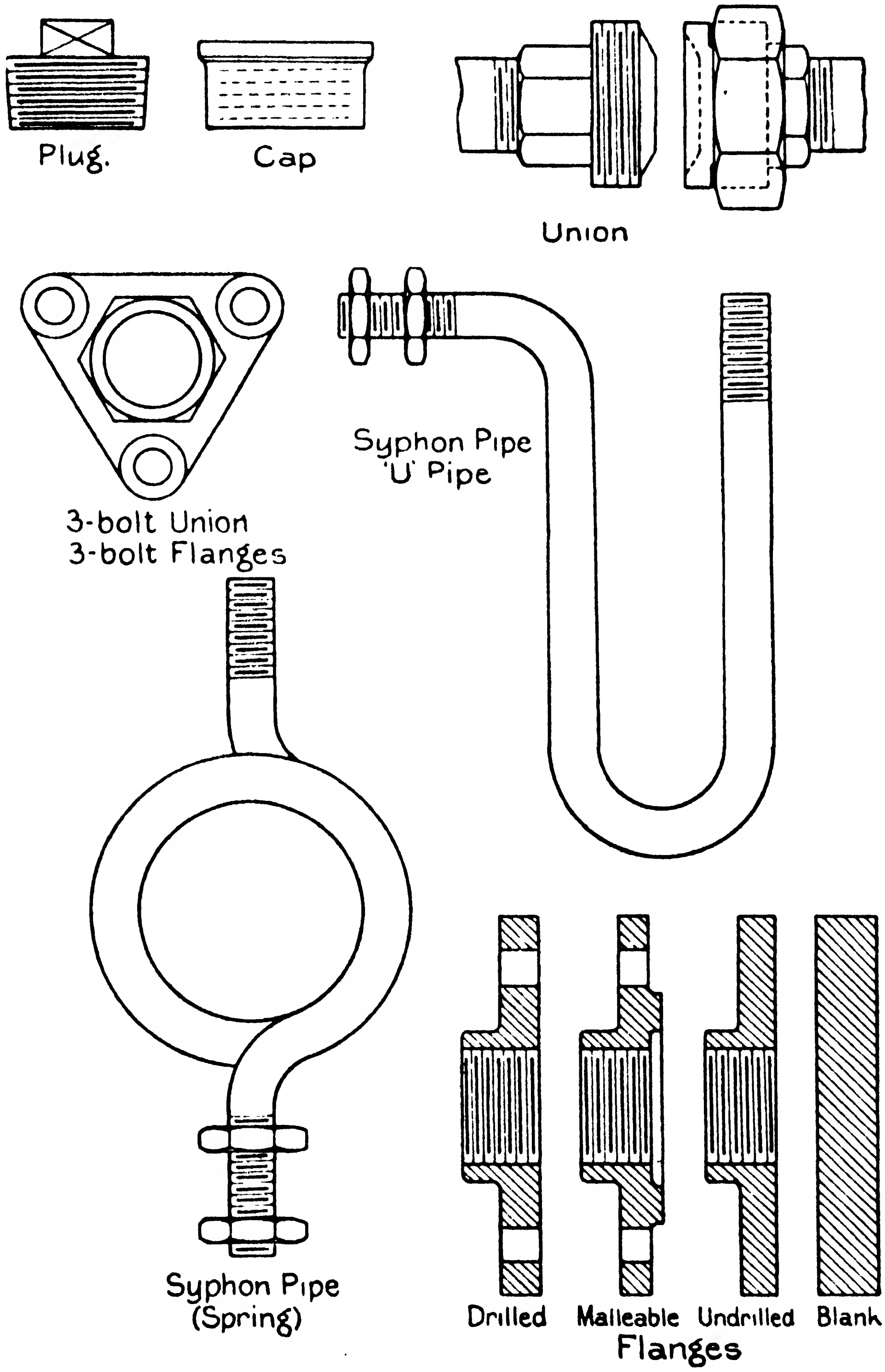


FIG. 87.—The Terms of Common Pipe-Fittings (2).

Pipe Unions.—The union is a common means of connecting pipes that are required to be detachable. There are several patterns, the one shown (Fig. 87) being the most common; it has a male and female cone, as may be seen. The large hexagon nut is free on the female end, and screws on to the male portion, thus bringing the two faces together to form the joint. To mention a few of the differing features it may be said that unions are made in malleable iron, brass, gunmetal, etc., and the iron ones may be had with gunmetal cones. In some patterns the cones are radiused to overcome slight errors in alignment. There is one pattern in which the faces are flat, and require a joint ring.

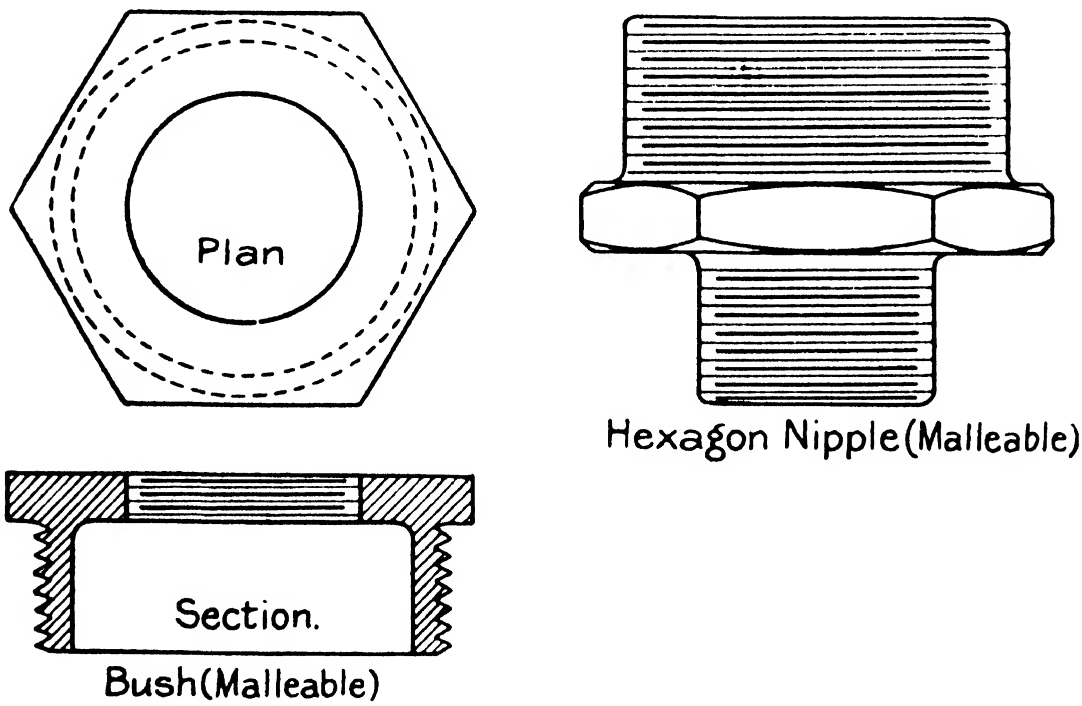


FIG. 88.—Malleable Fittings.

Three-bolt Unions.—There is also the 3-bolt union (Fig. 87), or 3-bolt flange as it is often described. Really the latter is incorrect, because there is a malleable iron fitting for hand-rail bases of the 3-bolt flange order, but it is not a union.

Pipe Flanges.—In Fig. 87 four types of flanges in common use are shown in section; a few points relative to these and which will be indicative of the general order are given here. There is a great difference in flanges in all respects except in the bore—that feature alone is constant. All flanges should be faced, those supplied by reputed makers will be, but others may not. Drilled flanges have the bolt-holes drilled to standard specifications. Undrilled ones are bored and screwed but not drilled for the bolts; they are often mis-named blank flanges, and this point should be clearly specified when ordering such. Malleable flanges have holes cast in, usually square ones, and have a ring face as shown. This ring face is not altogether peculiar to the malleable ones, some makers adopting the same principle on their steam-pipe flanges. Blank flanges are usually cast iron discs for " blanking " the ends of flanged pipes; they may be cast with holes to suit standard flanges or entirely blank; and are stocked in great variety by merchants and pipe-fitting firms. There is a wide range of so-called standards, and when the flanges are bought from local sources one is never sure of any dimension but the bore. Reputable firms always adhere to the B.S. (British Standards), and there is always satisfaction in dealing with such firms.

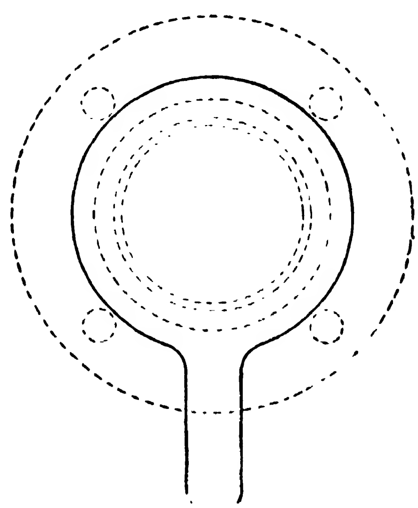


FIG. 89.
Sheet Metal Diaphragm for Pipe-Joint.

Blanking-off.—When a blank flange is not available, a temporary one can be cut from a piece of sheet metal and sandwiched between two standard flanges. In the fixing of long ranges it is often necessary to blank-off the portion that is completed, so that it way be put into commission. A sheet metal blank cut as shown in Fig. 89 and inserted between the flanges of a joint will effectually stop the flow. The advantage of this diaphram is that it can be withdrawn in a few minutes, and a further portion of the line put into use without causing undue delay; all that has to be done is to remove one or more bolts as the case may be, slack off the others a little, withdraw the blank and re-make the joint.

On Centres and Off Centres.—Regarding pipe-flanges, it may probably be of some service to the reader to know the meaning of two common technical terms which are employed on pipe contracts. These terms are " On centres " and "Off centres," and they relate to the position of the holes in the flanged pipes when being marked out for drilling, or when the drilled flanges are being fitted on to the pipes. The terms apply to flanges which have four holes, or any multiple of that number, as in such instances the pitch places four of the holes at right angles. "On centres" means that two holes are on the vertical centre line, and two are on the horizontal centre line. "Off centres" means that no holes are on either. The two terms are illustrated in Fig. 90.

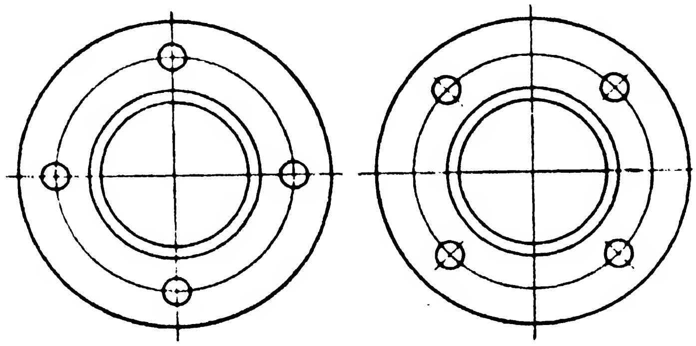


Fig. 90.
Holes "On Centres" and "Off Centres."

A clear straight pipe is unaffected, but any other—such as a pipe with a branch or a set in it—means that the condition has to be applied. "Off centres" is usually adopted in modern practice, but when ordering any flanged pipe this point should be made clear to avoid any likelihood of error.

Six-hole Flanges.—The position with a six-hole flange is that two holes are sure to occur on one plane, either the vertical or the horizontal, as shown in the sketch (Fig. 91). In ordering flanged pipes for such it is necessary in all but plain straight ones to state on which centre line the two holes occur.

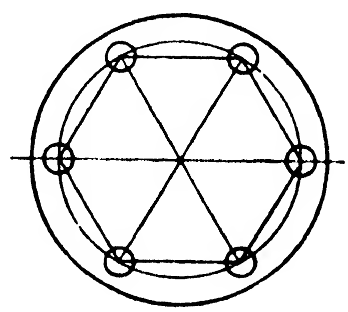


Fig. 91.
Pitching out a Six-Hole Flange.

Marking-out.—On straight pipes the starting point for marking-out the flanges—also for unattached flanges—may be anywhere on the bolt circle, but on all others one plane, either the horizontal or the vertical, must be defined, and all holes must be relative to this line. It is a curious fact that most men who mark out flanges and similar ring pitches always forget to employ a very useful, and yet simple, bit of geometry. After describing the circle for the holes one may often see the marker-out doing a lot of guess-work with his dividers to find the correct pitch, never thinking for one moment that the dividers set to the radius will step exactly six times around the circle already described. Here is a simple means of pitching out six holes, and any multiple of that number is easily obtained afterwards. To those readers who are not acquainted with geometry the sketch Fig. 91 explains this very simply.

U and Syphon Pipes.—The U-pipe refers to any pipe shaped like the letter, although it is usually inferring a pressure-gauge fitting. It is often referred to as a return bend, because of its adoption for the return at the end of a pipe line, as in heat pipes, brine pipes, etc. The stock pattern of U-pipe for a pressure-gauge is shown in Fig. 87, and is commonly known as a "syphon." Another form of pressure-gauge pipe is also shown ; it consists of one or more complete circles and it is known as the "spring" pipe. The function of these is to arrest shock, and in addition to this the pipes when fitted to boiling processes and steam pressure work hold cold liquid. On the top of these pipes the gauge cocks are fitted so that the gauges can be isolated for removal if necessary.

Malleable Fittings.—The range of malleable iron pipe-fittings is most complete and includes every conceivable design, but attention is called to their disadvantage in steam range application. They are not usually adopted for high pressures and temperatures, although they are good enough generally. The trouble is in their coefficient of expansion, for in the varying temperatures of steam-pipe work one never knows when a fitting will start leaking. This statement must not be taken to mean that they will never hold tight, for they usually do, and when adopted on low pressure steam work they rarely give trouble. Practical experience with these fittings causes this remark to be made, for during the Great War when pipe-fittings, like everything else, were at times difficult to get, malleable iron ones often had to be used in steam ranges ;

this was how the experience mentioned above was obtained.

Hand-rail Fittings.—There is a very extensive assortment of fittings for hand-rail work, and if a merchant's illustrated catalogue is handy, the designing of hand-rails is made easy. They are cheap too, and the fittings can be depended on to give no trouble in fixing together.

CHAPTER XXV

PIPE-FITTERS' TOOLS

Pipe-fitting Tools.—The list of tools required for pipe-fitting on site work is not a long one, and the tools are withal a most convenient kit. A short account of these as preferred by the practical men, together with their uses and features, is given below.

Screwing Tackle.—As a means of screwing or threading pipes, there is nothing to excel the " Oster " machine, and one of these for either hand or power is the best proposition for site work, for it may be that power is available. If the latter is not, the cranked handle is quite an easy turning affair for pipes up to 6 in. in bore. Hand operated stocks and dies for pipes held in the pipe-vice are available, but the screwing of pipes above 3 in. with such becomes a slow job : a pipe of the latter size can be cut and screwed with a good set of Oster Bull Dog Die-stocks in half an hour, but one must not expect two men to keep up that speed for it is a strenuous job.

The Oster Ratchet Die-stocks are to be preferred, as with this tool the operation is made so much easier for the users. By " Ratchet " is meant the action of the levers, which are fitted to a steel collar band containing a reversible pawl; this arrangement allows the levers to operate the dies in either direction. The levers are set at the most convenient angle, so that the men operating the dies have the minimum amount of action, which is done in the most favourable attitudes. Some of the stocks are fitted with cutters—not that these are to be preferred before the other types of pipe cutters—there is little in it except that the cutters on the stocks are neater in their result, acting as a parting tool does on a lathe, thus the end of the pipe is left without a burr. The cutters are edge tools, and as such they need a little attention at times, which is a trouble to most users, therefore the old familiar pattern of wheel cutters are preferred for rough continued usage.

The Oster Ratchet Dies are illustrated in Fig. 92, and these can be obtained to suit pipes up to 4 in. in bore. They are a decided improvement over most other patterns, and have a positive setting arrangement without the use of thumb-screw or friction clamps. The dies are controlled by a lever, by which they can be quickly opened or closed, thus all the reversing necessary when a thread is cut is just to knock off the burrs where the cut has ceased. The loosening of one nut allows the dies to be instantly taken out when it is desired to change from one size to another. The stocks are equipped with adjustable guides which do away with loose bushings, and are operated by one lever in like manner to the dies, by means of a scroll.

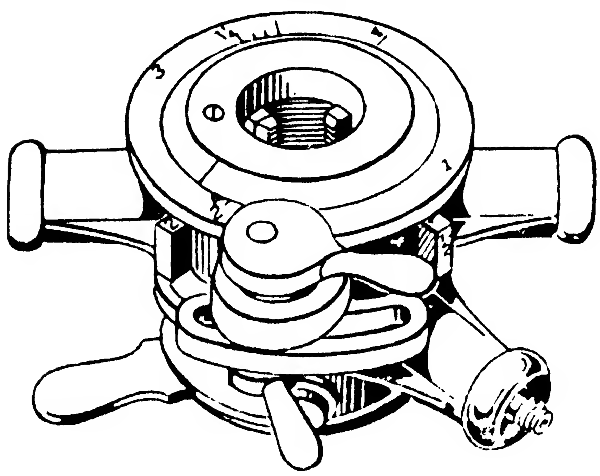


Fig. 92.
The Oster Ratchet Die-Stocks.

The Oster dies have the merit of being able to cut threads either above or below the standard size, which is at times necessary to suit a tight or a slack fitting. They are somewhat weighty, especially the larger ones, but they are not by any means awkward. The screwing machine has been suggested as the best proposition, because it has a vice to hold the pipe in opposition to the dies, whereas the hand tackle needs a good strong bench and powerful vice to resist the efforts of the men operating the tool. The vice on the machine may also be used as a pipe-vice as occasions arise ; this is an advantage too.

Die Nuts.—There are other good makes of pipe-threading stocks and dies especially for small bores. The old-fashioned die-nuts are handy for chasing a thread, but in cutting a new thread with one there is always a risk of a kink at the joint. In Fig. 93 is illustrated a machine in which the

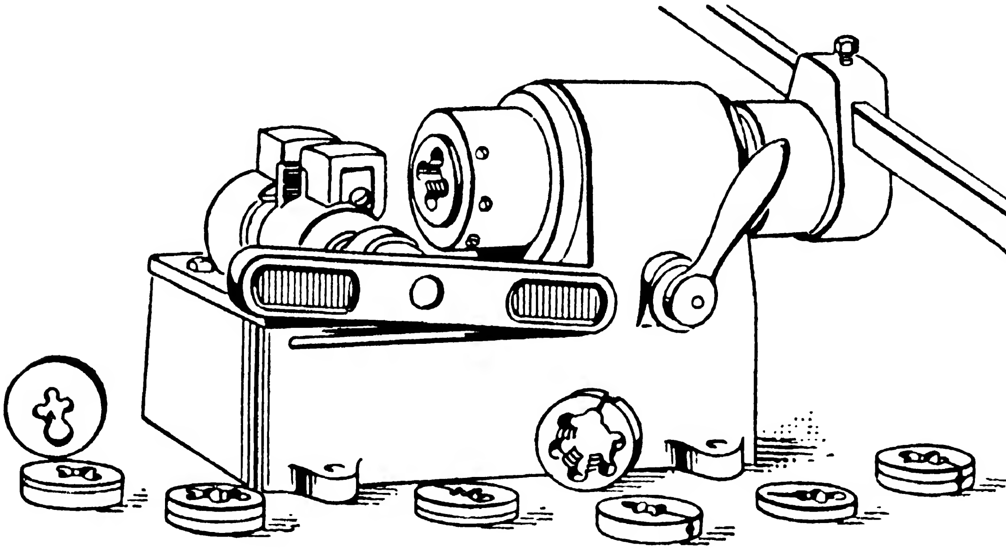


FIG. 93.—Portable Screwing Machine for Die Nuts.

modern die nuts can be used with every assurance of satisfaction. Not only can it be employed on pipes up to 1 in. in bore, but on Whitworth threads up to ½ in. in diameter. This is a most useful tool and works with lightning rapidity. The dies too are to be depended upon for hard service.

Pipe Cutters.—Pipe cutters of the wheel types are very popular, and are speedy in their work. When the wheel-cutters get blunt they can be replaced from stock, but a few

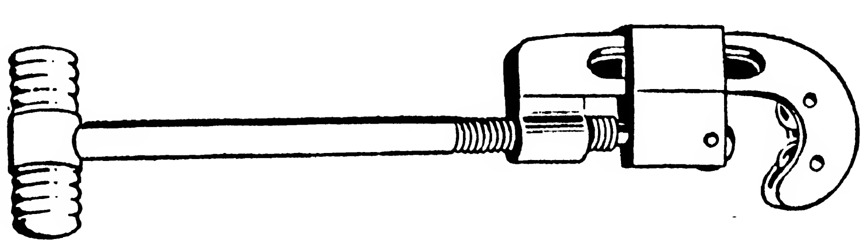


FIG. 94.—The Barnes Pipe Cutter.

spares should be kept handy. There are two designs, the fixed ones, in which two of the wheels are housed in a bow, and a third one fixed to a rack screw, as seen in Fig. 94, and the chain or link cutters that have the wheels pitched out in the links that compose the tool. In the former, which is known as the "Barnes" cutter, each size covers a range of 2 in., and sizes are stocked to cut pipes up to 12 in. bore. For general pipe-work the Barnes cutter is preferred to any other.

Chain Cutters.—The chain cutters shown in Fig. 95 are invaluable to gas and water engineers, as the tool can be

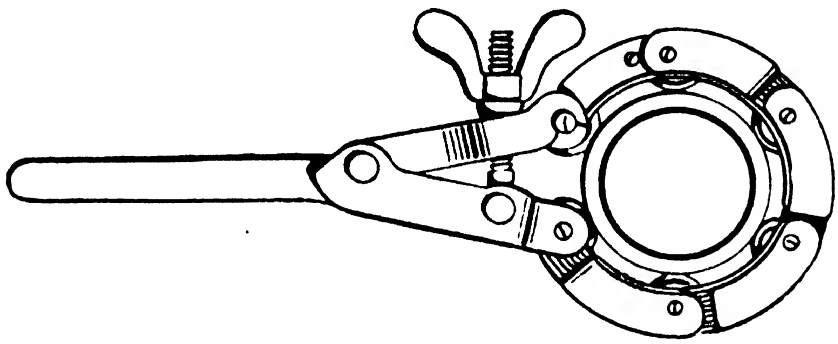


Fig. 95.—The Chain Cutter.

conveniently operated in narrow trenches and confined areas. By adding links the cutting range is increased. If the pipes are not quite round, they adjust themselves to the shape, and they require a very short stroke to join up the ring-cuts made by the wheels. The hand lever is short, but this may be lengthened by adding a piece of suitable pipe.

Pipe Wrenches.—Many types of pipe wrenches are available, and each has some merit—either imaginary or real. The practical pipe-fitter wants either of two makes, that are by test the best. For preference, no doubt, he would select the

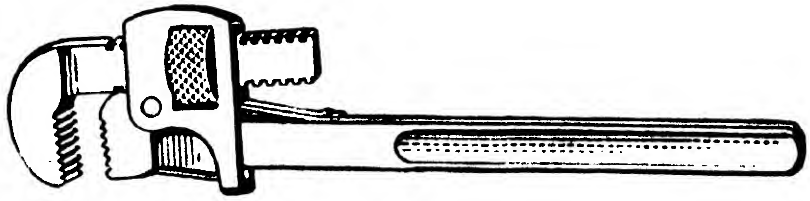


Fig. 96.—The Stillson Pipe Wrench.

Stillson pattern for the smaller bores, and the chain grips for the larger ones.

Stillson Wrenches.—The "Stillsons" are made in all sizes from 6 in. to 48 in., to fit pipes up to 5 in. bore. They are quick to apply and detach, and are efficient in use. Their service is of long duration, and damage is only caused by abuse, as for instance when—to obtain extra power—the user applies an unreasonable length of pipe to the hand grip. This abuse often results in deformity, but the tools rarely break. A fair margin of latitude is permissible, for every tool—like a power plant—has at times to bear a 25 per cent. over load. A rule that will be remembered, and one that will apply to most sizes of pipes, is to allow 1 ft. of leverage for every inch of the bore. Thus a 24 in. Stillson wrench will give all the power required for a 2 in. pipe: it will also do most of the work on 3 in. pipes, but a more powerful wrench should be applied for the final

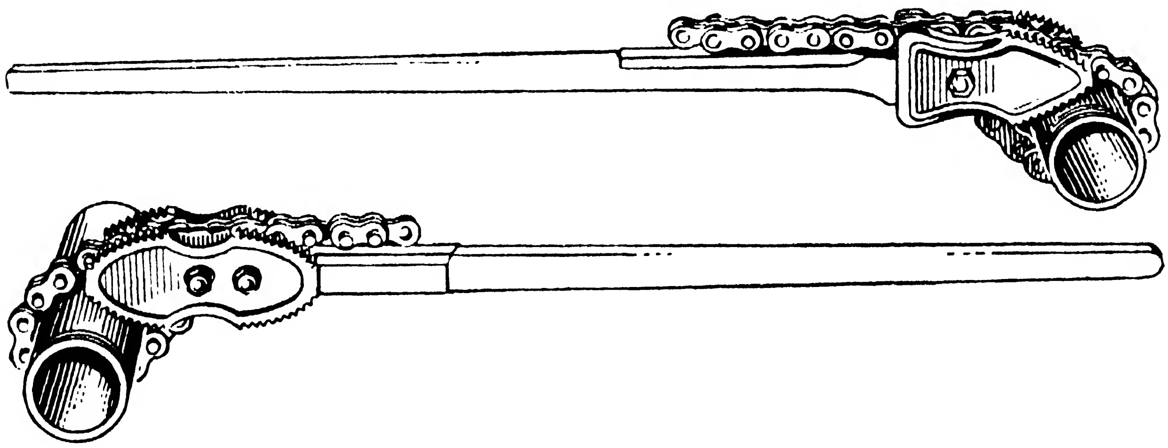


FIG. 97.—The Vulcan Chain Pipe Wrenches.

clench in preference to crippling the Stillson. The tool is illustrated in Fig. 96.

Chain Pipe Grips.—The Vulcan chain grips, as they are commonly called, are well up to their title. They are without question the most powerful pipe wrench on the market, and the two models are illustrated in Fig. 97. The tool rarely ever crushes a pipe of good make, because the line of the teeth is tangential and conforms with the encircling grip of the chain. If a pipe gets indented by this tool, probably the cause will be found in the fixing of the grips when too long a chain is allowed, and the nose of the jaws digs in almost at right angles. The Vulcan wrenches have a wide range, especially those of the larger sizes but, like the Stillson wrenches, their weight precludes them from being handy on the smaller pipes. There is really no outstanding feature that can be claimed for one over the other, and the price of the two wrenches are similar for comparative sizes.

The Footprints.—There is one other wrench that is a useful tool for many purposes and that is the "Footprint." It is called by that name because of the brand that is stamped on the original (and best) make. The small size is a handy pocket tool, and these wrenches—like the Stillsons—can be applied to any irregular shape, and to nuts of every description.

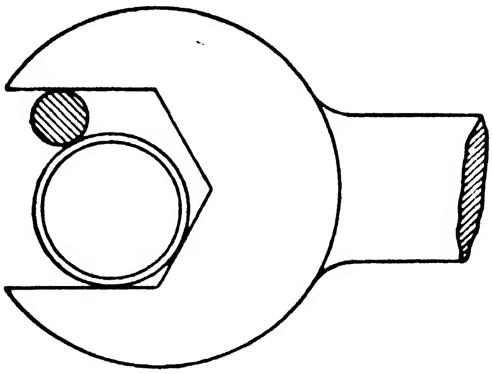


Fig. 98.
A Temporary Pipe Wrench.

Temporary Wrench.—A means of converting an ordinary spanner into a temporary pipe-wrench is worth knowing. The sketch (Fig. 98) clearly illustrates the idea, which is the locking of the pipe by the insertion of a broken round file. The size of the pipe is immaterial, providing the wrench is large enough to span it, and the smallest file is sufficient to bite the pipe when pressure is applied.

The Pipe-vice.—The pipe-fitter demands a very strong vice to hold pipes while he operates on them, but a strong vice would be useless without a secure anchorage for it. The Reed vice shown in Fig. 99 is the best possible tool; it is very powerful, being made of malleable iron, and very light to porter. A 6 in. vice weighs only 48 lbs. against the open-sided vice's 136 lbs. for the same capacity; which is a great feature of this make. The top jaw is fixed in a hinged frame with a self-locking catch, and this makes the tool equivalent to the open-sided vice. Each vice is capable of holding the smallest pipe made, and any size between that and the largest for which it is

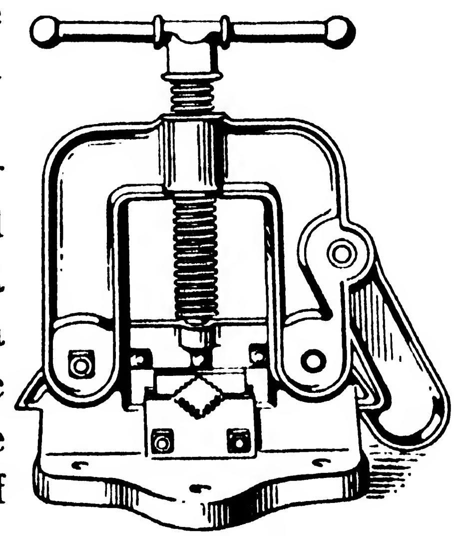


Fig. 99.
The Reed Self-Locking Pipe Vice.

constructed. No other vice offers the advantages that the Reed self-locking one does, and no better tool could be desired.

The Bench.—The bench, on which the vice sits at one extreme end, must be of very stout construction to stand the real punishment that it gets, especially with high pressure pipe-work. It need not be anything but a rough one, but it must be strong and well-braced. In addition to its own weight, some form of anchorage is usually necessary. Ballast is to be preferred to strapping the bench to a column, unless there is ample floor space beyond. Pipes have to be turned about and a clear floor space is a means of obtaining speed with safety.

Tube Expanders.—The Tube Expander is not always considered a necessary tool for the pipe-fitter, as each size

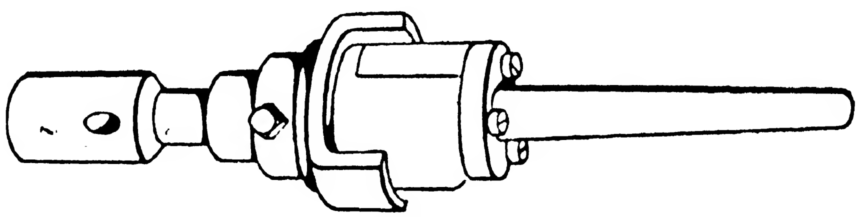


FIG. 100.—The Tube Expander.

means an independent tool. It is a very useful tool at times when flanging pipes, for it may happen that a batch of flanges fit easy on the pipe-threads, the expander will remedy this, thus the joint is made secure. The tool is illustrated in Fig. 100, and as will be seen, it consists of a housing—with loose rollers —for inserting into the bore. A mandrill is pushed down the centre to force the rollers against the inner face of the pipe, and this is turned round with a tommy bar. The rollers press hard against the pipe until it is sufficiently expanded.

Tube expanders are a common tool for engineers who fit the tubes in multi-tubular boilers, pans, and other vessels; generally the expansion of the tube ends is all that keeps the tube in position and at the same time makes the joint secure.

CHAPTER XXVI

PIPE-SCREWING AND FITTING

Pipe-screwing and Fitting.—Pipes that are delivered new have both ends screwed, to one of which a socket is fitted. This is the recognised practice. The included socket protects the thread on the one end, while the thread at the other end is protected either by cord or twine wrapped tightly around it, or—on bores of 3 in. and upwards—by protector rings, which are usually portions of sockets. This custom prevents the lead of the thread from being damaged in transit to any troublesome extent.

Flanged Lengths.—When it is desired to cut a length of pipe for flanged ends, one end should have a flange fitted first. The length overall is taken from the face of the fitted flange and the pipe is then cut as required. The thread should be sufficiently cut back to allow of the face of the other flange to rest flush with the end and a shade more than that when the end of the pipe is to be caulked. Due allowance must be made for jointings that are to be inserted.

Socketed Lengths.—With socketed joints, the most practical man cannot always judge the exact length at which the screwed connection will come out at the first time of trial, even though he allows what his skilled judgment dictates. More often than not the length comes out too much ; this is a good fault and can soon be rectified, although in the majority of cases there is sufficient latitude to pass the slight variation, but in a " closing " length accuracy is essential. Most closing lengths have a union joint or perhaps a flanged connection, so that attachment and detachment are simplified.

To Prepare a Pipe.—The pipe to be fitted is first cut off to length, then all the burr and the paint is cleaned away (paint clogs the dies) after which the end is fettled down with a coarse file to give it a lead into the screwing tackle. The pipe is now ready for threading.

The Pipe-thread.—The inexperienced engineer should study the shape of the end of a pipe which has been threaded by the makers. He will find that there is a decided taper the whole length of the thread to where it runs out to nothing, and such a thread means a good joint. In Fig. 101 the sketch illustrates two threads, and both when cut may be neat in appearance, but one will make a sound joint, whilst the other rarely will, even on low pressure work. All dies for cutting pipe threads are supposed to shape the end of the pipe correctly, but there may be occasions when the available dies will produce a paralleled thread. In such a case the screwing should be stopped immediately as the threads from such dies will be at least of doubtful fitting.

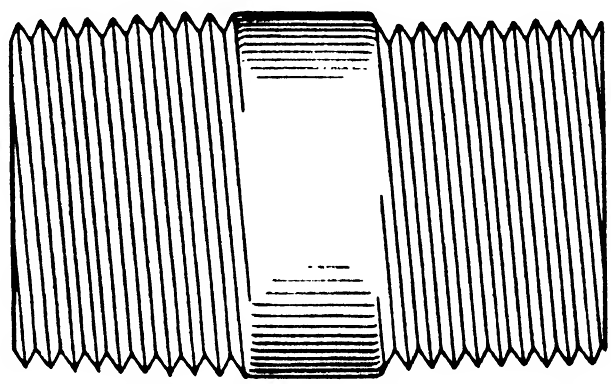


FIG. 101.
Showing Correct and Incorrect Pipe Threads.

When the ends of the pipes are correctly shaped there need be no anxiety about leaky joints, but if an end be doubtful then no amount of paste will prevent leakage. An incorrect joint as shown in the sketch cannot dependably be caulked to stem the slightest weep, whereas one may on a correctly shaped end, should that happen to be necessary. A very simple method of testing a threaded end is by screwing a coupling (socket) on to it. If the latter screws right to the end of the thread on the pipe, then the joint is faulty and should be scrapped, but should several threads be visible after the coupling is screwed as far as it will go, one may be assured of a good sound joint. Incidentally, it may be pointed out that the latter statement supplies the reason why the pipe-fitter cannot always judge the correct length when fitting socketed joints.

Screwing Pipes.—Unless it is assured that the dies will immediately cut a good correct thread, a trial should first be made on a piece of stock pipe, for a dead length may be spoiled if this precaution is overlooked. When the thread is of sufficient length the dies must be turned backwards a little, to knock away the burrs where the cut has stopped. The pipe is then removed from the dies, or vice versa as the case may be, and—for socketed joints—is ready for fixing. If the end

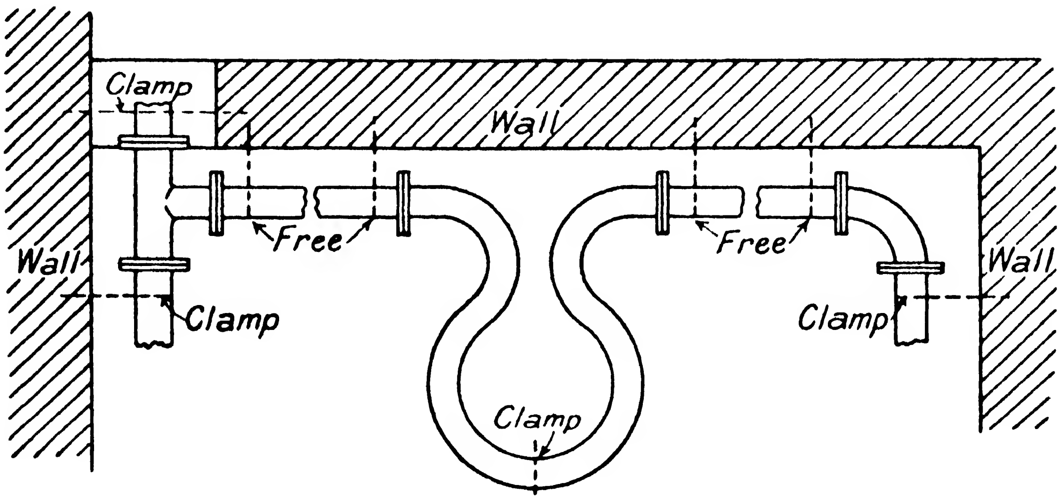


FIG. 102.—Diagram of Steam Range with Expansion Loop.

is for a flanged joint, the pipe is held securely in the vice, and the flange is fitted on after the thread has been previously "pasted" with jointing compound such as is marketed for the purpose.

Where the threads on pipes are of good fit and of unbroken continuity, they will be found quite sufficient for all pressures; and for socketed joints tightness is assured. Flanges that fit at all easy on the threaded ends of course would be very doubtful, and to make them sound expanders must be used inside the bore; or the flange must be screwed on to the full extent of the thread, and the end of the pipe then caulked over and dressed with a chisel. High pressure steam ranges have the joints flanged, or at least an equal number flanged in bores up to 4 in.; above that one never sees socketed joints for steam pipes, and comparatively few for other services, as the means of jointing is so awkward in most cases. Makers of steam pipes of large bores adopt one of two methods of sealing the flange threads: some expand the tube, whilst others prefer to weld the neck.

Any method of securing a flange whether expanding, welding, or caulking, should not be done until it is positively certain that the holes in the flanges are in correct register. It may mean a little trouble to try one in position first, but that may be a little thing compared with the efforts required to correct a flange after caulking, or treating by either of the methods mentioned above.

Opinions differ as to which is the better method — the welded flange or the expanded pipe, but it seems that most practical men prefer the latter method.

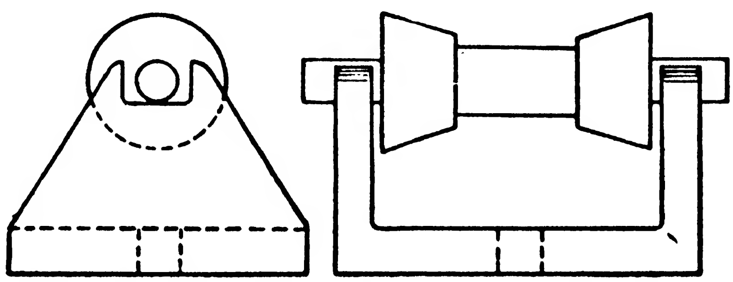


Fig. 103.
Bracket and Roller Pipe Support.

Steam Ranges.—Pipes that have widely differing temperatures need special consideration. Such pipes are mainly for steam, and provision has to be made for expansion and contraction, as these seriously affect a range of long length. A diagram of the customary method of securing and supporting a steam pipe is given in Fig. 102. There are two means of supporting the pipe to allow for this variation in its length. One is by slings, and the other is the bracket and roller method as shown in Fig. 103. When conditions will permit the sling is the favoured way, as by this method the pipes can be completely and neatly covered with insulating material, whereas a certain portion must be left uncovered for the paths of the rollers when those are fitted to carry the pipes. Another means of supporting long pipe lines for steam when short slings are used is to have trestles that are pivoted at the base, as shown in Fig. 104. This is a very satisfactory method, for such trestles are light in construction and of comparatively low cost.

On short lengths the bends at the ends will do duty as expansion bends, but an expansion loop or joint is necessary when the straight line is to be fixed at the ends, and when the length reaches say 50 ft. and over. It is customary to fit expansion loops of the horse-shoe type say every 150 ft. in long straight ranges, and for preference these loops should be

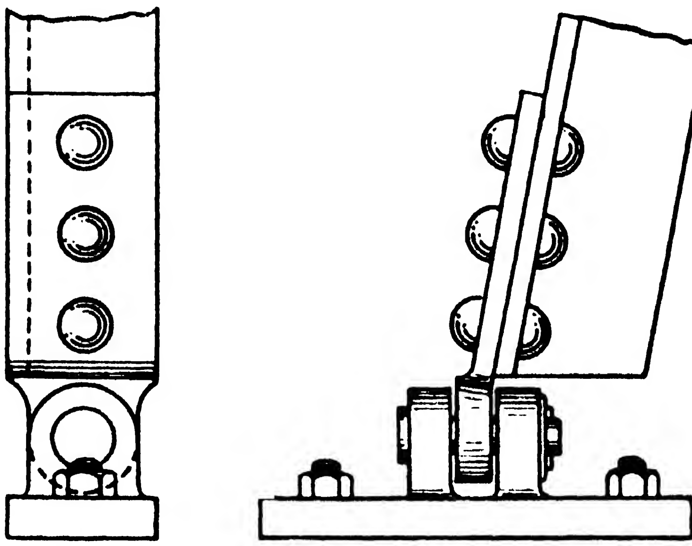


FIG. 104.—Pivoted Trestle Leg.

fixed horizontally as shown, otherwise special provision must be made for draining away the water of condensation which would lie in the pipes and choke the bore. When a loop is fixed in a straight length, the extremities of the line should be securely clamped to force all movement into the loop.

There are other forms of expansion joints which are of the glanded spigoted type, and many aver that these are eminently suited for cold ranges where the temperature varies only slightly, but for steam ranges they do not seem popular except in confined area where the loop is impossible.

CHAPTER XXVII

NOTES ON PIPE-JOINTING MATERIALS

Pipe-jointings.—With few exceptions, the jointing mediums for pipe-work are selected by the practical man. There are many recognised brands but really few different sorts, and a brief description of these together with their common application is outlined here.

Taylor Rings.—Probably the most popular and at the same time the cheapest form of joint-ring, for high or low pressure steam and water ranges, is the Taylor ring, which is the name by which all makes of such are known. These rings are usually of sheet brass, and are corrugated in concentric circles; they sit within the bolt circle and are only suitable for faced joints, but they can be used once only as may be understood.

To fit them the corrugations are filled with jointing paste; the ring is then inserted and the joint screwed up evenly until quite tight.

Taylor rings have largely displaced the well known insertion and the asbestos board mediums, taking far less trouble to fit and being much cheaper: they are also quite reliable.

Rubber Rings.—In large cast iron mains with flanged joints, thick rubber rings are preferred; these, like the Taylor rings, are fitted inside the bolt circles. They sometimes answer a dual purpose—they seal the joint, and allow for a very slight deflection from the straight line—should that be necessary. It will be understood that cast iron pipes will not spring like wrought ones.

Sheet Rubber.—All rings are stocked in standard sizes to suit every bore and every diameter of bolt circle, but where the infrequent use of rubber rings does not warrant the outlay on a stock of these, sheet rubber from which rings may be cut is the alternative.

In cutting a rubber ring due consideration has to be given to the size of the hole, because the squeezing effect on the ring will probably throttle the bore. Many fitters commit this error, the true effect of which can be easily ascertained by bolting two flanges together, with a rubber washer inserted. If the hole in the washer is cut to the exact bore of the pipe, no doubt the latter will be blocked a good fifty per cent. after the joint is made.

Rubber Insertion.—Rubber insertion is a jointing medium built up of alternate layers of rubber and canvas to the desired thickness, and cemented together. This material is not so soft as the pure rubber, and while the elasticity of the rubber is retained for sealing the joint, the tendency to squeeze out crosswise is effectively prevented by the canvas layers. It is made in plys, from three upwards. For steam pipes, insertion has a special merit, as the heat first softens the rubber and then vulcanises it. For cold joints it can be used repeatedly until the rubber has lost its nature.

Sheet Asbestos.—Asbestos board is a loose soft jointing medium which can be obtained in various thicknesses from one sixteenth of an inch upwards. It needs careful handling, but is a very useful jointing for hot dry connections at low pressure, such as exhaust pipes, flue doors, silencers, etc.

Compressed Asbestos.—There are "oids" and "ites" on the market in great variety. The "ites" are chiefly compressed asbestos, and usually have the name of the maker or supplier prefixed, as in Bellite, Hallite, etc. This is a hard jointing medium, nevertheless it is most useful for many joints. Actually this material functions best on wet joints, and is consequently suitable for chemical factories, refineries, distilleries, etc., in place of rubber jointing material, for when the liquor reaches the joint ring the latter swells and effectively seals the joint. It may be used on joints that are dry, but being hard it needs powerful clamping.

It may be here mentioned that much of this compressed asbestos is used in automobile work, and on the water jacket this is quite all right providing the bolt-lugs are strong enough. However, the insertion jointing is to be preferred. On the inlet and outlet for the gases, the soft asbestos board appeals more to the thinking engineer than does the hard compressed asbestos. Usually such connections have two lugs only, therefore much pressure has to be applied to the bolts when using hard rings, if tight joints are to be ensured.

The "oids" are chiefly substitutes for insertion, and special merits are claimed for them by the makers—merits which the practical man cannot often find.

Paper Jointings.—There are jointing materials of paper compounds, that swell in wet joints. These are very cheap, and are quite efficient as joint-rings for cold pipe-lines, also for steam pipe unions that require washers.

Leather Washers.—Leather is a jointing material that is limited in its application. It comes in very useful as washers for dry connections as in compressed air pipes, for oil pipe connections where rubber would soon perish, and of course for most hydraulic joints.

Cutting Joint Rings.—The cutting of joint rings from sheets of material is effected in different ways, according to the nature of the substance. Hollow punches may be used to make the holes in any material. The rings from insertion can easily be cut with a sharp penknife or leather-knife, those from asbestos board are better cut out with a wood chisel, and rings from compressed sheets may be sheared where it is possible to get the tinsmith's snips on it, whilst the holes can be cut with the tang of a centre-bit.

Spigot and Socket Joints.—Cast iron pressure pipes, which are usually laid in the earth, have spigot and socket joints. Firstly the joint is caulked with spun yarn—a loosely woven form of rope; or with lead wool, and then a clamping band is placed around the spigot near the socket. The band is so made as to allow molten lead to be poured into the joint. Sometimes the spigot and socket have machined faces.

Lead Wool.—Lead wool is really fine lead wire which is hanked for convenience. This substance has the merit of effectively sealing socketed joints without molten lead being poured in, but the practical man always feels more sure of the joint when the latter method is employed. There are occasions when it is not possible to "run" lead to the joints.

Heating-pipes.—Spigot and socket pipes for heating installations are jointed similarly, but with cement instead of molten lead. First the spun yarn is driven in—say two or three complete turns—then plastic cement follows, after which more yarn and cement is inserted alternately. The joint is completed by pointing the rim with a trowel, and once the cement has set there is little hope of separating the spigot from the socket again.

Plaited Sections.—There are ring-packings made of woven or plaited asbestos cord, of hemp, or of similar substances, some are treated with graphite, and some are impregnated with tallow. Made into rings of standard sizes, plaited asbestos forms a means of sealing manlids, firehole doors, and like. The rings are made in round, square and flat sections, and may be used repeatedly.

CHAPTER XXVIII

PIPE-SUPPORTS

Clips and Suspenders.—On every pipe line a number of clips and suspenders in various forms will be required. These have in many cases to be made from sketches and particulars taken on site, and, of course, there will generally be a miscellaneous assortment. Wherever possible the hangers and clips should be put in hand immediately the job is commenced, so that the temporary slings may be replaced as soon as time permits. There are many standard patterns in pipe-clips on the market, but when these are specified they usually fail to work in, as unforeseen modifications will crop up. In actual practice the better way is to leave all clips and hangers until one is sure that they can be used, for it generally happens on a contract of any size that there is a great heap of useless ones left after the services are completed. In some cases it is safe to anticipate requirements by ordering clip-bands, leaving the suspending rods until the length is decided; even then a good margin of latitude should be allowed for adjustment, as no pipe line should be truly horizontal. The sketch (Fig. 105) shows an assortment of simple designs in clips and supports, and selection can be made from these to suit most conditions. They are all of wrought iron or steel and can be made in the workshop.

The angle bracket A is a very good cheap form of suspender; by making it with a pair of angles and spacing them with short gas-pipe ferrules, the pipe sling B can be adjusted to suit the pipe line. It will need to be made proportionate to the weight of the loaded pipe that is to hang from it. If the bracket is for a brick wall the holes on the back can be drilled to suit the mortar courses: by cementing rag-bolts in the latter there is less labour in fixing them than by cutting the brickwork, but this method would not be suitable for pipes above 6 in. in diameter.

The clip and suspender B is of popular design, and is very much in demand for pipe lines that must not be clamped tightly because of the varying temperatures. The band, which is in two parts primarily, need only be so strong in section as to withstand the weather. The section across the hole is the weakest part, as is always the case, and that should be the deciding factor. Common hoop iron will carry pipes up to 3 in. bore, but in exposed situations attacks from the elements would soon rust it through. The suspending bolt is made to suit, and must be well screwed down to allow for adjustment in height; the eye need not be welded so long as the rod has its full diameter at that point. The following table gives some idea for the strength of clips and bolts for suspenders in pipe-work.

Bore of pipe.	*Section of Clip.*	*Diameter of Bolt.*
3 in dia.	1 in. by $\frac{1}{8}$ in.	$\frac{3}{8}$ in dia.
4 ,,	$1\frac{1}{2}$,, $\frac{3}{16}$,,	$\frac{1}{2}$,,
6 ,,	2 ,, $\frac{1}{4}$,,	$\frac{5}{8}$,,
12 ,,	3 ,, $\frac{5}{16}$,,	$\frac{3}{4}$,,

The bracket C can be adopted, together with the hook D for pipes up to 4 in. bore. If the table of the bracket is fish-tailed as shown and plugged with cement into a mortar course it will never draw; the strut may be secured to the wall with a light rag bolt or with a spike. The hook is not so neat as the clip B, but it is quite sound in practice. Modifications may be made to the brackets as fancy dictates.

The straight angle bracket and hook bolt, as shown in E, has been adopted on brick walls for supporting many miles of pipes that are of constant temperatures. When the ends are securely bricked in a good weight may be safely trusted on these brackets. More than one line of pipes can be laid upon them, and it will depend upon the leverage as to how strong the angles should be, and how far they should be let into the wall. One line of pipe close to the wall could be trusted on 4½ in. of angle let in, but with 9 in. let in, three

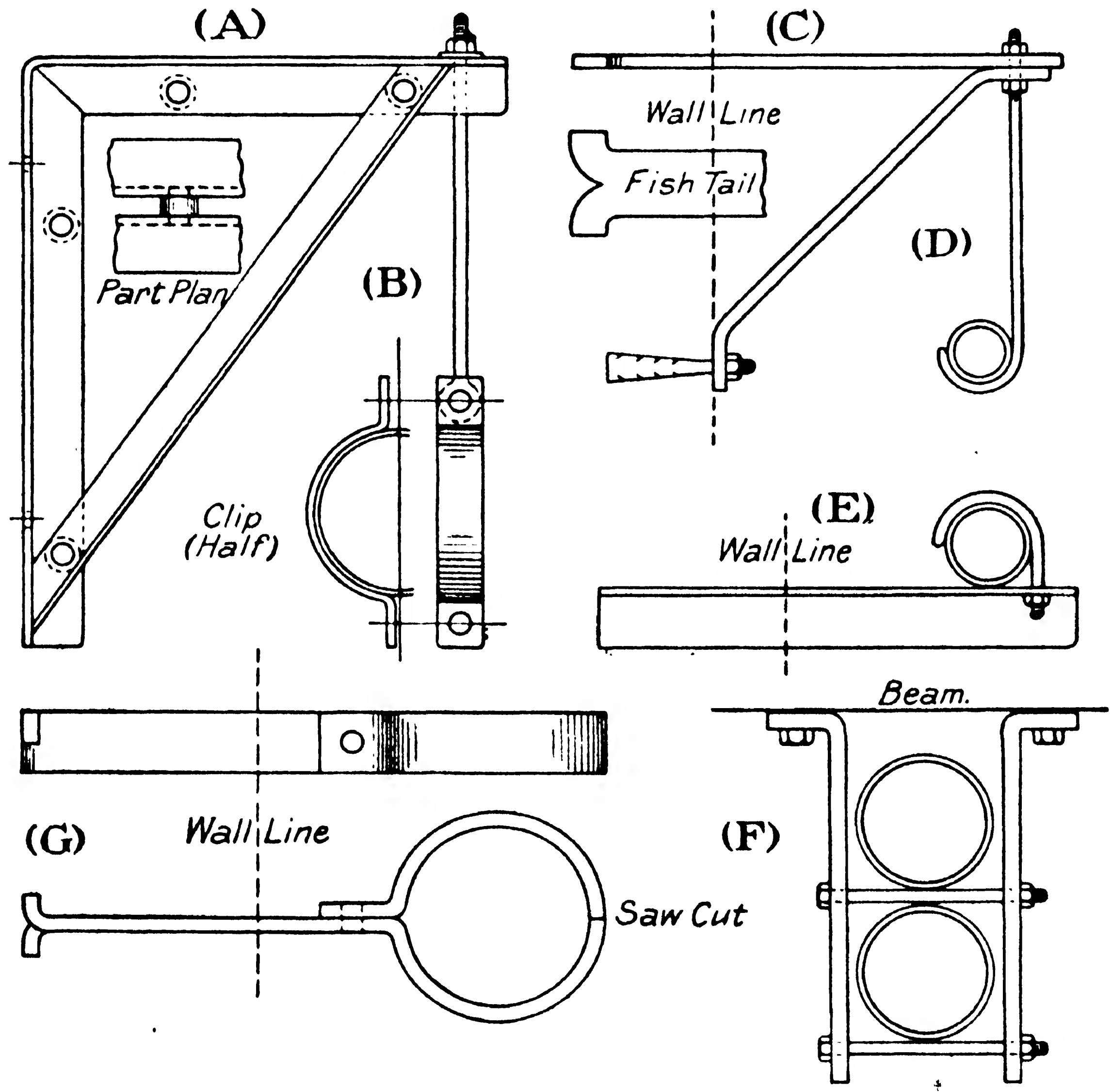


FIG. 105.—Some Pipe Clips and Suspenders.

times 9 in. may be left overhanging. The hook bolt is not likely to interfere with any slight expansion that may take place, but it is quite sufficient to keep the pipe from travelling about the table of the angle. This form of bracket must not be used within six courses of the eaves of a building, because there is insufficient weight above it to eliminate the risk of damage to the fabric.

The bracket F is capable of several modifications to favour its adoption. It can be lengthened to carry a greater number of pipes, or placed the other way up, and it may be secured to either beam or bracket. The strapping of coils of pipes is done on the same principle. The sketch is characteristic of supporting a brine service of flow and return.

The wall or ceiling clip G is a common method of supporting light pipes—up to say 4 in. bore—close to a wall or underneath a floor. The clip is bent from one piece of flat-bar around the section of the pipe to be clipped, the hole is drilled and then the loop is sawn through as marked. The fishtailed end may be as shown or as drawn for C bracket, both are secure when cemented in, and 4½ in. is usually sufficient for this style of clip to be let in the wall. It will be understood that the strength of the flat-bar used in such clips will not permit of much distance between the pipe and the wall, but for ceiling work there is really no limit. Where such a clip is needed for bolting to a beam or a girder, the wall end would simply be converted into a right-angled bracket and drilled for bolts or screws.

There are other designs in pipe supports, but the selection given and described here will cover every phase of general pipe-work. Brackets and expansion rollers for steam pipes of large bores are mentioned in the section dealing with pipe-fitting on steam ranges.

CHAPTER XXIX

CONCERNING STEAM-TRAPS

Steam Traps.—Steam traps, as their name implies, are vessels containing some form of mechanical device whereby the water of condensation is trapped from the steam and expelled from the pipes, so that the steam is allowed free access to all the system. Briefly, the draining of large ranges is effected by placing pockets at intervals along the pipes for the arrest of the water, and to these pockets smaller pipes leading to the traps are fixed. On small service pipes, Ts are inserted at the lowest points, also connections are made at the extreme ends for traps, so that means of allowing the water to escape is just where it is likely to collect and lie. The draining of steam pipes is absolutely vital, and if means for this were not provided the condensate would soon fill the bores and eventually go cold, then the mains would be useless. Partial water-logging will cause hammer, and disaster will soon follow in its train.

There are many designs of steam traps and there are many makers, but the principles on which they work are few. There are traps to suit every situation and condition of high or low pressures, whether for constantly discharging or for intermittent work, and although the traps work automatically when once adjusted, they should be placed where the discharge is in view so that a glance will satisfy the attendant that all is well or otherwise. Comparatively few engineers are acquainted with the various makes, except in a superficial manner, for few have to deal with these in actual practice. Several sketches are included in Fig. 106 to illustrate the principles of some well-known makes that are on the market.

In the high pressure systems it is the rule to fix either the bucket or the syphon type of heavy construction ; and lighter ones may be had for the low pressures. The strength of the two is a point that the engineer must note, lest a low pressure trap be fitted to a high pressure range and cause a mishap. For the small service pipes at low pressures there are many designs in float and expansion traps.

To explain the principles of the various types a brief description of each is here given. Full instructions for fitting and starting are included with all traps which are supplied direct by the makers.

The Bucket Trap.—The bucket trap, as will be seen in the diagram, has a bucket to which a needle valve is attached. The water first enters by the inlet pipe, and in this particular design falls into a gallery, which is a feature of one of the best traps of British make. When the water in the well overflows into the bucket the latter sinks and opens the discharge valve, the pressure of steam behind the water forces it out, and then the bucket is free to rise again, thus closing the valve. The diagram illustrates the principle and not necessarily the design of any particular trap, but it may be said that this style of bucket trap is about the best that the practical man can select. The hinged bucket is no doubt as efficient and dependable except for the hinge failing, although that is only likely to occur after years of use. Again, this style of trap has an air cock fitted to the lid, and by a test here it can be ascertained if the trap is working properly without noting the discharge.

Traps with steam pressure in them, such as the bucket type shown, are suitable for lifting the discharge to any desired height that the pressure will allow. Expansion traps cannot do this.

Referring again to the gallery shown in the diagram of

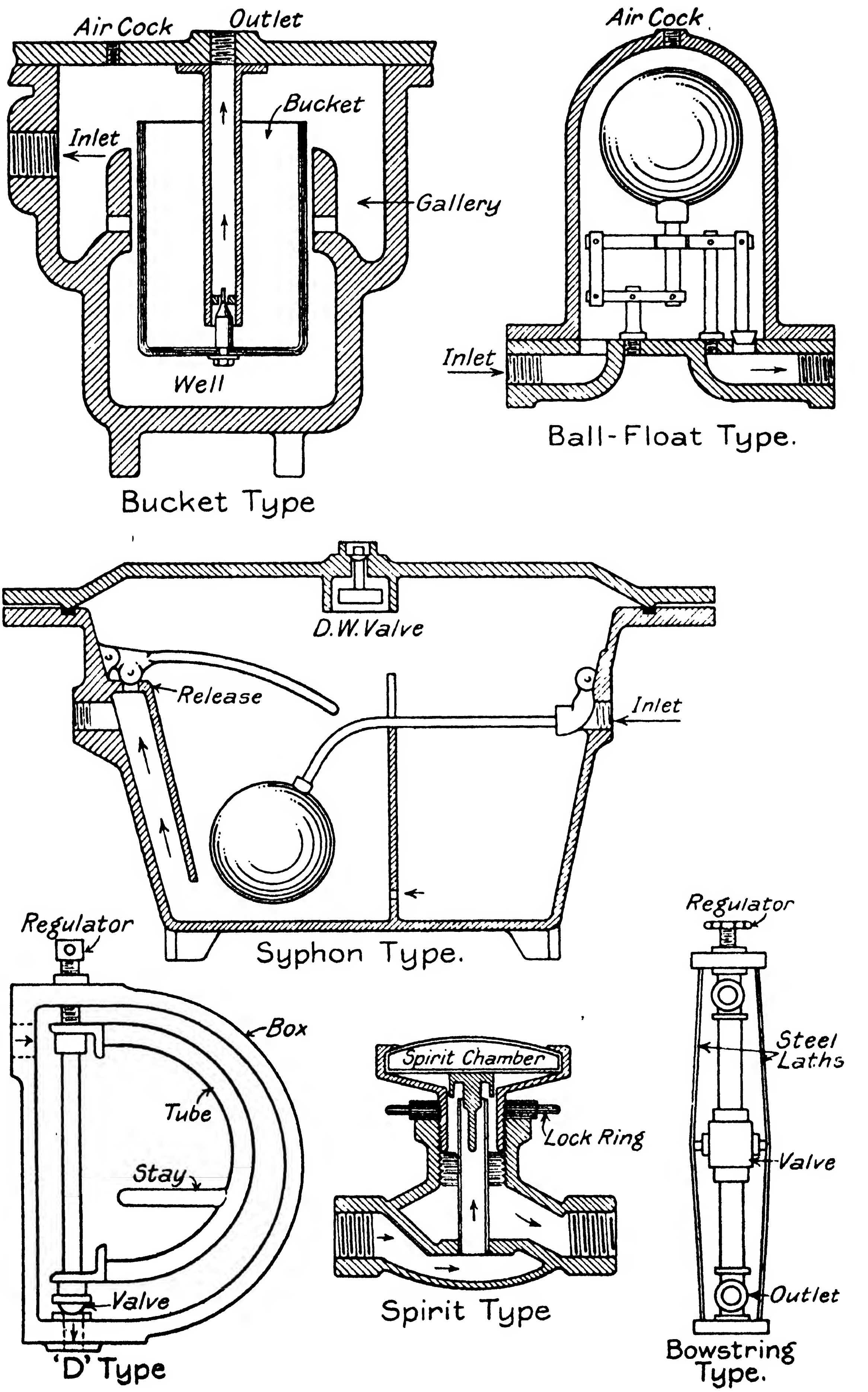


FIG. 106.—Steam Traps of Different Patterns.

the bucket trap its function can be described in a few words. After the discharge of the condensate from the bucket a quantity remains in the gallery, and this flows through orifices into the well, causing the bucket to speedily rise: the cut off of the following steam is thus hastened. The inlet and outlet need not be as shown, for there are designs with both in the horizontal plane or in the vertical one as preferred.

The Syphon Trap.—The syphon trap can be said to be very popular, as it is most efficient and silent in action; its cost, too, places it favourably for general adoption. This trap has to be partly filled, as does the bucket trap, for it to commence working, but the difference between the two is that the syphon trap will not admit either water or steam if there is not water in the well to operate the valve. The bucket trap as will be seen, will pass steam if the well is empty, and sufficient has to condense to float the bucket before it will close the valve. In the syphon trap as the ball float rises the arm lifts the release valve, and in action the trap adjusts itself to give an almost constant discharge. In the lid there is a dead weight valve, and by forcing this aside it can be ascertained if the trap is working when the discharge is invisible.

The Ball Float Trap.—The ball float trap is very simple to understand and is eminently suitable for low pressures. As the float rises on the water accumulating, the valve attached to the levers is opened over the discharge. Simple in construction, it is a type that is favoured by many who use low pressure steam, as it rarely gives any trouble.

Expansion Traps.—In factories where much steam is used for process, and in radiators for heating and drying, many small traps are necessary. It is not wise to instal one trap for two or more drain pipes. Each outlet should have its own trap, but beyond the traps the discharge may be collected into one channel. It is false economy to put in the lowest priced trap that money can buy, although some of the reputed makes are not costly in the initial outlay. Of the many designs and styles in expansion traps, probably the one with the semi-circular tube of gun-metal is difficult to excel. The diagram shows the trap with its cover removed. The inlet is at the regulator end and the outlet at the other; a ball valve seals the aperture when the heat of the inrushing steam expands the tube. There are traps considered neater in design and which are more simple to fit, but no low priced expansion trap can be better than this one for pressures up to 80 lbs.

The Bowstring Trap.—Another design which is of the same principle as the previous one is shown: this is of the bowstring type, in which spring steel laths hold the valve to its seat in the gun-metal column. The expansion of the column caused by the steam on entering it closes the valve by putting tension on the springs.

For Calorifiers.—The bowstring idea, it may be pointed out in passing, is largely adopted for controlling the steam supply for calorifiers, thus keeping the water supply heated to any desired degree of temperature.

The Spirit Trap.—A distinct type of trap is that in which spirit is enclosed in a container shaped somewhat like a mushroom, but its action is essentially the same as all expansion traps. In this, instead of a metal, a spirit having a high co-efficient of expansion is used, and as the steam reaches the trap, expansion of the spirit causes the valve to close. Adjustment is made by easing the lock-ring and regulating the spirit container until the discharge is correct, when the lock-ring is again secured.

Care of Traps.—Many of the expansion traps are very sensitive, and in intermittent use are liable to seize, and although the job of releasing one does not take more than a minute or two, a skilled man should attend to it. Irresponsible persons have been seen to emulate the pipe-fitter rather than be at the trouble of calling one in, and to get a hot douche for their interference.

Isolation Cocks.—A shut-off valve should be placed immediately before the trap, so that the steam can be shut off when the trap needs attention. If this is not done, it means that the service pipe has to be put out of commission whilst the repair is made. All traps need a little attention at times, because the action of steam and hot water is corrosive. Small particles of rust and scale from the pipes will at times cause irregular working. A jar on a small trap or a kick at a large one—that is refractory—will often start it working again, and this should be tried before further effort is attempted.

Uses of the Condensate.—The water of condensation from steam traps is very valuable for boiler feeding purposes. In every case where the plant is up to date all the water is conducted to the hot well from which the feed water is drawn. There may be a few isolated traps discharging small quantities of water, which will scarcely be worth the initial outlay on pipes and fittings necessary to link them up with the system of drainage, but usually the condensate is very precious.

Steam traps that are only working intermittently must be protected from frost. Long exposed discharge pipes in which the condensate has time to cool are susceptible to seizure, and when the discharge is stopped the trap cannot work; it will then freeze up and burst. The author recollects a frost of five degrees being responsible for the bursting of fifteen steam traps during one night at a large factory when the process was shut down.

CHAPTER XXX

VALVES IN GENERAL USE

Valves.—As previously stated, there is such a wide range of valves and cocks that space will not permit oi more than a brief reference to, and definition of, the various types, together with their applications and functions. Still, from this the uninitiated reader will be able to have at hand in concentrated form the information that is usually so elusive because of the several terms that apply to the same function. The various valves in connection with steam boilers will first be taken.

Safety Valves.—On every boiler there is at least one safety valve, and on the larger ones there are two or three. A safety valve, as is known, is one that blows-off to the atmosphere when the accumulated steam reaches more than a predetermined pressure. This applies not only to boilers, but to any container, be it a vessel or pipe. The word safety, as applied to a valve, is rarely used by engineers, the term is too vague, and so a more definite one is applied to each particular form.

Types.—There are three types of safety valves, namely, the lever and weight, the dead weight (D.W.), and the spring loaded—other names for these are used, but they apply to instalment of the valves other than on boilers, as will be mentioned.

High and Low.—On all large boilers there is a safety valve or alarm which warns the attendant of irregularity, i.e., when the pressure is too great, when the water is too low, and on some boilers, when the water is too high. This valve is called the "high and low" or the "compound," and its full title is the high steam and low water safety valve, or—as the case may be—the high steam and high and low water safety valve.

The sketch Fig. 107 depicts the high steam and low water valve as fitted to all Lancashire and similar boilers. As will be observed, there is a lever inside the boiler carrying a float

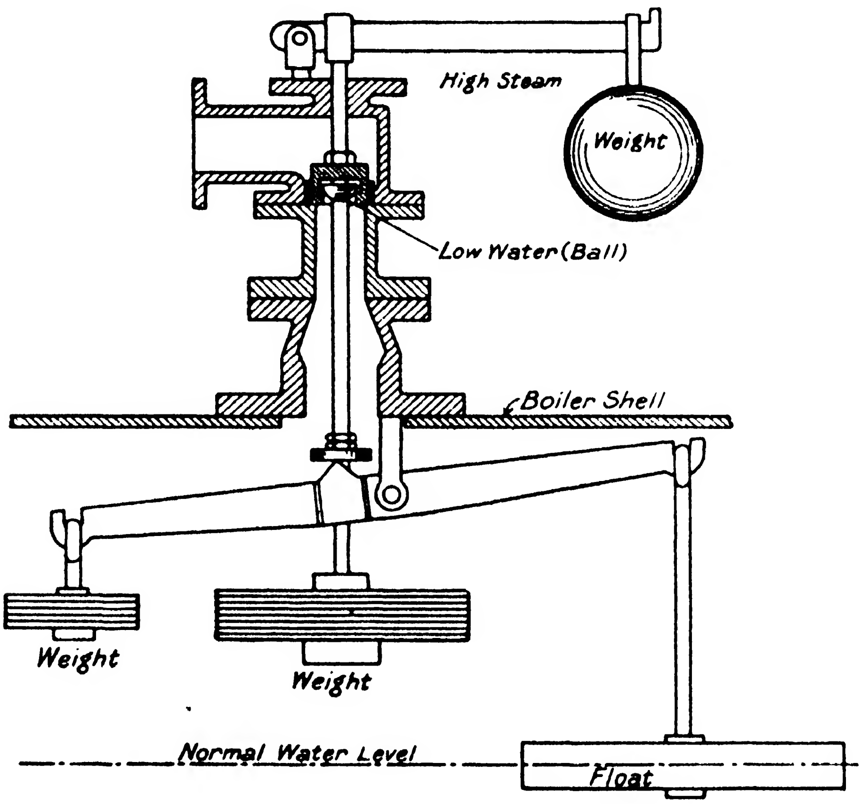


FIG. 107.—The High and Low Safety Valve.

at the one end and balance weight at the other. The valve is of the ball type, and this is held on its seating by the weight attached to the spindle which passes through an eye in the lever. The float is usually a rectangular earthenware slab, but some floats consist of a number of wrought iron cylinders. In action when the water level falls below a certain point and leaves the float suspended, the weight of the latter will operate the control lever; the points beyond the fulcrum will then rise and lift the ball valve from its seat, thus liberating the pressure and calling attention to the fact that something is irregular.

The sketch also shows the weighted lever safety valve for high steam pressure. Really there are two valves, one inside the other; the diagram makes this clear.

The High and Low Whistle Alarm.—In Fig. 108 a high and low whistle alarm is shown in diagram. This is a type fitted to water tube boilers, where little latitude in the variation of the working level is permissible, owing to the drums being of comparatively small diameter. This alarm is usually compounded with a dead-weight high steam valve. As will be seen, it has two floats, one for high water and one for

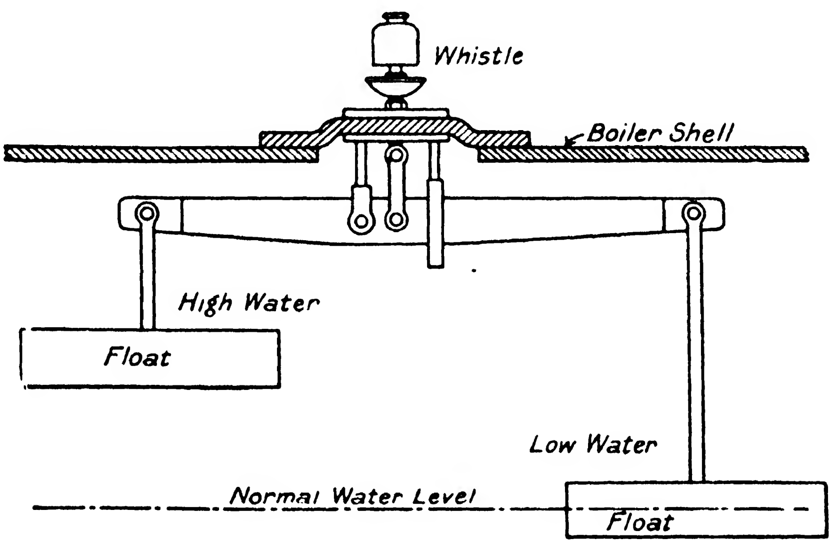


FIG. 108.—The High and Low Whistle Alarm.

low. The setting of these valves is fixed by the makers—who also supply the necessary working instructions—to suit the pressures of the boilers.

The Dead-weight Valve.—The dead-weight valve, as its name implies, is a heavy weight consisting of a number of cast iron annular rings saddled upon a valve similar in construction to that shown in Fig. 107; the area of the latter decides the weight. A common diameter for the dead-weight valve on a large Lancashire boiler is 2 in. and for the D.W. valve the boiler engineer will calculate the weight for an area of $2\frac{1}{16}$ in. diameter, to be assured of retaining the full working pressure of steam within the boiler. The sketch (Fig. 109) shows the standard type of D.W. valve.

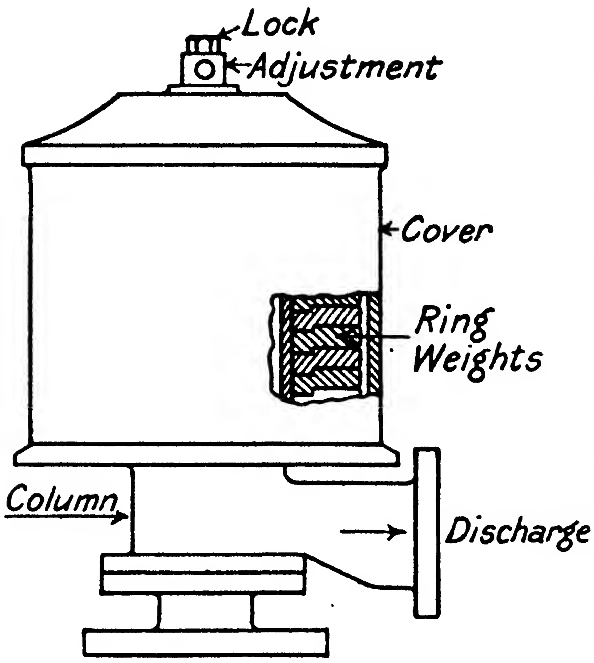


FIG. 109.
The Dead-Weight Safety Valve.

The Weighted Lever Valve.—The weighted lever valve, as seen in Fig. 107, is well known. The cheese weight is made and adjusted to suit the working pressure. This type of valve is common enough for all purposes of safety, but the spring loaded types are gaining greater favour everywhere, being more compact and quite as efficient.

The Spring-loaded Valve.—The spring-loaded safety valve differs from the lever and the D.W. types, inasmuch as the valve is kept to its seat by a coil spring in compression. Adjustment can be made with the nuts on the threaded spindle, as seen in Fig. 110. Some types have locks attached, and some have seals, to prevent any irresponsible person interfering with the setting.

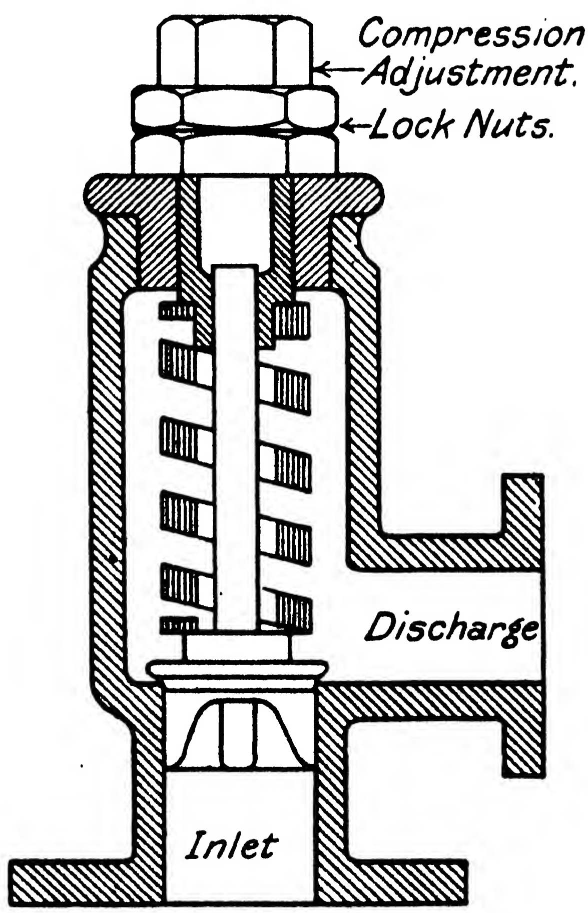


FIG. 110.
The Spring-loaded Safety Valve.

The Relief Valve.—The relief valve does not differ from the spring-loaded or lever-weighted safety valve, except in a technical sense. It is usually of the spring-loaded type, but there are several designs. One does not class a boiler safety valve as a relief valve, although in almost every other application it may be classed as such.

The Junction Valve.—The valve which controls the flow of steam leaving the boiler is usually called the junction valve. It is generally of the same pattern as the common angle valve, where the outlet is at right angles to the inlet. It may also be classed as a stop, or shut-down valve. The sketch Fig. 111 shows the style in diagram.

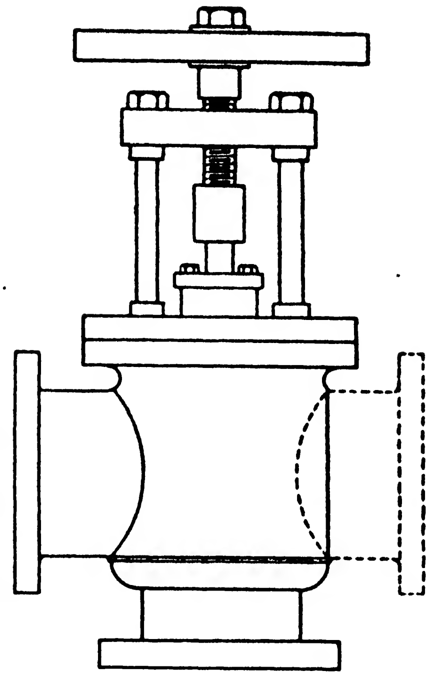


Fig. 111.
The Junction Valve.

The Feed Valve.—The valve by which the water is admitted to a boiler and other similar vessels is usually a combined stop and check valve. The flow can only be in the one direction because there is an independent valve which is lifted from its seat automatically by the inward rush of fluid, but drops back on to it when the flow pressure falls below that of the vessel: such a valve is necessary when a slow acting reciprocating pump is employed to give a constant feed.

The Blow-off Valve.—A blow-off valve is fitted to the bottom of a boiler for the purpose of blowing out at intervals the lower stratas of water which are heavier than the surface layers of water because they are charged with permanent hardness: the valve is also used for emptying the boiler. On large boilers these valves are of the parallel slide pattern, with a quick acting rack and pinion. (See also blow-off cock.)

The Isolating Valve.—An isolating valve may be any form of shut-off valve which isolates some service or generator. Usually it refers to a check valve, one type of which is fixed next to a blow-off valve on a boiler outlet, where a series of blow-off pipes discharge into one main. The isolating valve, or to give it another name—the non-return valve—is added as a precaution against the blow-off from any other boiler returning to an empty one in which men may be working. Another type is for inserting in the steam range for a like reason, i.e., to prevent live steam reaching a dead boiler.

The Scum Valve.—The scum valve is similar to the blow-off valve, but is fitted to the boiler on the water line where, owing to dirty water, it is necessary to clear the scum from the surface.

There is a make of vessel on the market which can be fitted to boilers to collect the scum, and at the same time circulate the water. Reference is made to this vessel in Chapter XIX, which deals with the fixing of a circulator.

This concludes valves appertaining to boilers in general, but we have to follow a series of valves for steam and general use.

Stop Valves.—All valves by which the flow of fluids can be stopped are stop valves, but the term is employed with more definite direction than when applying to all such. It usually applies to a valve that closes some service, whether for gas or liquid. The differences which cause these valves to be known by various names relate chiefly to the construction of the valve details, as will be mentioned later. Fig. 112 shows a common type of stop valve for gases, whilst the junction or the angle valve (Fig. 111) is another pattern.

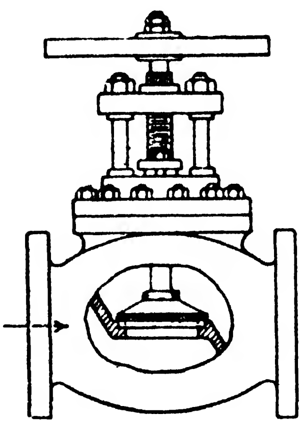


Fig. 112.
The Stop Valve.

The Superheat Valve.—For the resistance of high temperatures as well as high pressures, the superheat valve is especially constructed. It may be said that there seems to be some difficulty amongst many engineers in grasping the fact that superheated steam can be of very low pressure. It does not follow that the increase in temperature will considerably increase the pressure; it will only do this to a negligible degree. It need only be explained that steam already is a gas and it cannot expand sufficiently to record an increase in the pressure, as one often imagines it to do. Superheated steam is higher in temperature certainly, but it contains less heat in latent form than saturated steam.

Superheat valves as a general rule are strongly constructed so that they are able to withstand all steam pressures, and although they are of common design the valve and the seating are composed of substances which are not so rapidly affected by the high temperature of the passing steam. (See also M.A.C. valve).

The Fullbore Valve.—The fullway, sluice, or gate valve (Fig. 113) has a sluice which is operated by a screwed spindle attached to it and the hand-wheel. There are many patterns, but the principle is the same. Some have paralleled slides, and some have tapering ones with a wedge-shaped sluice. Some have the operating screw exposed and some have it encased; and there is a quick acting type which has a piston rod instead of a screw to operate the sluice. The sluices of the

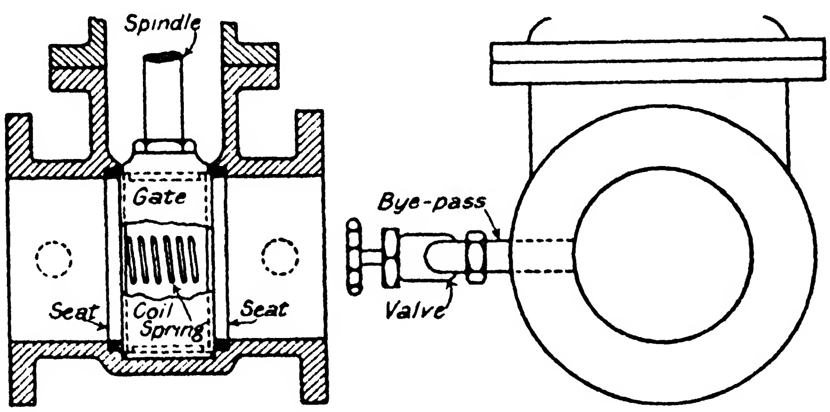


FIG. 113.—The Fullway Valve, showing Bye-pass.

paralleled class are constructed of two sliding portions, which are kept in position tightly against the seatings by means of a spring in compression, as shown in the diagram, but the wedge-shaped sluice usually consists of a solid diaphragm.

The fullway valves on large pipes under great pressure are difficult to open because of the pressure being against one face of the sluice only. On steam range valves a bye-pass, as shown in Fig. 113, is fitted: the use of this relieves the unequal pressure, and at the same time heats up the dead portion of the range slowly, thus preventing distortion in the pipe-line. To operate quick-acting valves on cold mains, a powerful leverage is applied to the spindle either by hand, or by mechanical or hydraulic power.

On the better classes of sluice valves an index finger is attached, so that one may know at a glance the position of the sluice without having to try the wheel.

The Reducing Valve.—When it it desired to bring down the boiler pressure to a suitable working limit for service pipes, reducing valves are inserted in the pipe lines. The majority of these valves are of the spring loaded type, as shown in the diagram Fig. 114, but there are other designs, a few of which are of the loaded lever pattern. Briefly the reduction is effected as follows :—The full pressure of steam is admitted to the valve chamber and attempts to lift the valve from its seat, but in opposition to this attempt the steam pressure exerts a closing effect by means of a flexible diaphragm of larger area attached to the valve spindle. The tension put upon the spring assists the pressure of steam to lift the valve from its seat. The coil spring is capable of being adjusted—within a certain range of course—to produce a predetermined pressure beyond the valve.

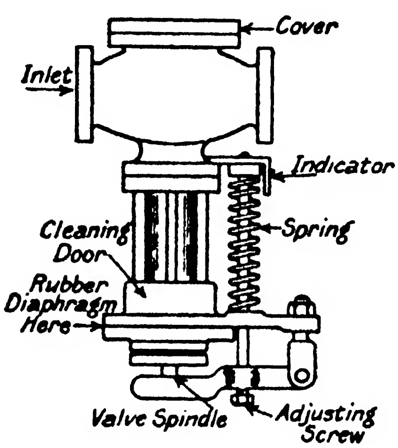


FIG. 114.
The Reducing Valve.

As the spindle of a reducing valve must operate in the steam or hot water it sometimes happens that corrosion, or dirt from the pipe, causes it to stick: if so a slight jar or a little more compression on the spring with a forked lever may free it. The adjustment should not be altered, as this will not cure the trouble. On all important steam ranges a spare reducing valve is kept handy, then if the one in use fails to give satisfaction it is removed, and the stand-by valve inserted.

On any pipe line where there is a reducing valve there should be a safety or relief valve immediately following the former as a safeguard against the higher pressure creeping into pipes and vessels not capable of withstanding it.

The Surplus Steam Valve.—Reducing valves are sometimes called surplus steam valves, the difference being not in the valves but in their application. By "surplus steam" is meant steam which primarily is generated to do some work in a high pressure capacity, and then it is passed through a reducing valve into receivers to function at a much lower pressure, as is often needed in factories where steam heat is largely used for boiling-pans, etc. The surplus is really to make up any deficiency of low pressure steam in the receivers, when the demand for such is greater than the supply coming from the exhausts of prime movers using the higher pressure. (The steam from such units is called back pressure or exhaust steam.)

The Exhaust Valve.—When exhaust steam is collected for further use, an exhaust valve is inserted in the circuit to pass steam to atmosphere—acting as a safety valve—when the low pressure steam receivers are fully charged.

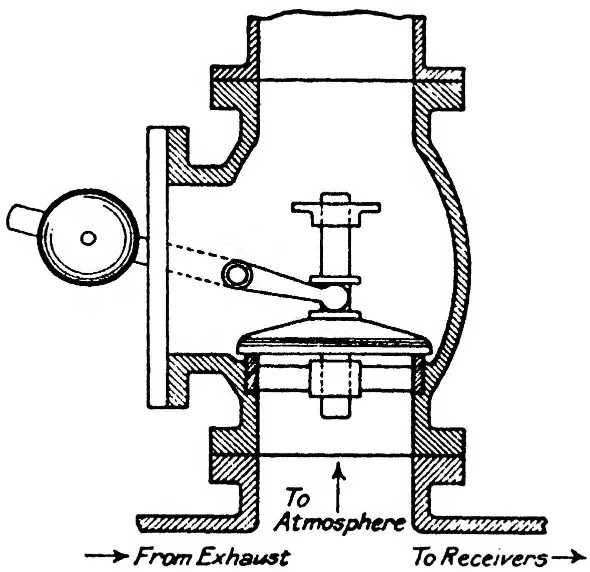


FIG. 115.—The Exhaust Valve.

Sometimes an exhaust valve is fixed to an exhaust pipe that has its outlet enclosed for the purpose of directing the steam to the low pressure receivers, or to the condensers. It is very necessary to instal one or more of these valves in such a scheme, otherwise the back pressure exerted against the exhaust of the high pressure units would cause the latter to cease running, should there be no other means of disposing of the steam.

The valve is balanced by means of a weighted lever, the latter being adjusted to suit the pressure. Some designs include a dash-pot (buffer) to soften the fall-back of the valve in closing. Fig. 115 is of a common type.

The Back-pressure Valve.—Back-pressure valves are really non-return valves, and they function exactly similar to the Check valves shown in Fig. 116. They are called back-pressure valves for the simple reason that they prevent pressure from getting back. The exhaust valve is sometimes referred to as a back-pressure valve because its function is to liberate back-pressure steam, when the receivers are fully charged.

The Ball Valve.—To the engineer a ball valve is a valve that contains a ball. Its usual form is a ball check valve—one of the non-return series—in which the ball is captive. The back pressure of the fluid sends the ball against the orifice and so prevents the return flow. The ball valve or cock, known to plumbers as well as to engineers, is really a ball-float valve, because the ball is a float which follows the level of the liquid, and so keeps the valve operating as required.

The Non-return Valve.—There is great similarity in the check, the retaining, and the non-return valve, for the principle and the function is the same. As with other types it is in their application that the terms and valves differ. The controllable check has its valve loose upon the valve-stem, the latter being connected to a hand wheel so that the valve can be held shut if required so. When the pressure is removed from the valve, the flow is free to lift it from its seat, but the return is checked. In Fig. 116 are shown diagrams of what are known as check valves of the horizontal and the vertical types; these are not controllable.

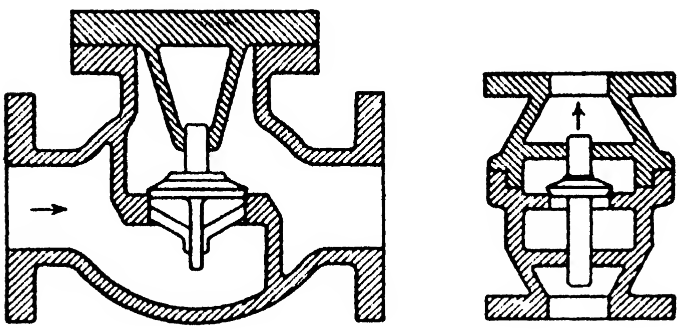


Fig. 116.—Non-Return, or Check Valves.

In Fig. 117 the swing-check, reflux, or retaining valve is shown.

The Foot Valve.—Foot valve is the name given to a retaining valve which is placed at the foot of a suction pipe. The valve or clack is free to lift by the flow, but drops back on to its seat the moment that the suction ceases, and so keeps liquid in the pipes. (See non-return valves.) In almost every instance one will see the term in combination with Strainer, for it is a certainty that where a foot valve is fitted there is also a strainer to prevent any solid particles from obstructing the action of the valve. If this precaution is not taken very often the suction pipe would drain itself, and priming of the pipe to start the suction again may be necessary.

The Globe Valve.—Some steam valves are designed with globular bodies, hence the term.

The M.A.C. Valve.—The celebrated M.A.C. valve (usually called Mac valve) is universally known to engineers. It is made by the patentees—Hopkinson's—a name which is itself quite sufficient recommendation for a valve. There are many valves with renewable valve and seat upon the market which under modern conditions will not stand up to the work for any length of time. Some foreign valves are particularly troublesome in this respect, but in the Mac valve a special metal (Hopkinson's Platnam) is used in the making of the valve and seat. The latter is also reversible, thus one may say that there are two seats in one.

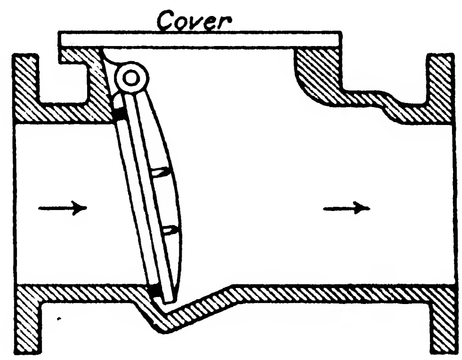


FIG. 117.—The Swing-Check, or Reflux Valve.

The valve throughout is of robust construction and is specially designed to meet all conditions; its trade mark is coined from the latter statement, and those three words—meet all conditions—furnishes the answer to a question which has been asked a countless number of times. The three letters—M.A.C.—have formed the subject of many arguments amongst engineers and others, but very few are acquainted with its origin and meaning.

The Clack Valve.—All retaining valves which are not of the ball type are clack valves. The name is coined by the noise made by some forms of this valve dropping back on to its seat, and it generally applies to the hinged, or swing, check type and to the common lift pump which has a lead-weighted leather clack.

The Poppet Valve.—The poppet valve, as fitted to most internal combustion engines, is also employed as a

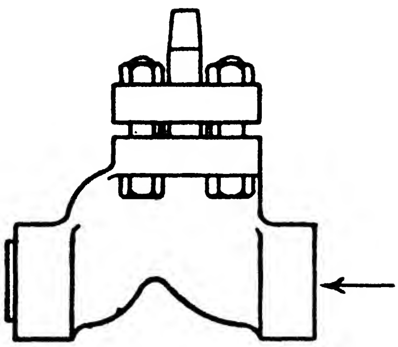


FIG. 118.
The Hydraulic Valve.

retaining valve on some air compressors and in similar cases where the fluid to be retained is gas—not a liquid. The valve is returned to its seat with the aid of a light coil spring, the latter not being sufficient to impede the flow more than a negligible amount.

The Needle Valve.—In the float chambers of many carburetters there is a needle valve operated by the float. The valve consists of a male and female cone. This idea is common to many hydraulic valves, the spindle of the needle having a thread which screws into a glanded nut. As the pointed end is screwed into the female portion it revolves and so seats itself perfectly. A standard type of hydraulic valve is outlined in Fig. 118.

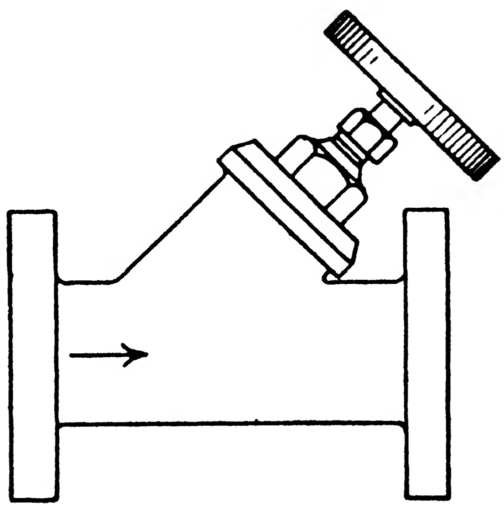


FIG. 119.
The Y Pattern Valve.

The Y Valve.—This valve is of the ordinary shut-off design, but is shaped as the letter Y. There are occasions and situations where the operation of the standard design of valve is impossible, or at least inconvenient; these are where the Y valves function. The style is illustrated in Fig. 119.

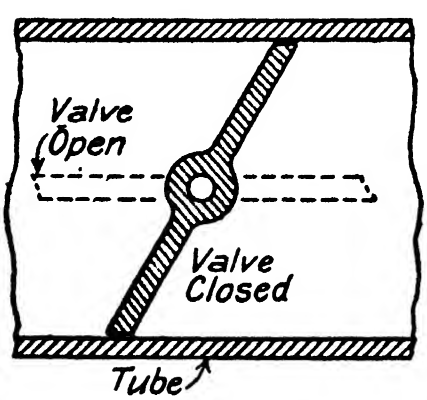


FIG. 120.
The Butterfly or Damper Valve.

The Butterfly Valve.—In Fig. 120 a sectional view of the butterfly throttle valve is shown. This valve is very quick acting, only one-sixth of a turn being required to open full or close the orifice. It does not shut off tightly and is only suitable to low pressures. The idea is extensively adopted on damper valves in flue and stacks.

Piston or Sleeve Valve.—The

piston valve is similar in shape to the stop valve, the difference between the two is in the opening of the orifice, which in the former is affected by means of a piston containing ports and this operates in a cylindrical chamber. The piston is actuated by a lever, and it will be readily understood that the latter need only travel through a very small arc to open the ports to their full extent. The piston valve is rarely met with so far as general engineering is concerned.

The Regulus Valve.—Regulus valves are similar to the other valves of standard types, but are generally constructed of lead alloy to withstand corrosives in chemical factories, etc. The name applies to the metal more than to the valve, although the latter are spoken of as Regulus valves—really they are Regulus-metal valves.

CHAPTER XXXI

COCKS IN COMMON USE

The Cock—The cock, as the engineer knows it, is composed of a tapering plug having a hole through its diameter, and a body in which the plug revolves so as to pass, or stop the fluid as required. The turn of the plug through an angle of 90 degrees or less opens the orifice from shut to full bore.

Types.—There is an assortment of cocks, as there is of valves, and it may be that there is little less variation in styles and designs, but the plug is common to all cocks. The differing designs are to satisfy the conditions in which the cocks are to function, and relate mainly to the direction of flow, and to the pressure to be sustained. Cocks are made in various metals such as brass, bronze, cast iron, and malleable iron ; and in glass and earthenware for chemicals.

In Fig. 121 is shown in diagram a collection of common types and various connections (methods of connecting) in which cocks are stocked by the makers. A is the standard plug cock for little or no pressure ; the plug is held in the body by the nut and washer shown. When these simple cocks are installed, the plugs should be smeared with a little petroleum jelly, as this prevents them from sticking, and arrests any slight weep that may occur if the plug is a little irregular. In every cock it is supposed that the plug is ground in to suit the body, but this applies only to reputed makes, and not to the low priced nameless variety which are stocked by many merchants. The latter are very costly when it is desired effectively to arrest drip from the plugs.

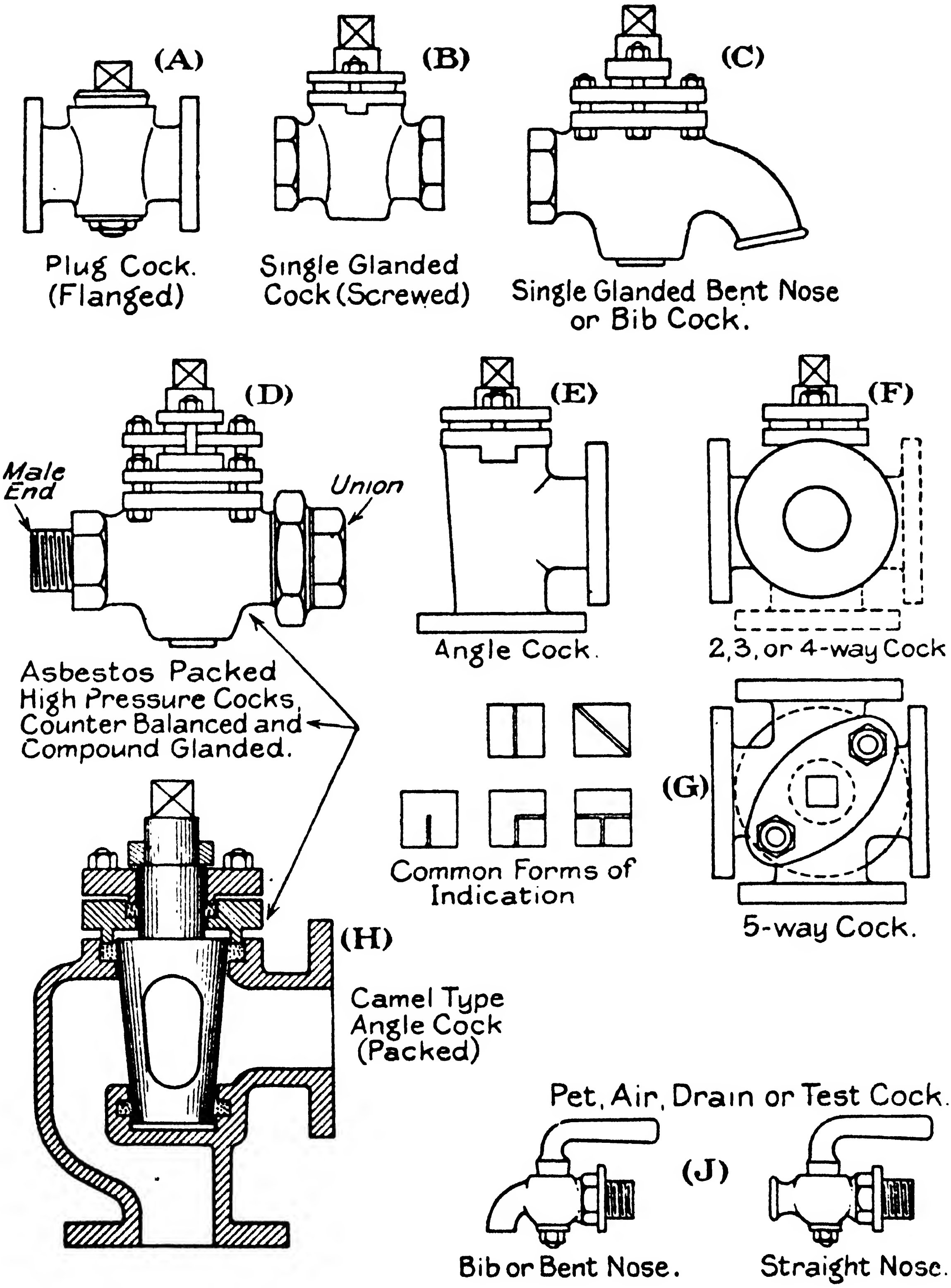


FIG. 121.—Some Types and Details of Cocks.

The single glanded cock B is selected for low pressures. A step further is the single glanded cock with holding-down plate, as shown in C. The latter cock is shown with a bent nose, and this style is usually called the bib-cock. The connections do not effect the name of the type, but are a matter of detail when ordering or specifying.

For high pressures there is actually one design of cock suitable, and that is the asbestos packed double-glanded type, D, the section of which may be learned from that shown in H.

Angle Cocks.—Angle cocks can be obtained with more than two ways; E, F, and G being characteristic of the design. H shows in section the type of angle cock known as the camel, and it is so designed that it can be packed for high pressure use: this type gives what is called the straight through flow, and in this respect it differs from type E.

Indicators.—Five common forms of indicators are shown. On the " square " at the top of the plug to which the cock-key is fitted will be found one of these forms. The groove indicates the position of the hole in the plug, thus one is able to tell at a glance how the latter lies relative to the orifice in the body of the cock.

Small Cocks.—On those cocks in which the key or handle is an integral part of the plugs, the handle is the indicator, as with the household gas-tap. The pet, drain, air, or test cock, as shown in J, is of the latter type, the handle being known as the lever handle so as to distinguish it from the T handle. Air cocks, test cocks and pet cocks are small articles, and are fitted as required for the discharge or admission of fluids; whilst the drain cock may be of any type of suitable bore, which will withstand the pressure from the fluid in the vessel to which it is attached.

Boiler Cocks.—The cocks appertaining to boilers are: the blow-off, the gauge, and the try cocks. The blow-off cock on a boiler of any importance has a special locking gland which prevents the cock-key from being removed except when the position of the plug is at " full open " or " closed."

Water-gauge and try cocks are constructed with openings opposite the passages so that after removing the plug the bores may be cleared of any obstruction from scale or dirt.

The Ball-cock.—Ball-cock is the name by which the ball-cock valve is known to many who employ it.

Earthenware Cocks.—Glass and earthenware cocks cannot be made for screwing or bolting into position, neither can they be made to withstand any considerable pressure, nor for greatly varying temperatures. The earthen cocks common to chemical works have flanged connections for clamping bands, and by these they are secured to the vessels, or to the line of pipe, as the case may be. The plugs, too, cannot be secured to the bodies as with metal cocks, nor will they stand rough usage: they usually have T-shaped handles.

CONCLUDING REMARKS

On many occasions the author has had engineering pupils assisting on outside erection work. Usually such pupils, whilst eager to work are no less eager to learn, consequently innumerable questions are asked, not only relating to the work in hand but to anything and everything that attracts the attention of an intelligent youth.

The latter remark will also apply to many draughtsmen whose duties take them to the site of erection, as no matter wherever one goes there is something that is new to an engineer.

Young engineers can be excused for possessing an enquiring mind that makes itself manifest by asking intelligent questions, the author always considers it a pleasure to answer such, so far as his knowledge will permit, but the asking of questions by engineers of mature years is not always appreciated. To reply intelligently to all the queries an engineer is asked is indeed an effort ; to give replies which are not sufficiently explanatory usually results in more questions being asked—perhaps the engineer's duties largely consist of replying to questions.

However, the author is convinced that the information contained in this book, especially in the chapters relating to pipe-work and valves, will furnish the answers to many of the questions usually asked. It will supply engineers and students alike with practical knowledge concerning the erection of plant—knowledge which is generally so difficult to acquire.

The subjects selected and the descriptions of the methods employed cover a wide range, such that will at least furnish ideas for the erection of any particular job of which no mention is made in the book.

It is the author's opinion that the engineering laboratories connected with our technical colleges should include in the curriculum some practice in the methods employed in erection work. At the present day there are no recognised classes whereby an engineer can obtain the most elementary tuition in the use of temporary lifting tackle. Surely this is an oversight, for it cannot be admitted that the knowledge is of no consequence. All engineers should be acquainted with such practice, for all engineers—at some time or other—come in close contact with the erection of some plant.

In conclusion it may be said that this book is of directly useful service to every student, and to every engineer irrespective of his particular sphere—or of his rank in that sphere.

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