THE POWER HANDBOOKS

ERECTING WORK

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COMPILED AND WRITTEN

BY

HUBERT E. COLLINS

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CONTENTS

I

FOUNDATIONS

An engine, to be properly set, must be set rigidly. It is necessary to have the foundation of ample size, rightly proportioned, of good material, and skilfully built. The nature of the ground must be carefully considered and provision made, in preparing it for the foundation, to reduce the liability of settling to a minimum.

Concrete foundations for engines have come into general use throughout the country, owing to their cheapness and durability, and some points on the building of these will be of service. Material for the foundations should be the best of its kind. The stone (if stone is used) should be broken clean and dry. The sand should be coarse and gritty.

Wet a small quantity of cement, and mold it in the hands; then put the sample away and see how long it takes it to set. After it has set, see how much pounding will be required to break it up. By these simple means, bearing in mind that good cement should set in twenty-four hours, or less, the quality of the cement can be readily determined.

The length of time it takes a foundation to set before weight may be safely placed on it can be ascertained, a day or two after placing the foundation, by drilling into the side for a distance of 12 in. or so. Beyond 12 in. the concrete will not be dry for several weeks, but it should be stiff enough to make some show of resistance after the first few days. Unless it does so, weight should not be placed upon it.

In "made" ground it is often advisable to drive piles, and if they are kept submerged in water, or if the ground is continually wet, the piles will not decay. The use of wood should be avoided as much as possible, however, because of its elasticity and its propensity to decay.

If a concrete foundation is to be built in the ground, with the top extending a few inches above the finished floor line, molds will not be needed for the body, but only the top is molded. A simple excavation of sufficient size and depth is all that is necessary, and after the templet and foundation bolts have been located the excavation is filled in. The size of the excavation depends on the dimensions and shape of the foundation plans furnished by the manufacturer. It should be large enough to allow for the foot measurements shown on the plans.

If no foundation plans are furnished, but only a center-line plan of the bolts, some knowledge of the principles of foundation designing is requisite. All well-designed foundations are widest and longest at the bottom, thereby securing large bearing surface, lessening the liability of settlement, and affording greater resistance to strain.

When the ground is soft and moist, the foundation should be flared considerably more than ordinarily at the bottom, to further resist the tendency to settle. If the foundation is built in quicksand and piles are not used, good results can be secured by first laying two courses of oak planks, well spiked together, extending some distance beyond the base of the foundation on all sides, the planks being 2 or 3 in. thick. The first course should be laid lengthwise of the foundation and the second crosswise of the first.

These instructions are only general, of course, and the erecting engineer should use his judgment as to how far to depart from the dimensions given in the builders' plans; or, in the event of there being no plans, how far to extend the foundations beyond that of precedent.

The forces which foundations are designed to resist are principally three in number: First and greatest weight (or gravity), which is always vertical in direction; second, inertia; third, the pull of the main belt or rope, when the unit is not direct-connected. "Inertia" may be subdivided into two classes: those of "rotation" and "reciprocation." The former is called centrifugal force, and the latter comprises the alternating forces of acceleration and retardation.

The forces of reciprocation act along the line of the piston's movement. The force of rotation acts in all directions radially from the center of the crank-disk. The forces of reciprocation become a very powerful component of the entire force exerted on the foundation when the speed is high and the "counterbalance" light. This reciprocatory influence and the force of gravity, acting at right angles to each other, produce a combined effort which is neither horizontal nor vertical, but at a greater or less inclination from the vertical, according to their relative magnitudes. When they are equal, the resultant angle will be 45 deg. from the vertical; when the inertia of reciprocation is greatest, the angle will be "greater" than 45 deg. or more nearly horizontal; if the inertia force is less than gravity, the inclination of the angle will be less than 45 deg. or nearer vertical.

Since in no case where these two forces act at angles to each other the resultant strain — their combined effort — is vertical, but is always inclined more or less outward, away from the engine bed, it is essential to build the foundation longest on the bottom, tapering gradually to within 12 in. of the top, so these resultant strains will be met directly by the resisting force of the masonry. The higher the rotative speed of the engine the more essential it is to have the ends of the foundation thus braced.

According to the laws of inertia, "the forces of reciprocation and rotation increase with given stroke as the squares of the revolutions of the crank, and with given rate of rotation directly as the length of stroke." Therefore, if the speed of an engine is doubled, the forces of reciprocation and rotation are quadrupled. If the stroke is then doubled, these forces become eight times as great as they were at the former rates of rotation and stroke.

The effect of reciprocation is modified more or less by placing a counterweight in the opposite side of the crank from the crank-pin. This counterweight opposes the forces of reciprocation, being in effect a centrifugal force, or force of rotation, which acts in direct opposition to them at the ends of the stroke only and exerts its full force upon the main bearing and front end of the foundation at midstroke, in a direction at right angles to the forces of reciprocation.

In horizontal engines, this counterweight force acts alternately in the same and opposite directions to that of gravity, but, unlike gravity, acts at the crank end of the frame only, requiring a foundation resistance directly beneath it. Suppose, then, the weight of the engine to be equally distributed along its entire length — greater strength would be required in the front, or crank end, than in the back, or cylinder end, of the foundation, and this is particularly true of foundations for high-speed engines.

The resultant of forces acting upon any point in the engine frame may be found by the following method: The heavy pointed lines in Fig. 1 represent the different forces and their direction, which are here spoken of as acting on a horizontal reciprocating engine belted to its work. The lines of force are shown lying in the direction in which they act, all meeting at a common point, as at *C*. Let two of these lines, as *C A* and *C I*, form adjacent sides of a parallelogram, *C A M I;* then the diagonal *C M* will be the resultant of these two forces. Now, with *C E* and *C D* as two sides, construct the parallelogram *C E F D*. The diagonal *C F* will be the resultant of the three forces *C I*, *C A* and *C D*.

The meaning of the pointed lines is as follows: The line *C A* represents the force of reciprocation on a horizontal bed; *C I* is the weight strain and *C D* the belt strain. The line *C B*, opposite and equal to *C A*, represents the inertia force on the return stroke. The forces of reciprocation surge forward and backward, giving a "sailing" motion to the engine frame when insecurely fastened to and held by the foundation.

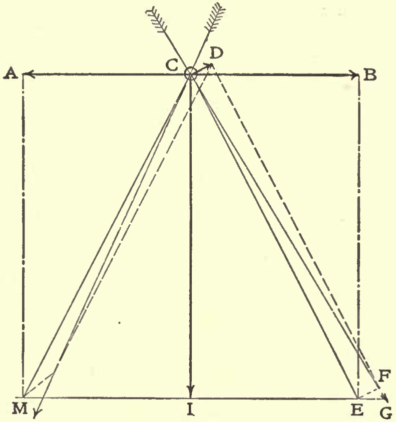


FIG. 1

Vertical engines act more directly downward upon their foundation; both weight and the forces of reciprocation acting in that direction, the former always downward and the latter alternately upward and downward. In this type of engine it is the force of rotation which necessitates widening the foundation at the bottom; therefore, the force developed by the counterweight has the same tendency to tip the foundation over as have the forces of reciprocation in horizontal engines. But counterweights should not be proportionately as large in vertical engines as in horizontal engines, for the reason that their effect is resisted with more difficulty than are the vertical strains of reciprocation.

In all foundations it is easier to provide for vertical than horizontal strains. The mass and form of foundation, for either a vertical or a horizontal engine, should be subject to modification, according to the speed at which the engine is to be run, the weight of reciprocating parts and the proportion of counterbalance to that weight. It should be remembered that increasing the counterbalance increases the force of rotation, while decreasing it, generally speaking, leaves a larger force of reciprocation unresisted within the engine, increasing its effort upon the foundation at a given rate of rotation.

With a vertical turbine the only force which acts upon the foundation is that of weight, or gravity. The twisting strain between the motor and generator is taken up by the frame itself. With a horizontal turbine, the strain on the foundation is that of weight, and unless the frame is sufficiently strong, the twisting strain also acts upon it. The frames are supposed to be strong enough, however, to take up all twisting strain.

Having pointed out certain essential features which govern design, it will be as well to consider the construction of the foundation. Concrete foundations will be considered first, although the foregoing applies to any kind of foundation.

The dimensions and shape of the foundation having been decided on, a mold must be made. The inside dimensions of the mold must be equal to the dimensions it is desired to make the foundation, of course. The mold may be made of planks, sufficiently heavy to withstand all pressure and strain of tamping the concrete, without "giving."

If the foundation is to remain rough on its surfaces, just as it comes from the mold, care should be taken

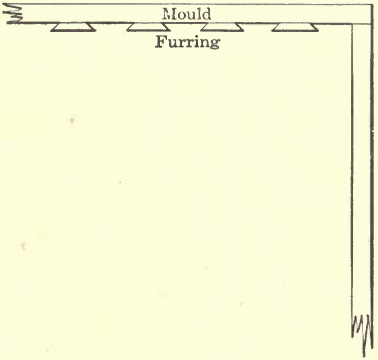


FIG. 2

so to construct the mold as to leave clean, uniform surfaces. When it is intended to give the foundation an extra finish, furring is nailed to the inside of the mold. When the mold is removed the furring will remain imbedded in the surface of the concrete and furnish a hold for the finish. This furring should be fastened lightly to the inside of the mold, as in Fig. 2.

If the foundation is to be located so the lower ends of the bolts will be accessible, recesses should be provided in the sides so nuts can be placed over plates on the lower ends of the bolts, as in Fig. 3. The openings for the foundation bolts should be provided for in the molds by boxes, or inserting pieces of pipe where the bolts are to come.

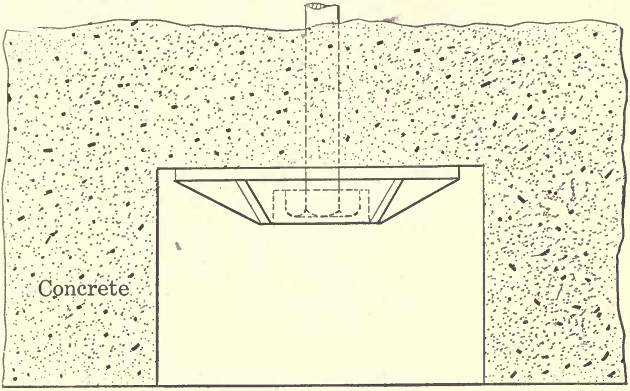


FIG. 3

The safest, as well as the quickest, way is to suspend the bolts from the templet over the mold with the nuts and plates in position, box the plate in at the lower end and slip over each bolt a section of pipe long enough to reach to the foundation top; or a wooden box can be made to serve the purpose. When the casing is placed over the bolt, pack rags, waste, or paper in the top, so as to hold the bolt central in the casing.

How to Set the Templet

Templets are furnished by most engine builders, and the makers' templets are the best. They are usually made with the outside edges of the templet of the same dimension as the top of the finished foundation; and in the case of concrete foundations sometimes the templet can be built into the top of the mold. If this is done, the templet must be placed with its bottom face corresponding in position to the finished surface of the foundation, and the bolts held high enough to allow for the thickness of nut and frame casting. This can be done by screwing the bolts far enough through the nuts on top of templet.

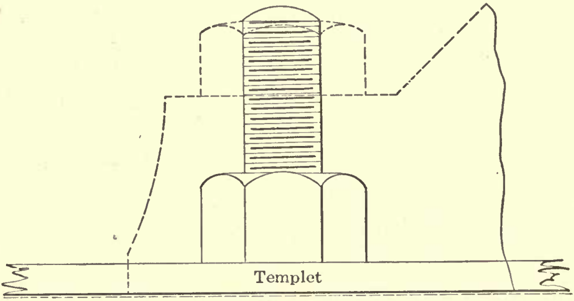


FIG. 4

Figure 4 shows how the templet, nut and bolt would look in the heavy lines, set to bring the bolt to a corresponding hight with the frame casting and nut in its final position, as shown by dotted lines.

When the foundation bolts are suspended so that their weight is on the templet, the latter should be reinforced strongly so the templet will not sag and leave the bolts at the wrong level. When the templet and mold have been placed on their proper level with the bolts in place, the templet must then be set in line.

On the templet are marked the center lines. In a horizontal engine there will be two lines, at right angles to each other, marked on the templet, the center line of the cylinder and the center line of the shaft. These lines will correspond with *a b* and *e f*, Fig. 5, and are used for reference in lining up the templet. If the engine is to be connected with a jack or line-shaft, then the center line of the engine shaft should be parallel with the jack or line-shaft and the center line of the cylinder at right angles.

To set the templet lines true, set up a line from targets on the wall to correspond with the center line of the shaft. This line can be at any convenient hight, but its two ends should be the same hight, and it should be stretched as taut as it will stand. Then set up a line from the walls, to correspond with the center line of the cylinder, the same hight as the other and as taut.

To get these lines at right angles with each other, mark off two points, *c* and *d* on the line *e f*, Fig. 5, which will be six feet from the point *g*, and then mark off the point l, eight feet from the point *g* on the line *a b*. Mark the points *c*, *d* and *l* with thread tied to the cord. If the two lines *a b* and *e f* are exactly at right angles, the distances *c l* and *d l* will each be exactly ten feet. If it is not, then the position of the line at fault must be changed until the distance is right. Be sure to keep the measurements *c g*, *d g* and *l g* exactly as given.

If these distances can be doubled to 12, 16 and 20 feet, the chances for error will be fewer. After these lines are set true they can be used for reference to set the templet lines by. If they are above the templet, plumb lines can be hung over them and plumb bobs dropped down to serve as guides to bring the templet into position. After the templet is set, secure it in place so there is no possibility of its moving. The mold under it must also be carefully secured and braced in place.

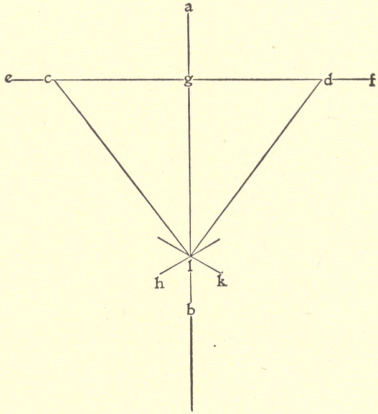


FIG. 5

If a vertical reciprocating engine is to be set, the center line of the shaft will be the only one marked on the templet. Turbines need not be set accurately, except that the piping surfaces must come in line, and for convenience of location.

Having set the templet and mold in position, with the foundation bolts in place, the actual mixing and placing of the concrete is in order. First, place the proper amount of stone in a pile and wet it; at the same time have some one mix the sand and cement in another pile, the two piles being side by side, as in Fig. 6. Wet

FIG. 6

both piles thoroughly. Put the mortar on top of the stone, as in Fig. 7, and start to mix the two. They should be mixed thoroughly by hand, first, and then,

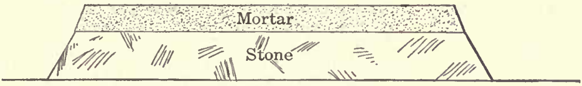


FIG. 7

beginning on each side of the pile of mortar and stone, shovel it into two piles turning each shovelful over in so doing. After making two piles of the mixed material, shovel them back into the center again into one pile. The proper proportions, using good materials, are six parts stone, three parts sand and one part cement (written 6–3–1).

Then begin filling the mold with the mixed concrete. If the mold is too deep the concrete should be run in by means of a chute, or rolled down over planks. The concrete should not be thrown in to a distance of more than 8 feet in depth. After the concrete is run in, ram it in with a spade all around the edges of the mold, to make sure that it will reach all points, and then tamp each course in until the water stands on top of the concrete. Fill the mold to within three-quarters of an inch of the line where the engine frame will set, leaving this space for the final grouting after the frame is leveled and bolted in place on wedges.

The foundation should then be allowed to set until its surface is hard, when the mold may be taken away and the setting up of the machinery begun.

General Remarks

Sometimes the erecting engineer will have problems to solve far different from those cited herewith. If the foundation bolts are to be placed in solid rock, or an old foundation, as is sometimes the case, holes must be drilled to a sufficient depth with a rock drill. When within 10 or 12 in. of the required depth for the bolt, change the drill so that one lip is longer than the other and finish drilling with it that way. This will make the hole larger at the bottom. Make the foundation bolt with the lower end split, lower the bolt with a partly entered iron wedge and drive it hard on the bottom, when the wedge will be entered so as to expand the end of the bolt, as in Fig. 8. When the engine is in position fill the hole with cement-and-sand mortar.

To avoid vibration from machinery, the foundation should be kept clear of the surrounding concrete floors by a narrow space, and if necessary this space may be filled with sawdust. Sometimes when foundations are set on a rock bottom, on which the building foundations also rest, the sound and vibration of the machinery is telephoned throughout the building to the annoyance of tenants. This can be avoided by first tamping a layer of sand over the rock, 6 or 8 in. deep, and placing the foundation over that.

Where brick foundations are to be built, they should be laid first on a bottom of concrete, or stone, of varying thickness, say from 12 to 24 in., and of sufficient length and breadth to extend a few inches beyond the bottom edges of the foundation all around. The templet, in this case, can be set on a scaffold the right

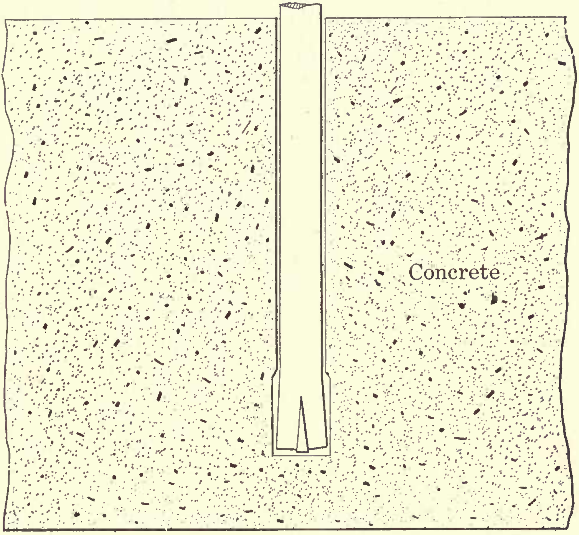


FIG. 8

hight and centered. If the space will permit, build the scaffold of sufficient length and breadth between supports so that the masonry can be built up inside of them. In every case, build the scaffold strong and secure it well to prevent possibility of moving.

The bricks for a foundation should be good, hard sewer bricks, laid in a mortar of two parts of sand to one of cement. Lay the bricks close, and make every fourth course a header. The center may be filled in with large bats well grouted.

In finding center lines to set templets by, it is always best for the erecting man to have the contractor, architect, or millwright of the building furnish a line to go by. It is not the duty of the erecting engineer to go beyond the immediate limits of the engine room to establish lines; let some one in authority furnish the first line for a guide, as then the engineer is not responsible for the position of the machinery when set true to the line furnished.

If rust joints are to be made, aim at a thickness of three-eighths of an inch all around between the edge of the engine frame and the foundation; an inch is the very outside limit.

In allowing masons to work to your plans, or setting, it will not do to give them leeway in the matter of working dimensions. While it may answer to allow a bolt to be a little out of position when there is a hole around it in the foundation, which allows it to move an inch in any direction, measure to sixty-fourths, or to thousandths, if possible, in locating center lines. You won't get them from masons, but if you start with quarters you will often be from two to four inches out all around. A mason may tell you that he made foundations before you were born, and he may be speaking truthfully, but even he cannot tell how many of the dimensions were failures. If you let him have his way, it may be necessary to tear down part of the foundation to relocate some of the bolts. If this is done it sometimes has the good effect of having him follow your instructions closely, next time. The erecting man is his company's representative on the ground and has to fight his employer's battles. We should begin by watching the mason who builds the foundation.

II

KNOTS AND HITCHES

FIGURE 9, made by two endless slings and used as shown in Fig. 10, is a reliable basket hitch when both slings are of equal length, or with one sling long enough to take in one-half of the cylinder's diameter and the other to run through both loops of the smaller and have its own loops catch the chain hook.

Some people hoist the shaft endwise by using a collar or lathe-dog as a safety stay; others use the bitting-rolling hitch shown in Fig. 11, but in one conservative concern whose screw and bolt department, on the fifth floor, is provided with an independent hoist chain, they use the rig shown in Fig. 12. The bucket is hoisted above the floor level and then pulled in as the hoistway is reversed and made to lower away.

It is a very common practise, in the absence of a ready-made endless sling, to tie a flat knot in a short length of rope and use it in lieu of a sling. Be careful to avoid a "granny knot," Fig. 13, which is unsafe and which we all know about; but there is another fool trick which can easily be played with this knot. As it may be new to some of the readers, an explanation of it may be made here by the following experience. In lowering a bed-plate, and as it was going down, to help keep it clear of the building, the man in charge took hold of *A*, Fig. 13 (you might take *B* for a change),

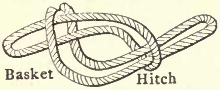


FIG. 9

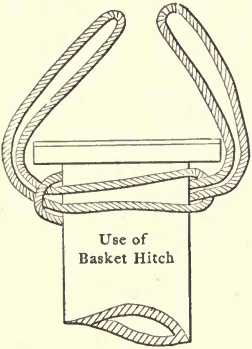


FIG. 10

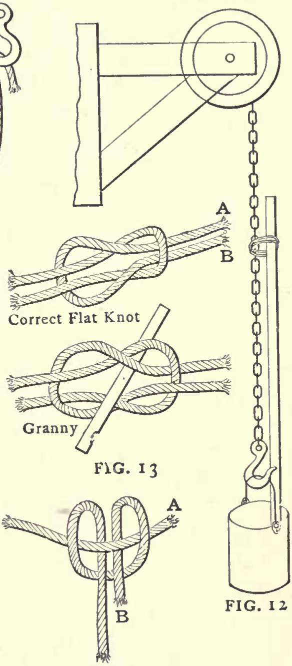


FIG. 13

FIG. 12

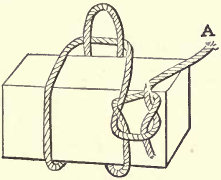


FIG. 14

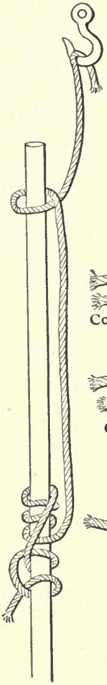


FIG. 11

FIG. 15

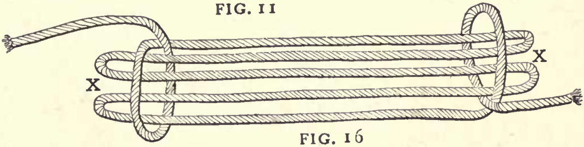


FIG. 16

and gave it a good strong pull, and down came the bed-plate with a rush. The explanation of the knot letting go is this: — By pulling at *A*, Fig. 14, caused the loop to double back, as shown in Fig. 15, and then the weight of the bed-plate pulled *A* out of his hand, through the doubled loop, and, presto! the trick was done. In making a flat knot with chains, a piece of pipe or wood should be run into it, as shown by Fig. 13 to prevent jamming.

Figure 16 shows a good and safe way, known as a sheepshank, of shortening a long rope. It is self-evident that any amount and any length of loop may be used, but it must be carefully borne in mind that at least a 6-in. length of over-lap loop at *X X* is essential to absolute safety.

The next is made without passing the end, and provides two loops to which a tackle block can be hooked. Fig. 17 shows the start; Fig. 18, the second stage; Fig. 19 the manner of rolling two loops into the standing portion of the rope, and Fig. 20, the two loops *X X* brought vertically down (after rolling) and ready for service. The block or fall must be hooked into both loops. The above is a safe and reliable hitch that can be wiggled in at any point in a rope, and besides being perfectly reliable, it is easily and quickly made and unmade.

Figure 21 is an old and well-known friend of the rigger.

Figure 22 is a simple and safe way to take a temporary hold, but as the mere shifting of the weighted loop will suffice to loosen the whole rig, the need of keeping meddlers away must be obvious.

Figure 23 shows how in using a chain block whose

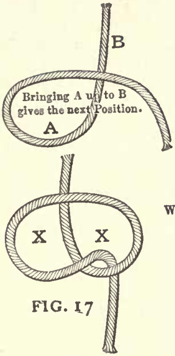


FIG. 17

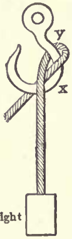


FIG. 21

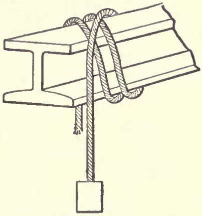


FIG. 22

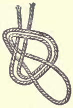


FIG. 24

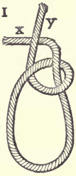


FIG. 25

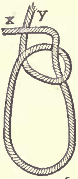


FIG. 26

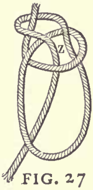


FIG. 27

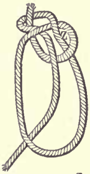


FIG. 28

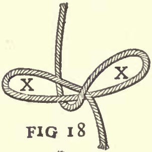


FIG 18

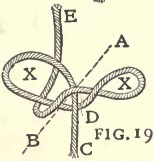


FIG. 19

The first turn of the loops XX should bring rope end C through loop D. Two more turns upward should then be taken along cross A B.

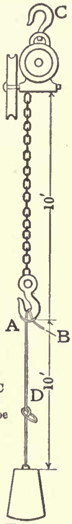


FIG. 23

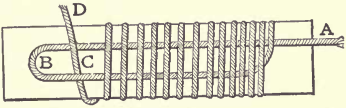


FIG. 29

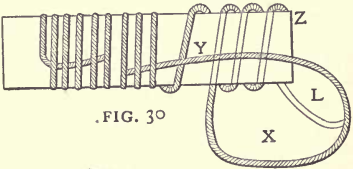


FIG. 30

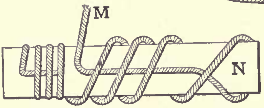


FIG. 31

FIG. 20

hoisting and lowering range is necessarily confined to the limit of its chain length, the weight may be raised or lowered to any distance. Thus in Fig. 23 the chain travel is only 10 ft., but the weight has to be raised 20 ft. We lower the chain and hook into the rope at *A*, hoist the 10 ft. and make the free rope's end *B* fast to any convenient projection overhead (if necessary, even to the chain block suspending hook *C*). We now unhook and lower the chain again for its new previously-prepared hold lower down, as at *D*, and up she goes, the 20 ft. or any other old distance. We emphasize *previously prepared hold* advisedly, as, if not so prepared, it will be found impossible to wiggle in a hold for the hook in the tautened rope. Fig. 21 cannot be used for second holds, and positively must not be used for a starter, or first hold, because, after fastening at *C*, it will be found both hard and dangerous to slip the hook out of it.

Either the double-up, non-slipping loop, Fig. 24, or bowlines should be used all along the line.

Speaking of bowlines, the slack line *X* may go either in front or back of the standing rope *Y*, as shown in Figs. 25 and 26; but in either case after going around *Y*, it must be passed through the loop *Z* in the manner shown at Fig. 27. Passing it through as shown at Fig. 28 cuts out the non-slipping feature and reduces the bowline to a farce.

A broken hammer handle, a split monkey-wrench handle, etc., may be nicely repaired by the endless-wound splice Fig. 29. The make-up is, we think, pretty clear as shown, and it is evident that by pulling at *A* the loop *B* will make a similar loop in *D* at *C*, and continued pull will draw the crossed loops out of sight. The loop ends may then be closely cut off.

Figure 30 is preferable for extra neat work, in that it does away with the bulge caused by the crossed loops. Until the loop *X* is reached, all is plain sailing. The rope *Y* must then be held steadily in its place on the stick *Z* while the loop is swung around both it and the stick, as shown by the dotted outline. Only at the finish (shown in Fig. 31) should *Y* be allowed to move. Then it, as a part of loop *L*, should be swung around the stick as shown at *N*. Setting the coils close and drawing up at *M* completes the job.

Always, and above all, in using ropes do not abuse them. Bagging, burlap, even waste or paper, if the first are not to be had, should always be interposed between a rope and all hard, angled, even if not sharp, edges.

The knot shown completed in Fig. 37 is also known as "jury mast knot" and "bottle hitch." It can be used in place of a "mast iron" at the top of a derrick to make guys fast to.

Although at first glance it appears to be complicated, it is very easy to make. To practise it, take a piece of stout cord between the thumb and forefinger of each hand with a space of about 6 in. between the hands. Then twist the cord *right-handed* with thumb and forefinger of the right hand only. This will throw up a "bight" like Fig. 32 with the part *A* under *B*. Grasp the loop between the thumb and forefinger of the left hand at the point where the two parts cross.

Then move the thumb and forefinger of the right hand along the cord about 6 in. and throw up another "bight" laying it on top of the first one. You then have Fig. 33. Hold these two "bights" with the left

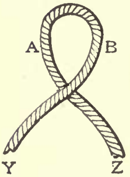


FIG. 32

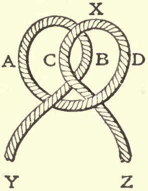


FIG. 33

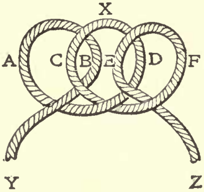


FIG. 34

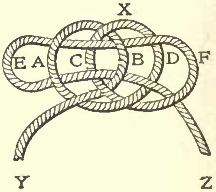


FIG. 35

thumb and forefinger, measure off another 6 in. and throw the last "bight." Place it on top of the last one made and you have Fig. 34. Take the part *E*

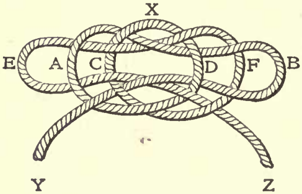


FIG. 36

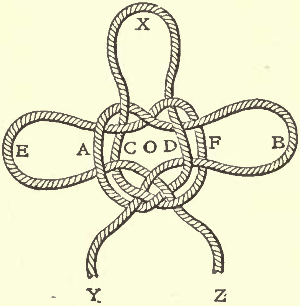
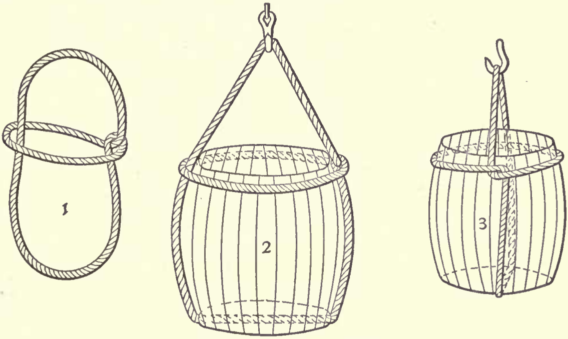


FIG. 37

in the last "bight" at Fig. 34 and — while holding the other parts in place — pass it under *B*, over *C*, and under *A*. This makes Fig. 35. Then take *B*, Fig. 36 and pass it under *D* and over *F*. The result is Fig. 36.

Then while holding *E* in the left and *B* in the right hand, take hold of *X* with the teeth and pull it. The result will be Fig. 37. In practise the part *O*, Fig. 37, goes over the reduced part at the mast or derrick head. The forestay or guy is made fast to *X*. The stays to *E* and *B*. *Y* and *Z* form the back stays. Any strain on the stays tightens up *O*. By pulling *Y* and *Z* in opposite directions the knot comes out.



SLINGING A BARREL

FIG. 38

It is often necessary to sling a barrel containing castings or liquids. While with both heads on and bung in place this is an easy matter; with one head out this is not so easy. The illustrations 1, 2, and 3 in Fig. 38 show how this can be easily done.

III

HAULING HEAVY MACHINERY THROUGH CITY STREETS

A city street makes a good roadway for moving machinery, even if it is heavy and on skids and rollers, and three thicknesses of 2-in. plank are enough for a track. The joints in the layers should be broken if the street surface is at all uneven and things are ready to move. If the street happens to be an old one with cobblestone pavement and poor material beneath to support that pavement, of course things will have to be evened up with blocking. But this principle holds everywhere: one block across another and short spans for heavy loads.

The most important question in hauling a heavy piece in this way, weighing sixty tons or more, is to provide the hauling force. The thing could be shoved with jacks and some progress made, too, or even with enough chain falls, three sets of three ton blocks, for instance, but the trouble with such rigging is of course the number of shifts that must be made and the time lost in making them. A good long rope falls with a pair of horses on the leading line is the quickest and easiest way of getting on. If the ground is level, a pair of good truck horses will haul that shaft with a one and one-quarter in. falls through a pair of three sheave blocks. That will give a pulling force of seven times the force exerted by the horses, for, of course, the team should pull in the direction of the onward movement and the ropes' end should be made fast to the load. This will give a speed of movement of one-seventh the speed of the team and will be amply fast for the best of level roads and a large gang of efficient men. If there were no pauses, which of course there must be, and many of them, a city block would be passed in seven or eight minutes. One great objection to going too fast will be the inability to stop a team of horses instantly. They like to go two or three steps after the time to stop, and this will mean a foot or so on the shaft.

If the ground is uneven, and hills and hollows lie in the path, more power will be needed, of course, and a capstan head for either one or two horses is most convenient. Motion is slower then, and there is less danger. The man hauling in the slack on the leading line, as the rope pays itself off, can check the onward motion instantly by slacking his hold, even with the drum in motion. The capstan will have to be shifted just as often as is the head block, and a new anchorage will have to be provided each time. If a capstan is not available, power can be gained quite as well with a luff tackle; that is, instead of hauling directly on the leading line of the main falls, hook another falls onto it and pull on the second leading line. A lighter rope will answer for the second falls, for the whole force it exerts goes through a single part of the main falls; inch rope or even three-quarter inch is amply large; smaller rope can be used, but this rope should be a long one, and there is not much call for a very long, small rope on other parts of the work. A set of half-inch blocks is convenient for small short lifts, valve gear and like pieces, but a long rope is very much in the way at such times.

When a luff is used, it is just as well to let the hauling line of the main fall come back toward the load and fasten the other line to the head block. This will cut off one-seventh of the pulling force, but if the head

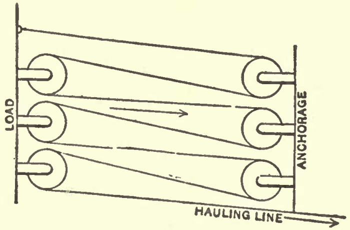


FIG. 39

block of the luff is itself fixed to the load, and its hauling line lead off to pull in the direction of the shaft motion, that seventh will be recovered. This will require an extra sheave in the luff blocks to equal the pull, were everything straightaway, but the advantage comes in not having to shift so many hitches so often. There will be one block that can always remain in place of this extra tackle. It will, of course, depend upon how much force is available, how much the load is, and how many men are upon the work. This will be made clearer in the sketches. Fig. 39 shows the straightaway pull with a pair of three sheave blocks, and with an arrangement giving seven times the force to move the load that is exerted on the hauling line. This is clearly a better arrangement than Fig. 40 shows,

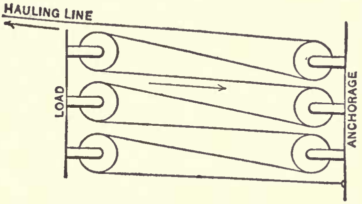


FIG. 40

where the force multiplies itself six times only. The difference in these two arrangements is so apparent that a man who handles machinery for a living would not be caught using Fig. 40. But it has been used by some pretty good mechanics.

The simplest and most powerful arrangement for a luff is to repeat Fig. 39 upon itself, that is, let the

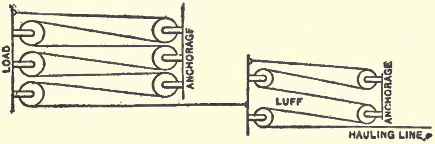


FIG. 41

hauling line be taken as the load and the new fall be hooked to it as if it alone were to be moved, as in Fig. 41. Here the main tackle gives a multiplication of seven, and its hauling line furnishes load to a fall which multiplies five times; so that the force urging the load on is thirty-five times the hauling force. The sketch shows the leading line of the main falls going by the main anchorage. Of course this is not necessary nor convenient. There is no reason why the main leading line may not be shortened up and the head block of the luff anchored at the same fixture that furnishes anchorage for the main fall. Fig. 42 shows an

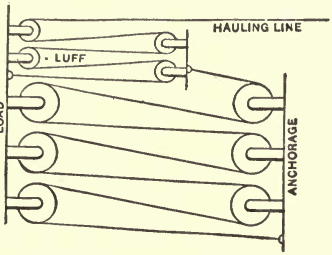


FIG. 42

arrangement of the two falls which is more often used, though some of the power is sacrificed. Here neither block of the luff tackle is stationary; what is really the head block being fast to the load itself while the other block hooks onto the leading line of the main falls. The force urging the load onward here is twenty-eight times the hauling force, a loss of 20 per cent. of the most powerful arrangement. Fig. 43 shows a method of main fall and luff with a multiplication of thirty-five and with the head block of the luff tackle fast to the load. Here, however, the hauling line leads back and is not always convenient. This arrangement would be an ideal one were a hand winch to be used and the lower winch fixed to the load itself and pulling away in the leading part of the secondary fall.

Any one of these methods can multiply power enormously. With the winch as just mentioned in connection with Fig. 43, the winch enters as a factor. An ordinary compound hand winch will multiply, by itself alone, any force acting upon the cranks, about

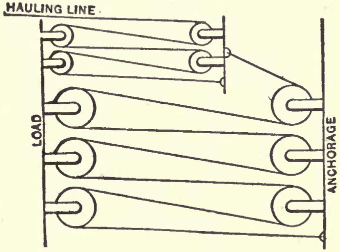


FIG. 43

thirty times, depending upon the gearing, of course, some being less and some more powerful. Here then the pulling or winding force furnished by the men with the handles is multiplied ten hundred and fifty times. If the shaft were to be lifted bodily, this hitch brings the force necessary down to a very small amount, less than one hundred and forty pounds, in fact, and is easily available with a few men. It is evident that to make all this force available, something more than seven parts of one and one-quarter inch rope is necessary. A bran-new inch and a quarter fall with seven hauling parts may be trusted for a straight pull of ten tons straight up in the air or in any other direction. But the rope must be in perfect condition.

These schemes of rigging apply to the multiplication of power only, and show methods of reducing the amount of force needed to move a load. There is no economy, it is clear, in making an arrangement that one man can manage with one hand lightly on a winch. Nor yet again is there economy in having a man haul on a rope with the entire strength he can muster. Thirty pounds is a good fair pulling force for a man to exert, and keep it up long enough to run out the length of a hitch, provided he has his load placed advantageously; and he will have a reserve even at this, that will help over a temporary increased pull. Two men on a winch will do more than twice as much as one man. If a seventy-ton shaft were to be lifted up, something more than seven one and one-quarter-inch falls, each one through three sheave blocks, would be used. Though they could lift it, were each one fully loaded, there would be no way of knowing when each one had its share, and each one might part separately one after another. More parts of more powerful rope are used for heavy lifts, concerning which more will be said later.

There may be some difficulty in finding anchorages along a roadway, solid enough to allow of a head block being hitched to them. If six tons are required to move the load along, there will come a backward pull of six tons on the anchorage, and something heavy must be found for the purpose, and good judgment used in hitching to it. The trunk of a tree will stand a lot of abuse. An 18-in. trunk will stand more horizontal pull than can be brought upon it in such work.

Sometimes it is possible to take a turn about part of an old building. In one window and out another with a rope or chain and taking in a good solid corner, if the walls are thick and firm, will answer very well. Corners of the building must be protected with pieces of plank and tree-trunks must have a thickness of plank all around to protect their bark from damage, as shown in Fig. 44. Lamp-posts and hydrants usually have to be avoided. They will not stand much, anyway, and

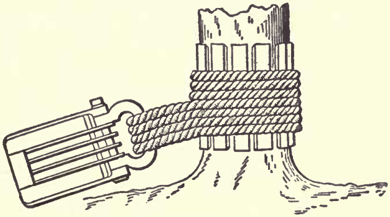


FIG. 44

the authorities are likely to pass unpleasant remarks besides. They have been known to help, however. Telegraph poles are good and can be used for a good pull. They have not the hold upon the ground that a tree has, however, and are rather small for the heaviest work. But sometimes two or three weak things can be combined to make one solid one. It is always possible to anchor a capstan by driving iron bars into the roadway. Take, for instance, a bar of two inch round iron, three feet long, and drawn down to a point on one end. Such bars can be driven into a roadway, with blows from a heavy sledge, for a distance of 30 in. Four or more such bars will anchor any capstan or hand winch, and if the pull is not too heavy, will serve for anchorage of the head block itself. It is possible, sometimes, to get hold of a coal hole in the sidewalk and tie to a bar across the inside stones.

There is one way always possible and always strong enough to resist any pull that can be brought to bear upon it, that is: locating a dead man. That means simply taking a good stout grip on the earth. The principle is that a lot of plank and blocking sunk deep in the solid ground are good for a tremendous pull. There is a good deal of tenacity in the ground itself and this is its useful property that makes its weight available.

A hole dug down 5 or 6 ft. deep, its depth depending upon the kind of soil, 6 ft. long, crosswise in the roadway and wide enough to get down into, three feet is ample, furnishes the foundation. The front side of this is partially covered with good three-inch plank and a block across the plank gives the something to pull on. A narrow and sloping trench should be dug for the rope, going up at an angle no steeper than 45 deg. and 30 is much better, and the rope provided with a block wherever it tends to cut down into a corner of the earth. Such a device is the last resort, but it is always good. Its disadvantage is the amount of work necessary to provide it and the trouble encountered in digging such a hole in the street. Fig. 45 shows a dead man. It is best to locate this thing where it can be used more than once, and for more than one purpose. If the front earth is left overhanging, as shown in Fig. 45, it may be used for a more vertical pull, and is useful where a hoist must be made from a winch and an anchorage found for snatch blocks. By such methods and appliances as here described, it is possible to move a shaft or any

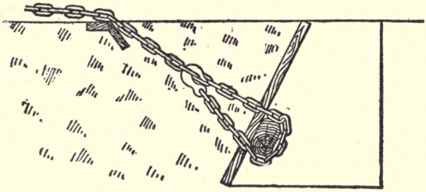


FIG. 45

other heavy piece through town streets, making track or blocking foundations where needed. And inasmuch as the crank-shaft is not usually the first piece needed in getting an engine in place on its foundation, it may well be left standing on its rollers, without the entrance to the building, while the balance of the machine is taken from the cars.

IV

RUNWAYS ON AN INCLINE

Raising a large crank-shaft on blocking and lowering it to its bearings requires a considerable degree of engineering skill. Not as much skill, perhaps, as is required in designing such a shaft, not as much responsibility involved. But there is a better precedent established for a large shaft design. It is possible to tell almost precisely what will happen to a 24-in. shaft, for instance, when it holds up 50 tons and turns it over 80 times a minute. The engineer handling the shaft knows what he has done before, but a new rigging has to be devised every time, for no two jobs are alike and the material at hand has to be used whether or not it is well suited to the purpose.

Some way must be devised of raising the shaft up and into the engine room. This may be done with jacks and blocking, but inasmuch as all the material must be raised to the engine room floor level, it is easier to build a runway for the first piece and use it for every other piece. That means it must be strong enough and good enough to furnish passageway for the shaft.

More care is needed in building an incline to be used for hauling machinery up than is necessary in building one for letting it down. The weight itself is no greater, but there is a vast deal more pulling and hauling to be done. In coming down friction is no hindrance, while in going up it adds to the load; so unless there is an abundance of pulling force to be had conveniently, a good long run should be built. A slope of one in six is steep enough and a longer one is better. This angle is steeper than the angle of friction. A shaft will keep moving after being once started on a well-built runway sloping one in eight, or possibly one in ten if it has plenty of rollers. It will not start of its own accord, however, on a slope of one in ten from a standstill; it takes very little to hold a shaft still on an incline sloping one in eight, that is to prevent it from starting of its own accord down hill. It takes no great force to prevent it starting itself down an incline of one in six; but it takes a pretty good pull to start it up a steep slope, and as a rule one in six is fully the limit of slope in the ordinary case and with ordinary tools and rigging. If there is room it will pay to make the runway longer.

For a long and high run, considerable timber will be required and some method will have to be adopted that will use only what is necessary. Cob house blocking will answer and is easily built, but it requires more material than does any other way.

It is better to do a little framing, as shown in Figs. 46 and 47. A wood column 10 in. square and 10 ft. high will stand an enormous load, full as much as a space of like area (10 in. square) will stand across the grain as it would in a pile of blocking. Such a column will hold up 30 tons with perfect safety and will stand a good amount of abuse in the way of rough framing, so that if bents are made, as shown in Fig. 47, and the

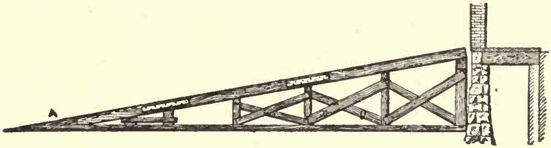


FIG. 46

main risers are 10 in. square, the bents will need to be placed no closer than 12 ft. so far as they are themselves concerned, though of course for this long span heavy string timber will have to be used on top.

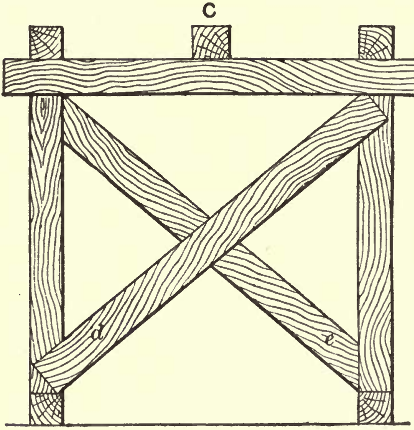


FIG. 47

The framing itself is not difficult. It is not necessary, of course, to make a tenon and mortise joint, nor even need the pieces be halved together; but something more than toe nailing is necessary. The easiest joint is the double covering strips just as is found in the up-to-date butt joint in a boiler, only plates are somewhat thicker. Fig. 48 shows the method, simply two pieces

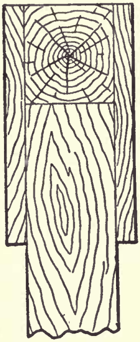


FIG. 48

of plank spiked to each of the two members, the plank being long enough to get a good grip on at least one piece.

The distance between uprights, Fig. 47, and also the length of the cross piece should be determined by the width between the skids of the heaviest piece, that is the shaft, and the thing should be arranged so that these uprights will come about under the skids.

The size of the cross pieces will depend upon the load they are to carry. Ten by tens reaching across a span of six feet and held down well with a good load at each end can be trusted with a center load of about six tons, but it will be difficult to make any great load come upon those cross timbers at their centers, for they will give more than the columns will, so the middle stringer *C*, Fig. 47, cannot be depended upon to take a third of the load. If the long timbers for these stringers are rather light it is better to have more bents and so shorten up the span, rather than to trust too much to the middle timber. For 12-in. square stringers a span of six or seven feet is in good proportion, and even then a middle stringer will be a convenience. It is not the strength of the structure so much as its stiffness that should be considered. The stiffer it is, the less it gives under push and pull, the easier will things slide up properly.

Each bent must be braced diagonally with plank spiked on solidly, as shown at *d* and *e*, Fig. 47. These diagonal planks will keep the thing stiff and able to resist any side twist. It would be exceedingly unstable without them. A high and curving trestle would require more secure side bracing than here shown. Further, each bent must be braced by diagonal plank to each of its neighbors, as shown at *x* and *g*, Fig. 46. These bind the whole thing together and add to the solidity of the whole. The foundation may well be two thicknesses of 3-in. plank or their equivalent resting fairly upon the solid earth. These planks should have a good bearing on stiff ground, over their whole length, as nearly as may be for the whole load of the column is concentrated at one point. Particular care should be taken to see that there is at least a good support directly under the point where the center of the column comes.

If the incline is steep, it is best to break the sharp depression at the entering point *A*, Fig. 46. The tendency is in passing over any change in slope in the path of a heavy piece on skids to concentrate the load at one or two points. If the change is slight, the piece will pass all right with a little care in arranging rollers and a slight extra pull. If the change is abrupt, serious damage may be done even so far as breaking the skids. So it is well to break all those sharp corners and a few pieces of block pared down to an easy taper will correct any such hollow as that shown at *A*, Fig. 47.

It is usually somewhat more convenient in erecting an engine of this kind, if the large door for entering machinery is at the end of the building, in the wall parallel with the center line of the engine itself and out a little way in front of the crank-shaft, so that a person standing in the doorway would look along down the engine room in a line just passing the outer circumference of the row of fly-wheels, if there are several engines. There are fewer turns to be made in getting the parts onto the foundation when this is the case. It is a common thing to find, however, that the door itself is more conveniently placed in the side of the building.

A runway in front of the engine foundation will have to be built strong enough to hold up the shaft. If there is a permanent floor already laid, it may be stiffened up with shores and blocking. It will have to be good and stiff, however, for loads will be concentrated at one spot by the jacks in raising the outfit to its necessary level. Plenty of room must be left in front of the door for turning the shaft about square with the engine. It is frequently possible to avoid a sharp corner by making a long turn; and an incline trestle may be built upon a curve, increasing its length and making less and easier work both in the raising and the turning. But this is true only of long turns. If the turn is so short that much jacking is necessary for shifting the rollers, it is better to concentrate all the turning at one place and then rig up and make a business of it. Straight runs on rollers are easily passed in good time and a long turn made by small cuts in setting the rolls are not difficult, but a general jacking all around every time a piece moves ahead its own length takes up more time than is reasonable.

In the case at hand it might be possible to build the incline neither perpendicular to, nor parallel with, the wall having the entering door, but on a long winding slant through the door cornerwise, if it is wide enough, and lay along in front of the engine without any sharp turns whatever. But in such a method the shaft is never moving straight ahead and every roll is binding against every other roll in its effort to do the guiding. It is better to use the room in front of the door by getting down a good stiff temporary floor and arranging to jack the shaft around in that one spot. The sliding can be done upon the rollers. Wood does not slide as easily on wood as it does on iron, particularly when the load is heavy, and less force would be necessary if the rollers were taken out and strips of iron laid on blocks were substituted. The objection to this is the difficulty in taking rolls out and putting the blocking in. Usually there is not room to haul a long roller out straight.

One jack should be used at each end, on opposite corners, one braced against the foundation or some part of the engine frame, while the other goes up against the wall of the building, and the ends will do all the moving, the center standing still.

Whenever a jack is braced up against the wall of a building, care should be taken to see that the wall itself does not yield. Of course no wall will stand all the load that can be brought upon it sideways with a jack. It is possible to stiffen things up with plank and blocking so that a large area will be taken in. Sometimes, it is well to give the jack a small rising slant so that it will have a slight lifting tendency as it shoves the shaft around. This may distribute the load better. Rollers should be laid out so that the shaft may come about on them, the last rolls being laid square with the new direction which the shaft is to take. The rollers will have to be rearranged after the shaft is wholly turned; but this is done easily with the jack and sledge.

V

WORK FOR A GIN POLE

There are always four or five wagon-loads of stuff belonging to an engine after the large pieces have been taken from the cars. Connecting-rods, cross-heads and pistons, valves and valve-gear, the governor and its connections, all in boxes, or secured to plank and skids; the piping between cylinders with gate-valves for same; the air-pump and its fittings if the engine is to have a condenser, all go to swell the total. And that loose stuff takes up a lot of room, too. Most of it must be stowed away under cover, for it is not best to leave finished and polished stuff out of doors where it can be injured, and all that can be taken care of is put around the engine room. All this material added to the blocking and rigging from the heavy pieces, blocking from the shafts, for instance, fills the engine room pretty full, and some care and management will be called for in placing the parts so that those needed first will not be at the bottom of the heap and the whole outfit have to be dug over three or four times. The eight valves may be safely kept in their boxes and placed at the bottom, followed by valve-gear and running-gear. Piping and condenser rigging should be kept separate, for that will be needed immediately after the machine is lined up in order to blow out cylinders and ports. Fly-wheel bolts should be accessible, for they will be needed as soon as the shaft is in place. The governor or governors, if there be two, will not be needed till toward the last end. But it may be advisable to have those where they can be hauled out. The governors have a property that no other part does. An engine appears pretty well along in its process of erection when the governor is up. It looks decidedly bare when it is without its governors. It is a good plan to bolt on such a piece the day after the lining up is over. It makes a profound impression upon the audience, and will take the curse off of three or four bad days — days when the public believes that things have gone slowly, and that the man setting the job up doesn't know much any way.

There is little in the way of lifting that cannot be done with jacks; but the slide section of the engine is about the worst piece to handle. It is not very heavy, but there is nothing to take hold of with a jack, and even after it is up high enough it must be slid ahead, square and level, in order to enter the counterbore made for it in the frame. It is a difficult matter to slide the thing ahead on rollers and blocking.

The slide section of the engine of the size here written of — 1200 horse-power — can best be handled with a stout gin pole. There are engines having slides cast with a foundation bearing all over the whole bottom surface. Of course, such a piece can be slid up and brought in line with wedges very easily. The section here described is one made by most of the builders now, having no foundation support between cylinder and frame. Fig. 49 shows a side view of such a slide and end view in Fig. 50.

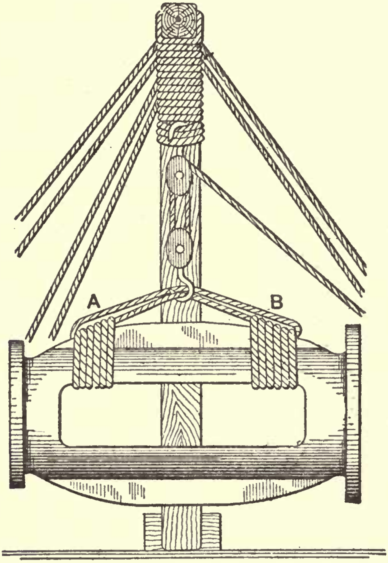


FIG. 49

The slide should be laid along the foundation roughly in the general line it is to take when bolted in place on its skids and rollers. Then the gin pole is to be stood up over it and the fall made ready to hoist. A 10 × 10 pole, 16 ft. long, will answer here. In selecting a pole for hoisting material of this kind it is well to pick out a good long stick once for all and use it for nothing else. The corners of the bottom end should be rounded up, so that at whatever angle the pole may stand the pressure will come in part way toward the center. Then the head block may be lashed securely to the top; also the main guy blocks. This work once done will save some time, for it need not be disturbed. The

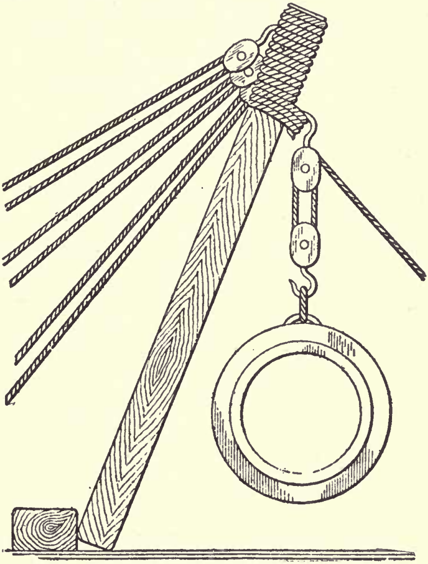


FIG. 50

head block for the hoist should be at least three sheaves for $1\frac{1}{4}$-in. rope. This will handle a load of six tons with a good new rope, even if there are but two sheaves in the bottom block.

For greater loads more rigging can be used, but it may be of the same kind, making no change except adding a greater quantity. Supposing the main hoisting blocks to be a three sheave at the top and a two sheave at the bottom; this will give five hoisting ropes, and with a 6-ton load only 2400 lbs. can come on one rope. An inch and a quarter line will hold that load, even after it has seen some wear, though no rope can be trusted with a load after it has seen abuse.

With a snatch block lashed to the load the rope's end may be led through and back to the head of the gin pole, increasing the safe load to seven tons and over. And another snatch block may be lashed to the top of the pole, which will allow the line to be brought back and made fast to the load. These two extra lines increase the original safe load 40 per cent. Of course, this might be carried on, adding snatch block after snatch block, and adding one useful rope for each snatch block. But it is better to add another set of blocks than to go too far in this direction. In fact, anything more than one added block at the bottom and one more at the top is unusual.

It is possible to cover a somewhat limited area with a gin pole 16 ft. long; that is, its head may be moved about, carrying the load with it, while the foot is stationary. And it does not take any great force to move sideways, provided the whole load is not upon the particular guy fall, which must be hauled in. It is more difficult to move a gin pole loaded, back and forth, for then the load has to be lifted.

With a heavy load the top of a 16-ft. pole may be moved to cover an area about five feet square, provided the casting itself does not take up so much room that the proper angle cannot be assumed by the pole. A movement of five feet does not make a very good traveling crane, but it is so much better than nothing that it is of accepted value. Care should be taken in arranging guy falls so that no overload will come there. There is frequently more stress thrown upon these falls collectively than the hoisting fall has to stand itself; and this stress is the greater as the slope of the pole increases, starting from a vertical line, and also as the

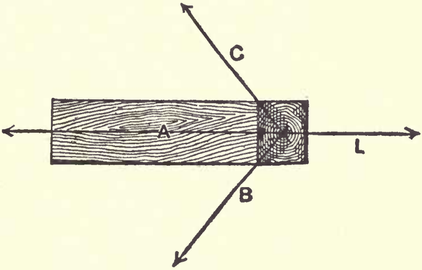


FIG. 51

guys themselves are made shorter and more nearly approach a vertical. So long guys, as nearly horizontal as may be, and a vertical pole place the least stress on all parts. About 30 deg. from a vertical is the usual limit of pole angle for a heavy load, and there should be three guys led back, one at the center of the load and the other two stretched out, including an angle of about 90 deg. in all. Fig. 51 shows their angular relations, which is a plan view in diagram. The load tends to pull the pole over in the direction *L*.

The guy *A* would itself prevent this, and if it were strong enough could hold the pole upright. But the pole would, of course, be very unstable and could not be trusted for an instant. So the additional guys *B* and *C* are led off to prevent the outfit from falling sideways. Also, it is evident that by hauling in on line *C* while slacking line *B* and holding line *A* fast, all at the same time, the pole and its load must go over toward *C*. Also, by taking in on all three lines, *A*, *B*, and *C*, at the same time must pull the load over toward *A*, while slacking off all three together, the load falls and moves in the direction *L*. It is evident that in moving toward *A* the load is raised, and that all three falls should be hauled in at the same time, for if *A* alone were taken in it would take the whole of the guy load, and in addition to becoming unstable might part, due to too great a load. The two guys *B* and *C* together hold about as much as guy *A* does alone.

Sometimes the snatch block for leading the hauling rope over toward the hoisting drum is lashed to the foot of the gin pole. This is allowable, provided this foot is securely held. It gives a pull on the foot of the pole nearly equal to the pull on the rope, and the foot must have anchorage equal to this added load. It is usually better to lash the snatch block to some other fixture — a part of the engine, or a foundation bolt for instance.

Making a hitch of lashing for the hook in the lower block on a piece, such as shown in Fig. 49, is not difficult, and a number of good ones may be devised. Whatever is adopted it should be made so that the hook may be shifted a little in order to bring the piece to balance approximately level. The easiest way is to take three or four turns of inch or inch and a quarter rope at each end, as shown at *A* and *B*, Fig. 49, binding four strands or more of 1½-in. rope, pulled up rather tight, into which the hook is fastened.

The hand winch will pull up this load easily. As it comes up it will be easy to see whether it is balanced properly, and if not it must be lowered off and the hooks slipped along a little. It is possible, with a piece nicely hung, to bring it up and swing it up to its place square and level, changing the guys, *B*, *C*, and *A*, to bring this about. Then a screw-jack placed at the back end will allow the hitch to be removed after bolting up.

VI

RIGGING FOR THE RECEIVER

THE section of a fly-wheel for a 1200 horse-power engine may weigh five or six tons. The rim itself is nearly square in cross-section, and an arm is cast right with the section coming out radially from the center of its arc. So there are as many sections as there are arms.

A fly-wheel section looks to be an awkward piece to handle. It cannot be skidded very well and there is not much surface for a roller. But they can be handled and upon rollers without skids. Most of the weight is in the rim. Probably there is less than a ton and a half in the arm itself. Those arms are frequently cored out for a portion of their length. A solid arm must, of course, weigh more. So if rollers are placed crosswise to the length of the rim, they take about four-fifths of the weight and the hub end of the arm weighing less than a ton can be pinched around with a crowbar. Fig. 52 shows the method of handling these pieces. The piece is guided with a crow-bar at *D* sometimes held back and sometimes pried ahead, for it is possible to so place the hitch that the hub end of the arm will be hauled around instead of rolling the rim end. The section can be rolled down the stringers to the wagon and loaded on sideways, that is at the side of the wagon. It is possible, of course, to load it at the end of the wagon, but in that case the end of the arm must be lifted over the top of the hind wheel, and there is nothing to be gained by loading in this way for one piece will make a load for a good team of horses.

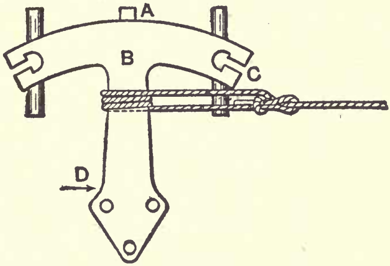


FIG. 52

Such a piece should not be left on the car, flat, with nothing under the rim to allow of entering the toe of a jack. When a section does lie so, it is best to begin to raise the arm at its center end. This will open up a space all over the rim except at a single point on the outer edge as at *A*, Fig. 52. Then as thick a piece of blocking as can be gotten under should be placed at point *B*, and the arm lowered to the floor again. This will tip up one end of the rim, as *C* about twice the thickness of the block at *B*. Then a stone jack can enter its toe at *C*, and the section can be raised very easily all over and with only one jack.

It is seldom necessary to go from one end to the other of a heavy piece with a jack when only one jack is to be had. It is always possible with any fairly regular shaped piece to go up with both ends and keep the jack continually at one end.

For instance, suppose the load to be represented by Fig. 53. The center of weight or the center of gravity

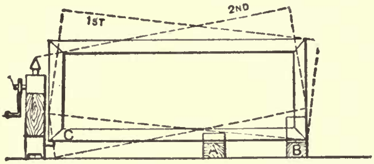


FIG. 53

goes up when one end is raised and the other stands still. Then if a block is placed at *A*, a little past the center, the opposite end, *B*, must come up when the jack is lowered off, away down to its limit. Now a block as thick as possible should be placed at *B*, Fig. 53, and the jack again made to raise end *C*. Now a thicker block can be placed at *A*, the jack lowered and the opening at *B* filled again. This method saves carrying the jack back and forth and is very rapid even for pieces of considerable size; for when two jacks are used, only one can be moving at a time.

The receiver of a 1200 horse-power engine is usually an awkward and ungainly affair, at least so far as handling it is concerned. It may weigh about three or three and one-half tons, so that no great force is needed to move it; and if it lies on skids with a small cradle cross-piece at each end it will slide along all right when on rollers. It is handled just as a cylinder is handled and hauled over to the engine room on a truck.

There is usually a place for the receiver of a large engine and if that place is under the floor, it is well to drop it down between the foundations, bolt its legs on once for all and leave it roughly in its proper position, out of the way before its passage is blocked by the shaft, or by any other part and ready to be piped up.

If a large receiver is to be stood up on end and lowered down beneath the floor, something more than jacks will be needed. While it is possible to do anything in the way of lifting weights with jacks and blocking, the process is exceedingly slow for long lifts.

An engine erector is entitled to the hope that there is something in the roof or ceiling of his engine room strong enough to pull on, say with moderate loads; a roof truss that can be trusted safely with a ton or more, or some main timber within easy reach. If the roof trusses will hold a ton at each of two of their joints, it is easy to rig up overhead work that will lift four tons; for two timbers can be placed, reaching from the joints of one truss to the joints of the next, and the blocks slung from these timbers. Sometimes there are no trusses, however, and the ceiling is as smooth as can be; then if there is no overhead rigging, something must be done to make some.

It is always possible to provide a gin pole out of the lumber at hand. A ten by ten square timber, 16 ft. long, can be trusted safely with fifteen tons, even when swung off at an angle and held with rope falls for guys. It would very likely hold more than this; but it is unusual to trust such a load, or even ten tons to the rigging that can be hung from a single stick.

In the case of this receiver the gin poles need not be 16 ft. long; 10 or 12 ft. is plenty and it will be most convenient to use two poles, one for each end. Sticks eight inches square are large enough, or even six inches if the timber is good and sound. The whole load will be thrown onto one pole, however, before the receiver is in place and allowance should, of course, be made for this. Also, the pole will not bear as much weight when it is swung off at an angle and held by guy lines as it would were it straight and held stiff under a mill floor, for instance.

The receiver may be run in between the two foundations, timber being strung across from one foundation to the other and plank laid down to furnish a temporary runway. It will appear, then, as shown in Fig. 54 and in Fig. 55, the first an end view and the second a side view of the receiver and its rigging.

The foot of the pole should come against a block, *B*, Fig. 54, to prevent its slipping in that direction. If the lift is not to be a straight one, and frequently it is not, the foot of the poles should be securely lashed to some solid fixture. Also guy lines should be led off, at least two, and if much movement sideways is required three will be needed. An inch fall makes the most convenient guy, for it can be taken up or slacked off most easily.

One great advantage of a gin pole over any sort of

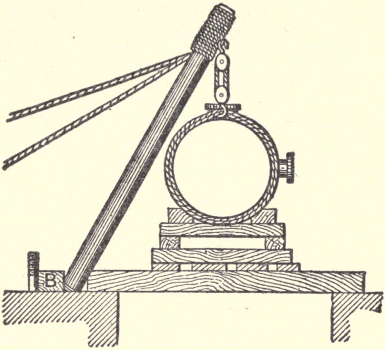


FIG. 54

overhead rigging is that it can be moved through a considerable arc, carrying load with it, by slacking or by hauling in the guy lines; and, of course, a rope fall is very convenient for such work.

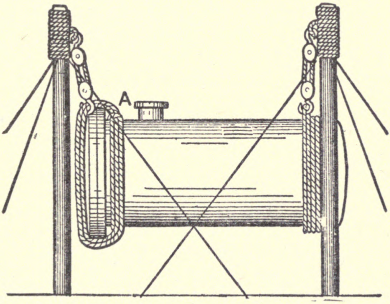


FIG. 55

The two pair of falls for the hoist here may be one and one-quarter inch rope through pairs of three and two sheave blocks, or even one inch rope will answer through blocks of the same size if the rope is new.

The hitch on the receiver will have to be made with some care, particularly the top end. The whole thing is to end up while being supported by this hitch and provision must be made for the slipping of the hook in

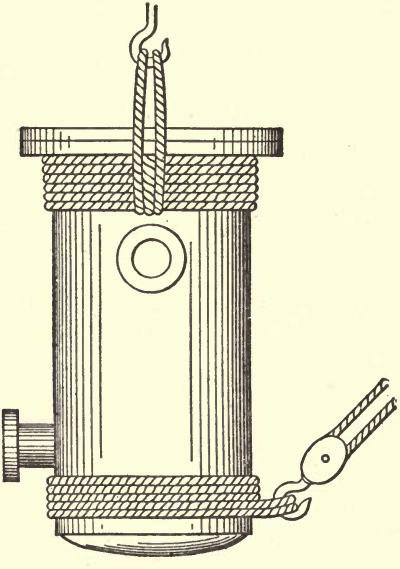


FIG. 56

the bite. The easiest way to do this will be to use a sling of one and one-half inch rope, and lash the sling to the top end, as shown at *A*, Fig 55, with a number of turns of one and one-quarter inch rope, say five turns. This lashing must be wound as tight as can be made by hand, and brought up close under the flange for the top head. This flange is what holds the hitch in place, of course. At least one round turn should be made by the sling about the lashing at top and bottom to prevent the slipping sideways. This is made apparent in Fig. 56, which shows the receiver dropped down to its landing. The sling need be nothing more than a piece of one and one-half in. rope made into a sling by tying a square knot for joining the two ends after the hitch is made. The hitch at the bottom end is nothing but a piece of inch and a half rope wound four times around the receiver with two of the bites passed up through the hook. The two turns about the barrel that do not pass through the hook keep the whole hitch tight and in place. This is one of the main principles of using rope in rigging. Another principle is that of using many turns where a lashing must be made tight with the two ends tied together after the turns have been made in a knot of some kind. There must be a little slack at the knot when the bends come. If there were but one turn, all this slack must go into that one and however tight the rope was pulled at first, the result must be loose. If six or eight turns be taken instead of one, that slack divides itself into six or eight parts and the whole hitch will be pretty tight.

Now something will have to be provided for hauling the lines of the main hoists. This would not be necessary were chain falls used, for two men can lift tons with chain blocks. But one disadvantage of the chain fall is its limited amount of motion. If the chain is made long enough for a long hoist, the spare chain is much in the way on short hoists. A hand winch is the machine for this work, provided there is no steam winch to be had conveniently.

There is but one capstan drum on a hand winch, or but one drum of any kind, and as this receiver must be raised and held up at each end in order to clear away the blocking, one of the ends must be raised at a time and held there while the other end uses the winch. It is best to begin with the bottom end, as this is lighter and can be easily slacked off from some stationary

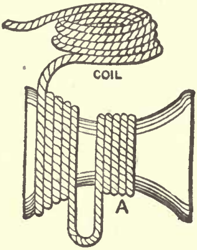


FIG. 57

anchorage. There will be required a pull of about eight hundred pounds to raise the one end, and as this is only a short lift, not over four inches to clear blocking, it could be done with a luff. But the winch is all there and ready, and is easily used. The bite only of the hauling part of the fall need be passed around the drum for these small short lifts. There is, of course, an extra part of the rope which is somewhat in the way, but this saves handling the long leading line over so many times. The drum will look as in Fig. 57, and one man can haul in on the slack line, *A*, without any trouble, keeping the loose rope out of the gears of the winch beside.

When the bottom end of the receiver is up four or five inches, enough to clear blocking and a little more to allow for what will be lost in making fast twice, some way must be devised for getting the hauling part of the fall away from the winch and holding it tight all the time in order not to let the load back and still have it possible to pay out one hundred feet or so of line in lowering off. The first move will be to seize two of the ropes on the fall with good stout twine — marline is excellent for this — but a strand of old rope will answer. Every rope in a fall moves in reference to every other rope when the fall itself is hauled in or let out; so if this relative motion of the ropes is prevented from taking place, the fall is held fast and the load with it. For this purpose two ropes should be chosen whose relative motion is great; the greater the better, for less stress is put upon the binding then. The two ropes which have the greatest relative motion are, of course, the hauling part, and the same rope after it passes once over the head block, numbered + 5 and − 5 in Fig. 58. In a set of 3-2 blocks as there shown, the relative motion is ten times the movement of the load and so only one-tenth of the load on the block could come on this binding. But it is not usually convenient to get hold of the hauling line and bind it to one of the other lines.

The next best pair of ropes are numbered + 5 and − 3, and here the load divides itself by eight before it comes to the binding, and as these two can be gotten at readily the fall in side view will appear as shown in Fig. 59. Of course, any pair of ropes might then be bound together, even two on the same side of the

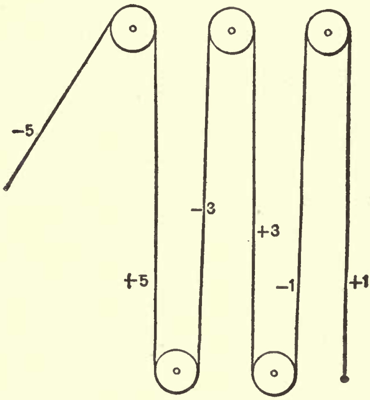


FIG. 58

sheaves, as + 1 and + 3. But one-half of the total load would come on the binding then, tending to make it slip; and when the leading line was slacked there would be only two ropes holding the load. For binding in this way, always select a pair of ropes nearest the hauling part and two running over the same sheave in the head block, or tail block.

The relative values of the ropes and their relative motion is shown in Fig. 58, where the load is supposed to go up one part. The motion of the other ropes is shown by the figures adjacent, the + sign showing upward, and – sign showing downward movement of the rope.

When the ropes have been securely bound, the leading line now on the winch may be taken off and led over to some stationary post, or part of the building, wrapped around about three turns and then tied fast. The bottom end of the receiver is now hung in the fall, and the winch is free to pull up the top end: Four inches will be found enough and then all blocking, skids and plank can be removed, and a hole made through the temporary floor for passing the receiver through.

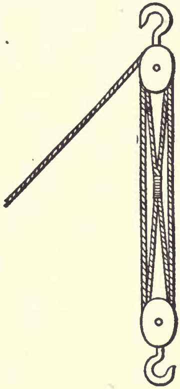


FIG. 59

Now the fall holding up the bottom end of the piece may be slowly slacked off and the receiver will right itself, nearly straight up and down. The fall on the winch in now slacked away and the piece slowly lowered to place, being straightened if necessary with a small watch tackle giving a pull over on top.

VII

MOVING A CYLINDER

It is always easier to get a horizontal engine together when the engine room is so arranged that the large opening for entrance of machinery is in front of the fly-wheel and the cylinder may be rolled into place before any of the other parts are in the building. When this is not the case, the shaft must be rolled in and laid over against the wall in front, while the frames are being brought in. Then the shaft may be rolled into place and the room cleared of lumber.

There are no pieces outside of the shaft of a 1200 horse-power engine that will need to be rolled through the streets on plank and rollers. A good, stout windlass truck will carry cylinders, slides and frames easily, one at a time.

Usually the cylinders of an engine are loaded onto the car lengthwise, that is, with center line of cylinder parallel with the long edge of the car. It is possible to handle a cylinder, even a 52-in. low pressure, sideways, and load it onto the truck, just as was the crank-shaft onto its first section of blocking. But there is nothing to be gained by it, and nobody ever does so. The cylinder should be jacked around square with the car and shoved lengthwise onto the wagon. There is nothing hard about jacking a cylinder around. There is always a nice handy place for the toe of a jack, and here of all places is a stone jack convenient. Place the toe of the jack at point *A*, Fig. 60, and go up far enough to clear a strip of half-inch iron, of width two inches, or of any other width, and also high enough to pull out and clear the nails

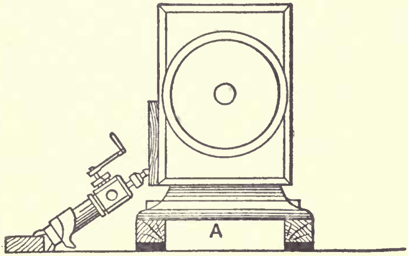


FIG. 60

with which the cylinder skids are nailed to floor bottom. Go to the other end and get another half-inch strip under, and things are ready to slide. Two blocks of wood should be spiked to the car floor for footings for jacks, one at each end, as in Fig. 61, and the jacks will squeeze the piece around very handily. The flat iron makes things slip easily and it need not be disturbed once under. When the piece is around square, the jacks can be put at *A* again and three or four rollers slid under on top of four inches of plank.

The wagon floor is some 15 in. lower than the car floor, and some stringers will have to be laid down to reach down and across. They need not be very long, however, 6 or 8 ft. is enough, and if the stringers are of 6-inch stuff they will be stiff enough to hold whatever load is to come upon them. The wagon wheels should be blocked with a good big chock and the load slowly slid on. If there is a windlass on the wagon, the easiest way to move the load is, of course, to run a line back from the drum around the cylinder. The rope should be protected where it goes over and around sharp corners with old cloth or bagging, for it

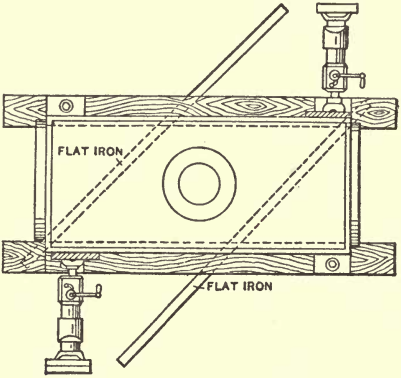


FIG. 61

is sharp corners that cut ropes. The cylinder will start without much of a pull on the rope and can be kept moving easily. A good stout rope or a small fall should be hitched to the back end of the cylinder to hold it back when it goes down the incline. Any part of the car, a stake hold, or some part of the under trussing, will answer for an anchorage for the head block, and one man with a turn or two about any convenient rail will hold and steady the piece down the hill.

It is a good plan, frequently a necessary precaution, to prop up the wagon where the end of the inclined stringers come. As the cylinder comes down the stringers, fully half and perhaps more of the weight is concentrated at that one point, while the truck will hold the load all right when spread out on the skids; it will not hold it when heaped right onto one spot. Two upright pieces of four by four resting on a plank on the ground will hold the wagon platform up stiff and strong. This precaution applies also when a jack is being used to raise one end, as in taking out or putting in rollers. Blocking on the axle is sometimes sufficient. In a case such as this, these are all the precautions necessary, for the load comes on at the back of the wagon and is nicely distributed all over its surface.

Whenever any piece is loaded upon a spring wagon it must be remembered that the springs give. Sometimes a weight has to be slid off over one front corner. If the front axle is provided with a platform spring there is a good chance of that corner going down and the load being dropped to the ground. No weight of any consequence ought to be slid either on or off a spring wagon's front end without first shoring up the two front corners.

A cylinder may be well left upon its rollers when on the wagon. The rope leading to the windlass should still be fast upon it, taking two or three extra turns for safety, and it can be hauled over to the engine room in this way.

It is an easy matter to take a cylinder off a wagon, whether the tops of foundations are high or low. If there is a fall down to the street level, an inclined runway can be built from the tail end of the wagon, and the cylinder will roll down of its own accord with nothing but the rope from the windlass on the wagon to hold it from going too fast. Frequently the platform of such a wagon or truck slopes back to a low hind end. This makes unloading down to ground level all the easier, for it makes the corner, where there is a change in angle of descent, less sharp.

Before letting a load come upon the engine room floor, in passing from threshold to foundation, with this cylinder, for instance, the floor timbers should be looked over. Many floors will not stand much loading, and in shoving machinery over a floor loads are liable to become concentrated at some weak spot. A weak floor must be shored up with sound and heavy timber. Ten by ten squares will answer in most basements, stood up on a good plank platform and coming up under a good thick piece, supporting two or three joists. Half a dozen such struts will stiffen up a good big area of floor. If the floor itself is light it can be covered with 2-in. plank.

There is some science in steering a piece on rollers by getting the proper angle for the rollers. A weight on an angle roller will move, of course, square with the roller, and clearly enough it makes no difference as to the shape of the piece. Fig. 62 illustrates this point. The weight here will move square across the roller just as it does in Fig. 63. Friction itself prevents it from doing anything else, unless it is shoved over by some force acting not in the direction of proper motion. So a roller should be placed square with the direction

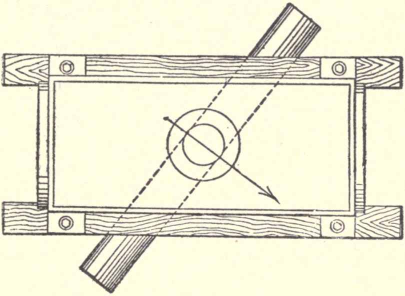


FIG. 62

in which it is intended to move the weight, and the friction of load upon roller and of roller upon plank will tend to make it take that direction when a force is

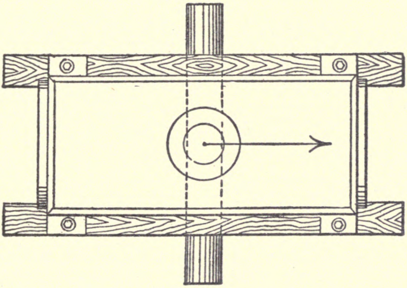


FIG. 63

applied. And it is nothing but friction that makes it take this direction.

This matter becomes more complicated when there are two or more rollers. In Fig. 64 rollers are parallel, and the weight moves square with each. Fig. 65 gives

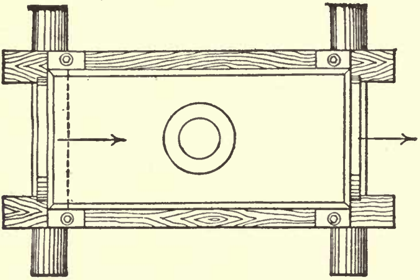


FIG. 64

a case commonly met with. The load is intended to bear off to the right and the front roller is cut around and the front end of the piece tends to move on a tangent to the right, while the rear end tries to keep

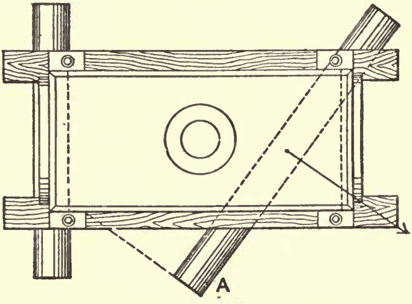


FIG. 65

on straight ahead. The piece itself is rigid, and, of course, something has got to slip. The slipping comes where slipping is easiest. If there is an equal load on the two rollers the slipping divides itself equally between the two, unless one roller happens to be smoother than the other. In the case shown above, the motion of the whole thing is about half way between these two directions, always providing the pulling force does not compel it to do something else. But the weight does not stay distributed equally more than an instant. As the load moves onward, more and more weight comes upon the front roller, relieving the rear roller, and the direction becomes more and more oblique, till the front roller has the entire weight and does all the guiding. It is possible in this way to make a weight turn quite a sharp corner. More pulling force will be needed, the load must move harder, for something has to provide the slipping force, and this may limit the shortest of the turn, for short turns pull hardest.

The guiding becomes more difficult when the number of rollers becomes greater, sometimes eight or ten or more on a long heavy load. It frequently happens on entering a cut roller, when there are only four rollers under in all, that no change in direction whatever takes place, even after the roller is some way under and has taken its load. The reason is, of course, that it is doing what it can, but the other rollers have three-quarters of the load, and they are determined that the thing shall keep on straight. So if a decided turn must be made, the direction of half the rollers should be changed. This can usually be done by striking at *A*, Fig. 65, with a heavy sledge or a timber ram.

If, however, the roller does not yield readily, the load should be relieved at this point with a jack and the roller then pounded around. Usually when a roller cannot be pounded around with the weight upon it, it will have some say in directing the load when the time comes to move.

When a roller is cut around, one end will begin to roll under the load till finally that end is away under the nearest skid. The dotted line in Fig. 65 shows this. The other end will be sticking away out ready to catch door casings or anything else in the way, and must be moved back. A jack is needed here. For wherever a roller is pounded endwise with any force it starts to split. Such practise should not be allowed among a gang of men. It is easier, but half a dozen good clips will spoil the best roller ever turned.

It is sometimes necessary to jack one end of a cylinder or other weight around, supposing, fòr instance, that one end is too near a door casing. It is enough to place the jack horizontally and the load will go around, provided there is any weight upon the roller nearest the jack. If all the load is at the center, or even a good share of it, the piece simply turns about that center; one end goes out while the other comes in, and nothing is gained so far as a shove over is concerned. A good share of the load must be made to come where the jack is placed if it is desired to move one end only. This will be known by the relative looseness of the rollers at the unloaded end, and before trying to move over sideways, some load should be taken here by blocking up the rollers an inch, or whatever is necessary.

There are always some gaps in the surface of a foundation. There must be one at least for the exhaust pipe, and frequently an opening is left under the slide. These spaces are 24 in. wide or so. Planks can be laid across for a footing for rollers and the surface made continuous temporarily. This is not necessary, however. If the width of a space is less than one-half the length of the cylinder itself (not the overall length of the skids), it can be passed very nicely, at least with anything but the largest sizes of cylinders. The prin-

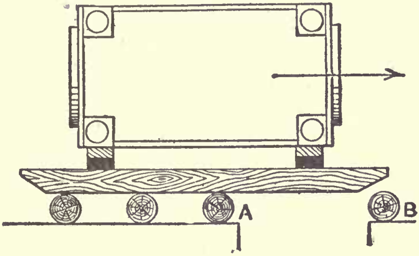


FIG. 66

ciple is that of the cantilever, and is shown in Fig. 66. The roller *A* does not drop down until roller *B* is just ready to catch its load. Rollers have to be watched, and rollers *A* and *B* should be good and sound, for on a wide gap they catch nearly the whole weight of the outfit, and if the load is too much for one roller the gap must be filled with blocking.

By such methods as these may a cylinder be rolled to its place, its skids removed and lowered down to its capstones resting on some strips of iron, to allow of entering a wedge when the time comes.

So also a slide section is hauled over on its skids; and the pillow-block section or main frame, the best of all to handle, for its weight is so low down and all six pieces may be strung along the foundation.

VIII

UNLOADING A HEAVY SHAFT

Two equal and opposite unbalanced forces applied to a rigid body will make it turn about its center of gravity. So with a crank-shaft, skidded and lying on a flat car. But the forces must both be unbalanced; and it is easy to tell when they are unbalanced, for the shaft will not move until they are. When the forces are sufficient, as for instance, the forces or pull coming from two leads to a hoisting engine drum and one of its capstan heads, the shaft ends around just as if it were on a pivot. It looks a little mite unusual at first, and the awful consequences of a dropped shaft do loom up, but there is not a safer or handier way of ending a shaft around. (Fig. 67). It is not always necessary to end a shaft around, however, to get it off its car. Sometimes it can be slid off the end; and if the shaft must be hauled along in the direction of the track for a ways, it is better of course to take the shaft off sideways. Then new skids must be provided, lying beneath and across the others. They are short and need not be very heavy, however; 10 × 10's are heavy enough, or even three 8 × 8's at each end. This will mean a good deal of jacking, lifting the shaft straight up, for there are the ten inches of short skid, eight inches of roller and there should be three inches more for planks for the roller to go upon, for they will bind the cribbing to the car and can be taken out when the

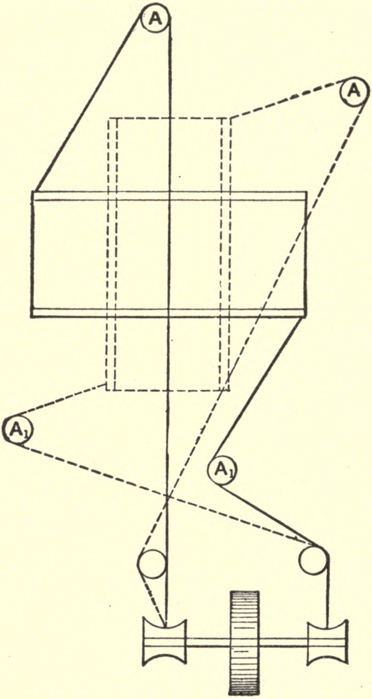


FIG. 67

shaft has been moved over and is being raised again to straighten the rollers. The skids and rollers will appear as shown in Fig. 68 when the shaft is ready to move.

It is apparent that great care should be used in plac-

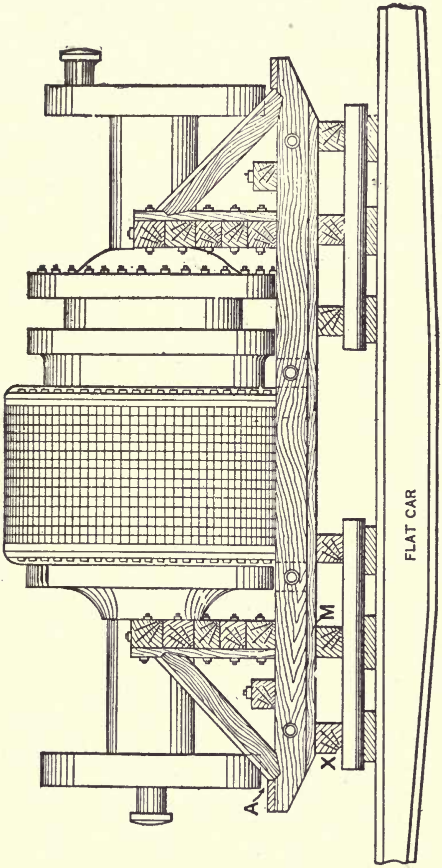


FIG. 68

ing jacks properly, and blocks should be so laid that they will take weight properly. In beginning to raise the shaft, the first hold is liable to be under one of the cranks, point *A*, Fig. 68. As pressure is brought on, the whole outfit should be watched to see that it all comes together square and even, that there is no tendency to slip or twist the jack, that its hold is good. Also the skids must be kept from spreading. If they are to be used more than once, long bolts should be run through from side to side with 8 × 8 cross braces to make things rigid. And one end only should be raised at a time. One end must rest solidly on blocking while the other is resting upon a jack. Whenever any weight rests upon three points with its center of weight inside the three, it is stable; so there must be always three points of support. In this case the friction of the other two keeps the jack in place and upright. If things move along properly there is no reason why the jack under *A* cannot be pumped up high enough to allow a 4-in. plank to be placed under at point *M*, precisely under the skid blocking which comes up under the shaft. A 4-in. block would answer, but when the other end is jacked up, starting under the crank as before, the weight is thrown cornerwise on the square block and it tends to tip up. This is prevented by placing a good wide plank under at *M*. In all this jacking the weight should be followed up closely with inch pieces and wedges, having surface enough so that they will not crush. When both ends are up four inches, both resting upon plank, the two jacks can be brought to one end, their toes placed at *M*, as nearly as may be, one on each side of the shaft, and things can be made to move faster. Eight inches can be gained at this one setting, or if the blocking seems all right, the jack can be shoved out to nearly its limit. It will take something more than plank to take the weight at the high end now. There are twelve inches to be blocked up and the principle of the cob house will have to be applied. Nothing could be more unstable than two 4-in. square blocks piled lengthwise one on top of the other, unless perhaps it be three such blocks. If they are depended upon to hold anything except weight, they are sure to topple over. If, however, two blocks, say six or eight inch, be laid lengthwise one on each side of each skid, two or three 2-in. plank laid across, the whole thing will make up the distance and allow the other end of the shaft to be raised. That end can be put right up to its place now, though it would be better to go only half way and bring the end up last from a 4-in. rise. The skids should, of course, not be allowed to rest upon a corner of a plank, with the whole weight of that end coming at that point. The outfit in coming up one end at a time must of course be out of level, and a platform of two planks or more, with wedges and inch pieces, should be used to give a bearing surface of ample area. This caution should be hardly necessary, for whenever too great a load is brought upon a piece of wood, it begins to yield slowly and there is ample time to strengthen up weak points if they are seen in time, and the most ordinary care will prevent serious mishaps from this cause.

When the shaft is brought up level, twenty inches in the clear, or a little more, between skids and car floor, resting upon plank and blocking, one end can be raised with the two jacks at points *M* and its opposite, and the short skids *X* put in place, also the rollers and the plank on top of the car floor, and the shaft lowered to its place. Before stirring the other end the rollers should be blocked from moving when they are supposed to be standing still. Pieces of 2 × 4 stuff are handy for this purpose. Cut them into 2-ft. lengths

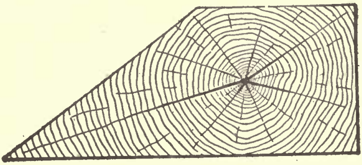


FIG. 69

and pare them down on one edge as in Fig. 69. These pieces will not slip. Both sides or at least two rollers should be securely blocked and a chock under every roller won't hurt. When one end is in proper position the other can be treated in the same way and the whole will appear as shown in Fig. 68.

Enough rollers should be used to make an easy bearing surface for the whole. It is rarely that a roller will actually crush, due to an overload alone. But overloaded rollers will sink into the wood, top and bottom, and the weight will move five times as hard as it should. The more rollers the easier the thing moves and the less danger of mishap. An 8-in. roller every eighteen inches is none too close on that heavy shaft.

When things are ready, as shown in Fig. 68, it will be time to build a runway along the car, and some nice square blocks and good plank are needed. Also some good long sticks of 12-in. timber will help. A flat car floor is about five feet above the tops of the rails and a good, solid foundation of blocking must be laid even with the top of car floor and as long as the skids, level and square. This first section can, of course, have no pitch, and somewhat more blocking will be needed than would be necessary when taking a shaft off endways. Eight-inch square blocks are most convenient for such work. They are big enough to count up pretty fast in the piling and are not too heavy to lift. However, a big 16-in. chunk has virtues which are prized by the fraternity, and even a pile of railroad sleepers are valuable. The ground is the beginning of the pile and it is easy to provide a good starting surface. Ordinarily the ground in these places is pretty soft and muddy. In such cases the best way, where it can be done, is to dig down a little way, enough to remove all the material that would be powder if it were dry, till a firmer material is reached (six inches is usually deep enough), and make a trench wide enough for two sleepers side by side, square with the track. Do this in four places and this start will be solid enough to hold up any weight that can be hauled on a railroad car. Long timbers are now needed. The whole length of the shaft skids will be about 16 ft. and timbers of this length are very convenient for the bottom of the block pile. Two 12 × 12 or three 10 × 10 of this length will make a good solid start. Lighter timbers may be used, but they should be supported often enough to make them good and stiff. The sleepers in the trench should be level and bear all over on their bottom faces, while the tops may come up an inch or so above the ground. The long timbers are laid directly upon these sleepers, stringing out parallel with the car and as far from it as convenient, say eighteen inches or two feet, to the nearer one. Now two sections of 8-in. square blocks can be started, so that the over all lengths will be a little more than the whole length of the skids, and two piles cob housed up to make a support for the top stringers. The stringers can be supported in at least four places and the longest span need not be over six feet, and only one-half the weight of the shaft can possibly come on this section, and even then the load will not come in the center. So three 12 × 12's or even three 10 × 10's will answer for the top stringers. Lighter timbers may be used, or even good sound plank laid one on top of another, but in these cases more supports should be used and a smaller crib built up between the other two.

The top planks lying across car body and blocking should be supported as often as possible.

The blocking will appear now as shown in Figs. 70 and 71.

When this first section of blocking is finished as shown in the figures, the shaft may be moved over and the car cleared. It will take considerable force to move it. A rope fall, or two or three chain falls, will furnish enough power, but it is usually not convenient to provide a fixed and rigid point for fastening the head block. A freight car will answer, or a good stiff piece of track, a frog for instance, but it will not pay to

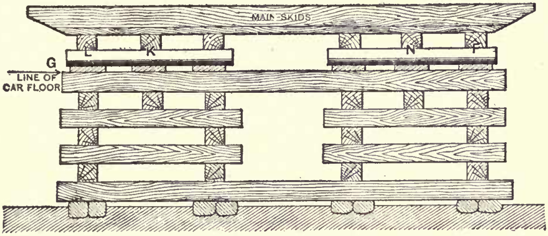


FIG. 70

locate a dead man for such a short pull. The most convenient tool for this work is a pair of stone jacks. Any kind of a jack can be made to answer, a screw jack, or even some of the patent ratchet jacks, but

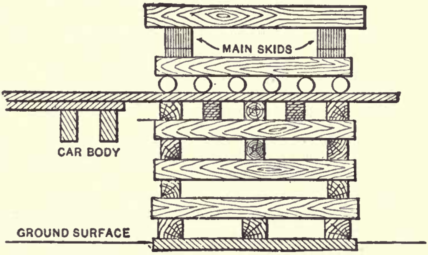


FIG. 71

nothing fits as well as the stone jack, and the stone jack will be a help all through the work. There is very little friction in its moving under load, at least in comparison with the screw jack, for there is so little rubbing, nothing but a train of gears held by a ratchet and pawl. The thing is as efficient as a compound hand winch. When two 6-ton stone jacks are used, one man at each end can make that shaft walk over very handily. The jacks will hold very well at an angle of 45 deg.; the more nearly to a horizontal position they are placed, the easier will the jack move. The foot will not slip at that angle, but if as the shaft moves onward the foot of the jack does not seem to hold well, a piece of 2 × 4 spiked to the car floor will answer, and it is easy to make two feet or more at each setting of the jack. The force required to move such a piece under these conditions is a small matter. It is easy to put two men on a jack. The time is used up in getting ready. If much space has been left between the car body and the pile of blocking it is well to keep the load off that point. It will be enough, however, to have a roller ready just before the advancing side gets across, and to place no roller in the middle of the space when the skid ends reach that point. The rollers already under need not be disturbed, for the load will be very well distributed before much of it comes here.

The shaft over, preparation can be made for taking away the rollers, plank and cross skids, and the new row of rollers put under, ready for the straightaway pull. The shaft is some 12 in. or more higher than it need be and must be lowered carefully to its proper bed. It will be found easiest to begin at the back end, for that end need be lowered very little if at all. The runway starts down an inclined plane, and if the front end only is lowered, the sharp corner where the track turns down will be avoided. There is considerable spring in the timber of skids and blocking, enough to pass by a good deal of unevenness. But that slanting track will start off at a pitch of one in five or so, and if the shaft were pushed on over this there would come an increasing load on the main skids as their center approached the corner, till finally the whole load would come at that point and the skids must break. That trouble can be avoided, as already pointed out.

The best place for the jacks is at point *X* (Fig. 68) and its mate opposite; foot of jack on the plank, over a good column of blocking, and the toes under the cross skid at *X*. A short rise will clear the other two planks, two cross skids and all the rollers at that end. Now the aim will be to build an inclined run, the high end eight inches below the bottom of the skids, just the diameter of a roller, and the low end just to cross the end *G*, Fig. 70. Only a short section can be built, for the blocks at the front end will be in the way, but it must be started now. The two 8 × 8's will answer for the top stringers, and an 8 × 8 with a short piece of plank will answer for block at the high end, and thinner stuff for the other end. The slope is gradual enough so that no trouble will be found in providing proper support for rollers. The roller farthest back should be placed at *N*, or at least not as far back as *X*, for this roller is to answer for a turning point in lowering the other end; but beginning there, cross rollers should be distributed about every 18 in. down the incline and chocked there in place.

For lowering the front end place the jacks at point *K* and its opposite on top of the 3-in. plank and under the 8-in. cross piece. Two planks, two blocks and all rollers will be made free. The cross plank at *K* will remain, but need not be in the way. The block *K* will have to come out later and a roller put in its place, but it gives a good hold for the present for the jacks. Now the incline should be finished to point *G* of blocks and plank, and a roller placed and chocked at *Z*, and more rollers strung out to cover the skids.

Lower on the jacks now and the shaft rests on a row of chocked rollers and a square block at *K*. It will be time to stretch out a small fall now, one inch or one and a quarter inches will answer, with a set of three sheave blocks for holding back on the shaft as it goes down the incline. It will not take a great force to hold the shaft, not nearly as much as would start it, of course, but hold backs are needed to avoid the outfit going down hill too fast. If the incline is short, two such falls should be used. Fasten the head blocks to a string of freight cars, if they are convenient, or to a track, though the falls should be long if they are to pull on the track, for of course the tendency is to lift the track. One frieght car would hold it down, however. Two or three turns with the leading line about some convenient fixed point, with one man to hold back, will answer for this end of the work.

The runway shown in Fig. 72 should be built now of the longest timber to be had, for 25 ft. is none too long for this slope. If long timbers are not to be had, shorter ones will answer, placed end to end. Timber

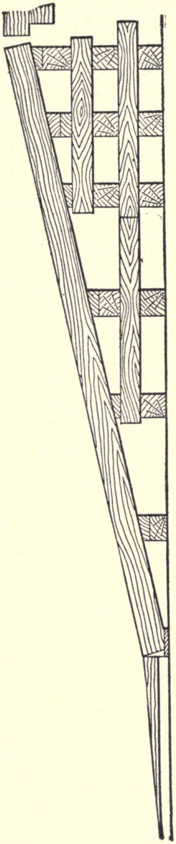


FIG. 72

laid directly upon the surface of the ground will answer for foundation here, with cob housing as shown in the cut. Support 10-in. timbers every five feet and 12-in. every seven or eight at the very least. Ease off the bottom hollow with tapering block and plank as shown, Fig. 72.

The jacks should be placed under the skids now and the block at *K* removed and a roller put in its place, all chocks removed and the shaft is ready to go down hill. Start it off with a push from behind with the stone jacks, and she can be kept moving as fast as the men on the falls holding back, slack off their hold. The movement should be slow. But with rollers placed square and true, the shaft will slide down to the ground without trouble.

IX

RIGGING FOR A HEAVY LIFT

HAULING a 65-ton shaft up an incline of one in six or one in eight will call for considerable force, fully double what is needed to make a move on level track, for, of course, the lifting takes its full share of the resistance. So the rope and rigging must be stronger, multiplying the prime force by two or more. The whole moving force at the shaft may be 12 or 14 tons for a long slope and force acting parallel with slope, approaching 16 or more as the slope becomes steeper. If this force runs higher than 16 tons, however, it will usually be found more convenient to raise the pieces straight up with jacks.

In lashing blocks for rope falls to a load such as this, they should be applied at the point where the resistance to onward motion comes as nearly as may be. The line of resistance in moving up an incline is not through the center of gravity of the piece, and is not in the line of shaft at all. It is away down to the very bottom surface of the skids, just on top of the rollers. Imagine the effect of a force pulling along the line of the shaft's center in Fig. 73. If the force were great enough the shaft would have to come, but what must happen to the skids, even if they were on rollers?

The whole moving force, whatever it might be, would be trying to make the skids take the shape shown in Fig. 74. There is nothing to make the skids themselves move except the force which comes down through the

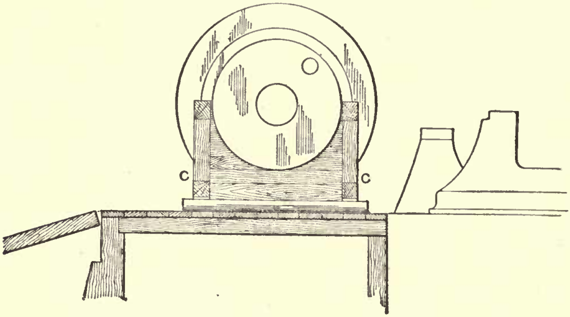


FIG. 73

pile of cross timber and the effect is the same as would come were two forces precisely equal, and each enough to move the weight applied as shown at *A* and *B*, Fig. 74. It is clear that as these two forces approach

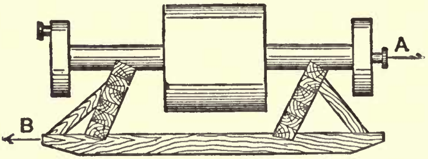


FIG. 74

each other, that is as *A* is applied lower down, the twisting effect becomes less and less and when *A* gets right down to the skids there is no twisting force whatever. So lashing should be so rigged that the pull will come down low, and the most convenient point will be at *CC*, Fig. 73.

In order to lash the block securely to this load, at least four turns of one and one-half inch rope should be used, and more, even six will not be much out of proportion. . This will give eight or more hauling parts but they are not, of course, pulling in the direction of motion and this whole strength is reduced in proportion to the shortness of the hitch. Long hitches are best, if there is none too much rope handy, and the lashing is bound about something that spreads the parts of the lashing out wide, as Fig. 73 will do.

A great many rope blocks will not take in four parts of one and one-half inch rope in the hook. Most blocks are defective in this respect. There is not room enough in the hook or clevis to take in rope enough to equal the strength of the fall itself. When this is the case, it is best to have a link or clevis forged that will take in plenty of lashing and big and stout enough to stand hard usage. The rope block may be hooked into this link. Also the hook itself should be looked at. These hooks are frequently weak. A clevis is better and stronger, though not always as convenient. On any heavy pull the hook should be bound with marline to stiffen it up, as shown in Fig. 75. This will help enormously in preventing the hook from straightening out, as shown in Fig. 76. It is a good plan to make a clamp, as shown in Fig. 77, to bolt on, which may make a hook almost as stout as a clevis.

A single rope fall for one and one-quarter inch rope, rove through three and two sheave blocks will not be strong enough to haul such a shaft as this up the hill. Two falls of this size will answer very well, however,

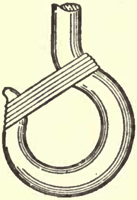


FIG. 75

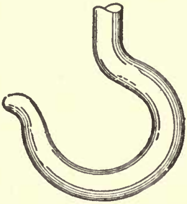


FIG. 76

but the rope should be in prime condition for such a pull. There is always one difficulty in getting two falls to do the work of one, which must be guarded against. If two falls each had an independent hitch to a load and their hauling lines are led to separate hand winches, it is easy to see that there is no way of dividing the load equally, or even approximately

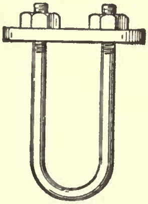


FIG. 77

equal between the two. So long as one was kept up taut, with no slack and perhaps a little load, it would appear just like the other which has the full load. Some idea may be had, to be sure, by taking a line in the hand, as to how much load it has, but this cannot be depended upon for halving a load up. A fall should always be tested in that way, however, when the amount of the load is at all uncertain. But if the load is so much that it seems best not to have much over one-half of it on each of two falls, some way of equaling things up must be devised. Fig. 78 shows an easy

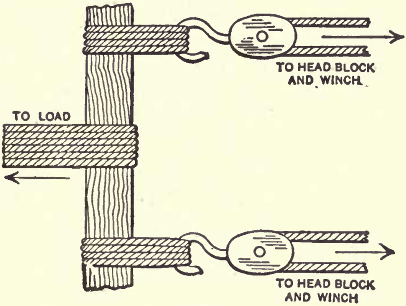


FIG. 78

way which is the principle of the evener on a two-horse wagon. One fall must have about the same load as the other if the cross timber is kept anywhere near square.

If there are to be many heavy pulls, it is of course more convenient to have one good heavy fall of 2-in. rope, two inches in diameter. It is always best in ordering rope to specify whether the measurement refers to circumference or to diameter. Some riggers and ship chandlers always speak of a size as referring to circumference, while an engineer always thinks of diameter. And again, rope is sometimes ordered by the circumference, three-inch, for instance, when a nice light fall of inch-diameter rope is wanted, and the next day a dray backs up with a hawser stout enough for a man-of-war. *In the articles relating to this subject a size refers to the diameter.* Six parts of 2-in. rope will be good for 40 tons on work such as this. Inch and one-quarter rope is spoken of here more often because it is a convenient size to handle and is still stout enough for heavy work.

If two falls are used on this load, there will be needed a hauling force on the leading ropes of about one ton, which may be furnished by the hand winches, or by luff tackles.

When a load is being hauled up an incline, the rollers must be followed closely with chocks to prevent the piece running down in case of a break in the rigging pulling ahead. Any one rope breaking of course lets the whole load back. And the chocks should be good big chunks. A load will go over an inch piece if it has a trifling start; more than one roller should be chocked. A man on each side with a chock in each hand taking in both ends of two rollers which have a good load on them will not be an over caution.

When a shaft has been hauled up in front of its pillow-blocks, as shown in Fig. 73, the easy part of the work is finished. There is less room to work in then, and there will be much for the jacks to do. The piece must be raised to the position shown in Fig. 79, high enough for everything to clear when the shaft is rolled over. If the generator frame parts in a horizontal plane, the shaft must go up till the bottom circumference of the armature clears the top of the lower half frame. This may require the whole shaft to go up so that its center is nearly seven feet above the tops of the foundation, or four feet higher than it will be when in place. And it will have to be raised some three feet higher than it is when lying on skids and rollers.

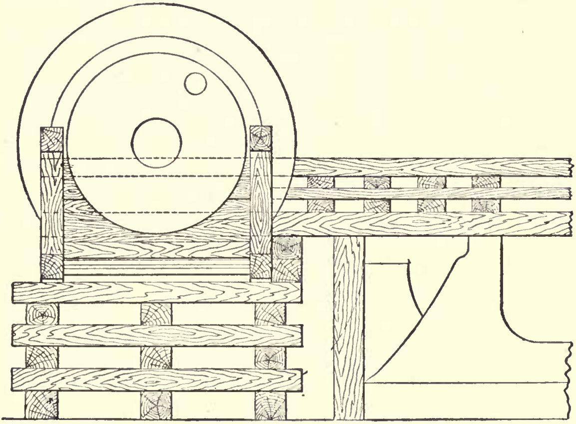


FIG. 79

It is possible to raise the shaft up clear of the skids, resting it upon blocking, and by taking the skids apart they may be pulled out of the way. But it is usually easier to let the shaft lie in the skids and raise the whole thing together. This will save a good deal of blocking nearly half of the whole amount needed in raising, and is quite as easy. The two jacks should be taken to one end of the skids, one on each side with toes under the point where the cross blocking comes.

One end goes up at a time, and a cob house pile of 8-in. blocks four high will usually be enough, the skids resting fair and level on such a pile at each end.

The next question will be in getting the shaft out of its seat on the skids and onto a run reaching over tops of pillow-block jaws, and coming up fair under what is to be the shaft journals. Now, one jack must be placed with its foot resting on a block laid across the skids, and with its top coming up under a saddle like that shown in Fig. 80, under the shaft. The jack

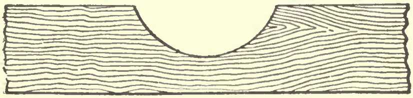


FIG. 80

may be placed either in front of the pile of cross block or behind it. There is usually more room behind it. Care must be used here for there is nothing but friction to prevent the shaft from turning over and knocking the jack out; so jacks must be placed precisely under the center line of shaft on such lifts as these, and the opening coming over the seat of the shaft must be filled up closely with blocking. Inch pieces and wedges must be shoved in wherever there is a chance. A piece of 2-in. plank should be shaped up as shown in Fig. 81 for each end. These will be used in lowering the shaft too, and will be the start of the blocking when raising out of the wooden seat. Two-inch pieces piled one piece atop of another will fill the hollow in the top block as the shaft goes up. One end, of course, must go up at a time, and it is best to make short lifts and keep the shaft pretty nearly level, for extreme care must be used here.

The shaft must go high enough to allow 12-in. timbers

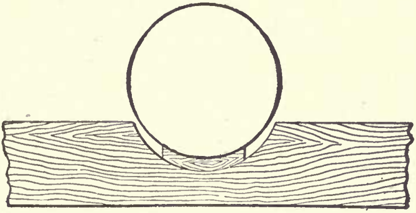


FIG. 81

to pass under, as shown in Fig. 82, side by side, and these timbers are to reach away across and rest on blocking on top of the pillow-block jaws. If 12-in. timber is not to be had, 4-in. plank may be used, stiffened up as

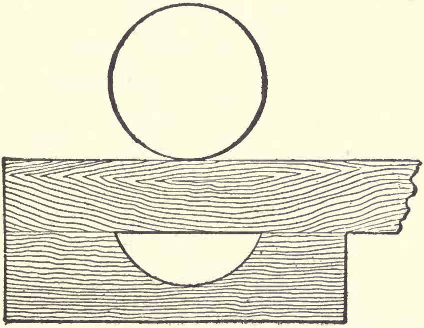


FIG. 82

shown in Fig. 79, and two or three piles made. The number and size of plank and blocking will depend upon the length of span. The load is concentrated at a single point here and allowance should be made accordingly. If two 12-in. timbers are laid side by side at each end, they should be supported about every three feet, either with a block or with a good solid stud.

No great force will be required to start the shaft rolling over and moving toward its bearings. It should be started square, for it is not easy to slide one end ahead to even things up. Five or six turns of inch and one-half lashing may be wrapped about one of the cranks and one end of the lashing hooked onto the hauling tackle which has its leading line going to the winding drum of the winch, as in Fig. 83. The other

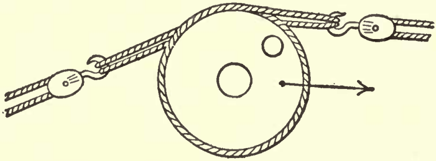


FIG. 83

end of the lashing may hook into a smaller fall for holding back and preventing things from going too fast, also for making the lashing bite onto the crank and not slip round. The small fall has its line take a turn or two about a post, and is paid out by one man who can check all rolling instantly. As the shaft approaches the point squarely over its bearings, checks should be ready to hold it in place ready for the jacks.

When the shaft is over and ready to be lowered to place, it will do no harm to lead off lines from both cranks, as shown in Fig. 83. These will prevent the shaft from rolling while resting on a jack. The cradle,

Fig. 80, should be used for a support on top of the jacks as the surface which should fit pretty well will tend to keep the jack in place.

Considerable more than one-half the weight of the shaft will come on the jacks now, for they are so near the center of the shaft length. As a solid footing must be provided, one side may be blocked up from the generator foundation and will require only a small

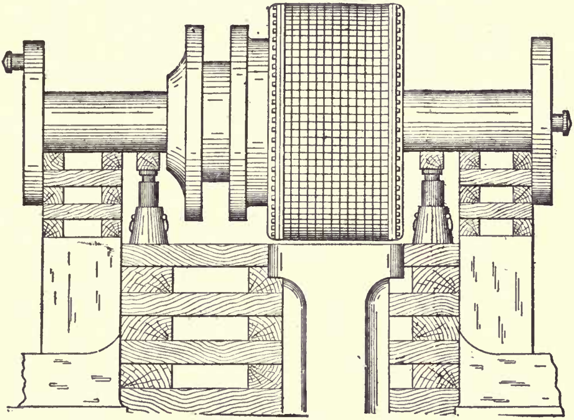


FIG. 84

amount of blocking. Sometimes both sides may be fixed in this way. If, however, the opening is too deep, it is better to stand two 10 × 10 upright columns braced to the foundation, with a good block for a bolster on top. Then a cob house pile of block may be built resting partly on the bolster and partly on the top of the foundation, extending across the gap for fly-wheel and generator as shown in Fig. 84. There is just about room enough for a jack at each end, and the blocking is all done from the frame itself. The first aim is to get rid of the long timbers, the skids and all loose blocking which is spread about now in quantity and a trifling raise will free all this stuff. Only one end rests it weight on a jack at a time, and only a thin block can be removed at one time, for of

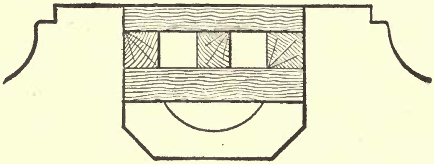


FIG. 85

course the crank checks will bind on the frame faces if one end is much lower than the other. Some blocks should be cut of length to fit nicely within the jaws of the frame, as shown in Fig. 85. Before the shaft is finally settled, while up about an inch above its seat, all dirt should be carefully blown out. Then the final lowering may come and the jaws filled with waste and bagging to keep out everything that can cut a bearing.

X

BUILDING UP A FLY-WHEEL

A MAN will not boast very much of his work on the fly-wheel if it takes over a day to get all the section in place with enough bolts driven in to hold the thing together over night. Sometimes, it does take longer than this if the rigging is not all ready, and particularly if there is some fitting to be done. The man who does get through in a day is entitled to a moderate boast. His speed depends upon the rigging he gets up to handle the sections; there are eight or more, and it pays to get up something which can be handled quickly. The sections will come in the door and be rolled up in front of the shaft on their rollers lying flat upon the floor in the position shown in Fig. 86. All this work has been done with crow-bar and winch with perhaps a little jacking. When the section is once up off the ground four or five inches it is not a bad piece to handle. It must be lifted up, turned and shoved in between the hub cheeks, and some stout lashing should be provided for this work. The first hitch will be shown in Fig. 86. It is not intended to lift the section here, but simply to stand it up ready for the lifting hold. Not over one-half the whole weight need come on the lashing here and the piece may be made to take the

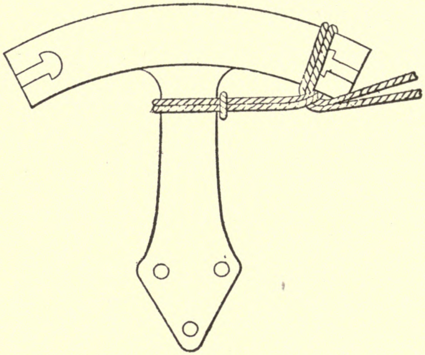


FIG. 86

position shown in Fig. 87. A 10×10 gin pole with a good head block furnishes the overhead rigging and six parts of one and one-quarter inch rope will answer

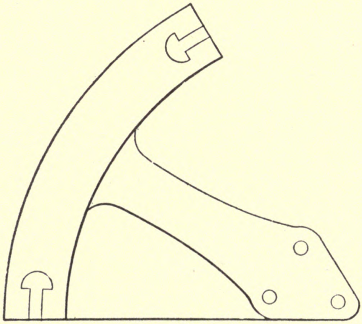


FIG. 87

for the hoisting tackle. No lashing used as a sling on these heavy sections should be lighter than one and one-half inches in diameter. A single sling of that size has all it should do in lifting half of this weight.

The piece will stand by itself when in the position shown in Fig. 87, and the hitch may be shifted for the final lift. The easiest way of taking hold of a segment is shown in Fig. 88, but stout rope will be required.

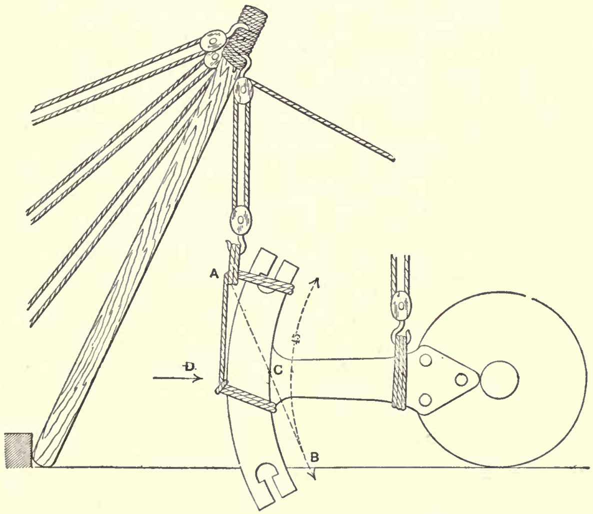


FIG. 88

Two parts of 2-in. rope will lift this section, but the rope must be new and in prime condition. It is safe then to go as here shown. The arm will not hang horizontally for the center of gravity of the piece is near the point *C* so the line *A B* will be vertical. This will do very well for swinging the weight on the gin pole by letting in and out on the guy falls. The arm may be lifted with a light fall or a chain tackle to bring it up horizontal, approximately, and the section is ready to enter. It should of course be seen to that the piece goes up fairly vertical and does not cant over very much. A little twist can be taken out by shoving a bar into one of the bolt holes, but not much force should be required here. The hitch itself should be made central. The section is swung up ready to enter by letting off on the back guy. It should enter a little way of its own accord. It may not, and probably will not, slide away down to its place by itself, but it should enter without forcing. There is no need of the fit being very tight. It is not a bad plan to caliper both arms and space before trying to enter at all; but it is not always worth while.

Some judgment must be used in pounding the arm home. The tackle holding the weight should be swung forward a little so that its tendency is to help the piece in. Then two men with a block weighing 150 lbs. swinging it as a ram, ought to be able to send the piece in by striking at *D*. It is easy to get up more force than this with heavier timber and more men, or even to rig up a jack. But if the arm starts in tight it will be a very difficult matter to force it out again. It is better to file the faces of the arm and ease things up a little. The surface is a large one to file over, and must be kept true; but there is usually not much to come off for the arms have been in there once, and if they enter hard the second time it is because the cheeks may be a trifle closer together this time. If the arm binds a little, it is sometimes possible to make it slide home by raising and lowering a little on the main tackle, enough to give it a new position. As soon as one of the holes comes in place the first bolt must be put in, and the other two follow by turning on that one as a center. The bolts themselves will fit tight, but may be driven in with blows from a sledge. But in driving the bolt should be watched, for if one binds it is not easily gotten out. A sledge alone will not start it, and it is frequently almost impossible to apply a jack to any purpose. Cases have been known where a tight bolt part way in had to be drilled out with a ratchet. Jobs of that kind take days and tie up all other work on the wheel in the bargain. The bolts and holes both may caliper all right, but sometimes the hole is not perfectly straight. The progress of the bolt must be noted as it is driven in. It is possible to tell with almost certainty whether the bolt is growing tighter and tighter as it advances.

When one section is in place and all three bolts are in their holes with nuts slack, it is possible to save some time by choosing the best section to put in next. So far as the amount of work in putting in the sections themselves is concerned, it makes no difference. The difference comes in in the number of times a wheel must be turned over and the amount of force necessary to do it. The most natural way is to take one section after another, in order, leaving only one section as a fill-in to complete at the last. This method places less stress than any other does on hub bolts and hub casting. The great objection is that the whole weight practically of three sections will have to be lifted at one time by the rigging in turning the wheel. This will be apparent from Fig. 90, which shows a wheel with eight arms. The section marked 1 is put in and lowered on to a block or a timber across the front face of the foundation. No. 2 is put in, and then both 2 and 3 have to be raised before the block can be taken out to let those sections down and out of the way. This is again true of 1, 2 and 3, before No. 4 can go in, and this same heavy lift is again encountered

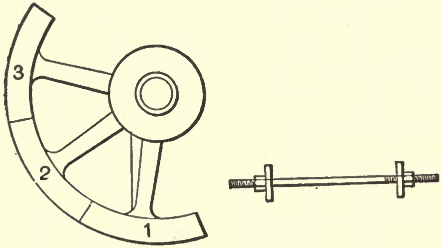


FIG. 89

by the fall on the other side of the wheel when the sixth section is put in. Each section does help to hold its neighbor, however, for they may be clamped together with a temporary bolt, as shown at the right of Fig. 89, and the load is distributed as well as it can be. The links are not put in till all sections are in place, but it is plain that the weight of No. 3 is partly borne by 2 and 1, thus relieving the shearing load on its bolts. In lifting these three sections or two and a half, perhaps, for the whole weight of No. 1 is not lifted, though the friction of the shaft about makes this up, it is clear that the hitch should not be made on the arm or the rim of No. 3. No. 1 is the arm to pull on. As an offset against these heavy lifts come the short distances of movement and the lifts are short. For this method two rigs are needed, one on each side of the wheel, that is, at opposite ends of a horizontal diameter and each capable of lifting three sections.

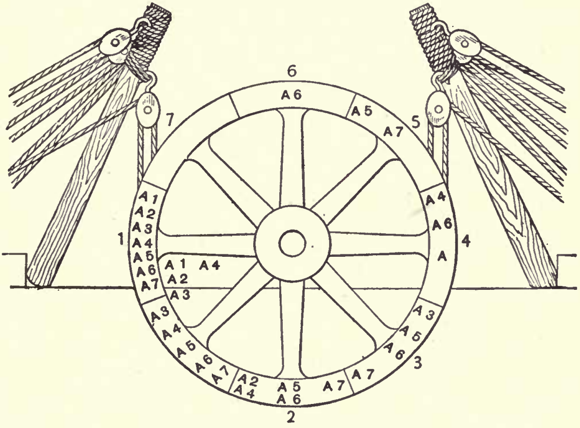


FIG. 90

It is possible to decrease this load if the arms are not too heavy in proportion to the size of the bolts, and can safely be hung out straight and horizontal from the hub, bringing of course a twisting load which must be resisted by the shearing resistance of the three bolts and their crushing strength. On many wheels the bolts are ample for this, and if the rim is of the steel-plate rim style, the bolts are more than adequate. The method is shown in Fig. 90. The principle is to let the heavy part of the wheel go down and stay there. The rigging must be stout enough to lift one section and at the same time turn the wheel, and one set of rigging must be used on each side of the wheel as before. The sections are all put in in the position marked 1 and the first section takes the position as shown in the figures on the outer circumference in the figure. Also the figure shows the position of the sections when any number of them are in. For instance, when there are four sections in they take the position marked *A* 4 and move to position *A* 5 when number 5 has gone in. This will be more apparent in Fig. 91.

The first piece is put in as shown in *A* and can be lowered to the bottom position shown in *B*. Its own weight takes it there and the fall in front of the wheel is slowly lowered off till the rotation stops of its own accord in the best place for sliding in section No. 2 as shown in *B*. Now the first fall is slaked again and the wheel stops again in the best position for the third section, leaving a gap precisely at the bottom as shown at *C*. The fall is again slacked off, but this time the wheel does not roll far enough to allow the fourth section to enter, and it must be helped out by the fall back of the wheel, though the latter will not have to lift as much as a whole section. Now in *D* there are two sections on one diameter which balance each other, and as the front fall is let off the other two sections govern the position the wheel will assume. It will not

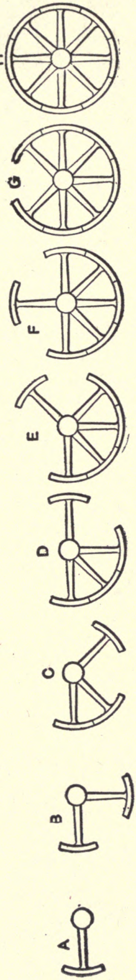


FIG. 91

roll quite far enough for the fifth piece, and a little load will have to be taken by the back fall, when the section will make the wheel appear as shown at *E*. In order to get in place for No. 6 the back fall now will have to lift a whole section, for in the position shown at *F* the wheel is in balance, and before No. 6 throws in its weight, the section directly opposite must be held by the back fall. A full section will rest in the back fall when No. 7 is put in as shown at *G*, but as soon as No. 7 is in the wheel is again in balance. The back fall now rolls the wheel on lifting one full section and the last piece is slid in place.

XI

THE ERECTION OF HIGH-SPEED CENTER-CRANK ENGINES[1]

THE high-speed center-crank engine, with which this article deals, is seldom sold in sizes greater than 200 horse-power. It is very well standardized as to design and the cost of even the best makes is comparatively small, so that the cost of erection, when this is done by an erector from the maker's shop, forms a large percentage of the total cost of the engine ready to run. The railroad fare and living expenses of the shopman are usually more than the actual expenses of erection, particularly when but one engine is installed.

To avoid this unnecessary expense it is quite common for the purchaser's engineer to erect the engine and it is the purpose of this article to give clear and concise directions for so doing. The method given is that used by most professional erectors. It should be borne in mind that the various makes differ somewhat as to details, but the erection as a whole is practically the same for all makes.

We will suppose that the foundation has been built with due regard to alinement with the machine to be

[1] Contributed to *Power* by H. V. Hunt and C. G. Robbins.

driven, if the engine is belted, or, if direct-coupled, with the building or other predetermined point; that its top presents an even surface, and that the anchor bolts have sufficient clearance around them to allow for any small inaccuracy in setting them. Also that the engine has been brought from the railroad and placed on the engine-room floor. This is usually a truckman's job and is contracted for a lump sum. Most engines of this type are provided with a subbase or foundation-box under the frame, high enough to allow the wheels to clear the floor by a few inches. Whatever leveling or alining is to be done to set the engine must be done to this box, for when it is set the whole engine is set.

The foundation-box will be left on blocks or rollers and can be moved directly over its place on the foundation, so that the anchor bolts line up fairly well with their respective holes, blocking being used so that the bottom of the box is about 1 in. above the ends of the bolts. It is seldom that the bolts are so set that they enter the holes without some little difficulty. The easiest way to place the box is to remove some of the blocking until the box rests on the ends of the bolts, leaving the remainder of the blocking about ½-in. below the bolt tops.

Then when the holes are pushed or driven over they will not spring back, and when the bolts are fair with the holes the box drops down over them to the blocking ½-in. below. At first sight it appears that the threads would be injured, but it seldom happens that they are marred in the least. After the box has been lowered until it rests upon 2-in. planks, the leveling bolts or wedges can be put in and the planks removed. The foundation-box can now be leveled and alined.

Locate on the machined top flange of the box the center line of the engine and the center line of shaft, making the marks good and sharp with a scribe or penknife, as shown in Fig. 92.

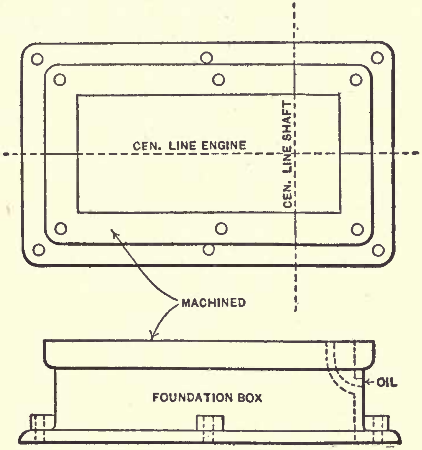


FIG. 92

If the engine is to be belted, find the distance *E*, Fig. 93, from the center line of the engine to the center line of the driving-wheel. Knowing the relation that this line and the shaft center line must bear to the driven machine, a convenient and accurate method of alinement must be found. That in Fig. 93 is very good. It represents the case of alining to a shaft. Attach a fine line to a convenient point *A* on the shaft, extending the line to any convenient point *a* beyond the engine. Square the line with the shaft by the well-known triangle of 6, 8 and 10; that is, measure out from *A* 6 ft. on the shaft to point *C*, 8 ft. on the line to point *B*, and move the end *a* of the line until the distance *B C* measures exactly 10 ft. The line is then square with the shaft.

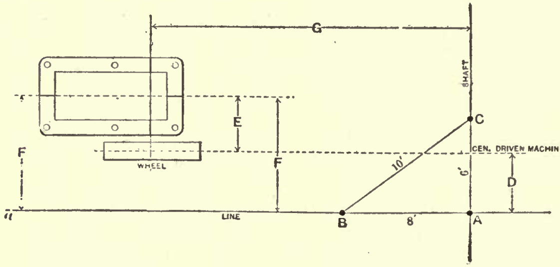


FIG. 93

Measure the distance *D* from the line to the center of the driven pulley and move the foundation-box over until the distance *F* at each end is exactly equal to the sum of the two measurements *D* and *E*. The engine is then in line with the driven pulley and square with the shaft; the belt-center distance *G* is not important, any inaccuracy being taken up by the belt. If the engine is direct-connected to a pump or generator the foundation-box can be set accurately enough for all practical purposes by direct measurements from the building or other given point to either of the center lines on the box.

For leveling the box, use a level which is accurate and fairly sensitive, an iron body level being preferable. Place the level parallel with each center line, thus leveling both ways, and make the necessary adjustments with the wedges or adjusting screws under the box.

After the box is set, leveled and alined it is always advisable to check up all the measurements, as any errors are more easily corrected now than later.

If these measurements are all correct, the box is ready to be grouted. For this use a mixture of 1 part Portland cement and 1 part sand, moistened enough to pack well; or the mixture may be made thin enough, by the addition of water, to be poured. If it is desired to pour the grouting, make a dam of clay around the outside of the box, about 1 in. outside of the lower flange, and pour the grout from the inside of the box until it completely fills the space between the foundation and the flange of the box. After this is set, it is a good plan to fill the box to a depth of about 6 in. with a mixture of 1 part cement, 2 parts sand and 3 parts broken stone. This prevents the drum-like noise sometimes produced by the large hollow box and in addition securely locks the engine in place. This is especially desirable where the engine is belted, preventing any twisting from the pull of the belt. After making sure that the oil catcher and oil hole are clean the box is ready for the engine frame. The frame can be brought alongside the box and blocked up, raising one end at a time, until it is a little higher than the top of the box. An old rail or a 6×6 in. iron-shod timber, well oiled, should now be placed under each end of the frame; one end resting on the foundation-box, the other on the blocking under the frame, as in Fig. 94. The frame can then be easily slid sidewise until it is directly over the box. After making sure that the surfaces are clean and that there are no burrs or rough places on either box or frame, it can be lowered until it rests on the top of the box.

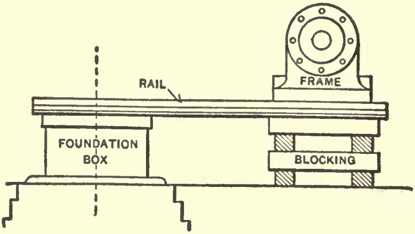


FIG. 94

Usually the frame is held to the box by bolts tapped into the latter. Alinement with the box is provided for in the shop either by making two diagonally opposite bolts a reamed fit, or by dowel-pins fitting tightly into holes in the box and frame. Some makers use anchor bolts extending up through the box and frame thus doing away with the tap bolts between frame and box; in such cases dowel-pins are used to line the frame to the box. In any case the dowel-pins or reamed bolts should be securely in place before the other bolts are tightened.

It will be found safer and easier to hoist the shaft and cylinder from overhead if means can be found to suspend chain blocks or rope tackle at the proper points. If there are no conveniences in the building a good gallows frame rig can be made as in Fig. 95. For ordinary work, the uprights and cross-beam may be made of 6×6-in. timbers and the bottom pieces of

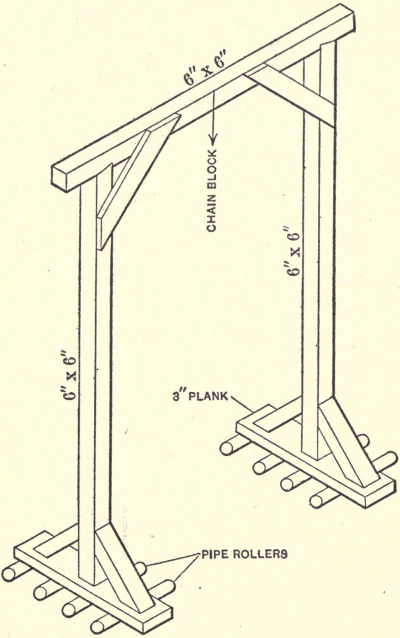


FIG. 95

3-in. plank. Chain blocks of sufficient capacity for the weight are hung from the center of the cross-piece, and 1½-in. pipe rollers will allow the necessary movement.

For belted engines, the gallows frame should be wide enough to clear the shaft; but in direct-connected engines, where the shaft is four or five feet longer, it is not necessary to make it so wide.

Figure 96 shows the frame in use in placing a shaft.

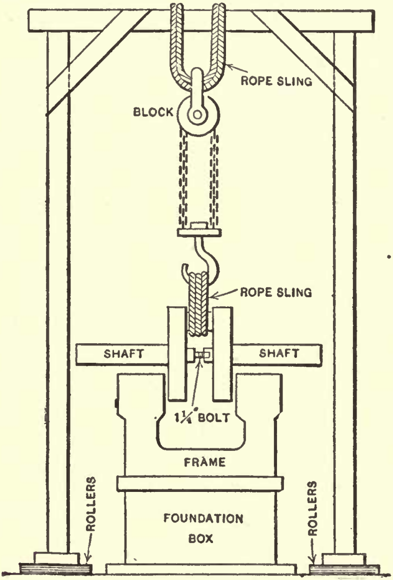


FIG. 96

The shaft is lifted by a rope sling around the crank-pin, raised until it is high enough to clear the bearings, and the gallows frame is rolled back until the shaft is over the bearings, when it is lowered into place. Before lifting any of the weight of the shaft, a block or pin must be placed between the disks to prevent the overhanging weight of the shaft from springing the disks together. For this purpose a 1¼-in. bolt with a nut, just long enough to go between the disks, may be used. The bolt is slipped into place and the nut backed off just enough to take the strain and to wedge the bolt tightly in place. This bolt is shown in Fig. 96. A block of wood or a piece of iron or pipe wedged tightly between the disks will of course answer the same purpose.

Another way to put in the shaft is shown by Fig. 97.

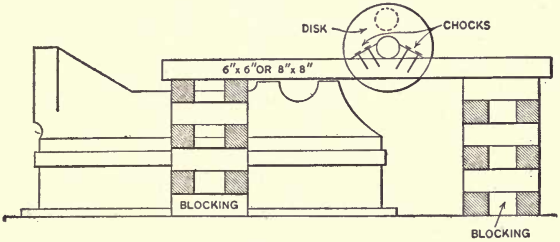


FIG. 97

Here a 6×6-in. or an 8×8-in. timber is put under each end of the shaft and the shaft is securely held in place on these timbers by "chocks" or stops. Each end of the timbers is then alternately raised by levers or jacks, and followed up by blocking until the shaft is at the proper hight, as shown. The chocks can then be removed, the shaft rolled to a point directly over the bearings, and, by removing the blocking, lowered into place. This is a very convenient method for placing the long armature shaft of a direct-connected engine.

After the shaft is lowered into place the quarter-boxes, if there are any, should be put into place and adjusted to bear against the shaft. The exposed part of the shaft should then be coated with a mixture of lamp-black and oil, and the shaft be rolled around. This blacking will be rubbed off the shaft on the bearings at the high points. The shaft should be lifted, the quarter-boxes removed, and the bearings scraped to a perfect fit. The caps and quarter-boxes should be fitted and scraped in the same manner, and thin liners should be used under the caps to prevent pinching or binding the shaft.

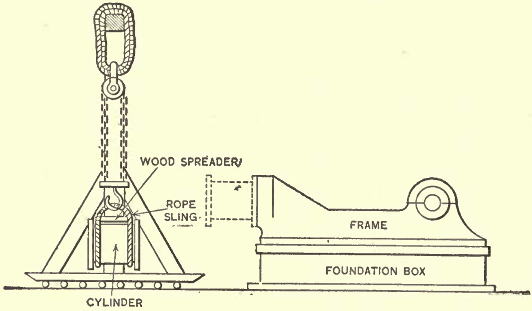


FIG. 98

The engine is now ready for the cylinder. This may be put on with the gallows frame, as shown in Fig. 98. The cylinder is moved to a position on the floor in line with the engine center, lifted by the chain blocks to the proper level and the frame rolled forward until the cylinder is in place. To insure the easy entrance of the bolts connecting the cylinder and frame it is absolutely necessary to have the cylinder perfectly level when lifting it, and to see that the steam-chest side is properly placed.

Unless the lagging is very heavy, it is best to remove it before putting on the rope lashing by which it is lifted.

If the engine is a tandem compound one, put on first that cylinder which is next the frame, place the piston for that cylinder on the rod and put it into the

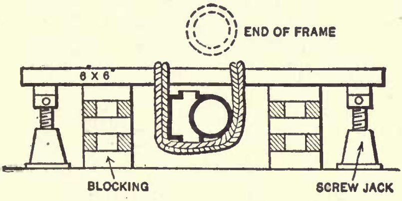


FIG. 99

cylinder. Next put on the clyinder head, distance pieces, etc., lifting them all with the blocks on the frame. The other cylinder can then be lifted and placed as before by the gallows frame. The support can then be placed under the cylinder, and then (and not until then) should the chain blocks be released.

The other piston should then be put on the rod, the cross-head put into place and the rod screwed roughly into the head. The final adjustment for equal clearance is not made until the connecting-rod is in place.

Figure 99 shows a method of raising the cylinder by blocking. The cylinder is firmly lashed to a 6×6-in. or an 8×8 in. timber, the ends of which are alternately raised by screw-jacks and followed by blocking until the proper hight is reached. Then by sliding the timber along the blocks toward the frame the bolts or studs are entered and the cylinder made fast.

There is usually a valve guide or rocker arm to transmit the motion from the ecccntric-rod to the valve-stem; this can now be put into place.

The governor wheel should now be put on the shaft and pushed on until the eccentric-rod when connected to the eccentric-strap will line up with the pin on the valve-guide or rocker arm. The eccentric carrier and

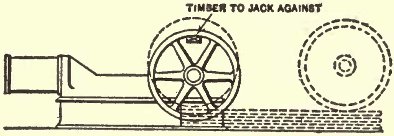


FIG. 100

the governor are usually carried on the wheel independently of the shaft and for this reason the wheels were not put on as soon as the shaft was finished — that is, the wheel could not be put on until the eccentric-rod pin, which governs the wheel's location, was in place. To exactly locate the governor wheel on the shaft some makers put a set-screw in the wheel hub and a corresponding pocket in the shaft. When the screw will just enter the pocket, the wheel has been pushed on to the proper point. In lieu of any other guide the method first described, *i.e.*, having the eccentric-rod line up with its pin, is sure.

Figures 100, 101, 102 and 103 show the method of raising the wheels and pressing them on the shaft. To raise the wheel to the proper hight, place a 1½ or 2-in. plank on the floor so that when the wheel is rolled up on the plank it will just clear the end of the bearing. Roll the wheel to one end of the first plank, place another plank on top of the first and roll the wheel back and up on to this second plank. Repeat the operation until the wheel is at the right hight to be worked over and entered on the shaft. It will usually be found that the wheel will go on the shaft freely for a few inches, but must be pressed on for the remainder of its bearing.

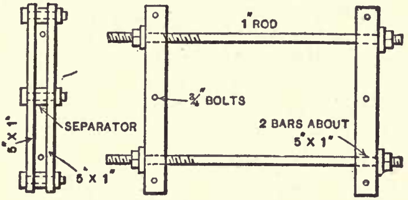


FIG. 101

For this purpose a pair of clamps like those in Fig. 101 are cheap and convenient and will not subject any of the engine parts to undue stresses. The cross-pieces of this clamp consist each of two pieces of flat iron ¾ or 1 in. thick and about 1 in. less in width than the space between the crank disks. Each pair should be bolted together with three ¾-in. bolts with 1¼-in. spreaders or separators, which may be wood, pieces of pipe or old nuts.

The rods should be 1 in. in diameter with two nuts, and should have about $1\frac{1}{2}$-in. thread on one end and 12-in. on the other.

The method of operation is shown in Figs. 102 and

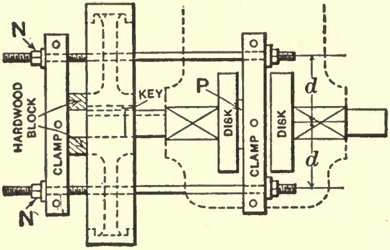


FIG. 102

103. Put one of the cross-pieces between the disks, using a plate *P* to keep the strain off the disk and counterbalance, and directly on the end of the shaft. Place the other clamp outside of the wheel, resting it

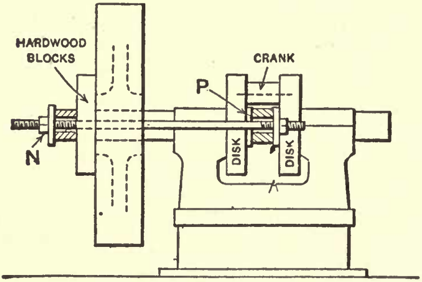


FIG. 103

on two hardwood blocks bearing against the face of the hub. After placing the bolts in position, the wheel can be pressed on by screwing up the nuts *N N*. In doing this be careful to have the rods the same distance from the shaft-center, as at *d d*, Fig. 102, and to screw the two nuts *N N* an equal amount as nearly as possible. This avoids cramping the wheel or pulling it on out of line. This method is superior to jacking the wheel on from the ouside, as it puts the stress entirely on the straight piece of shaft between the disk and the wheel on the one side of the engine, and cannot spring the crank or cause other damages.

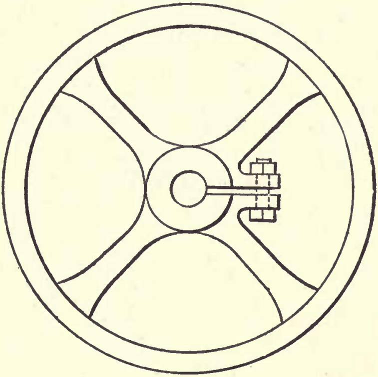


FIG. 104

Where the wheel hub is split, as in Fig. 104, a wedge can be driven in the split, opening it so that the wheel will go on easily. In such cases the pinch bolts should be heated quite warm just before being put in and tightened up; the contraction will insure them against working loose after a period of use.

The keyways in wheel and shaft should be made to coincide or match after the wheel is on a few inches and before the clamp is put on. To do this put a block of wood in the crank-pit so that the shaft cannot complete a revolution. Roll the engine until the crank is away from the block, then roll it back until the crank-pin strikes the block. This shock will shift the wheel a little on the shaft and can be repeated until the keyways are in line. In driving the keys be sure that they do not bind top and bottom.

Next the connecting-rod should be put in. First connect the rod to the crank-pin, leaving the other end free, first coating the pin with lampblack and oil. Key the rod up tight and swing it to see if the other end falls in the center of the cross-head pin. If it does not, scrape the boxes at one side until it does, being careful to leave a good full bearing in the boxes. Repeat this operation by connecting the rod to the cross-head pin and making it come central on the crank-pin. This will avoid "side lash" and it is a good plan to try it with the crank-pin at both ends of the stroke.

If there is any doubt about the shaft being square with the center line of the engine, which would affect the alinement of the rod, it may be tested before the wheels are on, as shown in Fig. 105. All that is necessary is to place a true straight-edge across the planed cylinder face and measure from it to the surface of the shaft at each side of the engine. These distances *a a* should be equal if both ends of the shaft are of the same diameter. The crank center should next be trammed. Fig. 106 shows how to do this. Turn the engine forward until the crank is 15 or 20 deg. from the center. Make a sharp scribe mark *A* on guide and cross-head. Make a punch mark *B* on the engine frame near the crank disk, and from this with a bent

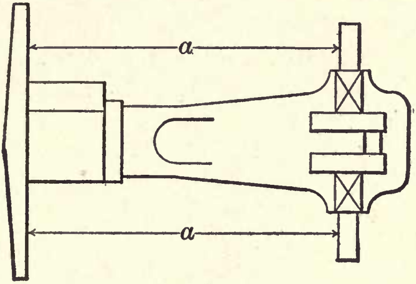


FIG. 105

tram make a mark *C* on the disk face. Turn the engine over until marks *A* and on the guide and cross-head again coincide. With the same tram and from the punch mark *B* make a second mark *D* on the disk.

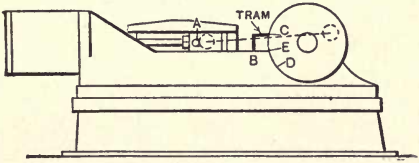


FIG. 106

Divide the distance *C D* with a pair of dividers and put a punch mark *E* exactly half-way between them. Turn the engine until the tram just fits the punch marks *B* and *E;* the engine is then on the center.

Note that all lost motion, if there is any, must be taken up in the same direction in all operations.

Now the engine should be put on the center and the piston-rod screwed into or out of the cross-head until the piston is traveling central in the cylinder, *i.e.*, until the clearance is equal at both ends. The rod can be screwed or unscrewed with a long wrench or by taking a number of turns of rope around the rod, holding the free end of the rope and unwinding it with the gallows frame and blocks. This will frequently start a tight rod.

The cross-head jam nut should now be made tight and the cylinder head put on. The valves can be put in and set and the governor adjusted. The details of these vary so widely as to prevent any instructions as to their setting. These are always furnished in the minutest detail by the builders.

The throttle, oil cups, lubricators and drain piping may now be placed, the engine carefully blown out to free it from dirt, etc., and it is ready for steam.

We cannot too strongly impress upon our readers the necessity for thoroughly cleaning and examining each part before erecting it, both to see that it has sustained no damage nor become filled with dirt during transportation and to save labor in rehandling the parts. Before closing up any part, such as cylinders, steam-chest, crank-pit, oil catcher, etc., it is well to make a final examination to see that no loose nuts, bolts, sand, gravel, chippings, etc., remain inside to give trouble sooner or later.

Another general point it is well to observe is that in tightening a number of bolts which hold the same part in place, such as cylinder-head bolts, bearing bolts, etc., an equal strain should be taken on each bolt, thus always keeping the part held by the bolts equally tight over its bearing.

XII

SOME OF THE LIGHTER WORK IN ERECTING

THE only hard part of putting the links into a fly-wheel is in finding some way to heat the links. The link should be heated uniformly throughout its length, and it is almost impossible to do this in any hand forge. The most convenient place is the furnace under one of the plant's boilers, and if the fire can be spared it is the cheapest place. A link will weigh something over 100 lbs., and is neither heavy nor hard to handle

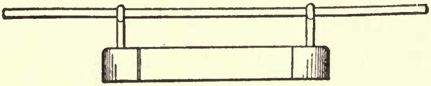


FIG. 107

when cold. Two men can shove it into a furnace door and place it anywhere in the fire with ease. It may be half an hour in heating up to a dull red. It should not be necessary to heat it hotter than this. The rake will haul it out on to the floor and an eye-bolt screwed into each end will make handling easy. Two men with a cart stake shoved through the eye-bolts Fig. 107 will carry a link anywhere.

It will be necessary to rig up a fall swung from the fly-wheel rim to lift the link into place. It is not heavy but men cannot hold the thing while it is being shoved in, for it throws out a lot of heat. The fall hooks right into the top eye-bolt and a few light blows drive the thing home. Usually about a sixteenth of an inch is allowed for the shrink; that is, the link is finished up $\frac{1}{16}$-in. short. But whatever this allowance is, it should not be so much that the link will not go in readily when at a dull red heat. If the links are finished up too short some stock should be machined off. It is better to let it be done by machine, too, for the biting surface should be kept square and have a good bearing. If this $\frac{1}{16}$-in. looks small let it be considered how much of a twist would have to be given a wrench to make $\frac{1}{16}$-in. in the length of a bolt 4 in. in diameter and 2 ft. long when the parts were already iron and iron. Too much allowance will require too hot a link and if the link is hot enough it will stretch permanently without biting much of anything.

When the link is once in, it will do no harm to cool it off with water till it bites and holds itself in place.

Links may be, and have been, heated in a wood fire, built on the open ground. The heat is certainly a good one, for the fire should be large; but the process is a very slow one. It will take at least one man's time to collect wood to burn, and the fire is torn down every time a link is taken out. Still this method is always possible, and that is a virtue, for there is not much in the heating line that cannot be done with a large open wood fire. A little time may be gained by rigging up an open grate with bars or rods of iron for grate-bars, resting on a few bricks laid so as to catch the wind for draft and more brick laid on top to form a short flue 18 in. long, perhaps, something as shown in Fig. 108. Also a sheet of iron may well be laid over

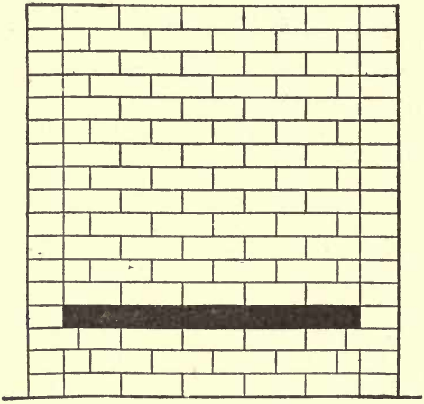


FIG. 108

the top of the link, boring a hole for the escape of smoke. This holds the heat in better and tends to heat both sides at once. But the outfit is not a very good one at best.

In shrinking in links it is common to follow around on one side for a way before doing anything on the other. This method, or any other method, is all right provided it does not pull things together in one place and open them up in another, due to some spots yielding more readily than do others. This must be watched and evened up by working where the openings tend to come. There is rarely any trouble found in the fit of the wheel itself, for the wheel has been together once before for the turning, but the links themselves, of course, have never been in the sockets.

The hub bolts will have to be made good and tight, and this is best done with a short stout wrench and a sledge-hammer. They fit tight in the holes when cold and evidently cannot be put in hot. All these nuts should be watched after the engine has carried its first loads, and it is a good plan to go over them all again and give them an extra pinch, after the first runs. If a bolt works loose, there is usually some cause for it, and the very fact that it wants to work loose is a reason for wanting to keep it tight. The best method of making rules for the care of a wheel is to watch each wheel itself and prescribe remedies for the cases as they appear, measuring all the facts carefully.

The cross-head of an engine having bored guides will require a little patience in being gotten into its place, twisted up and rested on its wedges. It is not heavy, but it has to go where little can be arranged to lift it. It must go in on its side, and after it has gotten seemingly beyond control it must be stood upright and the wedges put in. The guides are bored out concentric with the engine's center line, and, so far as the bore is concerned, it would be possible to make the cross-head revolve when the shoes are in, and so it is possible to put a cross-head in and roll it up in place in the guide while the shoes are in. But in order to do this the piece must be in line with the engine, for the new shoes, even when slacked away off, do not allow much play; and it is a mean thing to line up and hold in line while it is being turned on nothing. It is easier to leave off both shoes and enter them when the cross-head is standing in place.

The pistons are best put on to their rods before either piston or rod are put into the cylinder. Bull-rings and packing-rings may well be taken off and the piston head with its rod swung from the gin pole, as shown in Fig. 109. It can be made to balance by a man at the

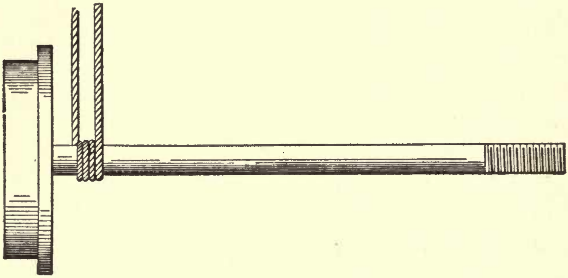


FIG. 109

end of the rod and nicely steered through the throat of the stuffing-box. The stuffing-box gland must not be forgotten, and the nut on the rod back of the cross-head should be screwed away on out of the way. A good, stiff piece of plank should be cut off just the length to rest across the cylinder barrel and keep the piston up central with the cylinder bore, as shown in Fig. 110. The thread will enter easily if the parts are in line and the piston screwed home by a wrench on the nut back of the piston, and the clearance divided up, after which both large nuts may be set up hard. The striking points should be marked on the slides for future reference. All the running gear and all the valve-gear is lifted easily and put in place by the gin pole, and the fly-wheel is turned in the direction it is to run

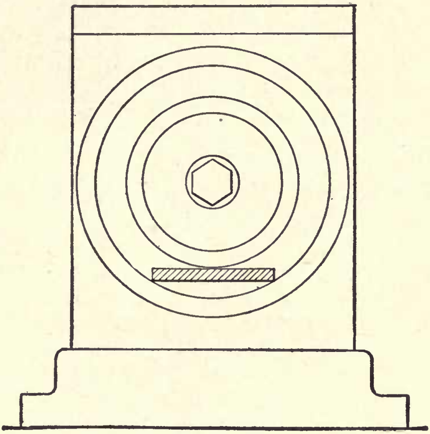


FIG. 110

for the valve setting by the same means. Journals and boxes should be left slack at first, their possible closeness being determined by the fits and by the care with which the erectors line the machine up.

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