HORIZONTAL SLIDE-VALVE ENGINE

The engine illustrated in Figs. 53 to 66 will give sufficient scope for energy and handiness with drill and soldering iron. The writer made an engine of the same kind, differing only from that shown in the design of the cross head guides, without the assistance of a lathe, except for turning the piston and fly wheel -- the last bought in the rough. Files, drills, taps, a hack saw, and a soldering iron did all the rest of the work.

Solder plays so important a part in the assembling of the many pieces of the engine that, if the machine fell into the fire, a rapid disintegration would follow. But in actual use the engine has proved very satisfactory; and if not such as the highly-skilled model-maker with a well-equipped workshop at his command would prefer to expend his time on, it will afford a useful lesson in the use of the simpler tools. Under 50 lbs. of steam it develops sufficient power to run a small electric-lighting installation, or to do other useful work on a moderate scale.

The principal dimensions of the engine are as follows;

1. *Bedplate* (sheet zinc), 13-1/2 inches long; 4-1/2 inches wide; 1/8 inch thick.
2. *Support of bedplate* (1/20 inch zinc), 3 inches high from wooden base to underside of bedplate.
3. *Cylinder* (mandrel-drawn brass tubing), 1-1/2 inches internal diameter; 2-13/16 inches long over all.
4. *Piston,* 1-1/2 inches diameter; 1/2 inch long.
5. *Stroke of piston,* 2-1/4 inches.
6. *Connecting rod,* 5 inches long between centers;
7. 5/16 inch diameter.
8. *Piston rod,* 5-1/8 inches long; 1/4 inch diameter.
9. *Valve rod,* 4-1/8 inches long; 3/16 inch diameter.
10. C*rank shaft,* 5 inches long; 1/2 inch diameter.
11. *Center line of piston rod,* 1-1/4 inches laterally from near edge of bed; 1-5/8 inches from valve-rod center line; 1-5/8 inches vertically above bed.
12. *Center line of crank shaft,* 10-3/8 inches from cross center line of cylinder.
13. *Bearings,* 1 inch long.
14. *Eccentric,* 9/32-inch throw.
15. *Fly wheel,* diameter, 7-1/2 inches; width, 1 inch; weight, 6 lbs.
16. *Pump,* 3/8-inch bore; 3/8-inch stroke; plunger, 2 inches long.

HORIZONTAL SLIDE-VALVE ENGINE

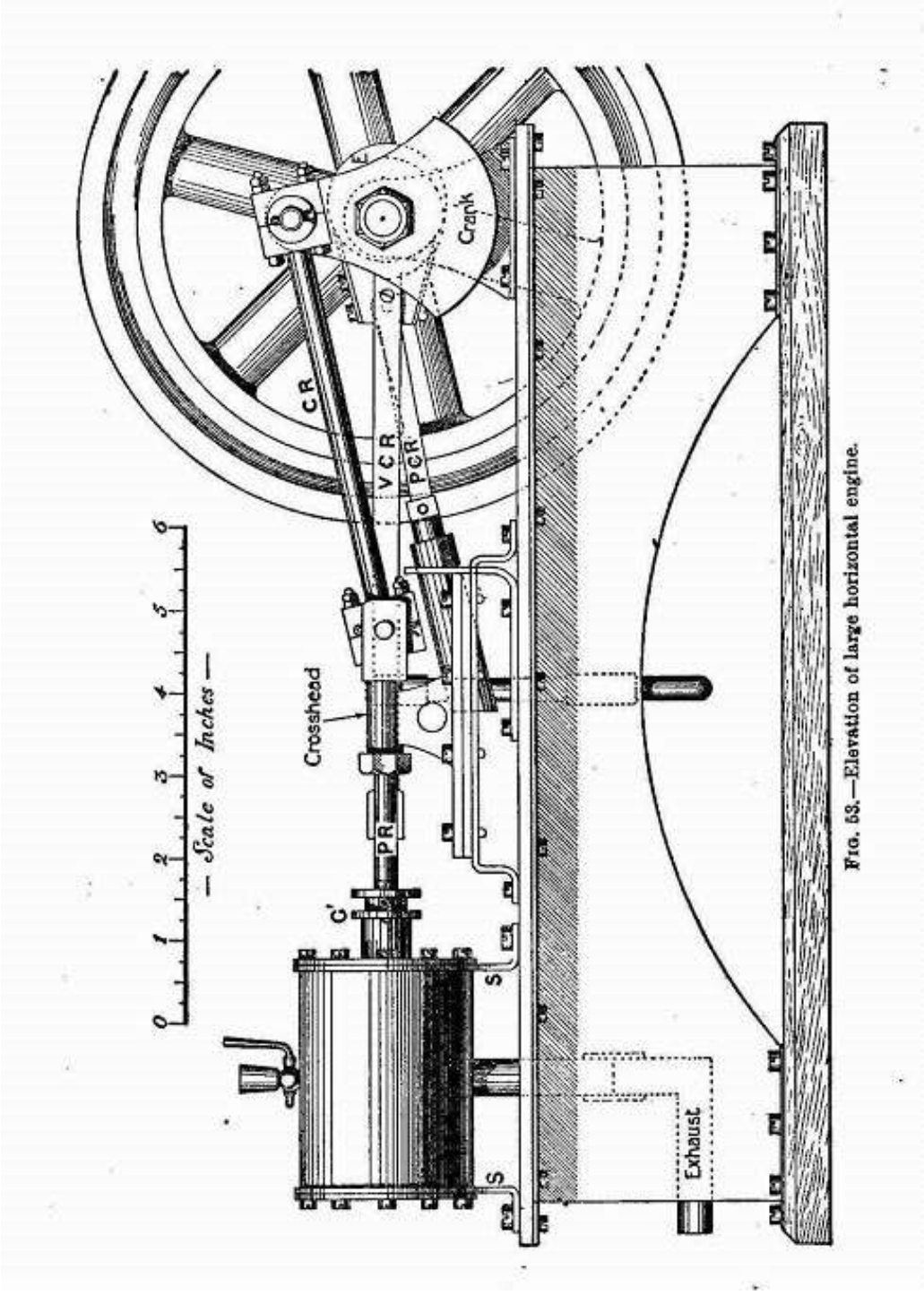


FIG. 53.—Elevation of large horizontal engine.

HORIZONTAL SLIDE-VALVE ENGINE

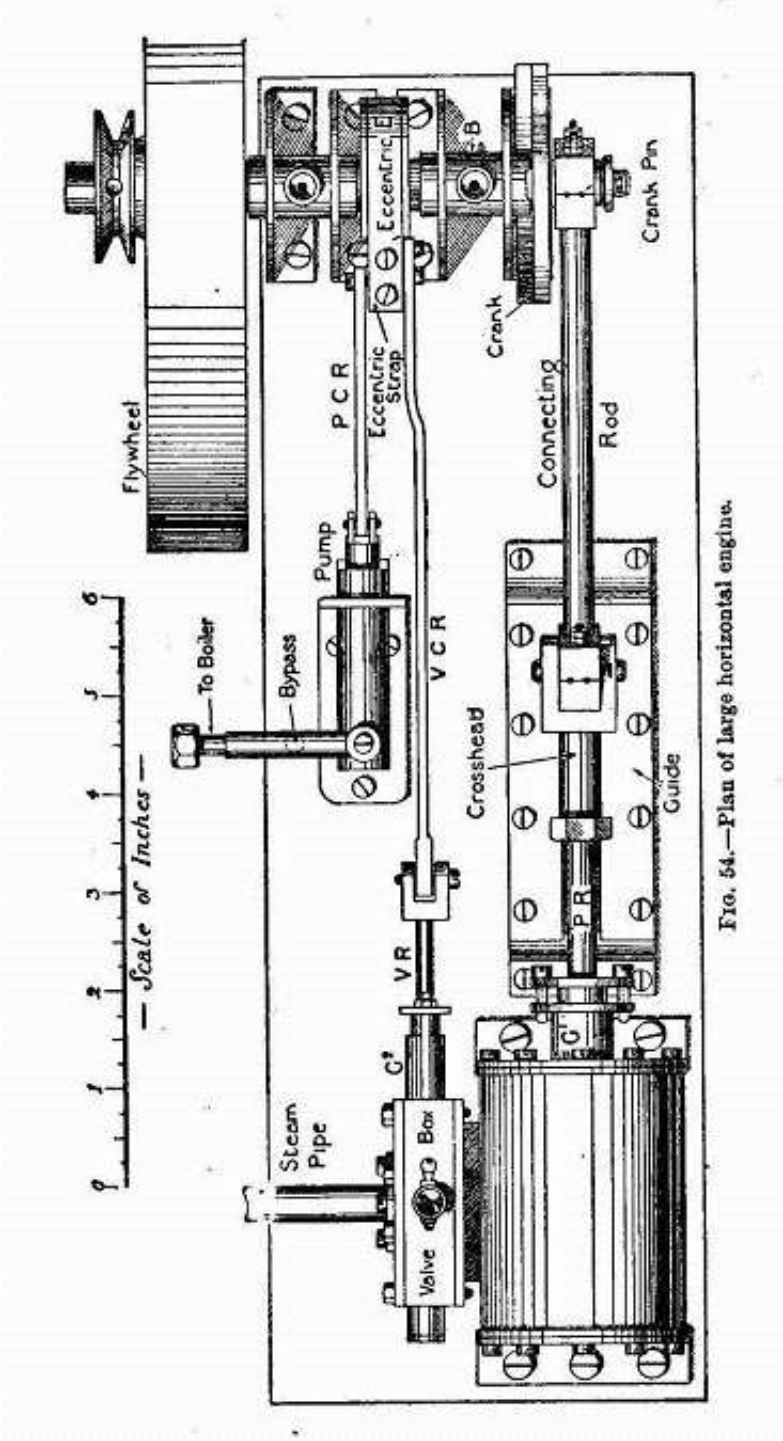


FIG. 54.—Plan of large horizontal engine.

Other dimensions will be gathered from the various diagrams of details. The reader will, of course, suit his own fancy in following these dimensions, or in working to them on a reduced scale, or in modifying details where he considers he can effect his object in a simpler manner.

The diagrams are sufficiently explicit to render it unnecessary to describe the making of the engine from start to finish, so remarks will be limited to those points which require most careful construction and adjustment.

The Bedplate

This should be accurately squared and mounted on its four arch-like supports. (For dimensions, consult Fig. 55.) Half an inch is allowed top and bottom for the turnovers by which the supports are screwed to the bedplate and base. The ends of the longer supports are turned back so as to lie in front of the end supports, to which they may be attached by screws or solder, after all four parts have been screwed to the bed. Care must be taken that the parts all have the same height. Drill all holes in the turnovers before bending. Use 1/8-inch screws. Turn the bed bottom upwards, and stand the four supports, temporarily assembled, on it upside down and in their correct positions, and mark off for the 3/32-inch holes to be drilled in the bed. A hole 3/4 inch in diameter should be cut in the bedplate for the exhaust pipe, round a center 2 inches from the end and 1-5/8 inches from the edge on the fly-wheel side, and two more holes for the pump.

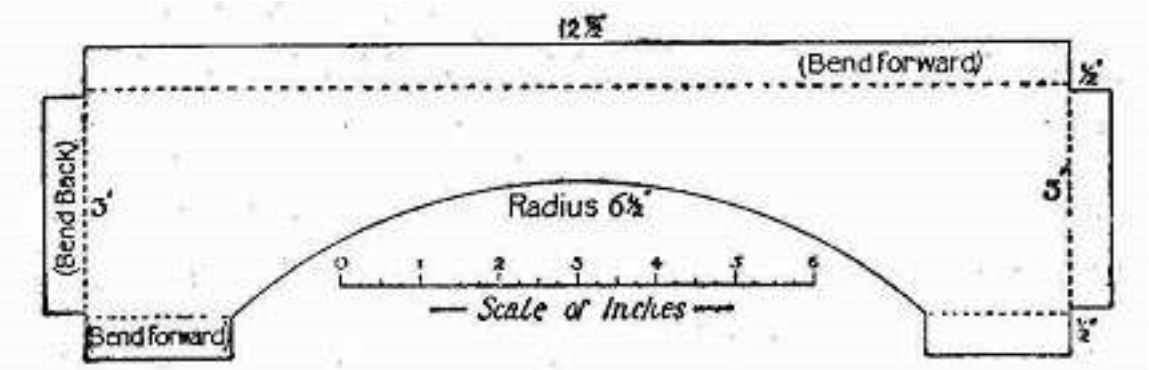
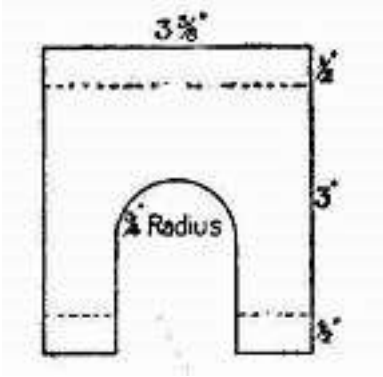


FIG. 55.—Standards of bedplate.



Making the Cylinder Slide and Valve

The cylinder barrel must be perfectly cylindrical and free from any dents. Mandrel-drawn brass tubing, 1/16-inch thick, may be selected. If you cannot get this turned off at the ends in a lathe, mark the lines round it for working to with the aid of a perfectly straight edged strip of paper, 2-13/16 inches wide, rolled twice round the tube. The coils must lie exactly under one another. Make plain scratches at each end of the paper with a sharp steel point. Cut off at a distance of 1/16-inch from the lines, and work up to the lines with a file, finishing by rubbing the ends on a piece of emery cloth resting on a hard, true surface.

A square-cornered notch 1/8 inch deep and 7/8 inch wide must now be cut in each end of the barrel, the two notches being exactly in line with one another. These are to admit steam from the steam ways into the cylinder.

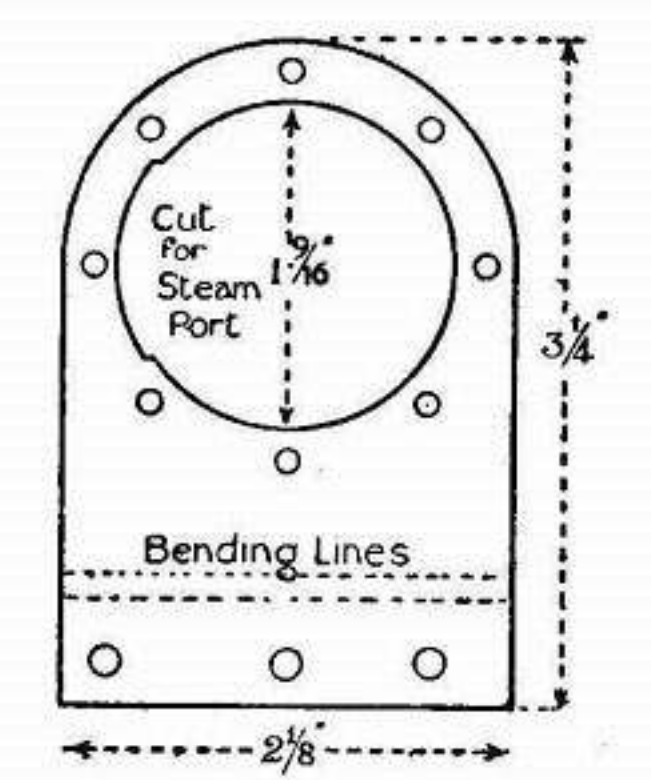


FIG. 56.—Cylinder standard before being bent.

Cylinder Standards

Use 5/64 or 3/32 inch brass plate for these. Two pieces of the dimensions shown in Fig. 56 are needed. Scratch a line exactly down the middle of each, and a cross line 1/2 inch from one end. The other end should be marked, cut, and filed to a semicircle. Drill three 3/16-inch holes in the turnover for the holding-down screws. The two standards should now be soldered temporarily together at the round ends and trued up to match each other exactly. Place them in the vice with the bending lines exactly level with the jaws, split the turnovers apart, and hammer them over at right angles to the main parts. Whether this has been done correctly may be tested by placing the standards on a flat surface. Take the standards apart, and scratch a cross line on each 1-5/8 inch from the lower surface of the foot on the side away from the foot. Make a punch mark where the line crosses the vertical line previously drawn, and with this as center describe a circle of the diameter of the outside of the barrel. Cut out the inside and file carefully up to the circle, stopping when the barrel makes a tight fit. On the inside of the hole file a nick 1/8 inch deep, as shown in Fig. 56. Remember that this nick must be on the left of one standard and on the right of the other, so that they shall pair off properly.

Standards and barrel must now be cleaned for soldering. Screw one standard down to a wood base; slip one end of the barrel into it; pass the other standard over the other end of the barrel, and adjust everything so that the barrel ends are flush with the, outer surfaces

of the standard, and the nicks of the barrel in line with the standard nicks. Then screw the other standard to the base. Solder must be run well into the joints, as these will have to stand all the longitudinal working strain.

The next step is the fitting of the cylinder covers. If you can obtain two stout brass discs 2-1/8 inches in diameter, some trouble will be saved; otherwise you must cut them out of 3/32-inch plate. The center of each should be marked, and four lines 45 degrees apart be scratched through it from side to side. A circle of 15/16-inch radius is now drawn to cut the lines, and punch marks are made at the eight points of intersection. Solder the covers lightly to the foot side of their standards, marked sides outwards, and drill 1/8-inch holes through cover and standard at the punch marks. Make matching marks on the edges. Unsolder the covers, enlarge the holes in them to take 5/32-inch screws; and tap the holes in the standards. This method will ensure the holes being in line, besides avoiding the trouble of marking off the standards separately.

Bore a 1/4-inch hole in the center of one cover--be sure that it is the right one--for the piston rod.

You can now proceed to the making of the piston-rod gland (Fig. 54, G1). Fig. 57 shows how this is built up of pieces of tubing and brass lugs for the screws. If possible, get the tubular parts trued in a lathe.

Before the gland is soldered to the cover, the cover should be put in place, the piston rod attached to the piston, and the parts of the gland assembled. Push the piston rod through the cover until the piston is hard up against the back of the cover. Slip the gland over the rod, turn it so that the screws are parallel to the foot of the standard, and make the solder joint. This is the best way of getting the gland exactly concentric with the cylinder so that the piston rod shall move without undue friction. But you must be careful not to unsolder the cylinder from its standard or the parts of the gland. Blacken the piston rod in a candle flame to prevent solder adhering.

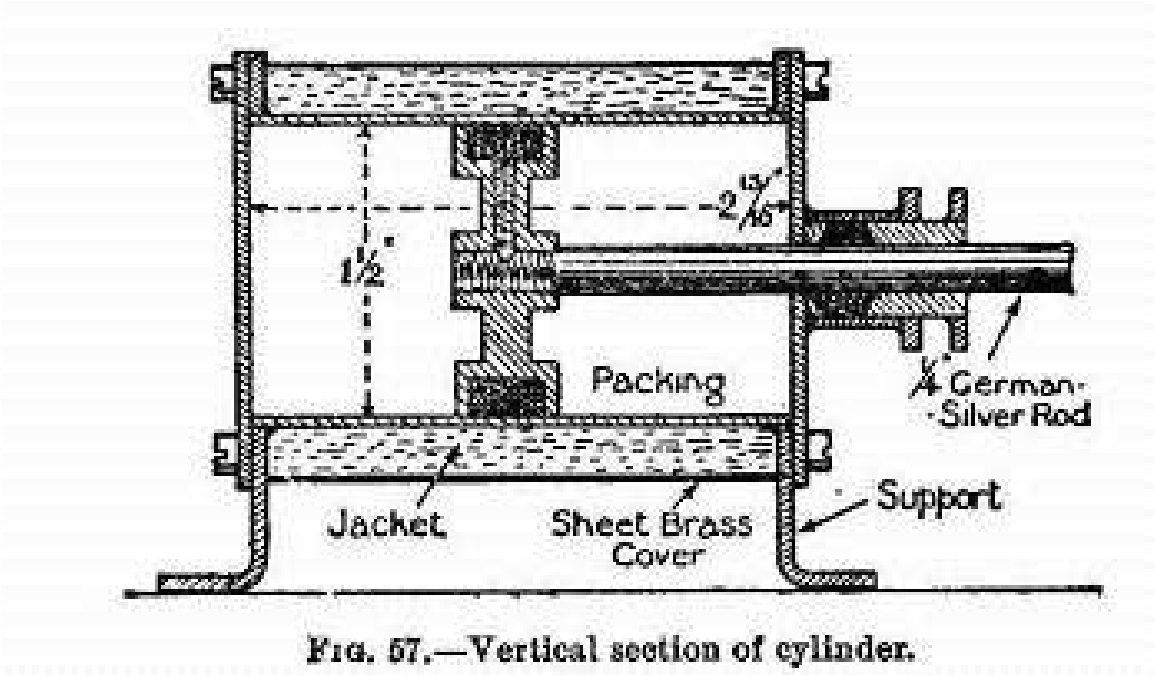


Fig. 57.—Vertical section of cylinder.

Steam Chest

The walls of the steam chest are best made in one piece out of 1/2-inch brass by cutting out to the dimension given in Fig. 58. A sharp fret saw will remove the inside rectangle. Get both inside and outside surfaces as square as possible in all directions, and rub down the two contact faces on emery cloth supported by an old looking-glass.

Two perfectly flat plates of 1/8-inch brass are cut to the size given in Fig. 59, or a little longer both ways, to allow for working down to the same area as the wall-piece. This operation should be carried out after soldering the three pieces together. File and rub the sides until no projections are visible. Then drill twelve 3/32-inch holes right through the three parts. After separating them, the holes in the walls and what will be the cover must be enlarged to an easy fit for 1/8-inch bolts, and the valve plate tapped.

Now drill 3/16-inch holes centrally through the ends of the walls for the valve rod. If the first hole is drilled accurately, the second hole should be made without removing the drill, as this will ensure the two holes being in line. If, however, luck is against you, enlarge the holes and get the rod into its correct position by screwing and soldering small drilled plates to the outside of the chest. Also drill and tap a hole for the lubricator. The attachment of the gland (Fig. 54, G2) is similar to that of the cylinder gland, and therefore need not be detailed.

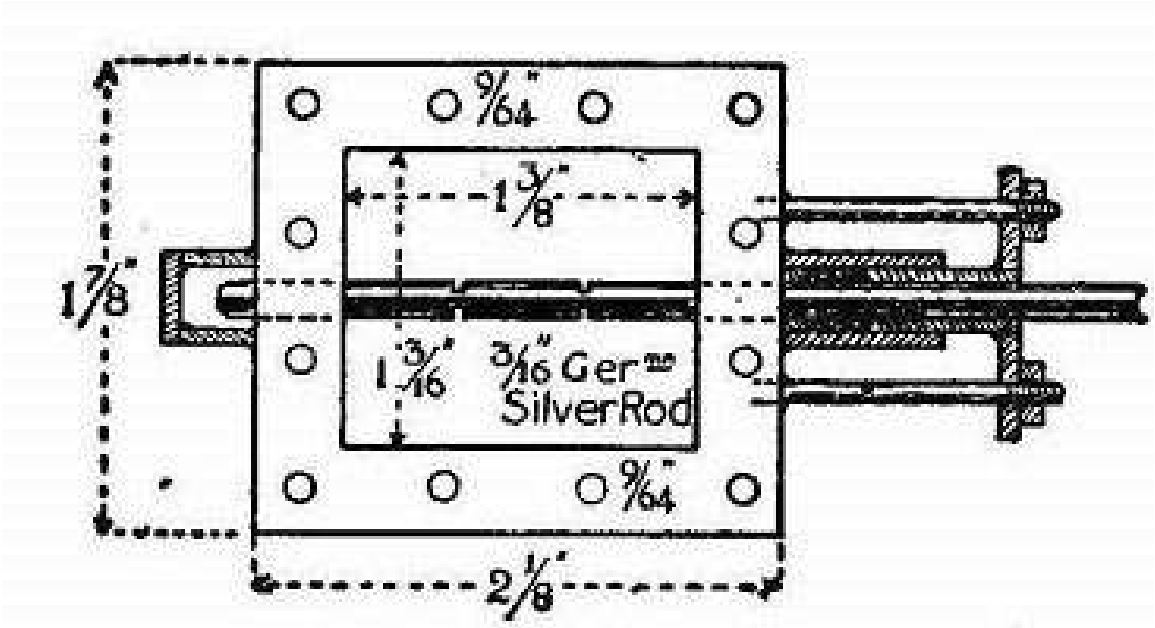


FIG. 58.—Wall-piece for steam chest, with gland and valve rod in position.

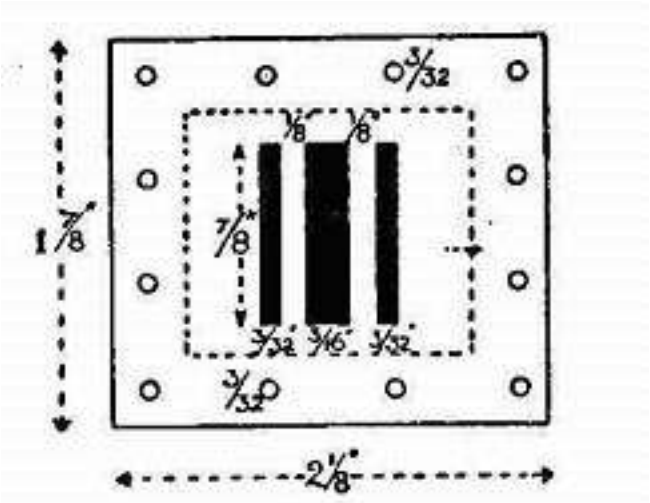


FIG. 59.—Valve plate.

The Valve Plate (Fig. 59)

Three ports must be cut in this--a central one, 7/8 by 3/32 inch, for the exhaust; and two inlets, 7/8 by 3/32 inch, 1/8 inch away from the exhaust. These are easily opened out if a series of holes be drilled along their axes.

The Steam Ways

The formation of the steam ways between valve plate and cylinder is the most ticklish bit of work to be done on the engine as it entails the making of a number of solder joints close together.

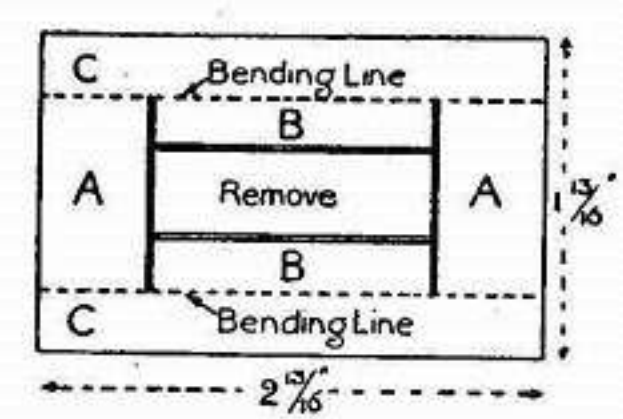


FIG. 60.—Piece for steam ways.

We begin by cutting out of 1/20-inch sheet brass a piece shaped as in Fig. 60. Parallel to the long edges, and 3/8 inch away, scribe bending lines. Join these by lines 5/8 inch from the short edges, and join these again by lines 1/4 inch from the bending lines. Cuts must now be made along the lines shown double in Fig. 60. Bend parts CC down and parts BB upwards, so that they are at right angles to parts AA. The positions of these parts, when the piece is applied to the cylinder, are shown in Fig. 62.

One must now make the bridge pieces (Fig. 61, *a, a)* to separate the inlet passages from the exhaust. Their width is the distance between the bent-down pieces CC of Fig. 60, and their bottom edges are shaped to the curvature of the cylinder barrel. Finally, make the pieces *bb* (Fig. 61), which form part of the top of the steam ways.

In the assembling of these parts a blowpipe spirit lamp or a little "Tinol" soldering lamp will prove very helpful.

The following order should be observed:

(1.) Solder the piece shown in Fig. 60 to the cylinder barrel by the long edges, and to the cylinder supports at the ends. This piece must, of course, cover the steam ports in the cylinder.

(2.) Put pieces *aa* (Fig. 61) in position, with their tops quite flush with the tops of BB (Fig. 62), and solder them to the cylinder barrel and sides of the steam-way piece.

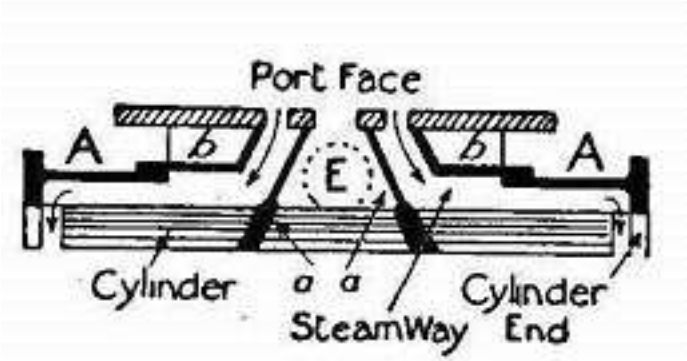


FIG. 61.—Valve plate and steam ways in section.

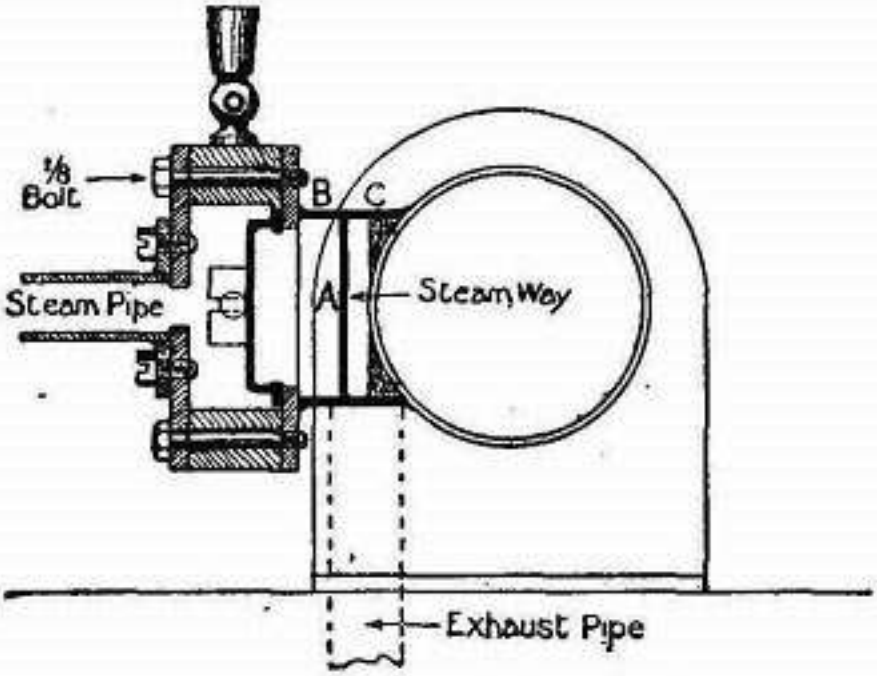


FIG. 62.—Cross section of cylinder and valve chest.

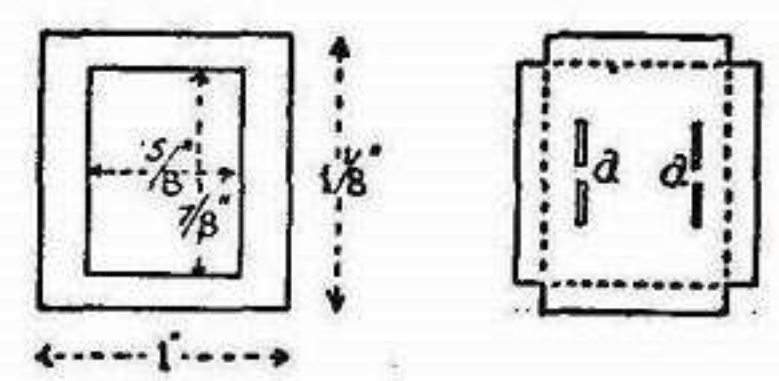


FIG. 63.—Parts of slide valve.

(3.) Solder the valve plate centrally to BB, and to the tops of aa, which must lie between the central and outside ports. Take great care to make steam-tight joints here, and to have the plate parallel to the standards in one direction and to the cylinder in the other.

(4.) Solder in pieces *bb.* These should be a tight fit, as it is difficult to hold them in place while soldering is done.

(5.) Bore a 5/16-inch hole in the lower side of the central division and solder on the exhaust pipe.

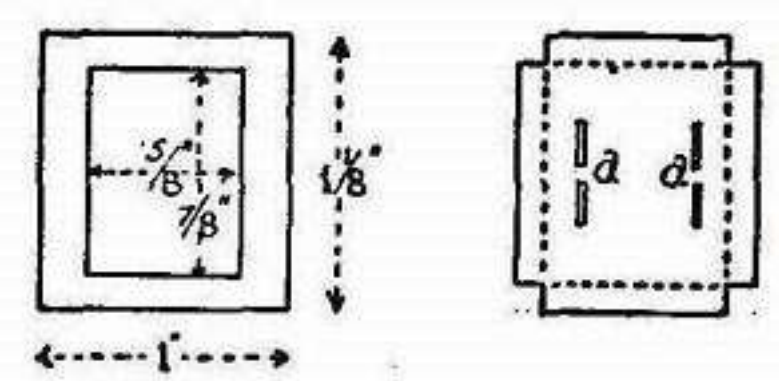


FIG. 63.—Parts of slide valve.

The Crank and Crank Shaft

The next thing to take in hand is the fixing of the crank shaft. This is a piece of 3/8 or 1/2 inch steel rod 5 inches long.

The bearings for this may be pieces of brass tubing, fitting the rod fairly tight. By making them of good length--1 inch--the wear is reduced to almost nothing if the lubricating can is used as often as it should be.

Each bearing is shown with two standards. The doubling increases rigidity, and enables an oil cup to be fixed centrally.

The shape of the standards will be gathered from Fig. 53, their outline being dotted in behind the crank.

Cut out and bend the standards--after drilling the holes for the foot screws--before measuring off for the centers of the holes; in fact, follow the course laid down with regard to the cylinder standards.

Make a bold scratch across the bedplate to show where the center line of the shaft should be, and another along the bed for the piston-rod center line. (Position given on p. 138.)

Bore holes in the bearings for the oil cups, which may be merely forced in after the engine is complete.

The crank boss may be made out of a brass disc 2-3/4 inches diameter and 3/16 inch thick, from which two curved pieces are cut to reduce the crank to the shape shown in Fig. 53. The heavier portion, on the side of the shaft away from the crank pin, helps to counterbalance the weight of the connecting and piston rods. In Fig. 54 (plan of engine) you will see that extra weight in this part has been obtained by fixing a piece of suitably curved metal to the back of the boss.

The mounting of the crank boss on the shaft and the insertion of the crank pin into the boss might well be entrusted to an expert mechanic, as absolute "squareness" is essential for satisfactory working. Screw-thread attachments should be used, and the crank-shaft should project sufficiently to allow room for a flat lock nut. The crank pin will be rendered immovable by a small lock screw penetrating the boss edge ways and engaging with a nick in the pin.

Fixing the Standards and Bearings

Place the two bearings in their standards and slip the crank shaft through them. Place standards on the bed, with their center lines on the crank-shaft center line. The face of the crank should be about 3/8 inch away from the piston rod center line. Bring the nearer bearing up against the back of the disc, and arrange the standards equidistantly from the ends of the bearing. The other bearing should overlap the edge of the bed by about 1/8 inch. Get all standards square to the edge of the bed, and mark off the positions of screw holes in bed. Remove the standards, drill and tap the bed-plate holes, and replace parts as before, taking care that the lubricating holes in the bearings point vertically upwards. Then solder bearings to standards.

If any difficulty is experienced in getting all four standards to bed properly, make the bearing holes in the two inner ones a rather easy fit. The presence of the crank-shaft will assure the bearings being in line when the soldering is completed.

The standards and bed should have matching marks made on them.

The Eccentric

This can be formed by soldering two thin brass discs 1-15/16- inch diameter concentrically to the sides of a disc of 1-15/16-inch diameter and 5/16 inch thick. The center of the shaft hole must be exactly 9/32 inch from the center of the eccentric to give

the proper valve-travel. Drill and tap the eccentric edge ways for a lock screw.

A piece to which the eccentric strap, eccentric rod, and pump rod are attached is cut out of 5/16-inch brass. Its shape is indicated in Figure 53. The side next the eccentric must be shaped as accurately as possible to the radius of the eccentric. The *strap,* of strip brass, is fastened to the piece by four screws, the eccentric rod by two screws.

Crosshead and Guides

The crosshead (Figs. 53 and 54) is built up by soldering together a flat foot of steel, a brass upright, and a tubular top fitting the piston rod. The guides, which consist of a bed, covers, and distance-pieces united by screws (Fig. 64), have to withstand a lot of wear, and should preferably be of steel. The importance of having them quite flat and straight is, of course, obvious.

The last 1-3/8 inches of the piston rod has a screw thread cut on it to engage with a threaded hole in the fork (cut out of thick brass plate), to which the rear end of the connecting rod is pinned, and to take the lock nut which presses the crosshead against this fork.

Assuming that all the parts mentioned have been prepared, the cylinder should be arranged in its proper place on the bed, the piston rod centrally over its center line. Mark and drill the screw holes in the bed.

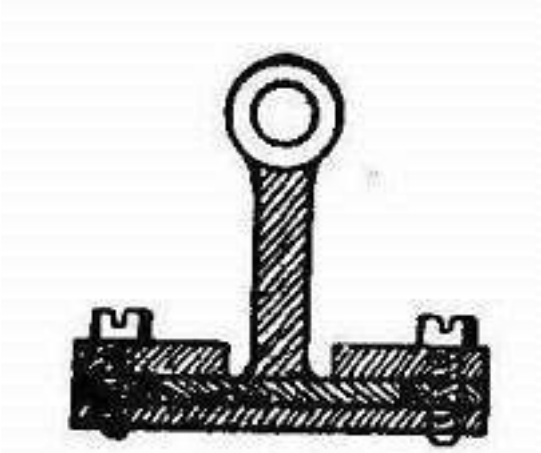


FIG. 64. — Cross section of crosshead and guide.

The Valve Gear. -- We may now attend to the valve gear. A fork must be made for the end of the valve rod, and soldered to it with its slot at right angles to the slots which engage with the valve lugs. Slip the rod into the steam chest, put the valve on the rod, and attach the chest (without the cover) to the valve plate by a bolt at each corner. Pull the valve forward till the rear port is just uncovered, and turn the eccentric full forward. You will now be able to measure off exactly the distance between the centers of the valve-rod fork pin and the rear screw of the eccentric. The valve connecting rod (Fig. 53, VCR) should now be made and placed in position. If the two forward holes are filed somewhat slot-shaped, any necessary adjustment of the valve is made easier. If the adjustment of VCR and the throw of the eccentric are correct, the valve will just expose both end ports alternately when the crank is revolved. If one port is more exposed than the other, adjust by means of the eccentric screws till a balance is obtained. Should the ports still not be fully uncovered, the throw of the eccentric is too small, and you must either make a new eccentric or reduce the width of the valve. (The second course has the disadvantage of reducing the expansive working of the steam.) Excess movement, on the other hand, implies too great an eccentric throw.

Setting the Eccentric

Turn the crank full forward, so that a line through the crank pin and shaft centers is parallel to the bed. Holding it in this position, revolve the eccentric (the screw of which should be slackened off sufficiently to allow the eccentric to move stiffly) round the shaft in a clockwise direction, until it is in that position *below* the shaft at which the *front* steam port just begins to show. Then tighten up the eccentric lock screw.[1]

The Connecting Rod. -- The length of this from center to center of the pins on which it works should be established as follows:--Slip over the piston rod a disc of card 1/32 inch thick. Then pass the rod through the gland and assemble the crosshead and fork on its end, and assemble the guides round the crosshead foot. Turn the crank pin full forward, pull the piston rod out as far as it will come, measure the distance between pin centers very carefully, and transfer it to a piece of paper.

The rod consists of a straight central bar and two rectangular halved ends. The ends should be cut out of brass and carefully squared. Through their exact centers drill 1/8-inch holes, and cut the pieces squarely in two across these holes. The sawed faces should be filed down to a good fit and soldered together. Now drill holes of the size of the pins, using what remains of the holes first made to guide the drill. The bolt holes are drilled next, and finally the holes for lubrication and those to take the rods. Then lay the two ends down on the piece of paper, so that their pinholes are centered on the center marks, and the holes for the rod are turned towards one another. Cut off a piece of steel rod of the proper length and unsolder the ends. The rod pieces must then be assembled on the rod, and with it be centered on the paper and held in position while the parts are soldered together.

OTHER DETAILS

Adjusting the Guides

Put the connecting rod in place on its pins, and revolve the crank until the guides have

1 The reader is referred to an excellent little treatise, entitled "The Slide Valve" (Messrs. Percival Marshall and Co., 26 Poppin's Court, Fleet Street, E.C. Price 6d.), for a full explanation of the scientific principles of the slide valve.]

taken up that position which allows the crosshead to move freely. Then mark off the holes for the guide holding-down screws, and drill and tap them.

Packings

.The glands and piston should be packed with asbestos string. Don't be afraid of packing too tightly, as the tendency is for packing to get slacker in use. The rear end of the cylinder should be beveled off slightly inside, to allow the packed piston to enter easily.

Joints

The cylinder head and valve chest joints should be made with stout brown paper soaked in oil or smeared with red lead. All screw holes should be cut cleanly through the paper, and give plenty of room for the screws.

When making a joint, tighten up the screws in rotation, a little at a time so as not to put undue strain on any screw. Wait an hour or two, and go round with the screw-driver again.

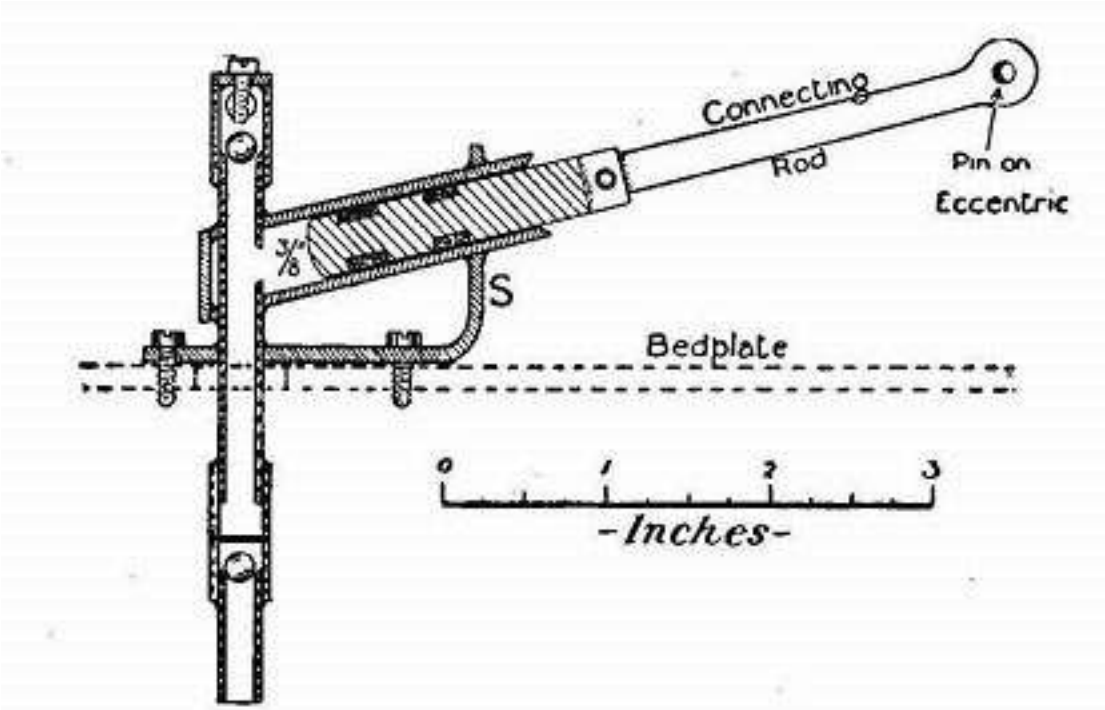


FIG. 65.—Vertical section of force pump driven by engine.

Lubrication

When the engine is first put under steam, lubrication should be very liberal, to assure the parts "settling down" without undue wear.

The Pump

Figure 65 shows in section the pump, which will be found a useful addition to the engine. (For other details, see Figs. 53 and 54.) Its stroke is only that of the eccentric, and as the water passages and valves are of good size, it will work efficiently at high speed. The method of making it will be obvious from the diagrams, and space will therefore not be devoted to a detailed description. The valve balls should, of course, be of gun-metal or brass, and the seatings must be prepared for them by hammering in a steel ball of the same size.

In practice it is advisable to keep the pump always working, and to regulate the delivery to the boiler by means of a by-pass tap on the feed pipe, through which all or some of the water may be returned direct to the tank.

The tank, which should be of zinc, may conveniently be placed under the engine. If the exhaust steam pipe be made to traverse the tank along or near the bottom, a good deal of what would otherwise be wasted heat will be saved by warming the feed water.

Making a Governor

It is a great advantage to have the engine automatically governed, so that it may run at a fairly constant speed under varying loads and boiler pressures.

In the absence of a governor one has to be constantly working the throttle; with one fitted, the throttle can be opened up full at the start, and the automatic control relied upon to prevent the engine knocking itself to pieces.

The vertical centrifugal apparatus shown in Fig. 66 was made by the writer, and acted very well. The only objection to it is its displacement of the pump from the bed. But a little ingenuity will enable the pump to be driven off the fly wheel end of the crank shaft, or, if the shaft is cut off pretty flush with the pulley, off a pin in the face of the pulley.

Turning to Fig. 66, A is a steel spindle fixed in a base, L, screwed to the bed. B is a brass tube fitting A closely, and resting at the bottom on a 1/4-inch piece of similar tubing pinned to A.

A wooden pulley jammed on B transmits the drive from a belt which passes at its other end round a similar, but slightly larger, pulley on the crank shaft. This pulley is accommodated by moving the eccentric slightly nearer the crank and shortening the fly-wheel side bearing a little.

The piece G, fixed to B by a lock screw, has two slots cut in it to take the upper ends of the weight links DD; and C, which slides up and down B, is similarly slotted for the links EE. Each of the last is made of two similarly shaped plates of thin brass, soldered together for half their length, but separated 3/32 inch at the top to embrace the projections of D. To prevent C revolving relatively to B, a notch is filed in one side of the central hole, to engage with a piece of brass wire soldered on B (shown solid black in the diagram). A spiral steel spring, indicated in section by a number of black dots, presses at the top against the adjustable collar F, and at the bottom against C.

The two weights WW are pieces of brass bar slotted for driving on to DD, which taper gently towards the outer edge.

When the pulley revolves, centrifugal force makes WW fly outwards against the pressure of the spring, and the links EE raise C, which in turn lifts the end of lever M. A single link, N, transmits the motion from a pin on M to the double bell-crank lever O (see Fig. 66)

pivoted on a standard, P, attached to the bedplate. The slotted upper ends of P engage with pins on an adjustable block, R, which moves the governing valve V (solid black), working in the tube S through a gland. The higher M is raised the farther back is V moved, and its annular port is gradually pushed more out of line with two ports in the side of the valve tube, thus reducing the flow of steam from the supply pipe to the cylinder connection on the other side of the tube. This connection, by-the-bye, acts as fulcrum for lever M, which is made in two parts, held together by screws, to render detachment easy.

The closer the fit that V makes with S the more effective will the governing be. The gland at the end of S was taken from an old cylinder cover.

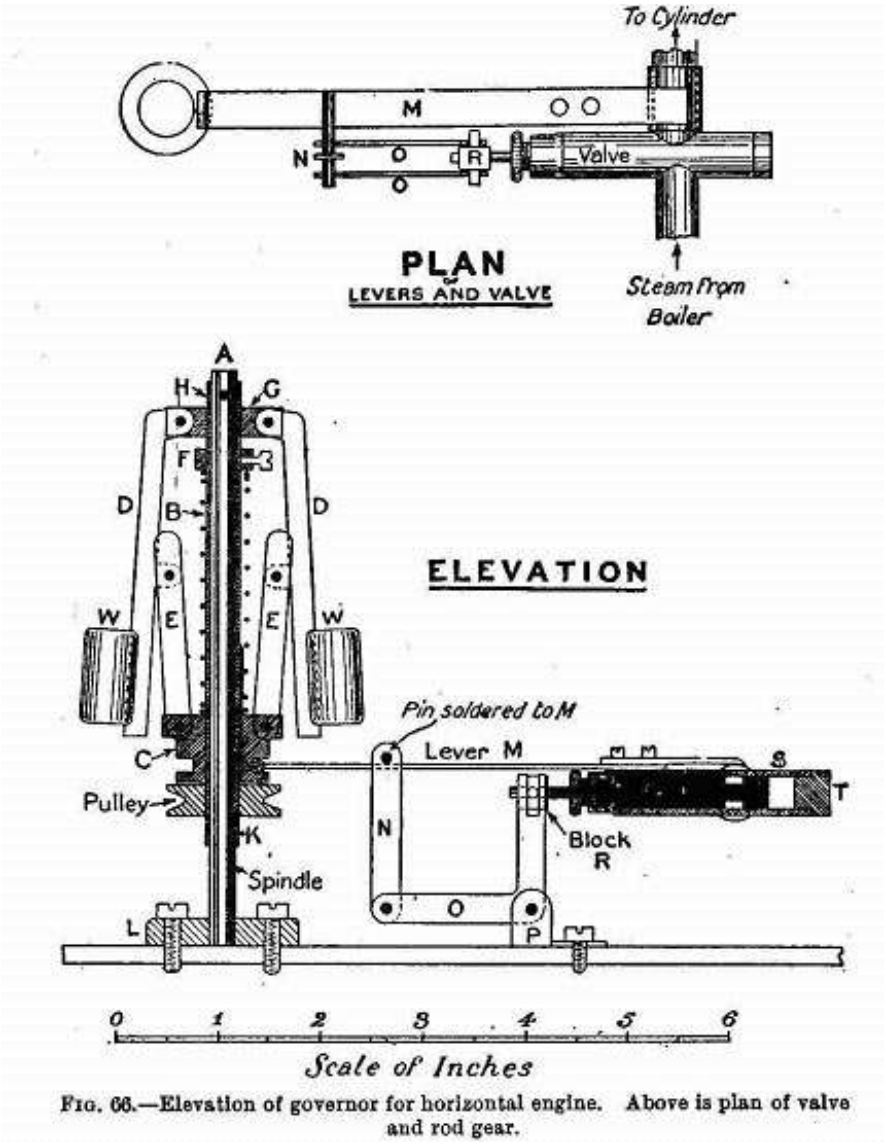


FIG. 66.—Elevation of governor for horizontal engine. Above is plan of valve and rod gear.

Regulation of the speed may be effected either

(1) by driving the governor faster or slower relatively to the speed of the crank shaft;

(2) by altering the position of W on D;

(3) by altering the compression of the spring by shifting F;

(4) by a combination of two or more of the above.

Generally speaking, (3) is to be preferred, as the simplest.

The belt may be made out of a bootlace or fairly stout circular elastic. In either case the ends should be chamfered off to form a smooth joint, which may be wrapped externally with thread.

FINAL HINTS

All parts which have to be fitted together should have *matching marks* made on them with the punch. To take the parts of the valve chest as an example. As we have seen, these should be soldered together, finished off outside, and drilled. Before separating them make, say, two punch marks on what will be the *upper* edge of the valve plate near the end, and two similar marks on the chest as near the first as they can conveniently be. In like manner mark the chest cover and an adjacent part of the chest with three marks. It is utterly impossible to reassemble the parts incorrectly after separation if the marks are matched. Marking is of greatest importance where one piece is held up to another by a number of screws. If it is omitted in such a case, you may have a lot of trouble in matching the holes afterwards.

Jacket the cylinder with wood or asbestos, covered in neatly with sheet brass, to minimize condensation. If the steam ways, valve chest, and steam pipe also are jacketed, an increase in efficiency will be gained, though perhaps somewhat at the expense of appearance.

Boiler

A vertical multi tubular boiler with about 800 sq. inches of heating surface will drive this engine satisfactorily.