

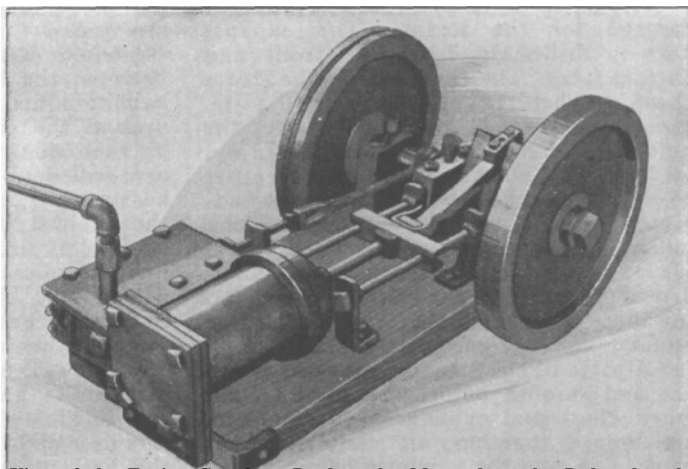
Building a Small Horizontal Steam Engine

THE small engine described in this article was built by the writer in his spare time—about an hour a day for four months—and drives the machinery in a small shop. At 40-lb. gauge pressure, the engine runs at 150 r.p.m., under full load, and delivers a little over .4 brake horsepower. A cast steam chest, with larger and more direct steam ports, to reduce condensation losses; less clearance in the cylinder ends, and larger bearing surfaces in several places, would bring the efficiency of the engine up to a much higher point than this. In the writer's case, however, the engine is delivering ample power for the purpose to which it is applied, and consequently these changes were not made, but, if the engine is to be used for continuous rather than intermittent service, it would be foolish to waste power costing more than the changes needed to conserve it.

It might be remarked, at this point, that no method of construction described here is to be taken as the best; many better methods of making each part will doubtless occur to the reader. Some improvements that were thought of too late to be incorporated in the engine will be mentioned in the proper place.

The cylinder, shown in Fig. 1, is made from a piece of steel pipe, selected with special regard to the condition of the inner surface. This may be bored to size, and lapped, or ground. A standard inside diameter will make the fitting of a standard auto-engine piston ring easy. The ends are threaded on the lathe, standard pipe-thread size, while supported on two conical hardwood blocks, held on a threaded mandrel, and drawn firmly into the cylinder ends with nuts and washers. The standard mandrels for this purpose, if available, are more convenient. The rectangular plate A, that supports the rear end of the cylinder, is also bored and threaded on the lathe, using a four-jaw independent chuck to hold it. This plate, the rear cylinder head, and a copper gasket are clamped together, and the similar holes in each all drilled at one time.

The front cylinder head is a pipe cap, the exterior of which is turned to present a more pleasing appearance, and drilled and threaded to receive the stuffing box, Fig. 2. The distance between the edge of the front-end steam port and the inner side of the cap, when screwed home, should be much less than that shown, not over $\frac{1}{4}$ in., for efficiency, and the same at the rear end. When the cap has been permanently screwed on the cylinder, one side is flattened, as shown, on the shaper or grinder, and the steam ports laid out and drilled. It would be a decided advantage to make these ports as much larger than given as is possible, as the efficiency with $\frac{1}{2}$ -in. ports is far below what it might be.



View of the Engine Complete, Ready to be Mounted on the Bed and to be Connected to the Steam Line. The Total Cost of Building Was \$15.40; This may be Considerably Reduced by Following Closely the Directions Given

To make the stuffing box, a length of 2-in. cast-iron rod is drilled to fit the piston rod, then turned out at the front, recessed to a width of .625 in. for the packing, and threaded to fit the gland nut. The piece is then reversed in the lathe, and the outside threaded to fit the cylinder. After cutting off, the wrench flats are ground on the shoulder. The gland nut is made of brass-bar stock, threaded to fit the stuffing box, and the hexagon ground on it. When the parts are assembled, with the packing in place, the piston and rod should work smoothly, but stiffly, in stuffing box and cylinder, and be almost immovable when the ports are closed.

The piston is made of cast iron, and undercut to reduce the weight, as in Fig.

3. The groove is turned to suit a standard .188 by 3-in. piston ring. The piston rod, which is of steel, must be fitted to the piston with great care, to insure their being exactly square with each other. If the face of the piston is square with the edge, the inner nut on the rod faced off square in the lathe, while on the rod, and the piston and locknuts then put on and tightened, no difficulty should be experienced.

The steam chest, shown in Figs. 4 to 7, is the hardest part of the engine to make. In this case, it is built up, using a square bar for the port block, an angle piece for the bottom and side, two endpieces, and a cover.

The port block, Fig. 5, is made of soft steel, the ports being drilled in as indicated by the dotted lines, from the ends and front, so as to provide a continuous passage for the steam. The exhaust port is drilled in from the front and bottom faces. The endpieces of the steam chest are held in place by short $\frac{1}{2}$ -in. capscrews, tapped into, and closing, the holes in the ends of the port block, and by long .312-in. bolts connecting the outer edges. The stuffing box on the front endpiece, Fig. 7, is made by brazing a blank nut to it, and making a snug-fitting gland for it, as shown in Fig. 8. The gland is drilled a neat fit for the valve rod, and for the $\frac{1}{4}$ -in. bolts that draw it into the stuffing box against the packing.

All parts of the steam chest are ground flat and smooth before assembling, and, when chest and cylinder are completed, are brazed together, all joints, the exhaust pipe, and the supports being brazed at the same time. When brazing, the steam ports should be plugged from inside the cylinder, to prevent any spelter from flowing into and closing them. The steam-chest cover is not brazed on, but is held by $\frac{1}{4}$ by $\frac{3}{4}$ -in. screws, entering the port block, and by long bolts at the outer edge, passing through a heavy strip of iron below the chest. Packing is used on the steam-chest cover joint.

The slide valve, Fig. 9, is cut from a block of soft steel, or cast iron, the opening in the face being cut as deeply as possible, drilling the center hole first, and plugging it to obtain centers for the drilling of the outer holes. If the steam ports are enlarged, the dimensions of the valve must be changed; the new dimensions can be found by making a full-size layout of the ports and valve, or by making cardboard models of steam chest, valve, and ports, and adjusting these until the correct dimensions are obtained.

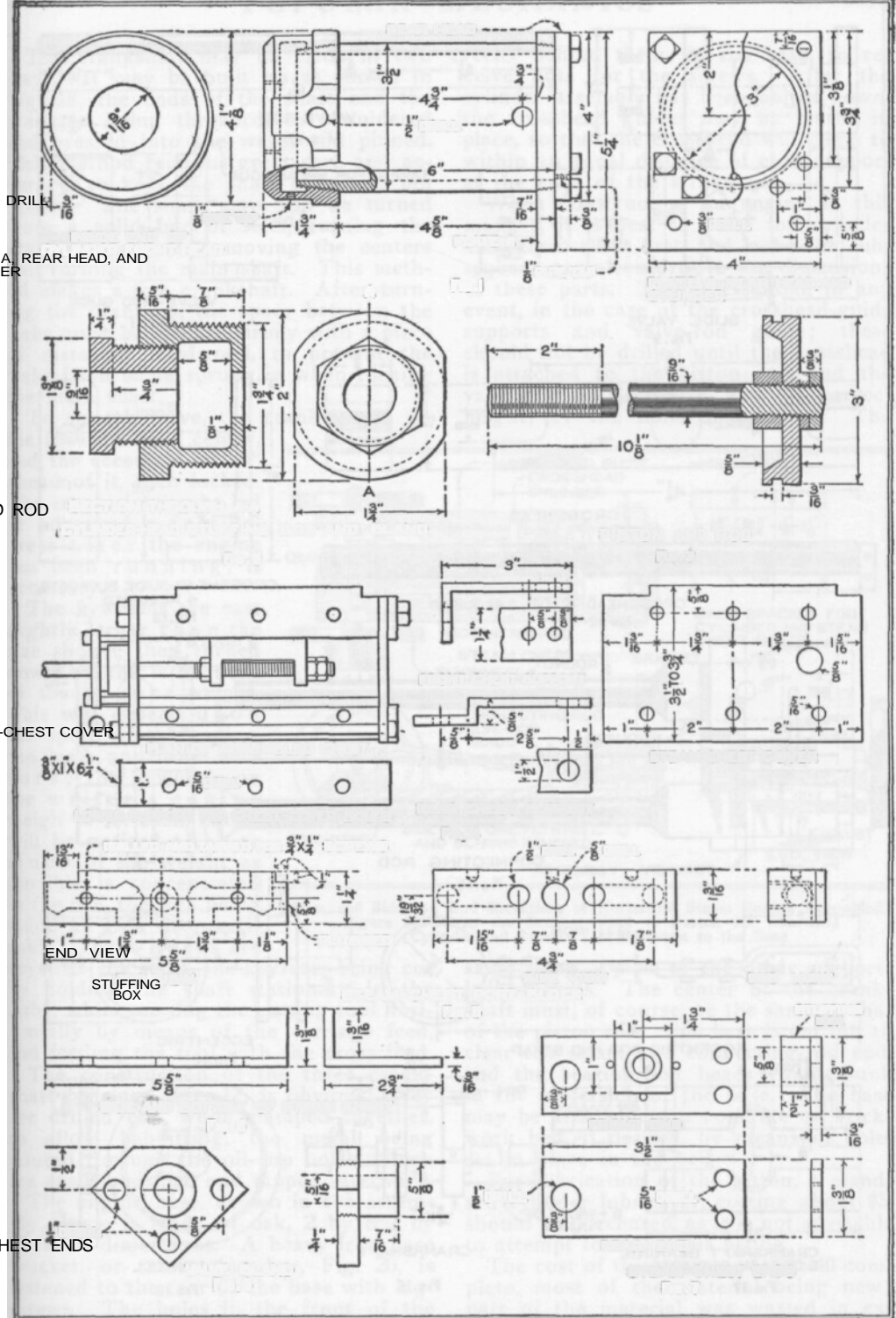
There is room for considerable experiment on the valve; any textbook on steam engines will provide suggestions for adding lap to the valve, to cut off the steam before the end of the stroke, and since it is comparatively easy to make this part, it is well to fit the valve to the engine after the latter is complete.

The crosshead and guides, shown in Figs. 12 and 13, are simple in construction. If a shaper or planer is available, a better construction may be made by following any of the designs seen on large engines. Oil cups on each bearing will furnish sufficient lubrication.

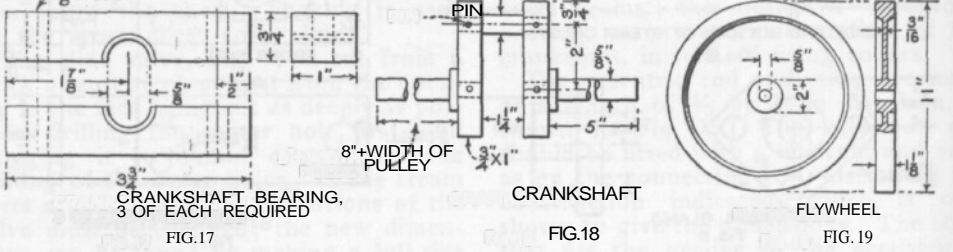
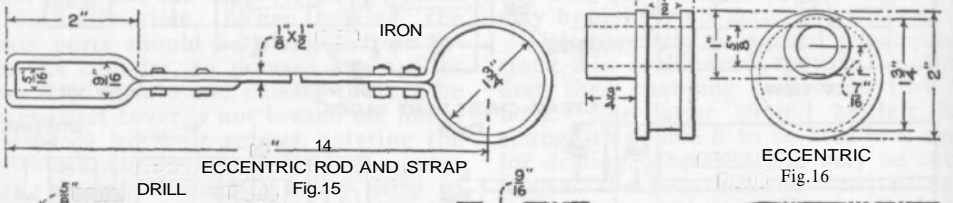
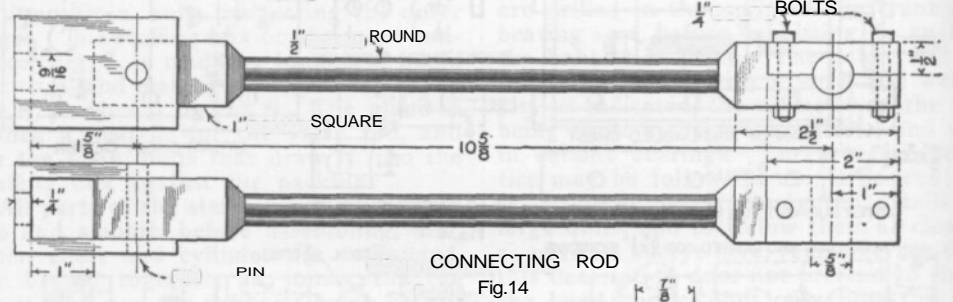
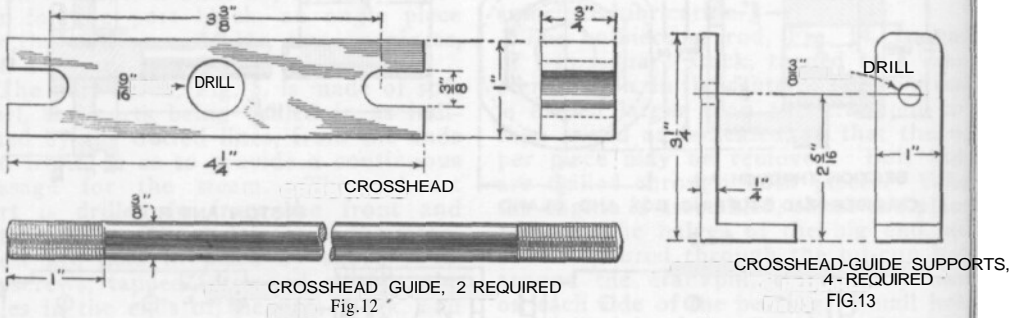
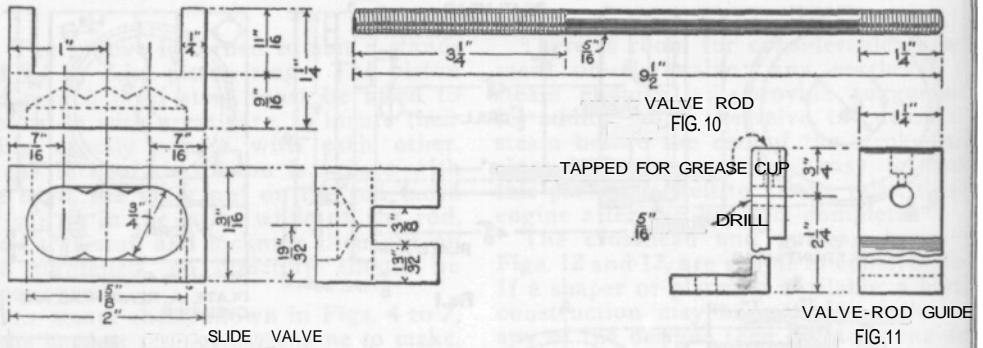
The connecting rod, Fig. 14, is made of 1-in. square stock, turned to a diameter of $\frac{1}{2}$ in. in the center. The "big end" is drilled larger than the crankpin, and then sawed as indicated, so that the upper piece may be removed. Bolt holes are drilled through both pieces. When the engine is assembled, shims are placed between the halves of the big end, and babbitt poured through the oil-cup hole, around the crankpin, using putty dams on each side of the bearing. Small holes are drilled in the walls of the crankpin-bearing seat, before babbiting, to anchor the babbitt in place. The other end of the rod is fitted with a yoke and wristpin, as indicated, the diameter of the pin being made as large as possible, and run in babbitt bearings. Large-engine practice may be followed here, if desired; in fact, it will pay to study the details of large units, and to follow them as closely as possible everywhere, remembering that this description does not pretend to show the best practice, but only how the job may be done with material at hand.

The eccentric is turned from round stock, 2 in. in diameter, cutting the sheave first, then changing centers to turn the boss. The latter should be left long enough to enable it to be held in a chuck for drilling, after which it may be cut to length; the boss may be fitted so as to bear against the outboard crankshaft bearing, to prevent side motion of the crankshaft, instead of using collars.

The eccentric rod and strap are made of a length of .125 by $\frac{1}{2}$ -in. flat iron, as shown in Fig. 15. The valve-rod end should be fitted with a wristpin and yoke as on the connecting rod, instead of the construction indicated, which is only shown to give the dimensions. The strap that fits the groove in the eccentric is lapped to a smooth bearing surface by clamping it round a mandrel covered with fine emery and oil, and grinding until the strap fits the eccentric sheave perfectly.



Figures 1 to 3, Complete Details of the Cylinder, Stuffing Box and Gland, Piston and Piston Rod; Figures 4 to 7 Show the Component Parts of the Steam Chest, as Built Up, and an Assembly View of the Finished Steam Chest, without the Cover; Note Carefully the Method of Drilling the Steam Ports in the Block Shown in Figure 6, and the Position of the Various Parts in the Assembly View



Figures 9 to 11, Details of the Slide Valve, Valve Rod, and Guide, Showing How Opening is Drilled in Valve; Figures 12 and 13, Crosshead, Crosshead Guides, and Crosshead-Guide Supports; Figure 14, Detail of Connecting Rod; Figures 15 and 16, Eccentric Rod and Strap, and Eccentric Sheave; Figures 17 and 18, Crankshaft Bearings and Crankshaft; Figure 19, Side View and Part Section of Flywheel

The crankshaft may be made in two ways. It may be built up as shown in Fig. 18, the ends of the shaft and the crankpin being threaded, or shouldered and pressed into the webs, and pinned. This method requires great care and accuracy, to keep the shaft ends and pin square. The shaft may also be turned from a solid bar of steel, turning the crankpin first, then moving the centers and turning the main shaft. This method makes a fine crankshaft. After turning the crankpin, the space between the webs must be blocked firmly with a piece of metal or hardwood, to prevent the webs from being sprung in when turning the main shaft.

To set the valve, the crank is put on the forward dead center, and the eccentric set 90° ahead of it, then locked. The eccentric may be led or advanced a few degrees after the engine has been running, if necessary.

The flywheels are cast slightly larger than the size shown, then turned down on the lathe until of the proper weight. This will depend upon the speed of the engine, the load, and other factors; the flywheels on the writer's engine weigh 10 lb. each, and it will be noticed that as much of the weight as possible is concentrated in the rim, the web being made as thin as practicable. The wheels are

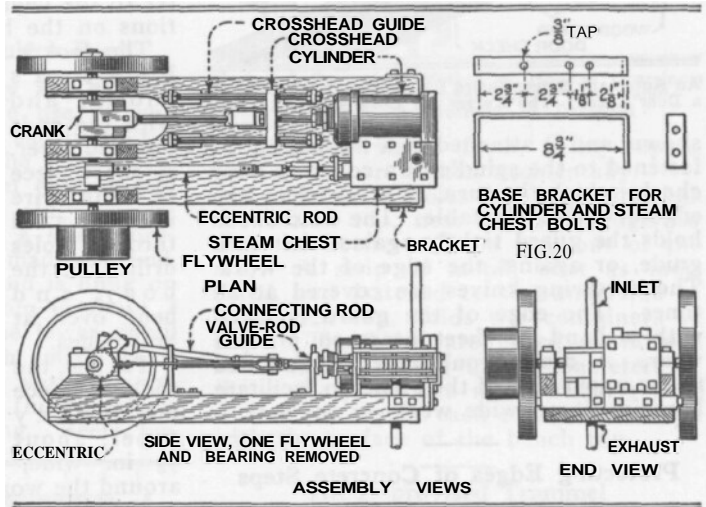
keyed to the shaft, the keyseats being cut by holding the shaft stationary in the lathe, while running the cutting tool horizontally by means of the carriage feed, and feeding the tool with the cross feed.

The construction of the three crankshaft bearings, Fig. 17, is obvious; they are drilled out, while clamped together, to allow babbitting, the metal being poured through the oil-cup holes, which are easily redrilled and tapped afterward.

The engine base, shown in the assembly views, is made of oak, 2 by $8\frac{3}{4}$ by 25 in. in dimensions. A heavy iron base bracket, or reinforcing bar, Fig. 20, is fastened to the rear of the base with lag-screws. The holes in the front of the bracket are tapped to take the cylinder and steam-chest support screws, or they may be drilled plain and pockets cut di-

rectly behind them, in the base, to receive nuts for the screws. After the cylinder assembly has been bolted down, the crosshead guides may be bolted in place, so that the crosshead will come to within an equal distance of each support at the ends of the stroke.

When constructing an engine in this manner, it is best to build the cylinder and steam chest first, and make the subsequent parts conform to the dimensions of these parts. This is essential, in any event, in the case of the crosshead-guide supports and valve-rod guide; these should not be drilled until the crosshead is attached to the piston rod and the valve rod to the valve, and the correct height for the holes determined. The



Plan, and Side and End Elevations of Horizontal Steam Engine Assembled: Figure 20 Shows the Bracket Used to Fasten the Rear-End Cylinder and Steam-Chest Supports to the Base

same thing applies to the other supporting brackets. The center of the crankshaft must, of course, be the same as that of the piston rod. The base is cut out to clear the crank and connecting-rod end, and the bearing-bolt heads countersunk in the underside of the base. The base may be attached to a concrete or brick-work bed, if desired, by means of bolts set in place in the bed.

For lubrication of the piston, a standard cylinder lubricator, costing about \$5, should be purchased, as it is not advisable to attempt to make this fitting.

The cost of this engine was \$15.40 complete, most of the material being new; part of the material was wasted in experimenting, and the cost of the engine could be cut in half, were the work to be done over again.