You needn't be a skilled machinist to make this perky little one-lunger from the detailed plans we have here. It'll bat along at 1200 rpm for 20 minutes on a boiler filling

**engine block**

The trickiest machining is boring the two holes—for cylinder and steam chest—in a piece of bronze bearing stock. After cutting the rod to approximate length, face both ends and scribe a diameter across what will be the lower end. Prick-punch centers for the two bores. Bore the cylinder as shown on the opposite page drilling 13/6 in. deep with a 3/8-in. drill; then enlarge to that depth with successively-larger drills, switch-
Mount the engine block off-center in a four-jaw chuck to bore the cylinder on a metal lathe. Use a series of drills from 1/16 to 3/16-in. Finish with boring tool.

To lap the steam-chest bore, the block is held in vise that's secured to the drill-press table. Final lapping rod is converted into a valve piston for perfect fit.

The crankshaft assembly, detached from the engine block, shows how the connecting rods link the pistons to the crankplate. Both the plate and the eccentric are soldered to flywheel shaft.

Exaggerated see-through sketches show two extreme positions of the pistons. At far left, drive piston has just begun power stroke, forced down by steam rushing through the steam chest, above retracted valve piston. Revolving eccentric is about to raise valve to cut off steam flow. Expanding steam in cylinder continues to push drive piston to bottom of stroke. In second sketch, engine is viewed from opposite side to show how energy stored in the flywheel thrusts drive piston upward. Valve position, now at the top of its stroke, presents exhaust passage to port between steam chest and cylinder. Rising drive piston forces steam down valve's hollow core and out the base of the bore.
going to a boring tool for a finish diameter of ½ in. Exact diameter isn’t critical; the piston will be machined to fit.

Remount the block so the steam-chest punch mark is centered, and drill 1¼ in. deep with a ¼-in. drill. Transfer the work to the drill-press vise and with a No. 41 drill, bore into the side, passing through the steam chest and into the cylinder. Switch to a ¾-in. drill and enlarge the hole into the steam chest only, to provide a seat for the steam-inlet nipple. Machine this nipple from a ⅛-in. length of brass rod and insert it until it butts the far wall of the steam chest. Anchor it with 20-80 solder.

This solder is 20 percent tin and 80 percent lead, and melts at a temperature of 532 deg. F. Don’t use ordinary 50-50 solder as it has a much lower melting point that can’t withstand the heat of the engine block. You can’t get 20-80 solder commercially, so make your own by melting together 1 oz. of 50-50 bar solder and 1½ ozs. of lead (fishing sinkers are fine). Stir the molten mixture and pour it into a simple mold, such as a blind saw kerf in the face of a board. Later, when you sweat the steam line to the nipple, buy 40-60 solder to avoid the risk of melting.

Now, with a ⅛-in. drill, drill out the steam-
An ignition-point file is chucked in a jig saw to finish off the connecting rod. For easy handling, piece is worked while still attached to parent strip of sheet metal. After filing, cut rod free. Use the same setup to file connecting-rod slots in pistons. At right is bearing block.

drill hole for bearing before removing 1/8-in. wood scrap used as bending form.

crankshaft bearing 3/8-in. dia. 1-in. long, bronze, 1/4-in. bore.

untapped holes 3 reed.

trim off excess here after bending other dotted lines.

1/2-in. 1/8-in. 1/8-in. 1/4-in. 1/4-in. 1/4-in. 3/8-in. aluminum.

chest bore, right through the soldered-in nipple, to the full 1 1/4-in. depth. Since a drilled-out bore is far from perfect, you must finish it to size. A better method than reaming is to lap the bore. First, machine from 3/8-in. drill rod a 1 1/2-in. long cylinder that just fits—without looseness—to the full depth of the bore. Using the drill-press setup shown on the first page of this article, coat the rod with oil and dental pumice (available at drug stores) and run it up and down in the bore with the drill press set for 600-800 r.p.m. After a couple of minutes, replace this first rod with one machined a few thousandths larger—big enough to stick when you try to insert it in the bore. Apply oil and pumice as before, but lap only until the rod can be run down the full depth of the bore. Back off immediately and flush out the bore with kerosene or paint thinner. This final rod is made into the valve piston.

valve piston

Cut the rod to length and mount it in a three-jaw lathe chuck. Face the cut end and center-drill to within 3/8 in. of the opposite end, to provide an exhaust passage. Machine the bottom to shape and hacksaw the connecting-rod slot. File this slot to an easy slip fit, then drill for the wrist pin, which can be a 3d finishing nail. Note that the slot aligns with the exhaust passage, forming its mouth.

With the rod in a drill-press vise, drill into the side (at right angles to the slot) to connect with the center hole. This provides the port which will mate with the cylinder exhaust port when the valve piston is at the top of its stroke. Since the valve continues to rise slightly during this exhaust operation, you must elongate its exhaust port by drilling a second hole overlapping the first, but not deep enough to meet the core hole. Grind out metal between these holes to form the stepped recess shown.

drive piston

This is machined from 3/8-in. cold-rolled steel rod. To get a good fit (without resorting to a small hole gauge) requires slow, careful machining; toward the end, take the diameter down half a thousandth at a time. That's half the space between adjacent marks on the numbered cross-feed thimble. For top performance, the final fit should be so tight that the piston must be lapped into the bore.

Shape and slot the bottom as with the valve piston, then trim to the length shown in the detail and face the cut surface.

connecting rods

Lay out the drive-piston rod and the flat section of the valve-piston rod on 3/8-in.-wide strips of 16-ga. sheet metal. Rough-shape with a coarse file, then do final shaping with an ignition-point file chucked in a jigsaw. Smooth with emery crocus cloth, and polish on a buffing wheel.

The brass eccentric ring for the valve rod is formed by hollowing out 1/4-in. brass rod, then cutting off a 3/8-in. width.
crankshaft assembly

To make the eccentric, machine the end of ½-in. drill rod, remove from the lathe and drill to accept the reduced end of the shaft. Then return to the lathe and cut the eccentric to width. It must be a smooth, sliding fit inside the valve rod’s brass ring.

The crankplate is turned to 1-in. dia. from the same bronze stock as the engine block, and cut off ⅛ in. thick. Cut off a second disk, trim off a segment for the counterweights, and rivet this to the crankplate, filing the rivets flush with the rear surface.

Thread the brass crankpin tightly into the socket tapped near the opposite edge of the crankplate. This, too, should be filed flush at the back—after punching several points around the edge of the socket to prevent unscrewing. To provide for an additional counterweight, drill and tap the counterweighted edge for a 6-32 screw.

Assemble the connecting rods to their respective pistons by cutting off the point of a 3d finishing nail and driving it through piston and rod; cut off the nailhead close to the piston, and peen both ends. The rod should swing freely.

The main bearing can be made from oilite bearing stock, or can be purchased as a stock-size bearing. In either case, lap the shaft into an easy-turning fit.

Once the crankshaft assembly is complete, insert the two pistons into the engine block, and the shaft through its bearing. With the column attached only to the underside of the engine block, position the feet on the base plate by trial, holding them down while turning the shaft to check piston function. Then tap for screws.

The engine at this initial-assembly stage is shown in the inset on the opening page. There is still an additional counterweight to add. For satisfactory operation, the counterweight on the crankplate of a vertical engine must balance the weight of the drive piston and connecting rod. The bronze segment so far added does little more than balance the weight of the crankpin. If possible, weigh the drive-piston assembly on a gram scale; the lead to be added can weigh a gram or two less. Use sheet lead, or melt a fishing sinker and mold it in a saw kerf. Drill the lead strip at the center and attach it to the counterweight side of the crankplate with a single screw. Wrap it around, trim both ends slightly beyond the counterweight and clinch around the bronze.

engine adjustment

To keep the piston connecting rod riding straight on the crankpin, its lower end has a projecting sleeve. The nominal length of this is given (in the engine assembly drawing) as ¼ in.—which does to start with. In the final assembly, file the free end of the sleeve to give the piston a smooth fit in its bore, without binding.

Use 50-50 solder to join the eccentric to the shaft; then grip the shaft vertically in a vise and
**KEEP THE ENGINE OILED**

Until the engine gets thoroughly hot, frequent oiling is required. With a squirt-type oil can, apply a few drops of 20-weight crankcase oil on the eccentric as shown. Also keep the bottoms of the pistons lubricated, so that oil is pumped up into the cylinders. The excess will run down the rods to lubricate the crankpin. Continue oiling every few minutes.

push the crankplate on, adjusting the pin position to the 15-deg. offset shown in the front elevation. Apply a drop of 50-50 solder to sweat the plate to the shaft.

If any further adjustment of the valve and piston relationship is needed, it can best be determined by operating the engine. To adjust at this stage, you must melt the solder joint between shaft and crankplate, using the tiniest possible blowtorch flame, and shift the crankplate as required. (That’s why high-temperature solder is used on the rod sleeve—to keep it from coming loose when the crankplate is heated.) Keep the eccentric straight up, so the valve is at the top of its stroke, while you tap the crankpin with a small screwdriver.

A double-capped pipe nipple with an underslung coil of copper tubing forms a boiler for this working-model steam engine. This assembly, suspended within an aluminum-sheathed asbestos firebox and fired with an ordinary propane torch, produces a head of steam in about two minutes to set the midget engine whirring.

* The boiler’s designed to be one of the fastest things you ever built. Its parts are all plumbing supplies available at hardware stores—including standard brass compression fittings for ¾-in. o.d. copper tubing. Before coiling the tubing, attach a fitting to one end and flare the tubing with a flaring tool. Then wrap the tubing four times around a length of ¾-in. dowel held in a vise, cut off the other end and attach the second flare fitting. The photo and sketch on page 916 show that when it’s assembled in the firebox, one end of the coil is higher than the other; this is easily achieved by making the lead to one end shorter. This higher end is located at the rear of the firebox, as it’s there that steam is generated. Water passes into the coil at the front end, which is relatively cool compared to the end at the tip of the flame.

Formation of scale on the coil can be minimized by proper firing: Keep the flame off the coil and never let the coil turn red hot. Scale tends to insulate the tube from the heat, so knocking it off the coil raises the steam pressure and speeds up the engine.

**assemble boiler parts**

To assemble the boiler parts, put pipe-joint compound on all threads, and turn them up tight. Don’t neglect to install a safety valve, as detailed on page 916. The plug is the head end of a plated wood screw, and its hole in the boiler is drilled with a numbered drill only a thousandth or two larger in diameter. File or spot-mill around the hole to make a tight seat under the screw head. The “modern Chinese” curve to the safety-valve arm in the photo (far left) isn’t a decoration: When you trim off a narrow piece of thin brass with shears, that’s the shape it takes. This arm pivots on a pin through the slotted end of a ¾-in. brass rod screwed tight in a tapped hole.

If you get careless with the blowtorch and generate too high a head of steam, this simple, positive-acting safety valve will prevent a serious accident.

Three sheathed asbestos panels are folded to form a box, as shown on page 916. The boiler (with coil attached) is suspended inside by means of two machine screws into each pipe cap. The inner cap is also cradled on the contoured edge of the end panel. This assembly is then set on the bottom asbestos panel, which is positioned next to the engine on a platform. This platform is a 9½-by-11-in. piece of ¾-in. plywood, with four ¾-in.-dia dowels glued into holes in the underside. The platform shown in the illustrations has been covered with the same type of aluminum used to sheathe the firebox. This protects the plywood from flame and steam.

To fire the boiler, pour 10 to 12 oz. of water into the filler hole and screw in the plug. Attach a heavy-duty nozzle to a propane torch and set a medium flame.

Prop the torch in a small cradle of wood so that the nozzle rests on the first ring of the coil. In about two minutes, steam should start coming