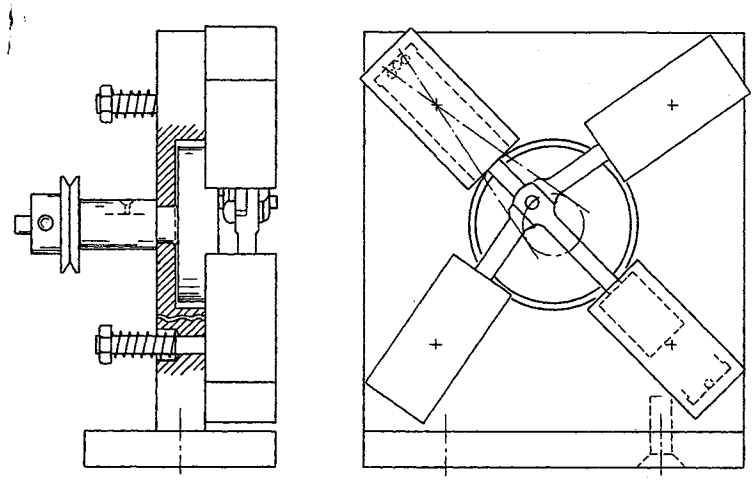
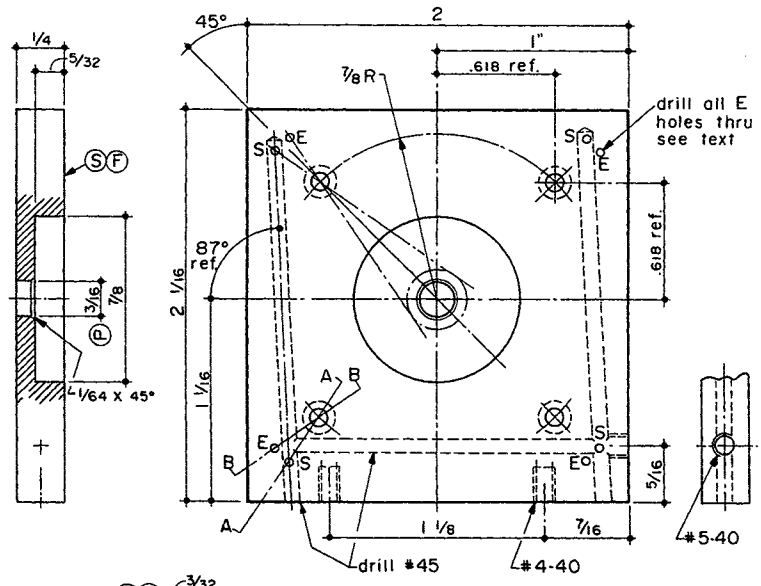
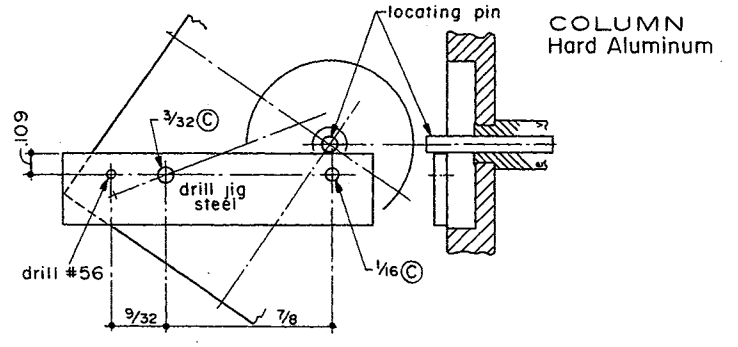
well, the #56 holes will break into the steam passages. In case the deep drill wandered, take it slow so as not to break a drill. The **E** holes can be drilled on through.

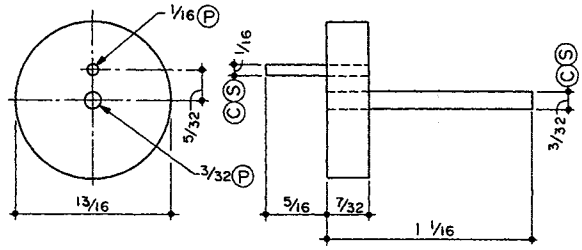
For the **CYLINDERS**, make four accurate, square brass blocks 3/8" x 3/8" x 13/16". Lay out the centers for the 1/4" bore 7/32" from one face and center punch. Center in the 4-jaw using a center test indicator. On the last pass before reaming, make an undercut at the bottom for reamer runout. There should be no shoulder that might hold up the Piston. Lay out and centerpunch the center for the Pivot Shaft. Protect from jaw marks when chucking in the 4-jaw, and center with a center test indicator. Check that the face runs true and then face, undercut and drill the 3/32" hole for the Shaft. Make four 3/32" x 21/32" brass Pivot Shafts. Thread one end 3-48. Make a close-fitting aluminum pin to enter the 1/4" bore. Apply a thin coat of flux to the pin and hole. Cut a tiny piece of 1/16" 430 degree solder, lay it against the Shaft and apply heat to the Cylinder until the solder melts and flows around the Shaft. Too much solder may keep the Cylinder off its seat. The solder will not stick to the aluminum pin. When the Piston/Rods are done, insert each into its own Cylinder and keep them together from now



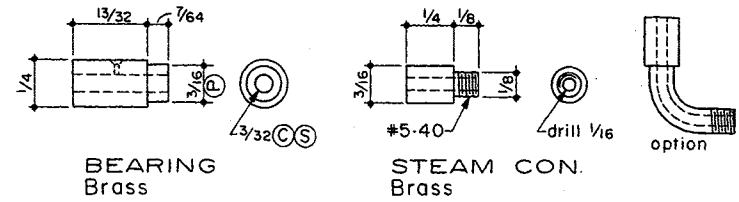
FOUR SQUARE

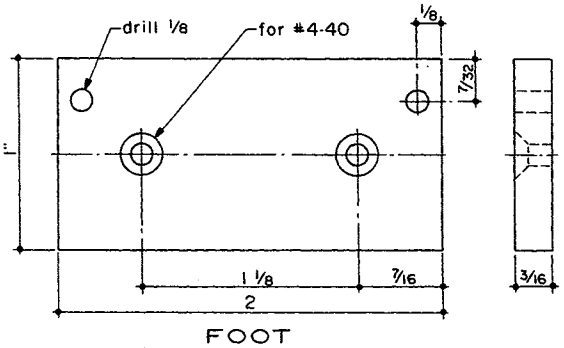






CRANKSHAFT
Steel





FOOT
Any Metal

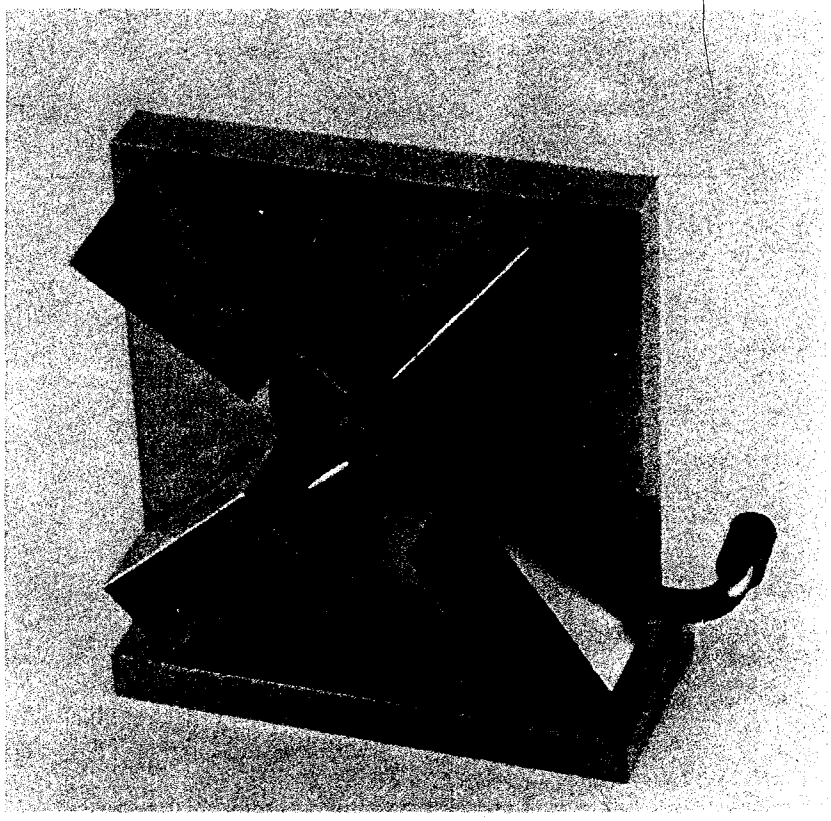
CHAPTER

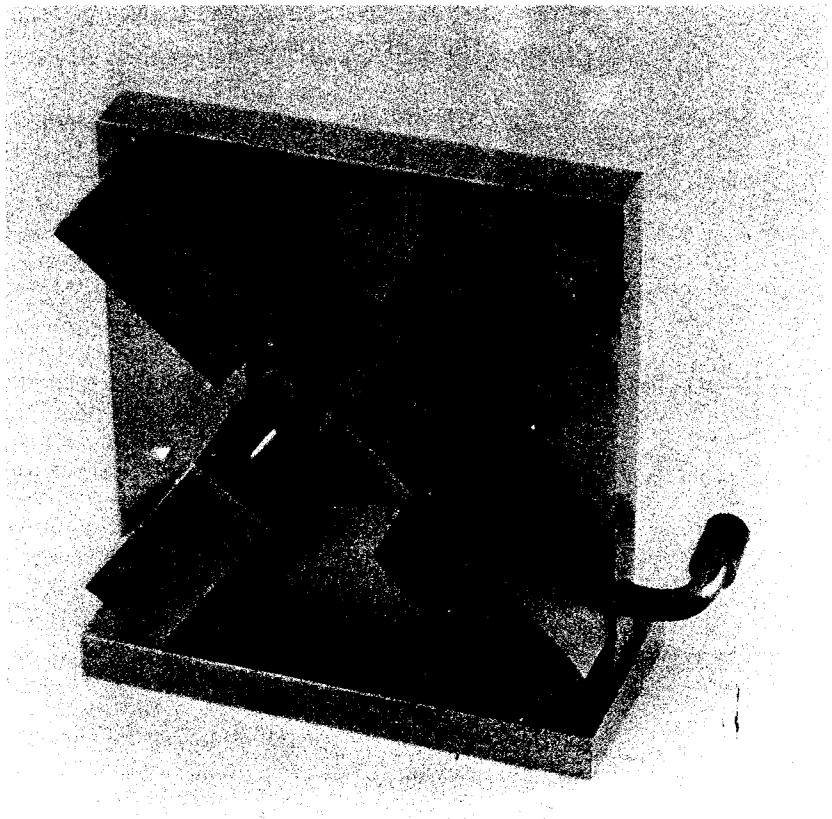
4 Four Square

Four Square is a simple four-cylinder engine with no outside tubing to the steam ports; a simple radial design using four wobbling cylinders. It is an interesting engine with some challenges and it is self-starting. The Column, or main body, calls for some accurate layout and deep drilling. The #45 drills just barely reach the required depth. The machining of the Piston/Rod units will require patience.

The **COLUMN** starts out as an accurate block, 1/4" x 2" x 2-1/16". Lay out, drill and tap the foot holes. The **FOOT** itself needs no comment. Lay out the Shaft center at 1-1/16" from the bottom and centered in the width. Related to this center, lay out the four pivot holes and machine as shown. Chuck this piece in a 4-jaw, centering on the Shaft center, and turn the 7/8" recess and ream for the Bearing. Bevel the 3/16" Bearing hole a bit to take the peening of the Bearing at assembly. Make the Bearing a press fit in the Column.

After pressing in the Bearing, peen the rim into the bevel with a small ballpeen hammer or use a punch to flare the end for a more secure anchor in the Column. Make the drill jig. Insert a 3/32" close-fitting pin through the jig and the pivot hole in the Column. Hold the jig against another 3/32" close-fitting pin in the Crankshaft Bearing and drill the #56 steam passage 1/32" deep. Turn the jig over to get the other port. Do this on all four pivot positions. Note: for now, make these holes only 1/32" deep. If they are deeper, they may deflect the deep drilling later. Use a small dab of layout dye to mark the four **S** (steam) holes. With a sharp red-leaded pencil, run a line from the upper **S** holes down through the lower **S** holes. This is the angle of the drill. To prevent this drill from breaking into an **E** (exhaust) hole, tilt the angle just a very tiny bit more for insurance. Transfer the point where the centerline through the **S** holes meets the lower edge across the bottom and center punch in the center of the stock. Hold in a drill vise with this centerline squared up with the vise jaw. As a check, bring the Column up behind a drill in the chuck and sight the clearance of the drill past the **E** holes. Using an accurate-pointed centering pin in the drill chuck, center and anchor the vise. It might be well to start the hole with a 1/16" drill as deep as possible, later enlarging and drilling to the final depth. Drill the crosshole 5/16" up from the bottom and then tap 5-40 for the steam connection. If all is





on. Here, it is well to plan the final relationship of the Connecting Rod offsets and maintain it through to final assembly. If a Piston is given a half turn after drilling the Cylinder, or transferred to another Cylinder, small errors can change the match of the steam passages. Make a trial assembly to show these conditions before you drill the Cylinder steam passages. Place the jig over the 3/32" Pivot Shaft. Run a 1/16" close-fitting pin through the jig and the eye of the Piston/Rod. Drill the #56 steam passage in the Cylinder.

All of you machinists who like to twirl the handles and read the dials will get a workout here if you make your **PISTONS** the way these were made. If you have other ideas, try them. Maybe you can make them by bending the offset or soldering. Some 1/4" brass rod was found to be a few tenths under .250 and a good fit in the reamed Cylinders. The stock was held in a V-groove in the milling vise and a 1/8" end mill used for all the cuts. Remember to favor the 1/4" diameter that will fit in the Cylinder. All the dimensions given are from some original, or already machined, surface so you have solid material to "mike." The cuts were made in the order shown. No. 1 makes the cut 7/16" back from the end leaving 11/64" material. No. 2 makes the 7/32" cut down to 1/16" remaining. No. 3 and 4 bring the stock down to 5/32" using the side of the cutter not the end. No. 5 and 6 plunge into each side bringing the neck down to 3/32". So far, there is a similarity in the operations for the **A** and **B** type ends. The **B** type needs one more cut No. 7 which required rotating the stock in the V-groove 90 degrees and cutting with the side of the cutter. Except for this last No. 7 cut, all passes were made without loosening the stock in the vise or changing cutters.

We have talked only of milling so far. In making the four Pistons, the end of the stock was milled as we have stated and then taken to the lathe and turned and, then, the stock milled for the next and that turned, etc., to avoid wasting stock. You can decide how you will do this. In turning, the stock projects out of the 3-jaw or collet about 1-3/8", so leave some length for chucking. You should have a toolbit ground as shown at about 20 degrees with about a .010" radius on the end honed keen and smooth. You can complete the neck or rod part of these pieces with one toolbit setting, leaving a little slant at each end and a small fillet just right for this part. Take care with light cuts; there is no tailstock support. Near the offset end you will have jump cuts so be extra careful. The 3/32" diameter is carried down to 5/16" from the end. Make a parting cut 1-3/32" from the end about halfway through the stock. Change to a 90 degree V-toolbit as shown. This is also a handy bit to have on hand. Break the corners and make the three oil grooves with this bit. Polish the 1/4" Piston area only enough to remove burrs and brighten it. Complete the parting cut. Round the offset end to about a 1/8" radius with a file. Lay out and make the 1/16" Crank pin holes.

The **CRANKSHAFT** is made of steel assembled with Loctite.

The **SPRING** drawing shows the proportions of the salvage springs that work fine in this model.

The **STEAM CONNECTION** is optional. Those shown are for use with 3/16" plastic aquarium tubing.

Now you've completed another example of steam power.