FLYWHEEL RIM
3½" PIPE
(D)

7/16"
3.591"
3.595"
3 31/32"

45°
90°
5/16" R.
3/32" R.
MILL VALVE PORTS
3/32" DEEP
TWO HOLES
DRILL 1/8",
5/16" DEEP

11/16"
2¾"
3/8"

1/4"
3/8"
3/16"
3/8"

7/8"
5/16"
1¾"
2½"

(E)
FLYWHEEL POST
ACTUAL SIZE
C. R. S.

3/8"

TWO HOLES
DRILL 1/8"
TO INTERSECT PORT
HOLES

DRILL 25
TAP 10-24

3/4"
CHAMFER ALL
EDGES 45°

11/16"
1⅞"

FOUR HOLES
DRILL 1/8"
5/16" DEEP

TWO HOLES
DRILL 11/64",
C'BORE FOR
8-32 SOCKET-
HEAD SCREW

2"

3/8"
5/16"
5/16"
5/16"
7/8"
1/2"
1"
4"

TWO HOLES
DRILL NO. 11,
C'BORE FOR
10-32 SOCKET-
HEAD SCREW

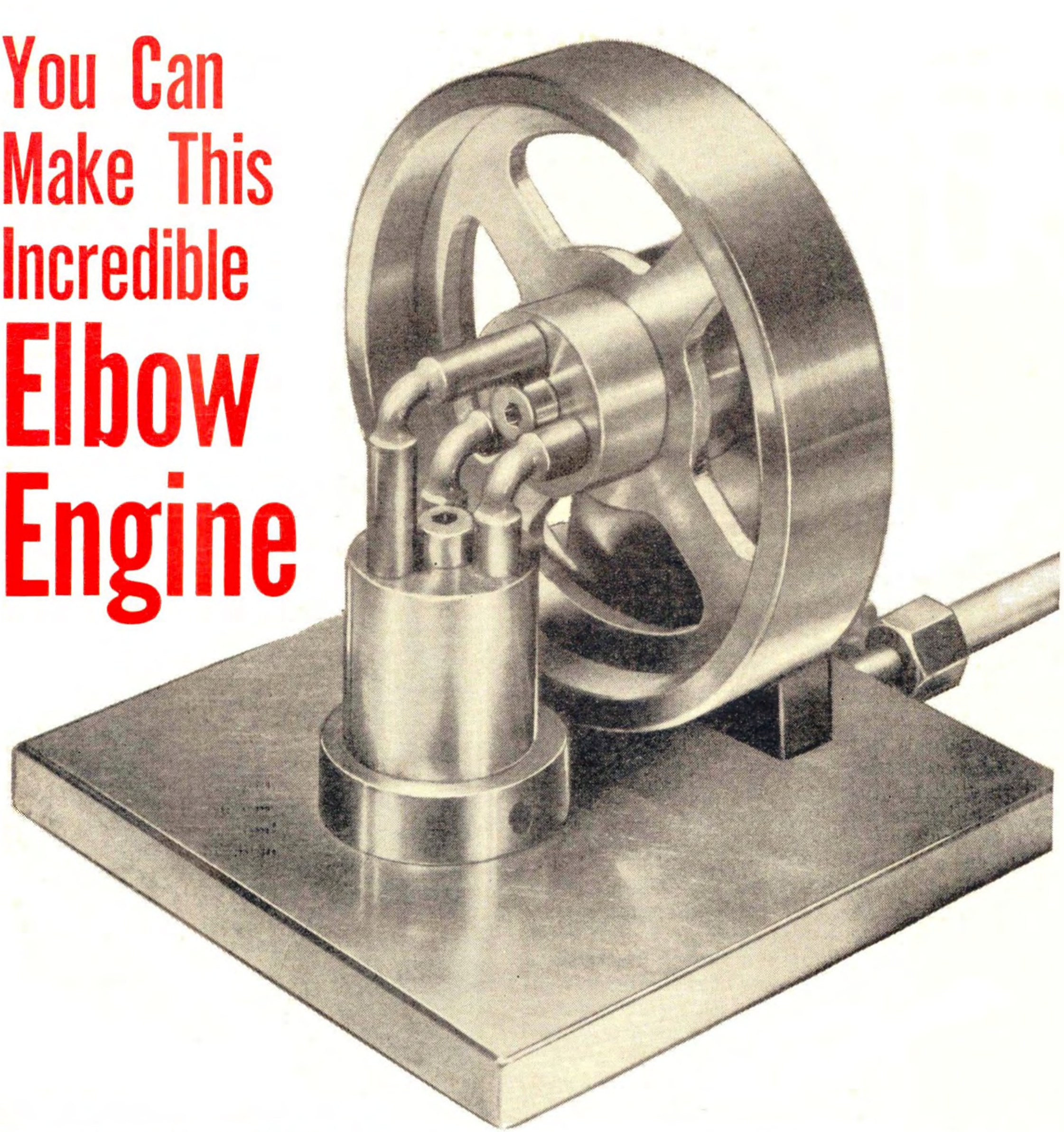
5/16"

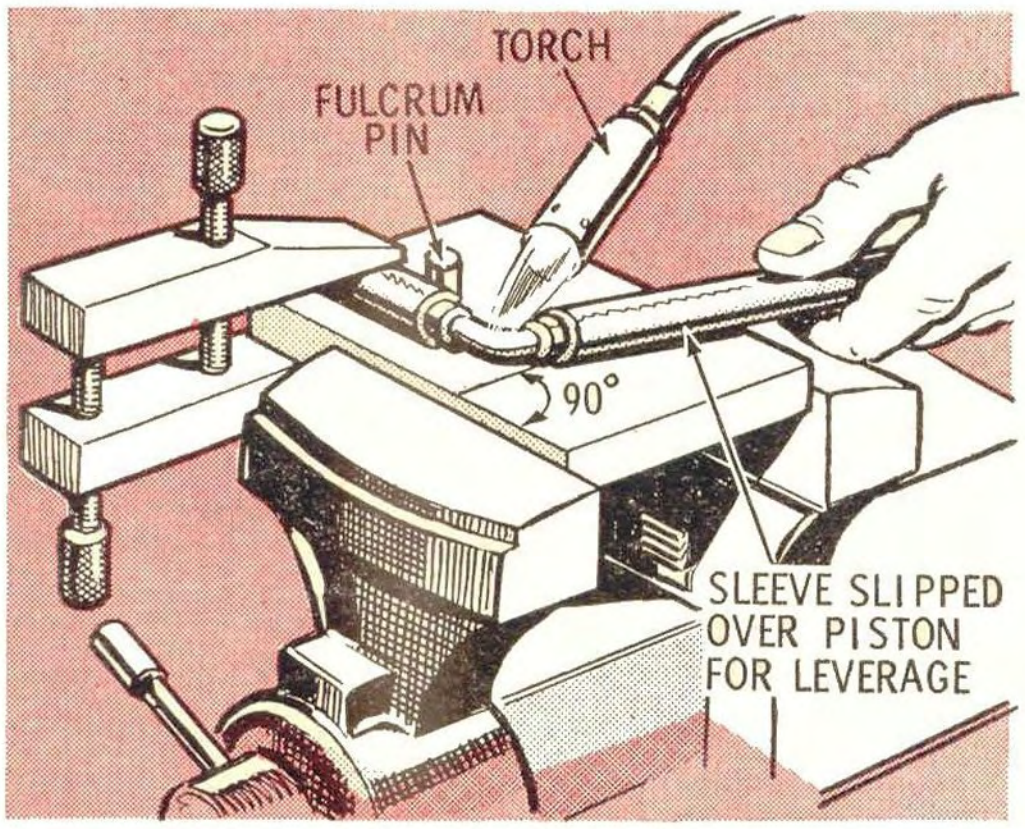
TWO HOLES,
DRILL 1/8",
C'BORE NO. 13

(F)
BASE—ACTUAL SIZE
C. R. S. OR ALUMINUM

4"

You Can Make This Incredible Elbow Engine





AFTER TURNING DOWN center to create piston pairs, bend elbows by clamping to plate-and-pin jig. Apply torch while pulling longer sleeve to the 90° mark

WITH AN ENGINE as novel as this, you don't ask "What's it for?"—it's for murmuring "Wow!" over when you hook it up to an air or steam line. It's *worth* a "wow," too: it's a six-cylinder engine that has only five moving parts!

The pistons are paired into three elbows that bridge two cylinder barrels. In order to *move* when they're activated, the pistons have to *turn* both barrels; thus back-and-forth motion is converted into rotary motion—without gears. Switch the pressure line (steam, compressed air or gas) to the exhaust port and the whole thing spins in reverse. Either way, there's more elbow action than you'd get from a line of señoritas in a maraca contest.

Valving is accomplished without adding a moving part. There are two crescent-

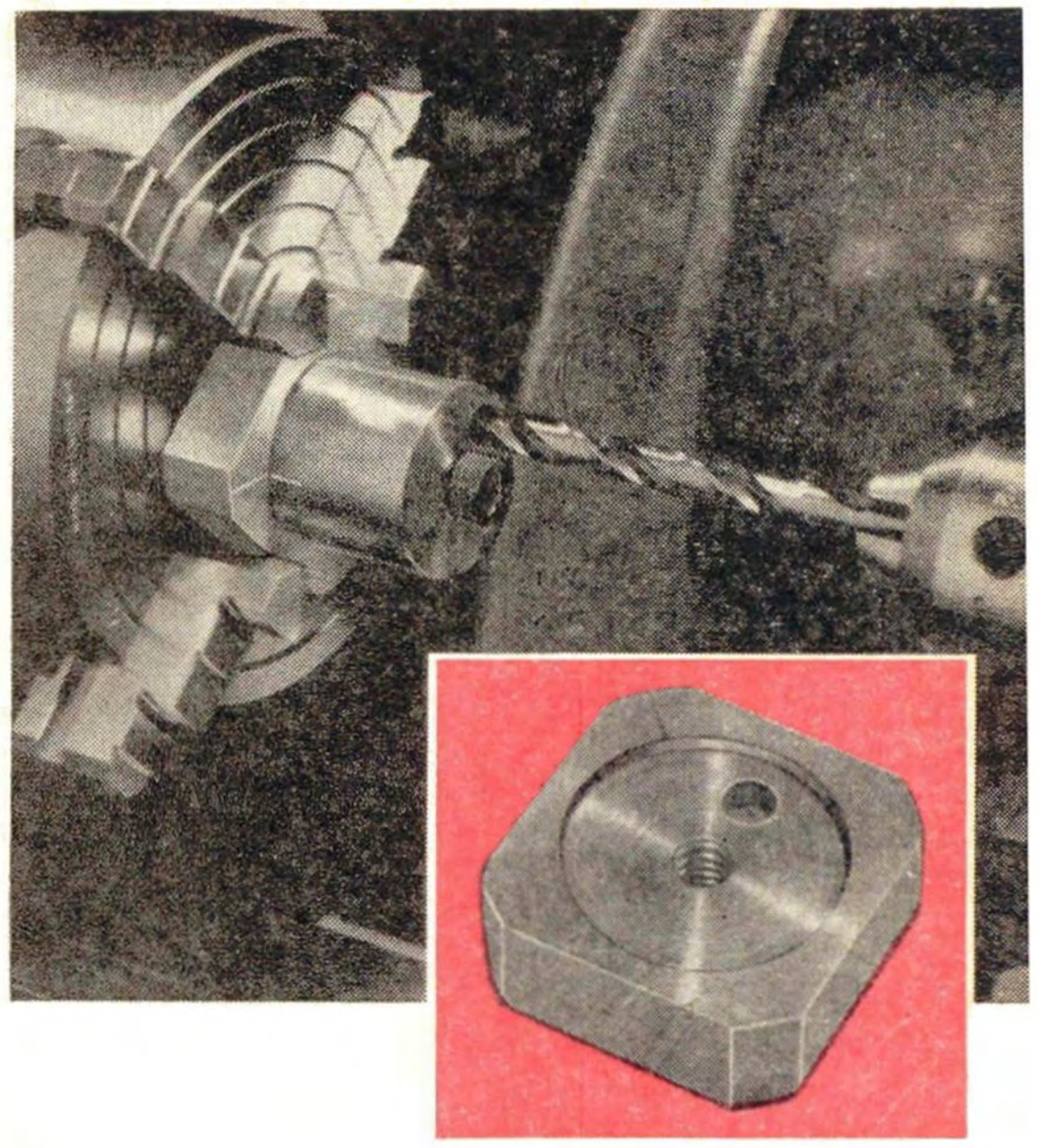
shaped slots in the plates that the cylinder blocks ride against. These slots are spaced so that pistons on an upstroke lie over one of them, while pistons on a downstroke lie over the other. Both ends of each piston pair are "fired" simultaneously, so the power-pulse pattern is like a three-cylinder engine. The action is based on a type of constant-velocity joint known as "Hobson's coupling." But the way the pistons dance is what engineer's call "simple harmonic motion."

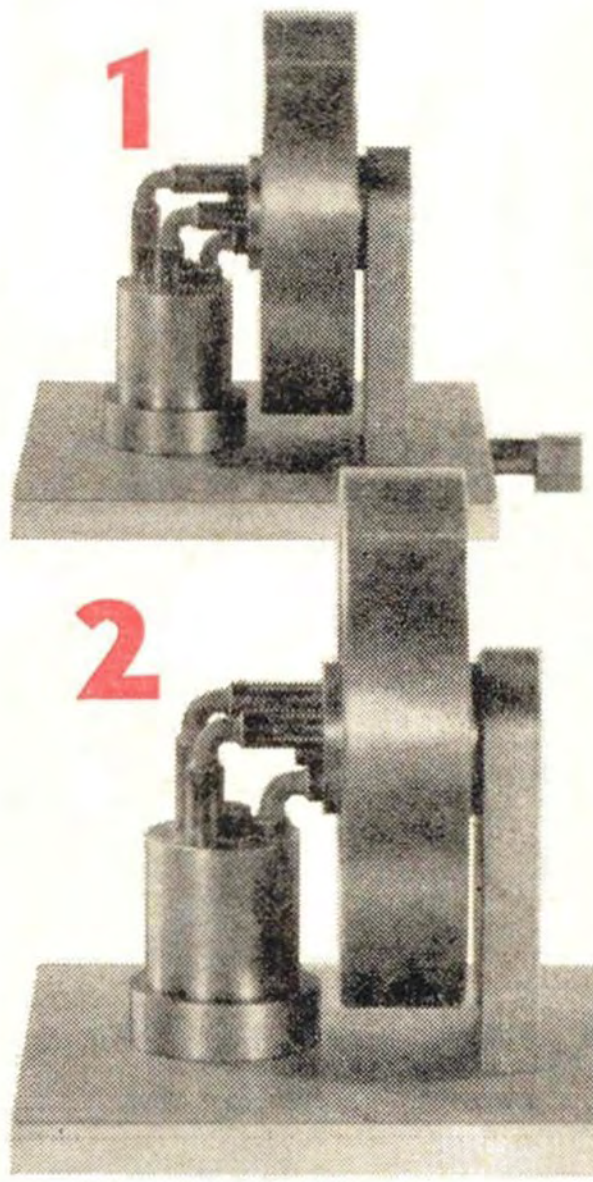
Although a milling attachment is useful for cutting these valve crescents, you can make the entire engine on a lathe alone, working from the full-size plans on pages 120 and 121. For those valve ports, for example, you'd just drill a series of overlapping holes along a scribed arc, using a bottoming drill. (The exact shape and depth of the ports isn't critical, as long as the cylinder barrel covers and seals them.)

Use bronze bar stock for the cylinders. Square both ends of each barrel accurately and finish-turn the outside diameter. Make two identical blanks, and postpone turning down a shoulder on one until later. Drill and ream a ¼-in. center hole in each barrel; then (with use of an indexing head if possible) scribe three axial lines 120° apart on the side of each barrel, running about ¼ in. up from one face.

You'll need the simple fixture shown at upper right to help space the cylinder bores. Chuck up a piece of plate or bar stock which has a face area larger than the cylinder barrels. Machine a 1/16-in.-deep recess to nest—snugly—the base of the barrel. Next, drill and tap a center hole for a ¼-28 bolt. In the recess, make a centerpunch mark on a 5/16-in. radius and scribe a single radial line at any one of the corners, as shown in the inset.

Mount this fixture in the lathe so the punch mark is centered; check the recessed face for true running, then use a ¼-28 Allen-head bolt to clamp one of the barrel blanks to the fixture, making sure it turns freely but snugly in the recess. Rotate the barrel until one of its index marks is in exact alignment with the radial mark on the fixture, then tighten the bolt and drill the first hole, using a center drill to start. If equipment is available for boring the last few thousandths on the diameter of the cylinder holes, this will give maximum straightness and smoothness. At any rate, work to a close slip fit with the ¼-in. stock used for the pistons. When the first hole is completed, simply loosen the clamping bolt and rotate to the next scribed line on the cylinder. Make the second cylinder barrel the same way, then turn down its o.d., as seen on the next page





DRILLING FIXTURE is just socket for chucking cylinder in lathe. Aluminum one, inset above, has already been used. Before use, there's only the tapped middle hole and an index mark

SEQUENCE SHOTS left; show how two completed cylinders (mounted at right angles) are spun by in-out action of elbow pistons which exert push-pull force

2 15/16"

7/16"

1 1/4"

1/4"

5/32"

1 23/64"

PISTON—ACTUAL SIZE
MAKE 3 OF (A)
DRILL ROD

90°

1 23/64"

1/4"

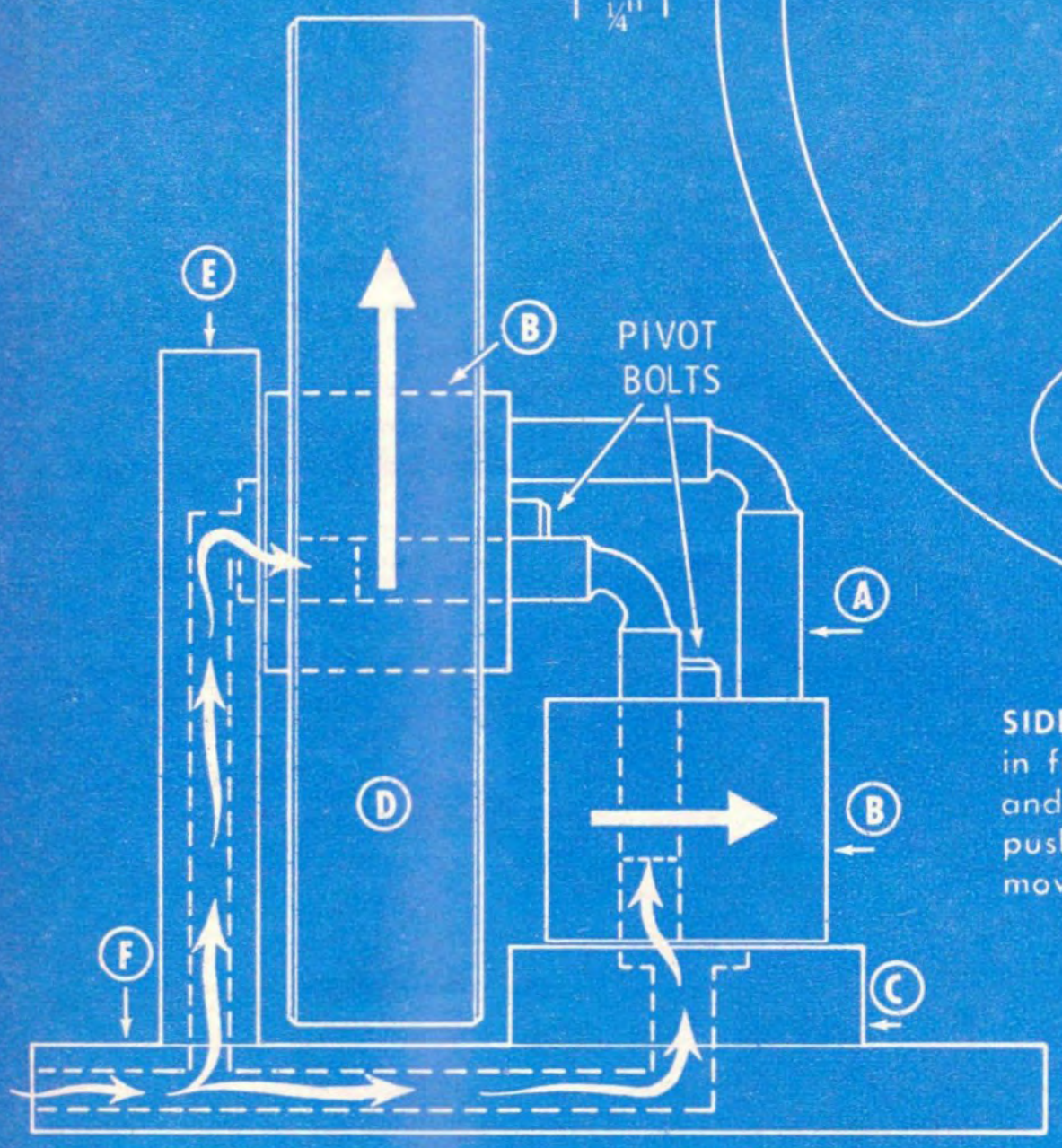
3/16" R.

3.594"

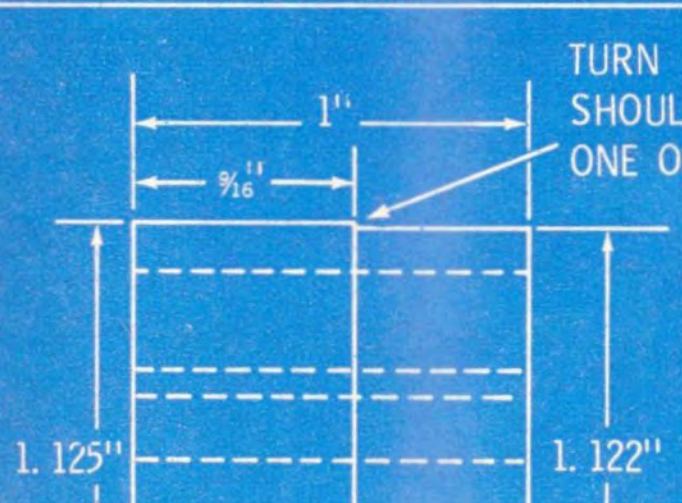
1.122"

1.123"

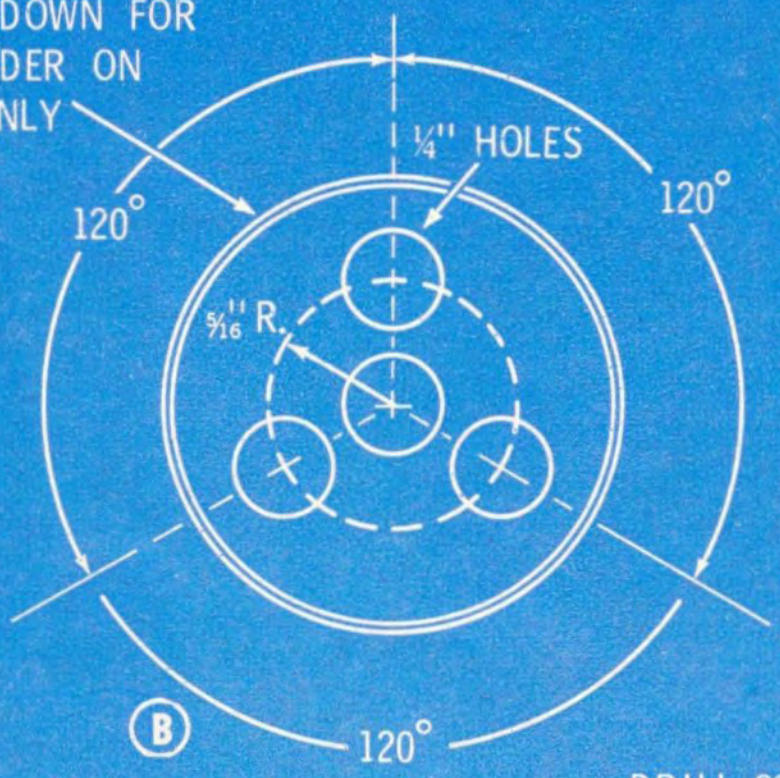
FLYWHEEL WEB
ACTUAL SIZE
1/8" ALUMINUM



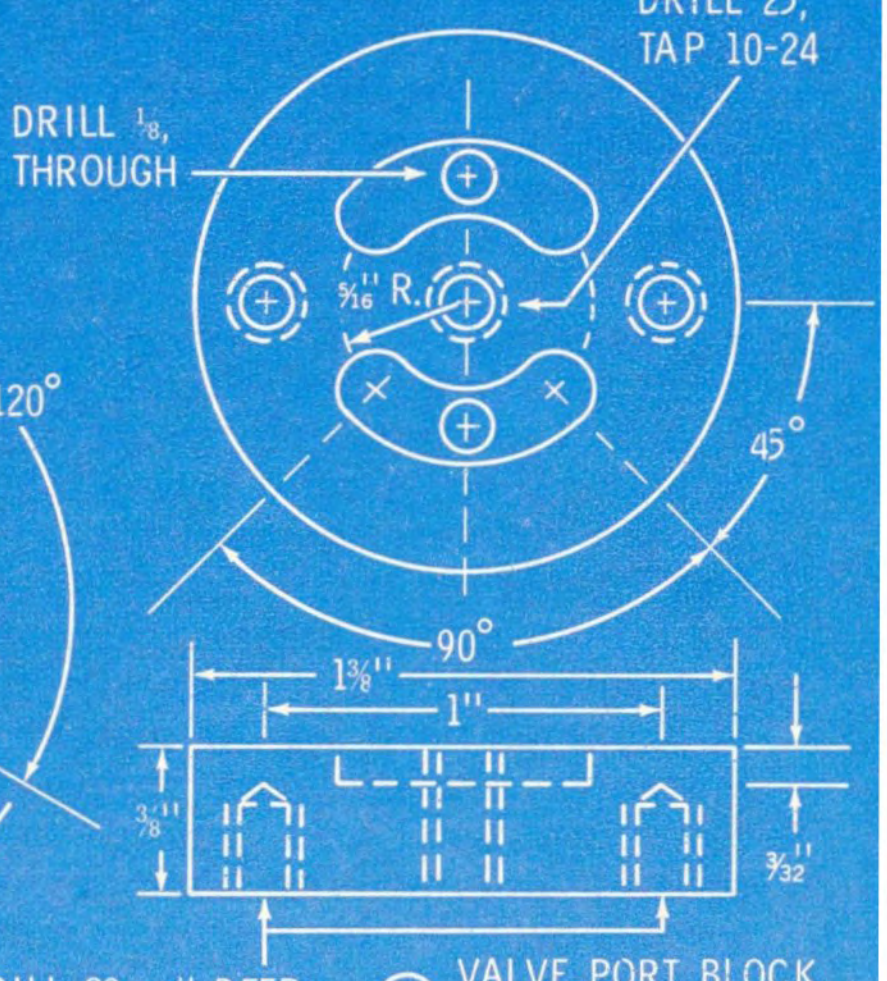
SIDE ELEVATION at left is key to assembly of parts shown in full-size plans. Arrows trace path of steam through base and post to valve ports. Both ends of elbow piston are pushed at once; cylinders spin so flow is cut off and holes move on over exhaust ports for elbow piston's return stroke



ELBOW ENGINE



(B) CYLINDER
MAKE 2 OF BRONZE



DRILL 29, 5/16" DEEP, TAP 8-32

(C) VALVE PORT BLOCK
COLD-ROLLED STEEL

in the drawing, to provide a press fit in the flywheel web.

The piston elbows are made from ¼-in. drill rod. This material is recommended because of its accurately ground finish and predictable diameter. Three pieces are cut to length, faced and necked down in the center to form the elbow of the 90-deg. bend. Keep that section cherry red while bending, and hold the sleeve you've slipped over the unclamped end firmly against the face of the jig to prevent misalignment by twisting.

There are several ways to make a flywheel, but the two-piece construction shown is probably easiest. The rim is 3½-in. steel pipe, with its i.d. reduced enough to form a press-fit shoulder for the aluminum web. The inside bore of the web, on the other hand, provides a press fit for the o.d. of the cylinder barrel. Once this three-part assembly is complete, test it for squareness. If it wobbles, lightly tap the web and rim until the unit runs true.

Make the base from ⅜-in. plate. Besides the tapped holes for attaching the port block and flywheel support, the base contains drilled passages for intake and exhaust of both cylinder barrels. These passages are identical ⅛-in. holes which run straight in from the back edge. Four short vertical holes intersect them, and mate with passages in the port block and flywheel support. Use thin paper gaskets under these parts to avoid leakage.

When assembling the engine, switch the pistons and bores in various combinations to find the best free-running arrangement. The engine should turn smoothly, with very little drag, once the pivot screws are tightened. End play of the barrels should be reduced until they just turn freely; this play can be adjusted either by shimming under the screw heads, or by machining the screw shoulders. Don't be discouraged if a little tuning is needed to make the parts move freely. The action of the mechanism is inherently very smooth, so it's worth some extra time to take full advantage of this characteristic.

Either of the two ports may be used as the intake. Press lengths of 3/16-in. o.d. tubing into the counterbored ports, for attaching the pressure line of your choice. The right load for your engine must be determined by experiment. The model shown runs best when compressed air is regulated to between 20 and 40 p.s.i., and the pistons are kept lubricated with SAE No. 10 motor oil. This, of course, kicks up an oil spray, so do your engine-tending in your shop and in old clothes. ★★★