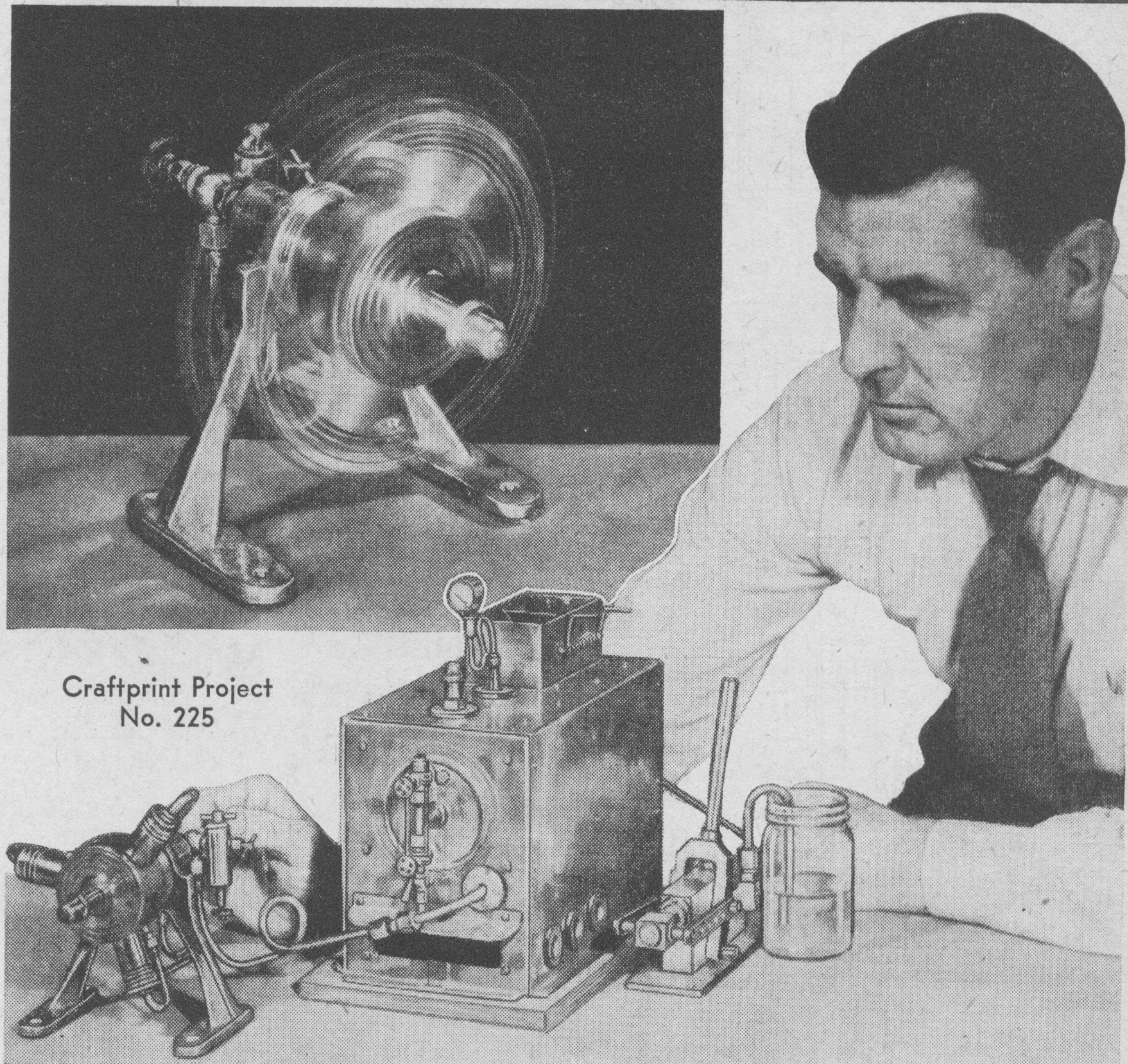
MODEL CRAFT



1 Fasten engine to baseboard before operating. Water pump is used to feed water to boiler while it has a head of steam. It is not needed for short runs. Cyclone measures 5¼ in. wide, 7¼ in. long and 6½ in. high. Because it is a rotary-type engine, no flywheel is needed.

CYCLONE

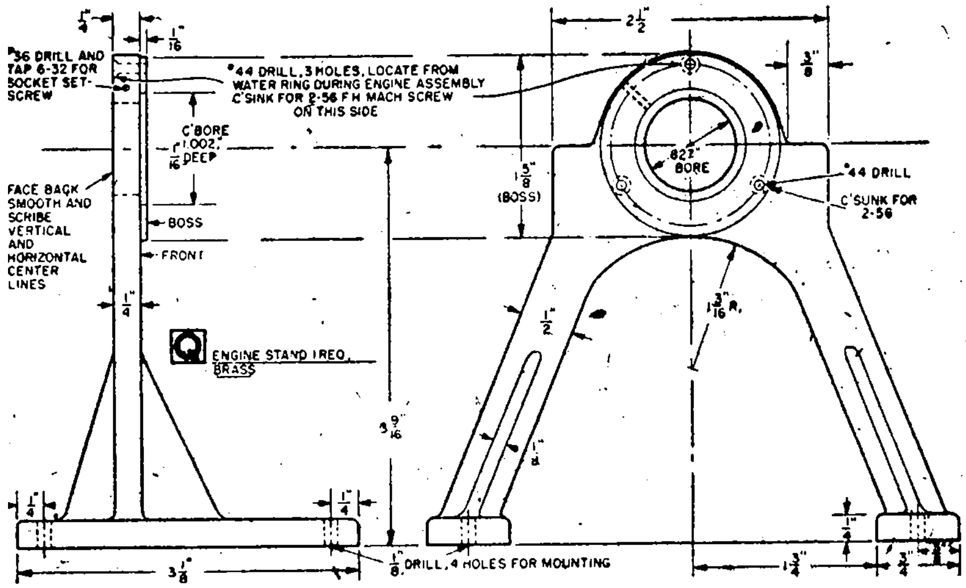
Unique 3-Cylinder Rotary Steam Engine and Boiler

Part I. Machining and assembling the steam engine

By JOEL B. LONG

IF YOU are a model builder who enjoys making "live steam" engines you'll find this high-speed rotary engine (Fig. 1) an interesting challenge in model making. This little handful of dynamite is a beautiful and smooth-running machine that will tick over like a watch on five pounds of steam pressure and deliver a startling performance with a rating of about ¼ hp on 100 to 125 pounds per square inch of moderately super-heated steam. The boiler (Fig. 1) is a slightly modified Scott marine-type boiler made entirely of copper. With its super-heater tube it will deliver moderately dry steam.

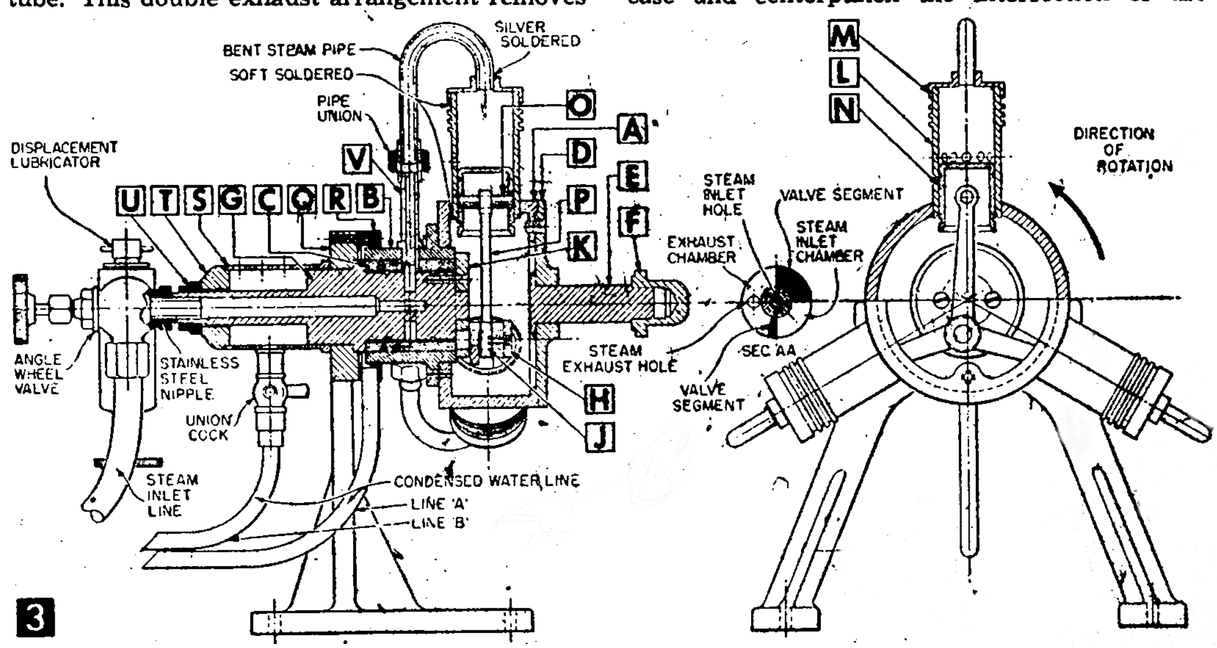
The engine is of the single-acting, rotary-type



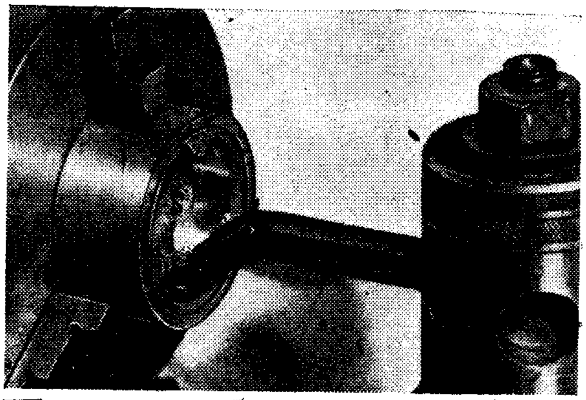
having three cylinders of ⅝-in. bore and ¾-in. stroke (Fig. 3). Crankcase, cylinders, pistons, connecting rods and drive shaft rotate around a combination main bearing and rotary valve so that perfect balance is maintained and no flywheel is necessary. The rotary valve is designed so that steam is admitted during 90° of the stroke, at which point it is shut off and the expansion of steam is utilized during the remainder of the stroke. The spent steam is then exhausted through a series of holes in the cylinders when the pistons are at the bottom of their stroke, and any steam remaining in the cylinders is forced out through the intake line, during the up-stroke of the pistons, to the exhaust chamber in the rotary valve. The exhaust steam in the valve chamber escapes through the ⅛-in. auxiliary exhaust hole, in the valve body (Fig. 2) and then out through three holes drilled in the exhaust tube. This double exhaust arrangement removes all steam pressure on the up-stroke of the pistons. Dead centers are practically eliminated because the three cylinders are spaced 120° apart.

Start by building the engine first, then the boiler. Although the engine can be machined and built from scrap bronze, brass, steel and aluminum of suitable size, a set of castings are available. Check list of materials for cost and supply source.

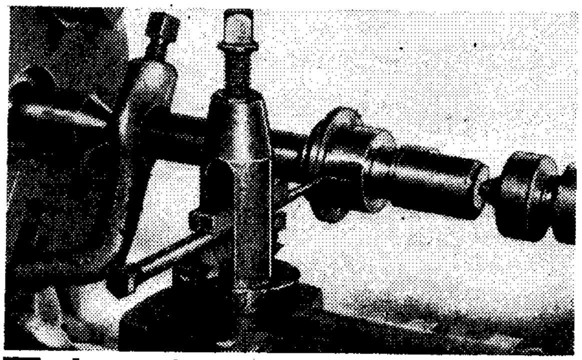
Engine Crankcase. Starting with the crankcase casting (Fig. 2), chuck it in a lathe 3-jaw chuck with the jaws inside the open end. Take a light turning cut across the closed end and turn the sides to the finished 2¼-in. dia. Then remove and reverse in the chuck, and with a cutting-off tool bring the casting to within $\frac{1}{32}$ in. of the length called for. Bore out the inside of the casting to 2-in. dia. (Fig. 4), counterbore and face off the lugs for the cover plate. Again remove and reverse in the chuck so that the closed end is out, and drill and bore 1.252 in. for assembly with sleeve body. Face off the end to bring the case to exact size. With a scriber clamped in the tool-post holder as in Fig. 5, scribe lines across the sides every 60° apart and in line with the centers of the lugs. Also scribe a line completely around the case at the location of the centerline of the cylinders (Fig. 2). Remove the case and centerpunch the intersection of the



3



4 Lathe setup for boring inside of crankcase casting.



5 Locate point of scriber even with lathe centers and clamp in tool post.

scribed lines.

To set up the case in the lathe for drilling and boring, grip the case between the head and tailstock centers with the points of the centers in punch marks 180° apart. Then, supporting the underside of the case with blocks and shim stock, clamp to the lathe carriage fixture or table as in Fig. 6. Drill small pilot holes through both sides of the case first, then open up with a ⅜-in. drill. With the case still clamped in position, bore and ream ¾ in. through the near side only for a cylinder. Reclamp and repeat the above drilling, boring and reaming 120° apart for the other two cylinder holes. The ⅜-in. hole opposite each cylinder hole permits easy assembly of the connecting rods.

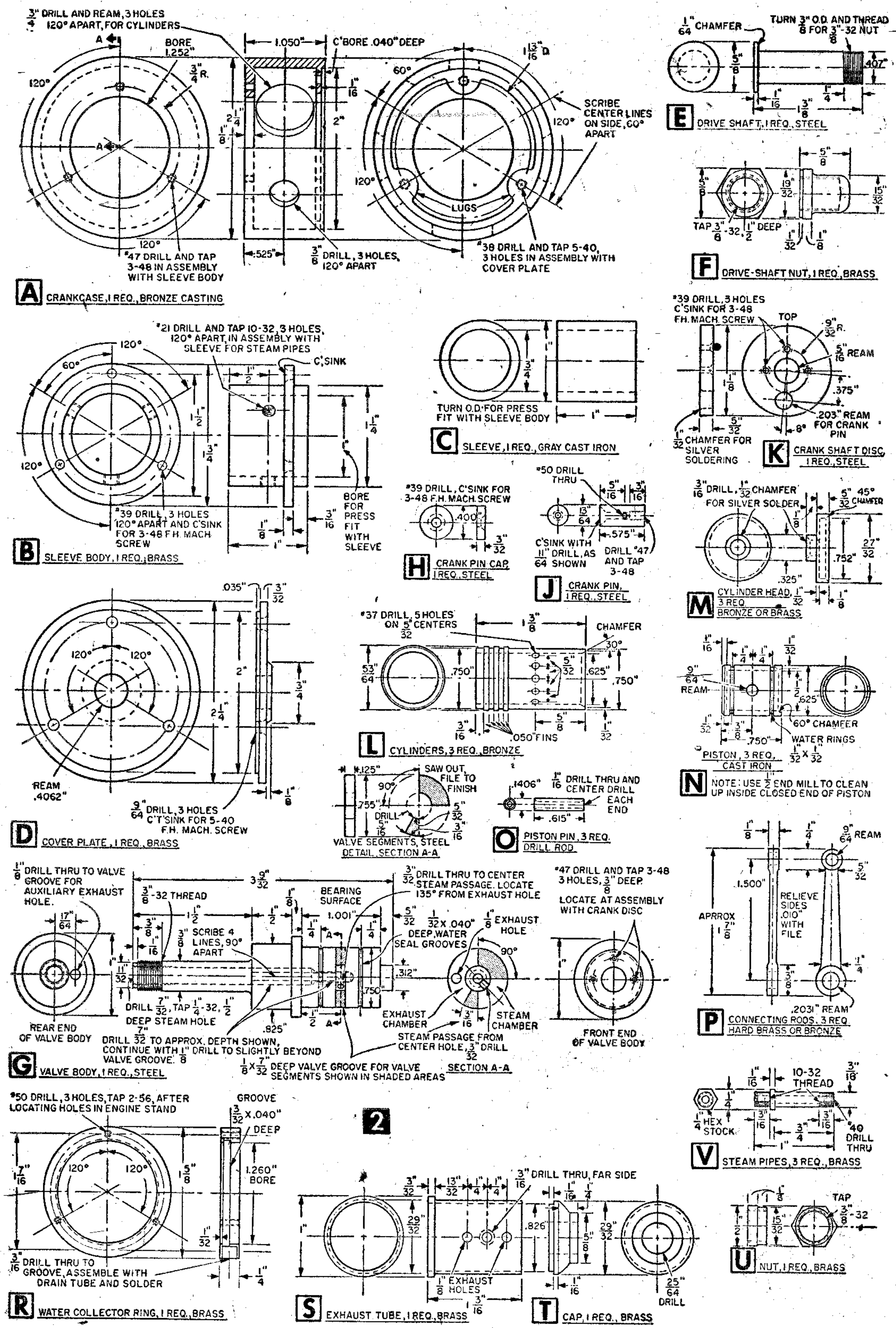
Sleeve Body. Chuck the body casting in the 3-jaw and take light trueing cuts across the end and outer surface. Rechuck by this turned surface, center drill, drill and bore the 1-in. hole for the cast iron sleeve. Then mount the body on a 1-in. mandrel set between centers and finish the outside to the dimensions given in Fig. 2. Set up the scriber in the toolpost on exact center again, and use the lathe index to locate and lightly scribe three lines 120° apart on the body surface (Fig. 5). Scribe another line ½ in. from the end intersecting the three previously scribed lines to locate the steam holes. Check the drawing for the location of the three screw holes in the flange and scribe a radius line and three lines indexed 120° apart. These holes are 60° from or between the steam holes and line up with the ⅜-in. holes and lugs when assembled to the crankcase. Assemble the sleeve body and crankcase and clamp together with a machinist clamp. Drill three holes through the flange of the body and case with a #47 drill. Remove the clamp and take the body and case apart. Open the holes in the body with a #39 drill and countersink for 3-48 *fh* screws. Tap the holes in the case for the 3-48 screws.

Sleeve. Chuck the gray-iron sleeve casting in a 3-jaw and center drill, drill and finish bore to .750 in. This hole must be very accurate and have a fine finish because it serves as the main engine bearing. Polish the bore with #400 grit abrasive paper. Then remove the sleeve and mount on a mandrel. Turn the length to the dimensions in Fig. 2, and the outside diameter for a light press fit into the body hole with no distortion. Assemble the body and sleeve on the mandrel. Square and true the ends of the assembly and polish the ends with #400 grit paper to reduce friction of end thrust. Remove from the mandrel and drill and tap the three previously located steam holes (Fig. 2). Clean off any burrs inside the sleeve resulting from tapping the holes and repolish.

Cover Plate. Turn the cover to the dimensions given in Fig. 2 and center drill, drill and ream or bore the hole through the center for the engine drive shaft. The cover plate should be a nice close fit in the counterbore of the case. Machine the shaft at this time for a press fit in the cover and assemble to the cover with soft solder around the chamfered shoulder. Place the cover in position on the crankcase and clamp securely. Locate and drill three holes through the cover and lugs with a #38 drill. Remove the cover and open the holes with a $\frac{9}{64}$-in. drill and countersink for 5-40 *fh* screws. Tap the holes in the case lugs with a 5-40 tap.

Install the cover on the crankcase and sleeve body assembly and tighten all screws securely. Turn a stub mandrel 1 in. long in the 3-jaw for a holding fit in the sleeve. Polish and oil the mandrel, and gently twist the crankcase assembly onto the mandrel until it is held securely. Then carefully centerdrill the end of the engine shaft. Support the shaft with a live center in the tailstock and machine the shaft to .375 in. with a high polish. Also true up the cover and surface of the crankcase and sleeve body (Fig. 7). If desired, three concentric grooves can be turned in the cover for appearance.

Valve Body. Mount the steel stock for the valve body between the lathe centers and turn to the dimensions given in Fig. 2. Leave the bearing surface .025 in. oversize. Cut the ⅛-in. wide valve groove to a depth of $\frac{7}{32}$ in. with a cutting off tool (Fig. 8). With a scriber clamped in the toolpost on exact center, scribe four lines 90° apart across the bearing surface and ends. Chuck the body in the 3-jaw and drill the $\frac{7}{32}$ hole and the ⅛-in. hole. Check with Fig. 2 for depth of drilling. Thread the end of the body stem on the outside ⅜-32.



3/4" DRILL AND REAM, 3 HOLES 120° APART, FOR CYLINDERS
BORE 1.252"
C'BORE .040" DEEP
SCRIBE CENTER LINES ON SIDE, 60° APART
LUGS
#47 DRILL AND TAP 3-48 IN ASSEMBLY WITH SLEEVE BODY
3/8" DRILL, 3 HOLES, 120° APART
#38 DRILL AND TAP 5-40, 3 HOLES IN ASSEMBLY WITH COVER PLATE
A CRANKCASE, 1 REQ., BRONZE CASTING
1/64 CHAMFER
TURN 3/8" O.D. AND THREAD FOR 3/8"-32 NUT
E DRIVE SHAFT, 1 REQ., STEEL
TAP 3/8"-32, 1/2" DEEP
F DRIVE-SHAFT NUT, 1 REQ., BRASS
#21 DRILL AND TAP 10-32, 3 HOLES, 120° APART, IN ASSEMBLY WITH SLEEVE FOR STEAM PIPES
C'SINK
#39 DRILL, 3 HOLES 120° APART AND C'SINK FOR 3-48 F.H. MACH. SCREW
BORE FOR PRESS FIT WITH SLEEVE
B SLEEVE BODY, 1 REQ., BRASS
TURN O.D. FOR PRESS FIT WITH SLEEVE BODY
C SLEEVE, 1 REQ., GRAY CAST IRON
#39 DRILL, 3 HOLES C'SINK FOR 3-48 F.H. MACH. SCREW
TOP
5/16" REAM
.203" REAM FOR CRANK PIN
1/32 CHAMFER FOR SILVER SOLDERING
K CRANK SHAFT DISC, 1 REQ., STEEL
#39 DRILL, C'SINK FOR 3-48 F.H. MACH. SCREW
H CRANK PIN CAP, 1 REQ., STEEL
#50 DRILL THRU
C'SINK WITH 11/64" DRILL, AS SHOWN
DRILL #47 AND TAP 3-48
J CRANK PIN, 1 REQ., STEEL
3/16" DRILL, 1/32" CHAMFER FOR SILVER SOLDER
45° CHAMFER
M CYLINDER HEAD, 3 REQ. BRONZE OR BRASS
REAM .4062"
9/64" DRILL, 3 HOLES C'T'SINK FOR 5-40 F.H. MACH. SCREW
D COVER PLATE, 1 REQ., BRASS
#37 DRILL, 5 HOLES ON 5/32" CENTERS
CHAMFER
.050" FINS
L CYLINDERS, 3 REQ., BRONZE
9/64" REAM
60° CHAMFER
WATER RINGS
PISTON, 3 REQ., CAST IRON
N NOTE: USE 1/2" END MILL TO CLEAN UP INSIDE CLOSED END OF PISTON
SAW OUT, FILE TO FINISH
VALVE SEGMENTS, STEEL DETAIL, SECTION A-A
1/16" DRILL THRU AND CENTER DRILL EACH END
O PISTON PIN, 3 REQ. DRILL ROD
9/64 REAM
RELIEVE SIDES .010" WITH FILE
APPROX 1 7/8"
.2031" REAM
P CONNECTING RODS, 3 REQ. HARD BRASS OR BRONZE
1/8" DRILL THRU TO VALVE GROOVE FOR AUXILIARY EXHAUST HOLE.
3/8"-32 THREAD
SCRIBE 4 LINES, 90° APART
BEARING SURFACE
3/32" DRILL THRU TO CENTER STEAM PASSAGE. LOCATE 135° FROM EXHAUST HOLE
1/32 X .040" DEEP, WATER SEAL GROOVES
1/8" EXHAUST HOLE
EXHAUST CHAMBER
STEAM CHAMBER
STEAM PASSAGE FROM CENTER HOLE, 3/32" DRILL
SECTION A-A
#47 DRILL AND TAP 3-48 3 HOLES, 3/8" DEEP. LOCATE AT ASSEMBLY WITH CRANK DISC
REAR END OF VALVE BODY
DRILL 7/32, TAP 1/4-32, 1/2" DEEP STEAM HOLE
DRILL 7/32 TO APPROX. DEPTH SHOWN, CONTINUE WITH 1/8" DRILL TO SLIGHTLY BEYOND VALVE GROOVE.
1/8 X 7/32 DEEP VALVE GROOVE FOR VALVE SEGMENTS SHOWN IN SHADED AREAS
FRONT END OF VALVE BODY
G VALVE BODY, 1 REQ., STEEL
10-32 THREAD
1/4 HEX STOCK
#40 DRILL THRU
V STEAM PIPES, 3 REQ., BRASS
#50 DRILL, 3 HOLES, TAP 2-56, AFTER LOCATING HOLES IN ENGINE STAND
GROOVE 3/32 X .040" DEEP
1.260" BORE
3/16 DRILL THRU TO GROOVE, ASSEMBLE WITH DRAIN TUBE AND SOLDER
R WATER COLLECTOR RING, 1 REQ., BRASS
2
3/16" DRILL THRU, FAR SIDE
1/8" EXHAUST HOLES
S EXHAUST TUBE, 1 REQ., BRASS
25/64 DRILL
T CAP, 1 REQ., BRASS
TAP 3/8"-32
U NUT, 1 REQ., BRASS

MATERIALS LIST—3 CYL. STEAM ENGINE

No. Req.	Description	Use
1	1/8 x 2 x 2" hard brass or bronze	connecting rods
1	1 dia. x 12" cold rolled steel	valve body, drive shaft and valve segments
1	1 3/4 dia. x 1/4" or 1/4 x 1 3/4 x 1 3/4" brass	water ring
1	1 1/4 dia. x 3/16 or 3/16 x 1 1/4 x 1 1/4" hot or cold-rolled steel	crankshaft disc
1	1/2 dia. x 1" cold-rolled steel	crank-pin cap
1	1 dia. x 2 1/2" or 1 O.D. x 3/4 tube, brass	exhaust tube
1	1 dia. 3/4" brass	exhaust-tube cap
1	1/2" hex. brass 3/4" long	valve-body nut
1	3/16" O.D. x 24" soft-copper tube	condensed water lines and bent steam pipes
1	1/8 O.D. x 6" soft-copper tube	condensed water lines
3	2-56 x 5/8" fh machine screws	water ring
3	5-40 x 1/4" fh machine screws	cover plate
6	3-48 x 1/2" fh machine screws	crankcase and crankshaft disc
1	5/8 hex. brass 1" long	drive-shaft nut
The following parts available for $14.50 from: Joel B. Long, 309 S/E 7th Street, Ft. Lauderdale, Fla.		
1	crankcase casting	
1	cover plate casting	
1	engine stand casting	
1	bearing body casting	
3	bronze cylinders (I.D. finished bored)	
1	engine bearing casting *(Mechanite)*	
3	piston castings *(Mechanite)*	
3	cylinder heads	
1	drill rod for piston pins and crank pin	
The following parts are manufactured items available from: Charles A. Cole, 1355 Church Street, Ventura, Calif.		
1	union cock, catalog #29 L 5/1	
1	displacement lubricator #28 K 11	
1	pt steam cylinder oil	
1	angle wheel valve # 28 K 2/3	
1	1/4"—32 stainless steel nipple #29 L 8/4	
3	3/16"—32 model pipe unions	

Make the valve segments (Fig. 2) next. Hacksaw the segments from a turned steel disc and file finish each segment for an easy push fit into the valve groove in the body. Locate and position the segments in the groove with the previously scribed lines on the bearing surface. To fasten the segments in place, heat the valve body with a torch and float a little soft solder around the inside edges and bottom of the segments. Shake off the surplus solder before it sets. The segments now form a leakproof steam chamber and an exhaust chamber. Drill a hole with a 3/32-in. drill through to the steam hole (Fig. 2) so that steam can enter the steam chamber and drill the 1/8-in. auxiliary exhaust hole through the body from the rear into the exhaust chamber.

Again mount the body between the lathe centers and turn the bearing surface to .750 in. minus one-half thousandths. Better still, finish to size with a toolpost grinder if you have one. Polish the bearing surface for a fine, free-running fit with the sleeve. Lapping compound can be used if you do not have a grinder. Remove the body from the lathe and tap the end of the 7/32-in. hole 1/4-32.

Crankshaft. Turn crankshaft disc from steel, to the size shown in Fig. 2 and drill for the three attaching screws. The hole for the crank pin must be reamed for a close fit. Machine the crank pin (Fig. 2) and silver solder in the reamed hole in the disc. The pin must be rigid, straight and true with the disc. Make up the crank-pin cap but do not assemble to pin until later.

Assemble the crankshaft disc on the end of the valve body so that the location of the three 3-48 tapped holes in the end of the valve body (Fig. 2) will be on the centerlines as indicated. Then spot drill the location of the three tapped holes in the end of the valve body, remove the crankshaft disc and drill and tap the three holes in the end of the valve body. When the crankshaft disc and valve body are assembled, the center of the crank pin should be 8° to the left of the vertical centerline of the valve body.

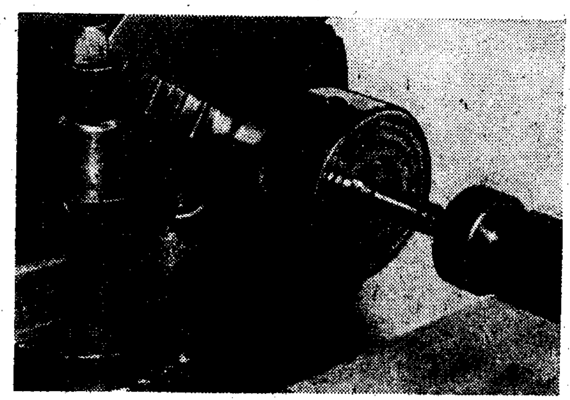
Cylinders, Pistons, Connecting Rods. Turn three cylinders and cylinder heads (Fig. 2) from bronze stock each exactly the same size so that their weight will be the same. Fit the cylinder heads to the cylinders and turn the cylinders for a close push fit with the reamed holes in the case, but do not permanently assemble until later.

Machine the pistons from fine-grain gray iron, cut the water rings and polish the outside diameter for a sliding fit with the cylinders.

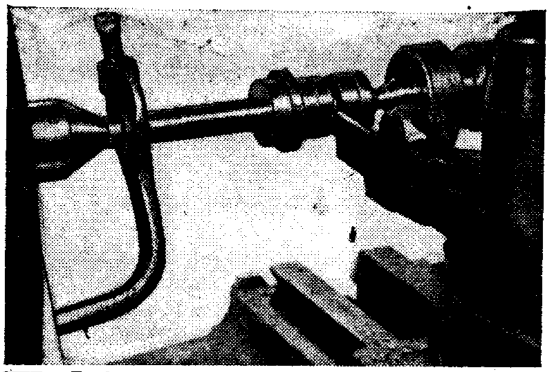
Use a tailstock crotch center to accurately drill the pistons for the piston pins which are turned from drill rod (Fig. 2).

Rough cut the connecting rods from 1/8-in. thick bronze or havel brass first. Then, with the three connecting-rod blanks clamped together,

6 Use shim stock to accurately locate position of crankcase for drilling and reaming.



7 Crankcase subassembly is mounted on a stub mandrel and a light truing cut taken from side of crankcase.



8 Engine stand easily clears lathe bed on 9-in. swing lathe.

locate, drill and ream the two bearing holes. The holes must be straight and true so that the rods can be assembled to the pistons and crank pin without binding. With the rods still clamped together, file them all at once to size so that they will all be exactly the same size and shape. After removing the clamp, relieve each side of each rod slightly by filing as in Fig. 2.

Assemble the rods to the pistons with the piston pins. The pins must not protrude beyond the piston sides and rub against the cylinder walls. To avoid this, swell the ends of the pins slightly after assembly with the pistons by tapping with a center punch placed in the center-drilled holes at each end of the pins.

Engine Stand and Water Ring. Chuck engine stand in a 4-jaw chuck as in Fig. 9 and drill, bore and counterbore to dimensions given in Fig. 2. Face off the front of the boss and remove from the chuck. Then mount on a stub mandrel with back side out, and face off the back to 1⅝ in. dia. Clean up the rest of the casting with a file and abrasive cloth and drill four ⅛-in. holes in the feet for mounting on a board.

Turn and drill the water ring as in Fig. 2, but do not tap holes at this time. Temporarily assemble the valve body, sleeve, sleeve body and water ring to the engine stand. Then, with the water ring exactly centered around the sleeve body so that it is not bearing against the sleeve body at any point, clamp the ring to the engine stand with two small C clamps.

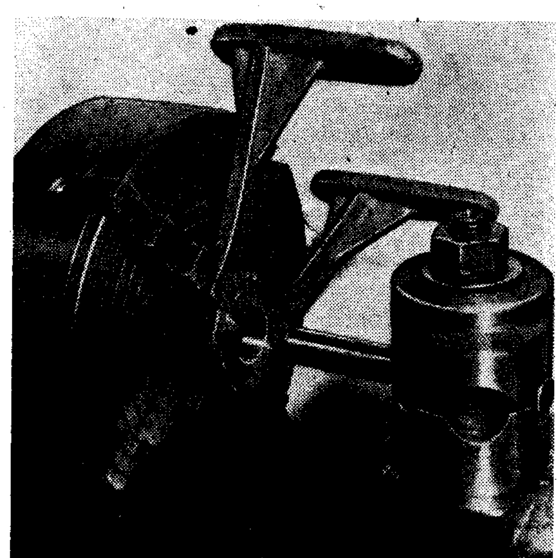
Remove the valve body, sleeve and sleeve body from the engine stand and spot drill on the stand the locations of the three holes for the 2-56 machine screws that are to hold the ring to the stand. Be sure the 3/16-in. hole in the ring is located at the bottom of the stand boss before spot drilling the three holes. Remove the ring and drill the three #44 holes in the stand and countersink the back side for 2-56 *fh* screws. Then tap the three #50 holes in the water ring with a 2-56 tap. Bend a 4-in. length of 3/16-in. O.D. soft copper tube to the shape of tube A in Fig. 3 and soft solder in the 3/16-in. hole in the water ring. Now permanently fasten the water ring to the engine stand with three 2-56 *fh* screws 9/16 in. long.

Exhaust Tube, Cap and Nut. Machine exhaust tube from solid round brass stock by drilling and boring or, if you can find a short length of 1-in. O. D. brass tube having a ⅛-in. wall thickness, boring time can be saved. Turn the cap (Fig. 2) for a snug fit with the tube and solder in place. Solder the threaded end of a 3/16-40 x ⅛-in. model union cock in the 3/16-in. drilled hole in the exhaust tube and connect a 2-in. length of ⅛-in. O. D. copper tube B in Fig. 3 to the union cock. Make the nut from ½-in. hex. brass stock.

Steam Pipes. Turn and drill three steam pipes from ¼-in. hex. brass stock as in Fig. 2 and thread ends 10-32.

Assembling the Engine. First, assemble three steam pipes to the valve body and fasten one half of 3/16-32 model pipe unions to the other ends of the steam pipes. Then bolt the sleeve body to the crankcase and set this subassembly aside a moment. Now assemble the valve body in the bored hole in the engine stand and position it so that the valve segments are located as in sec. A-A in Fig. 3. Line up the scribed centerlines on the valve body to coincide with vertical and horizontal scribed lines on the back of the stand. When the stand and valve body are lined up, assemble the exhaust tube and nut on valve body to hold it in place and spot drill the valve body through the 6-32 tapped hole for the socket-head setscrew in the stand (Fig. 2).

Now, going back to the crankcase subassembly, insert the cylinders in the bored holes in the crankcase, but do not solder as yet. Then, holding the subassembly in your left hand with the open end of the crankcase up, place the crankshaft disc in the crankcase. Slide the pistons complete with connecting rods in the cylinders and maneuver the connecting rods on the crankpin. A little hand-file fitting of the connecting rods may be necessary at this time if the rods rub or strike the piston or cylinder walls at any point. Secure the rods to the crankpin



9 Lathe setup for turning rotary-valve groove in valve body.

with the crank-pin cap.

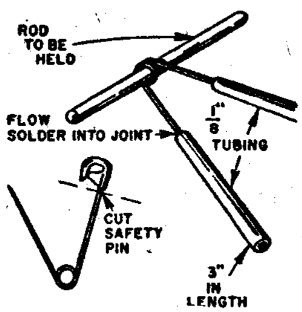
Next, slide the crankcase assembly on the valve body, position the crankshaft disc on the end of the valve body and fasten in place with three screws. To determine the exact position of the cylinders for soft soldering to the crankcase, turn the engine slowly until one of the pistons comes to top dead center. Then raise or lower the cylinder in the bored hole of the crankcase until the top edge of the cylinder is 1/32 in. above the top of the piston. The exhaust holes in the cylinder face toward the rear of the engine. Position all three cylinders in this way and, after checking to see that all cylinders are straight and true, spot solder them to the inside of the crankcase. Then carefully remove the crankcase from the valve body, take out the pistons and solder all around the cylinders on the inside of the crankcase. Insert the pistons and reassemble to the valve body as before.

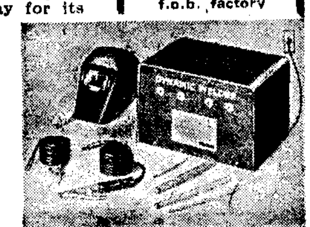
Make up the curved cylinder-head steam pipes from 3/16-in. O. D. soft copper tubing (Fig. 3). The three pipes should be exactly the same shape and size so their weights will all be the same. Thread one end of each pipe 3/16-32 to fit model pipe unions and silver solder the other ends to the cylinder caps. Soft solder the caps to the cylinders and connect the pipe unions. Fasten the cover plate to the crankcase and install the angle wheel steam valve and displacement lubricator (Fig. 3). Fill the lubricator with steam cylinder oil and *Cyclone*, the 3-cylinder rotary steam engine, is ready to connect to the steam boiler. Part 2 will explain how to build the boiler and operate the engine. In the meantime do not attempt to operate the engine on compressed air, because the lubricator will not deliver oil to the moving parts unless steam is used and damage to the engine may result.

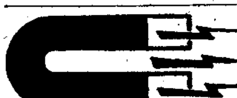
• Craft Prints in enlarged size for building model engines and boilers are available at $1 each. Order by print number, enclosing remittance (no C.O.D.'s or stamps) from Craft Print Dept., SCIENCE AND MECHANICS, 450 East Ohio St., Chicago 11, Illinois.

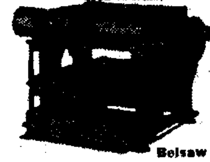
Safety Pin Vise Holds Small Rods

• To make a simple vise for gripping small metal pins for model-craft projects, cut the head off a large safety pin, or bend a piece of spring wire around pin to be held. Insert the ends into two 3-in. lengths of copper tubing and flow solder into the ends of the tubing around the pin shanks. When a round piece to be filed or cut is inserted through the loop of the pin, pressure applied on the tubing with the fingers will be sufficient to hold the piece.—WM. B. EAGAN.





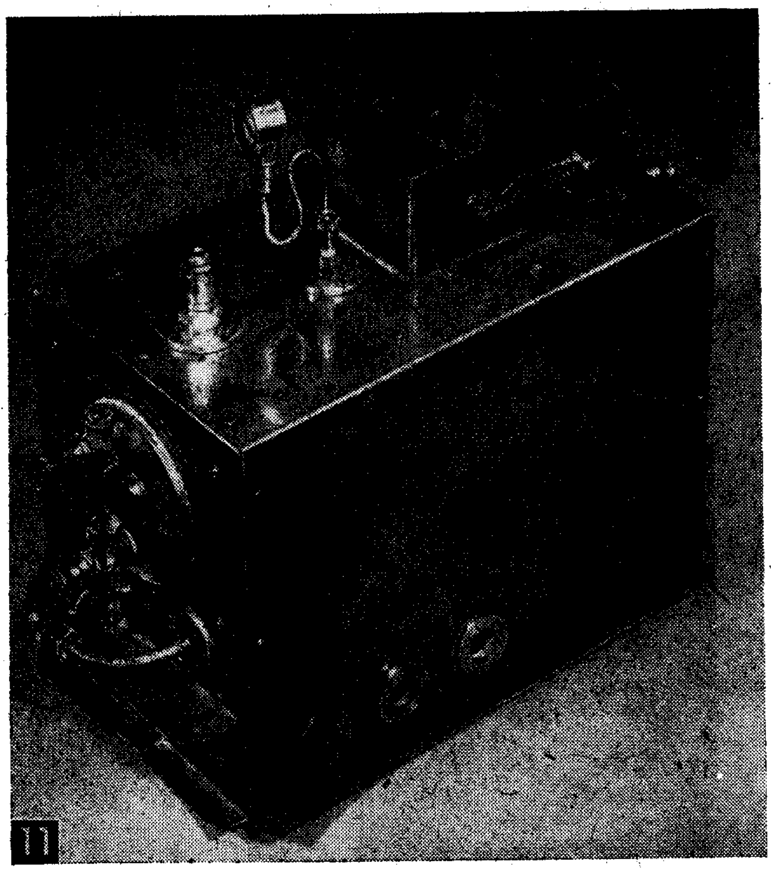




CYCLONE A 3-Cylinder Rotary Steam Engine and Boiler

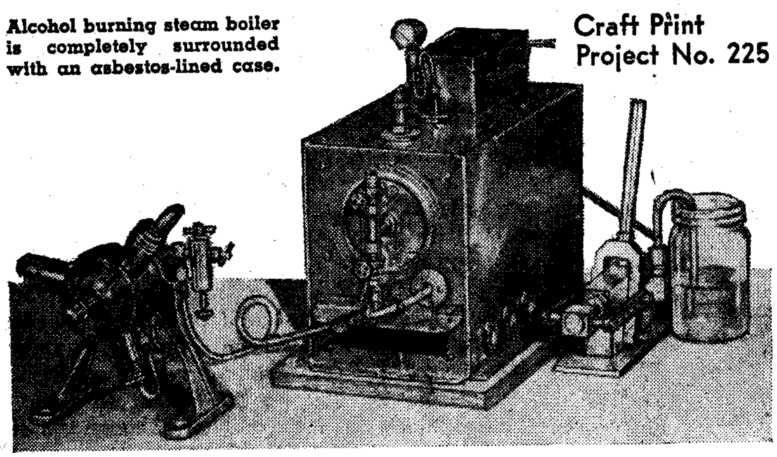
Part 2: Making the Boiler and Operating the Engine

By JOEL B. LONG



Alcohol burning steam boiler is completely surrounded with an asbestos-lined case.

Craft Print Project No. 225

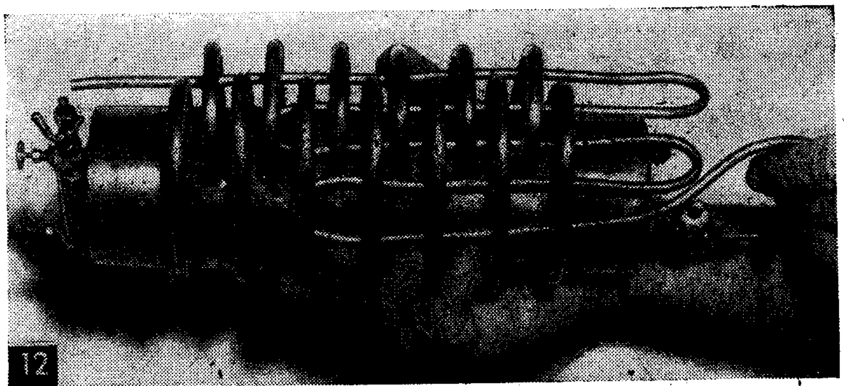


WHEN you have finished the steam engine (Part 1 S&M October 1955) your next step is to make the boiler (Fig. 11). It's a modified Scott marine-type boiler and could be called a semi-flash boiler because of the arrangement of the water tubes. With its superheater tube (Fig. 12) it will deliver moderately dry steam. When properly constructed and equipped with a reliable steam gage, safety valve and water gage, it can be safely operated at 100 to 125 pounds per square inch (*psi*) steam pressure. The boiler shown in Fig. 18. withstood a hydrostatic test of 800 *psi* without any indication of distress or leaks.

The boiler is made entirely of copper. Begin by chucking the 2⅝ O.D. coper tube (Fig. 13) which is to be the boiler shell, in your lathe 3-jaw chuck. Support the other end with a steady rest and true up the ends and inside of each end for a distance of about 5/16 in. Then, with a scriber clamped in the tool post so that its point is on exact lathe center, scribe a light line lengthwise on the tube. Rotate the tube 180°, using the lathe index for locating, and scribe a second line. Mark one line top and the other, bottom. Measure and mark the centerlines for the tube holes from the top and bottom centerlines (Fig. 13) on the tube. Also scribe light lines around the circumference of the tube 1½ in. from each end and scribe light lines lengthwise. Remove the shell from the lathe, layout and centerpunch for the 13 water-tube holes. Double check the locations of the tube holes before drilling, because they are to be assembled in alternating positions as in Fig. 14. Drill with a centerdrill first, then open with a ¼-in. drill.

Next, make the wooden jig (Fig. 15) for bending all the water tubes uniformly. Block B in Fig. 15 is shown full size, so merely trace it on thin paper and transfer to a ¾-in. thick piece of wood and jigsaw to size. Then, fasten to a baseboard along with Block A.

To use the jig, grip in a vise as in Fig. 16, insert a long length of ¼ in. O.D. copper tube between Blocks A and B and bend the tube around Block A. Saw each bent tube off at the designated marks on Block A. Thirteen of the



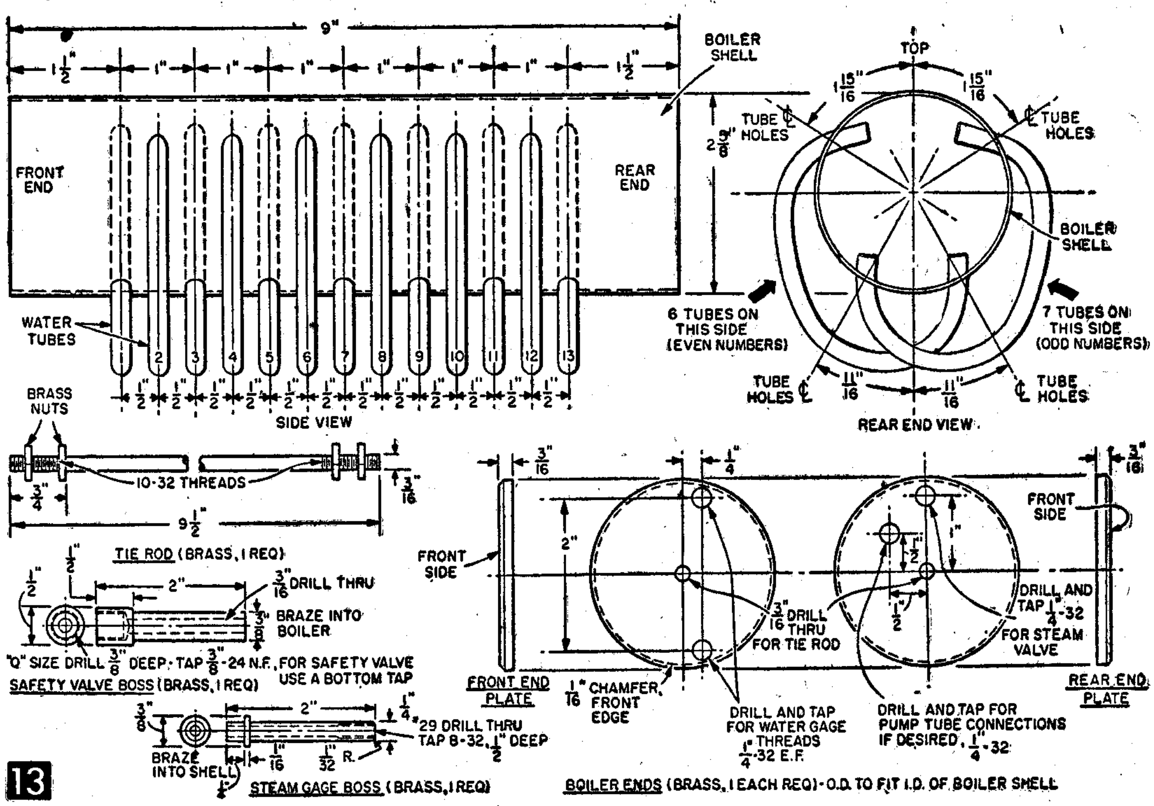
Super heater tube is install between boiler and water tubes.

torch. The actual brazing must be done with an oxy-acetylene torch. Heat the area to be brazed to a dull red and touch the heated copper with *Sil-Fos* brazing rod. If the temperature is correct, the brazing rod metal will flow like water around and into the seam making a strong water-tight joint. If you have not had any experience in brazing, have the brazing done at your local weld shop, because there is a possibility of heating the copper too much which will result in oxidation and a faultily brazed joint. If you are going to have the brazing done, make up all of the parts first, so that all the brazing can be done at one time.

bent tubes will be required.

Before the tubes can be inserted in the holes in the shell, the wall of the shell along the top holes will have to be bent slightly. Grip the shell in a vise and use a ¼-in. steel rod inserted through the holes as a lever (Fig. 17). Bend and try fitting one tube in place first. Then, having the correct angle or amount of shaping required on the boiler shell, bend the area around the other top holes and temporarily assemble all the tubes to the boiler (Figs. 13 and 14) to see that all of them fit properly. Since the tubes are to be brazed to the boiler, the area around the brazed joint must be perfectly clean. Disassemble the tubes and clean the ends of the tubes and area around the holes on the shell both inside and out with abrasive cloth. Again assemble the tubes and shell and apply brazing flux around the joints. Preheat the entire shell with a blow

Turn the ends for the shell from 3⁄16-in. thick copper, bronze or brass for a snug fit in the shell ends. Chamfer the outside and drill a hole in the center of each one, starting with a small drill and opening to 3⁄16-in. diameter. Drill and tap the front plate (Fig. 13) for the water-gage fittings and the rear plate for the steam valve and hand water pump, if one is to be used. The pump is used to make a hydrostatic test of the boiler upon completion, and also can be used to add water to the boiler while the boiler is working or carrying a head of steam. The pump is not necessary if the boiler is to be operated intermit-

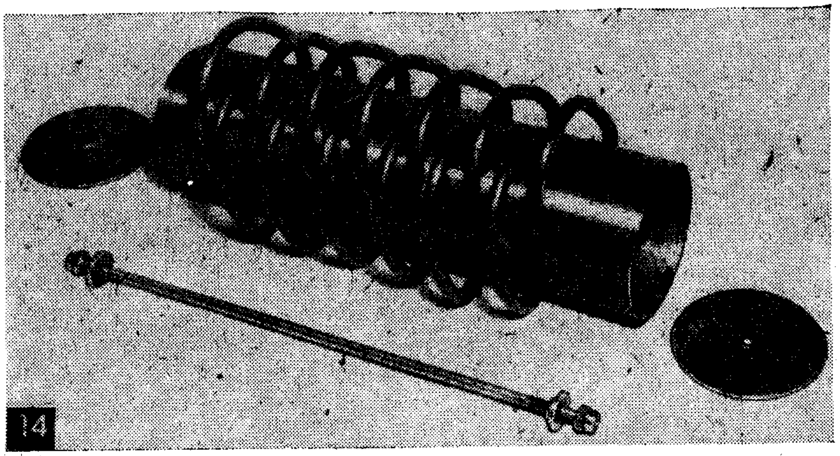


tently. A complete set of castings for building this pump is available (see list of materials).

The safety-valve boss and steam-gage boss are next on the list of items to make. Turn, drill and tap each boss as in Fig 13, and drill holes for each on the top centerline of the boiler spaced as in Fig. 18. Fasten in place by brazing.

The boiler ends can now be assembled to the shell. Make the tie rod Fig. 13 and locate the two nuts that will be on the inside of the end plates, so that the end plates, when assembled in the shell, will be 3/32 in. from the ends of the shell on each end (Fig. 18). Then screw on the outside tie-rod nuts and tighten. Braze the ends to the shell, filling up the chamfer with *Sil Fos* and braze the tie rod nut to the end plate and tie rod.

Testing Boiler. With all brazing on the boiler completed, it must be tested with water pressure. *Never use air or steam pressure for testing a boiler.* Install pipe plugs in the tapped holes for the water gage fittings on the front end plate of the boiler. The water gage should not be on the boiler when making a hydrostatic test. Connect a 300-pound air pressure gage with copper tubing to a steam valve fitting on the rear boiler plate (Fig. 19) and the hand water pump to the 1/4-32 tap hole in the rear plate. Now, completely fill the boiler with water and give the pumps a few strokes to drive air out of the line. Plug the



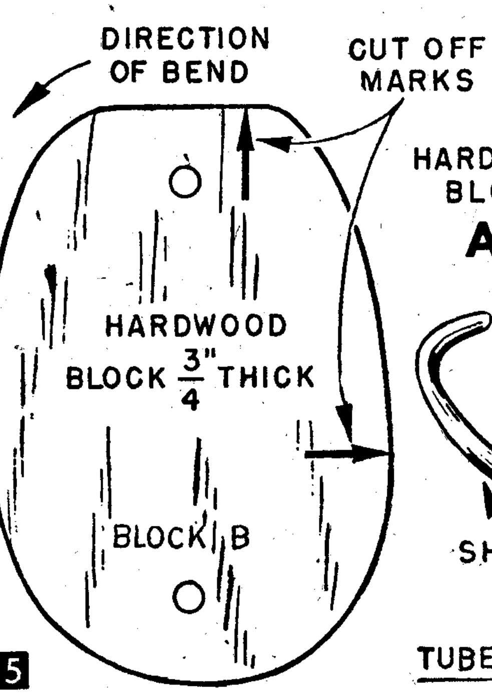
14

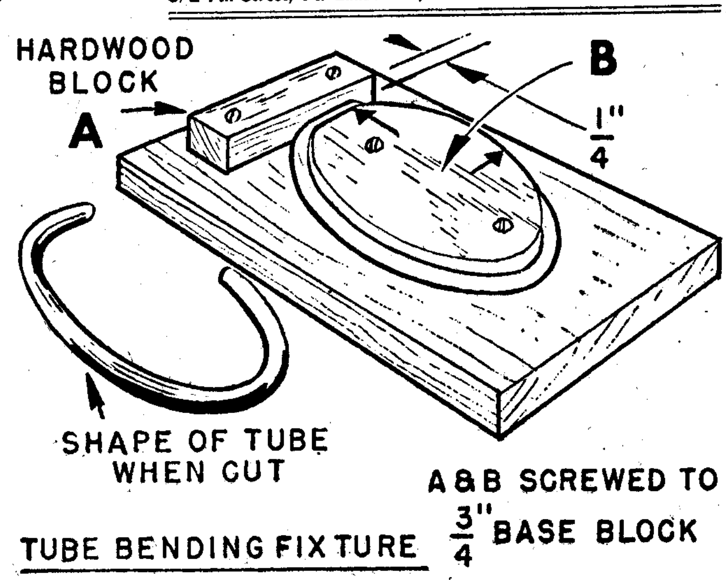
View of boiler before brazing. Note alternate arrangement of water tubes.

MATERIALS LIST—CYCLONE (Boiler)

No.	Description	Use
1 pc.	2 5/8 O.D. x 10" long x 1/16" wall thickness	boiler shell
1 pc.	12 x 36" x B & S gage (1/32") annealed sheet copper	boiler case
1 pc.	12 x 12" x B & S 26 gage annealed sheet copper	fuel pan and flame shield
2 pc.	3/16 x 3 x 3" copper or brass	boiler heads
1 pc.	3/16" dia. x 12" brass rod	boiler tie rod
4	10-32 brass nuts	boiler tie rod
1 pc.	1 1/4 dia. x 3" brass rod	draft-hole rings super-heater rings safety-valve ring pressure gage ring
1 pc.	1/2 x 5" brass rod	steam gage and safety valve bosses
1 pc.	1/4 O.D. x 144" soft copper tubing	water tubes
1 pc.	3/16 O.D. x 48" soft copper tubing	super-heater tube
3	3/16" brass compression fittings for 3/16" copper tubing	super-heater tube
1 pc.	1/8 O.D. x 12" soft copper tube	pressure gage syphon
1 pc.	3/16 x 9 x 33" asbestos sheet	boiler lining
1	water gage (catalog #29K6/3)	
1	3/16 O.D. x 6" glass tube	
1	steam pressure gage, 0 to 150 psi (catalog #29M1)	
1	safety valve (catalog #29M3/3	
1	steam valve (catalog #28K2/3)	
1	set of castings for making hand water pumps (catalog #29K4/10)	

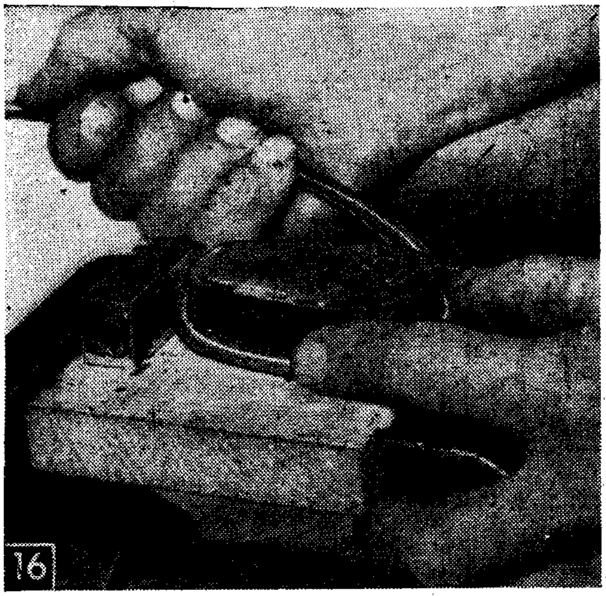
The above parts available from Charles A. Cole, 1355 Church Street, Ventura, Calif.
Cast Bronze boiler may be purchased from Joel B. Long, 209 S/E 7th Street, Ft. Lauderdale, Fla.





15

TUBE BENDING FIXTURE



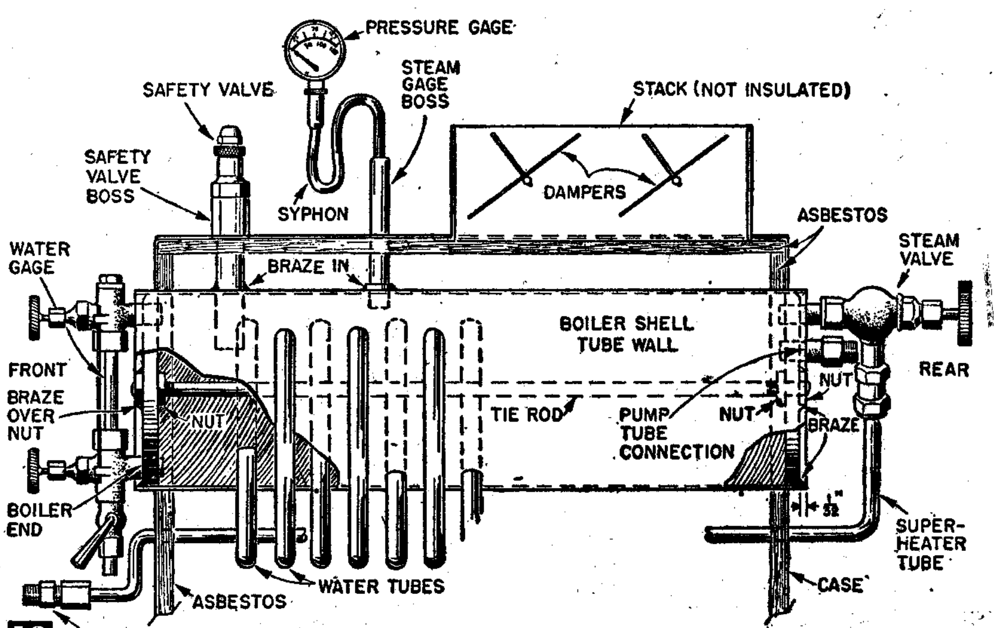
Bending water tube around wooden jig.

Using a steel rod inserted through water-tube holes to bend sides of boiler shell.

safety valve and steam pressure gage bosses with machine screws and gaskets. Operate the pump, drawing water from a jar at the pump intake (Fig. 18), until you build up a pressure of 300 pounds on the gage. Inspect the boiler carefully for leaks or weeps. If any show, drain the tank and repair by brazing and then run another test.

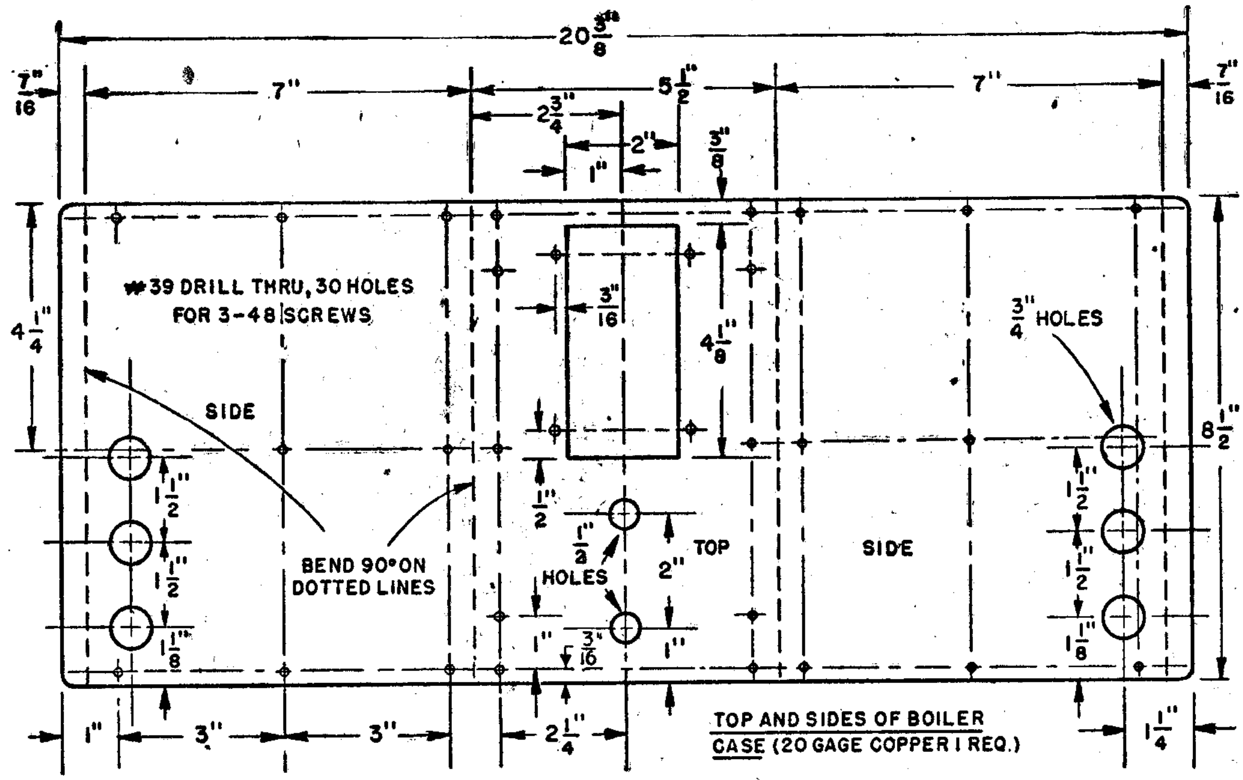
Boiler Case. The boiler case (Fig. 20) was made of 20-gage (approx. 1/32 in.) soft copper. However, half hard brass could be used. Layout drill and bend the piece for the top and sides (Fig. 20) first. Then make the front and rear ends so that each will fit inside the top and side pieces. Locate the 3-48 screw holes in the bent-over flanges of the ends by spot drilling through the top and sides. Make up the chimney and assemble to the shell with the bent flanges of the chimney on the inside of the shell. Also make up and fasten the flame shield to the case at this time. To fasten the draft-hole rings in place, tap the inside edges with a centerpunch in three places to spread the metal of the rings against the sides of the case as in Fig. 20. Position the other rings over the holes in the shell, spot drill and fasten to the shell with 3-48 *fh* machine screws.

Your next step is to line the entire inside of the shell with 3/16-in. thick asbestos. Mark and cut each piece to size placing the top in first, then the sides and ends. Use washers or 1/2-in. squares of scrap sheet copper as washers and 3-48 fillister-head machine screws through the boiler case to hold the asbestos in place. Fill the corners with asbestos cement, a putty-like mixture of shredded asbestos and water. The assembled boiler and superheater tube, which is simply a 45-in. length of 3/16-in. diameter soft copper tube bent and inserted between the water tubes as in Fig. 12, can now be fitted into the boiler shell. You will have to bend the ends of the super-heater tube to work it through the holes in each end. Work slowly and carefully to avoid kinking the tube. Once you have the boiler and tube in place, plug the openings where the boiler and tube extends through the shell with asbestos cement. To pre-



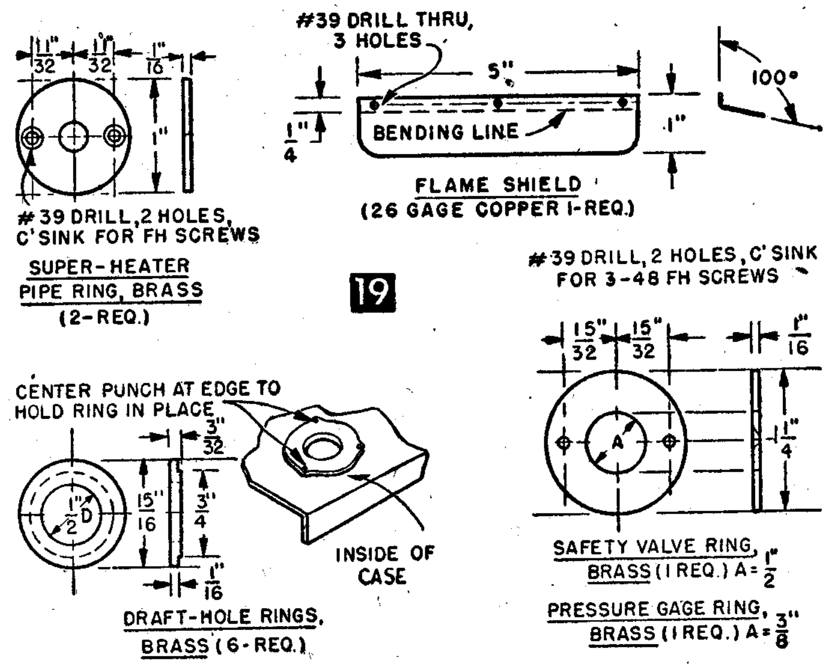
18 THIS END OF SUPER-HEATER TUBE CONNECTED TO ENGINE

LONGITUDINAL SECTION OF BOILER AND ACCESSORIES

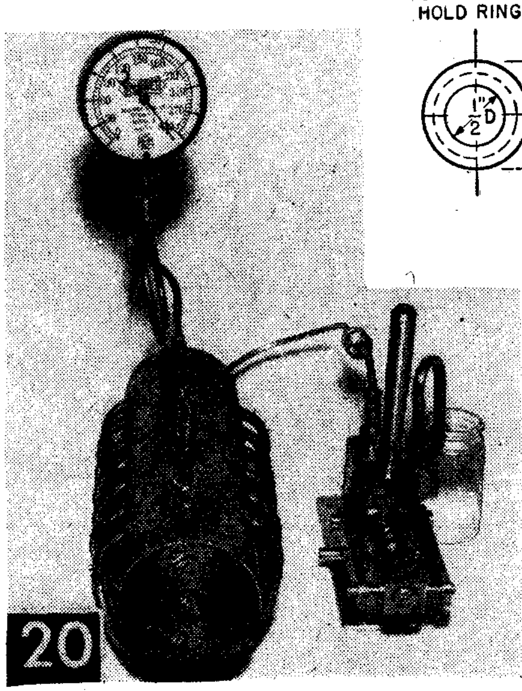


vent the asbestos from crumbling along the bottom edge of the boiler, tack braze a ⅜-in. strip of brass bent to an angle along the bottom edge of the case as in Figs. 21 and 22.

Make and install the dampers (Fig. 21) to the chimney next. These may be controlled individually and are used to regulate the fire to a certain extent. Make the fuel pan (Fig. 21), brazing the corners



19



20

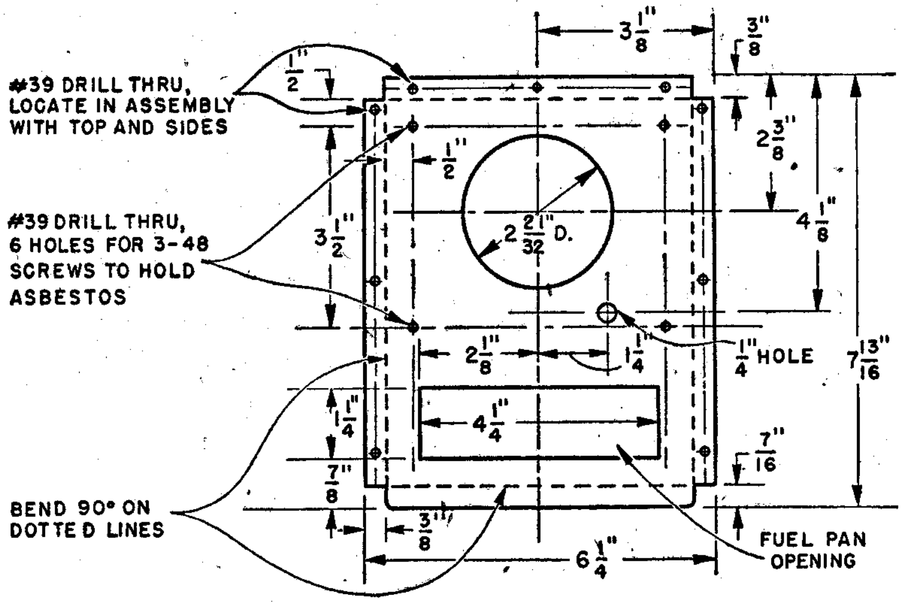
so that the pan will be leakproof. The handle must also be brazed on. In use, the pan is filled with asbestos fiber and saturated with wood alcohol. The alcohol can then be ignited with a match.

The boiler fittings, which are next on the agenda, are all purchased parts. To seal the joints when screwing the fittings together, use a paste made by mixing red lead and linseed oil together or a tube of *Permatex Form-A-Gasket No. 2. Connect the steam valve at the* rear of the boiler (Fig. 18) to the rear end of the super-heater tube. The other outlet at the rear of the boiler may be connected to a force-water pump, if water is to be

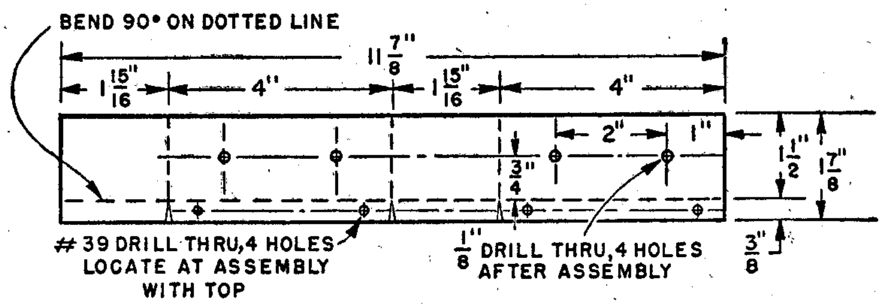
Hand operated, water force pump is used to make 300 psi hydrostatic test of boiler.

fed to the boiler while it is operating. Otherwise the outlet can be closed with a pipe plug or cap. The pressure gage must be fitted to a syphon to prevent live steam from coming in contact with it. Make up an S-shaped fitting of ⅛-in. copper tube as in Fig. 18 and solder to the gage and gage boss. Use a washer type of gasket on the safety valve fitting instead of the paste-type gasket, because the safety valve is removed occasionally to add water to the boiler if a force pump is not used. Fit the water gage to the front end of the boiler. All parts are purchased made up. You need only cut the glass tube to the proper length and assemble. Cut the glass tube by scoring it with the corner of a file and breaking in two.

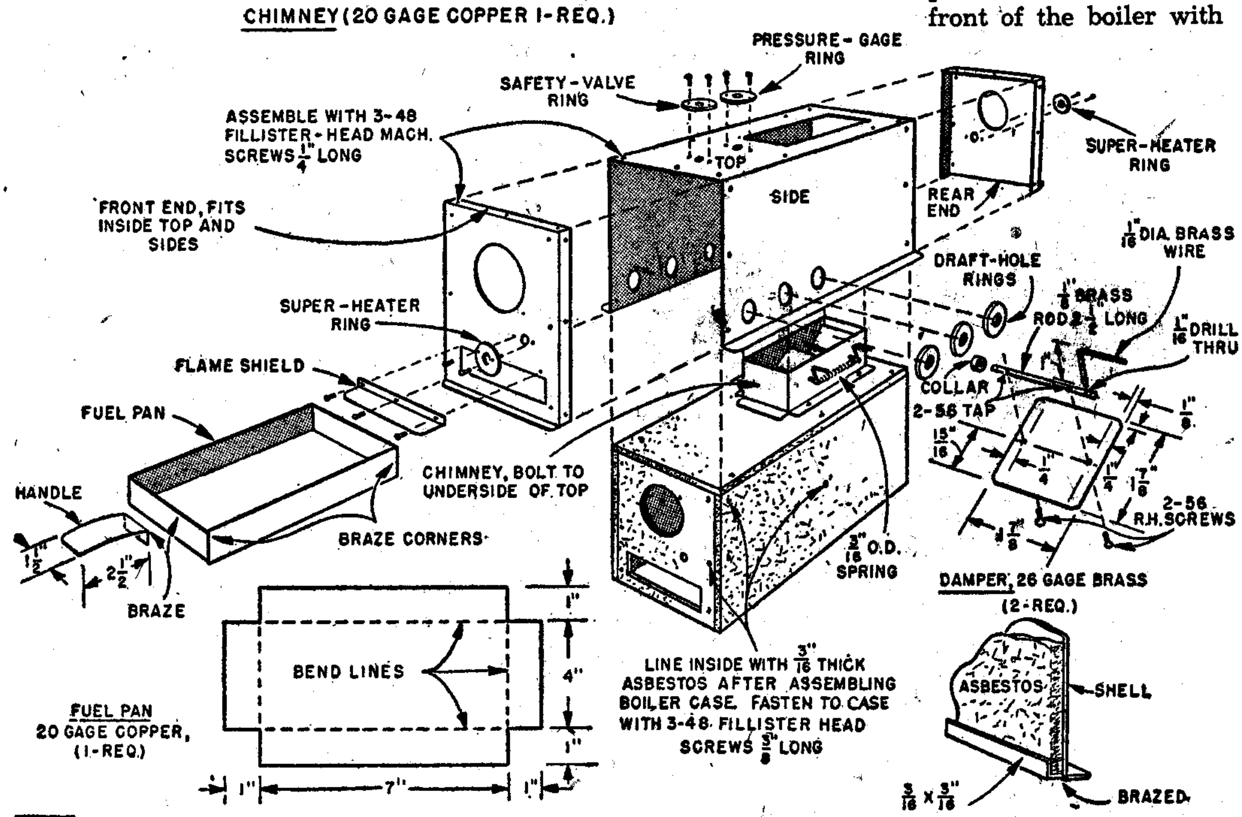
Operating the Engine. Connect the inlet valve on the engine to the super-heater tube at the front of the boiler with



FRONT END (20 GAGE COPPER 1 REQ.)
REAR END (SAME AS FRONT END BUT WITHOUT FUEL PAN OPENING 1-REQ.)



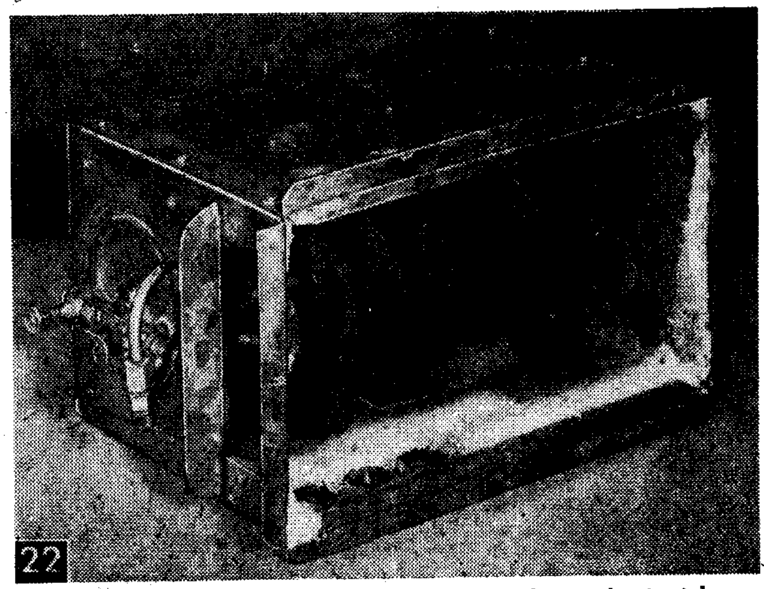
CHIMNEY (20 GAGE COPPER 1-REQ.)



21

PULLED-APART VIEW OF BOILER CASE

a short length of 3/16-in. copper tube (Fig. 2 Part 1 S&M Oct. '55). Remove the safety valve and pour water into the boiler until it is two thirds full. Ignite the alcohol in the fuel pan and slide the pan into the case. When the water becomes hot enough to show steam coming out of the safety valve boss, allow the steam to escape three or four minutes, so the gasket paste will have time to set up, then screw the safety valve in place and set for 80 to 100 *psi*. Check to make sure you have filled the displacement lubricator on the engine with steam cylinder oil. The needle valve on the lubricator may be adjusted to regulate the flow of oil. Open the steam valve at the rear of the boiler and slowly open the steam valve on the engine. If the engine does not start running, rotate it a few times by hand. Hot steam entering a cold engine causes condensation and some water will collect in the cylinder at first. Turning it by hand will force out the water, which will escape through the exhaust ports. The temperature of the engine must reach a certain point before condensation practically ceases and permits the engine to attain its maximum power. Always keep the safety valve ball seat clean so it will pop off at the set pressure. Also keep your eye on the water gage. The boiler, however, will not be damaged if it runs dry of water, because the alcohol flame is not hot enough to melt or weaken the brazing around the tubes.



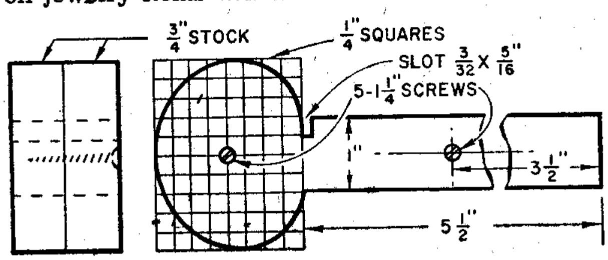
Underside of boiler and case showing water and super-heater tubes. Note brass angles along edge of asbestos.

Cyclone can be throttled down to rotate very slowly or "rev'ed up" to high speed. As a bench model, it is a constant source of interest to all who view it, because its design is so different from the usual run-of-the-mill type of live-steam model.—END

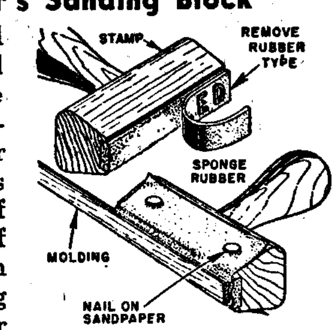
• Craft Prints in enlarged size for building model engines are available at $1.00 each. Order by print number, enclosing remittance (no C.O.D.'s or stamps) from Craft Print Dept., SCIENCE AND MECHANICS, 450 East Ohio St., Chicago 11, Ill.

Bracelet Forming Jig

• Those of you who go in for production work on jewelry items will find this bracelet bender a handy item to speed up your work. Make the jig of two pieces of scrap wood to obtain the needed 1½-in. thickness and grip in a vise or clamp to the bench top. In use, one end of the straight bracelet stock is placed in the slot and bent over the rounded end of the block. The bracelet is then removed from the jig and the other end bent in the same way.—R. J. DE CRISTOFORO.



Rubber Stamp Becomes Modelmaker's Sanding Block



• Model makers will find that a discarded rubber stamp may be converted into a practical sanding block for sanding uneven pieces such as strips of molding. Shave off the rubber type with a razor blade, leaving the sponge-rubber cushion in place. Then fold and tack sandpaper over it. The sponge rubber permits the sandpaper to shape itself to an uneven surface.—G. E. HENDRICKSON.