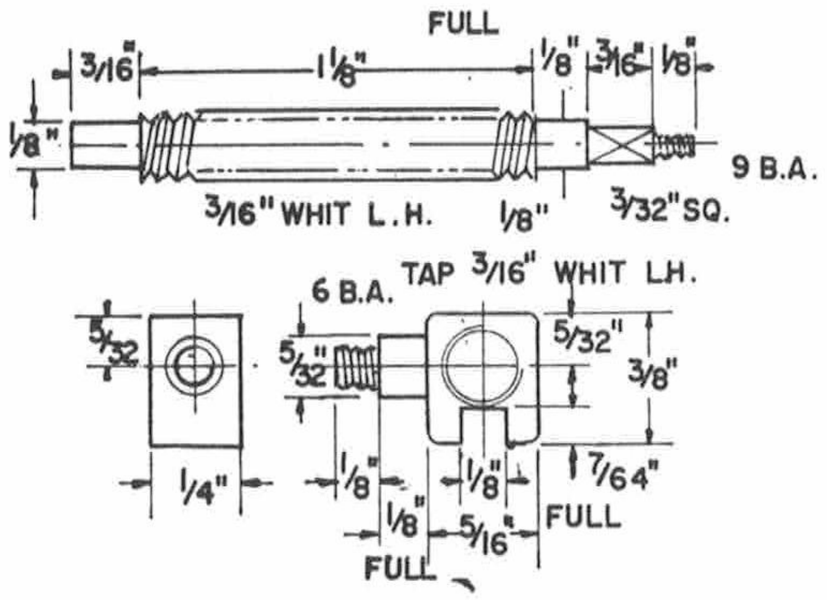
Wheel-and-screw reverser.

UNLIKE *Mona, Betty* is reversed by a wheel-and-screw gear, which allows of much finer notching-up on a continuous line. The stand may be a casting, or built up, using a piece of $\frac{1}{8}$ in. steel plate with the two bearing lugs turned from $\frac{3}{8}$ in. round bronze rod and silver-soldered on. A casting should be first cleaned up with a file, taking care to get the top edge between the bearings smooth and level. Drill the bearings with No. 30 drill. Open out the front one with 7/32 in. drill, tap $\frac{1}{4}$ in. x 40 and make a nipple to fit it as shown. Screw it right home and then put the No. 30 drill through both bearings to ensure that the holes are in line. Drill the screw-holes in the bottom as shown, and file a nick to clear the top of the drag beam when erecting.

The screw is turned from 3/16 in. steel rod held in three-jaw. Turn the first $\frac{1}{8}$ in. to 5/64 in. dia. and screw 9 B.A. File the next 3/16 in. length to a square, and turn the next $\frac{1}{8}$ in. to fit the hole in the bearing on the stand. Pull the rod another $1\frac{1}{4}$ in. out of the chuck, and screw it 3/16 in. Whitworth for a full $1\frac{1}{8}$ in. length. This should be a left-hand thread, but right-hand will do if left-hand taps and dies are not available. Part off at 3/16 in. from end of thread, reverse in chuck (don't grip tight enough to damage the thread), and turn the end to fit the other bearing, leaving the threaded part just long enough to fit between bearings without appreciable endplay.

The nut is made from $\frac{1}{4}$ in. x $\frac{3}{8}$ in. bronze rod. Chuck in four-jaw 1/32 in. off centre, turn $\frac{1}{8}$ in. to 7/64 in. dia. and screw 6 B.A., turn the next $\frac{1}{8}$ in. full to 5/32 in. dia. and part off at 5/16 in. from the shoulder. The hole for the screw is drilled and tapped level with the turned part at the side, and a groove is milled or filed to slide along the top of the stand. This should be an easy fit. To fit the screw, take out the nipple and put the nut between the bearings. Push the screw through the tapped bearing, squared end first, screw it through the nut, and push it through the plain bearing, finally screwing in the nipple over the turned end. The screw should turn freely when driving the nut up and down.

The wheel can be turned from a casting, or from a piece of $1\frac{1}{8}$ in. round rod, in which case the spokes

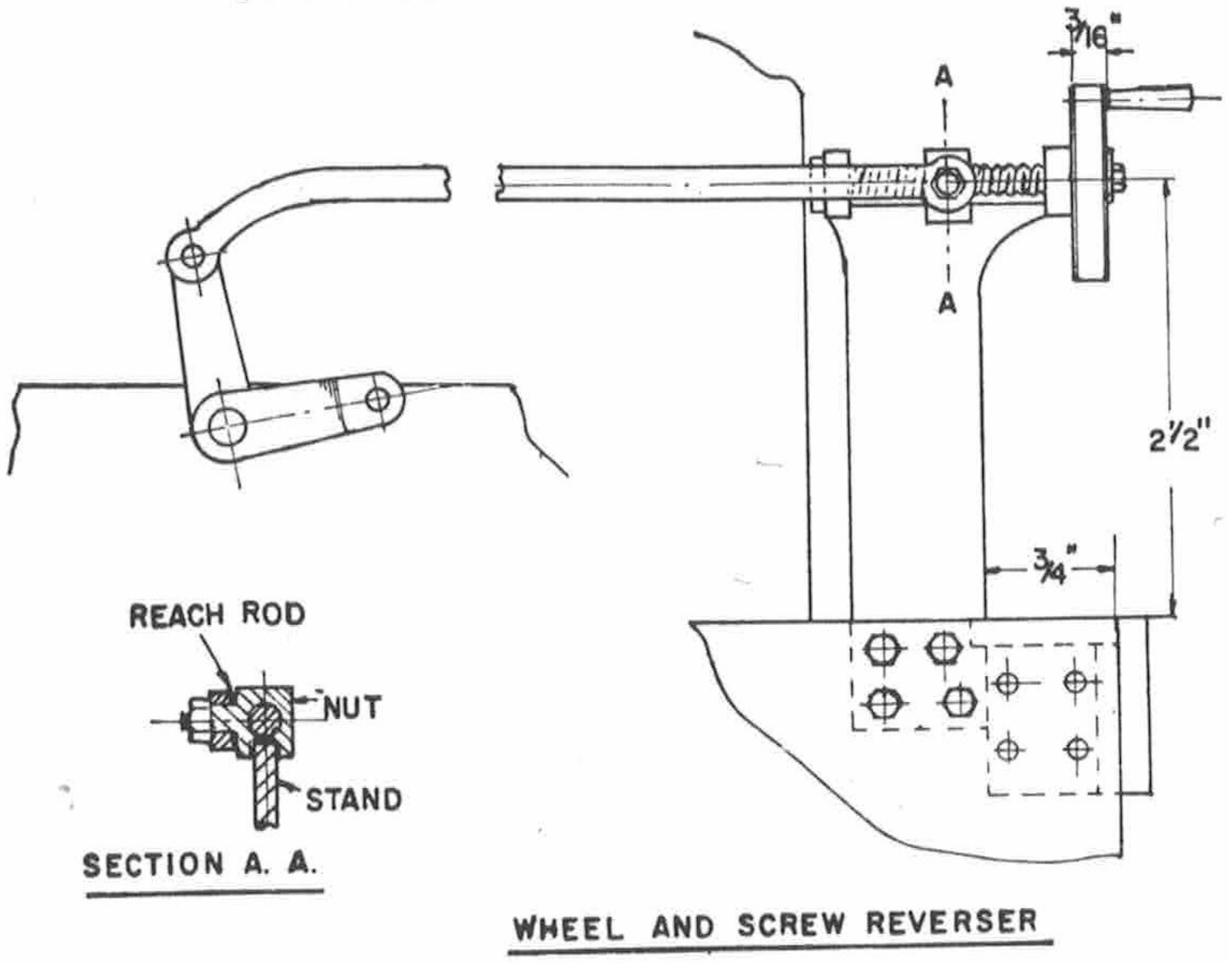


SCREW AND NUT

can be left out if so desired, the middle of the wheel being left as a solid disc. Drill a 3/32 in. hole in it before removing it from chuck, and drive a piece of hardened 3/32 in. square silver-steel through the hole. File the square on the screw to fit it tightly, and secure by a 9 B.A. nut as shown.

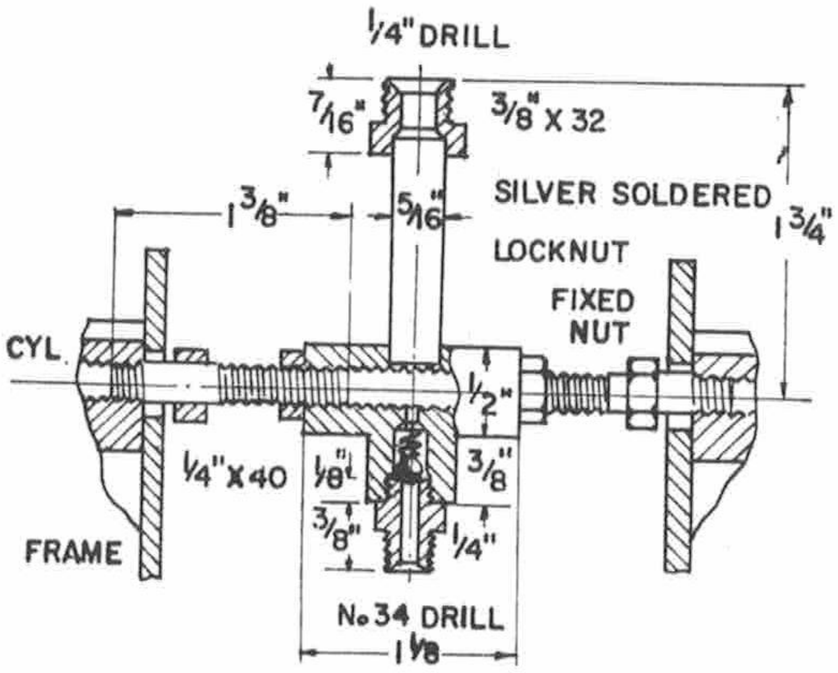
To erect, drill four No. 30 holes in the base at the spacing given, hold the stand in place outside the frame with a cramp, run the drill through the frame, using the holes in the stand as guide, shift the stand to the inside of the frame and secure it with four $\frac{1}{8}$ in. or 5 B.A. bolts.

The reach-rod is made from $\frac{1}{8}$ in. x 3/16 in. mild steel. A little block of 5/16 in. square steel is brazed on at one end and formed into a fork as described for forks in the valve gear. The eye section at the other end is filed up from $\frac{1}{8}$ in. x 5/16 in. steel, and half its thickness filed away for about $\frac{1}{4}$ in. length, the end of the reach-rod being filed to match after getting its exact length. To do this, set the nut on the screw halfway between the bearings. Put the valve-gear in mid-position, with the die-blocks in the middle of the links. Measure from the centre of the pin on the nut, to the centre of the hole in the reverse arm, which gives the exact length of the reach-rod between the pinholes in eye and fork ends *after bending*—don't forget that! Bend the fork end as shown, cut the rod to such length that when the eye section is fitted, the lot will be to exact length;

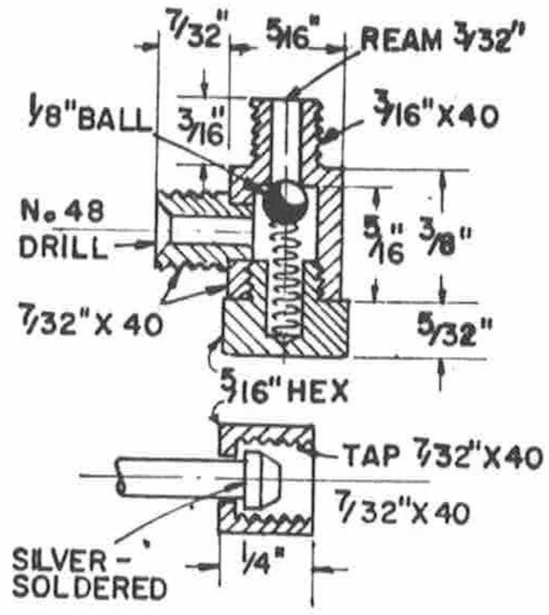


WHEEL AND SCREW REVERSER

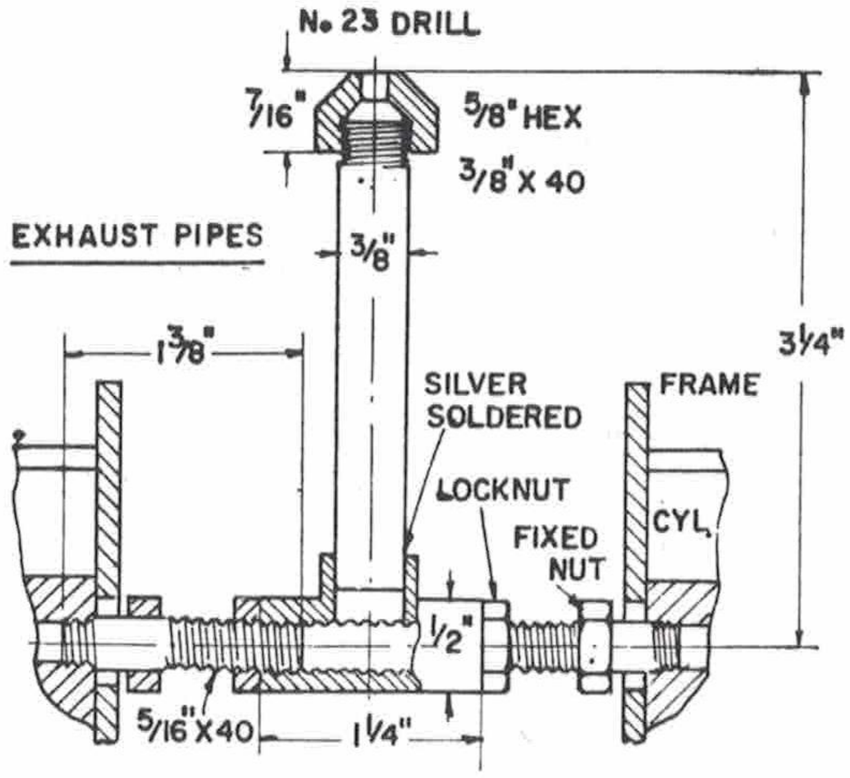
STAND



STEAM PIPES AND OIL CHECK VALVE



CHECK VALVE AND UNION



then fit the eye section and braze it. Trim the joint with a file, and clean up.

When the handwheel is turned, the gear should reverse quite easily in any position of the coupled wheels. With a left-hand screw, turning the wheel clockwise puts the gear in forward motion.

Steam and exhaust pipes.

The centre part of the steam pipe assembly is a ½ in. tee, which may be cast, or cut from a piece of ½ in. x ⅞ in. brass bar. It can also be made from ½ in. square brass rod if the oil check-valve body is turned up separately and silversoldered to the underside. Chuck the tee truly by one end in the four-jaw, face, centre, drill right through with 7/32 in. drill, and tap ¼ in. x 40. Reverse and face the other end to 1¼ in. overall length. Rechuck with the stem running truly, face, centre, drill 1/16 in. right into the tapped hole, open out to a full ⅜ in. depth with 7/32 in. drill and tap ¼ in. x 40.

Exactly opposite, on top of the tee, drill a 5/16 in. hole and in it fit a piece of 5/16 in. copper tube a bare 1⅜ in. long. Chuck a piece of ½ in. hexagon rod, face, centre deeply and drill ¼ in. for ½ in. depth. Turn 5/16 in. of the end to ⅜ in. dia. and screw ⅜ in. x 32. Part off at ⅛ in. from shoulder, reverse in chuck and open out the hole for a bare ⅛ in. depth with 5/16 in. drill. Fit this on the end of the copper tube and silver-solder both joints.

Pickle, wash and clean up, then chuck a piece of ⅜ in. hexagon rod, face, centre deeply, drill to 5/8 in. depth with No. 34 drill, turn ¼ in. length to ¼ in. dia. and screw ¼ in. x 40. Part off at ½ in. from the end, reverse in chuck, turn a full 1/8 in. to ¼ in. dia. and screw ¼ in. x 40. Put a 1/8 in. reamer through, skim the end true, seat a 5/32 in. ball on the hole, and assemble as shown, with a light spring in the pocket to prevent any tendency of the little ball to float in the thick cylinder oil.

Cut two 1⅜ in. lengths of ¼ in. copper tube about 20-gauge, put 3/16 in. of ¼ in. x 40 thread on one end, and ¾ in. on the other. Make two dummy nuts from ⅜ in. hexagon rod; chuck, centre, drill about ½ in. depth with ¼ in. drill, chamfer the corners and part off a 1/8 in. slice. Ditto repeato, then put them on the plain part of the screwed rods just clear of the long thread, and silversolder them. Make two ordinary tapped nuts from the same material, and screw these right to the end of the long threads, which are then inserted into the tapped ends of the tee, and screwed in until they meet in the middle.

To erect, anoint the threads with a smear of plumbers' jointing (Boss White, or any similar preparation used by the fraternity who are always supposed to leave their tool-bags behind when going to a fresh job) hold the assembly centrally between the frames, level with the holes in the steam chests, screw the pipes out of the tee, into the steam chest holes—now you see the idea of the dummy nuts—and when the two pipes are right home to the end of the 3/16 in. length of thread, set the 5/16 in. pipe ventically, run the locknuts back against the ends of the tee, and tighten them.

The exhaust pipe assembly is made up in similar fashion, but there is no oil check to bother about. If a casting is used for the tee, chuck it truly, face, centre, drill through with 9/32 in. drill, and tap 5/16 in. x 40. Use this thread, as a coarser one would weaken the pipe. Drill the stem ⅜ in. to take the blastpipe. In place of a cast tee, a piece of ½ in. square rod could be used, faced off to 1¼ in. length, with a ⅜ in. hole drilled in one of the facets for the blastpipe. This is a piece of ⅜ in. copper tube about 2¾ in. long, with a few ⅜ in. x 40 threads on one end, the other end being silversoldered into the tee.

The cross pipes are made in exactly the same way as those in the steam pipe assembly, except that they are 5/16 in. dia. They are furnished with fixed nuts and locknuts as described, and the whole bag of tricks is erected in exactly the same way. A nozzle will be needed for the blastpipe. Chuck a piece of ⅝ in. hexagon brass rod, face, centre, drill No. 23 for a full ½ in. depth, open out to 3/16 in. depth with 11/32 in. drill, and tap ⅜ in. x 40. Part off at 7/16 in. from the end, reverse in chuck and turn the other end to a blunt cone as shown. Fit this to the screwed end of the blastpipe. The blower ring will rest on the cone when the boiler is erected. Note that the hole in the cone doesn't represent the finished diameter of the blast exit. It will need slight enlargement with a taper broach when the engine has its trial runs on the road, to get the correct amount of draught on the fire with the minimum of back-pressure.

Mention of plumbers above, reminds me of a funny incident on my little railway soon after it was opened for traffic. I had a friend who was a plumber, and he brought a 3½ in. gauge locomotive that he was just completing, for a run on my line. The trial was a failure—*he couldn't get any water into the boiler!* I should have imagined that that was about the last thing that could have happened to an engine built by a plumber, above all people.

Mechanical lubricator.

The lubricator is one of my standard type, very similar to that described for *Mona*. The tank is made from a piece of 18 or 20-gauge brass or steel sheet 1¼ in. wide and 5 in. long. Bend this into a 1¼ in. rectangle, stand it on a piece of the same kind of material but a little thicker, 16-gauge, and about 1⅜ in. square. If brass, silversolder all around the bottom, and the corner joint. If steel, braze it. Steel does quite well for oil containers, as they don't get much chance to go rusty. Drill a 3/16 in. hole in the bottom plate, and another on the centre-line of one of the sides, 3/16 in. from the top. File the bottom flush with the sides.

The lid can be flanged over a 1¼ in. square former in the same way as a boiler plate, but an easier way is to cut out a piece of 20-gauge sheet metal 1¾ in. square, snip a ¼ in. piece out of each corner, and bend the remains into a tray, making it of such a size that it is a tight push fit on the tank. Then silversolder or braze the corners, taking care to avoid putting too much brazing material on, otherwise you'll get a fillet in each corner, and the lid won't fit at all.

The pump stand is made from a piece of 5/16 in. square brass rod, faced off at each end to a length of 1¼ in., which can be done in the four-jaw. Centre one end and drill to 3/16 in. depth with 5/32 in. drill, tapping 3/16 in. x 40. The 1/16 in. rebate at the top of the stand, and the recess farther down, can be milled or hand-filed. I usually do mine six at a time on the milling-machine, with the lot clamped together in the machine-vice; it saves much time, and when making a lubricator I have the bits handy. Take the greatest possible care to drill the tapping hole (5/32 in. drill) and the hole for the trunnion pin (No. 41 drill) dead square with the face of the stand. If you haven't a drilling-machine, use the lathe, with the drill in the three-jaw and the work held against a drilling-pad on the tailstock barrel. Tap the upper hole 3/16 in. x 40 for the bearing, and counterbore the trunnion-pin hole on the back of the stand to ⅛ in. depth with a ¼ in. pin-drill.

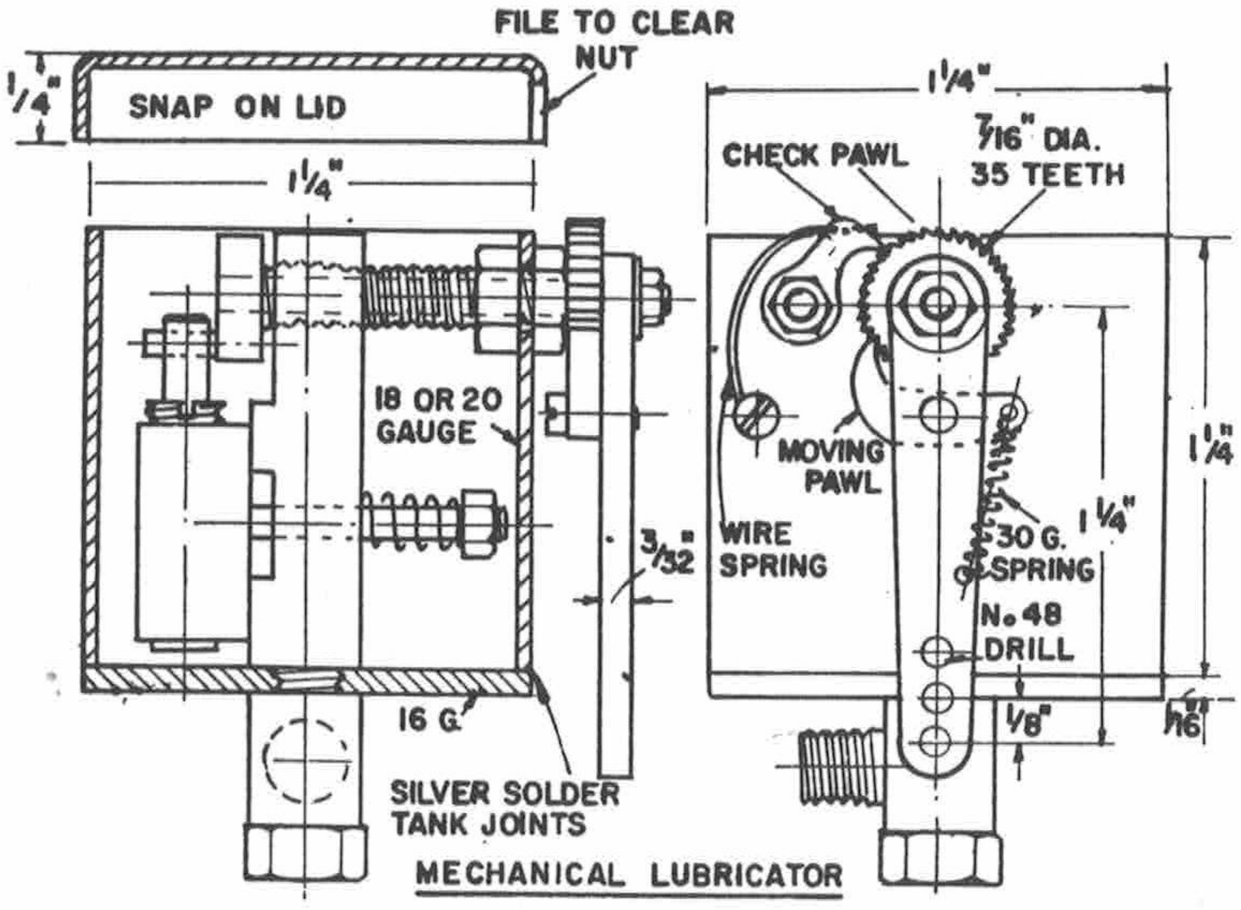
The ports should be marked out from the centre-pop mark for the trunnion pin hole before drilling it, using a pair of dividers with the points set ¼ in. apart to scribe the arc. Take extra care when marking the ports, to have them set at 1/16 in. each side of the centre-line. Use a sharp centre-punch, and make the pops fairly deep. Watch your step when drilling the right-hand one as the drill breaks into the tapped hole, otherwise the point will go west, and wee drills cost muckle bawbees the noo, ye ken. The left-hand port is only drilled 1/16 in. deep, then a groove is cut from it to the bottom of the stand, which can be done with a small chisel home-made from a bit of 3/32 in. silver-steel. Get a true surface on the faces by rubbing the stand on a piece of fine emerycloth laid on the lathe bed, same as for slide-valves and other surfaces which must be dead flat.

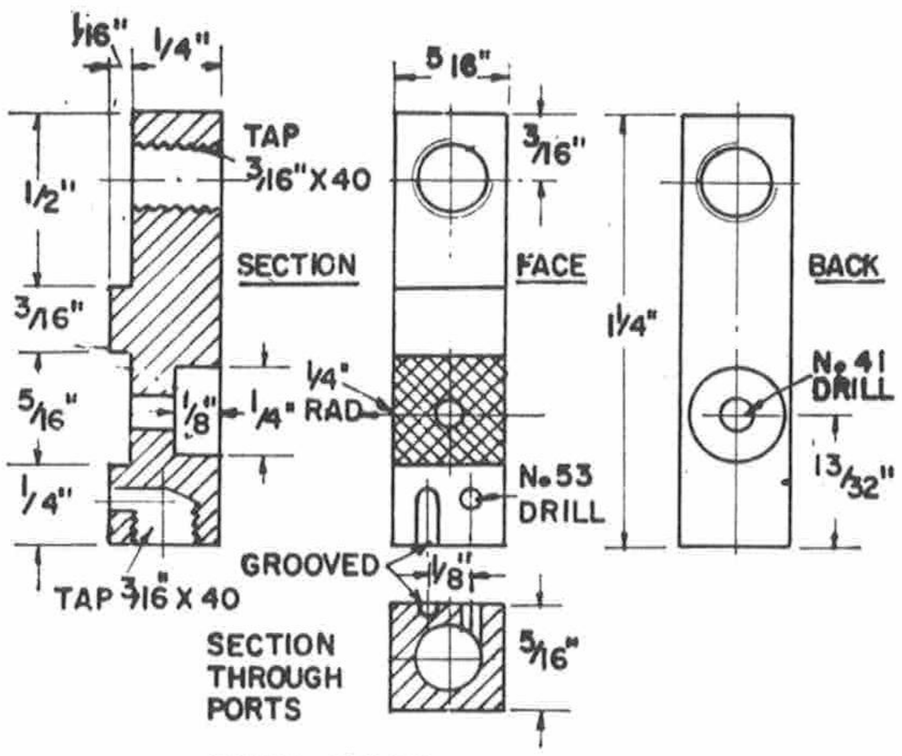
The pump cylinder is made from similar material, a piece faced off to ⅝ in. length being needed. Make a centrepop ⅛ in. from one of the facets, and chuck in four-jaw with this running truly. Drill right through with No. 34 drill, open out to 5/32 in. depth with 3/16 in. drill, tap 7/32 in. x 40 and put a ⅛ in. reamer through the rest of the hole. Turn up a little drive-fit plug for the bottom as shown, and make a headless gland from brass rod, like the steam-chest glands, but to the sizes shown.

Take the same strict caution as before, to get the hole for the trunnion pin dead square with the face. Drill No. 48 and tap 3/32 in. or 7 BA. Drill the port, then true up the sliding face as above, before screwing the trunnion pin home. This is made from 3/32 in. silver-steel to the size shown. The ram is a ⅞ in. length of ⅛ in. rustless steel, with a No. 48 cross-hole drilled at one end. Pack the gland with graphited yarn. The spring is wound from 22-gauge tinned steel wire (bit of a piano-string would do) around a bit of 3/32 in. steel rod, and secured by a commercial nut.

The crankshaft is made from a piece of 3/32 in. silver-steel to size given, the crank being a ⅛ in. slice of ⅜ in. brass rod with a bit of 15-gauge spoke wire screwed into it for a crankpin as shown. When screwing these items, never do them with the die in a hand stock; always hold the rod or wire in the three-jaw, and the die in a tailstock holder, and pull the lathe belt by hand while feeding the die on to the rod. It's the only way to get true threads.

For the bearing, chuck a piece of 5/16 in. hexagon rod, face, centre, drill to 1 in. depth with No. 41 drill, turn ¾ in. length to 3/16 in. dia. and screw 3/16 in. x 40. Part off at a full 3/32 in. from shoulder,





reverse in chuck, skim true and chamfer the corners of the hexagon. Make a locknut from the same size rod.

To make the check valve, chuck a piece of 5/16 in. round brass rod, face, centre, drill No. 44 for about ⅝ in. depth, open out and bottom to 5/16 in. depth with 3/16 in. drill and D-bit, and tap the end 7/32 in. x 40. Part off at 9/16 in. from the end, reverse in chuck, turn 3/16 in. length to 3/16 in. dia. and screw 3/16 in. x 40. Poke a 3/32 in. reamer through the hole. Drill a No. 24 hole in the side and silversolder a 7/32 in. x 40 union nipple into it as shown.

To make the cap, chuck the 5/16 in. hexagon rod again, face, centre, drill No. 30 for 3/16 in. depth, turn ⅛ in. of the outside to 7/32 in. dia. and screw 7/32 in. x 40. Part off at 5/32 in. from shoulder, reverse and chamfer the corners. Seat a ⅛ in. ball in the recess, and assemble as shown, with a spring like that holding the ball in the steam tee.

To assemble the lubricator, put the stand with cylinder attached, in the tank over the hole in the base and screw the check valve into it, leaving it slack. Put the bearing through the hole in the side, put on the locknut, then screw the bearing into the stand until the head touches the side of the tank. Next, tighten up the check valve (the nipple should point to the back, as shown in the assembly drawing, when the valve is tight) adjust the bearing so that its head is touching the side of the tank, then run up the locknut to the inside of the tank and tighten it.

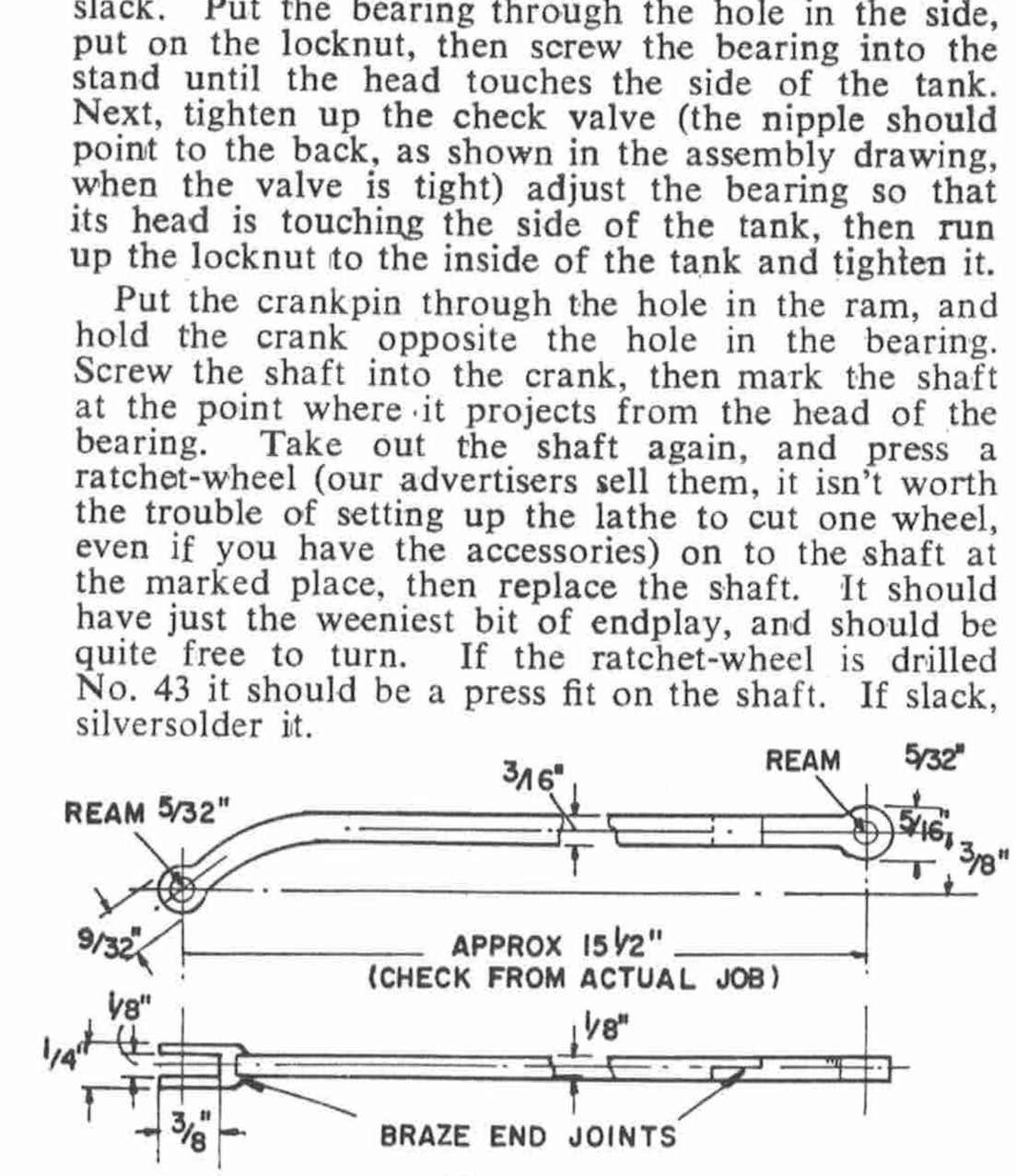
Put the crankpin through the hole in the ram, and hold the crank opposite the hole in the bearing. Screw the shaft into the crank, then mark the shaft at the point where it projects from the head of the bearing. Take out the shaft again, and press a ratchet-wheel (our advertisers sell them, it isn't worth the trouble of setting up the lathe to cut one wheel, even if you have the accessories) on to the shaft at the marked place, then replace the shaft. It should have just the weeniest bit of endplay, and should be quite free to turn. If the ratchet-wheel is drilled No. 43 it should be a press fit on the shaft. If slack, silversolder it.

The ratchet lever is filed up from ¼ in. x 3/32 in. mild steel, and the pawls can be filed from the same kind of material if they are casehardened as described for other parts. The assembly is shown in the illustrations, and needs no detailing. All parts must work perfectly free.

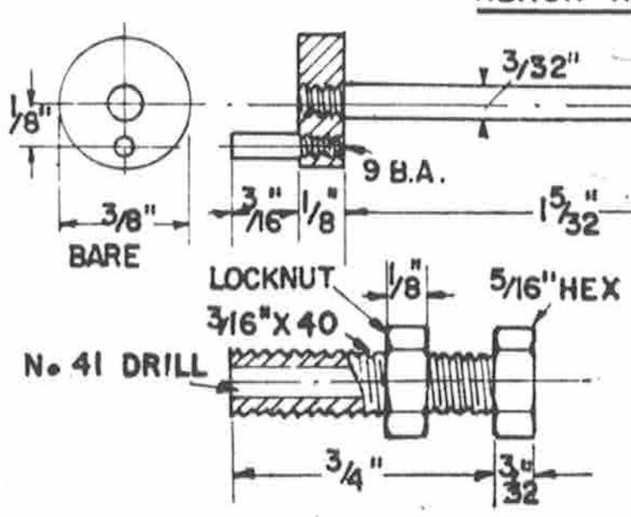
To test, put some oil in the tank—motor oil will do—and work the ratchet lever until oil comes out of the union underneath. Put your thumb over the union and squeeze for all you are worth, then work the ratchet lever again. If the oil pump is O.K. it will force oil past your thumb; if it doesn't, either the port in the cylinder is bridging those in the stand, or else the faces aren't true and are allowing oil to escape between them. Remedies obvious!

The tank is attached to the top of the buffer beam by a 1 in. length of ⅛ in. x ⅜ in. angle. This is attached to the front of the lubricator at ½ in. from the top, by two 3/32 in. screws, nutted inside the tank. The angle can be soldered to the tank as well, as an extra precaution against coming adrift. Drill two No. 30 holes at ¼ in. from the edge of the top of the beam, at 5/16 in. each side of centre, and countersink them. Hold the lubricator in place as shown, run the No. 30 drill through the holes in the beam, making countersinks on the angle; remove, drill the countersinks No. 40, tap ⅛ in. or 5 BA and attach with countersunk screws as shown.

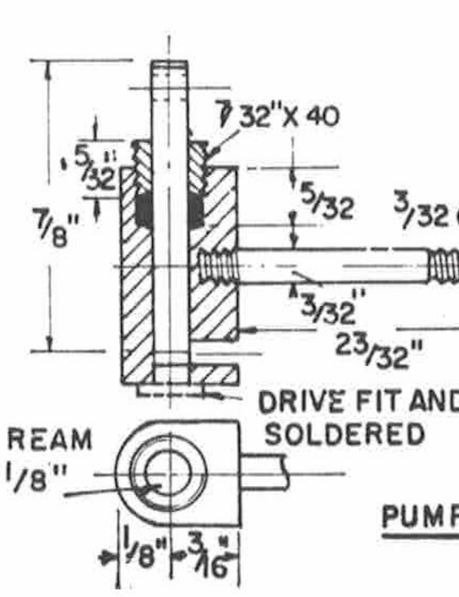
The ratchet lever is driven from the eccentric on the leading coupled axle by a ⅛ in. silver-steel rod with a fork at the end. The fork is made exactly like those in the valve gear, but from 7/32 in. or ¼ in. square rod, and the jaws drilled No. 48 for a pin

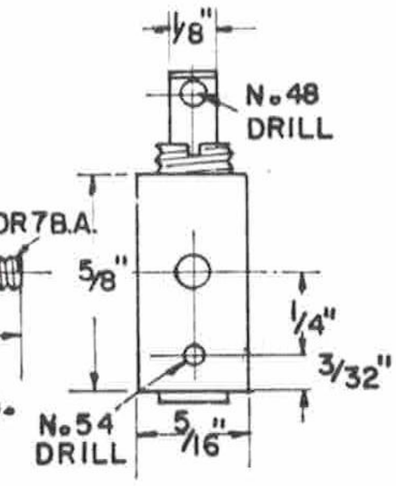


REACH ROD

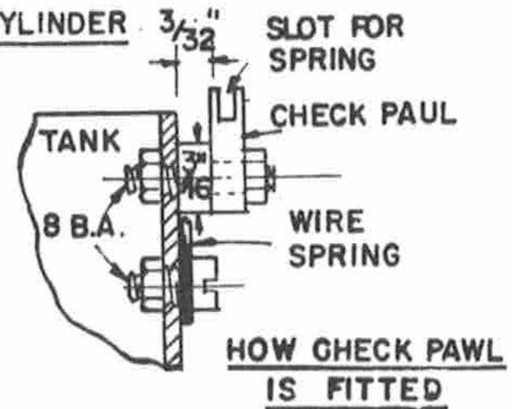


CRANKSHAFT AND BEARING



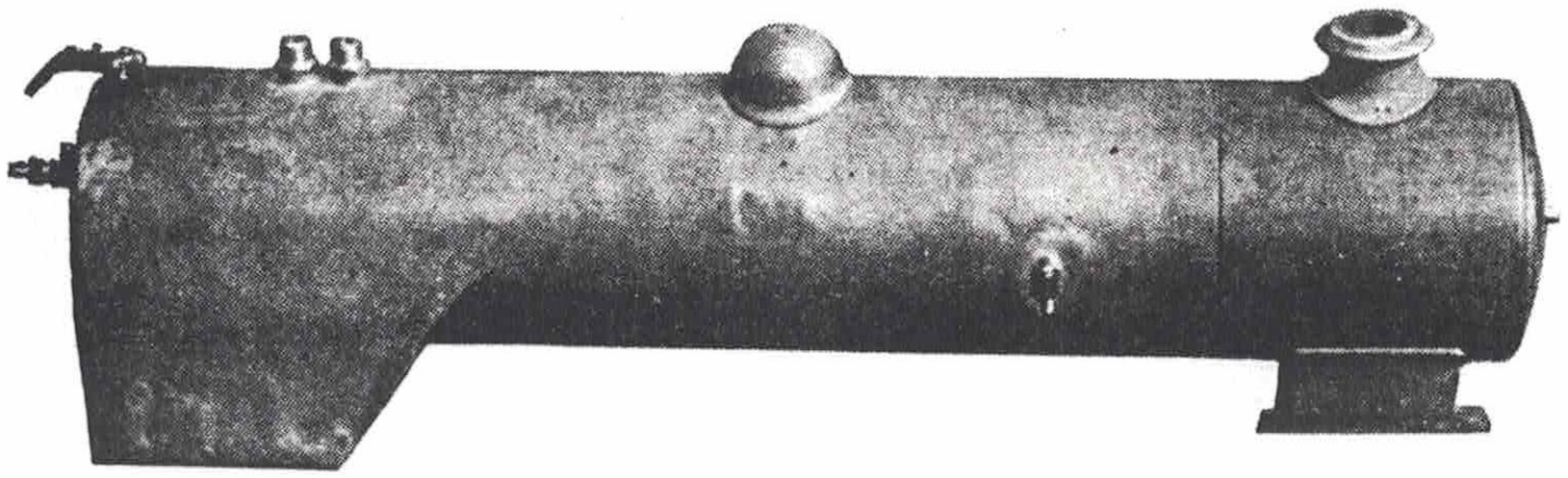


PUMP CYLINDER



HOW CHECK PAWL IS FITTED

LUBRICATOR AND PIPES ERECTED



made from 15-gauge spoke wire, screwed 9 BA at each end and nutted. The fork is screwed on to the driving rod. Machine up an eccentric strap exactly as described for the boiler feed-pump, but tap the boss $\frac{1}{8}$ in. or 5 BA and screw the drive-rod into it. Adjust the length of rod so that when the eccentric is on top centre as shown, the ratchet lever hangs exactly vertical. When the wheels are turned, the lever should ratchet one tooth, with a little overlap, so that the pawls don't stand any risk of jumping the teeth when the engine is running at a high speed.

Finally, connect the union on the check valve under the lubricator, to the union under the steam tee, by a $\frac{1}{8}$ in. pipe with union nuts and cones at each end, made as shown in the detail drawing of the check valve, which needs no explaining. The cones are silversoldered direct to the pipe, which dispenses with big ugly union linings and makes the pipework look neat. That about completes the working parts, and the next job will be the boiler.

Boiler.

ALTHOUGH the boiler for *Betty* differs in many respects from that specified for *Mona,* the actual work involved, such as plate flanging, riveting, brazing and silver soldering, tube fitting and so on, is all carried out in the same way, so I need not waste space by going through all the detailed rigmarole again. The principal difference between the two boilers is that *Betty's* has a wide firebox and a combustion chamber. This kills two birds with one shot. The most valuable part of the heating surface of any locomotive boiler is that provided by the firebox; long tubes are inefficient, as that part of them at the smokebox end doesn't contribute much to the task of keeping the pot boiling. A combustion chamber not only increased the firebox volume, but enables shorter tubes to be used.

Boiler shell.

The boiler barrel and firebox wrapper sheet can be made from a piece of 13-gauge (3/32 in.) seamless copper tube $4\frac{3}{8}$ in. outside diameter. Square off both ends to an overall length of $17\frac{1}{2}$ in. At 4 in. from one end make a transverse cut with a fine-tooth hacksaw at the angle shown, to a little over halfway through the tube. Make a longitudinal cut to meet this, then heat the sawn part to red, and plunge into clean cold water. It will then be possible to bend the sawn sections outwards to form the shape shown in the cross section.

File off any raggedness, and clean the edges. Cut a piece of $\frac{1}{8}$ in. sheet copper to form the throatplate; this fills in the space between the bottom of the barrel and the opened-out sides of the shell. Allow about 5/16 in. at each side for riveting, bend at right angles to form flanges, fit in place and put four 3/32 in. copper rivets through flanges and shell, to hold the throatplate in place while brazing up. This job is easier than brazing *Mona's* throatplate, as there are only the two sides and the bit under the barrel to do. It is done in the same way. Stand the shell in the brazing pan with the barrel pointing to the stars, pile up coke or breeze almost to the level of the joint, inside and out, flux well, then start at one bottom corner, work up to the barrel, go along between barrel and throatplate to the other side, then work down to the bottom again. Pickle, wash and clean up.

The firebox and combustion chamber are made from a piece of 13 or 14 gauge sheet copper measuring 8 in. x 11 in. At $4\frac{1}{8}$ in. from one end of each shorter side, make a snip $3\frac{5}{8}$ in. long. First bend the whole lot to the shape of the firebox as shown in the cross-section; then continue bending the $4\frac{1}{8}$ in. section until the ends overlap, and that part is the shape of the combustion chamber shown. Cut off any surplus so that the overlap isn't more than 5/16 in. and put a few rivets in to keep the edges in close contact. Fit a throatplate of 13-gauge sheet copper, same as the shell, but at right-angles to the combustion chamber, bending the bottom to match the shell throatplate as shown in the section.

Next make the formers for the tubeplate and doorplate to the sizes shown, drilling the tube location holes in the smaller one. Flange up the plates as per the *Mona* instructions, and drill and ream the tube holes. The oval tubeplate should fit on the end of the combustion-chamber like the lid of a coffee-tin; the soft copper can easily be coaxed to fit by judicious use of a hammer. Now turn the firehole ring from a piece of $1\frac{1}{2}$ in. x $\frac{1}{8}$ in. copper tube, and squeezed to an oval shape. Lay it on the doorplate at the position shown, scribe a line around the flange, cut out the piece, fit the ring and beat down the lip. The doorplate can then be fitted to the end of the firebox and secured with a few rivets.

The crown stays are made from sheet copper and fitted as shown in the drawings, care being taken to see that they make contact with the top of the firebox for their full length. They only extend to the end of the firebox, as the water-tube struts effectively stay the top of the combustion chamber. On top of this, drill six holes about 3/16 in. dia. and six more at the bottom, at the spacing shown. Open them all to 31/64 in. dia. with a drill, then put a $\frac{1}{2}$ in. parellel reamer through each pair, top and bottom. The water-tubes can then be fitted. Note—leave these extra long for a kick-off, projecting about $\frac{1}{8}$ in. beyond the chamber; they can be filed off almost flush after the brazing job is finished.

Cover all the joints with wet flux; tube ends, flange joints, and around the firehole ring. Stand the assembly in the brazing-pan with the doorplate upwards, the tubeplate resting on the coke. First do the tubeplate joint, letting the melted brazing material form a fillet all around the flange. There is no risk of melting the metal between tube holes

on this job, as they are out of the "line of fire." Next do the doorplate flanges and firehole ring, after which the assembly can be placed upside down and the lower ends of the water-tubes and the throatplate attended to. Finally, stand the lot right way up, do the crownstay flanges and the upper ends of the water-tubes. Inexperienced coppersmiths should use coarse-grade silver-solder for the crownstay flanges, and both ends of the water-tubes. It flows easier than brazing-strip, and doesn't need so much heat. After pickling, washing off and cleaning up, file the ends of the water-tubes almost flush with the combustion chamber.

Smokebox tubeplate and tubes.

A circular former 4 in. dia. is required for flanging the smokebox tubeplate, which is made from $\frac{1}{8}$ in. copper in the same way as that for *Mona*. Locate the tube holes by aid of the former used for the combustion chamber tubeplate, and drill and ream as shown; also drill and tap holes for longitudinal stays and steam flange. Turn off any raggedness left by the flanging process, then turn the flange to a tight push fit in the boiler barrel, holding it by the inside of the flange on the outside of the top steps of the outside chuck jaws. Countersink the tube holes both sides.

Cut the tubes and flues to lengths shown, and square off the ends; clean the ends well before inserting into the tubeplate. First put in the upper and middle rows of $\frac{3}{8}$ in. tubes, putting the smokebox tubeplate on the outer ends to support them, and line them up with the sides and top of the combustion chamber. About 1/32 in. should project through the tubeplate. Stand the assembly, tubes upwards, in the brazing pan, put plenty of wet flux around the tubes, heat the lot to dull red, keeping the flame off the tubes as much as possible until the tubeplate is heated, then apply a strip of best-grade silver-solder or Easyflo. Feed in enough to form a good fillet around each tube. Let the job cool to black, then quench out in the pickle, letting it soak for two or three minutes. Wash off, and if the remainder of the tube holes should appear dirty, clean them before inserting the bottom row of tubes and the superheater flues. The silver-soldering process can then be repeated, this time allowing the job to remain in the pickle about 20 minutes to get it thoroughly clean before washing off.

First stage of assembly.

With the shell upside down on the bench, slide the firebox and tube assembly into it until the inner and outer throatplates meet, as shown in the section. The crownstays should be resting on the wrapper. All joints should be cleaned. Put a toolmaker's cramp over the throatplate joint, making sure that the firebox is central in the shell, and another to hold the wrapper and crownstay flanges in contact. The joints can then be riveted up, and the cramps removed. Insert the smokebox tubeplate, flange first, and tap it down until it is almost touching the tube ends. Line up each tube with its respective hole, with a wooden skewer or a pencil, then drive the tubeplate further in until the tubes project through about 1/32 in. and the edge of the tubeplate is the same distance from the end of the barrel for its full circumference.

For the brazing job, get any old tray or lid and cut a hole in the middle big enough to slip over the barrel. Stand the boiler on end, put the tray over the barrel about 3 in. down, and prop it up with a brick, or something else that won't burn, at each side. Pile coke or breeze around the end of the barrel, and plug the tube ends with wads of asbestos string or flock. Cover the joints with flux, heat until the coke glows red, go around the edge of the tubeplate with easy-running strip or coarse-grade silver-solder, and do the tube ends with best-grade or Easyflo.

Transfer the boiler to the brazing pan as quickly as possible, and lay it on its back with the firebox overhanging the edge. Put a weight of some sort on the barrel to prevent it from tipping up. Put more flux along the crownstay flanges, heat them and the adjacent part of the wrapper to red by playing the flame both inside and out, and apply a strip of best grade silver-solder or Easyflo. When it melts and runs, blow the flame on the outside of the wrapper directly opposite the crownstay flanges, to sweat the silver-solder right through. Let it cool to black, and when dumping the boiler in the pickle this time, use the garden rake or something else with a long handle, standing well clear of the splashes. Leave it in the usual time before washing and cleaning.

Backhead and foundation ring.

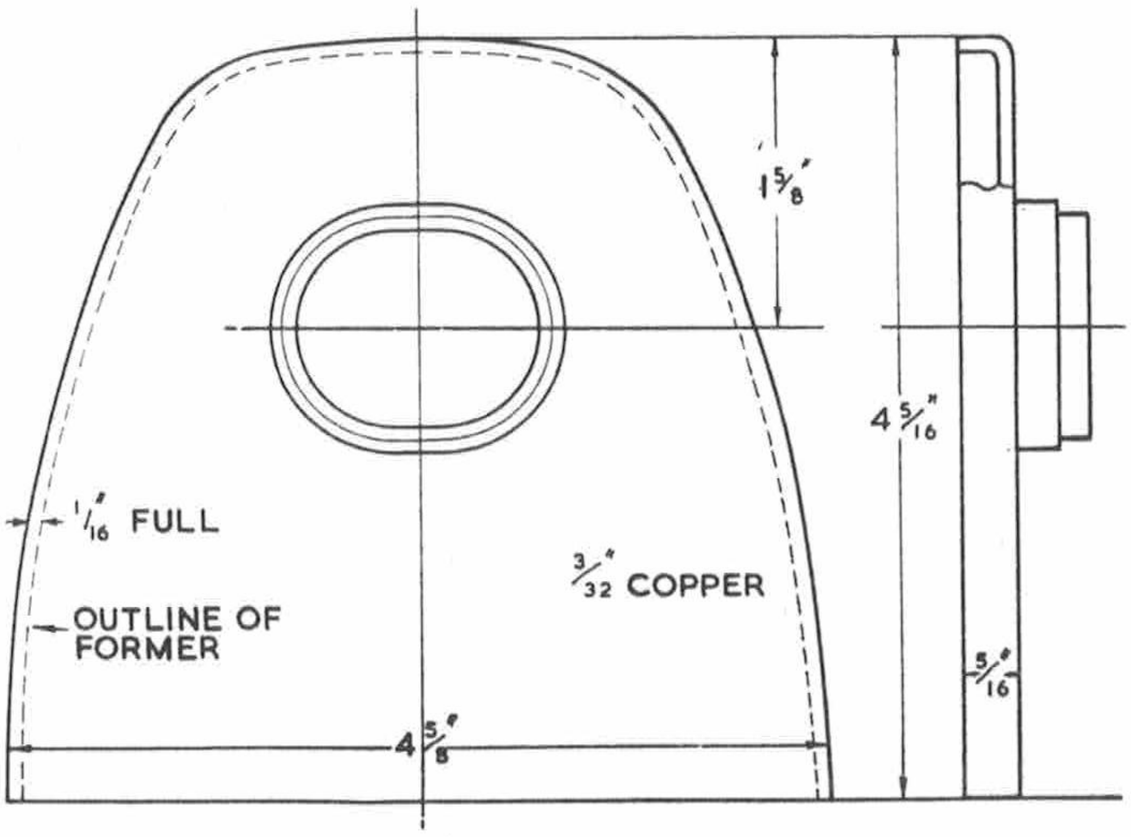
Cut out an iron former to the size given, and flange the backhead over it from $\frac{1}{8}$ in. sheet copper, cleaning the flanges well. Take the measurements from the top and sides of the wrapper to the firehole ring, and transfer them to the backhead, cutting the hole as shown, also drill and tap the stay and regulator holes. The holes at the bottom are for washout plugs. Clean the edges of the wrapper, insert backhead, with the lip of the firehole ring through the oval hole, and beat down the lip into close contact with the backhead. The wrapper should be in close contact with the backhead flange all the way around. If it isn't, hold it tightly with a big cramp, or whatever is available, drill a few No. 48 holes through wrapper and flange, tap them 3/32 in. and screw in a few stubs of 3/32 in. copper wire threaded to suit.

The spaces between the firebox sides and wrapper are filled in with pieces of $\frac{1}{4}$ in. square copper rod cut to fit, and riveted in with a few 3/32 in. copper rivets. If you haven't any long enough, use bits of 3/32 in. copper wire, hammering them over at each end. About four at each side will be plenty. Cut the bush holes in the top of the boiler as shown, and fit the bushes, which should preferably be of copper, but bronze or gunmetal will do. Don't use brass. Note—in addition to those shown, fit a $\frac{1}{4}$ in. x 40 bush made from $\frac{1}{8}$ in. rod, at each side of the barrel, on the centre line, and 2 in. from the front end. These are for the feed clacks, and are shown on the general arrangement drawing.

Final brazing job.

Use coarse-grade silver-solder for this, unless you can use an oxy-acetylene blowpipe, in which case the joints can be bronze-welded. I did mine with an Alda blowpipe and Sifbronze. Cover the joints with wet flux, lay the boiler on its back in the coke, and pile some up to the level of the foundation ring. Put some asbestos cubes or pieces of asbestos millboard inside the box, to prevent the flame blowing into the combustion chamber and cracking the water-tube joints. First heat the lot evenly, then start at one corner of the foundation ring, and work right around, taking in the joint between inner and outer throatplates on the way. Be sure to cover all rivet heads.

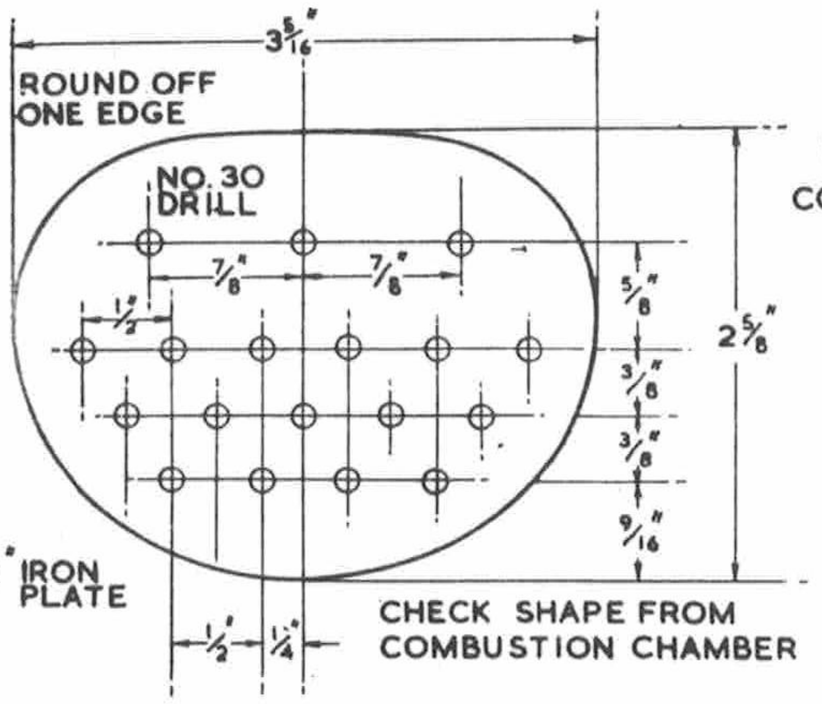
Up-end the boiler, which will be hot enough to do the backhead flange without any coke packing, start at one bottom corner and work right around. To do the firehole ring flange, play the flame straight on to it, and see that the silver-solder flows freely. When quite sure that no places have been missed, let the boiler cool to black. This time take extra care when lowering it into the pickle, as it is not only very heavy, but when the pickle runs inside and meets the hot metal, it usually blows out again with great alacrity, and there is terrible commotion for a few seconds! However, it soon behaves itself, and should be left in it for about an half an hour before it is fished out, drained, well washed inside and out, and rubbed up with steel wool or scouring powder. It can be tested for "pinholes" (which are caused by borax blisters formed by particles of flux) by plugging the holes and bushes, and pumping about 20 lb. of air into it by the aid of a tyre-pump and adaptor. If it is then baptised in the family bath, or any other receptacle big enough to hold it, a stream of bubbles will indicate the presence of any pinhole. This can be permanently stopped by



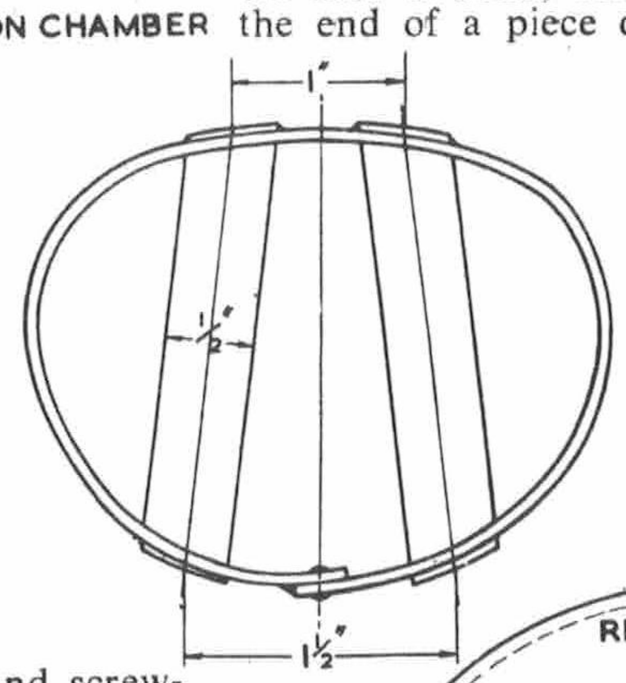
FIREBOX DOORPLATE

nut is put on the projection and well tightened up, but take care to avoid stripping the thread, which is easily done in soft copper. Snip off the stay about 1/16 in. from the plate, and hammer the projecting bit into a head, resting the nut inside the box on the end of a piece of stout iron bar gripped in the bench vice, horizontally. To prevent the bar from slipping down while heading the stays, take out one of the steel insets from the vice jaws, and rest the bar on the ledge.

Tip—drill the holes at such an angle that the stays will be square with the inside of the firebox when



FORMING PLATE AND TUBE HOLE JIG FOR COMBUSTION CHAMBER

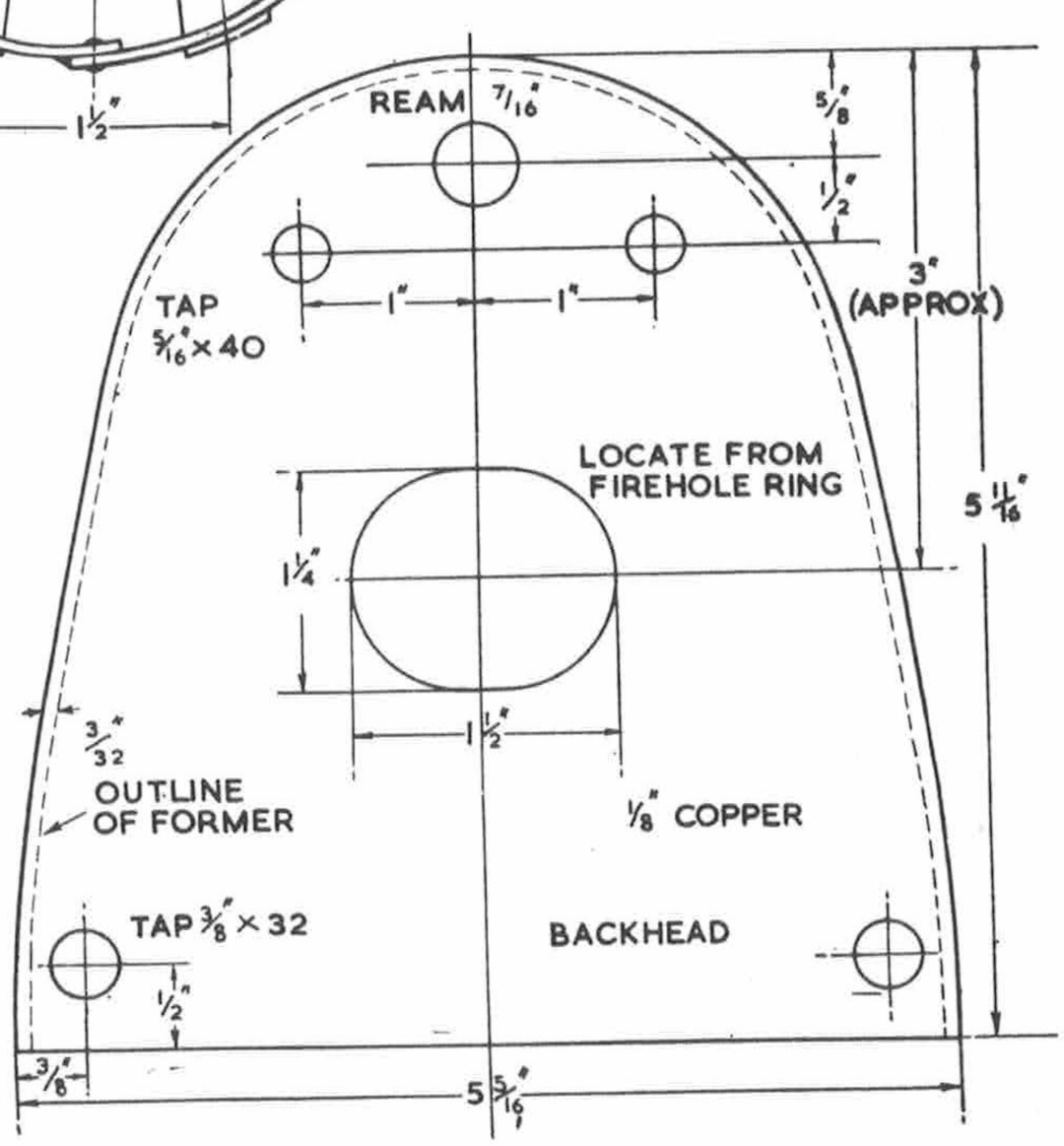


drilling a No. 55 hole, tapping it 10 B.A. and screwing in a stub of copper wire, smeared with plumbers' jointing.

Staying.

Two longitudinal stays are required, one of 3/16 in. copper or bronze rod, and one of 3/16 in. x 18-gauge copper tube, which carries steam for the blower from backhead to smokebox. Both are 17 5/8 in. long, the rod stay being screwed 3/16 in. x 40 at both ends, and the tube at one end only. The other end of the tube is silver-soldered into the blower valve, which is made exactly as described for *Mona*. Both ends of the rod stay are fixed by blind nipples as shown in the section, and a thoroughfare nipple is used on the end of the hollow stay, also the same as *Mona*.

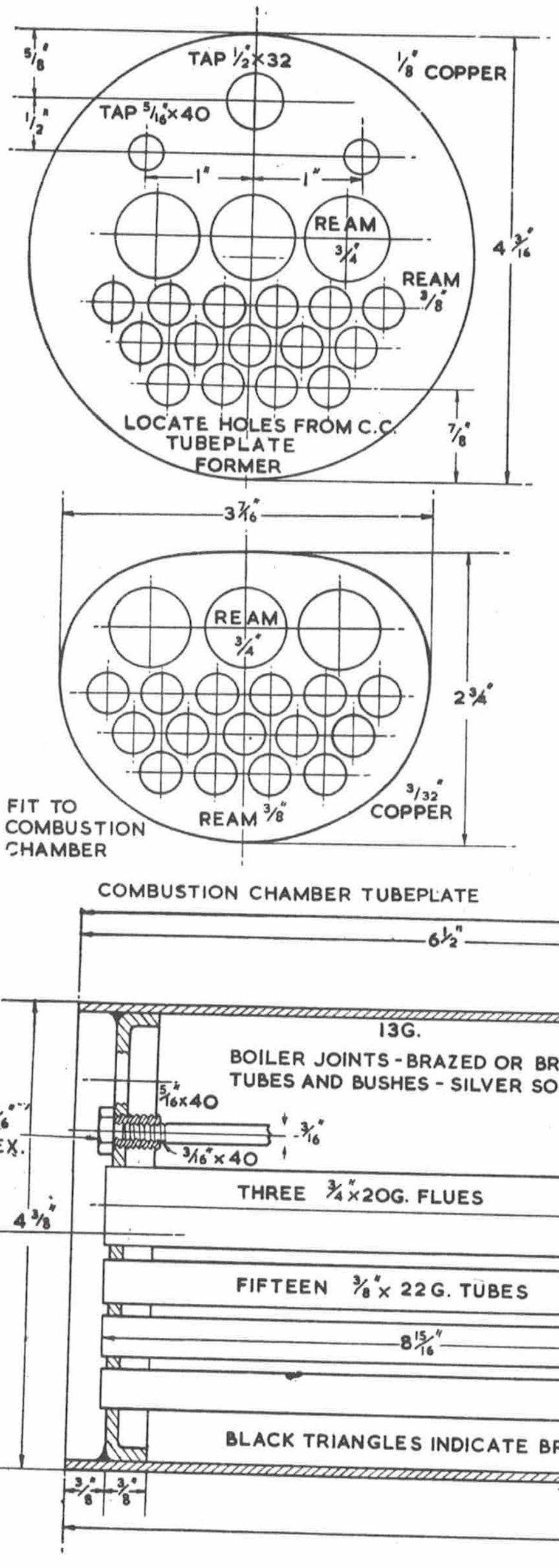
Thirty 1/8 in. or 5 B.A. copper stays are needed in each side of the firebox, and nine ditto in the backhead and throatplate, as shown in the drawings. Drill the holes with No. 40 drill, and use a pilot tap with a 3/32 in. pin for tapping the holes, so that the thread is continuous in both plates, and dead in line. The length of the stays will vary according to their position in the firebox, and they should be screwed so that when right home against the outside wrapper, about 1/8 in. of thread projects inside the box; a lock-

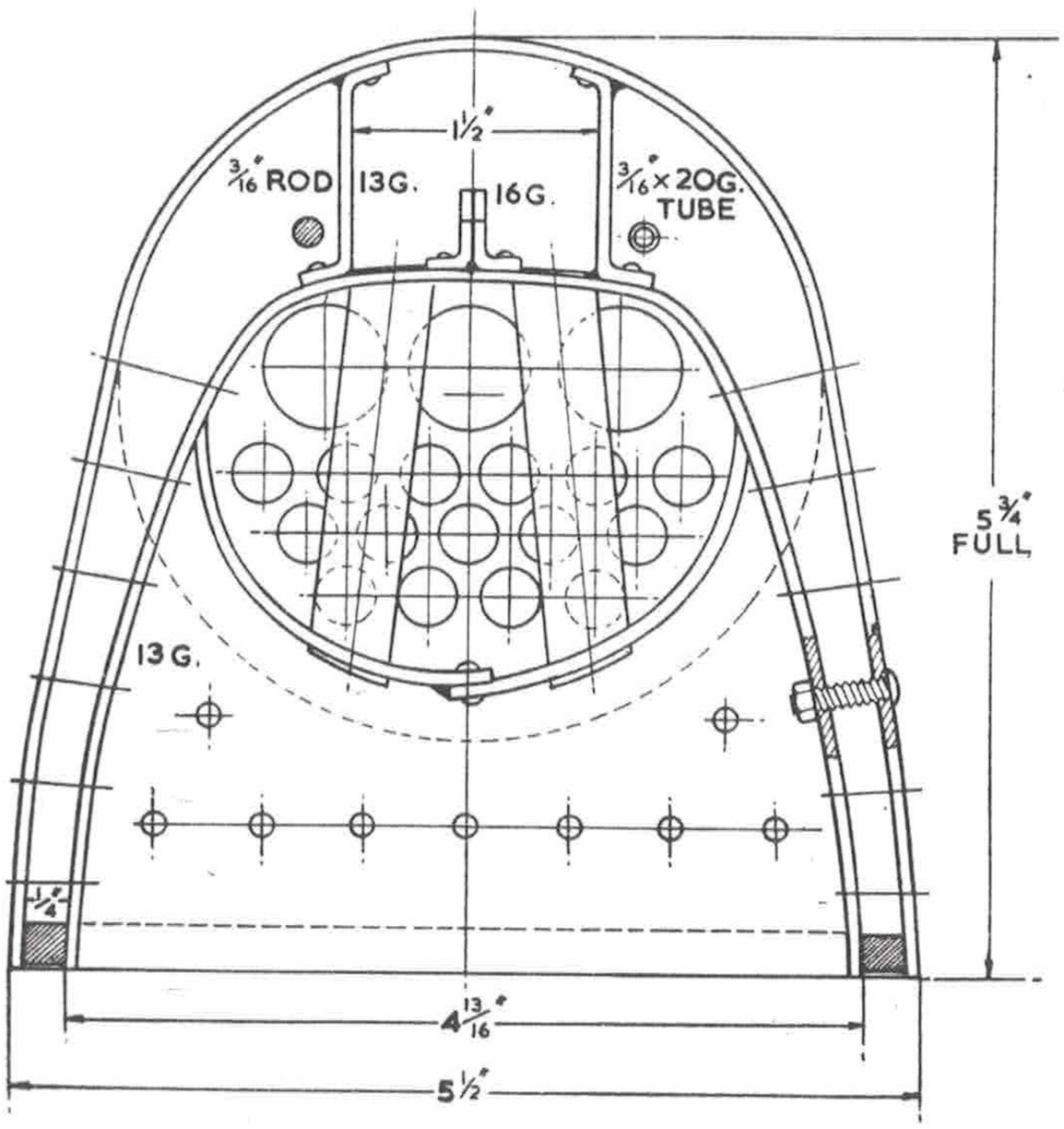


fitted, and the nuts will seat home against the firebox plate. If the stays emerge at an angle, they will break off when any attempt is made to tighten the nuts against the plate. The stays in the throatplate should be put in parallel with the boiler barrel. Beginners will probably wonder how the merry dickens they are going to drill and tap the holes, as both drill-chuck and tapwrench would foul the barrel. Simple when you know how, like the tricks of the old music-hall conjurers. Chuck a piece of 3/16 in. rod a little over a foot long, centre and drill it No. 42 for about ½ in. depth, and drive into the hole, the business end of the last No. 40 drill you were unlucky enough to break. Hold the end of the rod in the drill chuck, and the point of the drill will be far enough away to enable the hole to be drilled without the chuck touching the barrel. Keep the rod parallel to the barrel while drilling.

For tapping the holes, use a piece of 3/16 in. tube about the same length as the rod, for an extension tap holder. Knock one end square, to fit on the tap, and put the tapwrench on the other end. When tapping soft copper, always use plenty of cutting oil on the tap to avoid tearing the threads.

When all the stays are in, sweat over the heads and nuts with solder, which will seal any defective thread. Lay the boiler on its side in the brazing pan, brush some soldering-flux over all the stayheads and nuts, heat the lot to the melting-point of solder, melt a few blobs among the heads and nuts, and brush the melted solder all over them with a wire brush. This can be made by driving a bunch of fine iron wires into the end of a bit of copper tube about ⅝ in. dia. and flattening it to hold them. Fit the brush into a wooden handle, as the tube will become too hot to hold. Turn the boiler over for the other side, and up-end it for throatplate and backhead stays, finally washing well in running water to get rid of all traces of flux. Test to 160 lb. by hydraulic test



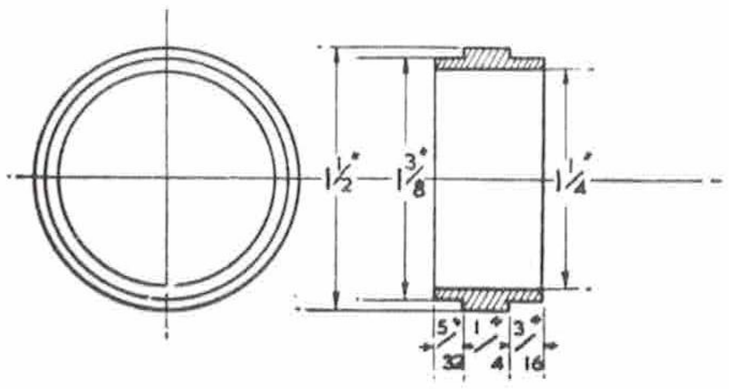


CROSS SECTION THROUGH FIREBOX

Smokebox

THE smokebox is made from a piece of 4⅜ in. x 13-gauge brass tube squared off at each end in the lathe, to 4½ in. length. Steel tube may be used where expense is a consideration. Don't forget to put a disc of metal or hard wood in the end before gripping the tube in the chuck, or it will fly out, and there may be a calamity. At 2-1/16 in. from one end, drill a 1 in. hole for the chimney liner. Diametrically opposite this, drill a 13/32 in. hole for the blastpipe, ⅝ in. ahead of this drill a ½ in. hole for the steampipe, and ⅞ in. ahead of that, a ¼ in. hole for the snifting valve.

The ring and door are castings, either bronze or iron. Chuck the ring by the edge, and bore the hole to 2⅞ in. dia., then chuck by the hole over the inside jaws, convex side out, face the front and turn the flange to a tight push fit in the smokebox barrel. You can't turn the outside of the door, because of the hinge straps cast on it, but there should be a chucking-piece on the outside which will allow it to be gripped in the three-jaw for facing the edge which makes contact with the ring. Centre and drill a 5/32 in. hole in the middle, then reverse and rechuck by the edge, to part off the chucking-piece and face the boss.



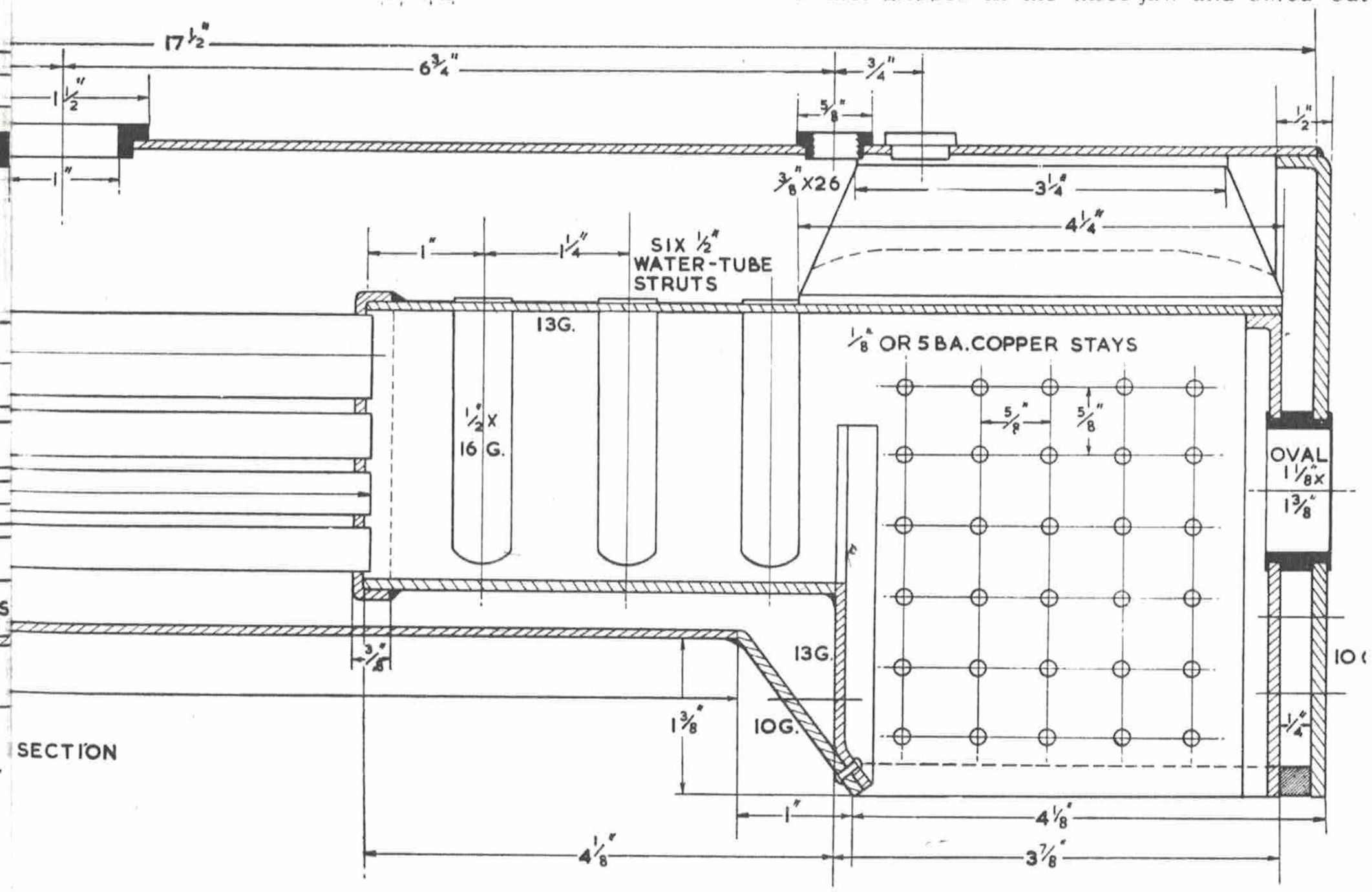
FIREHOLE RING SQUEEZE OVAL AFTER TURNING

The dart, crossbar and handles are made exactly as described for *Mona*, so I needn't go through all the rigmarole again. The dimensions are shown separately. Put the door in place, and mark the position of the hinge lugs, which are made from 3/16 in. x ⅛ in. brass rod, the stems being turned to 7/64 in. dia. and screwed 6 BA. Drill and tap the holes in the ring, screw in the lugs, then put the door in place again, and drill right through the bosses on the ends of the hinges, and the lugs, with a long No. 48 drill, so that they all line up to take the pin. This is a piece of 15-gauge spoke wire with a little boss screwed on one end. The whole set-up is shown in the front view, and the section.

Chimney and liner

The liner is a piece of brass tube of 18- or 20-gauge, 1 in. dia. and 2-5/16 in. long. One end is belled out to 1½ in. dia., which can be done by softening it and driving something tapered, like a metal bob as used by plumbers, into the end. It can also be held in the chuck and the bell formed by spinning, a burnishing tool being applied to the inside. Cut a piece of 16- or 18-gauge sheet brass or copper 2 in. square, bend it to the curve of the inside of the smokebox, drill a 1 in. hole in the middle, push the liner through it so that 1-3/32 in. projects from the convex side, and silversolder it from the opposite side. If any solder seeps through, file it away. Push the liner up through the hole in the top of the smokebox barrel, and secure the square flange to the inside of the smokebox with a 3/32 in. or 7 BA countersunk screw at each corner, nutting them inside the smokebox. If a smear of plumbers' jointing is put round the liner before it is inserted, the joint will be airtight.

The chimney is turned up from a casting, which is first gripped in the three-jaw and bored out to a



tight push fit on the liner. It can then be mounted on a mandrel, and the outside turned to the shape and dimensions shown. The base cannot be turned, owing to its shape, so it should be finished off with a half-round file while the casting is still on the mandrel. The bottom of the base, which sits on the smokebox, will be cast to the correct curve, and can either be smoothed with a file, or rubbed on a piece of emery-cloth laid on the smokebox barrel. Chimney castings may be in iron, to save expense.

The smokebox will be attached to the boiler, when the lot is erected, by a ring 4-3/16 in. dia. and $\frac{5}{8}$ in. wide. This may be cast (its thickness doesn't matter), or it may be bent up from strip metal, and the joint silversoldered. A slice of tube could be used, if a piece of the right diameter is available.

The smokebox saddle is a casting, either brass or iron, and will only need cleaning up with a file. It should fit nicely between the frames, and is secured by three $\frac{1}{8}$ in. or 5 BA countersunk screws at each side, put through the holes already in the frame, into tapped holes in the saddle. The bottom of the curved seating in which the smokebox rests, should be level with the top of the frames.

Regulator

The regulator is of the disc-in-a-tube pattern, and is entirely self-contained, the dome being too low for one with a stand like *Mòna*. The barrel is a piece of 18-gauge brass tube 11/16 in. dia. Face off both ends in the chuck to a length of $1\frac{3}{4}$ in. The throttle block is made from a piece of cast or drawn bronze or gunmetal $\frac{3}{4}$ in. dia. Chuck in three-jaw and turn about $\frac{3}{4}$ in. length to the same diameter as the barrel. Face the end centre, drill to 3/16 in. depth with No. 48 drill, slightly countersink the hole, and tap it 3/32 in. or 7 BA. Turn 3/16 in. length to a tight fit in the barrel, and part off at $\frac{3}{8}$ in. from shoulder. Reverse in chuck, gripping by the step; centre, drill to $\frac{1}{4}$ in. depth with 7 mm. or 9/32 in. drill, and tap 5/16 in. x 32. Turn the outside to the shape shown.

Be mighty careful about the next job. Scribe a line across the centre of the face (take care to avoid making a deep scratch, only a faint mark is needed), and at each side of this, at a bare $\frac{1}{8}$ in. from the top, make a centrepop. They should be 7/64 in. apart. From these, drill two No. 34 holes slanting down into the tapped hole, as shown in the section. I do the job in exactly the same way as I drill steam ports, holding the block of metal in the machine-vice on the slant, the vice being on the table of the drilling-machine, and sighting the drill by pulling it down outside the block. Take care as the drill breaks through into the tapped hole, or away goes the point before you know where you are. Next, with a small chisel, which can be home-made from a piece of 3/32 in. silver-steel, chip away the wall on the port-face between the holes, to form a sausage-shaped "entrance to the way out" about $\frac{1}{8}$ in. deep.

At 9/64 in. to the left of the centre-line, and a full 1/16 in. from the edge, drill a No. 53 hole and tap it 9 BA. True up the portface by rubbing it on a piece of fine emerycloth laid on the lathe bed or something equally flat and true, then screw a 3/32 in. stub into the centre hole for the valve pivot, and a stub 5/64 in. dia. screwed 9 BA into the other hole, for a stop pin. These stubs should be of hard-drawn bronze.

Regulator valve

The valve should be made from a different grade of bronze or gunmetal to the throttle-block. Chuck a piece $\frac{5}{8}$ in. dia. and turn about $\frac{1}{2}$ in. length to an easy fit in the barrel. Face the end, turn $\frac{1}{4}$ in. length to $\frac{1}{4}$ in. dia. and part off at a full $\frac{1}{8}$ in. from shoulder. Reverse in chuck, centre, drill No. 41 for $\frac{1}{4}$ in. depth, slightly countersink the hole, and skim the face truly. Cross-slot the boss to $\frac{1}{4}$ in. depth, either by milling, or careful filing with a key-cutter's warding-file. The slotting-blades furnished with the Eclipse 4S handy-man's tool come in very handy for jobs like this.

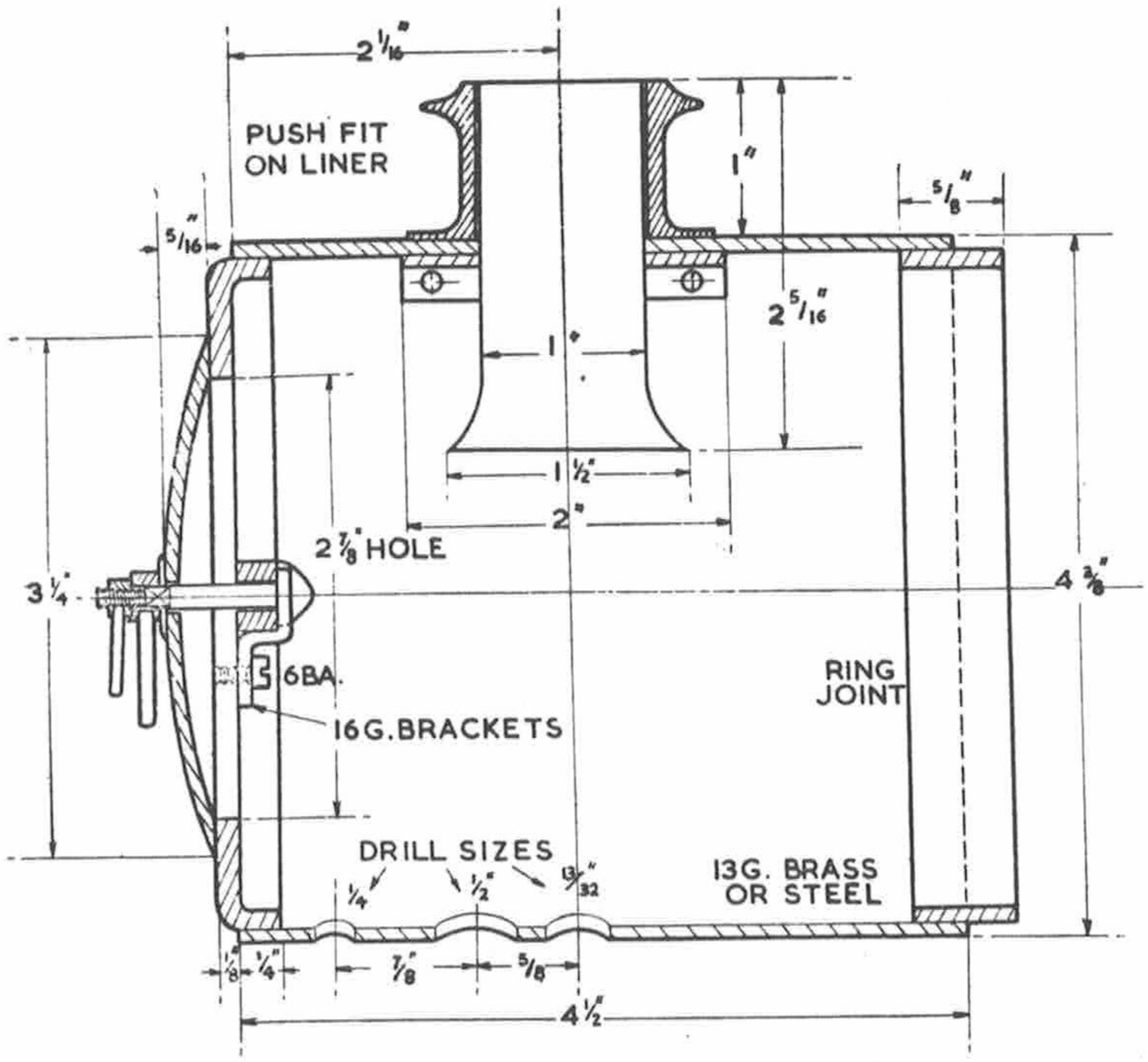
The sausage-shaped port should corerspond exactly with that in the portface, and can be formed by drilling two No. 34 holes touching each other and finishing the slot with a rat-tail file. Right opposite, file out a segment to the shape and size shown. This can be checked for correctness by trying the valve on the portface. When one end of the segment is up against the top pin, the ports should coincide exactly. When the other end touches it, the port in the valve should have moved right away from that in the portface, and the latter should be completely covered, the overlap being a bare 1/16 in. to make quite sure that no steam can get by. Face the valve truly on a piece of emerycloth as before.

The block which closes the other end of the regulator valve barrel is made in the same way as the throttle-block, but without ports and pins. After reversing in the chuck, centre and drill it right through with No. 21 drill, and open out and tap 5/16 in. x 32 to $\frac{3}{8}$ in. depth. The operating rod is a piece of 5/32 in. round bronze or rustless steel (but be sure it **is** rust-less!) 12 in. long. Turn down 5/32 in. of one end to 3/32 in. dia. and screw 3/32 in. or 7 BA. File the next $\frac{1}{8}$ in. to a $\frac{1}{8}$ in. square. File or mill the other end to form a tongue which will fit the slot in the valve boss easily but without being sloppy. Trim the end to bring the length of the rod as shown in the drawing. Chuck a piece of $\frac{3}{8}$ in. brass rod, face, centre, drill to about $\frac{1}{4}$ in. depth with No. 23 drill, and part off a 5/32 in. slice. Press this on to the rod until it is 13/16 in. from the shoulder at the tongue end.

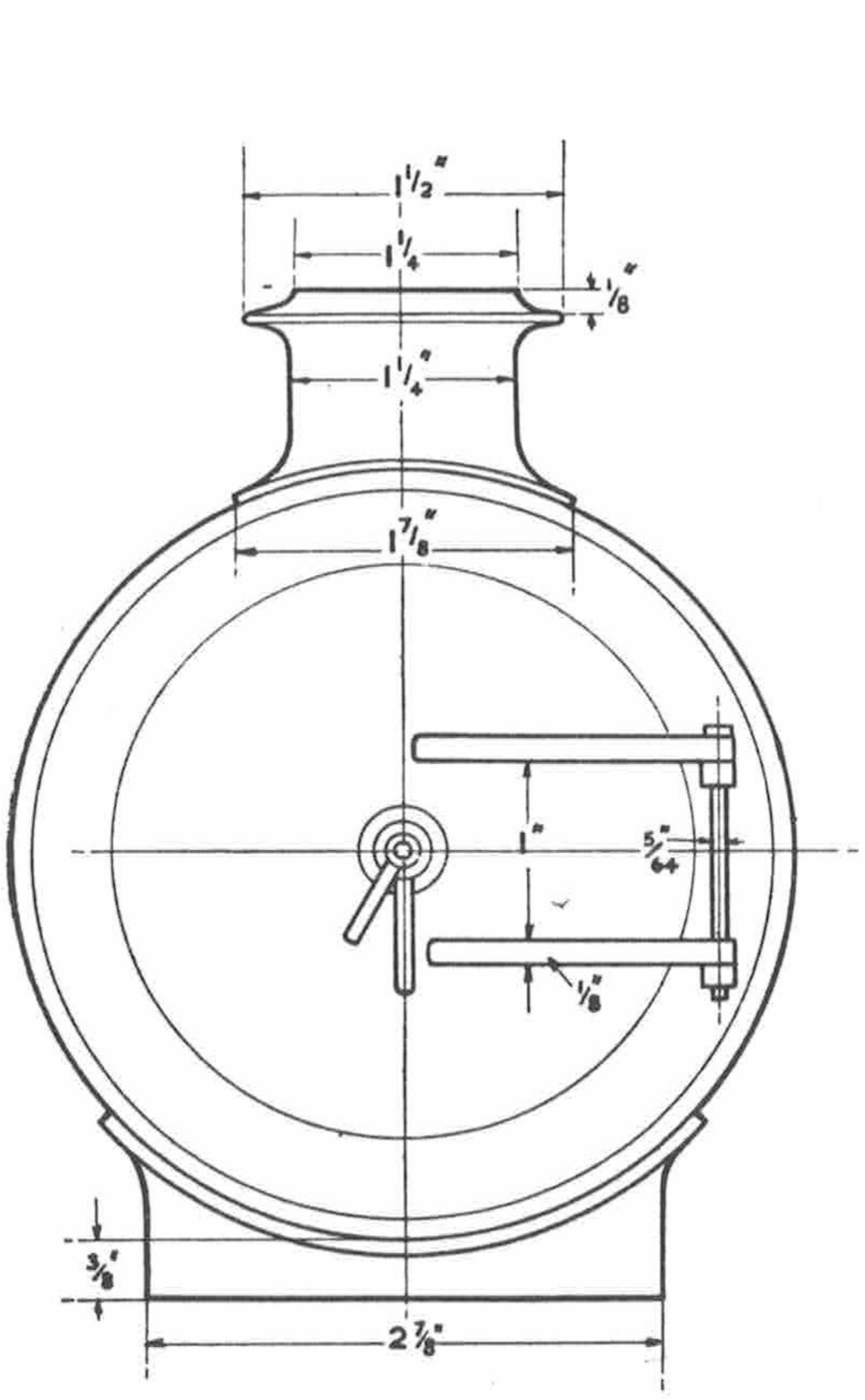
At $\frac{1}{2}$ in. from one end of the barrel, drill a 9/32 in. hole and tap it 5/16 in. x 40. Press the block with the hole through it into the opposite end, and push the long end of the regulator rod through the hole. Wind up the spring shown, from 22-gauge bronze or hard brass wire, and put it over the valve boss; anoint the portface and valve face with a drop of thick cylinder oil, which will make them stick together. The throttle-block can then be pressed into the barrel as shown in the section, the port being directly under the tapped hole in the barrel. When right home, there should be 1/32 in. end-play on the regulator rod. If more or less, the collar needs adjusting on the rod, forward if the rod is too tight, and backward if too slack. When the right place is found, pin the collar to the rod with a bit of 16-gauge brass wire pressed through a No. 53 hole drilled through collar and rod. The regulator can then be assembled **for keeps.**

How the regulator is erected

Two lengths of 5/16 in. x 18-gauge copper tube will be required, one 5-7/16 in. long, which is screwed into the throttle-block and forms the steam pipe. The other is 9-5/16 in. long and carries the regulator rod.



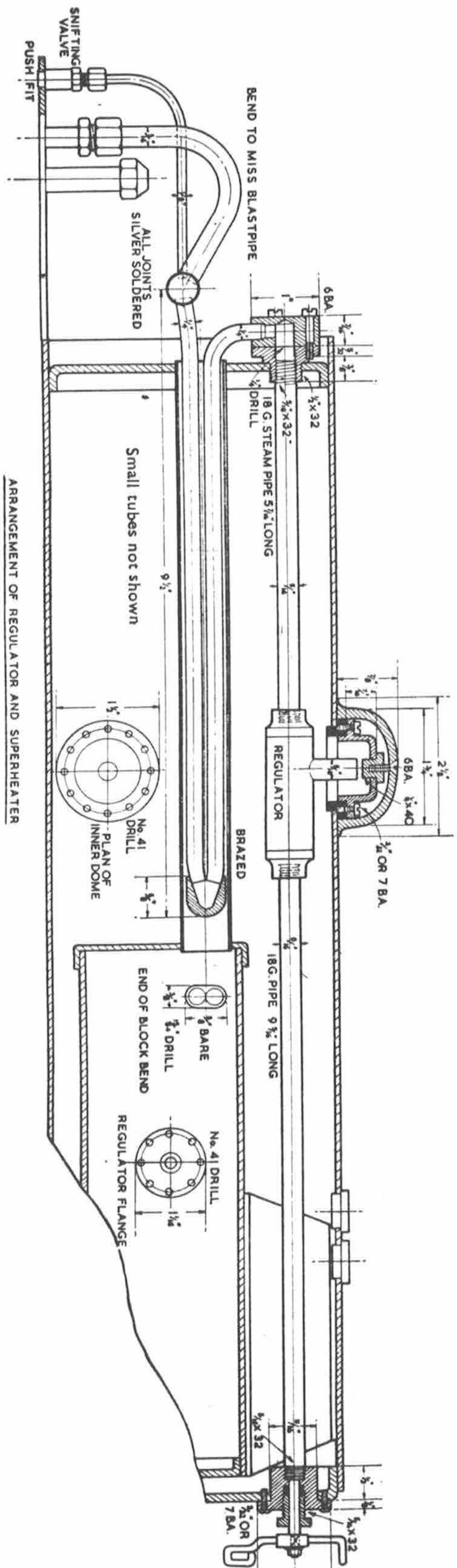
SECTION OF SMOKEBOX



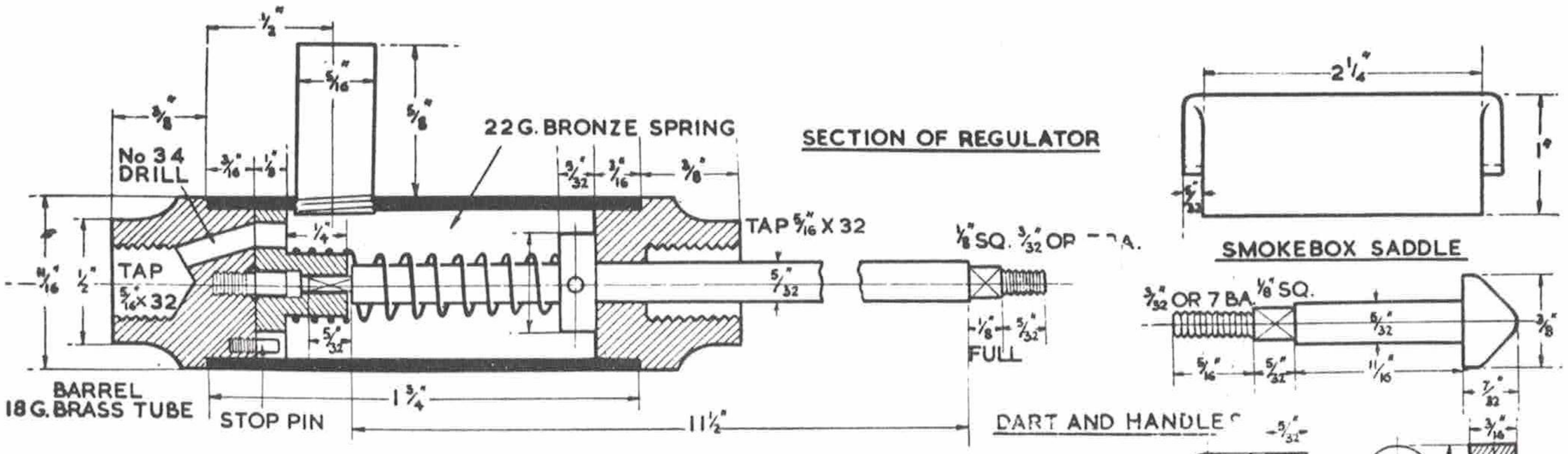
FRONT OF SMOKEBOX

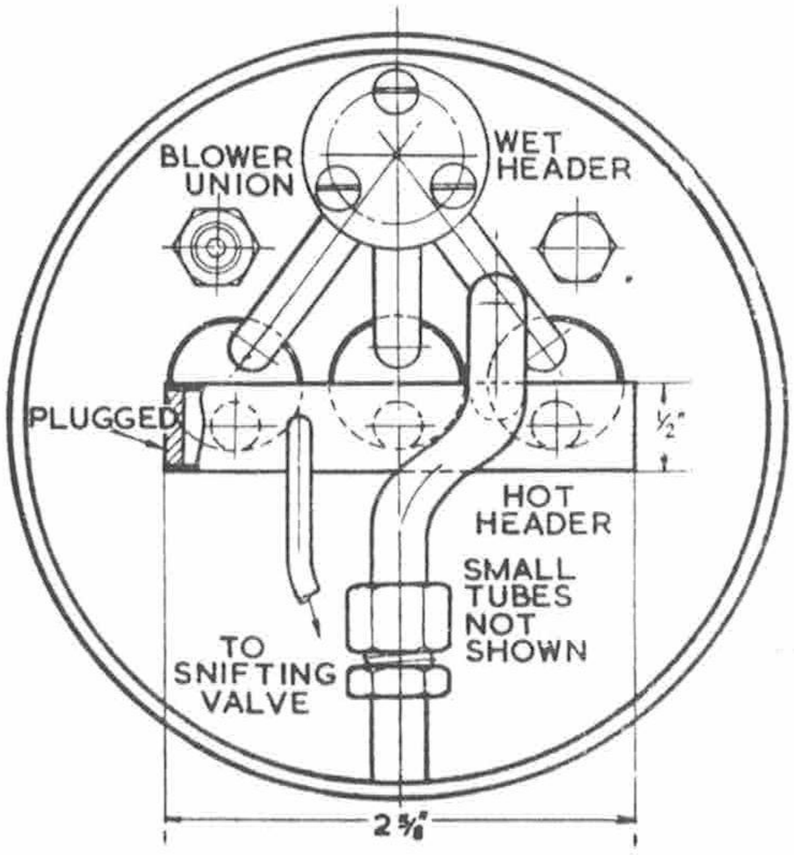
SAFETY VALVE

SNIFTING VALVE

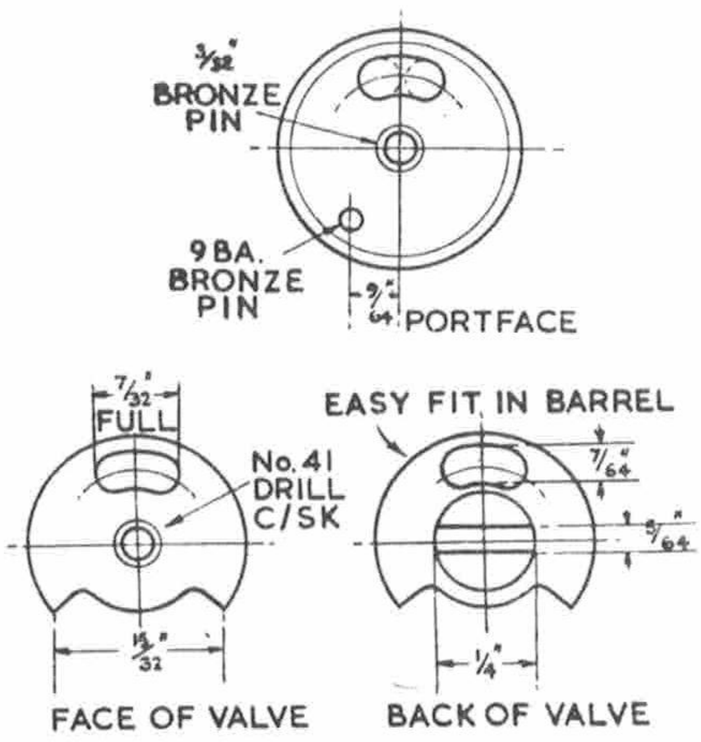


ARRANGEMENT OF REGULATOR AND SUPERHEATER

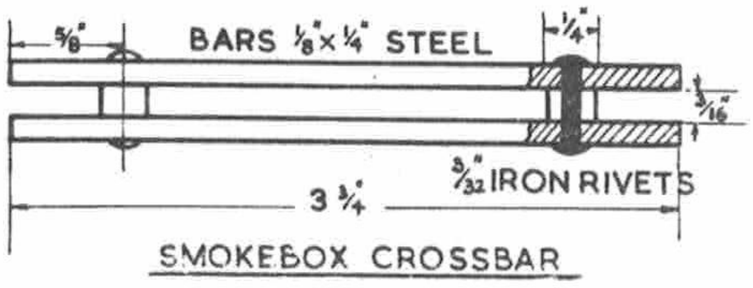




FRONT VIEW OF SUPERHEATER



PORTFACE AND VALVE



SMOKEBOX CROSSBAR

Both pieces are screwed 5/16 in. x 32 at both ends. A flanged fitting is needed on the backhead, to carry the regulator gland. This may be cast, or turned from brass rod 1-1/16 in. dia. Chuck in three-jaw, face, centre, and drill to $\frac{3}{4}$ in. depth with No. 21 drill. Open out to 3/16 in. full depth wit h7 mm. or 9/32 in. drill, tap 5/16 in. x 32. Turn $\frac{1}{2}$ in. of the outside to 11/16 in. dia. and part off at a full $\frac{1}{8}$ in. from shoulder. Reverse in chuck, open out and tap the hole as above, but to 5/16 in. depth, and skim the face true. Drill eight No. 41 holes in the flange, as shown in the inset sketch, and make a gland to fit, from 7/16 in. hexagon brass rod.

Screw this fitting on to the end of the longer tube. On the centre line of the backhead, at $\frac{5}{8}$ in. from the top (don't measure from the top of the wrapper!) drill a small pilot hole and enlarge it to a shade over 11/16 in. just enough to allow the regulator barrel to be pushed through. Insert the assembly, and guide the steam pipe to the corresponding tapped hole in the smokebox tubeplate. This will be found quite easy if a piece of rod about 6 in. long is pushed into the end of the tube. Turn the regulator barrel around until the 5/16 in. tapped hole in it is exactly under the dome bush; the flange on the backhead should then be pressed tightly against same, and the eight screwholes drilled and tapped in the backhead in exactly the same way as those in a cylinder cover. Remove the whole bag of tricks, then replace it with a 1/64 in. Hallite or similar gasket between the flange and the backhead. Use roundhead brass screws to secure the flange, and put a smear of plumbers' jointing on the threads before putting them in. The gland can be packed with graphited yarn. The handle may be of the shape shown (as fitted to my own engine) or any other you may fancy, and is fitted in the same way that I described for *Mona*. Drill the boss No. 32, file the hole square to fit the squared part of the spindle, and secure with a nut and washer.

Dome

The vertical steam pipe is just a $\frac{5}{8}$ in. length of 5/16 in. copper tube with about three 5/16 in. x 40 threads on one end, and is screwed into the regulator barrel through the dome bush. The inner dome is turned from a casting. Chuck by the spigot provided on top, turn the end to a push fit in the dome bush, and face the contact side of the flange. Reverse in chuck, part off the chucking spigot, centre, drill 7/32 in. and tap $\frac{1}{4}$ in. x 40. Make a plug as shown, drilling and tapping the head 6 BA to take the screw

holding the outer dome cover in place. This can be turned as described for *Mona*, and has a No. 34 countersunk hole in it for the setscrew. Drill twelve No. 41 holes in the flange of the inner dome, and secure it with brass screws (3/32 in. or 7 BA) in exactly the same way as a cylinder cover, putting a 1/64 in. Hallite or similar washer between the contact faces.

Superheater

First make the flange fitting which carries the steampipe. Chuck a piece of 1 in. brass rod; face, drill to $\frac{5}{8}$ in. depth with 7 mm. or 9/32 in. drill, and tap 5/16 in. x 32. Turn 5/16 in. length to $\frac{1}{2}$ in. dia. and screw $\frac{1}{2}$ in. x 32. Turn the next 1/16 in. to 11/16 in. dia. and part off at 3/16 in. from the shoulder. Reverse in chuck and skim the face true, then anoint the threads with plumbers' jointing and screw the fitting on to the end of the steam pipe showing at the smokebox tubeplate. The outer threads will engage with the tapped hole, and when the fitting is right home, there is no chance of steam leakage.

The wet header is made from the same size rod. Chuck, centre, drill 9/32 in. to $\frac{3}{8}$ in. depth, skim the end true, and part off at a full 7/16 in. from the end. Drill three No. 12 holes in the thickness, at the angles shown in the front view (these should all break into the centre hole) and open the ends with letter C drill to take the $\frac{1}{4}$ in. elements a tight fit. The holes for the fixing screws are drilled No. 34, and should just miss the angular holes, see front view.

For the elements, cut three $8\frac{3}{4}$ in. and three 9 in. lengths of $\frac{1}{4}$ in. x 20-gauge copper tube. Three pieces of $\frac{5}{8}$ in. x $\frac{3}{8}$ in. copper rod are needed for the block bends, each $\frac{5}{8}$ in. long. On one end of each, drill two holes with letter C drill (this is the drive fit size for $\frac{1}{4}$ in. tube or rod) almost touching, and drill in at an angle, so that the holes meet and form the steam cavity inside the bend, as shown in the section. Fit one longer and one shorter tube into each, and braze the joints, using brass wire or Sifbronze; just cover the joints with wet flux, heat to a bright red, and touch the joints with the wire. Quench in the acid pickle, wash well, then file the block bends to the shape shown. Soften the ends of the longer tubes, and bend them as shown in the section.

The hot header is a piece of $\frac{1}{2}$ in. x 18-gauge copper tube $2\frac{5}{8}$ in. long, plugged at both ends with discs of 3/32 in. copper. Drill three holes along one side for the elements, at $\frac{7}{8}$ in. centres. At $\frac{1}{2}$ in. from centre, drill a 5/16 in. hole for the steam pipe at the angle shown. At $\frac{1}{2}$ in. from centre, on the other side, drill a No. 32 hole for the pipe leading to the snifting valve. The steam pipe is $3\frac{3}{4}$ in. long, with a $\frac{3}{8}$ in. x 32 union nut and cone on the end. The snifter pipe is $4\frac{1}{4}$ in. long, with a $\frac{1}{4}$ in. x 40 union nut and cone.

To assemble the superheater, fit the bent ends of the longer elements into the side holes in the wet header, and the ends of the shorter ones into the three holes in the back of the hot header. Fit the 5/16 in. steam pipe and the $\frac{1}{8}$ in. snifting-valve pipe into their respective holes in the hot header; cover all the joints with wet flux, including the plugs at the ends, and silversolder the lot. After pickling, wash well in running water, letting plenty run through the elements to shift all the scale out. There is usually some left in pipes after brazing and silversoldering.

The wet header is attached to the flange on the end of the steam pipe by three long 6 BA screws as shown. Put a 1/64 in. Hallite or similar gasket between the faces, and be sure to cut a hole in the middle to let steam pass. That isn't a needless warning; I know of several cases where it has been forgotten, one of which wasn't discovered until the engine was steamed up for its first trial run! On the drawings, the superheater is shown connected up as it will be when the boiler is erected on the frames.

Safety-valves and snifting-valve

The safety-valves can be made from castings, or from $\frac{5}{8}$ in. hexagon bronze or gunmetal rod. Chuck a piece in the three-jaw, face the end, turn $\frac{1}{4}$ in. length to $\frac{3}{8}$ in. dia. and screw $\frac{3}{8}$ in. x 26. Part off at a full $\frac{1}{2}$ in. from shoulder. Ditto repeato for valve No. 2. Rechuck with the screwed end in a tapped bush held in three-jaw. Any odd stub of metal $\frac{1}{2}$ in. dia. or larger, does for a tapped bush; just chuck, face, centre, drill 21/64 in. slightly countersink, put the $\frac{3}{8}$ in. x 26 tap through, and Bob's your uncle!

Screw the valve blank into it, centre and drill through with No. 25 drill, open out and bottom to $\frac{5}{8}$ in. depth with 9/32 in. drill and D-bit, and tap the end 5/16 in. x 32. Turn the outside to the shape shown. Put a taper broach down the remains of the No. 25 hole and take just a tiny scrape out of it to true it up, then seat a 3/16 in. rustless ball on it. Make a nipple to fit the top, from 5/16 in. round brass rod screwed to fit fairly tightly, and drilled No. 40 for the valve pin. To make this, chuck a piece of 3/16 in. round brass rod and turn a full $\frac{1}{2}$ in. of it to 3/32 in. dia. Part off at 3/32 in. from shoulder, reverse in chuck and countersink the other end, to fit on the ball. Assemble the lot as shown, with a spring wound up from 22-gauge tinned steel wire on the pin.

For the snifting-valve, chuck a piece of $\frac{3}{8}$ in. round rod and turn about $\frac{1}{2}$ in. of it to 11/32 in. dia. Face, centre, drill to $\frac{5}{8}$ in. depth with No. 32 drill, open out and bottom to 5/16 in. depth with 7/32 in. drill and D-bit, and tap $\frac{1}{4}$ in. x 40. Part off at a full $\frac{1}{2}$ in. from the end, reverse in chuck, and turn $\frac{1}{8}$ in. of the other end to $\frac{1}{4}$ in. dia. Poke a $\frac{1}{8}$ in. reamer through the remnant of No. 32 hole, and seat a 5/32 in. ball on it. For the union cap, chuck a piece of $\frac{3}{8}$ in. hexagon rod, face, centre deeply, and drill to about $\frac{5}{8}$ in. depth with No. 40 drill. Turn 3/16 in. of the outside to $\frac{1}{4}$ in. dia., screwing $\frac{1}{4}$ in. x 40, and part off at $\frac{1}{4}$ in. from shoulder. Reverse in chuck, turn $\frac{1}{8}$ in. of the other end to $\frac{1}{4}$ in. dia., screw $\frac{1}{4}$ in. x 40 and cross-nick the end with a thin, flat file. Assemble as shown. The valve will fit into the $\frac{1}{4}$ in. hole in the bottom of the smokebox when the lot is erected.

Backhead Fittings

A COMPOSITE drawing showing the boiler backhead complete with its adornments, the cab front, and the connections under the drag beam is reproduced here. At the extreme left is the steam valve for the injector, which is made as described for *Mona* except that the peg which screws into the backhead flange is shorter and is left-handed, as the valve is on the left. The steam pipe leading to the injector goes straight down through the footplate, and is connected to an injector like that described for *Mona*, located at the side of the firebox below running-board level. The delivery pipe from this is connected to the left-hand clack on the boiler barrel.

The water-gauge is made and erected as on *Mona*. Same applies to the steam turret and whistle-valve, but the stem is shorter on account of the lower headroom under the cab roof. A $\frac{1}{8}$ in. pipe goes from the whistle-valve union to the whistle, which is located under the ashpan as shown in the drawing of that component. The other union on the left-hand side of the turret is connected to the end of the injector steam-valve by a 5/32 in. pipe. The union on the right is connected to the blower valve on the end of the hollow stay. The steam-gauge syphon is connected to an elbow screwed into the side of the wrapper and backhead flange. The clack taking the feed from the hand pump is the same as on *Mona*, but is connected to a union under the drag-beam as shown. The firehole door is of the swing type which most enginemen call an oven door, and can be made from a casting.

Grate and Ashpan

The grate may be made from castings or built up. If cast, it will be in three pieces, two with four bars and a central section with ten. The three sections are joined by a long $\frac{1}{8}$ in. pin passing through all the bars in the same way as shown for the built-up grate, with nuts on each end. The brackets are made from $\frac{1}{8}$ in. x $\frac{1}{4}$ in. steel strip and are located in the fourth space from each end. It is erected in the same way as the built-up version.

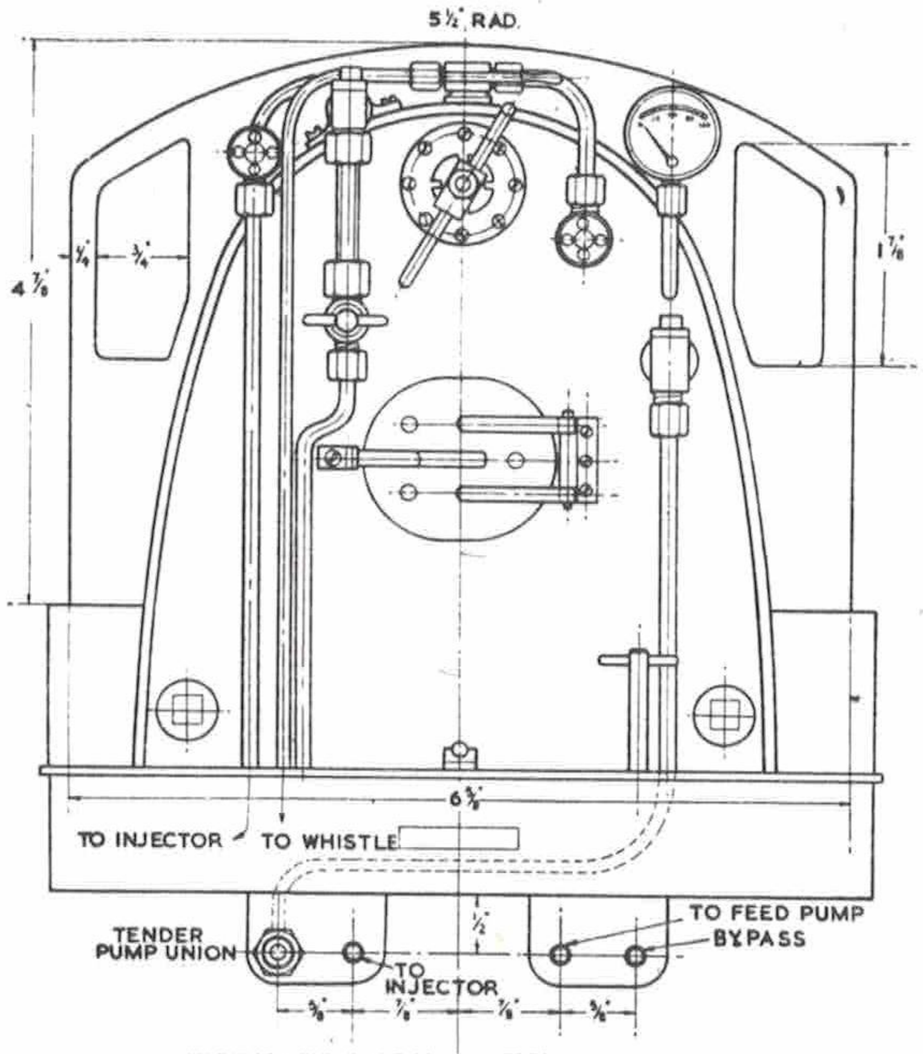
To make this, 18 lengths of $\frac{1}{8}$ in. x $\frac{5}{16}$ in. black mild steel strip each $3\frac{5}{16}$ in. long will be needed. At $\frac{1}{2}$ in. from each end of one of the bars drill a No. 30 hole, and use the drilled bar as a jig to drill the rest, so that all holes match up. For the spacers, chuck a piece of $\frac{1}{4}$ in. round rod in the three-jaw, face, centre, and drill No. 30 to the full depth of the drill flutes. Part off $\frac{1}{8}$ in. slices until the end of the hole is reached, then ditto repeato until you have three dozen. The brackets are made as mentioned above. The long bearer in a piece of $\frac{1}{8}$ in. round steel with a few $\frac{1}{8}$ in. or 5 B.A. threads on each end. Its overall length should be $4\frac{5}{8}$ in.

To assemble, put a nut on the end of the bearer, then a bar, then a spacer, then three more bars with spacers between. Next fit a bracket, then ten more bars with spacers between, then another bracket, then the remaining four bars with spacers between, and secure the lot with another nut. Burr the threads over outside the nuts so that they can't come off, but leave the bars free to swing on the bearer. Next divide the grate into three sections. On the outside of the fifth bar from each end countersink the bearer hole. Put a piece of $\frac{1}{8}$ in. mild steel rod $2\frac{1}{2}$ in. long through the ten bars, with spacers between the bars, and rivet the ends over into the countersinks, filing the ends flush. That forms the rigid ten-bar section which drops into the ash-pan when cleaning out the remains of the fire. Countersink one hole in each of the remaining brackets. Put a piece of $\frac{1}{8}$ in. rod $1\frac{1}{8}$ in. long through the holes in the four remaining bars at each end, with spacers in between them, then put on the brackets with the countersunk side of the hole outwards. Rivet one end of the $\frac{1}{8}$ in. rod into the countersink in the bracket, and form a cup head on the other end outside the end bar.

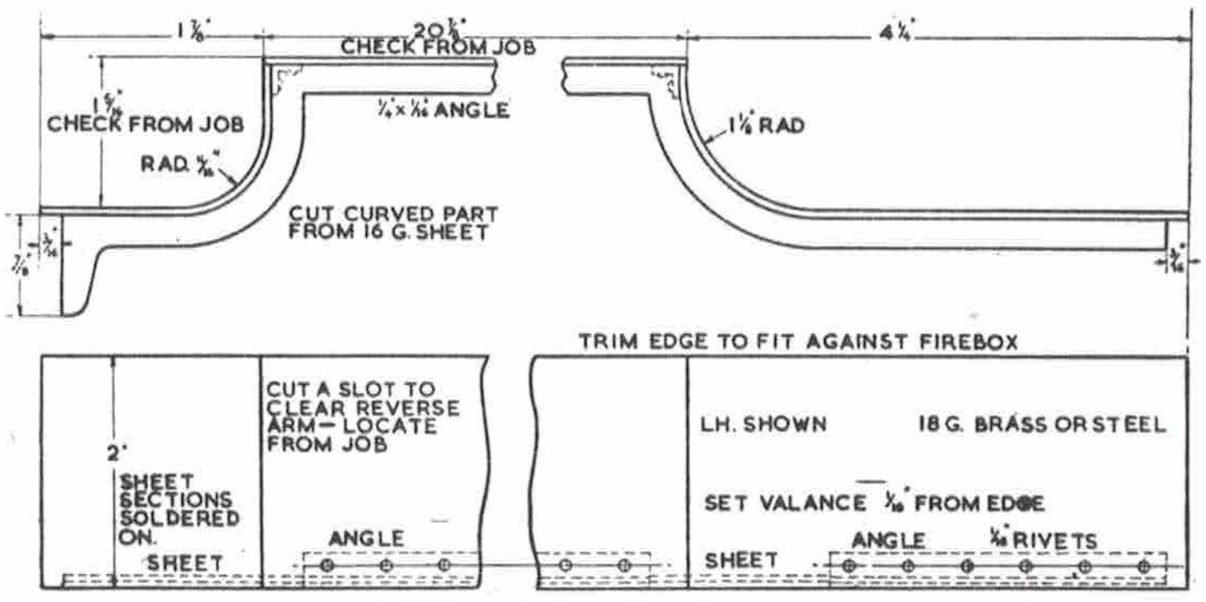
You now have a three-section grate with four "legs" to it, which fits in the well of the ashpan, and the lower holes in the "legs" are riveted to the sides of the well, as shown in the side and end views. The ashpan itself is a simple job, being bent to shape shown in the end view, from a piece of 16-gauge sheet steel 4 in. wide. This job is easily done in the bench vice. The front end is closed by a piece of the same material cut to fit, and brazed in; the back end is left open. After riveting the legs of the grate to the sides of the ashpan well, set the assembly in the cradle, with the upper edges of the ashpan resting on top of the cradle. To keep it in place put two $\frac{1}{8}$ in. or 5 B.A. bolts through the front end of the ashpan and the front of the cradle as shown in the drawings. The middle part of the grate should be quite free to drop down into the well.

Boiler erection

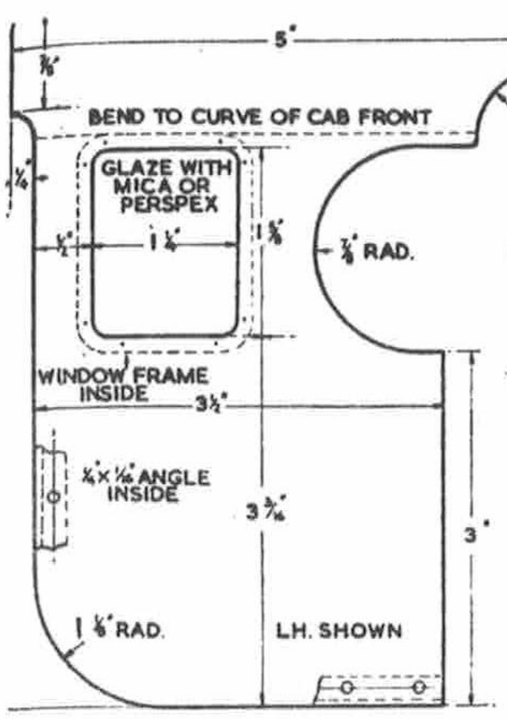
First put the smokebox saddle between the frames, level with the cylinders. Take off the blast nozzle. Smear some plumber's jointing around the ring at the back of the smokebox, and press it into the boiler barrel. Make sure that the chimney lines up with the dome



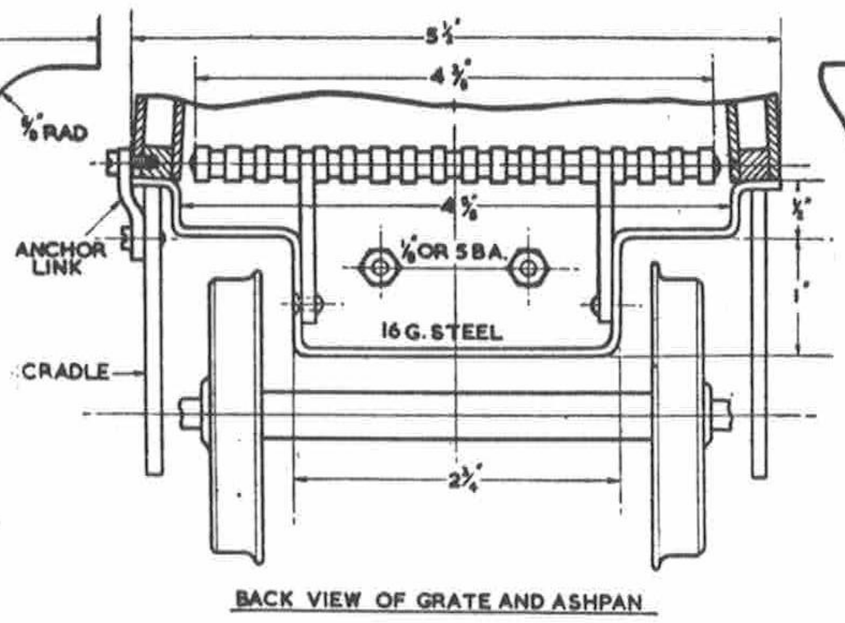
ARRANGEMENT OF FOOTPLATE FITTINGS



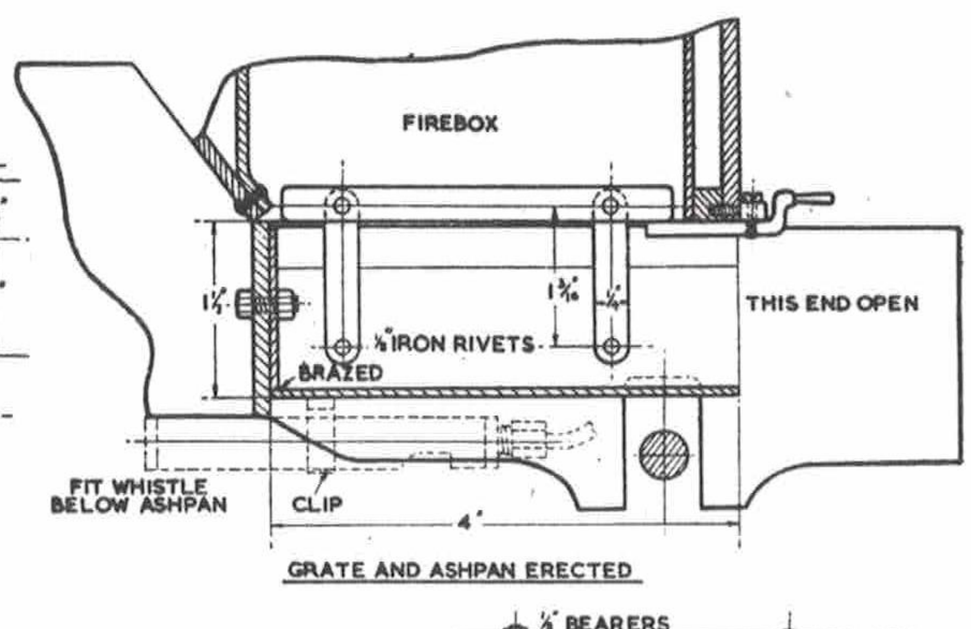
RUNNING BOARD AND VALANCE



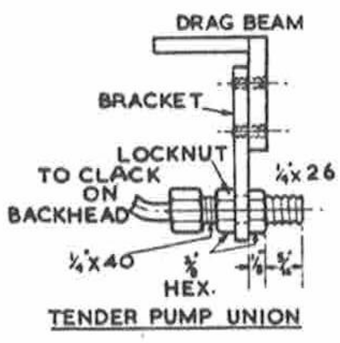
CAB SIDE



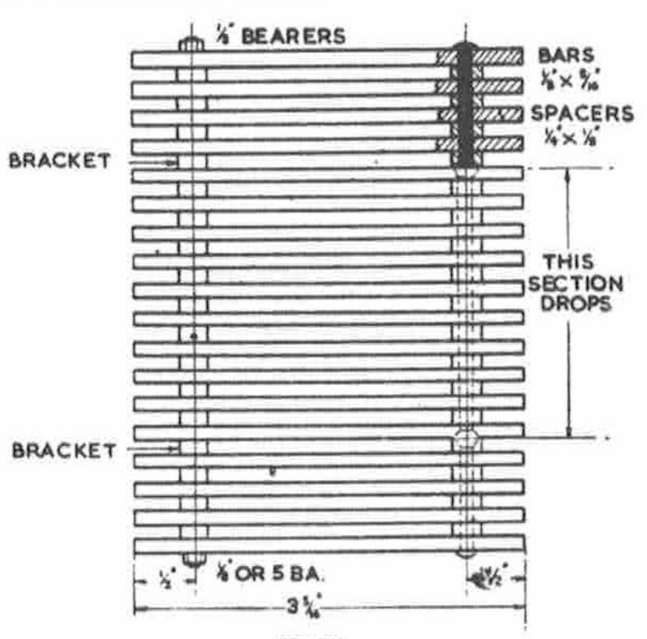
BACK VIEW OF GRATE AND ASHPAN



GRATE AND ASHPAN ERECTED



TENDER PUMP UNION



GRATE

so that it won't be all cock-eyed when the boiler is in place. Now put on the boiler, with the smokebox resting in the saddle, and the firebox on the ledges of the ash-pan—*see* end view. Adjust the smokebox saddle so that the bottom of the boiler is exactly level, parallel with the top of the frame, then fix the saddle with three $\frac{1}{8}$ in. countersunk screws through the holes already in the frame, running into tapped holes in the saddle. The smokebox is attached to the saddle by three $\frac{3}{32}$ in. or 7 B.A. screws through the saddle flanges at each side.

To prevent the boiler from lifting at the firebox end, make two anchor links as shown, from 13-gauge copper or brass. The screw for the upper end is tapped into the foundation ring, and the lower end into the cradle. This type of fixing allows for movement of the boiler under expansion and contraction stresses. To keep the middle part of the grate in position while the engine is at work, make a glorified turnbutton as shown in the side view. It is filed up from a bit of the material used for the firebars, and pivoted by a 6 B.A. screw to a lug screwed into the foundation ring on the centre line of the backhead. The running position is as shown; to dump the grate, simply push the handle to one side.

The pipes in the smokebox can now be connected up as shown in the drawing of the superheater assembly in the last instalment. The blower ring is made from $\frac{1}{8}$ in. copper tube as shown, and connected to the thoroughfare nipple on the hollow stay by a $\frac{1}{4}$ in. x 40 union nut and cone. The smokebox front, complete with door, can then be permanently fitted. Smear some plumbers' jointing around the edge, and press it in. No screws are required, as the front will stay put without, and is instantly removable if required. Be sure that the hinges are set horizontally when pressing in the front. The interstices around the pipes can be sealed with "asbestos putty", which is made by kneading up a few cuttings of asbestos millboard with a little water until a kind of pulp is formed. This sets hard as soon as it dries. *Note*.—If the smoke box isn't airtight, the boiler won't steam.

Running-boards

The running-boards are made in three sections, a straight piece of 18-gauge steel or brass $20\frac{7}{8}$ in. long and 2 in. wide forming the central section, and two pieces of similar material, bent to shape and length shown, forming the ends. They are connected by pieces of angle attached transversely, as shown dotted in the elevation sketch.

The straight part of the valances or edging is formed with $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass angle riveted on with $\frac{1}{16}$ in. rivets. The curved parts are cut from 16-gauge sheet brass, and soldered to the underside of the running-boards. It is, of course, possible to bend angle material to the curve, but unless a proper machine is available it is a ticklish job to get a nice sweep. A slot must be cut in the left-hand running-board to allow the reverse arm to pass through it, but the location of this can be obtained very easily from the actual job.

The ends of the running-boards rest on the tops of the buffer and drag beams, and additional support is afforded by the motion brackets. Small brackets made from 16-gauge steel should be fitted just ahead of the cylinders, and between the driving and trailing coupled wheels. Note that the inner edges of the running-boards must be cut to fit along the sides of the fire-box. Attachment to beam tops and brackets is made by 3/32 in. or 7 B.A. countersunk screws. Between the running-boards at the rear end a make-up piece is fitted which forms the footplate; this is screwed to the top of the drag-beam. Another piece is fitted ahead of the smokebox saddle. As this has to be removed for filling the lubricator, it cannot be fixed. Cut it to a close fit between the sides, and bend it to follow the slope of the front end of the frames. In place of fixing screws, fit two 3/32 in. pegs about $\frac{3}{16}$ in. long, in the part which rests on the buffer beam, and drill two corresponding No. 40 holes in the beam into which the pegs can fit. The dummy vacuum-brake pipe, which is made from $\frac{1}{8}$ in. copper wire, is brazed to the plate close to the front edge (*see* general arrangement drawing) and can be used as a handle to lift the cover when filling the lubricator. I find the one on my own engine very handy for this!

Cab

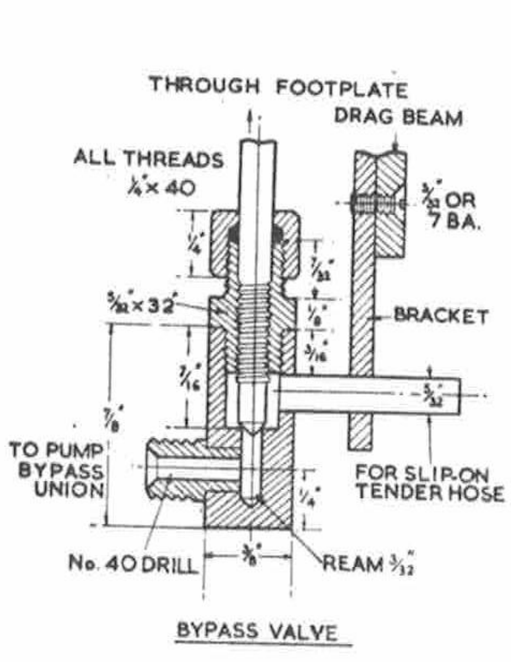
The outline and dimensions of the cab front are shown on the drawing of the footplate fittings. This should be cut from 18-gauge metal, brass or steel. I happened to have a piece of very stout tinplate, beautifully smooth and flat, and it made a lovely cab. It is a good wheeze to make a cardboard dummy or template first, getting this an exact fit over the boiler. If you spoil a dozen pieces before getting one O.K., all you lose is your time, but

guid metal costs muckle bawbees the noo, ye ken, and it doesna do tae waste ony! Cut the window openings with a fine-tooth metal-cutting fretsaw, then cut two similar openings in another piece of metal, which is then cut way all around the openings to form window frames about $\frac{3}{16}$ in. wide. These are riveted over the openings on the inside, with pieces of mica or perspex between, to form proper glazed windows. Use 1/32 in. rivets, or pieces of domestic pins. One of my few personal friends, who is fond of watch repairing, uses tiny watch screws. Patience is a virtue!

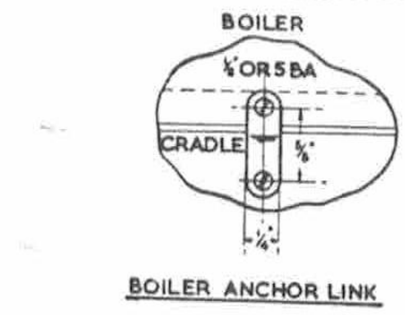
The sides of the cab are cut from the same kind of materiål. On the Southern engines the cab sides are extended and bent over to form part of the roof. This one is the same, the upper part above the dotted line being bent over to match the curve of the cab front. The window openings are "glazed" as mentioned above. Both sides are attached to the front by pieces of angle at each corner, the curved part at the top being soldered to the cab front, and reinforced by a little piece of angle soldered in at the end of the curve.

The roof is what the enginemen call a "sunshine roof", and is made in two pieces. A strip of thin metal about $\frac{1}{4}$ in. wide is riveted or soldered above and below the upper edge of each cab side, leaving a bare $\frac{1}{8}$ in. overhanging, and forming a groove. A piece of metal of the same thickness as the cab sides, and $2\frac{1}{2}$ in. wide, is bent to the curve of the cab front, and cut to a sliding fit in the grooves. This is pushed in until level with the overhang of the cab sides, and soldered to the front. A similar piece $2\frac{1}{2}$ in. wide is cut to slide similarly in the grooves. When this is pushed home, it comes level with the back edges of the cab sides and completes the roof. This piece is removed when driving the engine, thus giving full accessibility to the "handles".

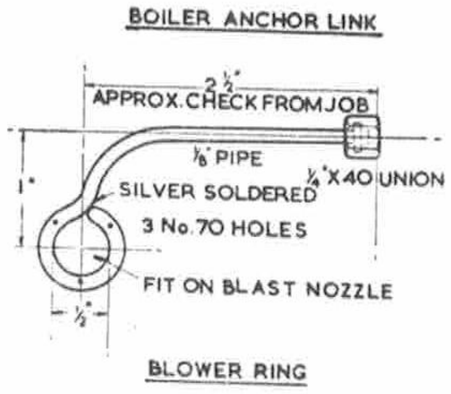
The complete cab is attached to the running-boards by pieces of $\frac{1}{4}$ in. x $\frac{1}{16}$ in. angle riveted along the bottom edges of the cab sides, and secured to the running-boards by 3/32 in. or 7 B.A. screws going through clearing holes in the running-boards into tapped holes in the angles. A beading is fitted around the semi-circular opening to the rear of the window. This is made from a strip of nickel-bronze (German silver) bent to shape and soldered on. At the bottom of the curve this is left projecting for $\frac{3}{8}$ in. and a No. 41 hole drilled through it at $\frac{3}{16}$ in. from the edge of the cab side. Put a 5 in. length of 3/32 in. nickel bronze or rustless steel through this from the underside, push it up until it touches the upper end of the cab opening, and solder it. Drill the thread out of a 3/32 in. steel nut, and slide it up the rod until it touches the underside of the projecting bit of beading, then solder that also. The ends of the bits of rod, now forming the cab pillars, will project below the bottom edges of the cab sides, so drill No. 40 holes in the running-boards to let the ends pass through. Before fitting the cab "for keeps", slide another drilled-out nut on each pillar. When the cab is fixed these will drop to the bottom of the pillars and rest on the running-boards. Fix them to the pillars with a tiny touch of solder, to make them stay put, but don't solder them to the running-boards or you won't be able to get the cab off. The whole assembly is shown clearly in the general arrangement drawing.



BYPASS VALVE



BOILER ANCHOR LINK



BLOWER RING

The Plumber's Job

Some of the pipe work was mentioned previously, but there is still more to be done. Two brackets are needed at the underside of the drag beam to carry the tender connections. These are made from 3/32 in. sheet brass or steel, and are attached to the beam by 3/32 in. countersunk screws as shown in the detail drawings of the bypass valve and tender pump union. The right-hand bracket has two 5/32 in. holes through it at $\frac{5}{8}$ in. centres, and the left-hand one has one 5/32 in. hole and one $\frac{1}{4}$ in. x 40 tapped hole. This carries the union screw for the tender pump connection. To make it, chuck a piece of $\frac{3}{8}$ in. hexagon rod in three-jaw, face, centre deeply, and drill No. 40 for .1 in. depth. Turn $\frac{5}{16}$ in. length to $\frac{1}{4}$ in. dia. and screw $\frac{1}{4}$ in. x 26. The coarse thread is more convenient for quick coupling, and lasts longer as it is in constant use. Part off at $\frac{5}{8}$ in. from shoulder, rechuck in a tapped bush held in three-jaw, turn $\frac{1}{2}$ in. length to $\frac{1}{4}$ in. dia. and screw $\frac{1}{4}$ in. x 40. Countersink the hole, then screw the long end through the tapped hole in the bracket, and make a locknut to fit it as shown. The fine-threaded end is then connected to the clack on the backhead by a $\frac{1}{8}$ in. pipe with union nuts and cones on each end, as shown in the drawing of the backhead.

A 5/32 in. pipe goes through the hole alongside the union, and is bent into an inverted swan-neck under the injector, so that it can be attached to the water union on same as shown in the photograph of the finished engine, published at the beginning of this serial. The left-hand hole in the right-hand bracket carries a 5/32 in. pipe which goes to the bottom union on the boiler feed-pump. The right-hand hole supports the outlet from the bypass valve. To make this, chuck a piece of $\frac{3}{8}$ in. hexagon rod, face, centre, drill to $\frac{3}{4}$ in. depth with No. 43 drill, open out and bottom to $\frac{7}{16}$ in. depth with 7/32 in. drill and D-bit and tap the end $\frac{1}{4}$ in. x 40. Ream the small hole 3/32 in. and part off at $\frac{7}{8}$ in. from the end.

At $\frac{1}{4}$ in. from the blind end, drill a 5/32 in. hole breaking into the No. 43 hole, and in it fit a $\frac{1}{4}$ in. x 40 union nipple. At $\frac{1}{4}$ in. from the tapped end, diametrically opposite to the nipple, drill a No. 23 hole and fit a piece of 5/32 in. copper tube $\frac{3}{4}$ in. long in it. Silversolder pipe and nipple at the same heat; pickle, wash and clean up. Chuck the $\frac{3}{8}$ in. rod again, centre, drill to $\frac{3}{4}$ in. depth with No. 31 drill, open out to $\frac{3}{16}$ in. depth with No. 21 drill; turn 7/32 in. length to $\frac{1}{4}$ in. dia. and screw $\frac{1}{4}$ in. x 40. Part off at $\frac{5}{16}$ in. from shoulder, rechuck in a tapped bush, turn $\frac{3}{16}$ in. length to $\frac{1}{4}$ in. dia. screw $\frac{1}{4}$ in. x 40, and tap the hole 5/32 in. x 32. Screw this end into the body. Make a gland nut to suit, same as a union nut. The valve pin is a 3 in. length of 5/32 in. rustless steel or drawn bronze; chuck in three-jaw, screw 5/32 in. x 32 for $\frac{3}{4}$ in. length, turn a blunt cone point on the end, and turn the thread off for $\frac{1}{8}$ in. beyond the point. Chamfer the other end, and fit a cross handle made from a short bit of 15-gauge spoke wire.

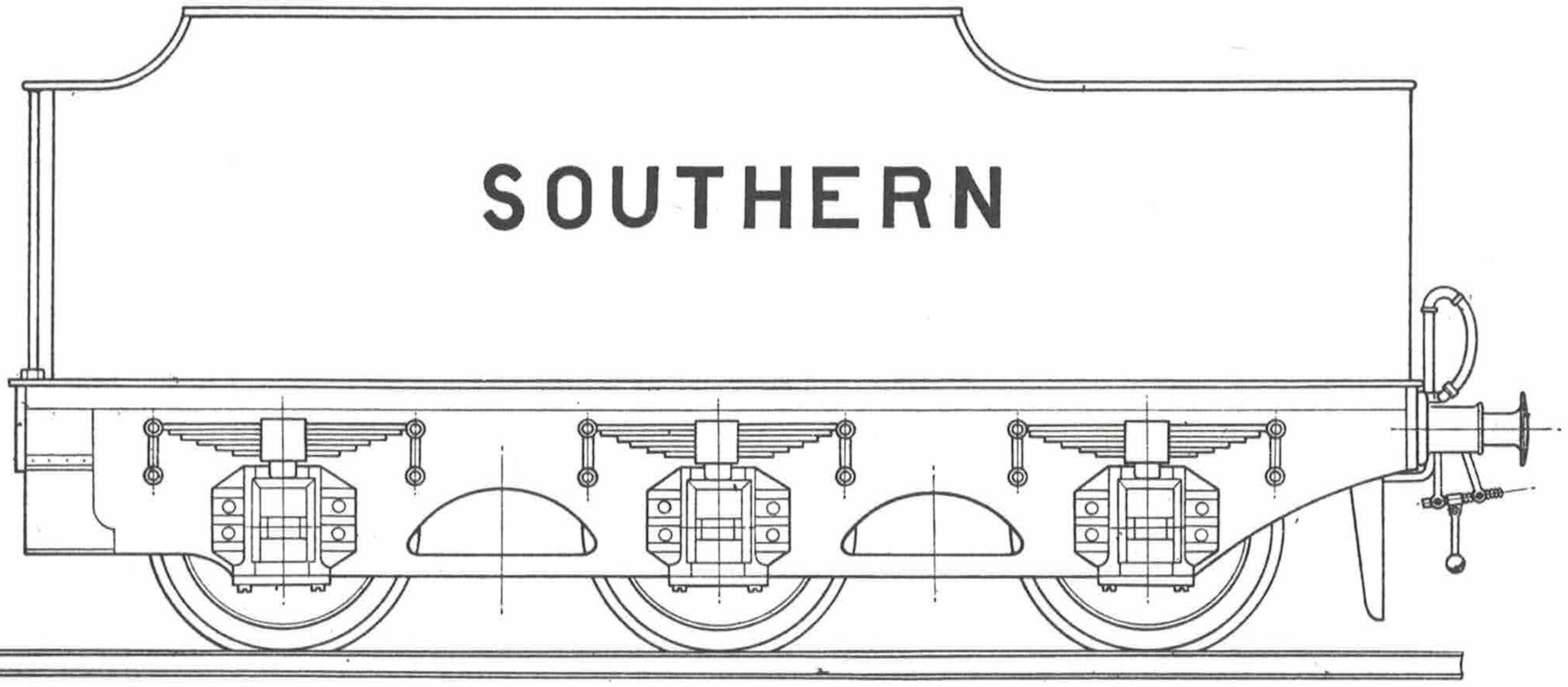
Drill a 5/32 in. hole in the footplate directly above the hole in the bracket, and about $\frac{5}{8}$ in. from the edge. Push the pipe in the valve body through the hole in the bracket, hold the valve level with the hole in the footplate, and screw the pin into the valve through the hole, so that it projects above the footplate as shown in the

drawing. The gland is packed with a strand of graphited yarn. The union at the bottom is connected to the union at the top of the pump (the one facing backwards, says Pat) by a 5/32 in. pipe with union nuts and cones at each end. The other union on the pump is connected to the boiler clack on the same side by a similar but shorter pipe. When the bypass valve is open the water delivered by the pump takes the line of least resistance and goes back to the tank. When the bypass valve is closed the water can't get back to the tank, so it just pushes up the clack ball and goes into the boiler.

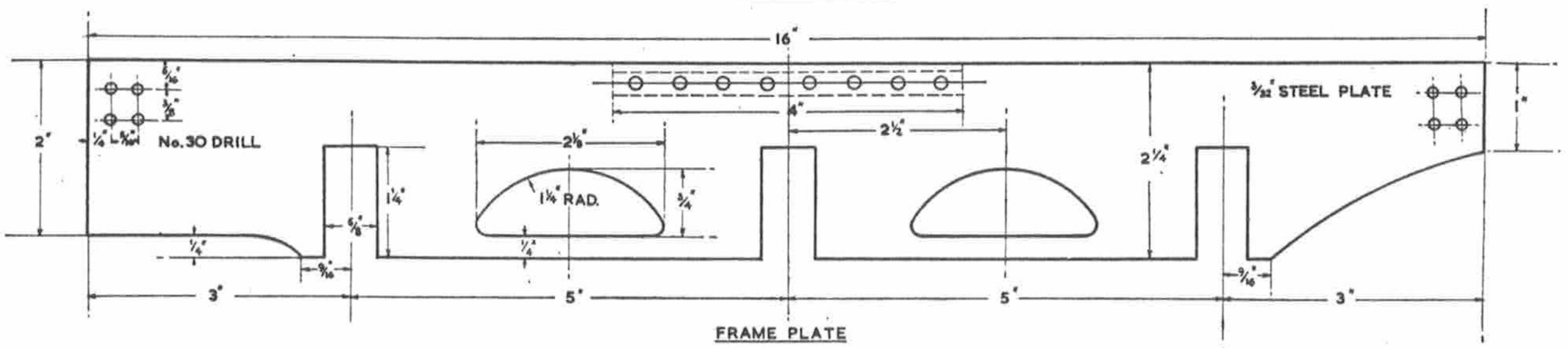
Trimmings

There is no need to go into full details of these, as they are the same as described for *Mona*. The buffers may be made from castings, or turned from $\frac{7}{8}$ in. round rod, to the sizes shown in the accompanying sectional drawing. Those on my engine have heads turned from rustless steel. Some of the boys who cleaned full-size engines in my young days would have loved that! They spent time and "elbow grease" plus lots of emerycloth in polishing up steel buffer-heads and coupling links, carefully tallowed them, and even then found rust after a day or night out in damp or rainy weather.

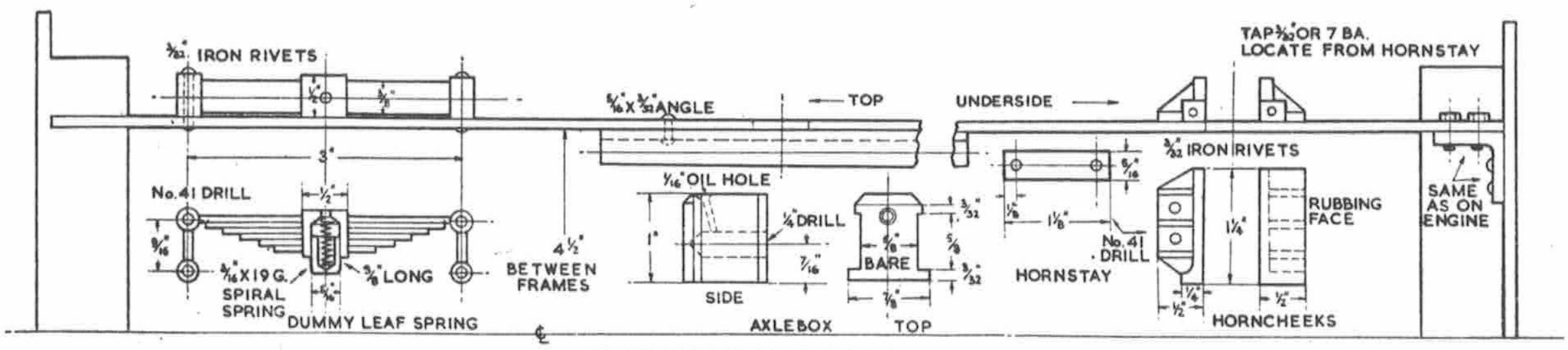
The handrails are made from 3/32 in. steel, rustless also preferred. There is hardly any need to bother about turning handrail knobs or pillars, as Reeves sells them at a reasonable price, and time is saved. A little dummy whistle is screwed horizontally into the cabfront just behind the safety-valves, for appearance sake. No lagging is needed over the boiler barrel, but a sheet of very thin brass or copper can be put over the firebox to hide the stayheads. This is secured by three or four $\frac{1}{16}$ in. or 10 B.A. screws at the bottom edge of the firebox. Boiler bands, which hold the lagging sheets on a full-size engine, can be made from narrow spring steel, which is a commercial article procurable from any metal merchant. Alternatively, they can be made from



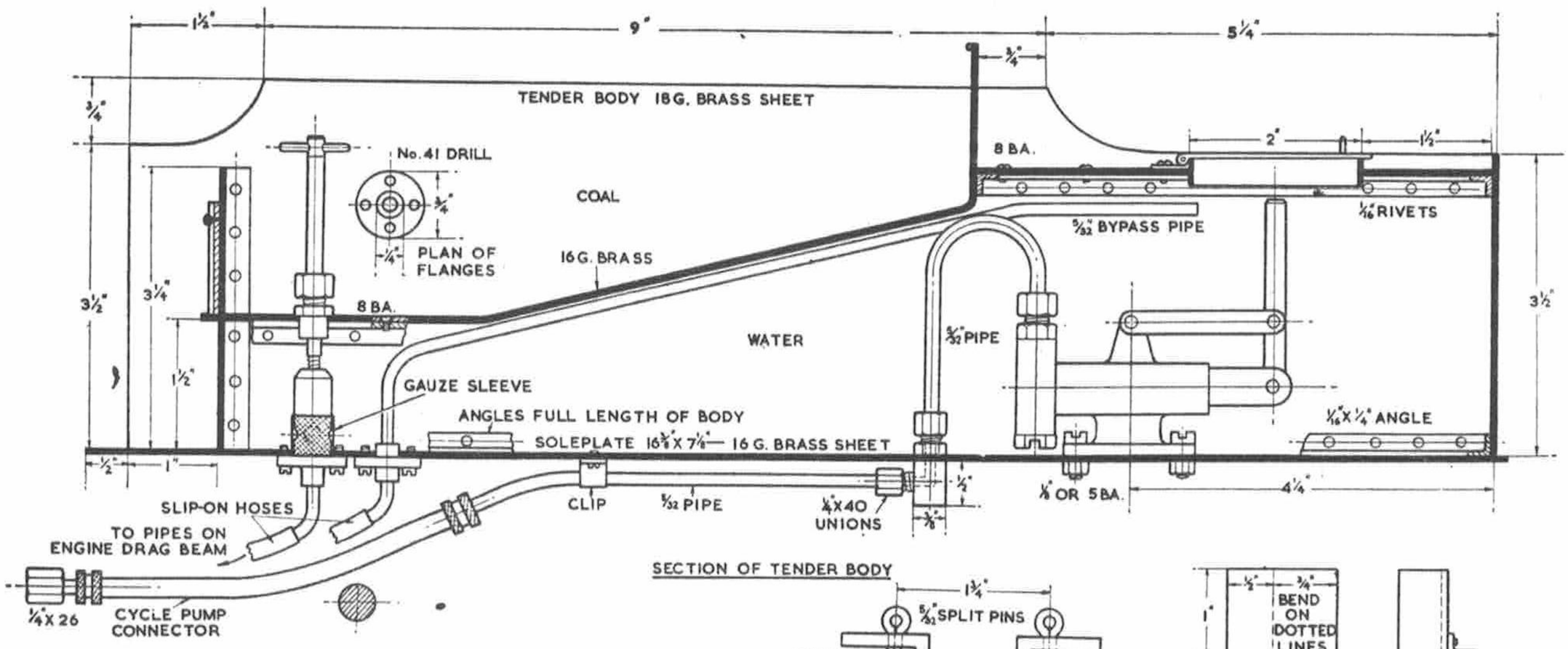
GENERAL ARRANGEMENT



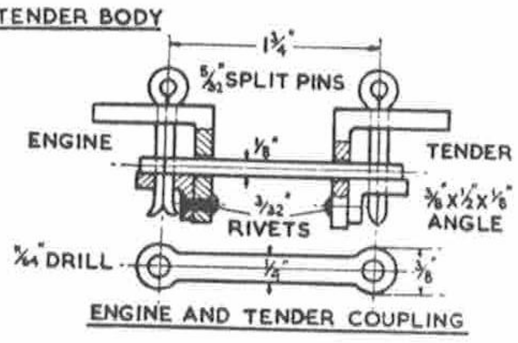
FRAME PLATE



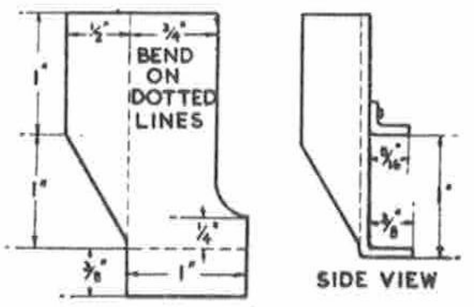
FRAME ASSEMBLY AND DETAILS



SECTION OF TENDER BODY



ENGINE AND TENDER COUPLING



TENDER STEP

the narrow brass strip known in the metal trade as "ticket wire"; personally I use this. Pieces are cut to the same length as the circumference of this boiler barrel. A full ⅛ in. of each end is bent at right angles with pliers, and a No. 50 hole drilled through. The band is then put around the boiler barrel, and secured by a 1/16 in. or 10 B.A. screw and nut through the lugs, the joint being underneath. The screw couplings are just the same as on *Mona*. Well, that's about all for the engine part; all we now need is a tender.

As the work involved in the tender is precisely the same as the engine, there is no need to go into details again. Sheet steel 3/32 in. thick is plenty strong enough for the frames, as there are no driving stresses to withstand, and it is easier to cut out. All dimensions are shown on the drawing. Rivet a 4 in. length of 5/16 in. x 3/32 in. angle in the middle of the top edge at each side, to which the soleplate is attached. The buffer and drag beams are the same as on the engine, but the holes for the buffers are tapped instead of plain. The frames can be attached to the beams as on the engine, or brazed into the slots.

The wheel-and-axle assemblies are much the same as the trailing axle of the engine, except that no side-play is required, and the horncheeks and axle-boxes are slightly different in size. The cast horn-cheeks only need cleaning with a file, and riveting at each side of the frame slots. The cast dummy leaf springs are drilled 5/16 in. to take a cup made from 5/16 in. round steel, drilled No. 10 to take a 3/16 in. spring, as shown in the section. The castings are riveted to the frame with the bottom of the hoop at 1/16 in. above the slots. The axle-boxes are machined up in the same way as the trailing boxes on the engine, and the hornstays, which prevent them falling out, are 1⅛ in. lengths of 5/16 in. x 3/32 in. strip steel secured by 3/32 in. screws tapped into the feet of the horncheeks. Hexagon heads may be used if preferred.

The instructions for turning the engine wheels apply to the tender wheels, which are finished to the sizes shown, and pressed on to ⅜ in. steel axles. The journals are shorter than those of the trailing axle on the engine, as no sideplay is required.

Tender body.

The soleplate is a piece of 16-gauge brass sheet measuring 16⅜ in. x 7⅛ in. and is attached to the tops of the beams and the side angles by 6 B.A. screws put through No. 34 clearing holes and nutted underneath. This allows the body to be removed from the frame at any time simply by taking off the nuts. If a piece of 18-gauge sheet brass is available which is long enough to form the sides and back of the body, they can be made in one piece by bending at the corners. Otherwise, use two pieces, each forming one side and half the back, with a butt joint in the middle of the back, the butt strip being inside. When the joint is soldered and smoothed off outside, it will be invisible when painted. The body is attached to the soleplate by pieces of ¼ in. x 1/16 in. angle brass riveted to the sides and back along the bottom edges, and screwed down to the soleplate by 3/32 in. brass screws.

The front plate needs a piece of 18-gauge sheet brass 3¼ in. wide and 7½ in. long. Bend over a full ⅜ in. of each edge to form flanges, and cut a hole 1¼ in. x 1⅝ in. for the coal gate. Rivet a runner made from 3/32 in. x 3/16 in. rod at each side of this as shown, then rivet the front into the body at 1 in. from the end as shown. The joints between body and soleplate are then soldered over to make them watertight. Do this with a soldering-bit; don't be tempted to use a blowpipe or lamp, or the sheet metal will buckle and go all shapes, and you'll never get it to lie flat any more.

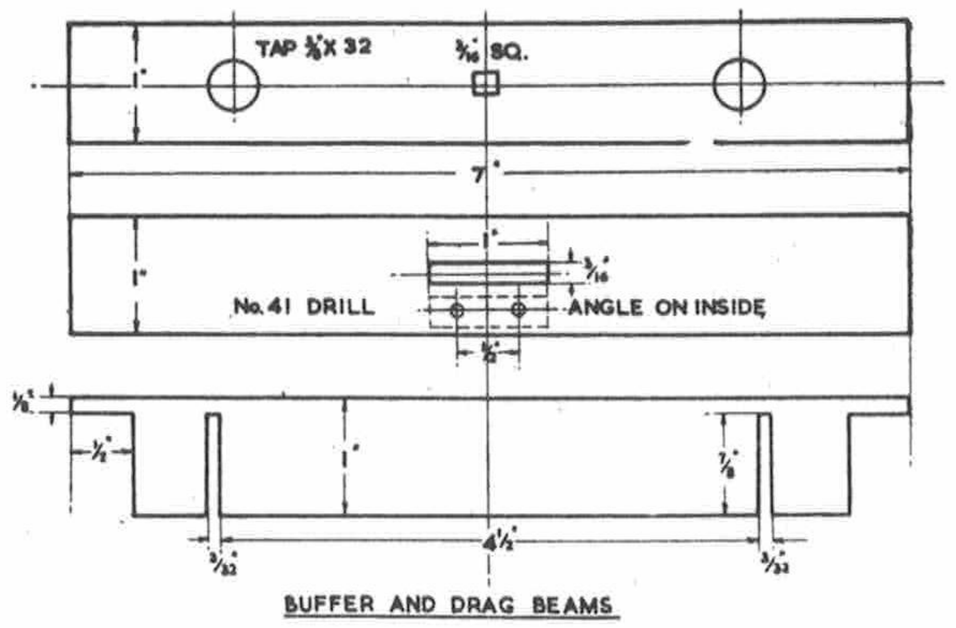
The coal plate will need a piece of 16-gauge sheet brass 11 in. long and wide enough to fit nicely between the sides of the body. Bend it to shape as shown, and cut away ¼ in. of the front at each side, to leave a tongue which projects through the coal gate. The plate is supported by angles at each side. To locate these, I cut a piece of cardboard to the shape of the underside of the coal plate along one edge, and straight along the other, the length being the same as the plate. This is placed in the tender

at each side, and a line scribed on the brass sheet, using the top of the cardboard template as a guide. The angles are riveted to the tender sides, level with the scribed lines. They will then be exactly level. The coal plate is screwed down to them by 8 B.A. countersunk brass screws, and soldered all round to make it watertight. Don't forget the bit under the tongue at the front end!

The back part of the tender top has to be removable. At ¼ in. from the top, along the sides, back, and at the back of the vertical part of the coal plate, rivet lengths of ¼ in. x 1/16 in. angle brass. Cut a piece of 18-gauge sheet brass to fit nicely in the opening. At 1½ in. from the end of this, cut an opening 2 in. x 1 in. for the filler. Solder a strip of brass 5/16 in. wide, bent to the shape of the hole, into the opening, and fit a hinged lid as shown. When the fittings are installed in the tank, this cover is secured by 8 B.A. roundhead brass screws put through No. 43 clearing holes close to the edges, into tapped holes in the angles. A beading of 3/32 in. half-round wire can be soldered all round the top edge of the body to give a finish, and at the front end it is projected and bent around the ⅛ in. handrail pillar, as shown in the general arrangement. The bottom of the pillar is screwed into a tapped hole in the soleplate, with a nut on the thread acting as a stop.

Internal fittings.

The fittings inside the tank consist of two screw-down water valves, for pump and injector, a pipe for water being bypassed from the engine pump, and an emergency hand pump. The flange section of the water-valve is made from ¾ in. brass rod. Chuck, face, centre, drill No. 34 to ⅝ in. depth, turn 3/16 in. length to 5/16 in. dia. and screw



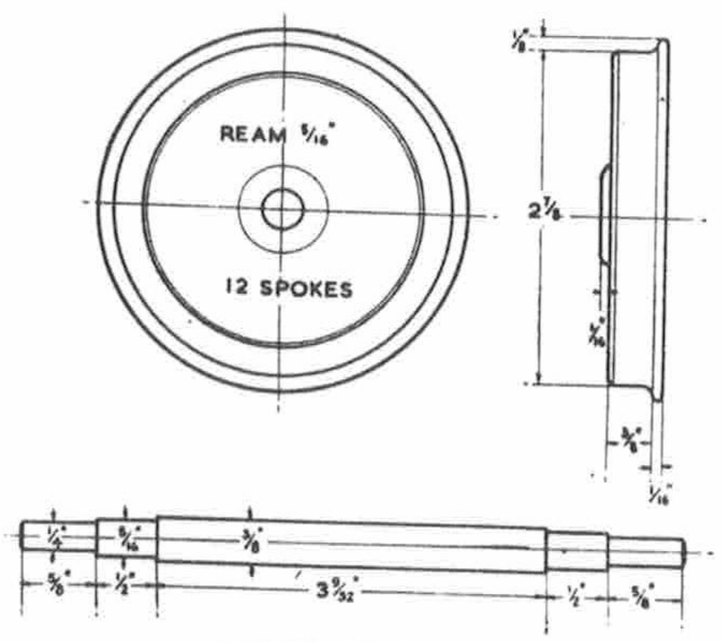
BUFFER AND DRAG BEAMS

5/16 in. x 32. Face off 1/32 in. to form a true seating for the valve pin. Part off at 5/16 in. from shoulder, rechuck in a tapped bush, turn 3/16 in. length to ⅛ dia. and counterbore the hole for ⅛ in. depth with No. 23 drill. Silversolder an inch of 5/32 in. copper tube into the counterbore.

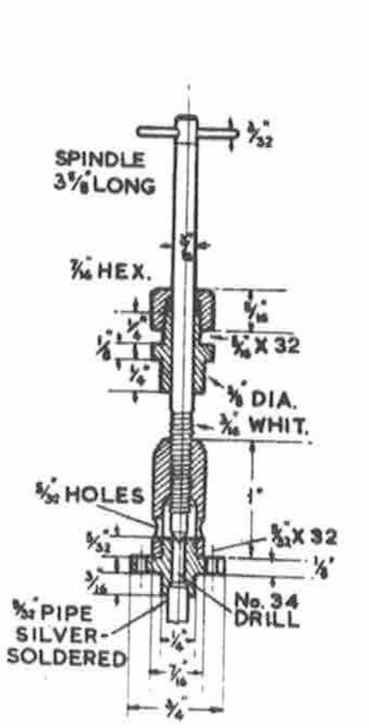
Chuck a length of 7/16 in. rod, face, centre, drill No. 25 for 1⅛ in. depth, open out to ½ in. depth with letter J or 9/32 in. drill, and tap 5/16 in. x 32. Part off at 1 in. from the end, reverse, chamfer the edge, and tap the hole 3/16 in. Whitworth. Drill two 5/32 in. crossholes at 3/16 in. from the tapped end. Drill the screwholes in the flange section and screw the fitting on to it. The valve pin or spindle is a 3⅝ in. length of rustless steel or drawn bronze, one end being turned to a point and screwed 3/16 in. Whitworth for 1¼ in. length. The top is drilled No. 43 and a cross-handle of 3/32 in. silver-steel wire squeezed in. The gland is made from 7/16 in. hexagon brass rod as shown.

At 1 in. behind the front plate of the tender body, and 1¼ in. each side of centre, drill a ⅜ in. hole in the coal plate, and carry on right through the soleplate, so that both holes are in line. Solder the bottom part of the gland fitting into the top hole, and open out the hole in the soleplate to 15/32 in. Wrap a piece of copper or brass gauze around the valve, to cover the holes and act as a strainer, so that no grit can get to pump and injector. Fit the valve in the hole, and secure it with four 3/32 in. brass screws through the holes in the flange, into tapped holes in the soleplate. Put a thin Hallite or similar jointing gasket between flange and soleplate. Put the gland nut on the spindle and screw the spindle through the fitting on the coal plate, into the valve underneath. Pack the gland with graphited yarn. The whole set-up is clearly shown on the drawings. The pipe is bent in a curve towards the front of the tender; and when the engine is on the road, both pipes are connected to the feed pipes under the engine drag beam by pieces of rubber pipe slipped on. No fixing is required, as there is no pressure in the pipes. The enginemen call these hoses "feed-bags".

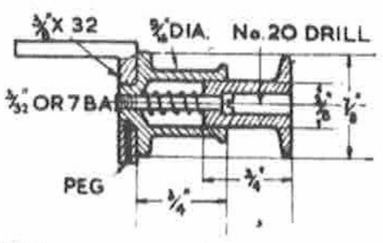
The bypass flange is made in a similar manner, but the upper part is plain, and has a long 5/32 in. pipe silver-soldered into it. This reaches to the filler opening as shown, so that the amount of water being bypassed can be seen by the driver. The flange is attached to the soleplate in the same way as the flanges of the valves, being located just behind the right-hand water-valve.



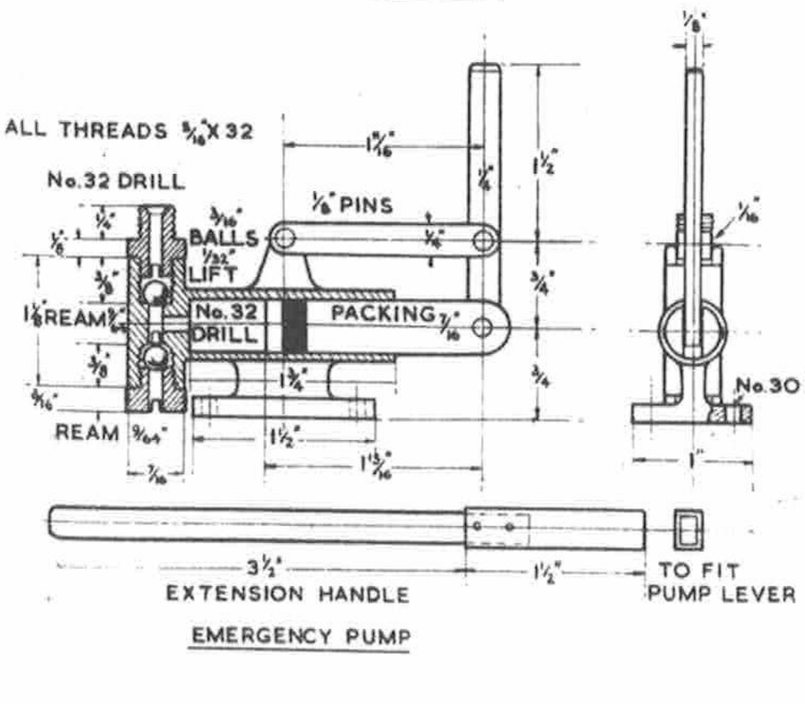
WHEEL AND AXLE



WATER VALVE



TENDER BUFFER



EMERGENCY PUMP

Emergency hand pump.

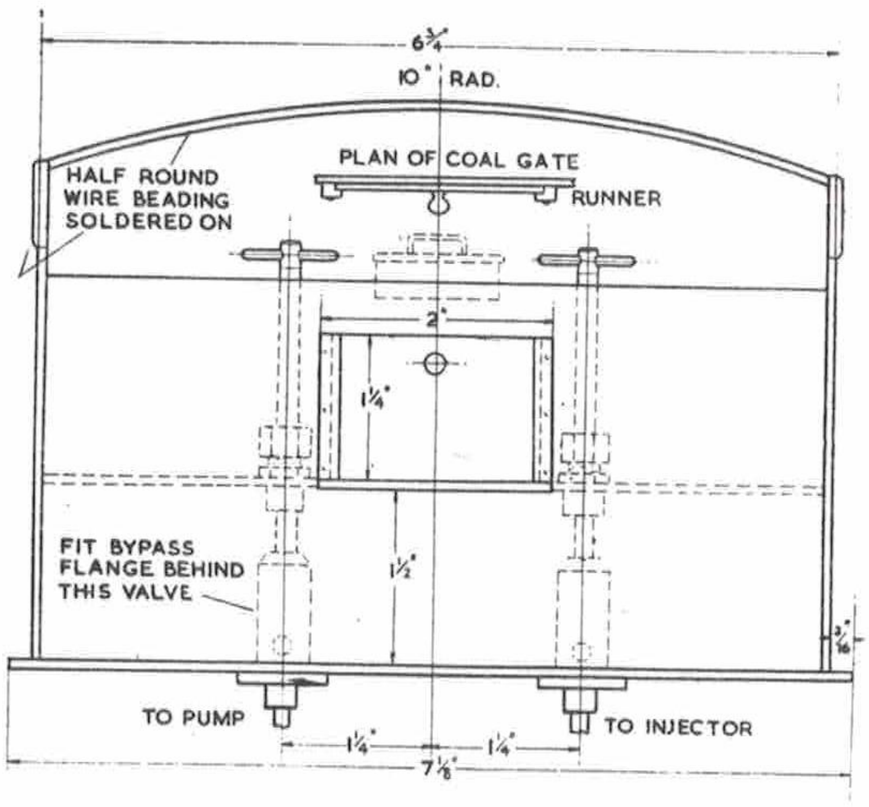
The hand pump is made from a casting, which should be chucked in the four-jaw with the upper end of the valve-box running truly. Face, centre, drill through No. 30, open out and bottom to $\frac{3}{8}$ in. depth with 9/32 in. drill and D-bit, and tap 5/16 in. x 32. Chuck a bit of $\frac{1}{2}$ in. rod in three-jaw, turn 3/16 in. to 5/16 in. dia., screw 5/16 in. x 32 and screw the pump valve-box on to it. The other end of the valve-box can then be machined likewise, but don't use the D-bit. Instead, nick the bottom of the hole as shown. Put 9/64 in. reamer through the remnant of small hole left.

There should be a chucking-piece cast on opposite the barrel. Grip this in the three-jaw tightly. Face the end of the barrel, which should be set to run truly. Centre and drill a No. 32 hole right through into the valve-box. Open out and bottom to $1\frac{3}{4}$ in. depth with 7/16 in. drill and D-bit. A piece of 7/16 in. rustless steel or drawn bronze rod should fit this without any turning. Part off a piece a full 2 in. long, chuck it and turn a groove 3/16 in. wide and $\frac{1}{8}$ in. deep at $\frac{1}{8}$ in. from one end, slot the other end $\frac{1}{8}$ in. for the lever, and cross-drill it No. 32 for the pin. Round off the end as shown.

The valve balls and caps are fitted in the same way as those in the engine pump, except that there is no union screw under the bottom fitting, a slot being filed across the hexagon part instead. The lever is made from $\frac{1}{8}$ in. x $\frac{1}{4}$ in. nickel-bronze or brass rod to dimensions shown, the links being made from $\frac{1}{4}$ in. x 1/16 in. strip of similar material. The pins should be of rustless steel or drawn bronze. Rivet over the ends slightly so that they cannot come out.

The complete pump is attached to the soleplate in the position shown in the section of the tender body, so that when the lever is vertical, it is exactly in the middle of the filler opening. It is fixed to the soleplate by four $\frac{1}{8}$ in. or 5 B.A. screws through No. 30 holes drilled in the pump base and soleplate, and nutted underneath. It is operated by an extension handle through the filler hole.

A swan-neck of 5/32 in. pipe connects the pump to the elbow union in the soleplate, as shown in the section. To make this, chuck a piece of $\frac{3}{8}$ in. rod in three-jaw, face, centre and drill to $\frac{3}{4}$ in. depth with No. 32 drill. Turn $\frac{3}{8}$ in. length to $\frac{1}{4}$ in. dia. and screw $\frac{1}{4}$ in x 40. Part off at $\frac{1}{2}$ in. from shoulder.



FRONT OF TENDER BODY

Drill a 3/16 in. hole in the side, and silver-solder a $\frac{1}{4}$ in. x 40 union nipple into it. The nipple should be drilled No. 32. Drill a $\frac{1}{4}$ in. hole in the soleplate just ahead of the pump (exact position doesn't matter a bean). Poke the screwed end of the elbow through it, and secure it with a locknut inside the tank as shown. The swan-neck is provided with union nuts and cones to suit the pump and elbow, and coupled up as per drawing.

To allow the engine to run around curves, the connecting pipe to the union under the drag beam must be flexible, as it has to stand the pressure of forcing water into the boiler, a slip-on hose won't do. The problem is easily solved by using a commercial cycle-pump connector. This is flexible and will stand the pressure. One end of it is connected to the elbow union by a piece of 5/32 in. tube with a union nut and cone at the end. The other end has a short piece of pipe screwed into it, which carries a $\frac{1}{4}$ in. x 26 union nut and cone for coupling to the union under the engine drag beam. That settles the tank arrangements, and the removable cover can be screwed down to the angles attached to the sides and ends of the rear part of the tank. A piece of 18-gauge steel or brass can be cut to slide in the runners at the side of the coal gate, and furnished with a little turned knob for lifting.

Trimmings.

Buffers with projecting spindles cannot be used on the tender, as the frames are in the way, so they must be made as shown in the section. The socket is turned like that on the engine, but the shank is only $\frac{1}{8}$ in. long and is screwed to suit the hole in the beam. Instead of drilling right through it, drill the shank No. 48 and tap it 3/32 in. or 7 B.A. After turning the head, chuck it by the shank, centre, drill through with No. 40 drill, and counterbore the hole with a No. 20 drill. Fit a spring and assemble the buffer as on the engine, then put a 3/32 in. or 7 B.A. screw down the hole in the head, and screw it home. This will allow the head to slide in the socket, but the head of the screw will prevent the head of the buffer from coming right out. Screw the shanks of the sockets tightly into the tapped holes in the beam, and to prevent them accidentally coming adrift, drill a No. 53 hole in the thickness of the beam, just penetrating the socket screw. Drive in a stub of 16-gauge silver-steel, and file flush.

The drawhooks, screw couplings and dummy brake pipes are all made and fitted exactly as described for *Mona*, so there is no need to go through all the ritual again. The engine and tender are coupled by a plain link running through the slots in the drag beams, and are secured by 5/32 in. split pins. I always use these in preference to turned pins, because if you drop one in long grass, it isn't worth the time and trouble looking for it—just get another! The pins are often dropped when coupling up engine and tender on an outdoor line. To get a straight pull, rivet a piece of angle under each drag-beam slot as shown. The steps are cut from 16-gauge steel, the back and bottom step being in one piece. The upper step is riveted on. Leave a tag at the side of the back part, so that it can be bent at right angles and attached to the inner side of the drag beam by countersunk screws and nuts.

As the Southern engines were painted green, I painted my own *Betty* that colour, but the colour is naturally the builder's own choice. I just cleaned all the grease off her with petrol (outdoors for

safety!) and gave her one coat of Valspar with a soft brush. It set hard in four hours. The black was put on after the green had dried. I did the lettering with yellow paint and a very small brush, but the following is a good tip for those who aren't good signwriters. Carefully mark out the figures and letters with a pencil. If you get them cockeyed at the first shot, the pencil marks will wipe off with a damp rag. When O.K. scratch away the paint inside the letters and figures, and the result will be lovely golden letters standing out. Removing the paint lets the brass of the tank sides show through.

Catalogue listed items for 3½" gauge BETTY:-

Drawings (3 sheets) MM923

Main & Trailing Frame Steel
Buffer Beams
Hornblocks (Hot-pressed type)
Axleboxes
Driving & Coupled wheels
Pony Hornblocks
Pony Axleboxes
Pony Spring Pockets
Pony Bolster
Pony & Trailing Wheels
Trailing Hornblocks & Cast Springs
Trailing Axleboxes
Cylinder Castings Set
Piston Blanks
Axlepump & Stay
Eccentric Straps
Eccentric Sheaves
Motion Brackets
Saddle
Smokebox Door & Ring
Chimney
Dome

Tender Frame Steel
Tender Buffer Beam Steel
Tender cast Springs
Tender Hornblocks
Tender Axleboxes
Tender Wheels
Handpump Casting & Tee
Buffer Heads & Stocks

Also available:
Copper boiler flanged plates.
All-copper boiler material set including flanged plates (but excluding solders, fluxes & bush materials).
Rolled & jointed brass smokebox tube.

Transfers "SOUTHERN"

All above items may be purchased from A J Reeves & Co(Birmingham(Ltd.

Holly Lane
Marston Green
Birmingham B37 7AW 021-779-6831
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