screw the end through the hole in the top of the stand until the head of the bearing just touches the side of the tank; then run the locknut back against the inside of the tank, and tighten it. The check valve can then be tightened also; when right home, it should be as shown in the drawing, with the union nipple pointing toward the back.

It is hardly worth while fixing up the necessary arrangement to cut a ratchet wheel when one can be obtained from our good friend Reeves, and anyway, very few builders would have the dividing attachment and cutter. The wheel should be drilled No. 43, which is a squeeze fit for the crankshaft. Press it on the longer-threaded end until approximately ¼ in. from the end of the shaft, and be sure that you put it on the right way, with the upper teeth sloping to the right, so that it will turn clockwise. Now put the crankpin through the hole in Pat's "little big-end," and hold the crank against the end of the bearing; the shaft can then be inserted through the bearing and screwed into the crank. When right home, there should be just the weeniest bit of endplay, not more than 1/64 in. at the most

The lubricator can now be tested. Put enough oil in it (any kind will do) to reach to the cylinder trunnion, and turn the ratchet wheel slowly until oil comes out of the union nipple on the check valve. Put your thumb over the nipple, squeezing it as hard as possible, and turn the ratchet wheel again. No matter how strong you are, you won't be able to prevent oil coming from the nipple, it will just push your thumb aside, provided that the workmanship on the lubricator is up to average. Should the ratchet wheel slip on the shaft, it should be silver-soldered, and any silver solder which runs on the shaft or sticks to the sides of the wheel, should be very carefully turned off, with the shaft held in the chuck, and a knife-tool in the slide-rest. Otherwise you won't be able to fit the ratchet gear properly.

This is a simple job, the lever being filed up from a bit of 3/32 in. x ¼ in. steel, and drilled No. 41 at the top, to fit on the shaft. At 5/16 in. below, drill a No. 48 hole and tap it 3/32 in. or 7 B.A. for the screw attaching the driving pawl. The three No. 48 holes at the bottom, are to allow the drive-rod being adjusted to regulate the feed. The pawls are filed up to shape shown, from 3/32 in. steel; rather a "watch-making" job, but only requiring care. If flat-ground cast steel (as used for making gauges) is available, use it, as the pawls can then be hardened right out. If mild steel is used, they must be case hardened, by heating to bright red and rolling in some good case hardening powder, such as "Kasenit," "Pearlite," etc. Reheat until the powder all fuses and the yellow flame dies away, then quench in cold water. The pivot holes in both pawls are drilled No. 41.

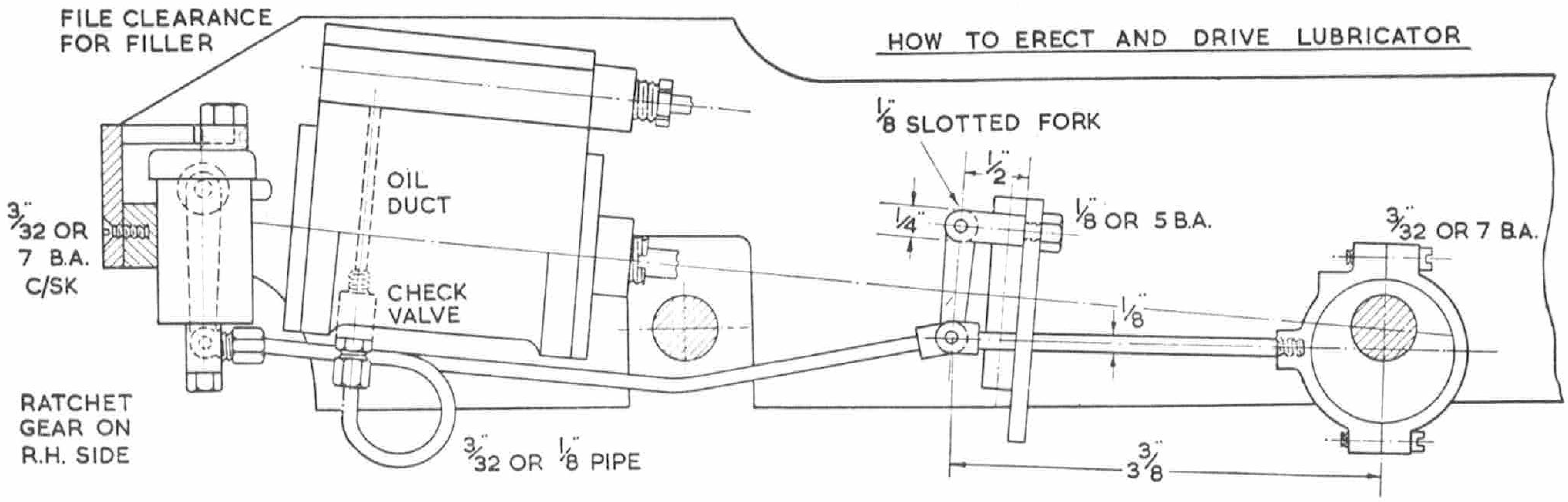
The drive pawl is attached to the lever by a screw having a full 3/32 in. of "plain" under the head, so that when screwed right home in the lever, the pawl is still free to move. It can be turned from a bit of 3/16 in. steel. I make all my own special screws, simply turning to required diameter and length with a knife-tool, from rod held in the chuck, and finishing with a die in the tailstock holder. Part off, slot the head with a saw, and there we are! The spring which keeps the pawl pressed to the wheel, is wound up around a 1/16 in. rod, from thin steel wire, about 30-gauge, and the ends hooked through holes drilled in the tail of the pawl, and the lower part of the ratchet lever, as shown.

The check pawl is mounted on a stud screwed into the little block attached to the tank. Chuck a bit of 3/16 in. steel rod, and turn down 7/32 in. length to 3/32 in. dia. then slip the check pawl over it, and turn down the bit that projects, to 5/64 in. dia. and screw it 9 B.A. Part off at 7/32 in. from shoulder, reverse in chuck, and turn down ⅛ in. of the other end to 5/64 in. dia. also screwing 9 B.A. Drill the little block with No. 53 drill, tap 9 B.A. and screw in the stud, mounting the check pawl on the plain part and securing with commercial 9 B.A. nut. This pawl must also be free when the nut is tight. It is kept in contact with the wheel by a wire spring, like those on the cheap alarm-clocks "made in Germany." Bend up the spring from a bit of 16-gauge steel wire as shown, and attach it to the tank by a 9 B.A. screw nutted inside the tank. The illustrations show how the lever is erected, and it is secured by a nut and washer. When the nut is tight, the lever should be free to swing, but not wobble about endwise. It's merely a matter of careful adjustment!

HOW TO ERECT AND DRIVE THE LUBRICATOR

FIRST drill two No. 41 holes in the buffer-beam, at 3/16 in. from the bottom, and 7/32 in. each side of the centre, and countersink them. Hold the lubricator against the beam, with the bottom of the fixing block level with bottom of beam, run the drill through the holes, making countersinks on the block, remove lubricator, drill the marked places No. 48 and tap 3/32 in. or 7 B.A. Replace lubricator and fix with countersunk screws. Don't forget to fit the filler to the lid before erecting "for keeps." Drill a 5/16 in. hole in the lid at the place shown in drawing. To make the bush, chuck a bit of ⅜ in. brass rod, face the end, and turn down 1/16 in. length to fit the hole. Part off at ¼ in. from the end, reverse in chuck, centre, drill right through with 7/32 in. drill, slightly countersink the hole, and tap ¼ in. x 40. Solder the bush into the lid. For the plug, chuck a piece of ⅜ in. hexagon rod, face off, turn 3/16 in. length to ¼ in. dia. and screw it ¼ in. x 40, part off at ⅛ in. from shoulder, reverse and chamfer the corners. File a clearance for it in the top of the beam.

Now for the drive. Make a fork, same as those in valve gear, from ¼ in. square rod, with a ⅛ in. screwed shank, ⅛ in. slot ⅜ in. deep, and a No. 41 cross-hole. Fit this to the hole at the top of the motion-plate as shown. The suspension lever is filed up from a piece of ⅛ in. x ¼ in. steel, the hole at the top drilled No. 41 and the bottom No. 43. The bottom pin, which is a squeeze fit, is a piece of 3/32 in. round silver-steel ⅝ in. long, with a bare ⅛ in. at each end turned down very slightly and screwed 8 B.A. The top pin is similar, but only ½ in. long, and a push fit in the fork. Put the top of the suspension lever in the fork, and secure it with the shorter pin, but make sure it swings freely when the nuts are tight.



HOW TO ERECT AND DRIVE LUBRICATOR

The eccentric-strap is turned up from a casting in exactly the same way as described for the valve-gear eccentrics, and fitted in similar fashion to the middle eccentric. The lug is tapped $\frac{1}{8}$ in. or 5 B.A. for the eccentric-road, which is a piece of $\frac{1}{8}$ in. round steel $2\frac{3}{4}$ in. long, one end being screwed to fit the lug, and the other turned down to 3/32 in. for $\frac{1}{8}$ in. length and screwed to fit a tapped hole in a little block of $\frac{1}{8}$ in. brass shaped as shown, and drilled No. 41 to fit the bottom pin in the suspension lever. A similar block of brass is fitted to a piece of $\frac{1}{8}$ in. steel a bare 6 in. long, the other end of this being furnished with a fork made from 7/32 in. square steel, slotted to fit the bottom of the ratchet lever. The boss of the fork is drilled No. 48 and tapped 3/32 in. or 7 B.A., with the fork held truly in the four-jaw chuck. The end of the rod is turned down for $\frac{1}{4}$ in. length to 3/32 in. dia. and screwed to fit. The rod is bent to line up with the suspension and ratchet levers, as shown in the right-hand photo in the issue mentioned, which shows at a glance more than I could explain in half-a-page of instructions.

The eccentric-rod goes through the hole in the motion-plate, and the block on the end is put over the left-hand side of the bottom pin in the suspension lever and secured by a nut. The block on the drive rod goes over the other side of the pin, and nutted, both being left free to move when the nuts are tight. The fork at the front end is connected to the ratchet lever by a pin made from 15-gauge spoke wire, screwed 9 B.A. at each end, and furnished with nuts. When the wheels are turned by hand, the ratchet should click one tooth at each revolution. If it doesn't, either the fork needs adjusting on the drive rod, or shifting to the next hole higher up.

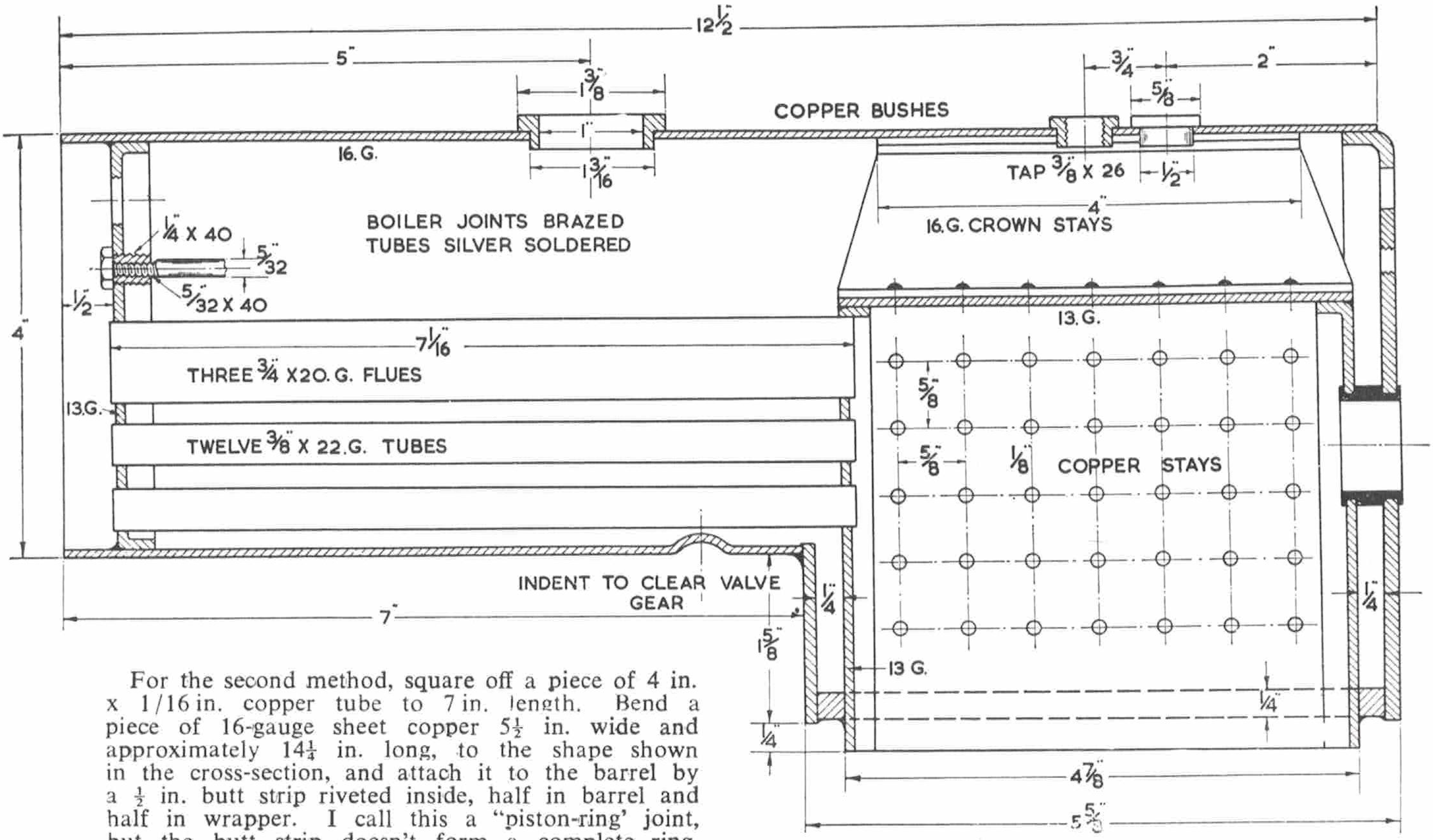
Screw the longer check valve into the tapped hole at the bottom of the oil duct in the cylinder casting, and connect the union on it, to the one under the oil-tank by a piece of thin-walled 3/32 in. pipe (or $\frac{1}{8}$ in. will do at a pinch) with union nuts and cones on each end, bending the pipe to the shape shown. For nuts, chuck a piece of 5/16 in. hexagon rod, face, centre, drill No. 40 or 30 to suit pipe, open out with 3/16 in. drill to 3/16 in. depth, tap 7/32 in. x 40, part off at $\frac{1}{4}$ in. from the end, and chamfer corners. For cones, chuck a bit of 3/16 in. rod, centre, drill to suit pipe, bevel off the end, and part off just behind the bevel. Silver-solder the cones to the ends of the pipe, the exact length of which can be obtained by bending a piece of soft wire to desired shape, and then straightening it out.

Boiler for $3\frac{1}{2}$in. gauge engine

The boiler described in the following notes is one of my "standard" types, the result of a life-time's experience. It is perfectly easy to make and erect by any builder who has the average amount of patience, perseverance, a five-pint blowlamp, and a few simple requirements. It is quite probable that he will also develop a five-pint thirst ere the job is through—but won't need any instructions for dealing with that! Lucky owners of oxy-acetylene or oxy-coal-gas equipment will find the job a piece of cake. I used an oxy-acetylene blowpipe for my own **Mona** boiler, and the joints are perfect and bottle-tight.

There are three ways of making the outer shell: first, a piece of 4 in. x 16-gauge seamless copper tube can be used for both boiler-barrel and firebox wrapper; secondly, the barrel can be made from tube, and the wrapper from 16-gauge sheet copper, the two being butt-jointed; thirdly, barrel and wrapper can be rolled up and bent from 16-gauge sheet copper, the barrel having a lapped seam which is underneath and out of sight. I used the first-mentioned, as I had a piece of 4 in. x 16-gauge tube in stock. I first hacksawed off a piece $12\frac{3}{4}$ in. long, wrapping my flexible steel rule around the tube to scribe the line, then I sawed round the line with a fine-tooth sawblade in the frame. This left the ends nice and square. A piece of hardwood was then pushed into one end, which was gripped in the lathe chuck, and the other end supported by a steady, while the end of the tube was cleaned up with a roundnose tool set crosswise in the rest. The tube was then reversed and the other end given a dose of the same medicine. However, the ends can be squared off with a file quite well, by anybody who doesn't want to set up the job in the lathe, or who hasn't a big chuck.

At $5\frac{1}{2}$ in. from one end, the tube was cut across with a hacksaw until the cut was $3\frac{1}{2}$ in. long, and then a longitudinal cut was made from the end to meet the cross cut. The sawn section was then made red-hot and quenched in water to soften it, after which the copper was bent outward at each side of the cut, to the shape shown in the cross section. Now the opened-out part wasn't long enough to give the required depth of firebox, so I cut two strips of 16-gauge copper $\frac{3}{4}$ in. wide and $5\frac{1}{2}$ in. long, and attached them to the bottom edges with a $\frac{3}{8}$ in. butt strip riveted on the inside by a few 1/16 in. copper rivets. This is shown in the cross-section by a dotted line.



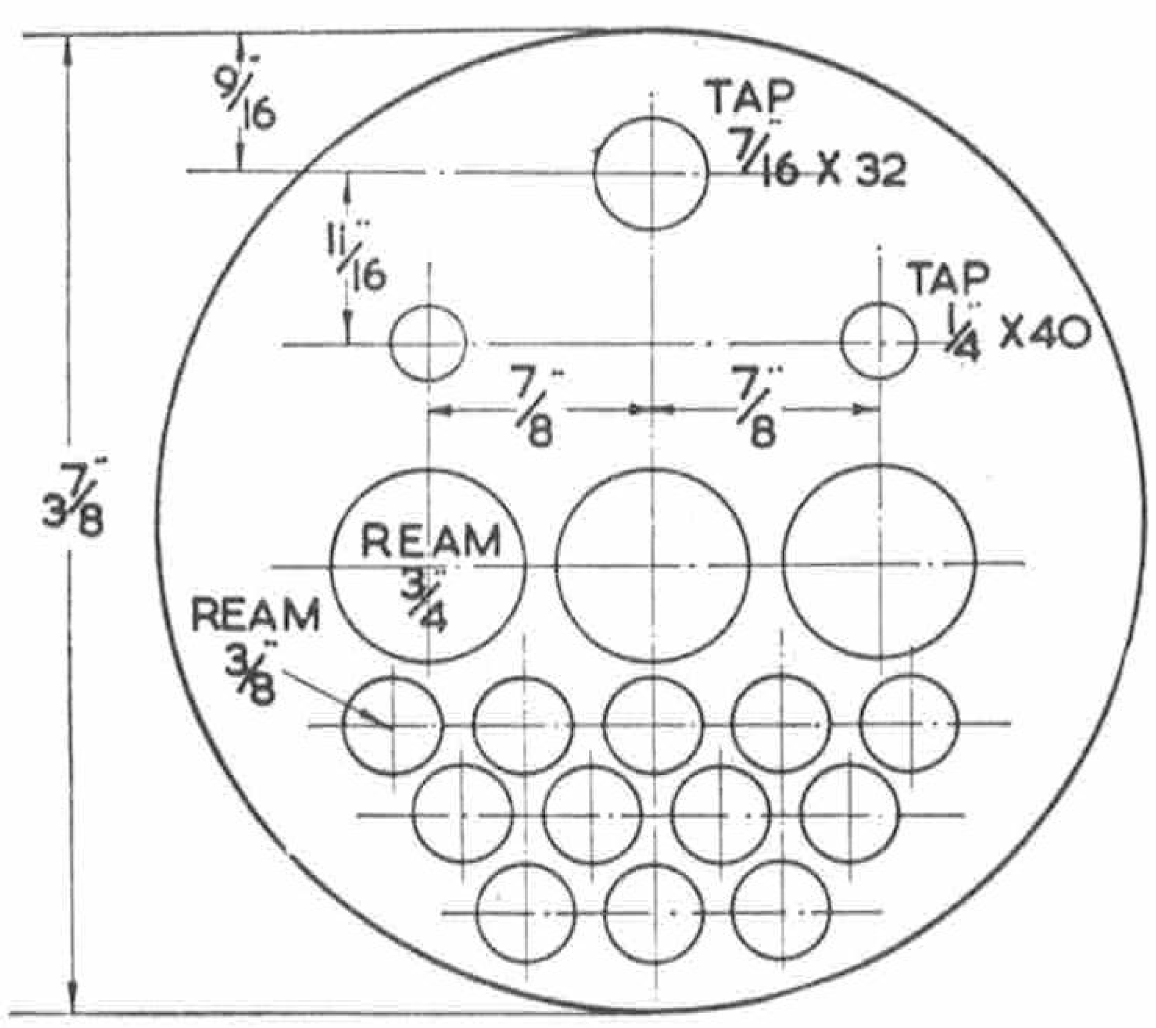
LONGITUDINAL SECTION

For the second method, square off a piece of 4 in. x 1/16 in. copper tube to 7 in. length. Bend a piece of 16-gauge sheet copper 5½ in. wide and approximately 14¼ in. long, to the shape shown in the cross-section, and attach it to the barrel by a ½ in. butt strip riveted inside, half in barrel and half in wrapper. I call this a "piston-ring' joint, but the butt strip doesn't form a complete ring. It only extends down as far as the point where the wrapper leaves the circular form and turns downwards to form the outer firebox casing. Readers may be tickled to know that when I was a small kid, I used to bend up tin boiler barrels around a ginger-beer bottle; that is, if I couldn't find a tin can of the size I wanted! Goodness alone knows how many tin boilers I made. When one rusted through and became more "holey" than righteous, I just went ahead and made a replacement.

The third method needs a piece of 16-gauge sheet copper measuring 12½ in. x 14¼ in. At 5½ in, from one end, on each shorter side, make a sawcut 2¾ in. long. First bend the whole sheet to the shape of an arch; this isn't difficult if the sheet is first softened as mentioned above. I've bent up more than one boiler shell on a piece of rainwater pipe. The 5½ in. section to the back of the sawcut is then bent to the shape of the firebox shell shown in the cross-section. Cut a strip about ⅝ in. wide off each side of the 7 in. section, and bend the remainder into a circle 4 in. dia. putting a few 3/32 in. copper rivets through the overlap. Don't worry about getting it to a true circle at first; that job can be done after the throatplate is brazed in, and the copper will be nice and soft and easy-workable. Well, that settles the shell.

Throatplate

As the throatplate is flanged up on the lower part of the backhead forming plate, this is the next job. It is made from a piece of ¼ in. mild steel, or black iron; maybe cast-iron formers will be available from Messrs. Reeves. The steel is sawn and filed to the shape shown by dotted lines in the drawing of the backhead. Beginners may wonder why the former is only made 3/32 in. smaller than the finished backhead, as this and the throatplate are made from ⅛ in. copper. It is just because the flange will be reduced to that thickness by the time it has been hammered over the edge of the former, and cleaned up with a file. Cast-iron formers, if available, will be of the right size and ready for use; but it will be found quite easy to saw the ¼ in. plate to shape, if some cutting-oil is applied to the sawblade. This is the same stuff used for turning steel in the lathe; I use a 50/50



SMOKEBOX TUBEPLATE

mixture of "Cutmax" and paraffin, which not only does the job, but keeps the lathe nice and clean. Soapy water is also a help in sawing steel, and the quickest way of applying either is to get a mate (an interested kiddy does fine) to feed it on to the sawblade at the point where it is cutting the metal, with an oilcan or some similar gadget with a tube spout. After smoothing off the sawmarks with a file, round off one edge of the former.

Saw out a piece of 1/8 in. sheet copper to the shape and dimensions shown in the throatplate drawing, allowing an extra 1/4 in. each side. Soften this by heating to red and plunging into cold water, then clamp it with the backhead former in the bench vice. The copper should be flush with the bottom of the former, and project the same distance each side; don't have any more standing above the vice jaws than absolutely necessary. With a fair-sized hammer (I use a 2 lb. one) beat the projecting edge of the copper down on to the former. Clean the beaten flanges with a coarse file; the scratches make a champion "key" for the brazing material. Put the finished throatplate between the sides of the wrapper sheet, butting it tightly up against the end of the barrel, clamp it temporarily in place with a couple of toolmakers' cramps, holding the flanges to the wrapper, and fix it with three 3/32 in. copper rivets at each side. Note, these are for holding it in position for brazing, and have nothing to do with the strength of the boiler, so there is no object at all in putting any more rivets in, than will hold the parts in close contact.

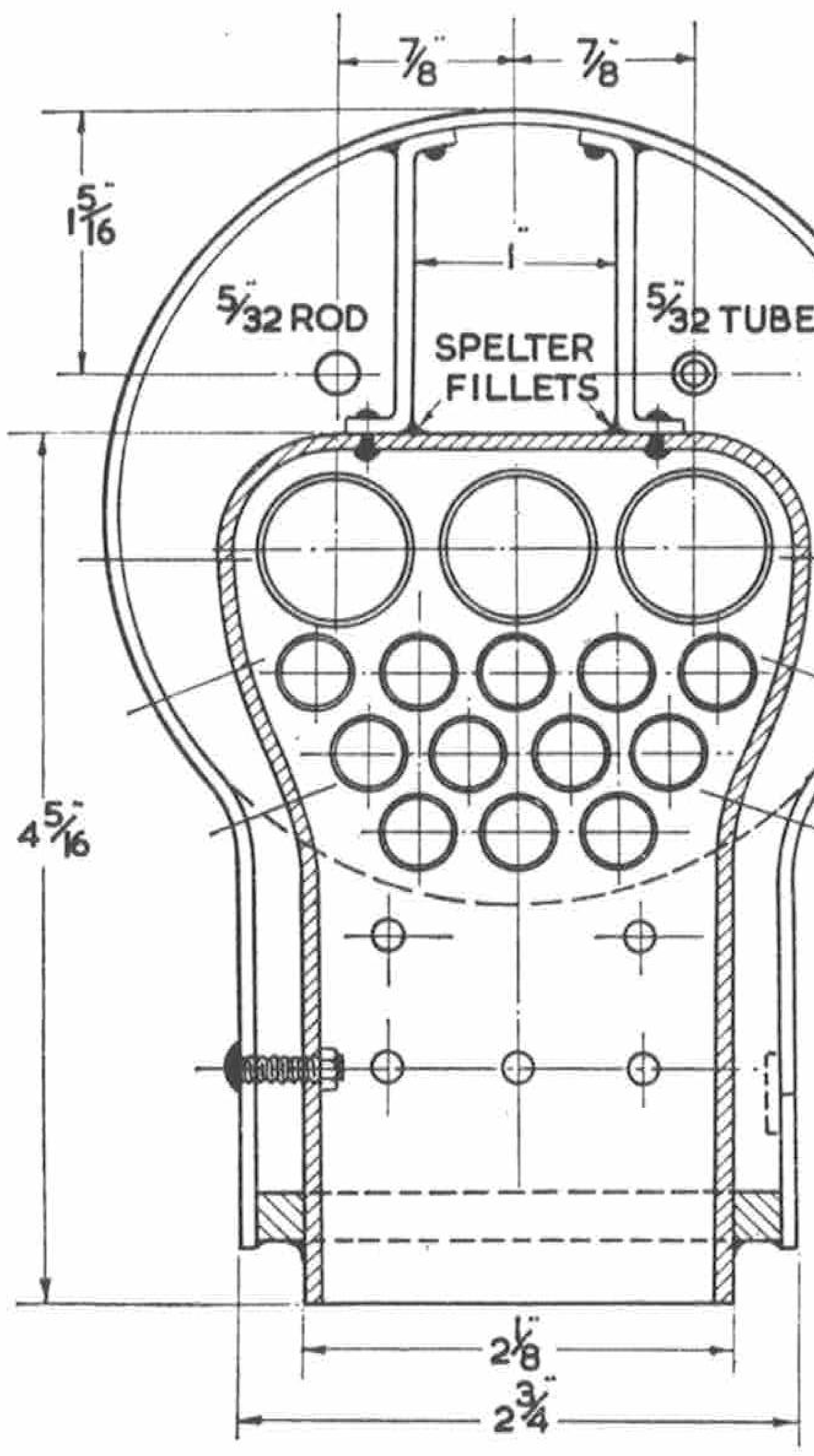
First brazing job

Many beginners are scared stiff at the very thought of brazing a boiler. No need for this at all. A discarded iron tray, even an old tea-tray, makes a swell forge, and a strip of sheet-iron about 9 in. wide, bent around at each end so that it will stand up, does for a back support. Put a layer of small coke or blacksmiths' breeze in the tray. A big pair of blacksmiths' tongs will be required to hold the boiler when hot, and a little pair, which you can make in a few minutes from two pieces of 1/8 in. x 5/16 in. iron strip, twisted at the end and hinged on an iron rivet, are useful for holding short lengths of brazing material or silversolder. For a scratching-wire, bend one end of a 2 ft. length of 1/8 in. iron wire into a loop, and file the other end to a point. Easy-running brazing strip can be purchased by weight at a reasonable price. Johnson-Matthey's B6 alloy is a little dearer, but very free-flowing, and needs less heat. The same maker's Easyflo is the best I have ever used for silversoldering tubes and fittings (and please note this is a friendly tip—I've no shares in the firm!) but best-grade silversolder can be used.

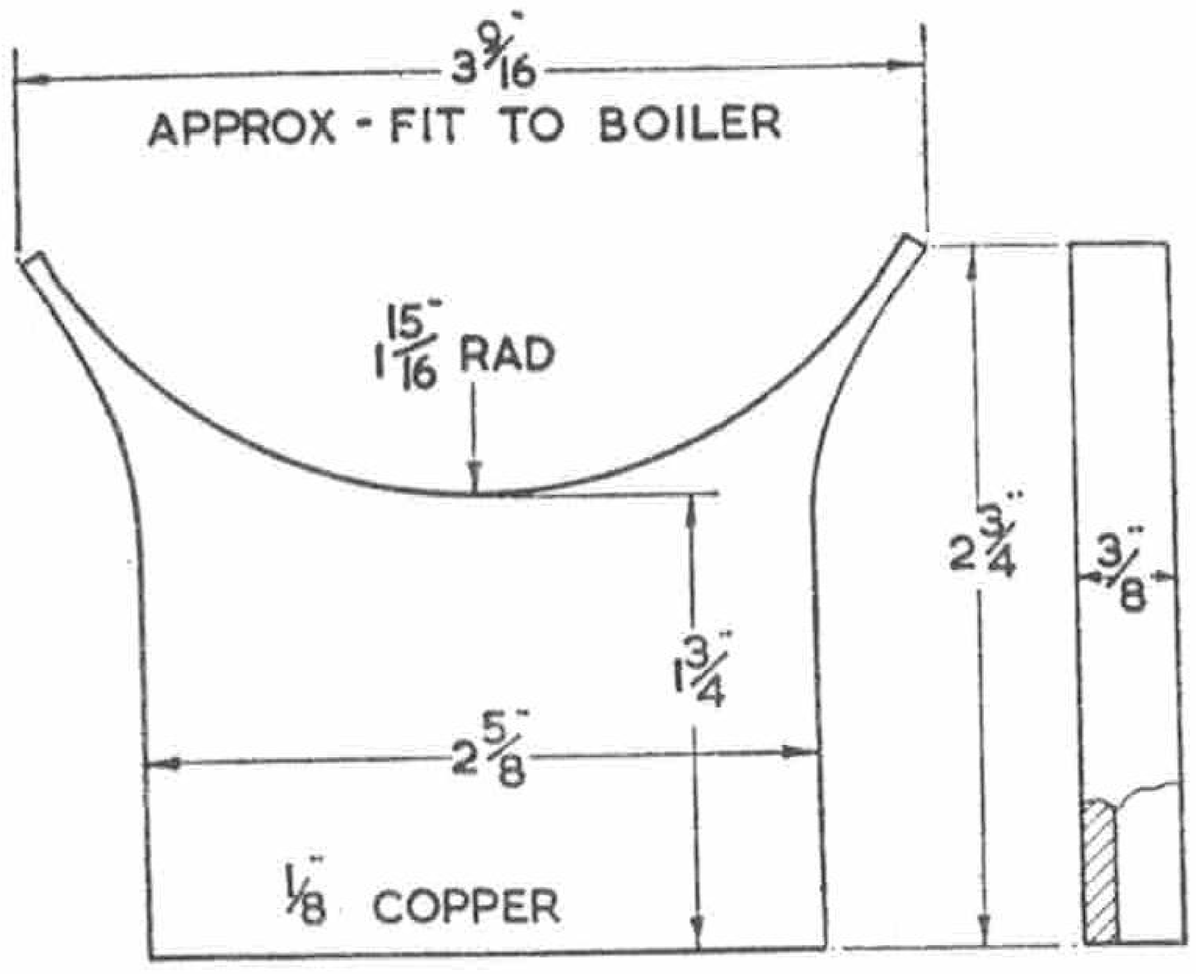
For fluxes, I use Boron (a blue compound sold in tins) for brazing, powdered borax for silver-soldering, and Easyflo flux for the J-M products. To clean the work after brazing, I lined an old wooden box, big enough to take a boiler, with 1/16 in. sheet lead. The corners were folded, just as I folded up little paper boxes when I was a kiddy, so that no joints were needed. This was nearly filled with water, and some commercial sulphuric acid added in the proportion of about 1 to 16, to form an acid pickle. Incidentally the box has long since rotted away, leaving the lead lining intact. Tip to beginners—before starting a brazing job, always see that you have all the requisites at hand, so that the job can be done nonstop; also if the lamp goes out for want of paraffin when halfway through, you've had it.

Now to tackle the job. Mix up some of the brazing flux to a creamy paste with water, and apply thickly to all the joints, then stand the boiler shell in the pan of coke with the barrel pointing skywards. Pile up some coke inside and outside the firebox wrapper, to within about an inch of the throatplate. Get the blowlamp going good and strong, and heat the boiler shell all over until the wet flux starts to boil up. Then concentrate on one bottom corner. When the metal, and the surrounding coke, are bright red—and NOT before; very important that! —dip the end of a piece of brazing-strip into the wet flux and apply it to the joint in the flame. If the heat is O.K. it will immediately melt and flow in. Move the flame along **very slowly**, feeding in more strip as the metal reaches bright red. A very little practice will enable the operator to move the flame along at the right speed to get a continuous flow of metal.

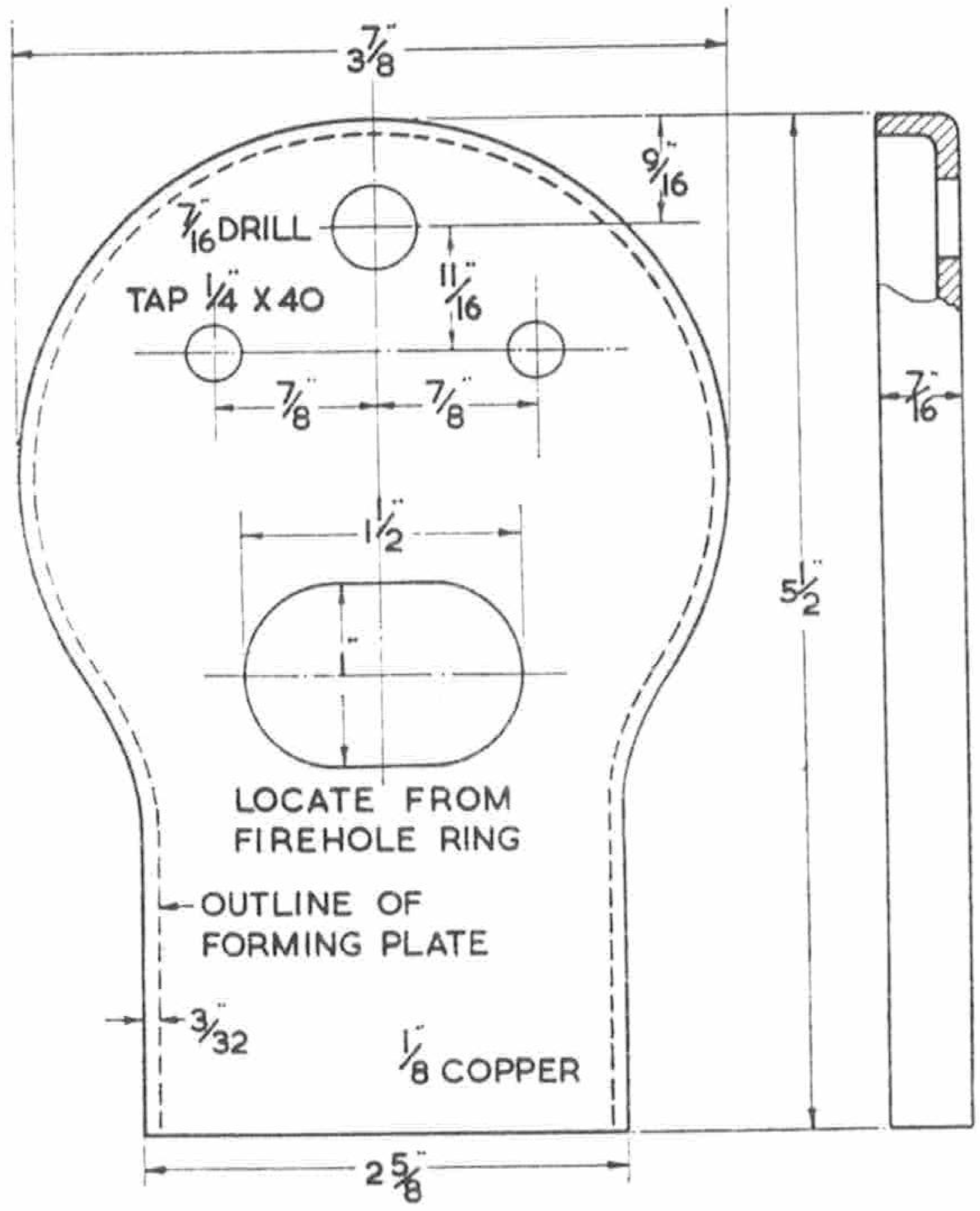
If the boiler-shell has been made by the split-and-open-out process, carry on as above until you reach the barrel; then go along the joint between barrel and throatplate, allowing enough brazing material to flow in, to form a nice, strong fillet between barrel and throatplate. When you reach the end of this joint, don't come down the other side, but restart at the bottom corner, and work up to the joint, same as the first side. When reaching that point, blow the flame on it a little longer, and apply enough brazing material to enable the two ends to amalgamate thoroughly. Sounds worse than it actually is!



SECTION THROUGH FIREBOX



THROATPLATE



BACK HEAD

For the boiler shell with the piston-ring joint, proceed as above, then lay the job on its side in the coke, and play the flame on the start of the circumferential joint between barrel and wrapper. When it becomes bright red, apply first a little silversolder, to kind of "start the ball rolling," then follow up with the brazing strip, going slowly right around until you reach the throatplate on the other side. Warning—avoid going back; once the brazing strip has "set," it will probably crack if reheated. A little silversolder at the finishing-point will help to make a perfect seal.

For the shell bent up from sheet copper, braze the throatplate in as first described, then lay the shell on its back in the coke, start at the open end of the barrel, and work slowly along until the throatplate is reached. Wait until the copper is an extra bright red before first applying the strip, and keep up the same heat all the way along, so that the melted metal sweats right through the lapped seam. Finally always remember that the secret of successful brazing is heat, and plenty of it, combined with sufficient flux to prevent oxidisation, or blackening of the contact surfaces. "Oxidation," by the way, is the correct word, but coppersmiths (especially amateurs) don't always use correct words—nuff sed! It is also a good wheeze to have some dry flux handy in a tin or jar, and keep dipping the strip in it.

Let the shell cool to black, and then put it in the acid pickle, holding with the tongs and standing well clear of splashes. If any get on your clothes or overalls, a spot of ammonia, or any of the washing-powders containing ammonia, will save them going into holes. If any splashes fall on your skin, wash them off at once, or they will set up irritation. Nothing like taking precautions! Leave the shell in the pickle for about 20 minutes, then fish it out with the tongs, well wash in running water, and clean it with a handful of steel wool, or domestic scouring powder. I can't bear handling dirty metal, and it isn't healthy, either, if you have any scratches or abrasions on your hands. Besides, clean metal means far better joints.

I have dilated on this first brazing job, because all the rest are done by the same "technique," and it shouldn't be necessary to waste space by repeating.

READERS who are building the 3½ in. gauge *Mona* will be interested to learn that the original engine is practically completed. When making the original outline drawing as published in the first instalment, I left out all the frills to make the job as simple as possible; but *Mona* in the flesh —or to be more accurate, in the metal—looked so bonny that I couldn't resist the temptation to doll her up. She has a bright chimney top, dome cover and safety-valves, and bright brass bands around the boiler; I have added a double coal-rail to the top of the bunker, and am now fitting her with working brake gear. She is painted dark maroon, with black smokebox and running-boards, and vermilion buffer-beams, and with her polished brasswork she looks a picture. I'm afraid that my old L. & N.W.R. 4-4-2 tank engine *Olga* is feeling quite jealous, as she is all black with no brightwork!

Mona goes as well as she looks. On her very first trial run she did her best to run away with me. The boiler steams like a witch, and the acceleration and pulling power is all that could be desired. However, our worthy editor will be able to tell you more about that when he has tried his hand at engine-driving; meanwhile, let's get on with the instructions.

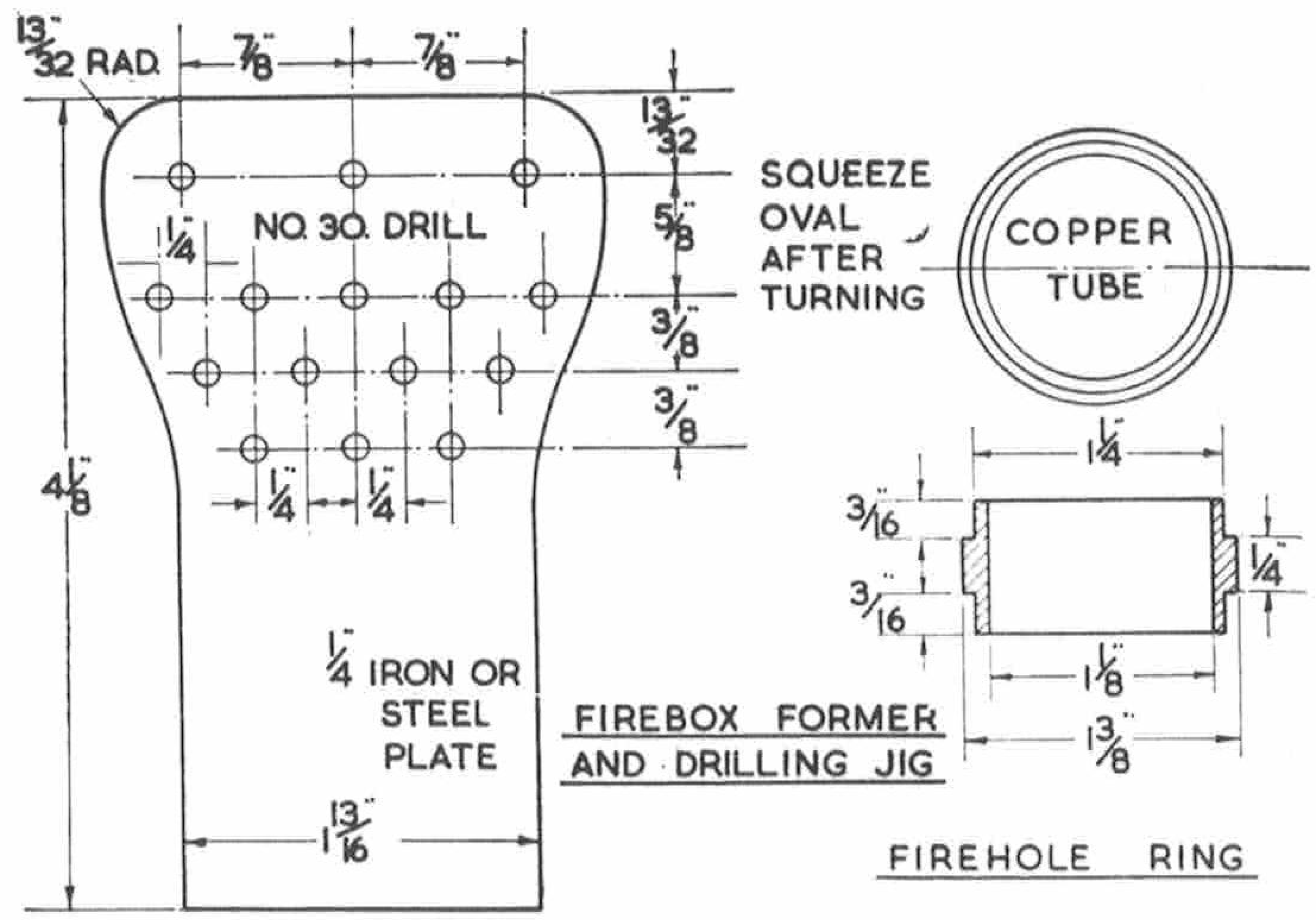
Firebox

The former over which the firebox tubeplate and doorplate are flanged, is cut out of 1/4 in. plate in exactly the same way as the one previously described, one edge being rounded off as before. This one is also used as a jig for drilling the tube holes in both the firebox and smokebox tubeplates; so very carefully set out and drill the holes as shown in the drawing. Lay the completed former on a piece of 13-gauge (3/32 in.) sheet copper, and scribe a line all around except at bottom, at a distance of 5/16 in, from the edge. Saw out the piece, then cut another one exactly the same. Clamp the former and one of the pieces of copper together in the bench vice, with the rounded edge next to the copper, then beat down the copper over the edge of the former. If the copper goes hard under the hammer, and starts to buckle, take it off the former at once, and anneal it by heating to red and plunging into cold water, otherwise it will crack.

When the flanging is done, before removing the plate from the former, put the No. 30 drill down all the holes, and drill right through the copper. Then clean up the flange all around with a coarse file and smooth off any ragged edges. Open out all the holes with 23/64 in. drill; put the "lead" part of a 3/8 in. parallel reamer into each hole in the three lower rows, just far enough to allow the end of a 3/8 in. tube to fit tightly. The three holes in the top row are opened out with a 47/64 in. drill, and reamed just enough to take a 3/4 in. tube. All the holes should be slightly countersunk on the side opposite to the flange.

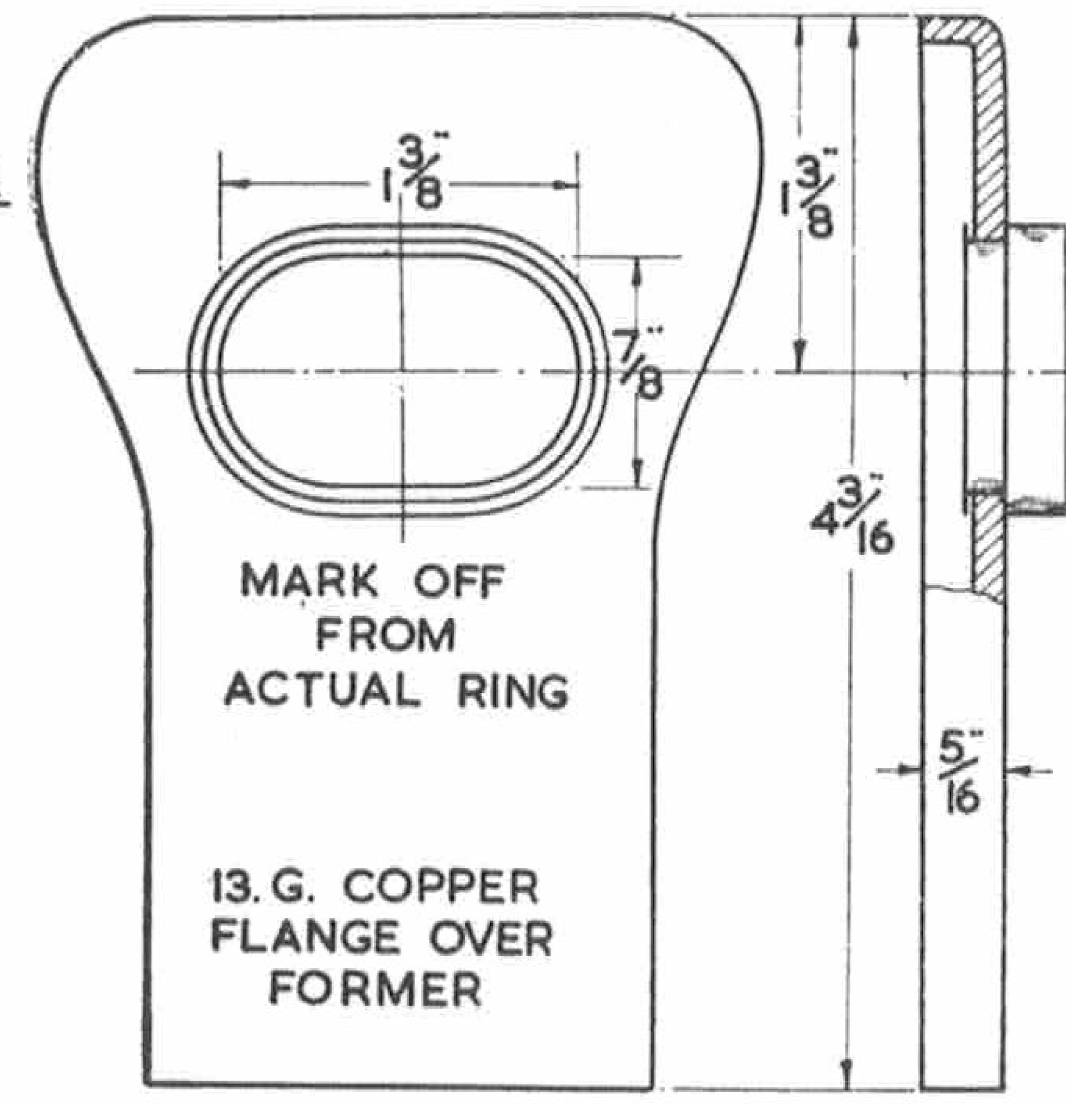
Flange up the second plate, but don't drill any holes in it. The firehole ring has to be fitted to this one. To make it, a piece of copper tube 1 3/8 in. dia. and 1/8 in. thick will be needed. This should be chucked in the three-jaw, and each end faced off; turn a step 3/16 in. long and 1/16 in. deep, leaving 1/4 in. of full diameter in the middle. A little of the cutting oil previously mentioned, is a great help in turning copper. Anneal the turned ring as previously described, then squeeze it to an oval shape in the bench vice, so that the hole will measure 7/8 in. x 1 3/8 in. Lay it on the doorplate so that its centreline is 1 3/8 in. from the top; make sure that it is midway between the sides, then scribe a line all around it. Cut out the piece, either by drilling holes close together all around inside the line, breaking out the piece, and filing to size; or else drilling one hole and cutting out the piece with a piercing-saw, or metal-cutting fretsaw. Push one flange of the ring through the hole on the side opposite to the flange, and beat the projecting lip down, outwards, on to the doorplate, so that the ring is clamped tightly to the plate as shown in the drawing.

The sides and crown of the firebox are made from a single sheet of 13-gauge copper 4 7/8 in. wide. Now sheet copper costs muckle bawbees the noo, ye ken, sae ye mauna waste ony; to get the exact length of the piece required, run a piece of soft copper wire, or fuse wire, around the flange of either of the firebox end plates. If this is straightened out and measured, you will know exactly how long to cut the sheets. Soften the copper, clean the edges, and bend to shape. Some folk will go to the trouble of making a block of hardwood the same shape as the firebox end plates, and bending the sheet over it. What I do, is to mark the places where the bends are required, put a piece of round bar in the bench vice with about 5 in, projecting



at the side, put the copper over the bar at the marked places, and press down at each side. It doesn't need much strength, and a nice even bend is the result, which needs little or no coaxing to fit closely to the rounded upper ends of the firebox plates. The slight side bends are made in similar fashion. The two end plates are then riveted to the ends of the shaped firebox with 3/32 in. copper rivets at about 1 in. centres. Make sure that the sheet metal is in close contact with the flanges all

FIREBOX DOORPLATE



around; a little judicious persuasion with a hammer will teach it good manners.

Crown Stays

The flat top of the firebox is prevented from collapsing under the steam pressure by two plate girder stays; I have found this type of staying far more satisfactory than rod stays, which waste away in the centre. The girders are simply two pieces of 16-gauge sheet copper 2 in. wide, one edge 4 7/8 in. lang and the other 4 in. Each edge is bent over at right angles in opposite directions for 5/16 in. width, leaving 1 1/8 in. between them, and the flange at the longer edge is riveted to the crown of the firebox by 3/32 in. rivets at 5/8 in. centres, the girders being set 1 in. apart, as shown in the cross section. The firebox is then ready for brazing up the joints.

Brazing the Firebox.

This job should really be easier than brazing up the outer shell of the boiler, as there isn't so much metal to keep hot. The same "technique" is followed. Cover all the joints with wet flux, and pay particular attention to the crownstay flanges where they are attached to the firebox crown. Stand the assembly in the brazing tray with the doorplate upwards, and pile some coke or breeze around it, to about halfway up. This helps to get the whole lot evenly heated. Now heat it up until the wet flux boils up and starts to glaze, then concentrate on one bottom corner, and when that gets to bright red, carry on in exactly the same way as described for brazing the throatplate, first applying the brazing strip, and then when a little melts off and runs into the joint, move the flame slowly along, applying more brazing material as the copper becomes bright red under the advancing flame of the blowlamp or blowpipe.

When the flame reaches the firehole ring, take that in your stride, in a manner of speaking. The flame should be directed straight on to the ring, so that it and the surrounding copper quickly become bright red. Then run in a little brazing material, keeping up the heat so that the molten metal forms a fillet all around the ring. Then you can either start from the bottom of the other side of the doorplate and work up to the top, or carry on along the top, above the firehole ring, and work downwards to the end. There is very little in it, either way, but beginners may find that restarting from the bottom and working up is more convenient for them. When reaching the top, give the meeting-point an extra special blow-up, so that the joint becomes continuous.

Once again, sharp's the word and quick the action. Grab the firebox with the tongs and turn it right over, so that the tubeplate is at the top. As the whole box is now well heated, there is no need to pile up any coke around it. The flux will all be dried, and probably glazed as well, so go right ahead and start at one bottom corner, working right around the joint as before. Just a word of warning to inexperienced coppersmiths. When the flame reaches the vicinity of the tube holes, keep it from playing direct on to the metal between the holes, otherwise they will all disappear suddenly, and in their place will be one big ragged hole. As you can't very well fit tubes in that, you've had it. The only thing you can do about it is to make a fresh tubeplate.

Next, stand the firebox right way up on the coke, and direct the flame on the crownstay flanges. Here again, keep the flame as close to the crown of the box as possible, not only to keep it well heated, but to avoid melting the edges of the crownstays. Some folk take the trouble to bend a piece of sheet-iron or steel double, and push it over the end of each stay, to protect it from the flame; this is a good wheeze, but with ordinary care it isn't necessary. To make sure that the joints between crown of firebox and crownstay flanges are perfect, and all the rivets sealed, apply a strip of coarse-grade silver-solder to the joints, before applying the brazing-strip. This will flow very readily right through the joints, as it melts and runs at a lower temperature than the brazing material. Some of the latter can then be applied to form a fillet right along the full length of both sides of each flange. Always bear in mind that extra time spent in doing the job properly at first, pays good subsequent dividends, as a boiler with sound joints at the outset never starts to grow Welsh vegetables.

Let the job cool to black, then carefully put it in the acid pickle for about 20 minutes, after which it can be washed well in running water and cleaned up with steel wool or domestic scouring powder.

Smokebox tubeplate.

Before fitting the tubes and flues to the firebox, the smokebox tubeplate must be made, as we need this for spacing and supporting the tubes while they are being silversoldered into the firebox. The former for flanging this is a plain disc $3\frac{3}{4}$ in. diameter, and anything of this size can be pressed into service, such as an old chuckplate or a wheel casting. If nothing "ready-made" is available, the only thing to do is to cut out an iron plate as before.

Cut out a circle of 3/32 in. copper, a bare $4\frac{1}{2}$ in. dia. which is gripped in the bench vice alongside the former, and flanged over its edge as previously described. Scribe a line right across the middle of the side opposite to the flange, then clamp the firebox former to it in such a position that you can see this line through the middle hole of the top row in the former plate, and the middle one also in the bottom row, which should be $\frac{3}{8}$ in. from the edge of the flanged plate. The plate is then correctly located for drilling the tube holes. First use No. 30 drill, putting it through the holes in the former, and drilling right through the tubeplate. Then remove the former, and open out and ream the holes exactly as described for those in the firebox tubeplate, except that the reamer is put right through, and the holes should be slightly countersunk on both sides.

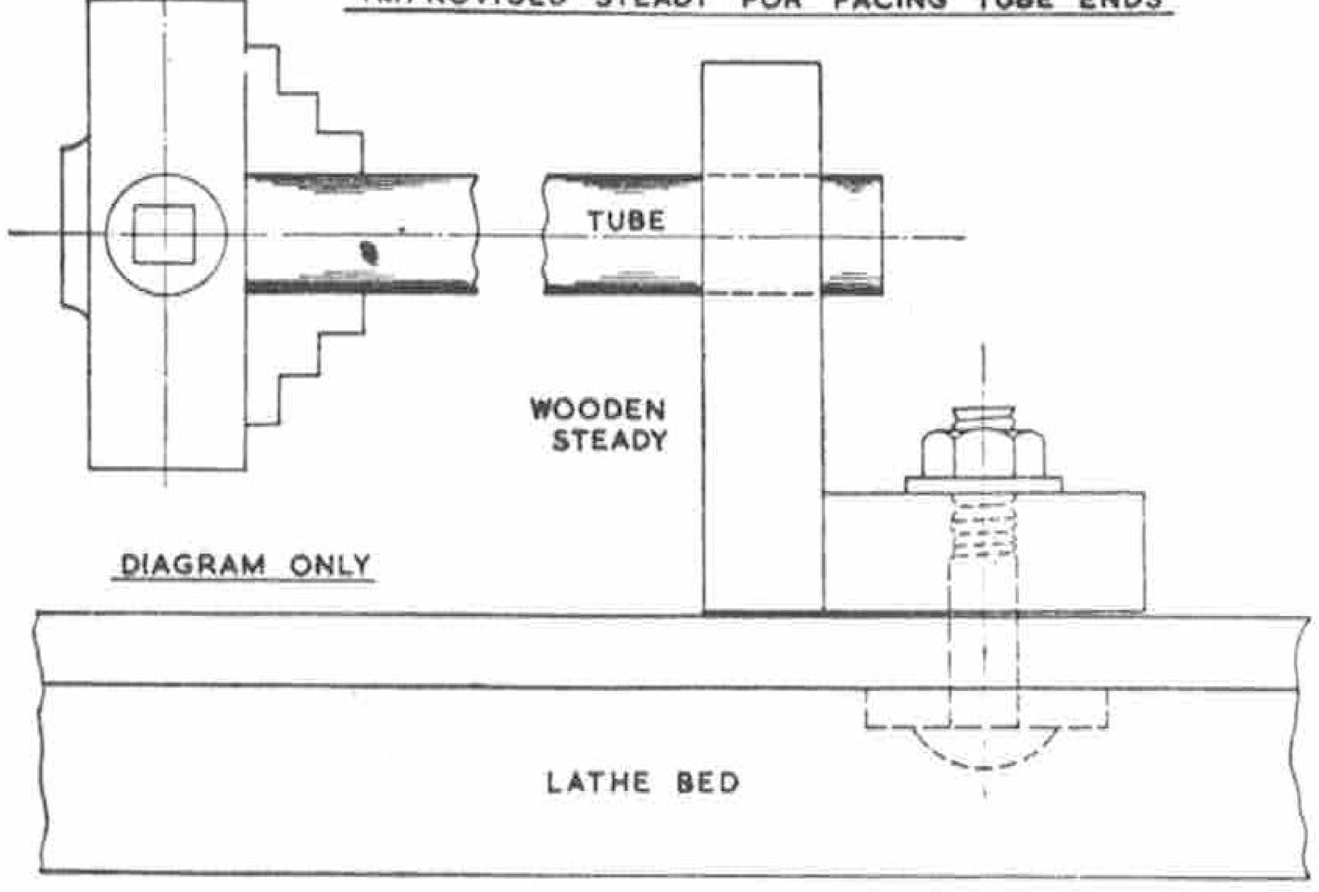
Next, chuck the tubeplate in the three-jaw, using the outside jaws, with the ragged edge of the flange outwards. Turn this off with a roundnose tool set crosswise in the rest, then reverse the tubeplate and put it on the outside of the jaws, opening same so that the plate is gripped tightly by the inside of the flange. Then carefully turn the outside of the flange until it is a tight fit in the boiler-barrel. Test with the barrel itself. The three tapped holes, for stays and steampipe, can then be set out, drilled and tapped as shown in the drawing.

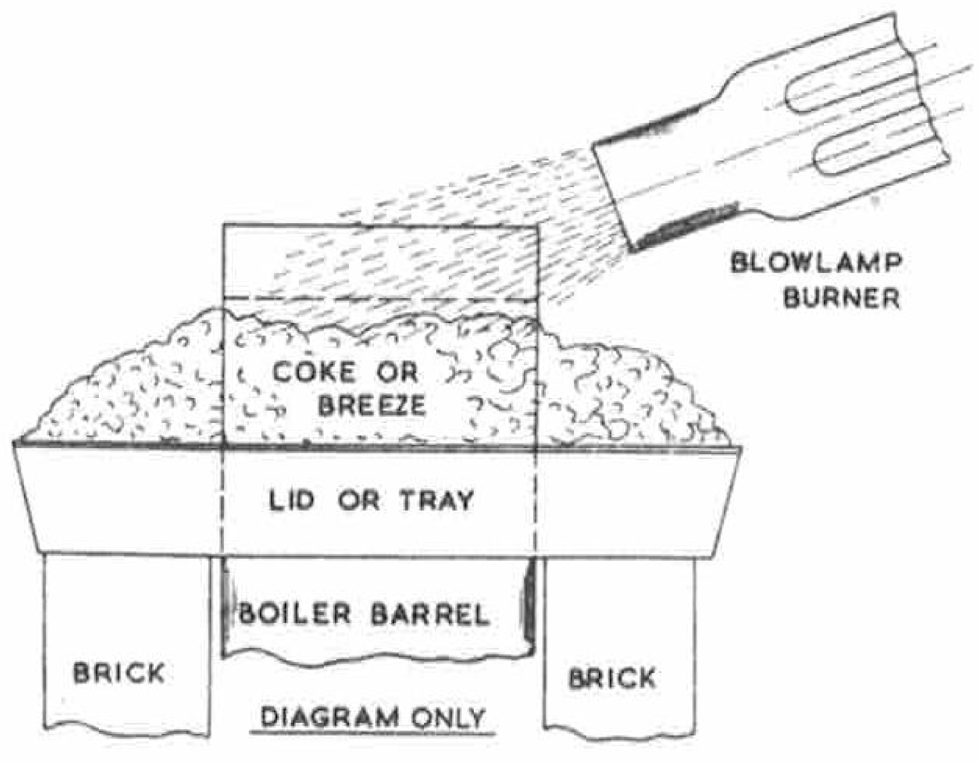
Fitting tubes and flues.

Three $\frac{3}{4}$ in. x 20-gauge superheater flues are needed, also twelve $\frac{3}{8}$ in. x 22-gauge fire-tubes; these should be cut to about $\frac{1}{8}$ in. over finished length with a fine-toothed hacksaw. Incidentally I have a weeny tube-cutter just like those used by plumbers and gasfitters, which cuts off tubes up to 1 in. diameter leaving the ends dead square; it saves a lot of time. The small tubes can be held in the three-jaw chuck for facing off the ends to finished length, 7-1/16 in. Most home-workshop lathes, such as the Myford, have a hollow mandrel which will allow the tube to enter; but the larger flues won't go in, and as the overhang would be too great without support, a steady must be used. If the lathe has no steady as part of its equipment, rig up a temporary one, which is dead easy and quick. All you need will be a couple of pieces of wood and a coach-bolt. Nail the bits of wood together to form a right angle, and put the bolt through the middle of one of them. Put a $\frac{3}{4}$-in. drill in the chuck, and run the wooden angle up to it, letting the drill go through the wood; this ensures that the hole lines up with the lathe centres.

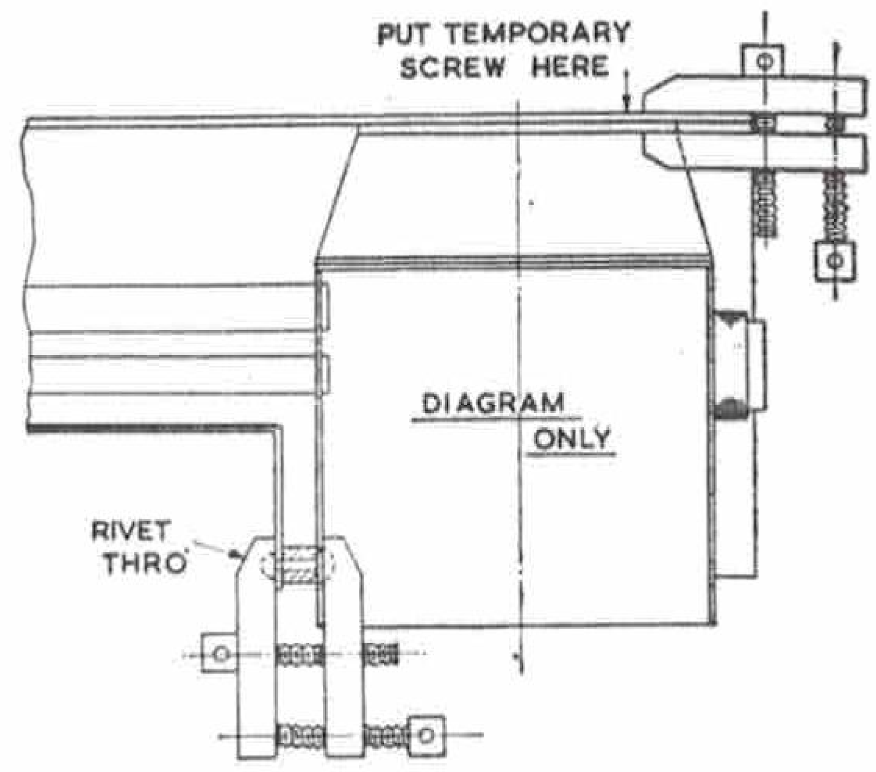
Next, clamp the improvised steady to the lathe bed about 6 in. from the chuck jaws, as shown in the diagram. If the tube is put through the hole in the steady, into the chuck jaws, so that about $\frac{1}{2}$ in. projects through the steady, facing off the tube ends will be just a piece of cake. Before removing tubes from chuck, hold a piece of emerycloth against them, while still revolving, to brighten them up for silver-soldering.

IMPROVISED STEADY FOR FACING TUBE ENDS





HOW TO SILVERSOLDER SMOKEBOX TUBEPLATE



HOW TO FIT FIREBOX AND TUBES TO BOILER

Experienced coppersmiths can silversolder the whole nest of tubes and flues into the firebox at one fell swoop, but beginners and novices had better take two bites at the job. The "passed craftsmen" should assemble all the tubes in the holes in the firebox tubeplate; if the reaming has been properly done, they will be a nice tight fit. They should project through into the firebox about 1/32 in. The smokebox tubeplate is then placed temporarily over the other ends; this sounds like a jigsaw puzzle, but is easy enough if the ends are guided into the holes with a pencil or wooden skewer. The holes being countersunk, and reamed full diameter, the tubes will enter readily when lined up. The whole bunch should then be adjusted so that they are parallel with sides and top of the firebox.

Stand the assembly in the brazing tray with the tubes pointing skywards, then smother the whole of the firebox tubeplate with wet flux, either powdered borax or Easyflo flux mixed to a creamy paste with water. See that it goes right around every tube. Cut a strip of best grade silversolder, or Easyflo, into little squares and drop them all among the tubes, and as close to them as possible. Pile up the coke or breeze about halfway up the firebox, inside and out. Heat the firebox end first, keeping the flame off the tubes until the box is well heated, then play on the lower part of the tubes, with the blowlamp flame directed partly on the tubes and partly in the firebox. The whole lot will gradually heat up, both tubes and firebox tubeplate, and when the right temperature is reached, the little squares of silversolder will melt and run all around the tubes, forming fillets. Warning — the molten metal will only run where the flux has been first, which is why you want to be especially careful that the flux has run completely around each tube. To make assurance doubly sure, as the old saw puts it, take a final blow with the flame right around the outside of the assembly, directing the heat on both tubes and firebox tubeplate. When you are satisfied that there is a fillet around every tube, let the job cool to black, and remove the smokebox tubeplate.

Before putting the lot in the pickle, heat the outer ends of the tubes to redness, to soften them, also take a look inside the box. If you see a silver ring showing around each tube, the job is O.K. and you can pickle it with a cheerful spirit. After about 20 minutes, take it out, wash well in running water, and clean up. Rub the crown-stay flanges with a piece of emerycloth, ready for the next job.

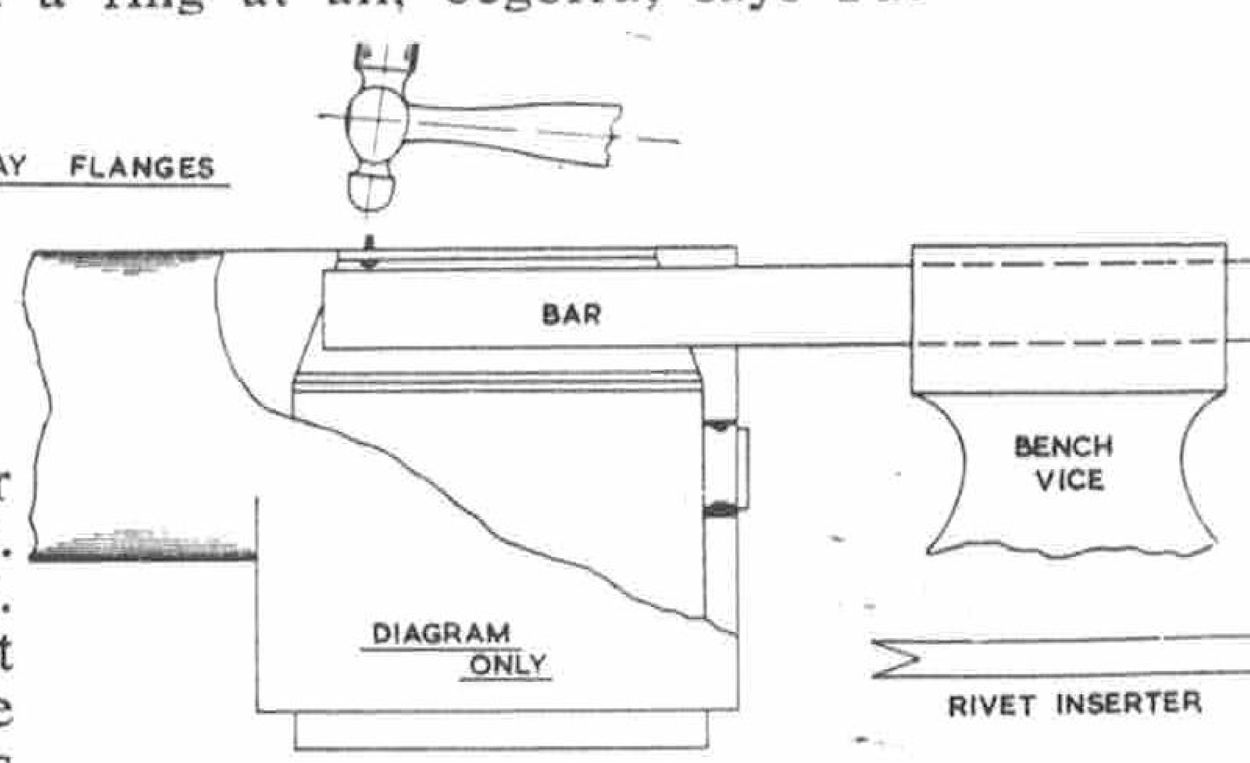
The not-so-experienced, and beginners, should first put in the superheater flues and the top row of small tubes. Put on the smokebox tubeplate as above, to act as support and spacer, then line up the tubes with the firebox as already mentioned, and apply the wet flux all around them. Stand the assembly, tubes upwards, in the brazing tray, and first heat up the tubeplate as already mentioned; then direct the flame partly inside the firebox and partly on the tube ends. When they are all medium red, touch each tube at the point where it enters the tubeplate, with a strip of best-grade silversolder, or Easyflo. If the heat is right, this will immediately melt and flash around the tube, forming a fillet. Easyflo can be purchased in wire form, and I find this more convenient than strip for many jobs, especially small fittings and union cones.

Let the job cool to black, then pickle and wash off as above, but it need not stay in the pickle for more than five minutes or so. Insert the rest of the tubes, and repeat process. The strip of silversolder, or Easyflo wire, can be applied to the two middle tubes in the second row, between those in the bottom row. When all have been given a dose of silversolder, pull off the smokebox tubeplate and soften the outer ends of the tubes as mentioned above, then pickle for about 20 minutes, wash well, and clean the flanges of the crownstays. If the job is O.K. you'll see a silver ring around each tube end in the firebox, same as if the lot had been done at once.

First stage of assembly.

The next job is to insert the firebox and tubes into the boiler shell, attach the crownstays to the top of the wrapper, fit the front section of the foundation ring, and fit the smokebox tubeplate. The foundation ring—which isn't a ring at all, begorra, says Pat—

HOW TO RIVET UP CROWNSTAY FLANGES

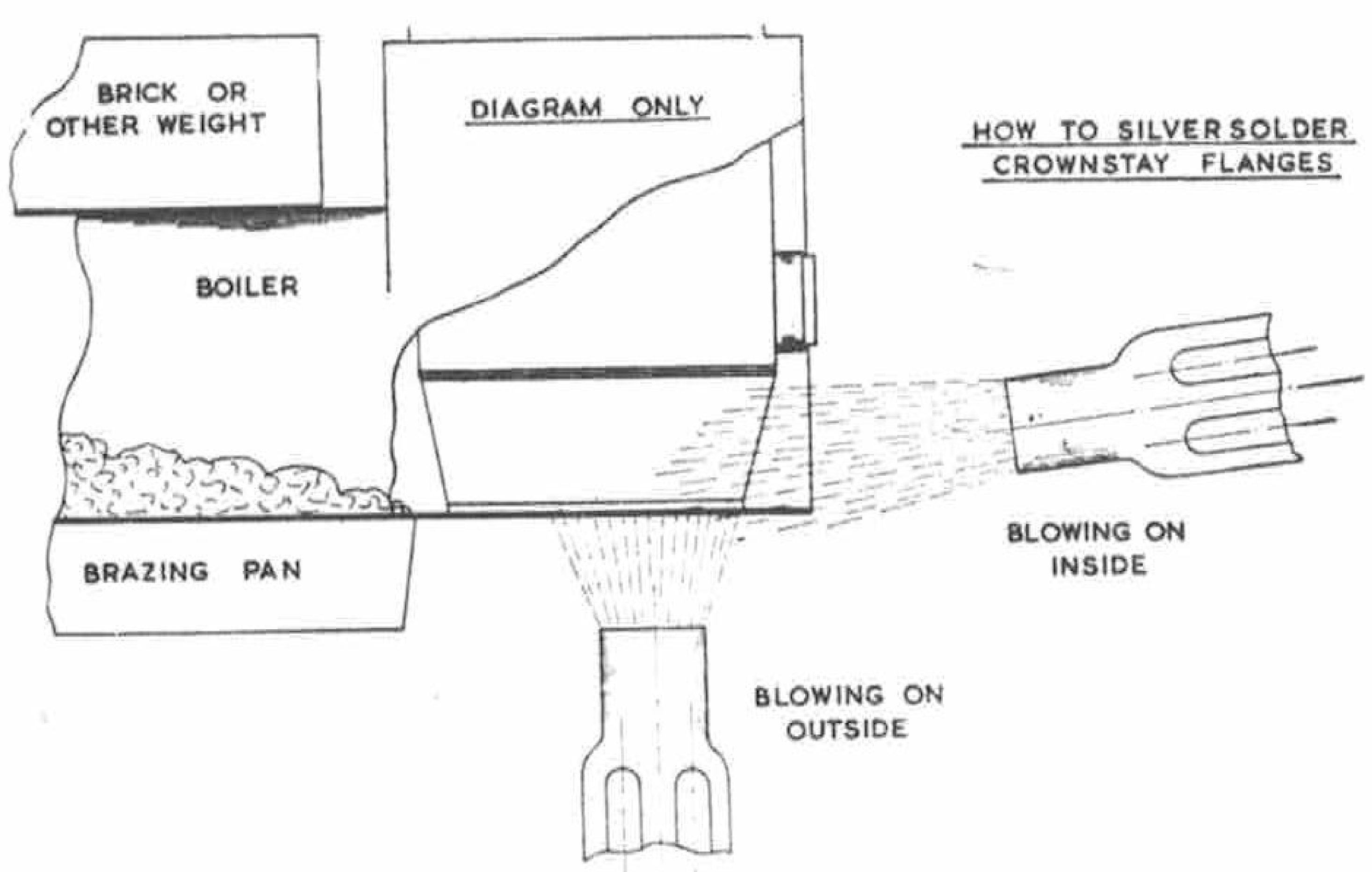


is made in four pieces from ¼ in. square copper rod. Cut a piece to fit tightly between the throatplate flanges at the bottom, and clean it well, also clean the inside of the throatplate along the bottom. Fit it about 1/16 in. up from the bottom edge of the throatplate; it should be tight enough between the flanges to stay put while the firebox is inserted.

Now lay the boiler shell upside-down on the bench, and slide the firebox-and-tube assembly into it. The front end of the firebox should butt up tightly against the piece of foundation-ring just fitted. Set the firebox tubeplate centrally between the sides of the wrapper, and put a toolmakers' cramp over the lot, to keep the parts in place. The top flanges of the girder crown-stays should be butting tightly up against the top of wrapper; put a cramp over the ends of the flanges, to hold them in that position while a couple of holes are drilled with No. 41 drill, through wrapper and flange, about ¼ in. from the back end of each flange. Put a 3/32 in. screw through each, with a nut to hold the parts together temporarily while the flanges are riveted to the wrapper, and remove the cramps.

Next item is to rivet the firebox tubeplate to the throatplate, to keep it in place while brazing, so drill three No. 41 holes right through throatplate, piece of foundation-ring, and bottom of firebox tubeplate and put in three 3/32 in. copper rivets. No need to bother about making fancy heads; the rivets don't show on the finished engine. Then drill a row of holes along the top of the wrapper, over the centre-line of the crownstay flanges, about ½ in. apart, starting from the temporary screws, using No. 41 drill. Countersink them on the outside of the wrapper, and file off any burring under the flanges. Put 3/32 in. x ¼ in. copper rivets through from the inside and rivet up. The rivets can easily be inserted from inside, by aid of a strip of tin with a notch in the end like a distant signal. If a rivet is jammed in the notch, it can be poked through the hole in flange and wrapper, and the strip pulled away. For a riveting dolly, put a piece of iron bar in the bench vice, about 1 in. x ½ in. section; leave about 5 in. projecting from the side of the jaws. The boiler is slipped over this, with the rivet-head resting on the bar, and the shank can then be hammered down into the countersink. If the piece of bar tries to slip down between the vice jaws, don't risk bending the handle and stripping the thread, but take out one of the hardened insets, and rest the bar on the ledge. When all the rivets are in, take out the temporary screws and replace by rivets, then file off any projecting bits flush with the top of the wrapper.

The smokebox tubeplate has now to be inserted, flange first, and be mighty careful that it is put in with the line that was scribed across it to locate the firebox former for drilling the tube holes, exactly vertical. If it isn't, the tubes won't go into the holes without twisting them. Tap it down until it almost touches the tube ends, and you can then see if they line up all right. It will be a miracle if they line up with the holes exactly, but they shouldn't be much out, maybe 1/16 in. or so; and if they are gently persuaded with a wooden skewer or a pencil, the tubeplate can be tapped in a little farther, so that the tube ends will come through the holes about 1/32 in. or so. The tubeplate can be checked for being square with the end of the boiler barrel, by taking the distance from edge of barrel to tubeplate at three places around the circumference, but there is no need to bother about "mike" measurements.

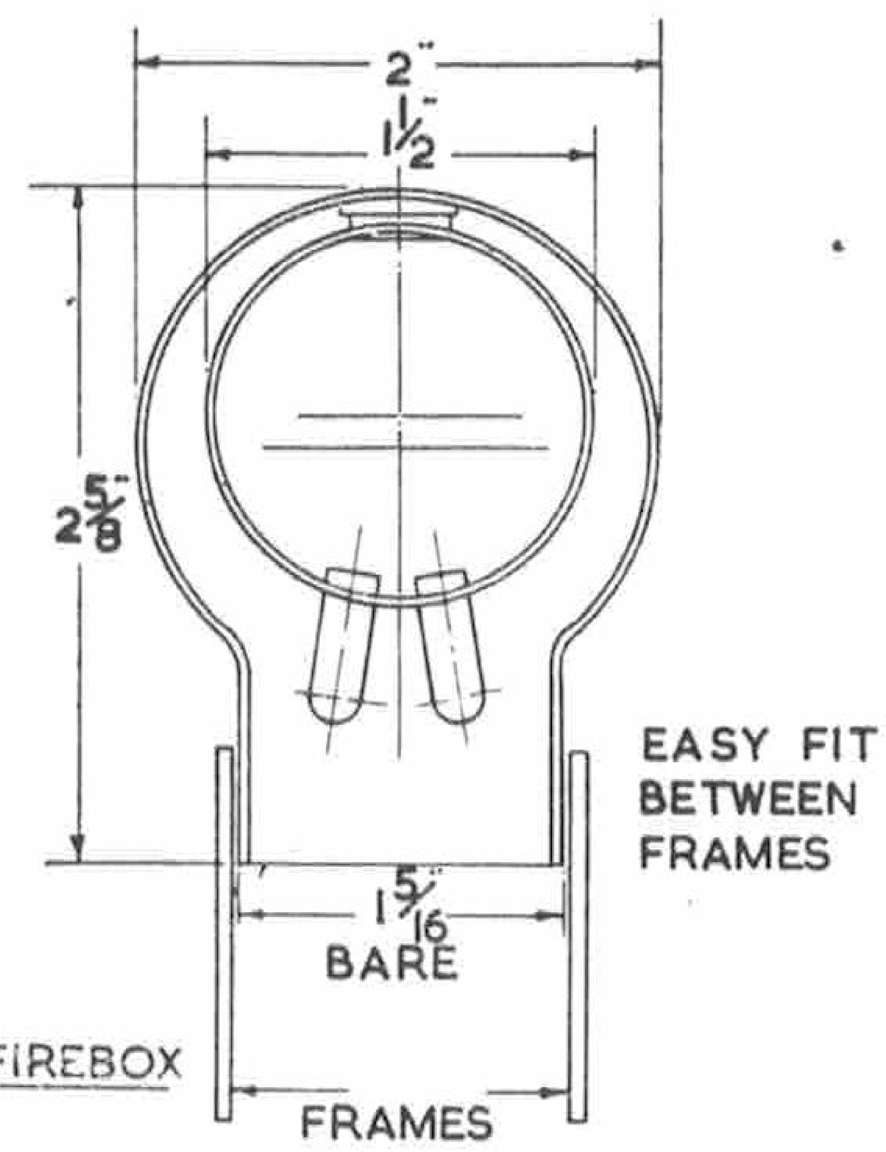


Another thirsty job !

First expand the ends of the tubes into the holes by driving a taper drift into the end of each. I use the taper shank of a broken drill, or anything similar, for this job; if it is greased, it won't stick, and even if it did, a sideways tap will release it. This will force the tube ends into close contact with the tubeplate. Now get a big tin lid, or a discarded small iron tray, and cut a hole in it just big enough for the boiler barrel to enter. Stand the boiler on end, barrel upwards and put the tray or lid over it for about 2 in down, and prop it up at each side with a brick or something similar that won't burn. Pile some coke or breeze around the boiler end. Put some wet flux all around the edge of the tubeplate and around each tube, and plug the ends of the tubes with little wads of asbestos flock or string, to prevent the flame blowing down them. Then get the blowlamp going good and strong.

The average amateur coppersmith will get the best results on this job by using a coarse-grade silver-solder (such as Johnson-Matthey's B6 alloy) for the circumferential joint, and best-grade for the tube ends. First heat the whole doings as evenly as you can, and when the coke begins to glow red, concentrate on one point away from the tubes, directing the flame partly on the tubeplate and partly on the barrel. When the metal become medium red, apply the strip of silversolder. If the heat is sufficient, it will melt and run into the joint, and all you then have to do, is to move the flame very slowly along, feeding in more silversolder as the metal becomes redhot under the advancing flame, until you complete the course and arrive back at the starting point, which should be given an extra blow-up so as to ensure the seal being continuous.

Now play direct on the ends of the three flues, and as soon as they and the surrounding metal glow red, apply a strip of best-grade silversolder or Easyflo. This should flash around each, just as it did at the firebox end; then ditto repeato with the whole nest of small tubes. When they are all done, prepare for quick action—and I mean just that! Grab the boiler with the big tongs, pull off the tray, and transfer the boiler to the brazing pan, laying it on its back with the firebox overhanging the edge; put a brick or something on the barrel to prevent it tipping up. Put plenty of wet flux along both sides of the crownstays (I usually do this before attending to the smokebox end; it saves time) and lay a strip of silversolder along each side of each crownstay flange. Heat up the whole lot by directing the flame both inside and out, and when it starts to glow red, blow upwards, straight at the place where the flanges are riveted to the wrapper. As soon as medium red is reached, the strips of silversolder will melt and sweat in between wrapper and flanges, sealing the rivets and making a perfect joint.



SECTION THROUGH FIREBOX

Final Assembly of Boiler

THE final job in the boiler assembly is to fit the backhead and the rest of the foundation ring, and braze them in. Sounds formidable, but with the experience already gained, even beginners can face the operation with confidence. First flange up the backhead. We made the former for this, in order to flange the throatplate on the lower part of it. Lay it on a piece of ⅛ in. sheet copper and draw a line all around at ⅛ in. distance, except at bottom. Cut out the copper to the marked line with a small hacksaw, or a metal-piercing saw (just a glorified fretsaw) which is easily done if some cutting-oil is applied to the blade. I cut out these plates on my Driver jigsaw, and if any builder has an ordinary fretsaw machine for sawing wood, it can be used for the job with a metal-cutting blade in the clamps. Our friend Reeves sells them. Clamp the former and piece of copper together in the bench vice, and flange the copper over the former as previously described for the other plates. File off any raggedness, and clean up the flange with a coarse file.

Measure from the top and sides of the wrapper to the firehole ring, transfer these measurements to the backhead, and that will give the location of the hole through which the flange of the ring will come when the backhead is fitted. Cut the hole undersize at first, and try the backhead against the wrapper; you can then see at a glance if the hole is in the right place, and if not, where it needs correcting. Then enlarge the hole to correct size, and drill and tap the other holes shown on the drawing of the backhead in the May issue. Put the backhead in place, with the flange of the ring through the hole, and beat down the flange outwards, same as was done with the one going through the firebox doorplate. Rest the inner side of the ring on a stout piece of bar held in the bench vice, with one end projecting.

The wrapper should be in close contact with the backhead flange all the way around. A little judicious coaxing with a hammer is usually sufficient, but if the wrapper tries to spring away from the flange, it can be taught better manners by drilling holes with No. 48 drill through wrapper and flange at about 1 in. spacing, tapping them 3/32 in. or 7 B.A. and screwing in stubs of 3/32 in. copper wire. Don't file them flush, just snip them off for the time being.

To finish off the foundation ring, cut three pieces of ¼ in. square copper rod to fit between the flanges of the backhead, and between the bottom of the wrapper and the sides of the firebox. They should be let in about 1/16 in. as shown in the drawing in the May number. Put five 3/32 in. copper rivets through the lot at each side, to keep the parts in contact while brazing, and two through the back part. If there are any interstices showing at the corners, just plug them with little splinters of copper driven in tightly.

Final Brazing Job

Cover the foundation ring with wet flux, and put plenty all around the backhead flange and the firehole ring. Lay the boiler on its back in the brazing pan, and pile coke or breeze all around the firebox, right to the level of the ring. Put some pieces of asbestos millboard, or asbestos cubes, inside the firebox to shield the tubes from the blowlamp flame. Now be sure and have all the requirements handy, for this job must be a nonstop one. Experienced workers can use easy-running brazing-strip for the joints, but I strongly advise raw recruits and anybody who isn't certain of their abilities, to use a coarse-grade silver-solder, which runs easier at a lower heat. Also if you can get a mate to hold another blow-lamp, it is a great advantage.

The same technique is used, but as there is now a lot of metal to heat up, more care is needed. Heat the lot as before, until the coke glows red and the flux starts to glaze, then concentrate on one corner of the foundation ring. If the mate is on the job, direct the flames so that they meet at an angle, one blowing from the outside and one from the inner side. When the copper glows red, aply the brazing-strip or silver-solder, and if the heat is O.K. it will melt and run in, forming a fillet at each side. It should sweat in and seal the rivets, but to make quite certain, touch each rivet-head as you come to it, with the brazing material. Work slowly right around, taking special care at the corners, and when arriving back at the starting point, give an extra blowing to make sure that there is no sign of a gap.

Don't give the boiler the least chance to cool, but grab it with the big tongs and up-end it in the pan, backhead up. There isn't any need to bother about packing coke around, as it should be well heated; just concentrate on one bottom corner with the flame, get it well red, apply the strip, or silver-solder, and when it melts and flows, work your way around as before. Don't hurry, make quite certain that the metal flows well in between the backhead flange and wrapper for the whole journey around. Tip—use best-grade silver-solder, same as you used for the tubes, to seal the flange of the firehole ring. As this is beaten down into close contact with the backhead, ordinary molten brazing-strip may not penetrate through, but silver-solder will.

Let the job cool to black, then put it in the acid pickle, but stand well clear, using the garden rake, or something similar, to support the boiler while lowering it in. As the pickle runs inside and meets the hot tubes, it will promptly blow out again, and there will be plenty of commotion during the first few seconds! However, it will soon die down; leave it in for the usual 20 minutes or so, and then rescue it, empty out any pickle inside, and well wash under the domestic tap, inside and out, finally rubbing up the outside with steel wool or scouring-powder.

Preliminary Test

If care has been taken, the boiler should be as tight as the proverbial bottle; but it can easily be tested by plugging the holes with temporary screwed plugs (wooden ones will do) all except one. In that, fit an adapter to take a tyre-pump; I use an old tyre-valve screwed to suit. Couple the pump to it, put the lot in the domestic bath with enough water to cover it, and pump about 20 lb. of air in. If there are any leaks, they will show by bubbling, same as testing a tyre tube. There is no need to heat the whole boiler again to seal a "pinhole"; just drill it No. 55, tap 10 B.A. and screw in a stub of threaded copper wire with a smear of plumbers' jointing on the threads. This will effect a permanent cure.

Bushes

Two bushes are needed at the front end of the barrel for the feed clacks, two on top for the safety-valves, and a big one for the dome. At each side of the barrel, on the centre-line, and $1\frac{3}{4}$ in. from the end, drill a 5/16 in. hole. On top, at 5 in. from the end, cut a hole 1 - 3/16 in. diameter and at the back end, drill two $\frac{1}{2}$ in. holes as shown in the section of the boiler, May issue. The smaller bushes can be made from copper or bronze rod, or from thick-walled tube, but don't use soft brass. Chuck the rod in three-jaw, face, centre, drill 7/32 in. for about $\frac{3}{4}$ in. depth, tap $\frac{1}{4}$ in. x 40, turn down 5/32 in. of the outside to a tight fit in the hole, and part off a full $\frac{1}{4}$ in. from the end, repeating process for second bush. The safety-valve bushes are turned by same process, to sizes shown. I made my dome bush out of a piece of $\frac{3}{8}$ in. copper plate $1\frac{1}{2}$ in. square, which I had in stock. It was chucked truly in the four-jaw and a 1 in. hole made in it by first drilling $\frac{3}{4}$ in. and finishing with a boring-tool. It was then chucked by the hole on the smallest step of the three-jaw, the outside turned to a $1\frac{3}{8}$ in. circle, and further reduced to 1 - 3/16 in. for $\frac{1}{4}$ in. length, to fit the hole in the boiler. Friend Reeves will probably supply a bronze or gunmetal casting for the big bush.

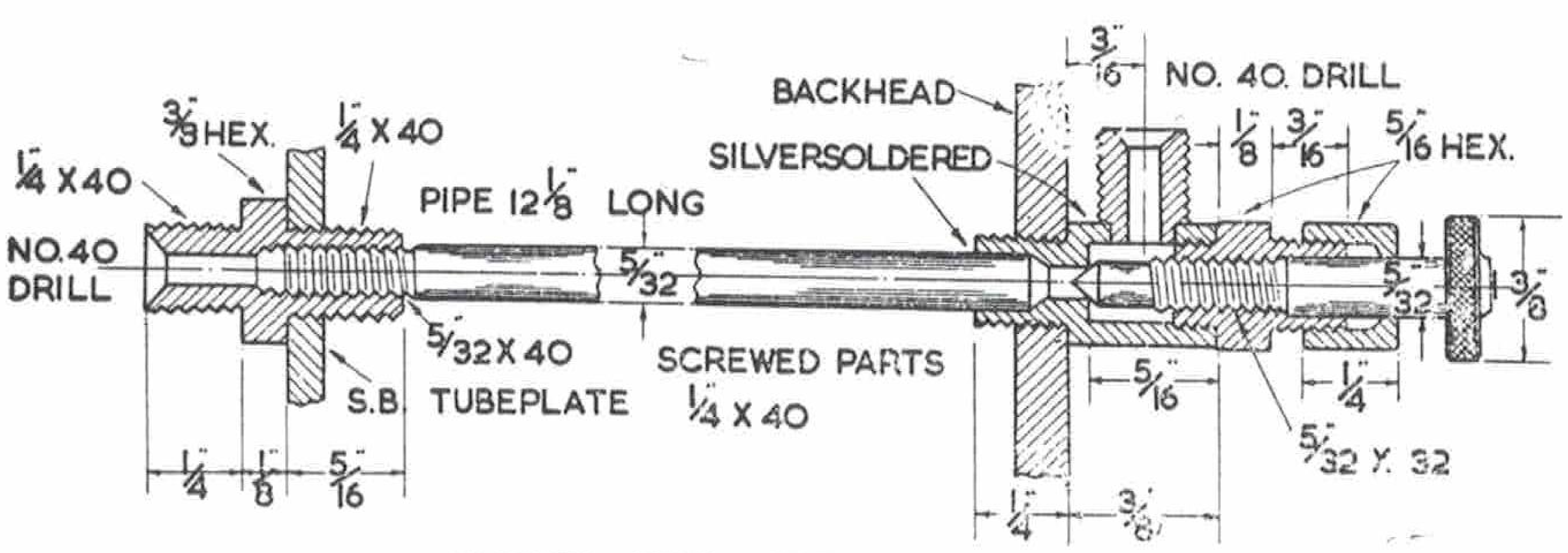
Push them tightly into the holes, put some wet flux around each, and silver-solder them with best-grade or Easyflo. If the blowlamp flame is played direct on each bush, it and the surrounding copper will become hot enough to melt the silver-solder without heating up the whole of the boiler. When all are done, put the boiler in the acid pickle again, but this time there won't be such a geyser-like effect as before! The bushes could, of course, be fitted before the final brazing job, and silver-soldered at the same heat, but the wasp in the jampot is that unless fitted exceptionally tight at the outset, they are liable to fall out when the boiler expands when heated for the brazing; and when replaced, the silver-solder won't "take", as scale has formed around the holes, so you have to do the job again. My correspondence tells many a tale!

How to Stay the Boiler

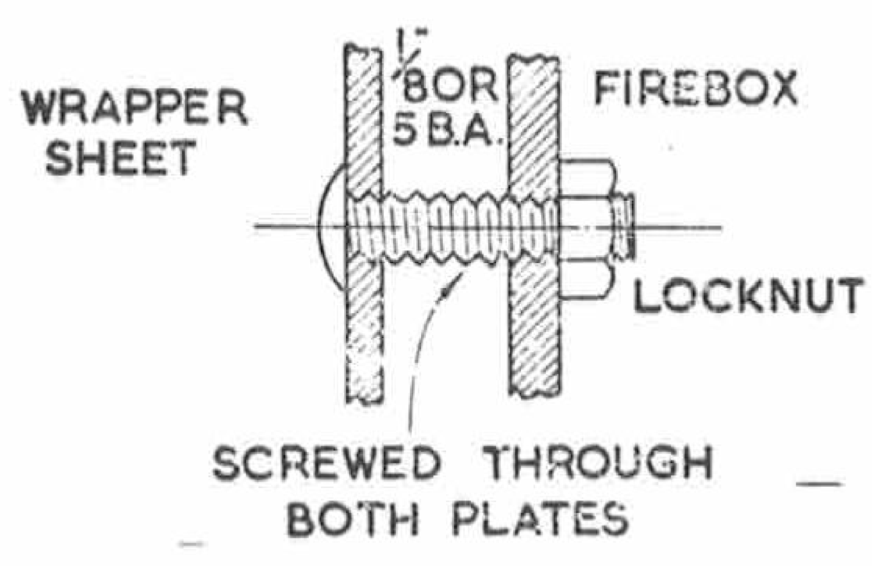
There are two longitudinal stays through the boiler, one of which is hollow to carry steam to the blower jet; thirty-five in each side of the firebox, and five at each end. I always believe in playing for safety, and a boiler with doubtful joints and insufficient staying becomes a steam bomb that can do considerable damage if it goes off. The solid long stay is fitted with a blind nipple at each end, one of which is shown in the section mentioned above. Chuck a piece of $\frac{3}{8}$ in. hexagon rod in three-jaw, face, centre, drill to 5/16 in. depth with No. 30 drill, and tap 5/32 in. x 40. Turn down 5/16 in. of the outside to $\frac{1}{4}$ in diameter and screw $\frac{1}{4}$ in. x 40. Part off at $\frac{1}{8}$ in. from shoulder, reverse in chuck and chamfer the corners, then make another. Cut a piece of 5/32 in. copper rod to $11\frac{7}{8}$ in. length, put about $\frac{3}{8}$ in. of 5/32 in. x 40 thread on each end, screw one nipple on for about three threads, and insert through the left hand tapped hole in the backhead. When the nipple is screwed home, the rod should project through the corresponding hole in the smokebox tubeplate (I usually guide it through with a long piece of thin 7/32 in. tube) and the other nipple is then put on and screwed right home. The stay is thus securely held between the two nipples.

The backhead end of the hollow stay carries the blower valve, and the smokebox end is supported by a "thoroughfare" nipple screwed at its outer end for the jet pipe union. For the valve, chuck a piece of 5/16 in. hexagon rod in three-jaw, face, centre, and drill to $\frac{3}{4}$ in. depth with 3/32 in. drill. Open out and bottom with 7/32 in. drill and D-bit to 5/16 in. in depth, tap $\frac{1}{4}$ in. x 40 for about 3/16 in. depth, and part off at $\frac{5}{8}$ in. from the end. Reverse in chuck, turn down $\frac{1}{4}$ in. length to $\frac{1}{4}$ in. diameter and screw $\frac{1}{4}$ in. x 40. At 3/16 in. from the tapped end, drill a 5/32 in. hole in one of the facets, and fit a $\frac{1}{4}$ in. x 40 union nipple in it, made like those on the pump. Open out the 3/32 in. hole in the screwed end with a No. 23 drill for $\frac{1}{8}$ in. depth; and in that, fit a piece of 5/32 in. copper tube $12\frac{1}{8}$ in. long, with about $\frac{3}{8}$ in. of 5/32 in. x 40 thread on the outer end. Silver-solder in the pipe and the nipple at the one heating.

Although the rest of the valve won't be needed for the time being, might as well make the bits now. Chuck the 5/16 in. rod again, face, centre, and drill to a full $\frac{1}{2}$ in. depth with No. 30 drill. Turn down a full $\frac{1}{8}$ in. to $\frac{1}{4}$ in. diameter and screw $\frac{1}{4}$ in. x 40; part off at 5/16 in. from shoulder. Reverse and rechuck in a tapped bush in the three-jaw; turn down 3/16 in. length to $\frac{1}{4}$ in. diameter and screw $\frac{1}{4}$ in. x 40. Open out the hole for $\frac{1}{8}$ in. depth with No. 21 drill, and tap the remains 5/32 in. x 32. The nut is made from 5/16 in. hexagon rod same as gland nuts and



BLOWER STAY ASSEMBLY



FIREBOX STAY

union nuts previously described; the thread should fit fairly tight. The valve pin is a 1⅛ in. length of 5/32 in. rustless steel or hard bronze rod. Chuck it and turn the end to a blunt cone point, then screw it for a bare ⅝ in. length with a 5/32 in. x 32 die in the tailstock-holder. Turn away ⅛ in. of the thread from the point. File a square for a wheel on the other end. Tip for beginners—chuck the pin with about 5/32 in. projecting from the jaws. Set one jaw vertical, and file a flat on the pin with a "safe-edge" flat file, holding it horizontally and keeping the smooth edge of the file pressed against the chuck jaws. Turn the chuck jaw to "three o'clock" position, and file another flat. Repeat operations with the jaw at 6 o'clock and 9 o'clock positions, and there is your square, all-present-and-correct-sergeant. The wheel can be turned from a piece of ⅜ in. rod, dural for preference. I knurl my wheels simply by pressing a second-cut file on the edge and working the lathe belt by hand. Drill the hole with a 3/32 in. or No. 40 drill, and drive a short bit of 3/32 in. square silver-steel through it. If the end of the steel is filed off truly, hardened and tempered to pale yellow, it will form a perfectly square hole, and the square on the pin should be filed to a tight fit. Push the wheel on, and slightly burr over the end projecting.

For the thoroughfare nipple, chuck the rod again, face, centre deeply, drill No. 40 for ¾ in. depth, turn down ¼ in. length to ¼ in. diameter and screw ¼ in. x 40. Part off at 7/16 in. from shoulder, reverse and rechuck in a tapped bush, turn down 5/16 in. of the outside to ¼ in. diameter and screw ¼ in. x 40, open out the hole for ⅜ in. depth with No. 30 drill and tap 5/32 in. x 40. To fit the stay, poke the tube with valve attached, through the right-hand tapped hole in the backhead, and screw the valve home; if you put a piece of wire in the screwed end of the tube, it can easily be guided through the corresponding hole in the smoke-box tubeplate. When screwed tight, the nipple on the valve should be vertical. Then screw the thoroughfare nipple on the other end; when that is tight against the tubeplate, the stay is locked solid. Put a taste of plumbers' jointing on the threads.

Warning to beginners—don't be tempted to use commercial brass screws for the firebox stays, to avoid the seemingly tedious job of screwing bits of copper rod. Some of my correspondents did that, to their sorrow. The zinc in the brass set up electrolytic action, the stays wasted away like a zinc rod in a bell battery, and the firebox collapsed. The finest stuff I ever used for firebox stays was some off-cuts of stranded cable as used for overhead transmission lines. These were made up from ⅛ in. strands and were easily unravelled, the copper being of the very best quality.

Mark out the location of the stays as shown, centrepop them, and drill No. 40 through both plates. Mind you don't hit the punch too hard and distort the copper sheet. Tap the holes with a ⅛ in. or 5 B.A. pilot tap, which is a tap with a pin at the end, long enough to go through both plates and guide the tap to cut a true thread in both. If there is any difficulty in obtaining one (there shouldn't be) one can be improvised by turning down the end of a piece of ⅛ in. silver-steel for about ½ in. to fit the holes in the firebox, screwing the next ¾ in. with ⅛ in. or 5 B.A. thread, filing four flats on the thread, and at the end, and hardening and tempering to dark yellow. To prevent the pilot pin breaking off through being too hard, hold the end of a red-hot poker against it until it turns blue. This tap won't cut a perfect thread, but it will start a continuous thread through both plates, and an ordinary tap can be put through afterwards, to make the threads perfect. A dose of cutting oil on the tap helps to make clean threads.

My pet way of staying is to cut a few lengths of copper rod about 6 in. long, and screw each end for about ⅝ in. length. A tapwrench is clamped in the middle, and one end screwed through the firebox plates. As it comes through, I hold a brass locknut inside the firebox, so that the end of the stay runs through it. When the rod is screwed in to the end of the thread, it is snipped off about ⅛ in. from the outside of the wrapper. This is repeated until all the screwed ends are used up. The nuts are then tightened inside the firebox with a home-made box-spanner, any projecting thread snipped off with a pair of side-cutting wire-cutters, the nut rested on the end of a piece of bar projecting from the side of the bench-vice jaws, and the bit outside the wrapper riveted over to form the stayhead. All the bits of rod are then re-screwed, and the process repeated until all the lot are in. I put the whole lot of the stays in the boiler of my own *Mona* in one Saturday afternoon, and boy-oh-boy, DID my fingers ache through twisting the tapwrench!!

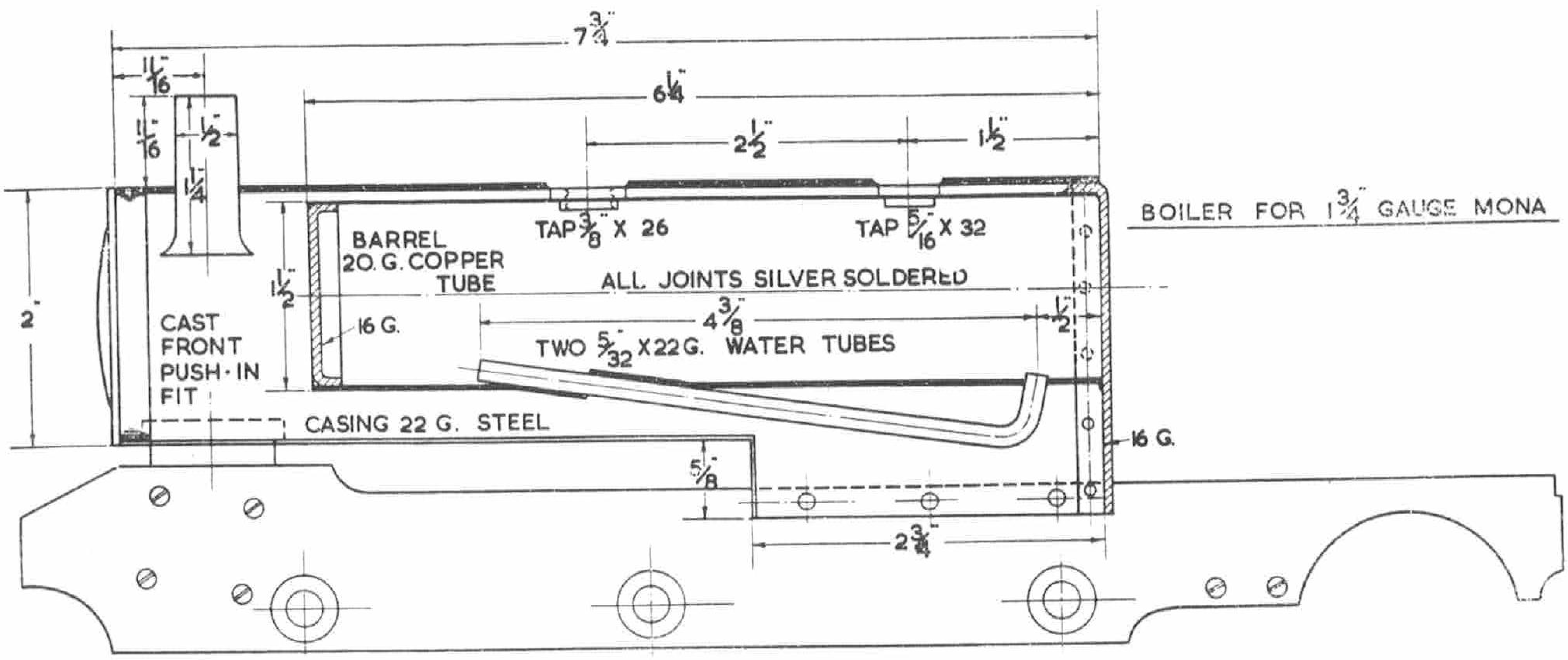
Sweating Up the Stayheads and Nuts

If the threads are perfect and the nuts tight, the whole bag of tricks should be steam-and-water-tight without further treatment; but it is a million dollars to a pinch of snuff that they won't be THAT perfect, and it is advisable to sweat over the lot with solder, as a caulking medium to prevent teardrops oozing through. Make up a ragtime wire brush by jamming a bunch of thin iron wires into the end of a piece of ⅜ in. copper tube and hammering flat to hold them tightly. Put a piece of wood in the other end, for a handle. Lay the boiler on its side in the brazing pan, and brush some *liquid* soldering-flux (not paste on any account) over the stayheads and nuts. Heat up the boiler with the blowlamp until a stick of solder applied to it, will melt at the end, and melt off a few blobs among the stayheads and nuts; then still keeping up the heat, brush the molten solder all over the lot, applying more liquid flux to any place where the solder doesn't take. Turn the boiler over to do the other side of firebox and wrapper, up-end it to do the tubeplates, and when you are quite sure that every head has been covered (the inside of the firebox should look as though it had been tinned all over) stand the boiler right way up, so that any superfluous solder will run away. When the solder has set, well wash the boiler inside and out with hot water, to remove all traces of flux. If any remains, it will form a green deposit which is not only bad for the boiler, but poisonous to cuts and scratches on your hands.

The boiler is now ready for a hydraulic test, but before going into that matter, I'd better say a few words about the much smaller boiler for *Mona's* baby.

Boiler for the 1¾ in. Gauge Engine

This is a simple little affair, consisting of a casing made like the shell of the bigger boiler, but from 22-gauge sheet steel, with a copper barrel inside it, which is silver-soldered to a flanged copper backhead,



and has two water-tubes underneath, to make it step lively. The shell is made in the same way as described for the larger one made from sheet-metal, but no brazing is required; the lap joint underneath is simply riveted with a few 1/16 in. rivets, and the throatplate is flanged over at each side and riveted to the wrapper. Holes are cut on the top line for chimney liner, dome and safety-valve bushes as shown. There is no separate smokebox, the front end being closed by a cast front with dummy door and hinges, turned to a push-in fit.

The backhead is flanged up in the same way as the larger one, but need not be thicker than 16-gauge (1/16 in.) the forming plate being made a bare 1/16 in. smaller all around, than the sizes shown in the cross-section. The barrel is a piece of 1½ in. x 20-gauge copper tube squared off at the ends to a length of 6¼ in. One end is closed by a flanged disc of 16-gauge sheet copper, made by exactly the same method described for the smokebox tubeplate of the larger boiler. Drill a ¼ in. hole in the barrel at 1½ in. from the other end, and another in line with it at 2½ in. farther on. Lay the backhead in the brazing-pan and stand the barrel on it, open end down, and the two holes level with top of backhead. The barrel should be close up to the flange. Cover the joint with wet flux, also the joint between barrel and front-end plate, and silver-solder them both, using coarse-grade silver-solder or B-6 alloy. No packing of the coke is needed on this little boiler. Pickle, wash off and clean up, then drill the holes for water-tubes. The back pair are drilled 5/16 in. apart at ½ in. from the backhead, and the front pair 3½ in. away, using No. 22 drill. Now comes a bit of jerry-wangling. To let the tubes go in straight, the front holes must be distorted. Just put a piece of 5/32 in. steel rod in each, and force it down almost level with the barrel. The tubes can then be cut and fitted as shown, the holes on top opened out and the bushes fitted, and tubes and bushes silver-soldered at the same heating, using best-grade silver-solder or Easyflo. After pickling, well wash out the inside.

THE requirements for giving the boiler a hydraulic test are a hand pump, a full-size pressure gauge reading up to 200 lb. per square inch or more, a couple of adapters, and pieces of copper tube for the connections. Now at this stage we can kill two birds with one shot; because the emergency hand pump which is installed in the right-hand tank, as insurance against low water when somebody lets the fire and water go down together, and there isn't enough steam to work the injector, is just the right tool for the job. If made now, that will be one job less to tackle later on.

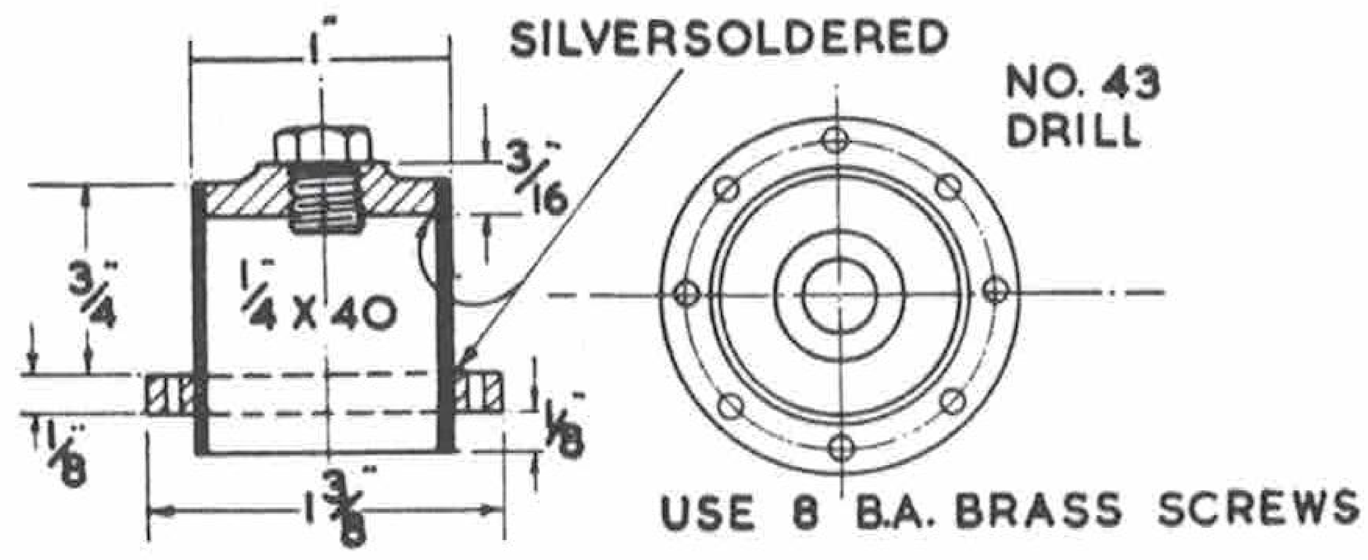
Castings should be available for the one-piece barrel, stand and base. Smooth off the underside of the base with a big flat file, and drill the screw-holes. Then mount it on an angleplate attached to the faceplate, same as the cylinder block, but put the clamping-bar across the extended side of the base. You can't put it across the barrel, as the anchor lug is in the way. Set the casting so that the barrel part runs truly; then face off the end, centre, put a 3/16 in. drill through first as pilot, open out with 27/64 in. drill, and finish with a 7/16 in. parallel reamer. To face off the other end, mount the casting on a stub mandrel in the three-jaw, same as the cylinder casting. Any odd bit of rod can be chucked and turned down to serve as the mandrel, which should be a tight fit in the bore. Smooth off the sides of the anchor lug, and drill a No. 30 hole through it.

For the valve box, part off a piece of 7/16 in. round rod a full 1½ in. long. Chuck in three-jaw, face, centre, and drill through with No. 24 drill. Open out and bottom to ½ in. depth with 9/32 in. drill and D-bit, and tap 5/16 in. x 32. Reverse in chuck and repeat operations, but instead of using the D-bit, cross-nick the drilled hole with a little chisel which can be filed up from a bit of $\frac{1}{8}$ in. silver-steel. Make the nicks deep. Half-way down the side, drill a 5/32 in. hole and tap it 3/16 in. x 40. At $\frac{1}{4}$ in. from the D-bitted end, drill another 5/32 in. hole exactly opposite; in this one, fit a $\frac{1}{4}$ in. x 40 union nipple, drilled No. 40, and silver-solder it.

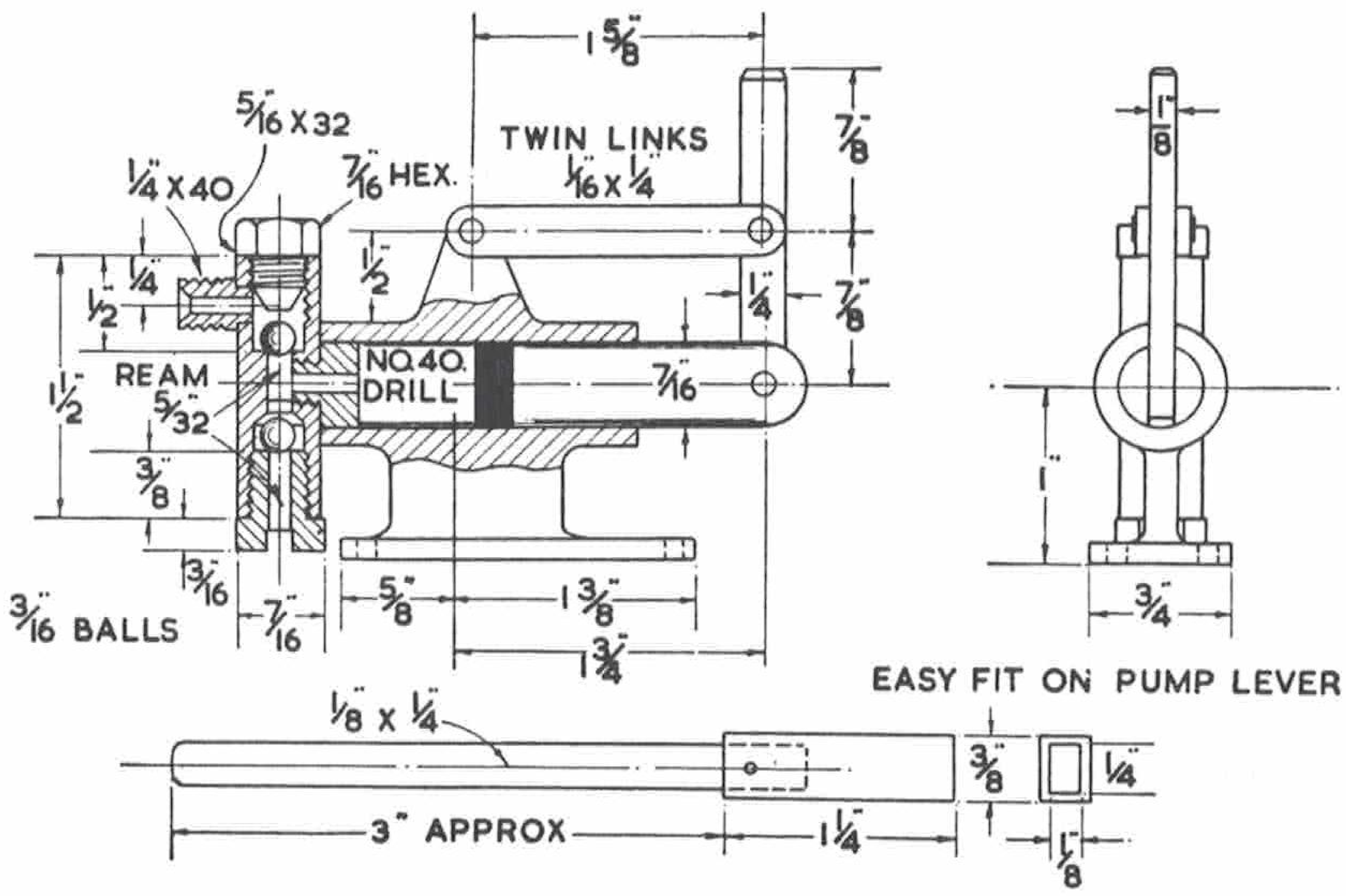
Chuck a bit of $\frac{1}{2}$ in. brass rod, face, centre, and drill No. 40 to $\frac{1}{2}$ in. depth. Turn $\frac{1}{8}$ in. length to 3/16 in. dia. and screw 3/16 in. x 40. Turn down the next $\frac{1}{4}$ in. to a very tight fit in the pump barrel, and part off at 3/16 in. from the shoulder. Squeeze this into the barrel, over the shorter end of the base, and screw on the valve-box. When right home, the D-bitted end must be at the top; then soft-solder over the joints. This will be O.K. as the pump doesn't get hot. Seat a 3/16 in. rustless ball on the D-bitted hole, and turn up a cap as shown, from 7/16 in. hexagon rod, bevelling it off as shown, so that it won't block the entrance to the way out (says Pat). Drop another ball into the other end and take the depth with a depth-gauge. Chuck the 7/16 in. rod again, face, centre, drill No. 24 to $\frac{5}{8}$ in. depth, turn down the length indicated by the depth gauge to 5/16 in. dia. and screw 5/16 in. x 32. Face 1/32 in. off the end, and part off at 3/16 in. from the shoulder. Reverse in chuck, chamfer the corners of the hexagon, and put a 5/32 in. parallel reamer through. This should be put through the valve-box as well, to remove all burring. Seat a 3/16 in. ball on the screwed end of the plug, and assemble the lot as shown. A piece of 7/16 in. ground rustless steel or drawn bronze rod should be a nice sliding fit in the barrel, needing no turning. If this isn't available, turn a piece to fit, from the nearest size you have, and part off at $1\frac{3}{4}$ in. from the end. Re-chuck and round off, then at 7/32 in. from the end, drill a No. 32 cross-hole. Slot the end $\frac{1}{2}$ in. deep and $\frac{1}{8}$ in. wide, by method described for slotting eccentric rods, forks and so on, but be sure that the slot is dead square with the cross-hole. At $\frac{1}{4}$ in. from the other end, turn a packing groove 3/16 in. wide and about $\frac{1}{8}$ in. deep. The lever is made from a 2 in. length of $\frac{1}{8}$ in. x $\frac{1}{4}$ in. rod (nickel-bronze for preference, but brass will do) the holes being drilled No. 30. The twin links are made from $\frac{1}{4}$ in. x 1/16 in. strip, same material, and drilled No. 32. The whole bag of tricks is assembled as shown, using pins made from $\frac{1}{8}$ in. bronze or rustless steel. If slack in the links or ram, rivet the ends over slightly.

Inner Dome

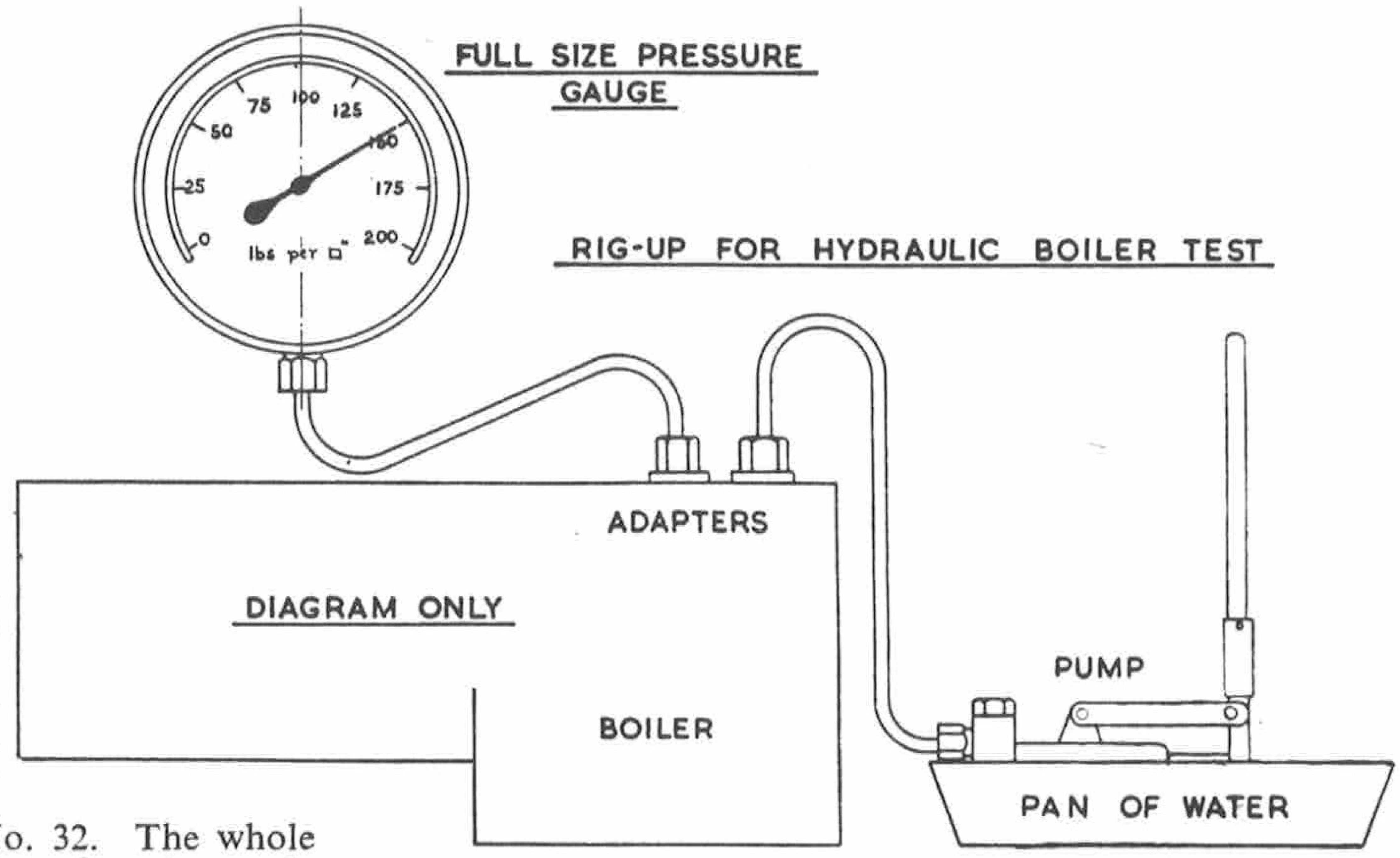
This item will have to be made and fitted before testing. Use a casting if available; if not, it can be made from a piece of 1 in. x 18 gauge copper tube faced off at each end to a length of 1 in. For the flange, either part off a slice of $1\frac{3}{8}$ in. rod



INNER DOME



EMERGENCY HAND PUMP



RIG-UP FOR HYDRAULIC BOILER TEST

a full $\frac{1}{8}$ in. thick, use a stamped brass blank (my favourite antic) or cut a circle of $\frac{1}{8}$ in. brass plate to required size. Chuck this in three-jaw, centre, drill through with 7/8 in. drill or nearest available, and bore to a tight fit on the 1 in. tube. Press it on to $\frac{1}{8}$ in. beyond the edge.

Chuck a piece of 1 in. brass rod and turn down ¼ in. length to a tight fit in the 1 in. tube. Cut back the end as shown in section, slightly bevel the edge, and part off at 3/16 in. from the end. The ¼ in. x 40 hole for the plug can be drilled and tapped before parting off, or left until the dome is assembled, as you fancy.

Press the cap into the tube, flat side first, then silver-solder both flange and cap at same heating. Set out and drill the screwholes around the flange, then chuck the dome, flange outwards, and take a truing-up skim off the contact side of the flange. The ¼ in. x 40 plug is turned up from ⅜ in. hexagon rod. Fit the dome to the boiler bushing, put the 43 drill through all the holes and make countersinks on the bush, drill them No. 51 and tap 8 B.A. Put a temporary gasket of 1/64 in. Hallite or similar jointing between flange and bush for the test, and use temporary steel screws.

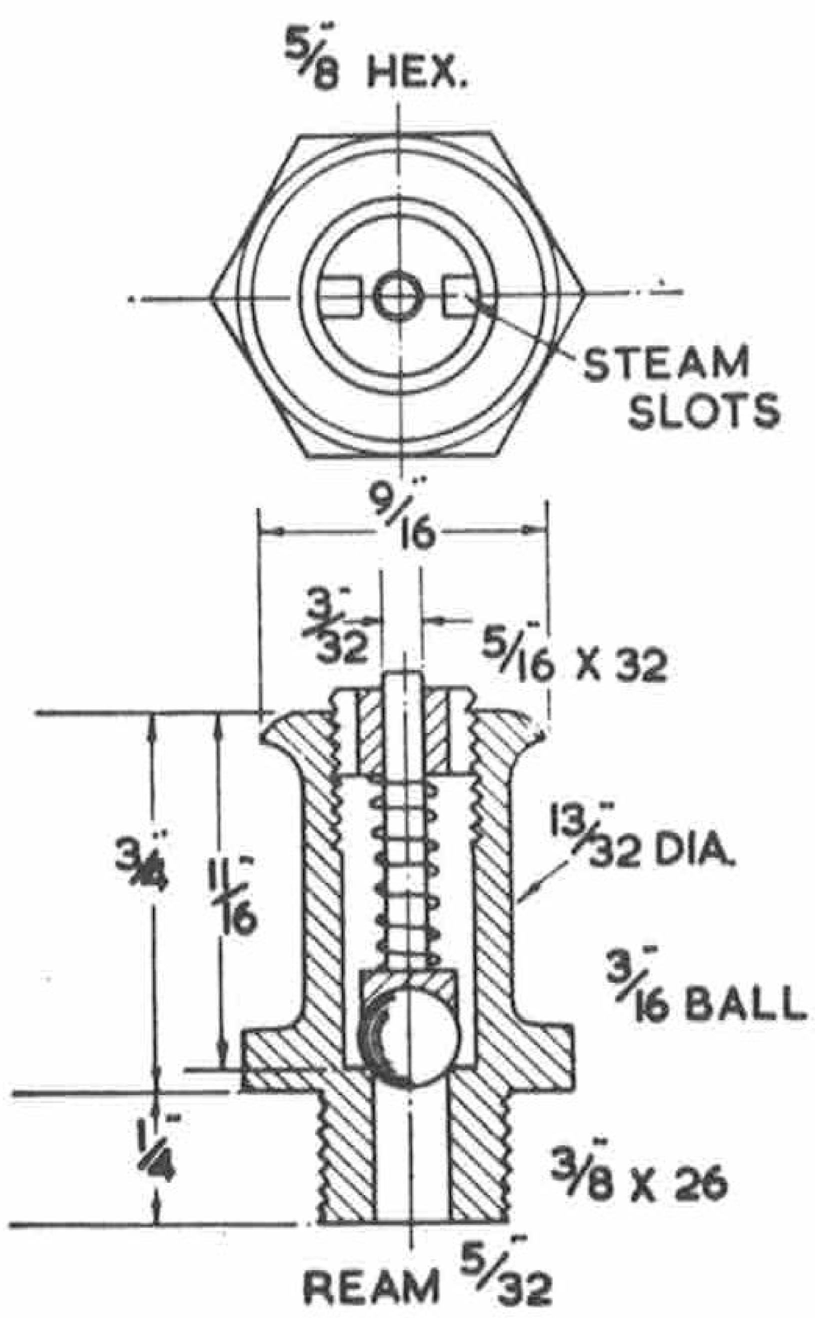
We shall also have to block up the regulator hole in the backhead, and the steam-pipe hole in the smokebox tubeplate, but these can be blanked off at one fell swoop. Take a piece of 3/16 in. rod (steel will do) a little longer than the boiler, and put a few threads on each end. Part off two slices of ¾ in. rod about ⅛ in. thick, and drill a 3/16 in. clearing hole in the middle. Cut two rubber washers same size, from a discarded tyre tube or anything similar, punching holes in them to fit tightly on the rod. Put one on one end of the rod, then a metal washer, and a nut. Poke the rod through the holes in backhead and smokebox tubeplate, put on the other rubber washer, then the metal one and a nut, tightening up until the rubber washers are squeezed up tight against the plates. That should stop any leakage.

How to make the pressure test

Two adapters will be needed for the safety-valve bushes. These are just pieces of ⅝ in. hexagon rod about ⅝ in. long, with one end turned down and screwed ⅜ in. x 26 to fit the bushes, and the other ends turned down and screwed ¼ in. x 40; they are drilled No. 40, and countersunk for union cones. One is connected to a full-size pressure-gauge by a ⅛ in. pipe. The gauge I use is a proper locomotive gauge, and my few personal friends are convinced that I "won" it from the old London, Brighton and South Coast Railway. Well, I just didn't! I bought it from a well-known engineering store in Southwark St., London, just after the Kaiser's war, and gave the princely sum of twelve shillings and sixpence for it. I am writing that out in full, in case the printer thinks I'm making a mistake if I put figures! Goodness only knows what it would cost now. It has a 6 in. dial, the finger is centrally pivoted, and it reads up to 360 lb. per square inch. It is as near perfect accuracy "as makes no odds" as my old granny used to say. Incidentally she was a little girl of two years old when the *Rocket* ran at Rainhill, so that I am a real link with the past; seems incredible, but it is so.

Returning to the job, the other adapter is connected to the pump by a ⅛ in. pipe with a union nut and cone on each end, and placed in a pan of water. Take out the plug on top of the dome, and fill the boiler with cold water right up to the plug. Screw it tightly home, and then operate the pump handle; it only needs three or four strokes to make the gauge pointer jump. Stop at 50 lb. and take a look to see if anything is happening. If the crown sheet moves 1/32 in. or so, take no notice. It will only be the soft copper settling itself in the best position to resist the stress. If O.K. go up to 100 and take another look. If still all serene, gradually pump to 150 lb. as shown on the "clock" in the diagram. There is no need to go beyond this, for a working pressure of 75 or 80 lb., as it would only unduly stress the boiler. If it stands up to 150 water, it will be all right with steam, for the lifetime of the engine, at normal working pressure.

I usually give my boilers a half-hour or so under steam, to see if there are any "pinholes" caused by bubbling flux. Coppersmiths call them borax blisters, and they wouldn't show up under cold test, but only when heat is applied. For this you will need the safety-valves. To make them, chuck a piece of ⅝ in. bronze or gunmetal rod in three-jaw; face off, turn down ¼ in. length to ⅜ in. dia. and screw ⅜ in. x 26. Part off at ¾ in. from shoulder, and repeat process. Chuck the other way about, in a tapped bush held in three-jaw. Centre and drill right through with No. 24 drill. Open out and bottom to 11/16 in. depth with 9/32 in. drill and D-bit, tap the end 5/16 in. x 32, and put a 5/32 in. parallel reamer through the remnant of the No. 24 hole. Turn the outside to the contour shown, which represents a Ross pop safety-valve.



SAFETY VALVE

Seat a 3/16 in. rustless ball on the reamed hole, same as a pump valve. For the cup and spindle, chuck a piece of 3/16 in. rod, face off, and turn ⅝ in. length to 3/32 in. dia. parting off at a full ⅛ in. from shoulder. Reverse in chuck and countersink the end sufficiently to let the ball sink in, as shown in the section. The nipple is just a 5/32 in. slice of screwed rod. Chuck the 5/16 in. rod, face centre, drill No. 40 for about ½ in. depth, screw the outside 5/16 in. x 32 for same length, part off two slices, and file or mill a 3/32 in. slot at either side of the hole, as shown in plan. The spring is wound up from 21-gauge tinned steel wire around a piece of 3/32 in. silver-steel held in the chuck, same as the axlebox springs. Touch each end on a fast-running emery-wheel to square off the ends of the coil, otherwise it won't bear evenly on the top of the cup, and the valve will "dribble" instead of shutting down tightly. The springs should start to compress when the nipple is inserted.

Put enough water in the boiler to cover the crown of the firebox to about ½ in. depth—you can see it through the safety-valve bushes—then stand it on a tray, or piece of asbestos, or something else that won't be affected by heat. Prop it up so that the firebox has an inch or so of clearance underneath. Screw in the safety-valves, and connect the big pressure-gauge to the hole in the top of the dome, by another adapter and a piece of ⅛ in. tube. For when he came along for his initiation as an engine-driver on my line!) and then the engine's own blower will take over. Open the valve a little, and remove the auxiliary gadget. While steam is rising to working pressure, couple on the driving car *and take good care* the chain and coupling hook are O.K. and not likely to slip. You'll know why when *Mona* starts to pull.

When the steam gauge is showing about 60 lb. put the reverse lever in the farthest notch forward, and open the regulator half-way. She won't start at once, as steam entering the cold cylinders will condense instead of pushing at the pistons. Help her along for the first few turns of the wheels. Keep clear of the chimney, as she will spit oily water from it. Then suddenly the wet exhaust will disappear and she will try to slip through your fingers. The cylinders have got hot, and she is what our American friends call "rarin' to go."

With the blower still on a little, put about half-a-dozen shovelfulls of coal on the fire, spreading them out evenly, shut the firehole door, take your seat on the car—spreading out your weight evenly so that all wheels bear an equal share—and open the regulator. By this time *Mona* will either be blowing off or very near it, so hold on tight as she pulls at the drawhook. Even if you are a sixteen-stoner she won't worry in the slightest, but if you have followed the notes and got the valve-gear and cylinders reasonably right, she will accelerate like nobody's business. It is now time to notch up, same as a full-size driver does, so pull the reverse lever back to the next notch to middle; the sharp cracks from the chimney will then die down to a steady purr. If she still tries to accelerate after getting up to what is a safe speed for you, close the regulator a little.

Keep a weather eye on the enginemen's nightmare, the water gauge. It will probably be showing a low level by this time, so look at the bypass pipe under the right-hand filler. If the bypass valve in the cab is open, water should be squirting from it. Close the valve, so that the water goes into the boiler. Meantime, don't forget the fire. Yes, there's certainly a lot to do when driving a wee locomotive; more so, in fact, than in the case of a full-size one, as you have to be both driver and fireman, and as the little boiler doesn't hold much water, and the firebox doesn't carry such a big fire, you can soon lose the lot. Don't forget that nature won't be "scaled," and the little fire burns, and the water boils away, *at the same rate in the little boiler as it does in a big one.* Novices—and also plenty of experienced folk—don't realize that, but it's gospel! Keep the fire a little way below the firehole, and remember that the best time to pop some more on, is when she starts to blow off. The fresh coal damps the fire a little and stops the safety-valves from roaring, but the heat below keeps the steam-gauge needle on the figure where it always should be when running.

If the water creeps up to the top of the glass, open the bypass valve a little, so that some surplus is returned to the tank. A little practice will enable you to set the valve so as to keep a constant level. If she still blows off with plenty of fire and water, open the firehole door a little, and let the fire sink sufficiently to take some more coal. Keep the blower valve shut when running, but always open it a little before closing the regulator to stop the engine, and keep it thus while she is standing still. In full size, shutting the regulator without opening the blower will cause a rush of flame through the firehole door, and this has been the cause of serious injury (and in some cases death) to forgetful enginemen.

When the run is finished, pull out the dumping pin and drop the grate, clean out all residue, and replace. Wipe the engine down while she is still hot, so that the oil and dirt will come off easily. Never put her away dirty, or the oil and dirt will stick, and be hard to remove, also the paint will soon get very shabby.

The 1¼ in. gauge engine is prepared for service in much the same way. Never fill the lubricator more than about two-thirds full, as space must be left for steam to enter and start the condensation on which the action depends. By the way, if it is found that the oil doesn't feed regularly, fit an auxiliary ⅛ in. pipe from the elbow union to the upper part of the lubricator, so that steam can enter the lubricator direct when the regulator is open, and leave the oil pipe to the steamchest for "one-way traffic."

The boiler should be filled just over half-full with boiling water (doesna use sae muckle speerit getting up steam, ye ken), and the bunker tank about three-parts filled with methylated spirit. Open the spirit valve after making sure the filler is screwed down tightly, take off the smokebox front, and light the burners. Open the blower valve a little. When steam is up, it will hiss from the blower jet. The smokebox front can then be replaced, and the engine is ready to go. If she is making a long nonstop run, the blower can be shut off while running, but if only making short runs, with plenty of stopping and starting, leave it on a little all the time, just sufficient to prevent flames coming out under the firebox. Wipe her down when the run is finished.

Catalogued items available from A J Reeves & Co.Ltd, Holly Lane, Marston Green, Birmingham B37 7AW Tel.021-779-6831 Fax. 021-779-5205.

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