formers exactly to outline, with a little judicious manipulation. When you have the formers to size, round off one edge, and they are ready for use.

Firebox Plates.

Lay the firebox former on a piece of 13 gauge sheet copper, and scratch a line all around it, except at the bottom, 5/16-in. distance away; the bottom line is flush with the former. Cut out the piece of copper, make it red-hot, and plunge into clean cold water; this will soften it for flanging. Clamp it in the vice, alongside the former, and beat down the projecting part over the edge of the former, using a fairly heavy hammer. Should the copper show signs of buckling, as the flange is being formed, re-anneal it, as described above; because hammering hardens the copper and makes it liable to crack. The flange of the front plate is at right angles to the top, but the flange of the door plate is a little obtuse (see longitudinal section of boiler) so the flange at the top should not be hammered down to a right angle. If you like, the top of the former could be filed to the correct angle before flanging the second plate over it. After flanging, trim off any raggedness with a file, and file the flanges bright, so they will be O.K. for brazing. Bend back the bottom edge of the front plate for 5/16-in. to the angle shown in the longitudinal section of the boiler.

Firehole Ring.

One plate carries the firehole ring, and the other the combustion chamber. The ring is of simple pattern devised by an old friend who worked in the L.B. & S.C. Rly. shops at Brighton when I was on the footplate, and forms a very substantial stay, as well as serving its original purpose. To make it you need a piece of seamless copper tube 1⅜-in. diameter, ⅛-in. in thickness, and ⅝-in. long after both ends have been truly faced. Chuck it truly in the three-jaw, and turn a step 3/16-in. long and 1/16-in. deep on each end, using a knife tool and plenty of cutting oil. Anneal by heating to red and plunging into cold water, then squeeze it to an oval in the bench vice, so that the hole measures ⅞-in. by 1⅜-in.; then clean up the flanges with emerycloth or steel wool.

Next, place the ring on the door plate—that is, the rear end plate of the firebox—with its bigger diameter midway between the two sides, and the flange ⅞-in. from the top. Scratch a line all around, leaving the outline of the ring on the copper; then remove the ring, and cut out the metal inside the oval scratch. This may be done by "fretsawing" around the line, using a metal-piercing saw, which is merely a glorified edition of an ordinary fretsaw, and is also known as a coping-saw; or a ring of holes may be drilled all around, just inside the line, the piece knocked out, and the roughness smoothed off with a half-round file. A drop of cutting oil, as used for turning steel, is a wonderful help when sawing soft copper. I have a motor-driven jigsaw which makes short work of these jobs; an ordinary pedal-driven jigsaw, as used for wood fretwork, is also very useful for sawing copper and brass, if a metal-cutting blade is used in the "bow."

Clean the metal all around the hole on both sides of the plate; push the flange of the firehole ring through, from the side opposite the flange, and then beat down the flange, outwards, until flat on the door plate; see longitudinal section of boiler. The door plate is then clamped tightly between the beaten flange and the shoulder on the ring.

Combustion Chamber Shell.

Before cutting the hole in the front plate of the firebox for the combustion chamber, the shell of the latter must be made, and the hole can then be cut exactly to suit. For the chamber you need a piece of 16 gauge seamless copper tube 2¾-in. diameter and 4½-in. long, with the ends squared off truly. This must first be annealed (drawn tube is usually very hard) and then squeezed to an irregular oval shape, as shown in the end views of the boiler. Stand the shell on the firebox plate with the flatter side as close to the flange as possible; scribe a line around it, remove shell, and cut out the piece inside the marked line, exactly as you did for the firehole ring. The shell should be a tight fit in the hole.

Firebox Sides and Crown.

Both sides and the top of the firebox are bent from a single piece of copper, 16 gauge, measuring approximately 11-in. by 4¼-in. overall, and cut to the shape shown in the illustration. Bend this at the dotted lines, and make the top slightly arched to suit the flanges of the firebox end plates. Put the front plate in the right-angled end, hold it in position with a toolmaker's cramp at each bottom corner, and put a couple of 3/32-in. copper rivets in each side, to hold it permanently whilst finishing off. Hold it up to the light and see if any "daylight" shows between the flanges and the plate; if so, close them up with a judicious application of a light hammer, and put in the rest of the rivets. You don't need many, just enough to hold the lot together whilst brazing; 1-in. apart would be quite sufficient. Repeat performance with the back end plate, in the sloping end of the firebox.

The crown of the firebox is supported by three girders, two of which are attached to the wrapper, converting the upper part of the boiler into a box girder, which any millwright will confirm, is one of the strongest known forms of construction. This is a far superior and much easier method of staying the crown sheet, than using direct rods, which must necessarily pass through the wrapper sheet at an angle, and are difficult to fix. Also, rod stays, when used in this position, waste away in the middle, eventually breaking and letting the crown sheet collapse.

Fix the central girder first; this consists of two pieces of 16 gauge sheet copper, bent into angles, placed back to back, riveted together and attached to the crown along the centre line. Each piece is 3¾-in. long, 1-in. wide at the centre, and ¾-in. wide at the ends; clamp in vice with the straight edge ⅜-in. above the jaws, and hammer down to a right angle. Thoroughly clean both pieces on the outsides, then clamp together back to back, and put about seven 3/32-in. rivets through. Drill about eight No. 40 holes through each bottom flange; stand the girder on top of the firebox, exactly in the centre, and hold it there whilst you make a couple of countersinks, through one hole at each end, with the No. 40 drill. Remove, drill out the countersinks, clean off any burring, replace girder, put rivets through the holes and hammer down tightly, then go ahead and put all the rest in, using the holes in the flanges to guide the drill through the crown sheet. When through, you can give the firebox a rough test by putting it on the floor and standing on it, throwing your whole weight on the girder. It should support you without turning the proverbial hair.

The two side girders are made from 16 gauge sheet copper, cut out to the sizes given in the illustration, and bent at the dotted lines. Note that the lower flanges are wide, to afford ample support to the large area of the crown sheet. These girders are riveted to the crown, flanges outwards, at a distance of 1½-in. apart; and make certain that the flanges are in close contact with the firebox for their full width and length.

Brazing Up the Firebox.

We can now proceed with the second instalment of brazing. First, apply the paste mixture of flux and water, to the joints at each end of the box, along each side of each girder, and around the firehole ring; then stand the firebox end-up in the brazing pan, the firehole ring being on top. Pile up the coke or breeze around it almost to the full height, also inside, to within an inch of the back plate; then proceed exactly as described for the barrel and throatplate, first heating the lot, then concentrating on one bottom corner, and when the brazing material starts to run and flow in, "working your way" up the joint, around the top, and down the other side. Then blow on the ring, and run a fillet of brazing material all around it. Turn the firebox the other way up, and repeat process with the front plate joints. Finally, stand the firebox the right way up in the pan, girders on top, and proceed to braze the flanges. Beginners please note, *it is absolutely essential that the molten brazing material (coppersmiths call it "spelter") should penetrate or "sweat" through the full width of the flanges;* so if you have any doubts of your skill, apply a little silver-solder to each of the flanges, before applying the strip. The silver-solder, having a much lower melting point, will melt and run through the joints like water; and wherever it goes, the melted brazing strip will try to follow. Don't forget to cover all the rivet heads, and run in sufficient brazing strip to form a fillet at the bottom of each girder, on the opposite side to the flange, indicated by black triangles in the cross section of the firebox. Take great pains to get all the joints perfect; and when you are quite satisfied that they are so, let the job cool to black, put it in the pickle for about 20 minutes or so, then wash off in running water, and clean up with a handful of steel wool, or some domestic scouring powder and an old nailbrush. It is then ready to have the combustion chamber fitted.

Combustion Chamber Assembly.

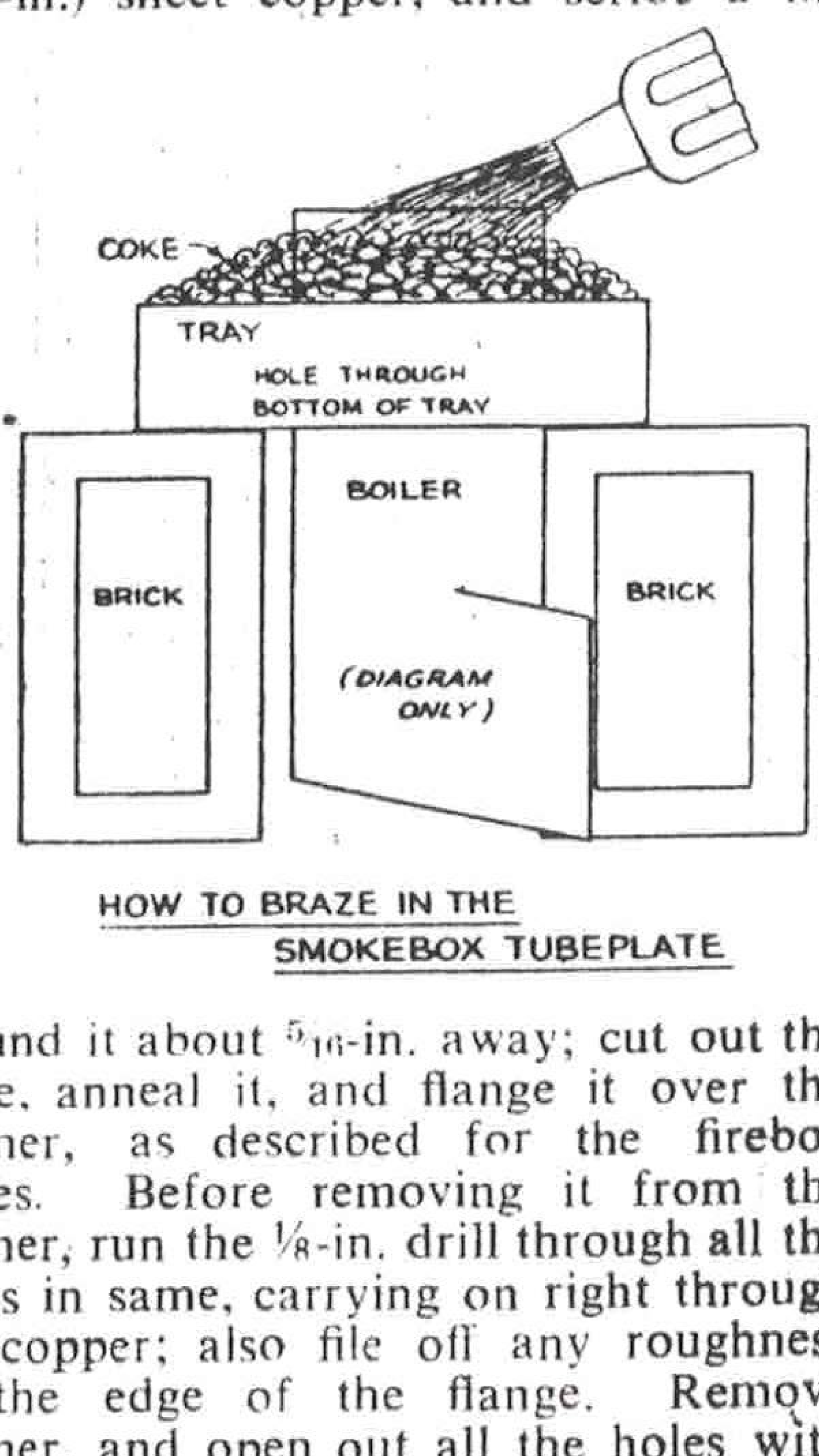
The main part of the combustion chamber is made from a piece of seamless copper tube, 16 gauge, 2¾-in. diameter and 4½-in. long. This must be squared off at each end in the lathe; if a disc of metal or wood is pushed tightly into one end of it, same may be gripped in the three-jaw chuck without fear of distortion of the tube, and the outer end faced off without any additional support. If you don't plug the end, the tube will probably fly out of the chuck as soon as turning operations commence, with resultant damage either to personal anatomy or the workshop window! Anneal the piece of tube by heating to redness and plunging into clean cold water; then clean up the ends, and squeeze it to the shape shown in the cross-sectional illustrations. Measurement should be approximately 3⅞-in. full across the widest part, and 2⅛-in. full across the narrower; exact shape and cross dimensions don't matter, so long as it is somewhere near the mark, because the actual area of the metal must necessarily remain constant.

The chamber is stayed, and its heating surface considerably increased, by six struts made from 16 gauge copper tube ¾-in. diameter. On the flattened top of the tube, scribe two lines 1½-in. apart—¾-in. each side of centre-line—and on the rounded side, two more, at a full ⅞-in. each side of centre-line. Starting ⅞-in. from one end, make three centre-pops at 1¼-in. centres, on each line; drill them out with a ⅛-in. or No. 30 drill, follow up with a 23/32-in. drill, and finally put a ¾-in. parallel reamer through each pair. Countersink them on the outside; judicious application of a small half-round file will do this job better than a drill, on account of the surface not being flat. Saw off six pieces of ¾-in. by 16 gauge copper tube, each a full 2¼-in. long; remove any burr from one end, and carefully drive them through the holes, so that an equal amount projects through the top and bottom of the chamber. The tubes should be approximately 1-in. between walls at bottom, and ¾-in. at top; see cross-sectional illustration and longitudinal section already published.

The shape and size of the former for the combustion-chamber tubeplate, is easily obtained from the chamber itself, by standing it end-up on a piece of ¼-in.

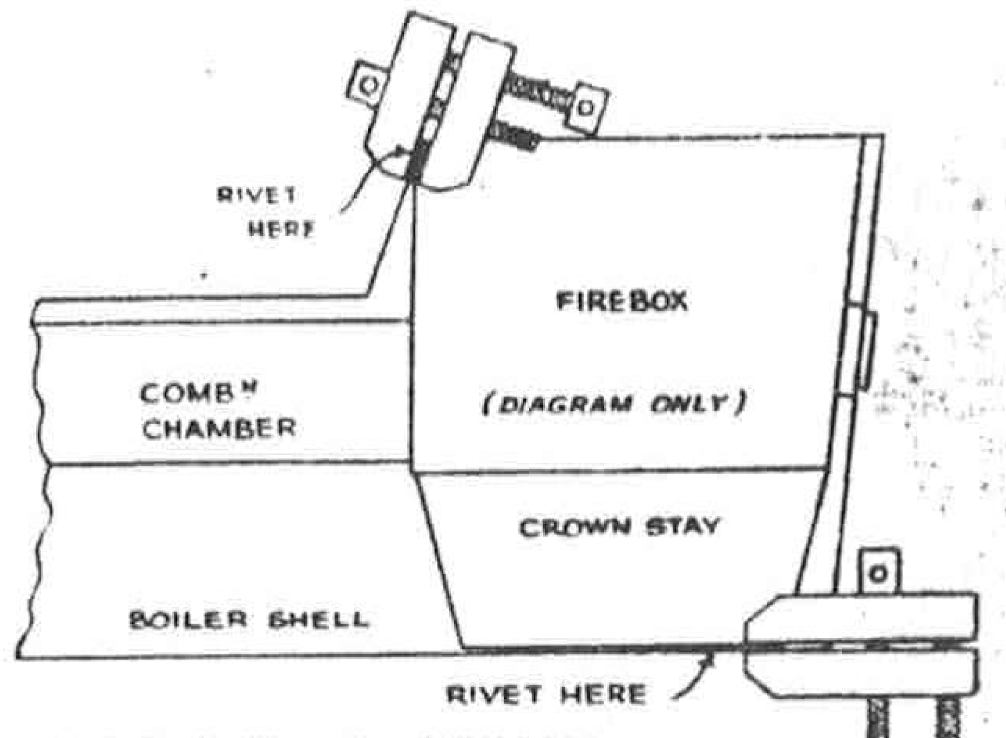
iron plate, and scribing a line all around it. The piece of iron (or steel) is then sawn and filed to shape, as described for the backhead and firebox formers, one edge being rounded off; and on it are set out the location of the tube holes, fifteen 3/8-in. diameter, and two 3/4-in. for the superheater flues. If a line is scribed across the former 9/16-in. from the top, and another the same distance from the bottom, both being intersected by a vertical centre-line, setting-out is easy. The centres of the two flues are centre-popped 7/16-in. side of the middle of the upper horizontal line; and the pops for the two middle tubes in the bottom row are 1/4-in. off centre, on the lower line, the outer two being 1/2-in. farther away. The rest can then be located, as shown in the drawing of the combustion-chamber tube-plate, the lot being approximately 1/2-in. centres. Drill a 1/8-in. hole through each centrepop, and smooth off any burring.

Lay the former on a piece of 13 gauge (3/32-in.) sheet copper, and scribe a line



HOW TO BRAZE IN THE SMOKEBOX TUBEPLATE

around it about 5/16-in. away; cut out the piece, anneal it, and flange it over the former, as described for the firebox plates. Before removing it from the former, run the 1/8-in. drill through all the holes in same, carrying on right through the copper; also file off any roughness in the edge of the flange. Remove former, and open out all the holes with a 23/64-in. drill further opening the two flue holes with a 47/64-in. drill; then ream 3/8-in. and 3/4-in. respectively. Countersink all the holes on the side opposite to the flange. Well clean the inside of the flange, and the end of the chamber nearest to the water tubes; then put the tubeplate over the end, same as you put the lid on a cocoa tin. Spread some flux-and-water paste all around the joint between flange and combustion chamber, and around each water tube where it sticks out of the chamber; then lay the assembly in your brazing-pan, and get busy with the blowlamp or blowpipe. The way I used to do it, was to heat the whole issue to bright red, and apply a length of easy-running brazing strip to the upper ends of all the six tubes, allowing the countersinks around each to become "moats" of liquid metal, which would "set" as soon as the flame was removed. The chamber was turned over, and the process repeated on the other ends. The assembly was then stood on end, open end upwards, in the coke, and the flame played on the flange of the tubeplate: when this became red, which it speedily did as the coke began



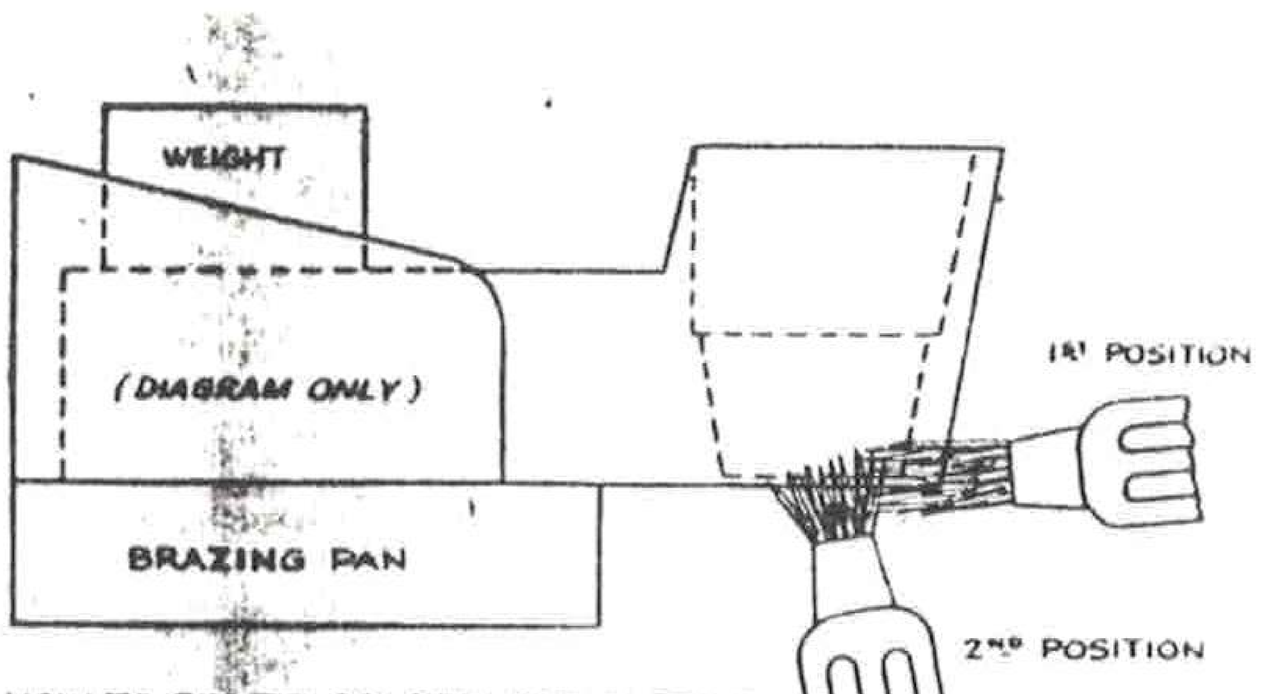
HOW TO FIT FIREBOX AND TUBE ASSEMBLY TO BOILER SHELL

to glow, an application of the easy-running strip sealed the joint, the metal melting, running in the slight interstice between tube and flange, and piling up in a little fillet all around the flange. Half was done at a time, the chamber being turned around so that the second half faced the operator; though if the forge or pan was in such a position that you could walk around it, the chamber would not need to be moved. Let it cool to black, then pickle and wash off as previously described.

If you haven't already cut the hole in the front firebox plate, stand the firebox end-up on the bench, and put the combustion chamber on the front plate. Scribe a line all around, then cut out the piece, and fit the combustion-chamber tightly in the hole. It should project through about 1/16-in., and the end of the chamber, also the metal around the hole, must be thoroughly clean. Then stand it end-up in the brazing pan, chamber pointing skyward; smear flux all around the joint, pile up the coke or breeze to the level of the firebox plate, inside and out, and heat the lot to redness. The "technique" for this brazing job is very similar to that used previously, viz., when the whole of the work is well heated, apply the flame in one place until that spot becomes hot enough to melt the easy-running brazing strip. Then feed a little in, shift the flame along slightly, apply more strip, and carry on until you have completed the circuit and got a nice fillet all around. It only needs care, patience, and a little of what is popularly known as "common sense," to make brazed joints that wouldn't spring a leak in a thousand years of service, and are actually stronger than the self-material of the boiler. Pickle, wash off, and clean up as before. The projecting ends of the water tubes can now be sawn off and filed flush with the surface of the combustion chamber.

Tubes and Flues.

There are 15 firetubes of 3/8-in. diameter and 22 gauge, and two superheater flues of 3/4-in. diameter and 20 gauge, all 8 3/4-in. long. Thicker gauges than those



HOW TO SILVER SOLDER CROWN STAYS

specified, should not be used unless no others are obtainable, as over-thick tubes are detrimental to the efficiency of the boiler in two ways; the thicker walls do not transmit heat so effectively, and the smaller bore reduces the draught area. In fact, tubes of 24 gauge would be more efficient than 22; but the "wasp in the jampot" in this case is that amateur and inexperienced boilersmiths are liable to burn the copper when silver-soldering them into the tubeplates. A very fine-toothed saw should be used to cut thin tubes; and the ends of each should be squared off in the lathe, and cleaned up with coarse emery or other abrasive cloth.

Before fitting the tubes, it will be necessary to make the smokebox tubeplate, as we shall need something to hold the outer ends of the tubes at the proper spacing, whilst silver-soldering them into the combustion-chamber tubeplate. The former for the smokebox tubeplate is a plain disc, a shade under 4-in. in diameter. Anything handy may be used; I have several old wheels with the flanges turned off, two or three iron stampings, and a couple of chuck-back castings. The *modus operandi* for flanging is exactly the same for the combustion-chamber tubeplate. Cut out a circle of copper, 13 gauge (3/32-in.) 4¾-in. diameter; anneal it, clamp in bench vice alongside the former, and flange the copper over it. Don't forget to re-anneal immediately if the copper goes hard and shows signs of cracking or buckling.

Chuck it in the three-jaw, flange outward, and turn off any irregularities in the edge of the flange; then chuck it again, this time holding by the inside of the flange. If your chuck won't take the tubeplate this way on the inside jaws, use the outside jaws, and mount the plate on the outside of the "top steps." This usually does the trick. Turn down the flange to a tight fit in the end of the boiler barrel. Don't run at too high a speed, use a tool with plenty of top rake on it, and douse liberally with cutting oil, as soft copper is rather tricky stuff to turn unless you "know the ropes."

The combustion-chamber tubeplate former is used as a jig to set out the tube holes in the smokebox tubeplate. Locate it centrally on the tubeplate, on the side opposite to the flange, with the bottom row of ⅛-in. holes exactly ⅞-in. from the outer edge of the tubeplate. Clamp in position with a couple of toolmaker's cramps; a little block of wood under the cramp, on the flange side, will prevent any slipping. Then run the ⅛-in. drill through the holes in former, carrying on right through the copper. Remove former, and serve the tubeplate exactly the same as you did its companion on the combustion-chamber, drilling out the holes 23/64-in. and 17/64-in., reaming ⅜-in. and ¾-in., and countersinking, both sides this time. The other holes shown in the drawing of the smokebox tubeplate, for stays and steam pipe, may also be drilled and tapped at this stage of proceedings.

Anybody who has had previous experience at small-size boilersmithing, or silver-soldering and brazing thin copper, can put in the whole of the tubes at one fell swoop; but beginners and inexperienced workers had better put in one row at a time. Better be safe than sorry, and tubes are easily burnt! In the former case, insert one end of each in the combustion-chamber tubeplate, letting them project through a bare 1/16-in.; then put the smokeless tubeplate on the outer ends.

Now carefully line up the whole nest of tubes, so that they are parallel with the sides, top and bottom of the combustion-chamber, and square the tubeplate; they can be adjusted by manipulating the smokebox tubeplate, which will retain them in position at the proper spacing. Stand the whole assembly end-up in the brazing pan, the tubes pointing to the sky; mix up some silver-soldering flux (either the special stuff sold for use with specialised silver-solders, or powdered borax) to a thin creamy paste with water, and put some all around the tubes with a small brush, completely covering the tubeplate. If you are using strip or sheet silver-solder, cut some little bits about ⅛-in. square, and drop them down among the tubes; you will need about a dozen pieces. Pile up the coke or breeze all around the combustion-chamber to within ½-in. of the tubeplate, and get busy with the flame. Don't let it play on the tubes until the coke around the tubeplate is well red, and the tubeplate itself begins to glow; then heat the tubes as well, just where they enter the tubeplate. When the correct temperature is reached, the little bits of silver-solder will melt, and the liquid metal will "flash" around all the tubes, forming a perfect seal.

A method of easily doing the whole lot at once, is practised by a friend, Mr. T. Hearn. He uses "Easyflo" and the special flux ("Tenacity") sold for use with it, but gets the silver-solder in wire form. This is wound up like a spiral spring, to the diameter of the tubes; and before inserting each tube, one coil of the "spring" of silver-solder is snipped off and placed over the tube end, so that when inserted, the ring of silver-solder lies around the tube, close to the tubeplate. The whole is then covered with the flux, mixed to a creamy paste with water, and heated up as described above. On reaching melting temperature, each ring just melts and disappears into the joint, making a perfect seal, and not wasting a scrap of the silver-solder by coating the tubeplate.

Beginners should first of all insert the two superheater flues and the five ⅜-in. tubes immediately below them, putting on the smokebox tubeplate, lining them up with the combustion-chamber, and then silver-soldering as above. As there are only a few tubes, and all exposed, it can easily be seen if the joints are sound, and the silver-solder has run completely around, before putting the rest in. After silver-soldering, let cool to black, pickle, and wash off. If all O.K. put in the rest, and repeat process; you won't hurt the tubes already in. Then, also those who put in the whole nest at once, let cool to black again, pickle, and wash off, using plenty of running water to get rid of all traces of acid; take off the smokebox tubeplate, heat up the ends of the tubes to redness for an inch or so—this is to soften them for expanding—dip in the pickle to clean them, and wash off.

First Stage of Assembly.

The throatplate of the boiler shell being sloped, and the front plate of the firebox bent to suit at its lower edge, no separate front section or a foundation ring is necessary, the plates being riveted together and brazed; see drawing showing longitudinal section. Lay the shell upside down on the bench, and slide the firebox and tubes assembly into it, so that the lower edges of throatplate and firebox plate butt together; then put a couple of small toolmaker's cramps on temporarily, and hold the bits together. The upper flanges of the crown stay girders should lie snugly against the top of the wrapper: if they don't, then make the necessary adjustments, and put on a couple more clamps to hold them in place. *Tip to beginners*: It is advantageous to have plenty of these cramps (I have about two dozen of various sizes) and there is no need to buy them; they can be home-made from square rod and ordinary commercial screws in a few minutes. I gave instructions for this in a previous issue, and need not repeat them, for you have only to take a look at one for a few seconds, to be able to copy the construction *ad lib*.

See that the firebox is central between the sides of the wrapper, and then drill a couple of No. 41 holes right through throatplate and firebox sheet, one at each end and about ⅛-in. from bottom; put in 3/32-in. roundhead copper rivets, heads inside, and rivet up. The cramps can then be removed. Next drill similar holes through wrapper and top flange of girder stays, about 1⅛-in. from the back of wrappper, just clear of cramps, and countersink them; remove one cramp and put a rivet in, from the inside: If you cut a strip of sheet metal about 3/16-in. wide, and match the end like a distant signal, the rivet can be jammed in the notch, inserted, and the strip readily pulled away, leaving the rivet in place. A piece of iron bar held horizontally in the vice jaws, projecting one side, serves as a riveting dolly or "holder-up," the boiler being slopped over it, so that the head rests on the bar, and the stem of the rivet can then be hammered down into the countersink. *Warning*: hit the rivet and not the wrapper; you don't want the boiler to look as though a Luftwaffe pilot has been trying to slaughter the "Bantam Cock" with a machine gun! After inserting the second rivet, take a look at the assembly and see if nothing has shifted; if all O.K. go ahead and put rivets in along both crownstay flanges and the front edge of firebox, at about ½-in. centres.

The next job is to insert the smokebox tubeplate and get the tube ends through it. Drive it carefully in, flange first, making certain it is absolutely vertical, until it almost touches the tubes; then, with a wooden meat skewer, a blacklead pencil, or the handle end of a penholder, carefully line up each tube with its respective hole in the tubeplate, after which the plate is driven down until the tube ends stand about 1/16-in. proud of the plate. See that the tubeplate does not go in what kiddies call skew-whiff; it should be the same distance from end of barrel to plate, all the way around. We now have to expand the tubes, which is done by driving what full-sized boilersmiths call a taper drift into each one. This is simply a piece of steel rod turned taper (exact angle doesn't matter) like a drill shank, and highly polished. A drill shank will do, if you have one available of the right size. Grease the end, insert into tube, and gently drive it with a hammer until the tube is forced out to a tight fit in the hole in the tubeplate. If the drift tries to stick on withdrawal, a couple of taps on either side of it will promptly teach it good manners.

The Second Brazing Operation.

The first scene in the second act is to fix the smokebox tubeplate, and the ends of the tubes; and this requires a special rig-up, as it cannot be done in the ordinary pan or forge, without the use of oxygen apparatus. An iron tray or a tin lid about 10-in. or more across, will be needed, and this must have a hole cut in it, big enough to allow the boiler barrel to enter. Stand the boiler end-up on something solid, and high enough to allow you to do the job in comfort. Put the lid or tray over the smokebox end, and set in about 3-in. down, propping up the tray with bricks, bits of stone or anything that won't burn. Plug the tube ends with little wads of asbestos flock or string, about ⅜-in. down. Pile small coke or breeze around the end of the barrel almost level with the tubeplate. Mix up some ordinary flux to a paste with water, and put a layer all around the edge of the tubeplate; use the same silver-soldering flux as before, for the tube ends. Also, if using ordinary silver-solder, repeat process of cutting squares and dropping among the tubes. Then get your blowlamp or blowpipe going, and heat the whole end of the boiler to dull red, after which follow previous instructions by concentrating on one point of the circumferential joint, letting the flame go partly to the inside, and partly out, so as to heat both barrel and tubeplate. Apply the brazing strip when the metal reaches bright red, then work your way completely around the circle, as before. Run in a fillet of brazing material right around the tubeplate. If the easy-running strip belies its name and shows disinclination to melt and run, apply a little silver-solder first, as a "starter"; the strip will soon show willing, when it meets the molten silver-solder. If there is any sign of bubbling, go around with the scratch wire, playing the flame mostly on the outside of the end of the barrel; this will cause the metal to sweat in like soft solder. Finally blow direct on the tube ends until all the silver-solder has melted, and run around the end of each tube.

Silver-solder may be used to fix the crownstay girders to the wrapper sheet, where only a blowlamp or blowpipe is available, as this will sweat through the full width of the flange quite easily, and is as strong as easy-running strip, though far more expensive. Take the "holey" tray off the barrel, and lay the boiler on its back in the brazing forge or pan, with the wrapper overhanging; put a brick, or something else of equal weight, on the barrel, to prevent the whole lot tipping up. Apply some flux to the crownstay flanges, and cut a strip of silver-solder to lay beside each one; then blow up, first inside, then out, until the wrapper sheet and the crownstay flange become hot enough to melt the silver-solder, and cause it to sweat through. In my "blowlamp days" (I have used acetylene apparatus since 1932) I got two blowlamps on this job, playing the flame of one inside, and the other outside; this job produced plenty of perspiration, but it most certainly did the trick. I also used two lamps for the backhead and foundation ring. When you are certain that the silver-solder has run well and truly right through, let the job cool to black, and lower it very carefully into the pickle, with the big tongs, taking precautions as before against getting splashed. The acid will bubble violently, and maybe spit, when it runs inside the hot barrel. Leave it in for about 20 minutes, then fish out with the tongs, wash off in running water, and clean up with a handful of steel wool, or some domestic scouring powder. *Note*: Don't attempt to do the front edge of firebox at this heating; this job is done at the same time as the foundation ring.

Backhead.

Lay the backhead former on a piece of ⅛-in. sheet copper, and draw a line about ⅜-in. from the edge of it, all around except at bottom. Saw out the piece of metal, anneal, and flange over the edge of the former, as described for the other flanged plates. Beginners may be pleased to discover that, except for having to hit a bit harder, the thicker metal is easier to flange than the thin material; it hasn't the same tendency to buckle. However, re-anneal immediately it shows any signs of going "hard" under the hammer, or it will crack. Clean up the flange with a coarse file, and smooth away any ragged edges. At 9/16-in. from the top, on the centre line, drill a ⅛-in. pilot hole, and open it out to ⅝-in., with drill and reamer, to take the regulator gland. Next, take measurements from top and sides of the wrapper, to the lip of the firehole flanges. Transfer these to the backhead, mark the outline of the hole, and cut it out, either with a piercing saw, or by drilling a ring of holes inside the line, knocking out the piece of metal, and filing up the ragged edge. *Tip*: leave the hole slightly undersize, and "offer up" the backhead, as the shopmen say, to the boiler. You can then see if the hole is in the right place for the lip to go through; if not, it can easily be corrected when filing the hole to the correct size. When O.K., insert the backhead into the end of the wrapper; see that same is in close contact with the flange all around, and the lip of the firehole ring projects through the hole in the middle of the backhead. Now rest the inner side of the firehole on a stout bar of iron held horizontally in the vice jaws, and carefully hammer the projecting lip outwards and down, until it lies flat on the backhead, and clamps same tightly against the shoulder. This will hold the backhead in position for subsequent operations, and in the completed job it forms a very substantial firebox stay.

Foundation Ring.

By the good rights, this isn't a "ring" at all, in the generally accepted sense of the term; but circular vertical boilers with enclosed fireboxes were made long before locomotive boilers, and these had a foundation ring which really was a ring, between the firebox and shell. Consequently, when the old boilermakers started building locomotive boilers, they fitted the same kind of support between firebox and shell, and the term foundation "ring" still stuck, although the firebox was rectangular instead of circular. Laymen usually speak of rolling-stock as "carriages" and "trucks," whilst railwaymen always refer to them as "coaches" and "wagons," terms handed down among the fraternity, from the far-off days of horse haulage on the highways and early tramways. There are many other instances.

The "ring" is made from ¼-in. square copper rod, in three pieces. Cut one piece to fit tightly between backhead and firebox; let it go in far enough to leave a little bit of the firebox and backhead plates projecting below it. Hold temporarily in position with a couple of cramps, then drill two No. 41 holes through the whole lot, one near each end, and secure with 3/32-in. roundhead copper rivets. Remove cramps, and put in the rest of the rivets, at about ½-in. spacing. The rivets are not for the purpose of resisting pressure in the finished job, but merely to hold the parts in close contact whilst the final brazing operation is performed. Then fit a similar piece of copper rod at each side of the firebox, between it and the wrapper, riveting it in same way. It is hardly necessary to add that the contact surfaces must be thoroughly clean before assembly, otherwise the brazing material may fail to "take," and an unsound and leaky joint will result; this is one reason why I always advocate well washing and cleaning the job after every brazing operation, apart from the fact that clean metal is safe to handle. If there should be any interstices left at the corners of the firebox, due to the copper rod not being filed to fit against the flanges, they can be plugged with small wedges or splinters of copper, which will be sealed solid in the final brazing operation.

The bushes can be fitted, and secured at the same heating. I usually make boiler bushes from thick-walled copper tube, if large, and from copper rod if small; the dome bush can be turned to the size given on the longitudinal section, from a piece of 1½-in. tube with ¼-in. wall, and the regulator bush from ¾-in. tube. The safety-valve bushes can be turned from ⅝-in. copper rod. If copper of the size given, is not available, castings in what is known as "plumber's weldable metal" may be used, or the bushes made from bronze or gunmetal rod or tube of good quality; but don't use brass if you can possibly get anything else, or when the brazing operation is going good and strong, you may suddenly find lots of nothing where there were once brass bushes! The melting temperature of some kinds of brass, especially the screw-rod alloys, is only a few degrees above that of the brazing material. There is no need to detail out the actual turning, drilling and tapping of the bushes, which is a plain straightforward simple job; suffice it to say they should be a good tight fit in the holes in the boiler.

The Final Brazing Job.

Beginners and inexperienced boilersmiths usually regard this job "with fear and trembling" as the poet says, but there is nothing whatever to be alarmed about. So long as you have adequate heat, it is quite easy. First, cover all the joints with flux paste; then lay the boiler on its back in the brazing pan. Also have the smaller pan with the hole in it, propped up on a couple of bricks, close handy, as it will be needed for the backhead. Pile up the coke or breeze all around the boiler and firebox, to the level of the foundation ring, and nearly fill the firebox itself with asbestos cubes; or put a piece of asbestos millboard over the end of the combustion-chamber, and fill the firebox with coke instead. Get your blowlamp or blowpipe going good and strong, first making certain that there is plenty of paraffin in the former, or that the latter won't die out on you for want of a penny in the slot. Heat up the whole lot to redness, and when the coke is well glowing, concentrate on one corner of the firebox, applying the brazing strip at bright red heat. When it melts and flows, carry on as before, working your way gradually around, and taking in the front joint where there isn't any ring, but only the two plates riveted together. If the strip won't run freely, use a little silver-solder with it, and keep dipping it into the flux before applying.

I might mention here, that the brazing alloy known as Johnson Matthey's B6—really a coarse-grade silver-solder—is excellent stuff for the foundation ring and backhead of a boiler of this size, where only a blowlamp, or gas blowpipe worked by fan or bellows, is available for heat. It costs more than easy-running strip, but runs at a lower temperature; it has ample strength for the job in hand.

When the circuit of the foundation-ring has been completed, grab the boiler with the big tongs and transfer it to the other pan, putting the barrel through the hole, and letting the throatplate rest on the bottom of the pan. Pile some coke around the firebox quickly, almost to backhead level, and get the heat on again with the least possible delay. When the whole backhead begins to redden, go around the joint same way as before, starting at the bottom corner, and working gradually right around. Use silver-solder for the flange of the firehole ring, and the regulator bush. Finally, stand the boiler right way up in the big pan, and play the flame direct on the bushes, applying a little silver-solder when both bushes and surrounding metal grow to dull red.

Make certain the molten metal runs completely around the bushes; then let the boiler cool to black, shake out any bits of coke remaining in the firebox and combustion-chamber, and carefully lower the lot into the pickle. *Warning*—keep the bushes pointing away from you. When the acid runs inside, it will naturally encounter the hot firebox, combustion-chamber, and tubes, and promptly blow out again in a shower of spray and small drops, for a second or two, before the interior is finally quenched. If you get in the way of this shower, you can not only say goodbye to your clothes or overalls, but stand a risk of skin rash, caused by the spray drying on your skin before you can wash it off. Grease is a good protection against acid splashes; just as a coating of vaseline or petroleum jelly (same thing!) will protect the terminals of an accumulator from corrosion, so it will prevent acid splashes attacking your hands.

Let the boiler remain in the pickle for 20 minutes or so; then give it a thoroughly good wash, inside and out, in running water, and clean up the outside as before, with steel wool or scouring powder. Any blobs of spelter, or "almond rock" as it is usually called, can be filed off; the outside of the boiler should be perfectly smooth. It can then be given a rough test for air leaks or "pinholes," by plugging the bushes, fixing an adapter to one of the safety-valve holes, and pumping about 20-lb. of air in with a tyre pump. If the whole issue is then immersed in a bath of water, any air leak will show by a stream of bubbles, like a cycle tyre with a puncture. Should any appear, drill the spot with No. 55 drill, tap 10 B.A., screw in a stub of copper wire "doped" with plumber's jointing, and cut off and file flush. This will effect a permanent cure, and save re-heating the boiler.

Longitudinal Stays.

With backhead and tubeplate of the specified thicknesses, only two longitudinal stays will be needed; one of these is solid, and the other a tube, to carry steam for the blower. First of all, two holes must be drilled and tapped in the backhead, to accommodate the blind nipple for the solid stay, and the stem of the blower valve, which is attached to the hollow stay; the positions of these are indicated on the cross section through firebox, recently illustrated. They are 1⁷⁄₁₆-in. from the top of wrapper, and 2-in. apart, being an inch each side of centre line. After centre-popping, first put a No. 30 drill through; but *note carefully—the fittings have to be horizontal, whilst the backhead slopes,* therefore the drill brace must be held so that the drill is parallel with the boiler barrel, and *not* at right angles to the backhead. Open out with ⁹⁄₃₂-in. drill, then tap ⁵⁄₁₆-in. by 40, taking care to keep both drill and tap parallel with barrel, as above. It will be found an advantage if a tap with a long taper is used to start the thread, and an ordinary "second" tap run through afterwards.

Longitudinal Stays.

A drop of cutting oil, same as used when turning steel, is a great help in drilling and tapping soft copper. Anybody who has a drilling machine, either bench or pedestal, which will admit the boiler between chuck and table (my own will) can get correct alignment of the stay holes, simply by up-ending the boiler and drilling the holes with the smokebox end resting on the table. Then put your tap in the chuck, feed it to the hole by the drilling machine lever, and turn the chuck by hand until the tap gets a "bite"; after which, slack the chuck, and take the boiler away with the tap still in the hole. You can then put the boiler on the bench, clamp a tapwrench on the squared shank of the tap, and finish the job. If you attempt to cut the full thread on the drilling machine, the chances are that the thread will be torn and distorted—I've had some!

"Blind" Nipples.

Beginners might wonder why it is necessary for the stayrods to be screwed into each plate; and I often receive queries from novices, asking if a plain rod through the boiler, with nuts tightened up against the plates, will serve the purpose. No; the rod *must* be attached to the plates themselves, because of expansion stresses. If the nuts were tightened up against the plates, and sweated over, at the working temperature of the boiler, the solder would crack when the boiler cooled off; the nuts would come out of contact with the plates, and bad leakage would result. To obviate screwing the full length of the stay-rod or tube, I use "blind" nipples, as shown in the detail illustration. To make them, chuck a piece of ⅜-in. hexagon brass rod in the three-jaw; face, centre, drill down ⅓-in. depth with ⁹⁄₃₂-in. or No. 22 drill, and tap ³⁄₁₆-in. by 40. Turn down ⅜-in. of the outside to ⁵⁄₁₆-in. diameter, and screw ⁵⁄₁₆-in. by 40. Part off at ⁹⁄₁₆-in. from the end; reverse in chuck, and chamfer the corners of the hexagon. You can hold the nipple by the threads for that light operation; they won't come to any harm.

For the stay itself, you need a piece of ³⁄₁₆-in. copper rod a full 16¾-in. long. Chuck in three-jaw, and put about ½-in. of ³⁄₁₆-in. by 40 thread on it, with a die in the tailstock holder; don't forget the cutting oil, if you want clean threads. Then serve the other end in like manner. Screw one of the blind nipples on about three threads; then insert the stay through the left-hand hole in the smokebox tubeplate. The left will be the right, as Patsy O'Finnegan would remark, when you are looking at the smokebox tubeplate; the left side of the engine, is the side to the driver's left when he is standing on the footplate and looking ahead. Work the stay-rod through the corresponding hole in the backhead, and screw the nipple right home. If any difficulty is experienced in getting the stay through the hole in the backhead—it usually tries to get out everywhere but the right place!—put a short bit of ¼-in. tube over the end; this can be manipulated easily until it comes out of the backhead hole, and guides the end of the stay to its required destination. Now make a washer out of one of the bits of scrap copper left over when the backhead was cut out; it can be filed to shape, and then thinned down to a wedge. Drill a ⁵⁄₁₆-in. clearing hole in it, and place it over the second blind nipple, which is then screwed on to the other end of the stay-rod just projecting through the hole in the backhead. When the nipple meets the plate, the external threads will engage with those in the tapped hole, and the nipple is then screwed home against the backhead, with the wedge-shaped washer adjusted so that the thick part is at the top. The whole issue will then be locked solid (see illustration.)

Blower Stay.

The blower stay consists of a piece of ³⁄₁₆-in. by 18 gauge copper tube 16¾-in. long, with a "thoroughfare" nipple at the front end, and the screw-down valve for regulating the steam supply, at the rear end. The tube is screwed in the same way as the rod previously mentioned. To make the "thoroughfare" nipples, chuck a length of ⅜-in. hexagon brass rod in the three-jaw, and proceed exactly as given for the blind nipple; but instead of parting off to leave a head ³⁄₁₆-in. in thickness, part off at ⅞-in. from the end. Reverse in chuck, and grip by the hexagon, so that about ⁵⁄₁₆-in. is projecting from the chuck jaws; then turn down ¼-in. length to ¼-in. diameter, and screw ¼-in. by 40. Centre the end deeply with size E centre-drill, and drill down with either ³⁄₃₂-in. or No. 40 drill, until it breaks through into the tapped hole at the opposite end, which completes that part of the proceedings.

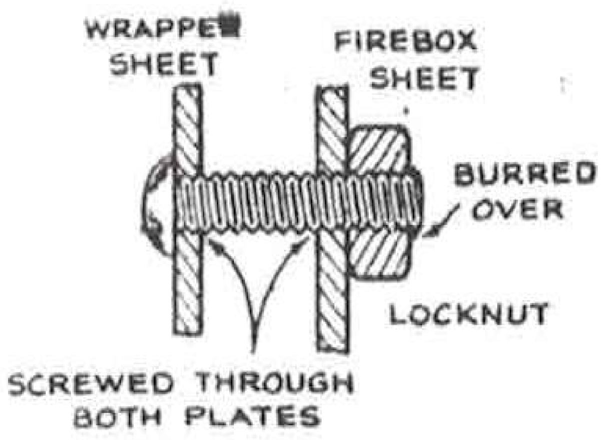
The blower valve is made from 7/16-in. round brass or gunmetal rod. Chuck a piece in the three-jaw, face the end, centre; drill down 1/4-in. depth with 5/32-in. or No. 22 drill, and tap 3/16-in. by 40. Turn down 3/8-in. of the outside to 5/16-in. diameter, screw 5/16-in. by 40, and part off at 1 1/8-in. from the end. Reverse in chuck, gripping by the full-size part, leaving about 3/8-in. projecting from chuck; turn down 1/4-in. of it to 1/4-in. diameter, and screw 1/4-in. by 40. Centre the end, and drill down with 5/64-in. or No. 48 drill until it breaks into the tapped hole at the other end. Open out with No. 30 drill, and bottom with a 1/8-in. D-bit to a depth of 3/4-in., then further open out the end with No. 21 drill, for about 1/8-in. down. Tap the No. 30 part 5/32-in. by 32 or 40, taking care not to let the tap go in far enough to damage the seating formed by the D-bit. Remove from chuck, and midway between the two shoulders, on the plain part, make a centre-pop, and drill it out with a 3/16-in. drill until the drill breaks into the tapped hole; then in this, fit a 1/4-in. by 40 union nipple. To make this, chuck a piece of 1/4-in. round brass or gunmetal rod; face the end, centre deeply with E centre-drill, and drill down with 3/32-in. or No. 40 for about 1/2-in. depth. Screw the outside 1/4-in. by 40 for about 1/4-in. down, and part off 7/16-in. from the end. Reverse in chuck, and turn down about 1/8-in. of the plain end, to a tight fit in the 3/16-in. hole in the valve body; force it in, and silver-solder the joint. Pickle, clean, and polish up.

The valve pin is made from a piece of 5/32-in. rustless steel, bronze or gunmetal rod; ordinary brass is too soft for valve pins, as the point would become grooved after being screwed down a few times, with consequent leakage. Saw off a piece, a bare 1 1/4-in. long, chuck in three-jaw, and turn down about 1/4-in. of the end to 1/8-in. diameter; then point the end. The exact angle doesn't matter, but a blunt point gives quicker action than a long taper. Either set over the top slide to the requisite angle and turn the point, or form it with a file; I usually adopt the latter method for quickness. Simply take a smooth flat file, hold it at the required angle, and take three or four steady sweeps over the end of the bit of rod, whilst the lathe is running at a good speed. This will produce a perfectly smooth and true cone point. Screw the next 1/2-in. or so, 5/32-in. by 32 or 40, to match the tapped hole in the valve; reverse in chuck, and file a square on the other end. In case beginners don't know the easiest way of doing this, I will briefly repeat the instructions. Have about 5/32-in. projecting from chuck jaws, and use a medium or second-cut flat file with one "safe edge," that is, a plain edge with no teeth on it. Set one of the chuck jaws exactly vertical, and file a flat on the propecting bit of rod, holding the file horizontally, with the safe edge bearing against the chuck jaws. Then move the lathe mandrel around 1/4 turn, until the chuck jaw points to "3 o'clock" position, and is horizontal; file another flat. The next is filed at "6 o'clock," the jaw then being vertical again, but upside down; the last at "9 o'clock," and there is your square, with all four sides nice and even. Simple, isn't it?

The Blower Stay.

The handwheel can be turned from a piece of 7/16-in. or 1/2-in. diameter rod, any metal you fancy; dural makes nice-looking wheels, and steel ones don't get as hot as brass. Make the rim about 3/32-in. wide, and the boss 1/32-in. thicker; slightly recess the face of the wheel between rim and boss; and after the wheel is parted off, four holes can be drilled in it, in lieu of spokes. Before parting off, centre the wheel and drill it 3/32-in. or No. 42; then set your parting tool, and run it in about 1/8-in. To knurl the edge of the wheel, use a coarse or second-cut flat file; merely run the lathe slowly, press the file on the rim of the wheel, bear down hard, and let the file run along as the wheel revolves. The teeth of the file will bite into the metal, and form a very good knurl; about three traverses of the file will produce a better and sharper-cut knurl than many regular knurling wheels I have seen in use. The wheel can then be parted right off. The square hole through the boss is formed by a punch; simply face the end of a bit of 3/32-in. square silver-steel truly, harden and temper to dark straw, and rub off any burring on an oilstone. Place this vertically over the round hole in the boss, and drive it through a little way with a hammer. On withdrawing the punch, the hole will be found perfectly square and true; file the square on the valve pin to fit tightly, drive it through the square hole in the wheel boss, and lightly rivet over the projecting bit. The gland nut is made from 5/16-in. hexagon brass rod, and is exactly the same as a union nut; it is packed with a few strands of graphited yarn. Assemble the valve to see that the pin works freely and shuts off tightly, then remove the pin and gland nut, and put them aside until the boiler is finished.

Screw the valve tightly on to the end of the hollow stay, using a smear of plumber's jointing on the threads; then make another wedge-shaped washer, and put it on the stem of the valve. Insert a bit of stiff wire into the other end of the stay, poke it through the hole in the backhead, and guide it to the hole in the smokebox tubeplate; you should be able to sight it through the hole. Then screw the stem of the blower valve into the hole in the backhead, arranging the wedge washer so that the widest part is at the top, and setting the nipple on the valve vertically, as shown in the illustration. The other end of the hollow stay should now be showing at the smokebox tubeplate. Pull out the guide wire, put a smear of plumber's jointing on the threads, and screw the thoroughfare nipple on the end of the stay. As with the solid stay and blind nipple, the outer threads will engage with the tapped hole in the tubeplate; and when the nipple is right home, the whole lot will be locked solid.



FIREBOX STAY

Firebox Stays.

The firebox stays must also be screwed through both plates. Again, some novices have suggested plain rivets, but they are no good if used in the ordinary way. Plain rivets *could* be used for firebox stays, if pieces of copper tube about ¼-in. diameter were placed between every inner and outer stayhole in the firebox, the rivets passed through them and well-hammered down, and the whole lot sweated over. However, it would be a difficult job to get the distance pieces in at the upper part of the firebox, so I recommend the screwed pattern, as shown in the small detail illustration. Twenty are needed in each side of the firebox, and seven in each end; 54 all told. Mark out as shown by the crosses in the sectional drawings of the boiler previously given; the spacing is approximately at ¾-in. centres, the outer rows being close to the ends of the inside firebox, so as to afford adequate support to the flat sides of the wrapper. Don't centre-pop too heavily, or you will distort the plates; soft copper needs fairly gentle treatment! Drill all the holes with a No. 90 drill, using plenty of cutting oil, and keeping the drill at right angles to the outside wrapper; then tap them with a taper tap, running through both plates, for which purpose the tap should have a long " lead " portion. Whilst an ordinary commercially-made tap will do the necessary, I find it an advantage to make a special tap for the job, and you don't need to be an expert toolmaker either. Simply chuck a piece of ⅛-in. round silver-steel in the three-jaw, and turn down ½-in. length to the size of a No. 40 drill. A pair of calipers applied to the drill shank will give the exact size. Don't leave a shoulder at the end of the reduced portion, but bevel it off a little. Now carefully screw ¾-in. length with a ⅛-in. or 5 B.A. die, and cut off the steel about an inch beyond the end of the threaded portion. Either file the end square, or else file a single flat place on it to take the screw of the tapwrench. For milling three flutes in the screwed portion, I use a ball-headed dental burr (your dentist would probably give you a few used burrs for the asking, as he uses fresh ones for every " victim "!) and anybody who hasn't a milling machine, could use this in the three-jaw, clamping the embryo tap under the lathe toolholder, and traversing it across the burr with the cross-slide. Alternatively, the flutes could be filed with a rat-tailed file; or as a last resource, four flats could be filed on the threads. A " four-square " tap, as these are called by the shopmen, will cut quite a respectable thread.

The tap must be hardened and tempered. First, make the screwed part and the pilot pin, redhot, and plunge into clean cold water; don't go above medium or cherry-red, or the tap will be burnt and brittle. The tempering part is rather tricky, as the pilot pin must not be hard enough to break off, yet the screwed portion must be hard enough to cut threads in the copper plates. Brighten up the pin, and the flats or flutes, with a piece of fine emerycloth; then lay the tap on a bit of sheet iron, and hold same with a pair of pliers over a spirit flame, or a bunsen gas burner. Have a pan of clean cold water right handy; watch the tap and, as soon as the tap turns to a dark yellow, tip it into the water quickly.

To soften the pilot pin without drawing the temper of the screwed portion any farther, put the kitchen poker in the fire, and when same is redhot, hold the pilot pin on it until it turns blue, then quench in the cold water. The tap is then ready for use. Sounds a lot to read, and takes a time to write, but the actual job is easily and quickly done.

The tap is driven with an ordinary tap-wrench; dip it in the cutting oil, and insert the pilot pin through the holes in both plates, then work the tap back and forth, so as to clear the chips and prevent torn threads. The pilot pin guides the tap truly through both holes, so that the thread is quite continuous. If the tap has been squared instead of fluted, it would be advisable to follow up with an ordinary commercial " second " tap, to true the threads to exact size for the staybolts.

The stays are made from ⅛-in. copper rod or wire. Don't on any account be tempted to use ordinary " brass " screws, as these are made of an alloy called " screw-rod," especially made for taking a thread easily. They contain an excess of zinc, and in addition to being brittle, waste away rapidly through electrolyte action. Gunmetal or bronze screws might be used if obtainable, but home-made copper staybolts are far and away more satisfactory. I usually cut off four or six pieces of ⅛-in. copper rod, or wire, about 4-in. long, and screw both ends of each length for a distance of about 5-in., holding in three-jaw and using die in tailstock holder. A tap-wrench is then clamped in the middle, and one end of the wire is screwed through the holes in wrapper and firebox, until the plain part prevents it going in any farther; it is then cut off about ⅛-in. from the plate. The other end is screwed into the next hole. When all are used up, the remains of the bits of rod are screwed again each end, and the process repeated until all the stay holes are filled up with bits of screwed rod. Locknuts —which may be of ordinary brass, as they do not come in contact with the water—are screwed on the projecting ends of the stays inside the firebox, and tightened up against the plates; and thread sticking out beyond the nuts, may be snipped off with a pair of cutting pliers. Put a bar of iron in the bench vice, so that it projects to one side; put the firebox over it, with a stay resting on it, and carefully hammer down the stub of rod on the outside of the firebox, to form a rivet-head, as shown in the detail sketch. When all are done, give the nuts a final tighten-up, and we are ready for the sweating-up performance.

Note: The staybolts in the throatplate will not enter the firebox squarely, owing to the difference in the angle or slope of the plates; therefore, after putting on the locknut, carefully bend the projecting part of the staybolt inside the firebox, until it is square with the firebox front plate. The soft copper rod will bend quite easily, and the nut may then be screwed up tightly against the plate, the surplus snipped off, and the stay headed as previously described.

Sweating Up of Stays.

If the threads in the copper plates are true and unbroken, and the staybolts all screwed exactly to size, the locknuts should bed tightly against the plates, and the stays should be perfectly steam- and water-tight without needing any further attention, just as they are in full-sized boilers. However, in case any unsuspected torn threads or undersized staybolts manage to get in—even experienced workers are occasionally "sold a pup," as the railway shopmen would remark—it is advisable to sweat over all the stay heads and nuts with soft solder. The kind used by plumbers is the best for this purpose, as the melting point is higher than ordinary "tinman's" solder; but the latter will do quite well if the former is not available. You also need a blowlamp, soldering bit (hatchet type for preference), some liquid flux, and a wire brush. The latter is easily homemade; simply cut a number of lengths of fine iron wire, make them into a bunch, and insert into the end of a short bit of copper tube, which is then flattened with a hammer at the end, to hold the bunch of wires securely. Put a stick of wood in the other end of the tube, as it gets mighty hot when in use. *Warning*: don't on any account use a plastic flux for boilersmithing. Never mind what the advertisements advise; the trouble with a paste flux is that it will get into the boiler, cling to the plates, and cause priming and false reading of the water gauge. Once the stuff is in the boiler, it is Sinbad's "Old man of the sea," you can't get rid of it! Personally I prefer Baker's soldering fluid, sold in small cans or bottles; but killed spirits of salts is a good substitute. This is made by dissolving pieces of zinc in raw muriatic acid until all fizzing ceases, and then adding a little sal-ammoniac. Commercial chloride of zinc, which can be purchased from any manufacturing chemist's in white lumps, when dissolved in water also makes an excellent flux.

Lay the boiler in the brazing pan, and brush a little flux all over the stayheads and nuts; then with the blowlamp, carefully and evenly heat up the whole of the boiler until the stick of solder will melt at the tip, if applied to a stayhead, and leave a little blob. Put one on all the stayheads you can get at; then, still keeping up the heat, dip the wire brush into the flux, and put a dab on each head. It will fizzle and "fume," but the liquid solder will promptly "flash" around the head and form a perfect seal. Turn the boiler over and do the other side, also the heads in backhead and throatplate.

It is easier to tin over the whole of the inside of the firebox, covering stays and seams, than do each nut individually; so brush some more flux all over the inside, and melt off a little pool of solder between the nuts. Keep up the heat, and brush the melted solder all over the inside of the box, going around all the nuts, and along the seams. If by any chance the solder doesn't seem to want to run around any particular nut, apply the copper bit to it, with a little extra flux and solder. This will do the needful. When every part of the inside is covered, and you are certain none of the outside heads have been missed, shake off any superfluous solder; then, as soon as the metal sets, and goes dull, the whole lot can be washed under the kitchen tap, or any other running water supply. Use a rag or brush to remove all traces of flux from the outside, and give the inside a real good swilling out. The boiler is then ready for a water pressure test, and to make this we need a pump. The tender pump can be utilised for the purpose.

Tender Pump.

For testing the boiler by hydraulic pressure, a pressure gauge reading to about 200 lbs. per square inch, and a hand-operated water pump, are the principal requirements. I use a full-size locomotive steam gauge reading to 360 lb. per sq. in., purchased many years ago at Willcox's engineering stores in Southwark Street, Borough, for about twelve shillings; it proved accurate when tested against a master gauge, and has served me faithfully. Every boiler I have made, has been tested by both water and steam pressure, by its aid; and I also use it to set safety valves, and check the small gauges fitted to all my own locomotives. However, any gauge is suitable for testing "Bantam Cock's" boiler, providing it is reasonably accurate and indicates up to the required test pressure. As to the pump, I keep a special pump with a long lever; but as beginners will probably have nothing in this line, they may as well kill two birds with one shot, and make the tender hand pump right away, using it for testing the boiler, and then putting it aside for installation in the tender later on. The pump is quite capable of delivering the required pressure, as one of these pumps was tested to force against nearly 400 lb. per sq. in. with no trouble.

No castings are required. The stand is bent up from a piece of brass or copper ⅛-in. in thickness, 1¼-in. wide, and approximately 5-in. long. The easiest way of doing it is to bend up the middle part over a bit of iron or steel bar 1-in. wide; then put the whole lot in the bench vice with the two "legs" standing up about ½-in. above the jaws, and the bit of 1-in. bar between them. Hammer the projecting lugs outwards and down, until they lie flat on the tops of the vice jaws; then clean up with a file.

The Tender Pump.

There is no need to bother about exact measurements, so long as you get the sides of even length, and the feet so that the whole gadget will stand on something flat, without rocking like a chair with a short leg. Drill a No. 30 hole in the middle of the top, and one in each corner, as shown; file a "bite" out of one of the feet, to allow clearance for the lower end of the valve box. Set the stand on something flat, and with a scribing block having the needle set ¾-in. "above zero," scribe a line across each end. In the middle of these lines, make a deep centre-pop; drill them out ⅛-in. or No. 30, open out to 35/64-in., and then put a 9/16-in. parallel reamer through both together. If you haven't a reamer, use a half-round file, and file the holes until a piece of 9/16-in. tube will enter both holes tightly.

Pump Barrel and Valve Box.

A piece of 9/16-in. brass treblet tube is needed for the barrel; for beginners' information, this is thin brass tube which has been through a drawplate three times (hence "treblet") to get it perfectly true and smooth inside and out. If not available, ordinary tube must be used, but this will require smoothing on the inside. Get a piece of round wood (a meat skewer or a pencil will do) and wind a sheet of fine emerycloth or other abrasive, around it until it fits the tube loosely. The tube, which should have been faced each end in the lathe, to a length of 1⅞-in., is then slipped over the emerycloth roll, and the end of same caught in the three-jaw. Run the lathe as fast as you can, without rattling the pictures off the walls, and, holding the tube loosely in your hand, move it up and down the improvised lap. A couple of minutes of this treatment will make the internal surface like glass. Be sure to wipe all the dust out, also clean it off the lathe bed, as it isn't good for slides.

Chuck a piece of 9/16-in. or ⅝-in. diameter brass rod in three-jaw. Face the end, centre, and drill down with ⅛-in. or No. 30 drill to about ½-in. depth. Turn down ½-in. of the outside to a drive fit in the 9/16-in. tube forming the pump barrel; then further reduce the end to 7/32-in. diameter for 3/16-in. length, and screw it 7/32-in. by 40. Part off at ⅜-in. from the end, and squeeze it into the tube, leaving just the screwed pip projecting beyond the end.

The valve box is made from 7/16-in. brass rod; chuck a length in the three-jaw, face the end, centre, and drill down about 1¼-in. with No. 23 drill. Open out a full ¼-in. deep with 9/32-in. drill, and bottom with a 9/32-in. D-bit to a depth of ⅜-in. Tap the hole 5/16-in. by 32, and mind you don't let the tap run in far enough to spoil the D-bitted seating. Countersink the end slightly, skim off any burring, and part off a full 1⅛-in. from the end. Reverse in chuck, and repeat operation on the other end, except that there is no need to use the D-bit; instead, nick the edge of the small hole with a little chisel made from a bit of ⅛-in. silver-steel. Halfway along the valve box, make a centre-pop, drill it out with 3/16-in. drill, and tap 7/32-in. by 40, re-chuck with the D-bitted end outwards, and run a 5/32-in. parallel reamer through the remnants of the No. 23 hole.

Screw the pip on the end of the pump barrel tightly into the hole in the side of the valve box; then poke the pump barrel through the big holes in the stand, until the valve box is within ¼-in. of it. Set the valve box exactly vertical, with the D-bitted hole at the top; then solder the barrel at the points where it goes through the stand, also solder over the joint between barrel and valve box, to seal any potenial leakage between barrel, plug and screw. Use the liquid flux, same as for boiler, and not paste, washing away all traces of it in running water after the job is done.

The valves are fitted pretty much the same as those on the engine pump. It will be noticed that the valves are smaller, although the pump is bigger; this apparent paradox is explained by the fact that the engine pump is fast-running and continuously in action, whilst the hand pump is only operated in emergency, and slowly at that, so that the valves have more time to rise and fall. The reliability of an eccentric-driven or crosshead pump depends to a great extent on the size and lift of the valves. On the Stroudley engines of the L.B. & S.C.Rly. the crosshead pumps had 6-in. valves, three times the diameter of the ram; and it was very seldom indeed they ever gave us any trouble, whilst they pumped perfectly at over 70 miles per hour, even when the feed water was nearly boiling. Some of the exhaust steam was diverted to the tenders and tanks, to warm up the feed; a wheeze which saved much coal.

Drop a 3/16-in. rustless steel ball into the D-bitted end of the valve box, seat it with a hammer-blow, and fit the top union screw exactly as described for the engine pump, except that the stem is screwed 5/16-in. by 32, and the union screw is ¼-in. by 40 (see sectional illustration). The lower fitting is a plain cap, and has no union screw. Drop a ball into the hole and take the depth with a depth gauge; chuck a piece of 7/16-in. hexagon rod in three-jaw, face the end, centre, drill down about ½-in. depth with No. 23 drill, turn down the outside to 5/16-in. diameter for a length equal to the depth shown by the gauge, and screw 5/16-in. by 32. Skim 1/32-in. off the end, to form the ball seating; part off ⅜-in. from the end, reverse in chuck, chamfer the corners of the hexagon, and put a 5/32-in. parallel reamer right through. Cross-nick the hexagon with a wide hacksaw, or a watchmaker's or keycutter's flat file. Stand the fitting on something solid, put a 3/16-in. rustless steel ball on the seating, give it just one gentle crack with a hammer, and assemble as shown. A smear of plumber's jointing may be applied to the threads before screwing home: but take mighty good care that none of it gets on to the valve seatings, or you'll soon be finding trouble!

As mentioned when dealing with the engine pump, bronze balls can be used if rustless steel ones are not available—they *should* be, ere this—but use a steel cycle ball of requisite diameter to form the seatings. If you start hitting a bronze ball, there will be a flat one side and a ring on the other, and it will be impossible to make it watertight.

Ram and Levers.

If the bore of the pump barrel is ½-in., a piece of ½-in. drawn bronze rod may be used for the ram, and will not require turning to fit; on the 9/16-in. treblet tube barrels I have made, ½-in. rod has fitted exactly. If the bore is larger or smaller, depending on the gauge of tube used, the barrel must be turned full length, from a piece of rod held in the three-jaw; there is no need to make it fit as exactly as a steam piston, a nice easy sliding fit without any suspicion of slackness, being all that is required. Part off at 2 3/16-in. from the end. Re-chuck with ½-in. or so projecting, and turn a groove 3/16-in. wide and about ⅛-in. deep, for packing. Reverse in chuck, and slightly reduce the other end, as shown in the sectional illustration. At 2-in. from the grooved end, drill a No. 32 cross hole, and then slot the reduced end at right angles to the cross hole, to take the lever. This can be done by clamping the ram under the slide-rest tool-holder, at right angles to the bed, and feeding up to a ⅛-in. slotting cutter on a spindle in the chuck; or it may be done by hand, cutting a slot with two sawblades placed side by side in the hacksaw frame, and truing up the result with a keycutter's file, or a watchmaker's flat file.

The lever is a 2½-in. length of ⅛-in. by ¼-in. brass rod. At 3/16-in. from one end, drill a No. 30 hole, and another at 1-in. above it; round off the bottom end, and slightly bevel off the top end. The connecting links are double, made from 3/32-in. by ¼-in. brass rod; the holes are drilled No. 32 at 2-in. centres, and the ends are rounded off. Drill them both together. The anchoring lug is made from a bit of ⅛-in. by ¼-in. brass rod; chuck truly in the four-jaw, and turn down ⅜-in. of the end to ⅛-in. diameter, screwing ⅛-in. or 5 B.A. Part off at ⅜-in. full from the shoulder, round off the end, and drill a No. 30 hole through it; poke the stem through the hole in the top of the stand, and secure with a commercial brass nut.

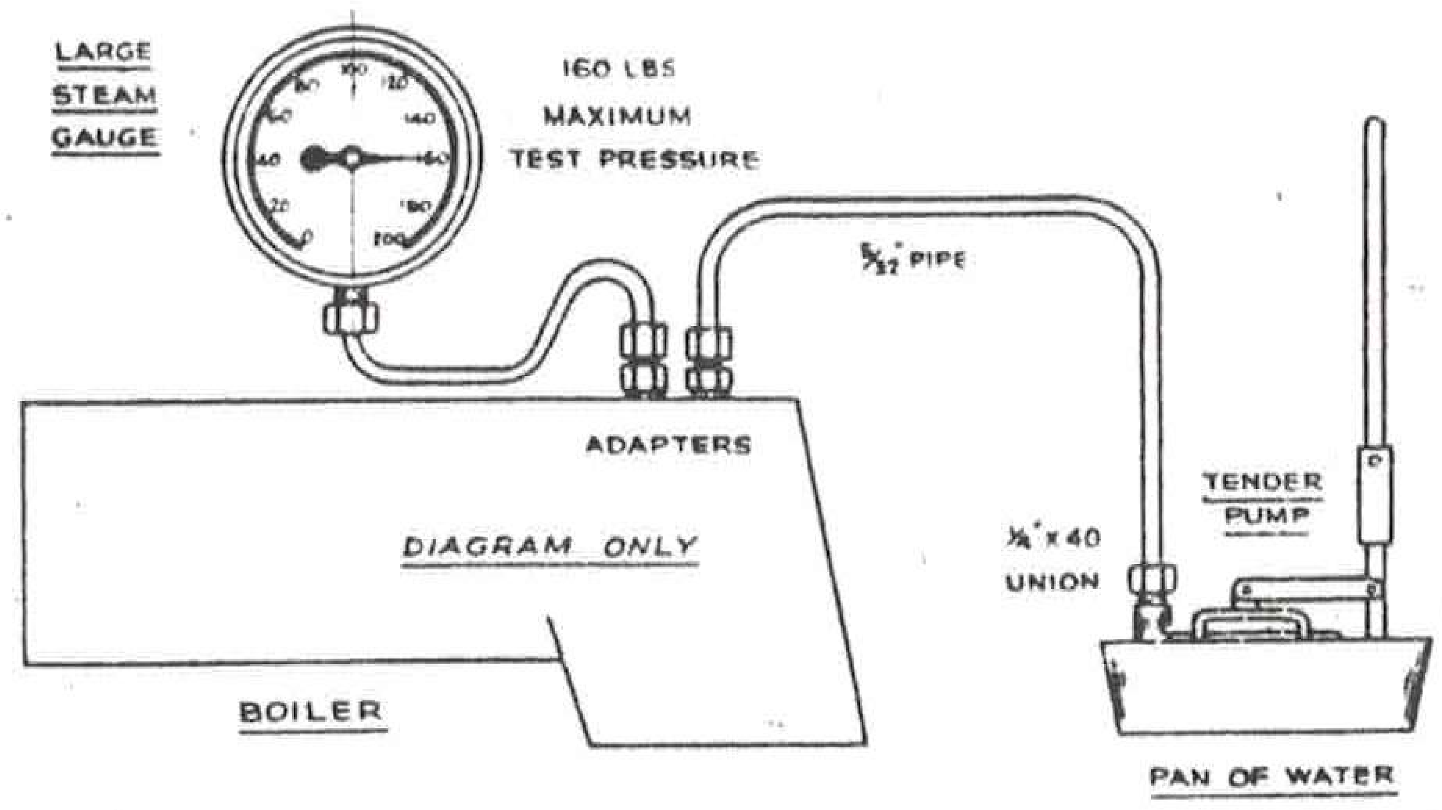
To assemble, pack the groove in the ram with a few strands of graphited yarn, or a bit of hydraulic pump packing, obtained by unravelling a few strands from a short length of the full-size article. Put the bottom of the lever in the slot, and pin it with a piece of ⅛-in. bronze or rustless steel wire driven through the lot. Place one of the thinner links each side of the lever, and line them up so that another pin may be driven through; if at all slack in the links, slightly rivet the pin over each side. Insert the ram into the barrel, put the other ends of the links at each side of the anchor lug, pin as above, and the pump is complete. It is operated, when in the tender, by an extension handle worked through the filler hole, and this had better be made now, as the leverage it gives will be needed for getting sufficient pressure to test the boiler. A 1½-in. length of rectangular-section tube is required, of a size that will just fit over the pump lever; this is a commercial article, but if not immediately available, bend it up from a bit of sheet brass, using a bit of the ⅛-in. by ¼-in. rod for a former. Fit a length of this rod into one end of the socket, round off the end, and silver-solder it. The total length of the extension handle should be about 6-in., and the socket should be an easy sliding fit on the pump handle. If the pump is placed in a pan of water, and the handle operated vigorously, it should send a jet of water several feet up in the air, like a fountain.

Cover for Dome Bush.

Before testing the boiler, we must close the dome bush, so the next job will be to make the cover for it. Castings should be available, with a chucking piece on top; simply grip this in the three-jaw, and set the casting to run as truly as possible. Face the flange, and true the other side of it with a parting tool, so one chucking finishes the job: also turn down the edge of the casting to the same diameter as the dome bush. There is no need to machine either the inside or outside of the domed part. If a casting is not available, a piece of 1½-in. brass bar could be used. Chuck in three-jaw, face the end, centre, and drill a ½-in. hole about ¼-in. deep. Open out with an ordinary round-nose boring tool until the recess is ¾-in. diameter and ⅜-in. deep. Part off at ½-in. from the end; reverse in chuck, gripping by the edge, and turn the outside to shape as shown. Alternatively, the outside could be turned first: and after parting off, the cover could be held by the reduced part whilst the recess was drilled and bored. Eight No. 30 holes are drilled equidistant around the flange, as shown in the illustration, and countersunk; any burr should be carefully filed off, or the flange rubbed on a piece of emerycloth laid on something flat, same as when facing valves. The cover is then attached to the bush by eight ⅛-in. or 5 B.A. brass countersunk screws, the actual fitting, drilling and tapping, being carried out same as described for the cylinder covers. A jointing gasket made from 1/64-in. Hallite or similar jointing, is placed between cover and bush.

How to Test the Boiler.

First make a temporary brass plug to screw into the steampipe hole in the smokebox tubeplate, a simple job that



HOW TO TEST BOILER BY WATER PRESSURE

needs no detailing out. Next, two adapters are needed for the safety-valve bushes; these are made exactly the same as the fitting at the top of pump, except that the stems are screwed 3/8-in. by 26, to fit the bushes. Fill the boiler completely with clean cold water; before screwing in the adapters; then connect up as shown. Stand the tender pump, complete with extension handle attached, in a pan of water, and connect it up to one of the adapters by means of a piece of 5/32-in. pipe with a union nut and cone on each end. The steam gauge is connected to the other adapter by a similar bit of pipe, the union on the outer end of it being made to suit the screw on the gauge. Now start pumping; it will only need very few strokes. There will be two or three easy ones, then the pump will "go hard," and each stroke will send the gauge needle well up. Stop at 60 lb. and see if there are any leaks showing, or any distortion of the firebox plates; if all O.K., carry on, stopping at every 20 lb. increase, and examining, until you arrive at 160 lb., which is twice the working pressure. If the boiler is still tight and undistorted, congratulations on good work!

Should any small leaks show, let the pressure off by slacking one of the union nuts, empty out the water, and sweat up the leaky place before proceeding; it will probably only be a stayhead or nut. If the firebox crown moves about 1/32-in., take no notice; it will only be the soft copper settling itself to the best position to resist pressure. When 160 lb. has been finally reached without any further casualty, keep it at that for a few minutes, then let it off. The boiler can then be safely "passed" for strength and workmanship. There is not the slightest danger in testing the boiler by water pressure in the manner described; because if there should be any fault, and a joint, or tube, or something else gave way, it instantly releases the pressure without explosion. A few drops of water will escape noiselessly from the fracture, and that is all there is to it.

There is another way of testing a boiler, without a pump; this has been advocated by other folk, but it is not so definite as the pump test. It consists of filling the boiler completely with cold water, and then applying heat, which expands the water and raises the pressure. I tried it myself, but found that much better control over the test pressure was obtained by use of the pump, so do not recommend the "heat treatment" method. After the hydraulic test has been successfully passed, the boiler is ready for smokebox and fittings, so we will proceed to that job right away.

Smokebox.

The shell of the smokebox is made from a piece of 16 gauge brass tube 4 3/8-in. outside diameter. Square off each end in the lathe, to an overall length of 4 1/2-in., and take the same precautions as when squaring the boiler barrel, viz., put a wood or metal disc in the end held in the chuck; otherwise, despite the short length, the tube will fly out as soon as the turning tool starts to cut. At 2-in. from one end, cut a 1-in. hole for the chimney liner. Anyone who has a 1-in. parallel reamer and the necessary drills, can first drill a 1/8-in. pilot hole, and then open out in two or three stages until the largest drill below 1-in. has been through; finish to dead size with the reamer. *Caution*: don't try to drill the hole full size at one fell swoop, or you'll not only get a polysided hole, but the drill will probably "catch up" and do some damage. Those builders who are short of big drills and reamers, should make a centre-pop at the desired spot, scribe a 1-in. circle with dividers, drill all around inside the circle with a 3/32-in. drill. Use a bit of 1-in. tube or rod as a gauge; it should fit the hole tightly. Then exactly opposite, on the other side of the tube, drill a 3/8-in. clearing hole for the blastpipe. At 5/8-in. ahead of that, on the same centre line, drill a 5/16-in. clearing hole for the steam pipe. The correct drill sizes are letters W and O respectively, but if you haven't those sizes, use the nearest factional sizes larger than the pipes, say, 25/64-in. and 21/64-in.

Ring and Door.

Castings are available for the complete smokebox front; I am using a cast ring and door on my own engine. They can also be made from 1/8-in. stamped brass blanks, or discs cut from 1/8-in. sheet brass. To machine the cast front, chuck it in the three-jaw, holding by the flange in the "outside" jaws; take a cut right over the whole surface with a roundnose tool set crosswise in the rest. Next, with a boring tool, true up the door hole. Reverse and re-chuck by putting the hole over the "inside" jaws of the chuck; then carefully turn the flange with a roundnose tool until it is a very tight fit in the end of the smokebox shell. It will not be possible to turn the outside of a cast smokebox door, because of the dummy hinge straps cast on it; but the edge which makes contact with the smokebox front can be faced up, by chucking the door in the three-jaw by means of the chucking spigot provided, setting it to run as truly as possible, and using a roundnose tool set crosswise as before. Before removing from chuck, centre the door and put a No. 22 drill through it; then saw or part off the chucking piece, and clean up the outside of the door with a file and emerycloth.

For the alternative ring, made from brass as mentioned above, a ⅛-in. stamping about 4⅞-in. diameter would be needed, or a disc sawn out of ⅛-in. sheet to same diameter. It can be flanged over a circular former like that used for the smokebox tubeplate, the process being exactly similar; only, as the brass sheet is thicker and harder than the copper, it must be well annealed, and a little more "bashing" will be called for, to get the flange well down on the edge of the former, which should not be less than ¼-in. in thickness, and about 4-in. diameter.

It is turned up in a very similar manner, the plate being first chucked in the three-jaw with the flange outward, and the ragged edge of same turned off. Then reverse, and chuck convex side outwards, holding by the inside edge of the flange. Face the plate, and turn the flange to fit the smokebox shell as described above, leaving a radius at the edge; then re-chuck, gripping by the turned flange, with the convex side out as before. Put a parting tool crosswise in the rest, and set it a little over 1¼-in. from the lathe centres; then feed it into the chucked plate, applying a little cutting oil and running slowly. It will cut out a disc a little over 2½-in. diameter; and the hole then left in the plate is enlarged to 3-in. diameter with a boring tool; take off the sharp edges, or you may get a nasty cut finger at some future time when cleaning the smokebox out, with a risk of poisoning the cut with dirt and ashes from the residue in the smokebox. There's nothing like playing for safety, and prevention is always better than cure!

For a door to match, a disc or stamping about 3½-in. diameter and ⅛-in. in thickness is required. Anneal this, place on a block of lead, and hit it with the ball end of the hammer-head until it assumes the shape of a deep saucer. You can start from middle and work outwards, as I do, or vice versa, as recommended by some coppersmiths; please yourselves; the process is known as "dishing." When the dish is about ½-in. deep at the centre, chuck in three-jaw with the concave side out. Centre, and drill right through with a No. 22 drill; then, with a roundnose tool set crosswise in the rest, turn a flat place in the middle about ¾-in. diameter. Remove from chuck; change jaws to "inside," and chuck a piece of round brass rod (any short scrap end will do, of any diameter between ½-in. and ¾-in.) on which, a 5/32-in. pip is turned to fit tightly in the hole in the door blank, so that the faced end butts up against the turned place in the middle. Put a few drops of Baker's fluid or other fluid flux around the joint, along with a bead of solder, and hold it over a gas or blowlamp flame until the solder melts and runs all around the bit of rod. Let the solder set, then wash off any traces of flux (this would rust up your chuck), chuck the bit of rod in the three-jaw, and the door can be turned on the outside, and the contact edge trued up, at the one chucking. Any toolmarks left on the front of the door by an inexperienced turner, can be removed with a fine file followed by emerycloth, whilst the job is still in the chuck. When through, melt the solder and pull out the brass stub.

Hinge straps can be made from material about 18 gauge, cut from a piece of sheet, to a width of about ⅛-in. Steel, or the stuff we used to call German silver, are best, but brass will do at a pinch. Bend one end into an eye, 3/32-in. inside diameter, with a small pair of roundnose pliers, and silver-solder the joint; then rivet the straps to the door, using bits of domestic pins as rivets. The straps are 2¼-in. overall length, and spaced 1-in. between.

The lugs for both cast and built-up door hinges are made from ⅛-in. by ¼-in. flat rod; chuck truly in four-jaw, and turn down one end for ¼-in. length to 7/64-in. diameter; screw 6 B.A. Part off ¼-in. from shoulder, and round off with a file. Don't screw them into the smokebox front yet; wait until you have the dart and crossbar fitted, so as to get correct location.

Crossbar and Dart.

The crossbar is only a few minutes' work. All it consists of are two 3¾-in. lengths of ⅛-in. by ¼-in. block steel rod. Clamp together and drill two No. 40 holes 2¼-in. apart. Chuck a bit of ¼-in. round steel rod in three-jaw, face, centre, drill No. 40 for about ½-in. depth, and part off two spacers 3/16-in. wide. Put them between the bars opposite the holes, poke a couple of 3/32-in. by ½-in. iron rivets through the lot, and rivet up.

To make the dart, chuck a piece of 7/16-in. round steel rod in three-jaw. Turn down 1⅛-in. length to 5/32-in. diameter, then further reduce ¼-in. of the end to 7/64-in. diameter, and screw 6 BA. Directly behind this, file a squared portion a full ⅛-in. long. Part off to leave a head 3/16-in. in thickness; file this flat both sides, flush with the stem, and then shape it, as shown in the sectional illustration. The inner of the two handles forms the key to turn the dart, and the outer one is the locking screw. To make the former, chuck a piece of 5/16-in. round steel rod, face the end, centre, drill down about 3/16-in with ⅛-in. drill, and part off a 5/32-in. slice. File the hole in it with a watchmaker's square file, until it fits the square on the dart. Drill a No. 51 hole in the edge, tap 8 BA, and screw into it a bit of 3/32-in steel wire or rod, filed slightly taper. The hole should be drilled in such a position that the handle will be parallel with the head of the dart, so that when the latter lies across the bars of the crossbar, the handle hangs straight down. The locking screw is made from ¼-in. round rod; chuck, centre, and drill No. 44 for about 3/16-in. depth; part off a 5/32-in. slice, rechuck, run a 6 BA tap through, and fit a handle as above, slightly shorter than the key handle. The sectional illustration shows the assembly; if a door made from sheet brass or a stamping is used, place a washer about 7/16-in. diameter between the inner handle and the door. On a cast door, the stub of the chucking spigot may be filed or faced off flat, and will serve in lieu.

When assembling, put the crossbar temporarily in place, and attach the door as shown, putting the dart head through the bar, and screwing up the locking handle just tight enough to prevent the bar slipping. Then adjust the door on the front ring so that it is exactly central, the bar crossing the centre of the door hole. Two small brackets can then be bent up from 16 gauge steel ¼-in. wide, and attached to the inside of the front ring, under the bar, as shown, to retain it in position when the door is opened, and allow it to be easily removed to get access to the interior of the smokebox. The brackets are attached by 3/32-in screws (brass for preference), the stems of which are filed off flush with the smokebox front.

The hinge lugs can now be fixed. If a cast door is used, drill the cast-on eyes with a No. 41 drill; then exactly under the centres of the holes in either cast or strip-metal eyes, and 1/16-in. below them, make centre pops, drill No. 44, and tap 6 BA. Remove the door (you can't screw the lugs in with the door in place) or else turn it around a little, out of the way; screw in the lugs, and replace door, with the eyes directly over the lugs. Run a drill through the holes in the eyes, and carry on through the lugs; if the chuck on the handbrace fouls the smokebox, use a long-shanked drill, made by soldering a drill (broken-off end may be used) into a couple of inches of ⅛-in. rod with a suitable hole in the end. The hinge pin can be made from a piece of 3/32-in. silver steel a full 1½-in. long, one end being slightly burred over so that it won't fall through; or a headed pin may be turned from a piece of 5/16-in. round mild steel. Slightly round off the bottom end.

Don't press the completed smokebox front into place yet; we shall need the full opening to get at the inside and make all the pipe connections, after erecting the boiler.

Chimney and Liner.

The chimney is a casting; it can be chucked in the three-jaw, base outwards, are carefully bored out like a cylinder, until a piece of 1-in. tube will slide into it. It can then be mounted on a wood or metal mandrel, and the outside turned to the shape and dimensions given; the mandrel isn't anything elaborate, merely a piece of round wood or metal held in three-jaw and turned to a tight fit in the chimney bore. In fact, you can use a piece of 1-in. rod or tube, with a piece of foil jammed between tube and chimney bore, to make it fit tightly. The base cannot, of course, be turned all over; turn down as far as you can, and finish the curve and saddled part with a half-round file and emery cloth. The curved underbase can be finished to the radius of the smokebox shell, by wrapping a piece of emery cloth partly around same, and rubbing the base of the chimney back and forth on it. I am lucky here, as the wheel of my linisher, with the emery band on it, is the right radius, so I only have to start the machine and press the chimney base against it!

The liner is a piece of 1-in. brass or copper tube about 18 or 20 gauge, and 2½-in. long, squared off at both ends in the lathe. One end is softened and belled out a little, as shown in the sectional illustration; the exact shape of the bell does not matter, and it can be formed by driving anything tapered or curved, such as the end of a hardwood file handle, into the tube. The object of the bell mouth is to prevent any of the steam from the ring blower jets escaping into the smokebox and destroying instead of creating a partial vacuum.

There are two ways of fixing the liner; please yourselves which you use. The first is the method I usually adopt, as it is quick, and I have a blowpipe that does the whole doings in the proverbial jiffy. The liner is cleaned on the outside, and the metal around the hole in the smokebox shell is also cleaned. The liner is then poked through the hole from the inside, projecting to the amount required according to the height of the chimney; in the present instance, 1-in. It is then carefully adjusted so that it is square all ways with the smokebox shell, and doesn't lean over either front, back or sideways it should, of course, be a tight fit in the hole in the shell. A smear of "Tenacity" flux is then put all around it, and a ring of "Easyflo" in wire form, dropped over it so that the ring rests on the smokebox shell, in the same way that Mr. T. Hearn prepares his boiler tubes for silver-soldering. The blowpipe flame is then applied; and in a minute or so, the ring melts into the joint, forming a perfect and almost invisible seal, which is as strong as the metal of the smokebox itself. Ordinary borax flux, such as jewellers use, does very well in the absence of the kind mentioned; and a couple of tiny squares of thin sheet silversolder of best grade (No. 1) may be used in place of the "Easyflo" wire, but mind they don't blow away when the blowpipe or blowlamp flame gets busy, and the flux boils up!

Method No. 2 is to silversolder the liner to a copper or brass flange, which is screwed to the smokebox on the inside. Cut out a piece of 16 gauge brass or copper 2-in. square, and drill a 1-in. hole in the middle, as described above. Bend it to the radius of the inside of the smokebox shell, which is easily done by putting it inside the shell and squeezing it into contact. Then push the liner through the hole so that it projects 1 1/16-in. on the convex side, setting it true and square, and silver-solder it. Pickle and clean up then put a smear of plumbers' jointing around the liner, close to the flange, and push it up through the hole in the smokebox shell, from the inside, until the flange is in close contact with the shell. Drill four holes with

No. 41 drill, at about 1⅝-in. centres, near each corner of the flange, clean through both shell and flange, and countersink on the outside. Put in four 3/32-in. or 7 BA countersunk screws, and secure them with nuts on the inside. Brass nuts are preferable to steel inside a smokebox, as they will not corrode. The cast chimney is then pushed on over the liner, on the outside of the smokebox, and requires no further fixing. If it is at all loose, merely push a piece of tapered metal or hardwood down the liner, and give it one or two sharp taps, which will expand it to a tight fit in the chimney. Try the complete smokebox on the end of the boiler barrel, over which it should be a tight push fit to the extent of approximately ¼-in.; but it is not permanently attached until all the fittings are on the boiler, and the whole bag of tricks is ready for erection.

Smokebox Saddle.

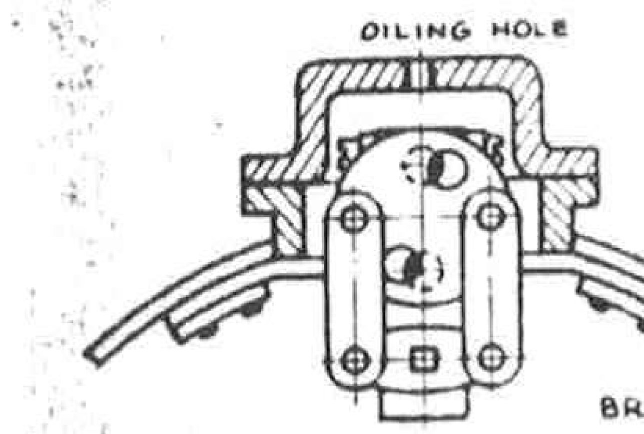
Castings for the smokebox saddle will be available, and will save a lot of work, as they should only need cleaning up with a file; a half-round file will do the needful to the seating in which the smokebox rests, and a flat one can be used on the part which goes between the frames. The saddle is made wide enough to rest on the frames, and carry the smokebox at the correct height above them; but as the cylinder castings come right to the top of the frames, and the saddle is the same length as the cylinders, some provision has to be made for attaching the saddle beyond the cylinders. This is managed easily, by casting on extension pieces below the saddle at each side, which fit between the frames and project ½-in. each side of the saddle. When fitting, set the saddle exactly in line with the cylinders, and then drill four holes with a No. 30 drill, clean through frames and saddle extension pieces, one at each point, securing with ⅛-in. or 5 BA. screws and nuts. Put the screws through from inside, and nuts outside. A small clearance will have to be filed in the extension at each side, to clear the cross steam pipe, and allow the saddle to seat properly on the frames.

Regulator.

In order to make the job as easy as possible, I am specifying a disc regulator with quadrant handle, instead of the usual L.N.E.R. pull-out pattern. Pull-out regulator handles, with a slide-valve "throttle" in the smokebox, held sway on the old Great Northern for many years, as they were eminently suitable for the domeless boilers beloved of Patrick Stirling and his predecessors; but with the coming of Ivatt from the Great Southern and Western of Ireland, the domed boiler appeared on the G.N., and the regulator in the dome was operated by a quadrant handle. When Sir H. N. Gresley took over, he retained the dome, operated by a pull-out handle. This is rather a tricky to reproduce in small size, and still to work perfectly; so we just revert to the Ivatt handle, and use with it a double-ported regulator of the Stroudley pattern, which is about the most reliable type I have ever made.

The good folk who have supplied castings for the rest of the locomotive should be able to supply another for the regulator head, by the time these notes appear. It requires very little machining. Clean up with a file if necessary, then centrepop the top of the column, and drill down it with ¼-in. drill until within ⅛-in. of the bottom. As it is desirable that the steam pipe should screw truly into the boss, so that the column is at right angles to it, and square with the end, it would be advisable to drill and tap the boss in the lathe, and this is easily done by chucking the column boss outwards, in the four-jaw, and setting the boss to run truly. Face it off, centre, and drill ¼-in. until the drill breaks into the hole down the column: open out for ¼-in. depth with an 11/32-in. drill and tap ⅜-in. by 40.

Reverse in chuck, and set the circular valve face to run truly. Face it off, centre, drill No. 48, and tap 3/32-in. or 7 BA. for the little trunnion pin on which the valve is mounted. Tap the hole in the top of the column 9/32-in. by 40, and screw in a stub of brass rod, which must not enter more than ⅛-in.; a smear of plumber's jointing should be put on the threads, and the stub sawn off and filed flush with the top of the column. If you have no suitable tap and die, slightly broach the top of the hole, drive in a disc of brass ⅛-in. in thickness, and soft-solder over it. This will be quite O.K., as the pressure is



END VIEW OF REGULATOR

outside the column. Next, drill the two 5/32-in. ports shown in the illustration of the valve face; these go right into the central hole. The weeny boss below the valve face, is the bearing for the regulator rod; face it off with a file, flush with the port face, and drill it No. 30, *but take care not to penetrate the centre hole.* If, however, you are one of those unlucky folk who frequently "overshoot the platform," as the enginemen say, file the boss clean away, open out the hole little boss with a 3/16-in. by 40 shank to 5/32-in., tap 3/16-in. by 40, turn up a about ⅛-in. long, reverse it in chuck, centre and drill as above, and screw it into the hole with the usual anointment of plumber's jointing; and all's well that ends well. The boss should be filed flush with the valve face as before.

If for any reason a casting cannot be readily obtained, the stand may be easily built up. The column is a piece of ⅜-in. square brass rod, faced off at both ends in the four-jaw chuck, to a length of 1¼-in.; centre it and drill down with ¼-in. drill to ⅛-in. of the other end, as above. At ¼-in. from the " blind " end, drill a 3/16-in. hole right across, cutting through the centre hole. Chuck a piece of ½-in. brass rod in the three-jaw, and turn a ⅛-in. pip to fit tightly in the hole; part off at 5/16-in. from the shoulder. Reverse in chuck, centre, drill right through with 3/32-in. drill, open out to ¼-in. depth with 11/32-in. drill, and tap ⅜-in. by 40. Squeeze the pip into the hole at one side of the column. Chuck a piece of ¼-in. round brass rod, and turn a pip on the end, as above, but 3/16-in. long part off at 1/16-in. from the shoulder. Reverse in chuck, centre, and drill down a full ⅛-in. with No. 30 drill; squeeze the pip into the hole on the opposite side of the column. Slightly broach the end of the central hole in the column, and turn a ⅛-in. plug to fit the end tightly. On the same side as the little boss, file a rebate or step in the column, 1/16-in. deep and ¾-in. long. Chuck a piece of ¾-in. rod, bronze or gunmetal for preference, face the end, centre, and drill down about 3/16-in. with No. 48 drill. Part off a ⅛-in. slice, and fit it into the recess, either tying it in place with a couple of strands of iron binding wire, or attaching by a 9 BA. screw put through the hole in the centre of the disc, into a tapped hole in the column; then silver-solder the whole issue—disc, both bosses, and the top plug, thus "fabricating" the equivalent of a casting. Pickle, clean up, and finish off same as described for the casting.

To make the valve, chuck a piece of ¾-in. rod, face the end, centre, and drill down about 3/16-in. depth with No. 41 drill; countersink the hole a little, and part off ⅛-in. from the end. If a casting is used for the stand, a bit of drawn bronze or gunmetal of any grade will do for the valve; but if the stand is a built-up one, use a different grade of metal to that of the valve face, as dissimilar metals work best together. Drill the ports and screwholes as shown; note that the centrelines of ports and screwholes are not at right angles, but when the screws are level with each other, the ports should be just half covering the ports in the valve face on the stand. Now carefully face up both the valve and the portface, first by rubbing them on a dead smooth file laid on the bench, then on a piece of fine emery cloth or similar abrasive, laid with its business side up on something absolutely flat and true, such as a piece of plate glass, or even the lathe bed. Take particular care to get both faces perfectly true, or the engine will very likely trot off on its own, if left unattended for a few minutes! The trunnion pin is a ½-in. length of 3/32-in. bronze or brass wire, threaded at both ends, and screwed into the centre hole in the port face; the spring is made from 22 gauge brass wire, and secured by an ordinary commercial 3/32-in. or 7 BA. brass nut.

The valve is actuated by a double-armed lever, connected by two vertical links. The best material for these, is the stuff we used to call German silver, but which is really nickel-bronze; failing that, brass will do. The lever is filed up to the outline as shown in the drawing; the square hole in the middle can be formed by drilling a ⅛-in. hole, and either driving a square punch through it, or filing it with a watchmaker's square file. The punch is easy enough to make, being merely a couple of inches of ⅛-in. square silver-steel with one end filed or turned off dead square, and hardened and tempered. The two links are plain filing and drilling jobs, and need no detailing out; the dimensions are given in the illustration. Don't use commercial screws for attaching the links to the lever and valve; make special ones from bronze or brass rod. Simply chuck a piece of rod 5/32-in. diameter, face the end and turn down a bare ¼-in. to an easy sliding fit in the holes in the links. Screw 3/32-in. or 7 BA. with a die in the tailstock holder, for ⅛-in. length; beginners might like to make use of one of my own pet wheezes in my early days, for getting the length of thread right. Slip a washer, ⅛-in. in thickness, over the turned-down part of the rod, letting it rest against the shoulder; then run on the die until it touches the washer. Part off so as to leave a head about ⅛-in. in thickness the slot for the screwdriver can be made with a thin hacksaw blade.

The complete regulator assembly is supported partly by the steam pipe, and partly by two brackets made from sheet metal, and attached to the inside of the boiler barrel by countersunk screws put through from outside. Note very carefully the position of these; they are exactly 7/32-in. ahead of the centre line of the dome bush, one close to the bush itself, and another ¼-in. below it; see plan sketch. Make centrepops at the places shown, drill No. 41 holes, and countersink them. The brackets are strips of 1/16-in. copper or brass ¼-in. wide and approximately 1½-in. long; they are bent at right angles ½-in. from one end, the other being curved down to suit the radius of the boiler barrel. As the thickness by itself is hardly sufficient to provide enough hold for the threads, solder a thickening piece of the same section to the underside of each bracket, as shown in the illustration. Now carefully insert one of the brackets in position in the boiler, and make scriber marks on it through the screwholes in the barrel. I use a small hand-vice for holding the bracket, in preference to pliers; for if you accidentally let go, the bracket doesn't drop inside the boiler! Remove bracket, drill No. 48 and tap 3/32-in. or 7BA at the marked spots, also drill a No. 41 hole near the top, for the screw holding up the regulator stand. The bracket can then be replaced, and brass countersunk screws used for permanent fixing; "ditto repeato" on the other bracket. Next, by virtue of a little judicious manipulation, you'll find you can get the regulator stand down the dome hole and between the brackets; adjust until the regulator projects just ¼-in. above the bush, fix temporarily with a toolmaker's cramp, then run a No. 41 drill through the upper fixing holes, make countersinks on the side of the stand, removing drill the countersinks No. 48, and tap either 3/32-in. or 7BA.

The Rod, Gland and Handle.

The rod operating the regulator is approximately 11⅜-in. long, and is made from 3/16-in. round bronze (nickel or phosphor) or hard brass. Chuck in three-jaw, and turn a bare 1/16-in. of one end, to ⅛-in. diameter, an easy fit in the hole in the small boss under the valve; slightly chamfer the end. Immediately behind that, file a square, to fit the square hole in the double-armed lever; I have already described a simple method of filing true squares. On the other end of the rod, turn a 3/32-in. pip about 5/32-in. long, and screw it 3/32-in. or 7BA; behind this, file a similar square, to take the driver's handle.

Chuck a piece of ⅝-in. hexagon or ¾-in. round bronze or brass rod in three-jaw. Face, centre, and drill down about ⅞-in. depth with 3/16-in. clearing drill (No. 11); turn down ⅝-in. of the outside to ½-in. diameter, and screw ½-in. by 32. Part off to leave a head about ⅛-in. in thickness. Reverse in chuck—you can hold it by the threads without hurting it, or it can be held in a tapped bush, just as you prefer—and open out the hole to ½-in. depth with letter R or 11/32-in. drill; tap ⅜-in. by 32. Make a gland to fit, from 7/16-in. or ½-in. hexagon rod, same process as for cylinder glands. The Ivatt type handle is very simple to make, looks well, and gives very good control of the regulator when driving the locomotive on the road. The centre boss is rectangular, being simply a piece of ⅛-in. by ¼-in. flat rod, ⅜-in. long, with a square hole in the middle, same as the double-armed lever; but it is advisable to leave the squaring of the hole until the regulator is completely assembled, so as to get the right angle of tilt for "on" and "off" positions. The grips are made from 3/32-in. steel or nickel-bronze wire, bent to the shapes shown, and screwed into the boss. Of course, any other desired pattern of handle may be fitted.

Steam Flange and "Dry Pipe."

Castings should be available for the steam flange, but if not, a piece of ⅞-in. hexagon brass rod can be used. In either case, the overall length should be ⅝-in. Chuck in three-jaw, and face the end; centre, drill right through with letter R or 11/32-in. drill, and tap ⅜-in. by 32. Turn down ⅜-in. of the outside to ⅝-in. diameter; further reduce ¼-in. length to ½-in. diameter, and screw ½-in. by 32. Reverse in chuck and take a skim off the contact face to true it up.

The steam pipe is a 6-in length of ⅜-in. by 16 gauge copper tube; the thickness is necessary because both ends are screwed. One end is ⅜-in. by 40, the other ⅜-in. by 32. Use a die in the tailstock holder, holding the tube in the three-jaw, and don't forget cutting oil ensures clean threads on soft copper. Apply a smear of plumber's jointing to the threads; replace the regulator assembly in the boiler, and secure it with a couple of brass screws through the holes in the tops of the brackets, putting some "dope" on those as well. Insert the steam pipe into the boiler *via* the hole in the smokebox tubeplate, fine-threaded end first, and screw it home into the boss at the bottom of the regulator stand. This is easily done by jamming the end of a round file in the opposite end of the steam pipe. The serrations in the file "lock" in the copper, but release at once when the file is turned backwards. Now put some more "plumber's friend" on the threads of the steam flange; screw it on to the end of the steam pipe which should just be showing out of the hole in the tubeplate. Keep on turning, and the outside threads will engage with those in the tapped hole in the tubeplate, so that when the shoulder fetches up against the plate, the whole issue will be locked solid, yet can be dismantled in a few minutes, should occasion ever arise. I have used this method of fixing steam pipes for many years past, and have found nothing to beat it.

Final Assembly.

Chuck a piece of ⅜-in. round brass rod in the three-jaw; face, centre, and drill down about ¼-in. with No. 14 drill; part off a slice fully 3/16-in. wide. If this won't go on the regulator rod, put a taper broach through, until it *does* go on a tight fit; then push it on the screwed end to a bare 1-in. from the shoulder. Insert the other end into the boiler through the bush in the backhead, and with a little patience and perseverance, you will get it through the square hole in the double-armed lever, the little spigot entering the hole in the small boss at the bottom of the column. This isn't as tricky as would appear at first sight, as the lever can be seen down the dome hole. Now put the gland socket on the other end, and screw it right home; the end will come up against the collar, and force it along the rod. Remove gland socket and rod, push the collar a bare 1/64-in. farther along the rod, to give same that amount of end play, then pin the collar to the rod by drilling a No. 53 hole through the lot, and driving in a piece of 1/16-in. bronze or brass wire. Replace the rod and gland socket, putting some plumber's jointing on the threads; pack the stuffing box with a few strands of graphited yarn, and screw the gland in. Work the regulator open and shut, by holding the squared part of the rod with a pair of pliers or small hand vice, to ascertain if it operates O.K., then shut it. Note the position of the square projecting from the gland, and file the square in the hole in the boss of the handle, so that when it is put on, the handle slopes from right to left, like the hands of a clock at ten minutes past eight. Put it on, secure with a nut, and that part of the job is complete. Don't forget a spot of cylinder oil on the contact faces.

Before putting on the cap over the dome hole, chuck it in three-jaw, centre, drill a No. 40 hole in the middle, and tap it ⅛-in. or 5BA. This serves a double purpose, holding the stud which secures the outer cover, and allowing the valve to be oiled, by removing the outer cover and unscrewing the stud. The cap can then be screwed on, with an oiled paper joint, or one made from 1/64-in. Hallite or similar jointing, between the contact faces. You will probably have to fill the top corners of the stand slightly, to allow the cap to fit properly.

Superheater.

The superheater is of the twin element pattern, with block return bends which project right into the combuction chamber. This arrangement allows a free passage of gases through the flues, and eliminates all risk of "birds'-nests," the engineman's term for a collection of cinders which sometimes pile up against the end of a superheater element inside a flue, and prevent any heat passing. There is no chance of the bends burning off, as they would do in an ordinary firebox, being well out of the way of the direct action of the fire. The elements themselves are made from ¼-in. copper tube of about 20 gauge; four pieces are needed, two 10-in. and two 11-in. One end of each longer piece should be softened.

The return bends are made from blocks of copper, ⅝-in. wide, ⅜-in. in thickness, and ⅝-in. long. On the centre-line of one end, make two centrepops 9/32-in. apart, and drill them down for ½-in. depth with ¼-in. drill, running it in slightly on the slant, so that the holes break into each other, as shown in the section. Then file the outsides to the shape shown, otherwise they won't go through the flues.

Drive one longer and one shorter tube into each return bend, and braze the joints with brass wire, or Sifbronze them. Silver-solder isn't good enough for this job, but the process is the same, only requiring a bright red heat. After pickling and washing off, bend up the ends of the longer tubes as shown in the illustrations.

The Headers.

The "wet" header, so called because it receives the saturated steam from the boiler, is made either from a casting, or from ⅞-in. round rod, and is ½-in. long. Chuck the casting, or a suitable piece of rod, in the three-jaw, face the end, centre, and drill it with 9/16-in. drill for full ⅜-in. depth; reverse in chuck, and skim up the other end truly. On a circle ⅝-in. diameter, drill three No. 34 holes at equidistant points, for the fixing screws; then, in the edge, drill two ¼-in. holes for the superheater pipes, at ½-in. centres, one at either side of one of the screwholes. Drill right into the centre hole. Dont drill the hole for the snifting valve yet, as the exact location of this is best obtained from the hole in the smokebox shell. The two bent-up ends of the superheater elements are then cleaned, driven into the holes in the edge of the header for about ¼-in., and silver soldered.

The "hot" header, so called because it receives the superheated steam from the two elements, is made from a piece of ⅝-in. by 18 gauge copper tube 2-in. long. Clean inside of both ends, after squaring them off in the lathe, and cut two discs of 16 gauge copper to fit tightly; alternatively, a piece of ⅝-in. rod can be turned to a tight drive fit in the ends of the tube, and a couple of 1/16-in. slices parted off it, instead of sheet-metal discs. Drill two ¼-in. holes at ⅞-in. centres, 9/16-in. from each end; with these holes horizontal, and away from you, drill another hole with 5/16-in. drill, on top of the tube at the right-hand end. Put the two straight ends of the elements into the holes in the side of the header, as shown in the illustrations. Next, bend up a swan-neck of 5/16-in. copper tube; this can easily be done if the tube is softened. One end is fitted with a ½-in. by 26 union nut, which is made by the same process as described earlier for smaller union nuts, using ⅝-in. hexagon brass; the little cone is turned from copper rod or thick tube. The correct length of the swan-neck is best obtained from the actual job; if the boiler is stood temporarily in place on the chassis, and the superheater elements pushed into the flues, you'll see at a glance the exact amount and curvature of pipe needed, to connect the screw at the top of the steam fitting, with the hole at the end of the header. The pipe must be bent to clear the chimney lines, as shown in the end view. When the pipe is fitted to the header, the whole lot—elements, steam pipe, ends of header, and the union cone on the end of the steam pipe, can all be silver-soldered at one heating. Pickle, wash off, and clean up; replace the completed superheater assembly on the boiler, hold the wet header against the steam flange, see that it is central, then run a No. 34 drill through one of the screwholes, making a countersink on the flange. Drill this out with a No. 44 drill, tap 6BA, replace the header and secure with a 6BA screw; then treat the remaining holes same way. Remove the superheater again, clean off any burring around the drilled holes, and replace, putting a gasket of 1/64-in. Hallite or similar jointing between the faces.

Snifting Valve.

For beginners' information, the object of this valve is to admit air to the cylinders when coasting with steam off, thus preventing grit and ashes being sucked down the blastpipe, to the detriment of the valves, faces, cylinder bores and pistons. All modern full-sized engines have them, although they are not all located on top of the smokebox; some of them are "twins," one at each side of the smokebox, and some are out of sight altogether. When steam is on, the pressure below the ball lifts it and holds it up to the seating, thus preventing any steam escaping; but on shutting the regulator, the valve drops off the seating, air enters by virtue of the pumping action of the cylinders, and circulates through the superheater elements, preventing them from overheating, at the same time becoming warm, so that it does not cool the cylinders. It is expelled up the blast pipe; thus nothing in the way of grit and ashes can get down where it can do harm.

To make the valve, chuck a piece of 5/16-in. round bronze or brass rod in the three-jaw: face the end, centre, and drill down about ½-in. depth with No. 40 drill. Turn down 3/16-in. of the end to 7/32-in. diameter, and screw 7/32-in. by 40. Part off 7/16-in. from the end, reverse in chuck, turn down ⅛-in. of the other end to 7/32-in. diameter, and screw that 7/32-in. by 40 also. Cross-nick the end with a thin file or hacksaw. Chuck the rod again, centre, and drill down about ⅜-in. with No. 40 drill; open out to about 3/16-in. depth with 3/16-in drill, and bottom the hole to a full ¼-in. depth with a 3/16-in. D-bit. Tap the hole 7/32-in. by 40, but don't let the tap go in far enough to spoil the D-bitted seating. Part off at a bare ⅜-in. from the end; reverse in chuck, and round off the end. Drop a ⅛-in. rustless steel ball in the cup, stand it on something solid, put a bit of brass rod on the ball, and give it a sharp crack with a hammer, to form a seating. If only a bronze ball is available, use a steel cycle ball of same size, to form the seating. Screw the nicked end of the other part of the valve into the cup, putting the usual "dope" on the threads, and the valve is complete.

Drill a 5/16-in. clearing hole in the top of the smokebox, ½-in. from the back end, and dead in line with the chimney; then put the smokebox on the boiler, seeing that it is exactly vertical, with the chimney in line with the top of the boiler, and the snifting-valve hole over the top of the

Safety Valves.

The full-sized engine, like most of its present-day contemporaries, has Ross pop safety valves. It is easy enough to make these in the small size, but not advisable in the present case, for the simple reason that, as I have often pointed out, you can't "scale" nature. For the benefit of new readers, and others unacquainted with locomotive lore, I might briefly repeat that when a safety-valve starts to blow off, there is a reduction of pressure on the surface of the water immediately below the valve; and the pressure on the surrounding water forces up a little "hill" or "mound" into the reduced pressure space. This takes place on *any* engine, big or little. Well, it can easily be realised that the greater the pressure drop, the bigger the "hill"; and the sudden big drop caused by the full opening of a pop safety valve, generates a miniature waterspout under the valve. On a big boiler, this has no effect on the escaping steam; but on a little one, where there is only, say, 1½-in. between water and valve, the tip of the "water-spout" will not only reach the valve, but the rush of steam will take a skim of water off the sides of the column as well, with the result that the valve primes furiously. I have had so many showerbaths from the pop safety-valves fitted to my own locomotives, that I replaced the whole lot with ordinary plain valves; and the above is the reason I am specifying plain valves for "Bantam Cock."

The valves are made from ½-in. hexagon bronze, gunmetal or hard brass rod. Chuck a length in three-jaw, face the end, turn down ¼-in. length to ⅜-in. diameter, and screw ⅜-in. by 26. Part off at ⅝-in. from shoulder, and repeat process for second valve. Re-chuck the other way around, in a tapped bush held in the three-jaw; any odd bit of metal over ½-in. diameter will do for the bush. Simply chuck it, face the end, centre, drill 11/32-in., tap ⅜-in. by 26, countersink slightly, skim off any burring, and screw the valve blank in without removing from chuck. Centre the blank and poke a No. 24 drill clean through; open up to about 7/16-in. depth with letter J or 9/32-in. drill, and bottom with a D-bit to a total depth of 9/16-in. Tap 5/16-in. by 32, but don't run the tap in far enough to spoil the seating; then put a 5/32-in. parallel reamer through the remnants of the No. 24 drill-hole. Turn the outside to the shape shown in the drawing; the diameter of the lip is 9/16-in., and of the body 7/16-in. Leave ⅛-in. of hexagon, so that you can use a spanner to tighten the valves when screwing into the boiler.

The nipple is made from 5/16-in. round brass rod. Chuck in three-jaw, set to run truly, put a few threads of 5/16-in. by 32 pitch on it, face the end, centre, and drill down about ⅜-in. with No. 40 drill. Part off a couple of ⅛-in. slices, and file a couple of nicks in each as shown, to let the steam escape from the valve columns.

To make the cup and plunger, chuck a bit of 3/16-in. brass rod in the three-jaw, turn down about 7/16-in. length to 3/32-in. diameter, and part off to leave a disc about ⅛-in. thickness on the end. Reverse in chuck, centre the disc, and put a 3/16-in. drill in until it cuts full depth, leaving a countersink with a knife edge. Skim off any raggedness. Seat a 3/16-in. rustless steel ball on the hole, same as you did for the feed pump valves; should there be any difficulty in getting balls of rustless steel—they seem to be plentiful enough now!—a bronze one can be used, but make the seating with an ordinary steel cycle ball of same diameter. The spring is wound up from a bit of 22 gauge tinned steel wire, same as the springs under the axleboxes. The assembly is shown in the illustration; don't forget to touch each end of the spring on a fast-running emery-wheel, so that the end is square and takes a fair thrust on the ball cup and nipple. If it doesn't, the valve will never shut down tightly, but will everlastingly be "dribbling."

Backhead Fittings.

If there is one thing more than another, that I just hate to see on any locomotive, big or little, it is a badly-arranged backhead. On the L.B. & S.C. Rly. our fittings were neat and symmetrically arranged, the most full-sized locomotives have the "handles" set out in good order; but it is not so in the small sizes, the commercial jobs usually having fittings not only outsize and clumsy, but just apparently stuck on higgledy-piggledy without any attempt at neatness. One particular job, made by a firm which boasts of its "accuracy and realism," turned out a specially-made 2½-in. gauge engine for a price of £139, in which the fittings, without a word of exaggeration, looked as though they had been thrown at the backhead and screwed in where they hit!! On top of that, the regulator flew wide open as soon as it was touched, being useless for regulating purposes; whilst the three-cock water gauge was totally incapable of giving anything like an accurate reading, principally because the holes through the cock plugs were literally "pinholes," and did not allow steam and water to pass freely. Incidentally I took the engine in exchange, from a friend, for a reconditioned one which would really "do the doings," though a little smaller, and in due caurse reconditioned the "dud" for use on my own road. I still have her.

A glance at the layout of "Bantam Cock's" footplate as shown in the previous issue, will reveal that there is nothing like the above about her! On top of the backhead, there is a combined turret and whistle valve, the turret supplying dry steam to the blower, injector, and whistle. Directly below, is the handle of the regulator, handy to operate without burning your fingers against the boiler head. To the right is the blower valve, also fully accessible; to the left, a really reliable water gauge, placed vertically as on the full-sized engine. It has a screw blowdown valve, the waste water going down through a pipe to the underside of the footplate. To the left of the gauge, is the injector steam valve. Although I don't quite approve of feedwater going into a boiler at the firebox end, I have arranged for the feed clacks to be placed on the backhead, one either side, as there are no side clacks on the barrel of the full-sized engine; but the clacks have internal pipes which are easy to remove, for cleaning purposes, in districts where the feed water is what the enginemen call "dirty," that is containing impurities which form "fur" or scale. For the same reason, two washout plugs are provided at the bottom corners, so that any accumulation of mud or chalk can be readily washed out; something else always overlooked on commercial jobs! The syphon pipe of the steam gauge is attached to an elbow screwed into the wrapper flange, where there is enough metal to provide plenty of hold for the threads. The firehole door is of the old but very satisfactory "swing" or "oven" type, has a spring catch, and a handle that can be operated by the fireman's shovel, when you want to fire up whilst the engine is running. In order to save making an extra drawing of the front of the cab, I have used same as a "frame" for the fittings picture, in a manner of speaking, and given the dimensions of same; so this won't have to be repeated, and builders can refer back to the footplate drawing when they make and fit the cab.

The regulator gland and handle has already been described in recent notes; the blower valve was dealt with, in connection with boiler staying, in the issues of November 23rd and 30th last, so we can go right ahead with the remainder of the fittings.

Combined Turret and Whistle Valve.

These little gadgets can easily be built up from brass or gunmetal rod, though castings can be used if desired. For the former method, to make the body of the whistle valve and turret, a piece of 5/16-in. round rod 1 3/8-in. full length is needed. Chuck in three-jaw, face the end, centre, and drill right through with a No. 40 drill. Open out to about 1/2-in. depth with 3/16-in. drill, and bottom to 3/4-in. depth with a 3/16-in. D-bit; tap the end of the hole 7/32-in. by 40, countersink slightly, and skim off any burrs. Reverse in chuck, open out the No. 40 hole with 3/16-in. drill to 7/16-in. depth, tap the end 7/32-in. by 40, and countersink and skim off as before. Put a taper broach in the D-bitted end, and very slightly enlarge the end of the No. 40 hole, to form a true seat for the valve ball.

At 1/2-in. from the D-bitted end, put a 3/16-in. drill through the side of the valve body, going right across, so that the drill comes out on the other side. Midway between, drill another 3/16-in. hole, breaking into the central hole only; then drill a similar hole 1/2-in. farther along, in line with the first hole. This one should break into the shorter central hole which has not been D-bitted. In the first two holes drilled, and the last, fit screwed and countersunk 1/4-in. by 40 nipples, exactly as described in November 30th issue last, for the blower valve. In the hole between the first two nipples, which will be underneath the valve, fit a 1/4-in. by 40 shouldered nipple, as shown in the side view; then silver-solder the whole four at one heating, pickle, and clean up.

Seat a 1/8-in. rustless steel ball on the D-bitted seating; wind up a light spring from 26 gauge hard brass wire (steel wire is no good for this, as it will rust away) and secure it in place with a little cap turned from 5/16 hexagon rod, and drilled about 1/8-in. up, to keep the end of the spring central. Both ends of the spring should have the end coils filed off square, or the valve will leak most of the time. To make the handle fitting, chuck a bit of 3/8-in. hexagon brass rod in the three-jaw; face, centre, and drill No. 41 for about 1/2-in. depth. Turn down 3/16-in. length to 7/32-in. diameter, and screw 7/32-in. by 40, part off 1/4-in. from the shoulder. File away two of the angles on opposite sides, so that the hexagon becomes an oblong; then slot it across, either by milling, planing or judicious use of a thin flat file. Turn up a little handle from 3/16-in. rod, and file the stem flat, so that it fits easily in the slot; fix it by a piece of a domestic pin running through drilled holes in the fitting, and in the end of the handle. It must be perfectly free. Fit a little plunger made from 3/32-in. brass rod, of such a length that when the handle is pushed in, the ball is just forced off its seat; the exact length is best obtained from the actual job. Drill and tap a 1/4-in. by 40 hole at the edge of the wrapper, directly over the regulator handle, and screw in the fitting, with a smear of plumber's jointing on the threads. The body of the valve should be parallel with the boiler, and the handle end should just overhang the backhead. Connect the right-hand union nipple, with the one on the blower valve, by a piece of ⅛-in. copper pipe having a union nut and cone on each end. *Tip for beginners*: You can get exact lengths of all pipes by using a bit of soft copper or lead wire as a template, which is easily bent to shape, and on being straightened out again, gives the exact length of pipe needed.

Injector Steam Valve.

This is optional; but as reliable injectors can easily be made by following my detailed instructions, are handy for feeding the boiler when the engine is standing, and certainly more "real" than waggling the lever of the emergency hand pump, I thought it might as well be included. It is made from a 1¼-in. length of 5/16-in. round or hexagon brass or gunmetal rod. Chuck in three-jaw, face the end, turn down ¼-in. of the outside to ¼-in. diameter, and screw ¼-in. by 40. Reverse in chuck; face, centre, drill down 1-in. depth with No. 40 drill, then proceed exactly as given for the blower valve. At ¼-in. from the shoulder, drill a 3/16-in. hole into the central passageway; and at ½-in. from the shoulder, and diametrically opposite (see sectional illustration) drill another; fit screwed nipples into these, and silver-solder them. The blind end of the completed fitting is screwed into a tapped hole in the backhead about 1-in. from the top, and 1⅜-in. to the left of centre, as shown in the view of the complete backhead. It doesn't matter about these fittings standing square with the backhead, that is, with a slight upward tilt, as they have no horizontal connections inside the boiler, as is the case with the blower valve and the regulator.

Water Gauge.

For the top fitting, chuck a piece of 5/16-in. round brass or gunmetal rod; face the end, centre, and drill down about ¼-in. depth with 3/16-in. clearing drill (No. 11). Put about 3/16-in. of 5/16-in. by 32 thread on the end, part off at 11/16-in., reverse in chuck, slightly countersink the other end, tap 7/32-in. by 40, and skim off any burr. Drill a 3/16-in. hole in the side, halfway along. Chuck a bit of ⅜-in. round rod; centre, drill down about ⅝-in. with No. 30 drill, turn down ¼-in. of the outside to ¼-in. diameter and screw ¼-in. by 40. Reverse, and rechuck in a tapped bush held in the three-jaw; turn the outside to the outline shown, and reduce 1/16-in. of the end to a tight squeeze fit in the hole in the other part of the fitting.

To make the bottom fitting, a piece of ⅜-in. rod 1½-in. long is required. Chuck in three-jaw, face, centre, and drill down about ¾-in. depth with 3/32-in. or No. 43 drill. Open out to ⅜-in. depth with No. 30 drill and bottom the hole to ½-in. depth with a similar sized D-bit. Shanks of broken or worn-out drills make good odd-sized D-bits. Tap the hole 5/32-in. by 32 or 40; former for preference, as it gives quicker action. Reverse in chuck, turn down ¼-in. of the end to ¼-in. diameter, and screw ¼-in. by 40. Face, centre, and drill down ⅞-in. depth with ⅛-in. or No. 30 drill. At ⅜-in. from the shoulder, drill a 3/16-in. hole breaking into the passage-way; at ½-in. further along, and diametrically opposite, drill another. In the latter, fit a screwed and countersunk nipple, same as whistle valve; in the other hole, fit a nipple screwed 5/16-in. by 32, drilled right through with ⅛-in. drill, and opened out for ⅛-in. depth with No. 11 drill, to take the end of the gauge glass. Silver-solder all the nipples on both fittings, pickle, wash off, and polish up. The two gland nuts are made from ⅜-in. hexagon rod by same process described earlier in this series for union nuts, being drilled No. 11 for the glass, and tapped 5/16-in. by 32 to screw on the gland nipples. The valve pin is made exactly the same as the blower and injector valve pins; but as a variation, the end can, if desired, be bent over to form a handle instead of fitting a knurled wheel, or a cross handle can be substituted.

In order to keep the glass vertical, as on a full-sized engine, a socket will have to be made and fitted to the wrapper, over the backhead, at the location of the gauge. This is easily done. The screwed part of the socket is made by chucking a bit of ⅜-in. rod, facing the end, centring, drilling a blind hole a full ⅜-in. deep with 7/32-in. drill, and tapping it ¼-in. by 40. Countersink slightly and skim off any burr. Part off at ½-in. from the end. Bend a bit of 3/32-in. sheet copper to the curve of the boiler; it should be about 1-in. long and ¼-in. wide. File a flat on the socket, and silver-solder the flange to it; after cleaning up, drill a No. 30 hole through the underside of the flange into the socket, and two No. 40 holes in the flange for the fixing screws. At ⅞-in. from the crown of the wrapper sheet, and ⅛-in. from edge of plate, drill a No. 30 hole through wrapper and backhead flange, into the boiler; put the fitting exactly over it so that the holes line up, and secure it by two 3/32-in. or 7BA brass screws. You can either use a 1/64-in. Hallite or similar joint between flange and wrapper, and give the screws a taste of plumbers' jointing, or sweat over the whole issue with solder; the latter is preferable where the copper is at all rough.

Screw the top fitting of the gauge into the socket, so that it is vertical; then at 2-in. exactly below it, drill and tap a ¼-in. by 40 hole in the backhead, and screw in the lower fitting, lining them up by judicious use of a piece of 3/16-in. rod put through the holes where the glass fits. The gland nuts should be screwed on whilst lining up; and put some plumber's jointing on the threads that screw into the backhead and socket. A piece of glass tube about 1½-in. long and 3/16-in. diameter, is needed for the gauge; glass tube can be bought from most chemists who sell photographic and laboratory supplies, and ordinary soda-glass will do, providing the walls are over 1/32-in. in thickness. Incidentally, don't encourage the profiteering fraternity by paying sixpence or more for an inch, because the last lot I bought, at a laboratory furnisher's store just off Farringdon Road, worked out about three feet for one penny! It can be cut simply by nickong with a file, and breaking off.

The packing rings are made by cutting 3/32-in. rings off a piece of ¼-in. rubber tube, with a wet safety-razor blade that has outlived its usefulness for its original purpose. Wet the glass and the rings; insert glass down the top fitting, put on a ring, then the two nuts bac kto back, then another ring. Push the glass down to its correct position with a thin pencil, or a bit of a wooden knitting needle; prod the rings into the gland nuts, and screw them home. They should be little more than fingertight, so that the glass is free to expand. One of the most ridiculous designs I ever saw, for a "fancy" water gauge, had the glass clamped rigidly by the ends, which bore on two solid packing rings inside the fittings, and allowed no room whatever for expansion. That, and the gauge described here, represents the difference between theory and actual personal experience! The upper fitting is closed by a little plug turned from 5/16-in. hexagon brass rod. The blowdown pipe is not fitted until the boiler is erected on the chassis, when we shall connect up all the other pipes.

Feed Clacks.

Two feed clacks are needed, one taking the delivery from the hand pump and the other from the eccentric pump; if an injector is fitted, it need not have a separate delivery clack, as the feed from it can be teed into either of these. The clack bodies are made from 3/8-in. rod, gunmetal or bronze for preference, as the ball seatings lead the strenuous life when the engine is running. Chuck a piece in the three-jaw, face the end, and centre deeply with size E centre-drill. Turn down ¼-in. length to ¼-in. diameter, screw ¼-in. by 40, and part off 13/16-in. from the end. Repeat process for second clack; then reverse in chuck, centre, drill right through with No. 24 drill, open out to 3/8-in. depth with ¼-in. drill, and bottom with ¼-in. D-bit to 7/16-in. depth. Tap the end 9/32-in. by 32 or 40, and countersink slightly; skim off any burr. Run a 5/32-in. parallel reamer through the remains of the No. 24 hole. Drill a 3/16-in. hole, 5/16-in. from the top, in the side of the clack body; and in it, silver-solder a fitting made exactly like that just previously described for the upper fitting of the water gauge. Seat a 3/16-in. ball on the hole at the bottom of the ball chamber, and make a little screwed cap from 3/8-in. hexagon rod, to fit the top of the clack box. Chamfer off the bottom of the plug as shown in section, and make a countersink in it with a 3/16-in. drill; the length of the plug should be just sufficient to allow the ball 1/32-in. lift, and this can best be obtained from the actual fitting.

Open out the end of the nipple that screws into the boiler, for about 5/32-in. depth with 5/32-in. or No. 22 drill, and tap it 3/16-in. by 40, or preferably 3/16-in. by 60 if tap and die of this size are available. Screw the end of a 6-in. length of 3/16-in by 22 gauge tube to match, soften it, and screw it into the nipple. At approximately 2-in. from the top of the wrapper sheet, and in line with the water space each side of the firebox, drill 7/32-in. holes and tap them ¼-in. by 40. Screw in the clacks with a smear of plumber's jointing on the threads. The pipes will take the incoming feed water clear of the firebox into the space alongside the combustion chamber where there is plenty of circulation going on, and there will not be any ill effects around the firebox plates and stays. The pipes will just clear the top rows of stays, and they can easily be removed for cleaning, in districts where the water is chalky.

Washout Plugs.

For the same reason, it is advisable to provide a couple of washout plugs in the backhead. These are easily made from round brass rod, 3/8-in. diameter. Chuck a piece in three-jaw, face the end, turn down ¼-in. length to ¼-in. diameter, and screw ¼-in. by 40. Part off at ½-in. from the end; reverse in chuck, or re-chuck in a tapped bush, slightly reduce the diameter, and file a square to take a spanner, or plug key. Drill and tap a couple of holes close to the edge of backhead, at the bottom, to suit the plugs, and screw them in tightly with the usual "dope" on the threads. A small nozzle at the end of a piece of rubber tube attached to the kitchen tap, introduced through the holes, will soon shift all the dirt and scale from around the foundation ring, or "mud ring," as our cousins over the big pond call it, literally with truth! Incidentally, the washout plugs on a full-sized engine have no flanges, but are turned taper, and tallowed before screwing tightly home. It is rather difficult to turn a taper with *full threads* all the way along it on the average amateur's lathe, so I substituted the flanges.

Firehole Door.

Castings are available for the firehole door, and need very little fitting; no separate drawing is needed. Chuck the door in the three-jaw by the spigot provided, and turn down the end of the distance-piece to form a pip about 1/8-in. long and 1/8-in diameter. Cut out an oval piece of 16 gauge sheet iron or steel, that will fit in the firehole easily; drill a No. 30 hole in the middle, put it over the pip, and rivet over the end of the pip to hold hold the baffle plate tightly in place. Drill three 5/32-in. holes in the door, in the positions shown in the illustration of the complete backhead, to admit a little air over the fire when the door is shut.

Drill the hinge lugs No. 52 for a 1/16-in. pin; the stationary part of the hinge can either be filed from any odd piece of brass of suitable size, or made from 18 gauge sheet, a tag being left at the side, and bent around to take the pin. It is attached to the backhead by two 3/32-in. brass screws. The hinge pin should not be a fixture, but removable, so that by pulling it out, the door can instantly be removed. I use the head end of the large domestic pins known as blanket pins, for this purpose, also for the smaller size smokebox door hinge pins. The door-handle is merely a strip of steel about 18 gauge and 5/32-in. wide, riveted to the door by pieces of domestic pins; the end is bent around in the form of a loop. I discarded latches long ago, as I found they were a nuisance to operate when running, especially in the dark. In place of a latch, I now fit a small piece of springy brass, bent at right angles and attached to the backhead by a single brass screw. The projecting part of this bears against the handle loop, and keeps the door shut when running. When you want to fire up, you just hit the loop with the shovel blade, and the door flies open. The brass angle can be seen to the left of the door, partly behind the water gauge blowdown pipe.

Steam Gauge.

A ¾-in. pressure-gauge reading from 0 to 120 or 150 lbs. per square inch, is needed, and this had best be purchased; the good folk who supplied the castings will probably be able to oblige. A little steam gauge is not a difficult thing to make but it requires careful calibration with a full-sized gauge, if it is to be at all reliable, and rather delicate work is needed on the weeny links and pivot, so that the job is hardly worth tackling when a ready-made gauge is to be obtained for a reasonable price. It must be attached to the boiler by a syphon pipe, as shown in the illustration of the complete backhead; the syphon contains water, and prevents the hot steam coming in contact with the very thin and delicate C-tube which operates the gauge needle, causing false indications.

Chuck a piece of ¼-in. round brass rod in the three-jaw, face the end, centre, and and drill down about ⅜-in. with 1/16-in. or No. 52 drill. Turn down 5/16-in. of the end to 3/16-in. diameter, and screw 3/16-in. by 40. Part of ¼-in. from the shoulder. Drill a No. 32 hole in the side of the plain part; and in it, silver-solder a piece of ¼-in. copper tube about 3½-in. long, on the other end of which is the union nut and cone for attaching the gauge. After pickling, washing off and cleaning up, drill and tap a 3/16-in. by 40 hole in the wrapper and backhead flange, and 2-in. from the crown of the wrapper. Screw in the elbow fitting, with some plumber's jointing on the threads: bend the tube into an inverted sawn neck, as shown, and attach the gauge by means of the union nut.

Ashpan

On a small edition of a full-sized locomotive which has a wide firebox and a carrying axle under the ashpan, the arrangement of the latter and the grate presents a little difficulty. It isn't that they are difficult to make; far from it. The trouble is that a fireman on the full-sized article can go underneath to clear out his ashpan, and get the clinkers out through the firehole door, but he can't do the same on a 3½-in. gauge engine. True enough, the engine can be up-ended, and the residue shaken out, but apart from the weight of the little engine, it isn't a very "realistic" way of doing the job, to say the least of it, and the ashes and grit are liable to "do the works a bit of no good," as the kiddies would remark. On an engine with a trailing pony truck, I usually pivot the pony truck on an ashpan made from very stout metal, and arrange matters so that by pulling out a retaining pin, the whole lot—pony truck, grate and ashpan,—all come away from the engine, bringing the residue with them and leaving the firebox quite clear and unobstructed. This cannot be done when the trailing axle runs in bearings in the trailing frame, which prevent it being dropped; so the only alternative is to fit the deepest-possible ashpan between the trailing wheels, and arrange for a portion of the grate to drop into it. This allows any clinker or other refuse on the firebars to be easily removed via the open back of the ashpan; and is the method adopted for "Bantam Cock," as shown in the accompanying illustrations.

The ashpan is of the hopper type, and to make it, a piece of 16 or 18 gauge sheet steel is needed, measuring 7½-in. long and 4⅜-in. wide. This is bent to the shape shown, so that the internal width of the hopper base is 2⅝-in., the overall width over the ledges 5¼-in., and the ledges themselves approximately ¾-in. wide. No front plate is fitted, as the ashpan fits up closely against the front end of the trailing frame or firebox cradle. Take note here, that in order to get it up close, the front ends of the sloping portion will have to be set in for about ¼-in. or so, to match the bend of the frame.

In the middle of each ledge, and ⅛-in. from the edge of same, rivet a small piece of angle; this may be ordinary commercial brass angle, or bent up from the same kind of material used for the ashpan; it should be about ⅜-in. over the angles, and is shown in place in the cross section. Put the ashpan in place, and drill a couple of No. 40 holes clean through frame and angle, at each side, to accommodate the fixing bolts when the ashpan is erected "for keeps." The ledges of the ashpan should come flush with the sides of the trailing frame where same are parallel; but they will, of course, overlap the narrowed-in portion. This is quite in order, as the ashpan has to cover the bottom of the wide firebox for its full length, and prevent any cold air going in at the front end close to the side-plates, which would affect the steaming of the boiler.

The grate is composed of 15 firebars, each 3 11/16-in. long, made from either cast iron or ordinary commercial black strip steel. By the time these notes appear in print, it may be possible to purchase the three sections of the grate with bars and spacers cast integral; and if so, it will save a lot of work. The only machining necessary to assemble the grate would be to rivet or screw the four carrying brackets or "legs" to the narrow side pieces, and pivot the drop section between them. The erection is the same as for a built-up grate. To make the latter, cut 15 pieces of ⅛-in. by 5/16-in. black strip steel, to a length of about 3¾-in. At ½-in. from each end of one of the bars, make a centrepop in the middle of its width, and drill No. 30. Use this bar as a jig to drill all the others: file off any burrs. Twenty-four spacers will be required; these are made from ¼-in. round mild steel. Chuck in three-jaw, centre, and drill down about 1-in., parting off 5/32-in. slices until you get to the end of the hole; then "ditto repeato" until you have the required number of spacers. Don't drill deeper than 1-in. at one go, or the drill will probably begin to wander, and the holes won't be central.

The supports, or legs, are made from four 1¾-in. lengths of ⅛-in. by ¼-in. black strip, with the ends slightly rounded as shown. Drill a No. 32 hole at one end, and two No. 40 holes at the other, as shown: the exact spacing doesn't matter. The front bearer for holding the bars together, is a piece of ⅛-in. steel or iron wire approximately 4⅜-in. long, screwed ⅛-in. or 5BA at both ends, the plain part between the threads being not less than 4 1/16-in., as the bars *must not be clamped tightly*, otherwise the drop portion just won't! The back bearer is in three sections; one 2½-in. long, unscrewed, and two 1-in. long, screwed at one end only. The grate is assembled as follows:

Screw a nut on the end of the long bearer, then put on a bar, a spacer, bar, spacer, and a third bar. Then put on one of the legs, with a 1/32-in. washer to make up the correct spacing, followed by nine more bars with a spacer between each. Then comes another 1/32-in. washer, followed by another leg; after that, the remaining three bars and two spacers. The nut on the end should screw tightly to the end of the thread, leaving the bars quite free to turn on the bearer.

The other end is a little more tricky. First of all, put the 2½-in. length of ⅛-in. rod in the bench vice, and burr up one end slightly, like a rivet head. Next, with a 3/16-in. drill in the hand brace, slightly counter-sink the holes in the fourth and twelfth bars, on the outside of the grate. Poke the unburred end of the bearer through No. 4 bar, and thread through the next eight, putting a spacer between each; the end bars can, of course, be thrown back out of the way. Now up-end the middle part of the grate, resting the burred end of the bearer on something solid, and rivet over the other end into the countersink in bar No. 12, thus clamping the back end of the drop portion of the grate solid. Countersink one side of the No. 32 hole in the top of each of the other two legs, and drive the unscrewed ends of the two short bits of bearers through, so that they just project beyond the countersinks. Grip the bearer in the bench vice, and rivet the end over into the countersinks; then put the screwed ends of the bearers through the three bars beyond each end of the drop portion, with spacers between, and nuts on the outside as shown in the illustrations. These nuts *should* be quite tight against the bars. Squeeze the legs in a little, so that they will just go down into the narrow part of the ashpan, as shown in the cross section; then adjust the height, so that the three bars each side, which are attached to the legs, are approximately ¼-in. above the ledges of the ashpan. The legs can then be riveted to the sides of the ashpan as shown, the pan of course being temporarily removed for that purpose. We then have the required arrangement, the central nine-bar section of grate being free to drop down into the ashpan, the front ends of the grate bars being level with the ashpan front. Before finally riveting the legs to the ashpan, clamp the grate in the bench vice and trim up both ends of all the bars, so that they are of even length, which should be 3 11/16-in. The ends may be slightly rounded if desired. It will be seen from the above, that the grate and ashpan are not attached to the boiler itself in any way, but are carried by the trailing frame or cradle.

How to Erect the Boiler

First put the smokebox saddle between the frames at the front end, the main part of the saddle resting on them, level with the cylinders, and the projections at the bottom going between them, the legs sticking out fore-and-aft, as our nautical friends would say. Next put a smear of plumber's jointing around the inside of the back end of the smokebox, and press it on to the boiler barrel for about ¼-in., taking care the dome and chimney line up correctly, and the hole for the snifting valve comes over the top of the hole in the header into which it screws. Then put the boiler in place on the chassis, the holes in the smokebox bottom going over the steam and exhaust pipes, and the firebox fitting over the grate, the foundation ring resting on the ashpan ledges. If any slight inaccuracy has occurred in building the boiler, it doesn't matter in the least, because any error in length can be easily discounted, either by slightly drawing the holes in the bottom of the smokebox with a round file, or filing the angles between frame and cradle to suit the angle of the throatplate. If all is O.K., the boiler should sit perfectly level, with the bottom of the barrel approximately 1/16-in. above the top edge of frame.

The saddle is attached to the frames by a ⅛-in. or 5BA countersunk screw put through a clearing hole in the frame, into each lug where it projects beyond the saddle. The smokebox can be attached to the saddle by a few small hexagon head or rounded screws; 8 BA, or 3/32-in. would do, or a row of smaller ones if you like; put through clearing holes in the side flanges of the saddle into tapped holes in the smokebox shell. The back end of the boiler must be free to expand; and the easiest way to keep it from lifting, yet allow the necessary freedom, is to fit a little vertical link at each side of the firebox, as shown in the small detail sketch. The links can be cut from sheet copper of 16 gauge, and are 5/16-in.

wide and 1⅛-in. long, with a No. 30 hole in each end. Drill a No. 40 hole through the wrapper sheet into the foundation ring at each side, taking care to keep well below the water space, and about ½-in. from the end of the boiler; tap these ⅛-in. or 5 BA, and screw the links to the boiler by brass screws of corresponding thread. Any shaped head will do. Bend the links in slightly, so that they lie close against the trailing frame, and put the No. 30 drill through the bottom hole, making a countersink in frame. Drill it through No. 40, tap ⅛-in. or 5 BA, and put a screw in.

Smokebox Essentials

For beginners' benefit I might here remark that one of the most important conditions for a fast-steaming boiler is an absolutely airtight smokebox. If air leaks in at any point, and the vacuum created by the blast is partially destroyed, the fire won't "draw," but will burn dully and patchy, and will not generate the heat necessary to make steam. For this reason, every place where air leakage might occur, must be effectually sealed. The smear of plumber's jointing put around the smokebox before attaching it to the boiler, will effectually seal the circumferential joint. Plumber's jointing, by the way, is a commercial article sold in tins for a shilling or so at any ironmongery stores selling plumbing requisites; the brand I use is known as "Boss White," but any other known brand will do. It is like semi-liquid putty in appearance, and sets quite hard in a short time, but joints made with it may be easily broken without harm to screws or faces, at any time. If this product cannot be readily obtained, a mixture of red lead and gold size is a good substitute; white lead thinned with boiled oil may also be used, but this sets very hard and cracks under heat.

If the snifting valve has not already been fitted, screw it in now, with a taste of jointing on the threads, and put a little around inside, where the top of the valve goes out through the smokebox. If there is only a very small clearance between the steam and exhaust pipes, and the holes in the bottom of the smokebox shell, a fillet of the jointing may be sufficient to fill the interstices; or a piece of asbestos string, coated with jointing, may be wound around the pipes for two or three turns, and well pressed down to form a sort of grummet. If, however, the holes have been filed, and the pipes are not central, knead up a few scraps of wet asbestos millboard into a sort of putty, and put a fillet of that all around them, completely covering the holes. Press it down well. When the moisture dries out, the fillet will have set hard, and oil will not affect it.

Connect up the superheater union to the steam pipe leading to the cylinders; screw on the blastpipe nozzle, and connect the blower union to the nipple on the end of the hollow stay by a piece of ⅛-in. pipe with a union nut and cone on each end. I have already described how to make union nuts and cones, so need not repeat instructions. Lastly, the smokebox ring and door may be fitted. Put a smear of plumber's jointing around the inside of the front edge of the shell, then very carefully insert the ring, with the door, dart and crossbar all complete and screwed up tight. Be very careful to have the engine standing on something level, so that the hinge straps can be set horizontally. When the ring is properly set, gently tap it right home with a hammer and a piece of wood, holding the wood against the ring close to the edge, and working right around so that the ring enters evenly. It must not be hit hard enough to cause any distortion, otherwise the door will not close airtight. Drive it in just as far as the radius—see general arrangement drawing; if a reasonably tight fit, no screws or other fixing will be needed. I never put any screws in mine. The front end is then complete, but there are two small jobs to be done before the pipe work is tackled.

BEFORE making the injector there are two little jobs to be done: the first is to line up the blast nozzle with the chimney. Get a piece of straight rod (I use a length of silver steel) which will exactly fit the blastpipe nozzle without shake, and put it down the chimney into the nozzle. The part projecting above the chimney should be exactly central with same; if it inclines to one side, very carefully bend the blastpipe until the rod is central. You are then certain that the jet of exhaust steam will fill the liner correctly and create maximum draught.

Item No. 2 is a means for retaining the drop grate in the horizontal position when the engine is working. Right in the middle of the backhead, opposite the central firebar, and just below it, drill a No. 21 hole through the foundation ring, keeping as far below the water space as possible. Cut a piece of silver-steel rod 5/32-in. diameter and about an inch long, round off one end, and screw the other 5/32-in. by 40. Turn up a "button" from ½-in. rod, any metal; screw it on to the pin, and knurl it with a coarse-cut file, same as a valve wheel. Push up the drop part of the grate with a piece of wire—the fireman's pricker does this job when the engine is complete and running—insert the pin as shown in the assembly sketch [Mar. 29] and let the grate drop and rest on it. When the engine has finished a run, pulling out the pin allows the grate to drop and discharge all the residue through the open back of the ashpan.

Injector

Before starting to connect up the feed pipes, we had better make the injector; then the whole of the pipe work can be done right away. Judging from my correspondence, most builders of small locomotives seem scared of tackling the making of an injector, but it is merely a question of "knowing how." An injector suitable for "Bantam Cock" is a simple little gadget, as you will see from the following notes; once made and installed, all you have to do is to keep it clean, and it will feed the boiler without any trouble. As to reliability, some of my own engines have no pump at all, and rely entirely on injector feed; so far, none of them has ever been short of water. Injectors are now universally used on full-sized locomotives; the only engines having pumps, are those with separate feedwater heaters, which render the feed too hot for injector working. I might add here, for the benefit of beginners, that the action of an injector is simply that the jet of steam, issuing from the steam cone, meets a stream of water and condenses in it, imparting its speed to the water, which rushes out of the second cone with sufficient force to bump up the clack valve and enter the boiler. If the steam cannot condense, due to the feed water being too hot, the injector will not work.

No castings are needed for the injector, the body being built up from two bits of brass silver-soldered together. Chuck a piece of 5/16-in. square brass rod truly in the four-jaw; any grade of brass will do, even "screw-rod"; there are no moving parts in the injector, and nothing to wear out. Face the end, centre, and drill down about 1-in. depth with No. 23 drill. Turn down 5/32-in. of the end to ¼-in. diameter, and screw ¼-in. by 40. Part off ⅞-in. from the end. Reverse in chuck, and see that the hole in the centre of the piece of metal runs truly; I usually slack No. 1 and 2 jaws of the chuck, and tighten the same two when replacing the bit of metal, which does the trick. Repeat the turning and screwing operation mentioned directly above, then poke a 5/32-in. parallel reamer right through. You now have a piece of 5/16-in. square, 9/16-in. long, with 5/32-in. of thread at either end. Check off, as the overall length is important, the correct adjustment of the cones depending on it.

Draw a line down the centre of one of the facets, and make a centre dot ⅛-in. from each shoulder; that is, 5/16-in. apart. Drill them out with a No. 40 drill, one going clean through the piece, and the other just penetrating the centre passage. Open out this last one with an 11/64-in. or No. 18 drill. Open out the bottom half of the first one, as far as the passageway, with a No. 30 drill, tapping it 5/32-in. by 40. On the facet directly opposite, make a centrepop dead in the middle, and drill into the central passageway with a ⅛-in. or No. 32 drill. Run the 5/32-in. reamer through again, to clean off any burrs, and fit a ¼-in. by 40 nipple in the 11/64-in. hole, as described for the boiler fittings.

Chuck a piece of ½-in. round brass rod in the three-jaw, face the end, and part off at 5/16-in. length. The toolmarks will show the true centre of this piece; so scribe a line across it, cutting through the centre, and on that line, at 1/16-in. from the centre, make a centrepop. Chuck the piece in the four-jaw with the centrepop running truly; drill right through with a No. 34 drill, open out to about 3/16-in. depth with 7/32-in. drill, bottom to ¼-in. depth with 7/32-in. D-bit, slightly chamfer the end of the hole, tap ¼-in. by 40, taking care not to let the tap damage the D-bitted seating, and skim off any burring. Put a ⅛-in. parallel reamer through the remnant of the 34 drill hole. The next bit must be done carefully. Turn the piece over, and at ⅛-in. from the edge farthest away from the ⅛-in. reamed hole, make another centrepop. Drill this out diagonally, so that it breaks into the tapped part of the other hole about ⅛-in. from the top; see sectional illustration.

The two pieces now have to be silver-sided together. Mix up a little powdered borax—or better still, "Easyflo" flux, to a creamy paste with a few drops of water, and smear the parts to be joined, also putting some around the nipple; then place them together so that the ⅛-in. reamed hole in the circular section comes over the ⅛-in. hole in the middle of the square section. The end of the diagonal hole should coincide with the No. 40 plain hole, as shown. Tie the parts together with a few strands of iron binding wire, such as used for making up bunches of flowers. Put the assembly in your brazing pan, carefully bring it to a dull red, and apply a touch of best grade silver-solder, or "Easyflo" if you can get it. This will melt, run around the nipple, and penetrate clean through the joint. When it cools to black, drop in the pickle-bath to quench out; then wash off, remove the wire, clean up, and file away the superfluous metal at each side, leaving the top looking oval in plan, as shown.

Drop a 5/32-in. rustless steel ball in the hole, and seat it with a hammer and bit of brass, as described for the boiler feed pump; then take the depth from top of hole to ball, and turn up a little cap from a bit of 5/16-in. brass rod, the screwed part being the same length as the depth indicated by the gauge. Before parting off the cap from the rod, make a countersink with a 3/16-in. drill, about 1/16-in. deep; see section. After parting off, reverse the cap in chuck, and chamfer the hexagon. As the ball chamber is open to the atmosphere via the diagonal hole, the cap need only be screwed in finger-tight, and no jointing material is needed on the threads.

Cone Reamers

As the cones have tapered holes in them, it will be necessary to make some reamers of the required taper; a job which is quite simple, and taking very little time. Chuck a piece of 5/32-in. round silver-steel about 2½-in. long, and turn a cone point on it 13/16-in. long; if your top slide has a graduated scale, you will find that setting it over to about 4½ degrees will do it. Chuck another similar piece, and turn another cone point 1 1/16-in. long; set over to about 3½ degrees. If your slide-rest has no graduations, the only thing to do is get the lengths by trial and error. Chuck a third piece of steel, and turn a cone on it 5/32-in. long, then radius it out as shown; the exact curve does not matter, as it is only used to form the bell-mouths of the combining and delivery cones, but it should be gradual as shown. File the turned part of all three pieces to the centre-line, see illustration; then harden and temper them to dark yellow. For beginners' benefit, here is a brief resume of the way to do the job. Heat each to medium red, and plunge vertically into clean cold water. Brighten the flat part by rubbing on a piece of fine emery cloth, *but don't destroy the sharp edges*—very important that! I usually touch mine on a fast-running emery wheel. Now lay each separately on a piece of sheet iron, and hold it over a gas or spirit flame with a small pair of tongs. Watch the brightened part, and as soon as it turns yellow, tip the reamer into clean cold water. Finally, rub the flat on an oil-stone, to smooth the cutting edges, and the reamers are ready for use.

How to Make the Cones.

The combining cone (centre one) is made and fitted first, as the other two can be adjusted to it. Chuck a piece of 3/16-in. round brass rod in the three-jaw, and turn about 1/2-in. of it to a very tight drive fit in the reamed hole through the injector body. Beginners should first turn the end of the rod for about 1/8-in. length, until it will push in the hole very tightly; then turn the cross-slide handle back about half a turn, bringing it forward again almost to its original position, but not quite. If the cross-slide has a "mike" collar, about half-a-division short of the original reading will be about right. With this setting, turn the half inch mentioned above, and turn away the 1/8-in. under-sized bit. With a very small centre-drill, held in the tailstock chuck, make a centre in the end of the rod; then drill it for about 3/8-in. depth, first with a No. 72 drill, then with a No. 70, so as to get the hole exactly the right size. Form a slightly blunt nose on the end, as shown in the illustration, and part off at 9/32-in. from the end. Don't be scared of drilling the weeny hole for fear of breaking the drill in it. The cause of a drill breaking in a hole is usually the flutes becoming choked with chippings, causing the drill to seize up; to avoid this, all you need do is to work the drill in and out like a piston-rod working in a cylinder. This allows all the chippings to fall clear, and you can put a No. 80 drill, if necessary, down to the full depth of the flutes without breakage. High speed is needed; I usually run a No. 70 at about 4,000 r.p.m.

Reverse the cone in the chuck, and try the end of the reamer with 13/16-in. taper, in the hole, noting how far it goes in; then put it in the tailstock chuck, and with the lathe running fast, ream the hole in the cone until the point comes through a shade less than it went in at the other end. I use a stop on all my reamers; simply a piece of brass rod, drilled No. 21 and furnished with a set-screw, see illustration. If this is slid over the reamer to the length of the cone plus the required projection, and the setscrew tightened, you cannot push the reamer through too far, and spoil the size of the exit hole. Test with a No. 69 drill; if that goes through, the hole is too big. Slightly radius the end of the hole with the stubby

Cones

The combining cone may either be completely divided, as in the full-size Holden and Brooke injectors, or slotted like the American injectors of Sellers make. For the former, hold the cone, nose outwards, in the three-jaw, with a little over one-half projecting; saw off the piece with a jeweller's hacksaw close to the jaws, then face the end with a knife tool, cutting back slightly as shown. Put the other piece in the chuck, sawn side out; face that also, and very slightly radius the hole, with the short-nosed radiusing reamer. The two parts of the cone are then squeezed into the injector body, using the vice as a press. Centre the nose end of the cone into the nipple end of the body, and squeeze it flush, with a piece of soft copper between vice jaws and injector, to prevent damage; then put a piece of brass rod a little less than 5/32-in. in diameter, between cone and vice jaw, and squeeze the half-cone in until the end is about 1/64-in. past the centre of the ball-seat hole. The cap and ball should, of course, be removed whilst pressing in the cone. Then repeat the performance with the second half of the cone, pressing in until the halves are 1/32-in. apart under the ball seat. If the reamer is then tried in the taper hole, it should seat in both halves of the cone without shake.

To make the Sellers type cone, chuck in three-jaw, and instead of sawing it in two, form a groove in the middle a little under 1/16-in. deep, with a parting tool 3/32-in. wide. Then with a thin flat file such as watchmakers use, file two slots about 1/32-in. wide, in the middle of the groove at opposite sides, cutting into the central passage; see illustration. Run the taper reamer in again, to remove any burring; then press the cone into the injector body, from the nipple end, as described above, so that the groove comes below the ball seat.

Steam Cone

Chuck a piece of 7/32-in. brass rod in the three-jaw; face the end, centre it, and drill down about 1/4-in. depth, first with a 65 drill, and then with a 63, to get correct size hole. Put the reamer with the 13/16-in. of taper in the tailstock chuck, and slightly broach the hole with it; if you enter the point of the reamer to a depth of 5/32-in. it will be just right. Now turn 5/16-in. length to a fairly tight push fit in the injector body; just tight enough to get in and out with your fingers. The outer end is then turned to the shape shown; note, the curve is most important, because if the nose is too blunt and too thick, the injector will not work. The length of the shaped part is 5/32-in., and the extreme tip should be almost parallel as shown, being turned down practically to a knife edge around the broached hole. Part off to leave a shoulder 3/32-in. wide; reverse in chuck, centre, and drill down ½-in. depth with No. 30 drill. This will leave a taper at the end, corresponding to the drill point, and it may be slightly " streamlined " by judicious application of the reamer used for broaching. Be careful not to overdo it and enlarge the throat of the No. 63 hole, or you will destroy the ability of the injector to work at the higher pressures. Skim off any burr left by the drill, and the cone is complete.

Delivery Cone

This one requires a little more care, as a smaller size drill is needed. Chuck the 7/32-in. rod again, face the end, centre, and drill down about 5/16-in. depth, first with a 77 drill, and then with a 75. Incidentally, for centreing before using these small drills, I use a home-made centre-drill, as the commercial variety makes too big a hole. Mine is simply a broken stub of a dental burr, ground to a weeny arrow point; but anybody can make one from an inch or so of ⅛-in. silver steel, if they turn an ordinary round cone point on the end, then form the end into an arrow point by rubbing flats each side, on a fine oilstone, and hardening and tempering to a dark yellow. Next, with the very short reamer, bell-mouth the hole to a diameter of 3/32-in.; then turn down the piece for a length of 9/32-in., to a tight push fit in the injector body, as before, further reducing ⅛-in. of the end to the shape shown. Part off to leave a flange 3/32-in. wide behind the shoulder; reverse in chuck, centre, and drill down with the No. 70 drill until you meet the 75 hole drilled from the other end. Put the reamer with 1/16-in. taper in the tailstock chuck, and carefully ream out the hole until the point just shows at the bottom of the bell mouth; it is best to take the cone out of the chuck when checking. Finally, slightly bell-mouth the flange end with the short reamer, and skim off any burr.

The diameter of the throat should be tested by trying to push a 74 drill through it; this should not pass, but a 75 should pass easily. If you have been unlucky, and the 74 *does* pass, don't worry, the cone can be used. Drill both steam and combining cone one size larger, so that the combination is 62-69-74 instead of 63-70-75. The injector will work over the same range of pressures, but it will feed a little faster, and probably reduce the steam pressure a few pounds when used whilst the engine is running.

When the steam and delivery cones are pushed into their respective ends of the injector, the steam cone should enter the combining cone to a depth of 1/32-in., and there should be a gap of 1/32-in. between the end of the delivery cone and the nozzle of the combining cone, as shown in the sectional illustration.

Most full-size injectors have a delivery clack self-contained in the body casting, but ours is too weeny for that, so we have to make a separate delivery clack and screw it on to the delivery end of the injector. Chuck a piece of 5/16-in. round brass rod in the three-jaw, face the end, centre, drill down 9/16-in. depth with a No. 33 drill, open out with 7/32-in. drill to about ¼-in. depth, and bottom the hole to 5/16-in. depth with a 7/32-in. D-bit. Poke a ⅛-in. reamer into the remains of the No. 33 hole, and tap the upper part ¼-in. by 40, taking care not to let the tap spoil the D-bitted seating. Slightly countersink the end, and part off to a length of ⅝-in. At 5/16-in. from the blind end, drill a 3/16-in. hole into the central passageway. Chuck the 5/16-in. rod again; face, centre, and drill down to ½-in. depth with ⅛-in. drill. Open out with 7/32-in. drill, and bottom with 7/32-in. D-bit to ¼-in. depth; tap ¼-in. by 40. Part off at 7/16-in. from the end, reverse in chuck, and turn a pip about 3/32-in. long on the other end, to a tight press fit in the hole in the side of the other piece. Press it in, and silver-solder it; pickle, wash and clean up. Seat a 5/32-in. ball on the hole in the vertical part, and make a cap to fit, same as described for the top of the boiler feed pump. The ball should have a good 1/32-in. lift, and the nicks should be large enough to let the water pass easily. The complete assembly is shown in the sectional illustration, and the whole gadget is screwed on the end of the injector body over the flange of the delivery cone. It should stand vertical when right home; if it does not take a tiny skim off the back of the delivery cone, and try again, until it does. The injector is then complete. This size and type, by the way, is suitable for any locomotive of 2½-in. or 3½-in. gauge. It takes about 2½ minutes to feed in a pint of water, at any pressure from 80 lbs. down to almost nothing, and does not use enough steam to worry any 2½-in. gauge boiler of my design.

I always arrange the pipes under the engine drag-beam and the front of the tender, so that any engine can be used with any tender of the same gauge; and a sketch of the arrangement for an engine with one pump and one injector is reproduced here. The pipes on a wide-firebox engine having a trailing cradle, such as " Bantam Cock," are carried in two plate brackets screwed to the beam, the pipes passing through holes, but not fixed in any way. The only fixture is the union screw for the hand pump connection. The drawing explains itself; the brackets are pieces of 3/32-in. brass sheet, 1¼-in. square, with 3/16-in. holes drilled for the pipes in the location shown, and a ¼-in. hole for the hand pump union. They are filed to clear the angles attaching the drag beam to the cradle, and are themselves attached by two countersunk screws and nuts, as shown in the small side view.

Like the wires in a radio set, as long as the pipes start and finish at the right places, it does not matter a great deal as to what route they take between terminal points; so I have shown the pipe connections in diagram form, the same as the radio designer shows a " schematic " diagram of his wiring. The hand pump connection can be made first, the ¼-in. by 26 union fitting being made from 5/16-in. hexagon brass rod by the same process described for the top fittings of the hand and eccentric-driven pumps, one end being screwed ¼-in. by 26, and the other ¼-in. by 40. Measure the length of pipe required, from the bracket to the union on the left-hand clack, with a bit of copper wire, and cut a piece of 5/32-in. copper pipe the same length. One end is silversoldered into the ¼-in. by 40 end of the union fitting; the pipe is then put through the bracket (temporarily removed), the union also being pushed through and locknutted, as shown in the small detail side view. A union nut and cone is put on the other end of the pipe. Put the nut on first, then the cone, and silversolder the latter. To make the cone, chuck a piece of 7/32-in. gunmetal or bronze rod in the three-jaw; face, centre, drill No. 40, turn the end to a cone with the topslide set over to 30 degrees, or else use a tool with the edge ground off to that angle. Part off to leave about 3/32-in. of parallel rod behind the cone, reverse in chuck, and drill 3/32-in. depth with No. 23 drill, which should counterbore the cone to a tight fit on the pipe. All the union cones are made the same way, using suitable size rod, and drills to suit pipes, so we need not go over the process again. Replace the bracket, and bend up the pipe in a nice curve, to meet the union on the clack; the pipe should be straight above footplate level, and lie close to the backhead.

Bypass Pipe

The bypass pipe can be fixed next, the valve being made exactly as described and illustrated for the injector steam valve, except that a long handle is fitted, to go up through the cab deck or footplate, and it has a cross handle instead of a wheel, for easier manipulation when running. Instead of the outlet union, which is the one nearest the gland, silversolder in a piece of 3/16-in. copper tube, which is pushed through the extreme right-hand hole in the bracket; see diagram. The valve is, of course, arranged vertically. Make up a length of pipe to go from the lower union on the valve, to the right-hand clack. This pipe has a double tee in it, made simply by drilling a piece of ¼-in. or 5/16-in. rod to suit the pipes, drilling two holes in the side, and silver-soldering a couple of 5/16-in. by 32 nipples in. These are made the same as those on the screwdown valves already described, except for the larger threads. From the bypass valve to the tee, use 5/32-in. pipe; between tee and clack, use 3/16-in. pipe; the tee should be located just where the pipe turns upwards to meet the clack union.

Run a 3/16-in. pipe from the left-hand hole in the right-hand bracket, to the union at the bottom of the eccentric-driven pump, securing with the usual nut and cone. Run another 3/16-in. pipe from the top of the pump to one of the unions on the double tee. These pipes will run below the ashpan, and may be fixed to it by a small clip, to prevent both rattling and sagging, if you so desire.

All that remains, is the injector. As this weighs less than an ounce, it needs no support other than the pipes, and by unscrewing the three unions, it may be instantly removed for cleaning out the cones, which tend to fur up if the water is not pure. It can be placed in any position between the drag beam and the ashpan, but not too close to the latter. Run a 5/32-in. pipe from the steam end of it, to the steam valve on the backhead; the upper end of the pipe carries the usual union, and the lower end has the ordinary nut, but instead of a cone, silversolder on a little flat collar, as shown in the section. This not only makes a steamtight joint, but holds the steam cone in position. From the top of the delivery clack, take a 3/16-in. pipe to the other union on the double tee; and from the nipple under the injector, take a 3/16-in. pipe to the vacant hole in the left-hand bracket. A piece of 5/32-in. pipe about ¾-in. long, screwed into the overflow hole under the injector, completes the " plumber's job."

There is no valid objection to the pump and injector both delivering through the same boiler clack, because each fitting has its own delivery valve, so that the pump cannot blow back through the injector, nor vice versa. When the pump alone is in use, the pump water valve on the tender is left full open, and if there should be too much water going into the boiler, the by-pass valve is opened, so that the excess may return to the tank. When the injector is being used, both the pump water valve and the bypass valve are closed entirely; the injector is regulated by its own steam and water valves, and turned on and off as required, as on a big engine. Personally, I have followed big practice in my own locomotive building, and now use injectors only, as they give no trouble, and require less pipe work than a pump, also there are no moving parts to wear out. A few evenings ago, time of writing, my 3½-in. gauge L.N.W.R. 4-4-2 tank engine made a non-stop run of 40 minutes, during which run I never touched the fire, and used the injector twice. The actual distance covered was over 2½ miles. The engine purred along as quietly as an electric train, with the firehole door partly open, steam gauge steady at 90 lbs., and the blast practically inaudible. Compared with the locomotive, my weight is equal to about 16 coaches in full size.

The Whistle

The last working component is the whistle—must not forget that, or the " Bantam Cock " will not be able to crow! The " bell " is a piece of thin brass tube about ½-in. diameter and 3-in. long; square off both ends in the lathe, and slightly bevel one of them. Turn up a plug for the other end from ½-in. brass rod, with a No. 30 hole in the middle; soft solder will do to seal it in, if a tight fit to start with. The stem is a piece of 3/16-in. brass rod approximately 3¾-in. long; one end is turned down for ⅜-in. length to ⅛-in. diameter and screwed ⅛-in. or 5 B.A., the other has a few threads of 3/16-in. by 40 pitch at the end. The blowing part is made from a 7/16-in. length of the same kind of tube used for the bell, squared off at both ends. Chuck a piece of ½-in. brass rod in the three-jaw, and turn down 7/16-in. of it to a tight fit in the tube; turn another 1/32-in. off for a length of about 5/16-in., and form a groove with a round-nosed tool, as shown in the sectional illustration. Centre, drill a hole about 3/16-in. deep with a 5/32-in. drill, and tap it 3/16-in. by 40. Part off at ¾-in. from the end; reverse in chuck, turn down ¼-in. length to ¼-in. diameter screw, ¼-in. by 40, centre deeply and drill a 3/32-in. hole into the tapped one. Drill a couple of No. 40 holes across the groove; force the piece into the short tube, and assemble the lot as shown in the sketch. For a clear note, the distance between the bell and the blower should be about 3/16-in.; if husky at all, at 60 lbs. pressure, adjust the bell either by putting washers under the shoulder at the top, or turning a shade off it. You cannot blow this whistle by lung pressure, as it is intended for high pressure steam; but if properly made, and properly adjusted with the bell lined up with the groove, and at correct distance away, you could hear it half-a-mile off in still air. Hang it just clear of the drag beam by a couple of small clips, and connect it to the union on the whistle turret by a ⅛-in. pipe furnished with the usual nuts and cones.

Boiler Lagging

If any "Bantam Cock" builder wishes to lag his boiler, now is the appointed time, before fitting superstructure and running-boards. It is not necessary to lag the barrel; in fact, if the brazing has been neatly carried out, and the stayheads nicely formed, so that they are not unsightly, there is no need to put any lagging on the boiler, as the heat losses are small on a 3½-in. gauge locomotive. Only a few extra shovels of coal are needed on the coldest day. I usually put a cleading of thin sheet metal over the firebox wrapper, which hides all the stayheads and gives a smooth surface for painting. As a certain amount of condensation takes place under the cleading sheet, it is best to make it of thin brass or copper sheet, of about 28 gauge, as iron or steel cleading sheet would rapidly corrode.

Cleading Sheet

To make certain of a perfect fit for the cleading sheet, make a paper template or pattern; cut it from stout brown paper and fit it over the firebox wrapper. Take out the safety valves, and rub your fingers on the paper over the bushes; their position will be indicated by the marks on the paper, and you are thus enabled to cut the holes in the correct location. The clearances needed for the turret and steam gauge fittings can also be marked and cut out. If the pattern is then laid flat on the sheet of thin metal, it can be marked out, cut, and drilled to correspond: and you know that it will fit exactly, no metal being wasted. As I never use drawings when building my own engines, having no need of them, I sometimes use paper patterns for other parts of a locomotive, to check my "mental arithmetic," and avoid any waste of metal.

When the cleading sheet is cut out, stretch it tightly over the firebox wrapper, and attach it at the bottom by a couple of 1/16-in. or 10 B.A. screws each side, running into tapped holes in the wrapper at foundation-ring level. The front end should be sufficiently long to extend slightly beyond the throatplate: make a nick at each side where the throatplate joins the barrel, and bend the projecting bit of sheet below the nick, around the front of the throatplate under the barrel.

Boiler Bands

The boiler bands can be made from brass "ticket wire," which is a commercial article; it is thin brass strip about 5/16-in. wide. If not available, spring steel of the same width and about 30 gauge can be used, or the strip might be cut from the sheet used for the cleading plate. The ends of each band are bent at right angles, and drilled or punched to take a screw and nut. Put one close to the smoke-box; another goes as near the throatplate as possible, and passes over the edge of the cleading plate, holding it down to the barrel. Two more are put between, at even spacing; their position is shown on the general arrangement drawing in the opening instalment, also on the full-size blueprint. The bent-over lugs are located underneath the barrel, and the screws should be just tight enough to hold the bands from slipping sideways; if too tight, the lugs will break off.

Running-boards

The high running-board obviates the need for wheel splashers, saving one tiresome job, and making for easier fitting. Each side can be made from a strip of 18 or 20 gauge steel or hard-rolled brass, 2-in. wide, and can be either in one or two pieces. If the former, first form the radius at the front end, and then make a sharp right-angle bend above it; the strip is then straight and level for 5¼-in., after which it rises ⅜-in. higher, following the curve of the frame, for a length of 1⅛-in. It then goes approximately 10⅝-in. at "high level," dropping to its original height again at the trailing coupled wheel, at which point it has to be cut away for a depth of 1⅛-in., to pass the firebox; see plan sketch.

Before cutting the clearance, "offer up" the metal to the frame and boiler, and mark on it the exact position of the clearances needed; then, if you have made any slight error in frame or boiler dimensions, same won't matter a bean, as the running-board is cut to suit. Same applies to the clearance for the reversing lever in the left-hand piece, and the hole for the reach rod. If preferred, the sharp curve at the front end can be made separately, and attached to the horizontal piece above it, by a short bit of angle riveted or soldered underneath.

Valance

The edging, or valance, is made from angle and sheet. The ornamental bit at the front end is made from sheet, and soldered to the underside of the running-board; the straight part, and the easy curves, are made from ¼-in. by 1/16-in. angle brass, riveted to the underside of the running-board about 1/16-in. from the edge. If the angle is softened by making it red-hot and plunging it into water, a careful workman can coax it to the radius of the curve above the trailing coupled wheel; otherwise, use sheet metal cut to the correct outline. The front end of the running board is attached to the top of the buffer beam by small countersunk screws, the rest is supported by the cylinders, top of expansion link bracket, and small pieces of angle brass between the driving and trailing coupled wheels, and at the rear end. Rivet the angles to the running-board, and attach by screws to the frame, so that the whole issue can be removed bodily in case of need, by taking out the screws. The two ends of the valance should fit nicely against buffer and drag beams.

Engine Buffers

The buffers can be fitted at this stage, and the sockets either made from castings or solid rod. If castings are used, grip the casting in the three-jaw by the body; face the shoulder, turn the stem to ⅜-in. diameter, face to ½-in. length, and screw ⅜-in. by 26 or 32. Centre, and drill right through with No. 30 drill. Reverse, and re-chuck in a tapped bush held in three-jaw, as described for other fittings; turn the outside to dimensions shown, and open out the hole with a 7/16-in. drill to a depth of ⅝-in. bare. If turned from solid, chuck a piece of ⅞-in. round rod in the three-jaw; face, centre, drill No. 30 for a depth of 1¼-in.; turn down ½-in. of the end to ⅜-in. diameter, and screw as above. Part off at 1 3/16-in. from the end; re-chuck the other way round in a tapped bush, and proceed as described for the casting.

Buffer Heads

To make the heads, chuck a piece of ⅞-in. round mild steel in the three-jaw; such as a piece of steel shafting. Face the end, centre, drill No. 40 for about 3/16-in. depth, and tap ⅛-in. or 5 B.A. Turn down ½-in. length to a nice sliding fit in the socket, using a roundnose tool and finishing to the outline given. Part off a full ⅝-in. from the end, reverse in chuck, and finish off the flange as shown, with a radius at the edge that may be formed with a file as the lathe is running. Warning to beginners: you can use brass heads, and tin them over, to avoid using steel; but avoid aluminium, or they will be shapeless if the engine bumps into anything.

Buffer Spindles

The spindles are 1⅝-in. lengths of ⅛-in. round steel rod—mild or silver—with ¼-in. of thread at each end. They are screwed into the tapped holes in the heads. The springs are made from 20 gauge steel wire wound around a piece of ⅛-in. rod, as described for the axlebox springs, and the whole is assembled as shown in the sectional illustration. Drop a spot of thick oil inside the socket, before inserting the head, to keep the spring from rusting. The head is prevented from coming out, by an ordinary commercial nut on the end of the spindle behind the socket. Push the stems through the holes in the buffer beam, and secure by brass nuts, made from ½-in. hexagon brass rod. They are only a few minutes' work. Chuck in three-jaw, face, centre, drill down ½-in. or so with 11/32-in. drill, tap ⅜-in. by 26 or 32 to match the stems, part off two 3/16-in. slices, then chuck each one and chamfer the corners of the hexagons.

Cab

The best material for the cab is 20 gauge hard rolled sheet brass; but if not available, use whatever you have. Galvanised iron, or even stout sheet tin would do at a pinch, as the whole issue is painted. The cab front, or weatherboard, needs a piece 6¼-in. by 6¾-in.; the top is cut to a radius of 4⅞-in., leaving the sides also measuring 4⅞-in. in height. For the outline of the cab front, including the shape of the windows, and opening for the boiler, please refer back to the drawing showing the backhead and all the fittings in place. The easiest way to get the right shape for the opening which fits over the firebox wrapper, is to lay the backhead former on the cab front, and draw a line all around the former, but ⅛-in. away from it. The piece can be cut out with one of those exceedingly useful gadgets known as an "Abrafile," or else with a metal-piercing fretsaw; suitable blades for cutting metal, may be purchased at any tool-dealer's, and used in an ordinary fretsaw frame.

A suitable frame can also be easily bent up from ¼-in. steel rod. After cutting out the piece roughly to shape, try it over the firebox wrapper, and correct with a file until the cab front beds down on the running-boards, at the same time fitting close to the wrapper. A gap here looks bad. The shape of the windows can also be seen in the drawing referred to; they can also be Abrafiled out.

Window Frames

Make a couple of window frames by cutting similar openings in any available piece of sheet metal; cut all around outside the openings, leaving a frame ⅛-in. wide. Place a piece of mica or cellophane over each window; lay the frame on it, so that the openings coincide, and rivet the frame to the cab front, using bits of ordinary domestic pins for rivets. The pins we get are soft iron, and make very good rivets.

The sides of the cab call for two pieces of sheet metal measuring 5 5/16-in. by 4½-in., which are marked out to the dimensions shown on the illustration. The lower part of the cabside is 4-in. wide, up to a height of 3⅝-in.; thence it is curved to meet the top as shown. The window openings are cut out by the processes mentioned above, and trimmed up with a file; a beading of 3/32-in. half-round wire may be soldered on outside, all around each window. A similar beading may be soldered to the back edge of the cab side, extending right around the curved part, to the roof.

The window openings are "glazed" with mica or cellophane, but this is not a fixture; it slides in two runners, one above and one below the windows. The runners are formed by planing or milling a 1/32-in. rebate in a 3-in. length of 3/16-in. by 1/16-in. flat brass strip, and riveting or soldering them above and below the openings, as shown; a piece of mica or cellophane is then cut to slide between the runners, in the rebates, and long enough to cover both window openings. Should the "glazing" accidentally become damaged, it can easily be replaced by a fresh one.

Milling Rebates

The rebate is easily milled in the lathe, if you solder the thin strip of metal to a piece large enough to clamp under the slide-rest tool holder, and then traverse it across a small endmill in the three-jaw, so that the latter cuts the corner out. Any fragile piece of metal can be machined, by soldering it to a heavier "backing" piece; and it is the work of a couple of minutes only to re-heat, melt the solder and clean off any surplus sticking to the machined piece. The old-time turners and other machinists made free use of solder chucks and shellac chucks for holding fragile work; merely discs which screwed on to the lathe mandrel noses, the job being literally "stuck on." I still use the same wheeze for making box-type expansion links, and curved guides for Joy valve gear.

Runners can also be made from strip metal, and need no machining. Cut a strip of 20 gauge metal 3/16-in. wide and 3-in. long, and another ⅛-in. wide, of the same length. Rivet or solder them together, with one long side of each in line. Note, the runners are fixed inside the cab sheet.

Cab Sides

The top of the cab side is bent inwards, at the point indicated by the dotted line, to an angle matching the curve of the cab front. The sides are attached to the front, by a piece of angle brass in each corner, extending from top to bottom, to ensure adequate strength. The angle may either be riveted with 1/16-in. brass roundhead rivets, or soldered, as there is no heat or pressure to withstand; but riveting makes the best job. Hammer the rivet shanks into countersunk holes on the outside, and file off flush. Pieces of angle are also riveted along the bottom of each cab side, and these angles are screwed to the running-board when the cab is erected.

Cab Roof

To make the roof, a piece of 20 gauge sheet metal is needed, 7¾-in. long and 4⅝-in. wide. This is bent to the curve of the top of the cab front, and attached to the sides by screws and nuts. Part of the roof slides forward, for access to the regulator and other handles. Cut out a piece 4½-in. wide and 2¼-in. long, as shown in the plan sketch; and at each side of this rivet a runner similar to those above and below the cab windows, except that the groove should be 1/16-in. deep, and wide enough to allow a 20 gauge plate to slide in it. The sliding part is a piece of metal 4⅝-in. long and 2⅜-in. wide, so that it just overlaps the hole in the roof, and is bent to the same curvature. It should slide freely in the runners. When the engine is at work, the piece can be taken out, or pushed forward; in the latter case, make the runners the full length of the cab roof. Two rain strips are needed, which are made from the beading used for window and rear edging, bent to the curve shown in the general arrangement drawing, and soldered in place. Tip for beginners: if your soldering is rough, get an old flat file, grind off the end square, and grind off the teeth for ¼-in. or so, which will leave you with a square-ended scraper. Touch it up on the oilstone, and apply it to any blobs of solder, or any streaks you wish to remove; it will leave a smooth surface quite different to that left by a file.

Assembling the Cab

Anybody who owns, or has the use of, an oxy-acetylene blowpipe, can put a cab together easily by its aid. Use 20 gauge steel sheet, cut the sides and roof as specification given, but don't bother about any bent-over top to the cab sides, nor any angles. Just butt the parts together, apply a little Sifbronze flux paste, heat with the blowpipe, using a tip not greater than 150 litre, and run in a little Sifbronze, using their 1/16-in. rod. This is easier, even, than soft-soldering; no rivets are required, and the job is sound and permanent. This "fabricated" construction is now being used in full-sized engines. That completes the engine part all except a few oddments, such as handrails, etc. So now we will proceed to give the "Bantam Cock" a tail, otherwise a tender.

AFTER clinging to the ancient type of tender with flared coping and separate coal-rails, for years, the L.N.E.R. at last followed the lead of the Southern and the L.M.S., and adopted the straight-sided tender. Incidentally, the last of the "Big Four," the G.W.R., has also provided straight-sided tenders for their latest 4—6—0 locomotives, so now they all have them. "Bantam Cock's" tender is of this pattern; it is very simple to make, and an illustration showing the general arrangement is included herewith.

Materials and Method

There are three ways of making and erecting the chassis part. The frames may be castings, with hornchecks and dummy leaf springs cast integral; steel frames may be used, with cast horns and dummy leaf springs separately riveted on; or the whole lot may be built up as in real practice, with working leaf springs.

I don't know at the moment whether our advertisers will be supplying complete cast side frames especially made for this locomotive; but I *do* know they have cast frames in stock, originally made for "Maisie" (my 4—4—2 Great Northern engine) which are exactly the same length and depth, and can be used for "Bantam Cock." The differences are very slight; the middle wheels are a little nearer centre, the cut-away at the back wider, and the holes are arch-shaped instead of oval. As the tender of the 4—4—2 is typical L.N.E.R. pattern, the frame castings, if used, would not be "out of place." All that is needed in the way of machining is to clean out the jaws between the hornchecks, and drill the dummy leaf-spring hoops for working spiral springs. A file and emery-cloth would soon make any rough places in the casting look presentable.

Machining Hornblocks

Anybody owning a milling, planing or shaping machine, or having the use of one, would not have difficulty in cleaning out the jaws. They could also be done in the lathe, in two ways; one, by clamping the frames under the lathe tool holder, and feeding up to a cutter on a spindle between centres. The jaws should be at right angles to the bed, and the cutter could be either a regular milling cutter, or a home-made fly-cutter. This is merely a little boring tool made from 3/16-in. silver-steel, and stuck through a cross hole in the cutter bar; a setscrew at right angles would secure it. The cutting edge is turned either to right or left according to which side of the jaws is being milled. Careful manipulation of the slide-rest handles would enable the cutter to clean out both sides of the jaws; a piece of ⅝-in. steel bar should be used as a gauge, and should fit easily without being sloppy.

The second way would be to clamp the frames in a machine-vice attached to a vertical slide, with the frames at right angles to the lathe bed, and use an endmill in the three-jaw; but this would need a long endmill, to reach to the full depth of the jaws, viz. 1⅛-in. If no means of milling or otherwise machining out the jaws is available, they could be carefully hand-filed, as described for the hornblocks on the main frames of the engine.

Steel frames are made in exactly the same way as engine frames to the sizes shown in the accompanying drawing, so there is no need to go over all that ground again in detail. If cast horns and springs are available, they are simply riveted on, as in the engine's trailing cradle; and hornblocks could also be made from angle-brass, where nothing else is available. Brass 3/32-in. by ½-in. should be used; either cast or angle horns should be attached by 3/32-in. charcoal-iron rivets. Copper rivets are rather soft for frame work, and work loose.

Buffer and Drag Beams

The only difference between the engine and tender buffer beams, is the size and spacing of the frame slots, the slots for the tender frames being 4½-in. apart and 3/32-in. wide. The latter thickness of steel is quite suitable for the tender frames, as there are no driving stresses to withstand. The drag beam, which is at the leading end of the tender, is also made from 1-in. by ⅛-in. angle. Either brass or steel will do; cast beams may also be available, in which case they will have lugs on them, to which the frames may be screwed. The beams made from angle will need pieces of similar angle riveted on between the slots, as on the engine, if the frames are to be attached by screws; personally, I never bother about this method nowadays.

The frames are simply jammed in the slots in the beams, the assembly lined up true and square, and a few minutes' operation with my "Alda" blowpipe plus a stick of No. 1 Sifbronze, fixes it for good and all time. A 4-in. length of 3/8-in. by 5/32-in. angle brass is riveted on each frame, on the inside, midway between the beams, to form a rest and means of attachment for the soleplate.

Axleboxes and Springs

The tender axleboxes and springs are fitted up exactly as for the trailing wheels of the engine, so again we need not repeat in detail. The only difference is, that no side play is required; so there is only a small running clearance between the wheel bosses and the backs of the axleboxes. The latter are made either from a stick cast to the correct section, or a piece of bar not smaller than 7/8-in. x ¾-in. section; the machining of this has already been described for the engine boxes. The holes for the axles are drilled with ¼-in. drill, 5/16-in. from the bottom, to a depth of 5/8-in., as shown in the back view and section; a small diagonal oil hole is drilled from the top of the box, to the journal hole, with a 1/16-in. drill, and countersunk at the top, to make it easier for the oil can spout.

For an illustration of how to drill the hoop of a dummy cast spring, and fit a real working spiral spring to it, please refer back to the illustration showing a part section of the spring for the trailing axle of the engine. The hornstays are pieces of 1/16-in. x 1/8-in. strip, secured by two 9 B.A. screws in each. Alternatively, in the cast frame, the bottoms of the hornchecks are flat, and the hornstay may be placed against them if preferred, thus giving the axleboxes a little more up-and-down movement. If hornstays made from angle are used, the jaws made be prolonged a little if desired, and the flat-strip hornstay replaced by a bolt made from 5/32-in. silver steel, nutted at both ends.

Wheels and Axles

The six wheels are 2¾-in. diameter on tread, with 1/8-in. by 1/16-in. flanges, the centre holes being reamed 5/16-in.; and they are machined up exactly as described for the engine wheels. The axles are turned from 3/8-in. round mild steel; the only difference between them and the trailing axle on the engine, is that the tender axles have slightly shorter journals. Each end can be turned at one setting, with the piece of steel held in the three-jaw; there is then not the slightest doubt about wheel seat and journal being absolutely concentric. The wheels can be pressed on right away, the bearings being outside.

The assembly of the wheels and axles is easy. The coil springs are wound up from 18 gauge tinned steel wire, as fully explained previously, pieces of suitable length being snipped off, touched on a fast-running emery wheel to square the ends, and then dropped into the holes in the hoops of the dummy leaf springs, the chassis being upside-down on the bench for assembly purposes. The springs should just be taking the compression when the axleboxes are at the ends of the horncheck jaws. Put an axlebox on each journal; drop each pair of wheels, complete with axleboxes, into place—mind you don't get the axleboxes in wrong way up!—and put on the hornstays. Without any body on the chassis, the axleboxes will be right up against the hornstays when the assembly is standing right way up on its wheels; the axleboxes should be in correct running position when the body is completed, and the tank half-full of water. The spring lengths can be adjusted for this result, if necessary, later on, when the bodywork is all finished.

Soleplate

No separate drawing is needed for the tender soleplate, which forms the bottom of the water tank. It is made from a piece of 16 gauge sheet brass or copper, 15⅞-in. long and 7⅛-in. wide. This is placed on top of the frame assembly, and attached to the top of the buffer and drag beam angles, and the two pieces of angle at the sides of the frame, by 6 B.A. roundhead brass screws, four at each end, and three in each side angle. The exact position of the screws does not matter, so long as they hold the soleplate firmly in contact with the frame assembly, and keep it quite flat. Drill all the holes with No. 34 drill, through soleplate and angles, with the latter temporarily clamped in position, and secure with nuts underneath. The heads of the screws which come inside the tank, have to be soldered over; and this method enables the soleplate, with body and fittings complete, to be easily detached from the frames, should necessity arise, such as damage by collision or derailment. The valance, or edging to the soleplate, which extends from the drag beam to the back buffer beam, is a 15½-in. length of ¼-in. x 1/16-in. angle brass, riveted to the underside of the soleplate by 1/16-in. brass rivets. It should be level with the ends of the beams, and 1/16-in. from the edge of the soleplate.

Tender Body

THE best material for the tender body is 20 gauge hard-rolled sheet brass, which is easy to work, does not kink or dent, and has a surface ideal for painting. If not available, copper can be used, or galvanised or leaded iron of same gauge. It is not advisable to use ordinary sheet iron or steel unless a separate copper or brass water tank is fitted inside it.

Not so long ago, I saw a tender, made by a well-known commercial firm, which was made of a material grandiosely described in their catalogue as "tinned steel plate" (biscuit and cocoa tins are made of the same stuff!) and the bottom of it was full of pinholes caused by rust. This material would also call for a copper lining.

Bending

If you can get a piece of material measuring 36¾-in. long by 4¾-in. wide, the sides and back can be bent up all in the one piece, the outline of sides and back being marked out on it, the top edge cut to the shape shown, and a small-radius bend made 15-in. from each end, as the corners of the full-sized tender are similar.

The bends are easily and neatly made as follows. Take the removable steel jaws out of your bench vice, and replace them by two pieces of bar steel, say about 1-in. by ½-in. section, long enough to project about 5-in. from one side of the jaws. The pieces need not be screwed to the recesses unless you wish. Place the piece of metal between the extension bars, just clear of the vice body, with the marked lines level with the bars; tighten vice, then go ahead and bend.

If you cannot get the metal down to a right angle with a small radius at the bend, by hand pressure alone, use a lead or hide-faced hammer, so as not to deface the smooth surface; alternatively, hold a piece of wood on the metal, and biff that with an ordinary hammer. If a piece of metal of the length given is not available, use two pieces, each 18⅜-in. long, each piece forming one side and half the back. The joint is made in the middle of the back, by bringing the edges together, riveting a ½-in. butt strip inside, and soldering the joint to make it watertight. When smoothed off with a file on the outside, and painted over, the joint will be invisible.

Front Plate

For the front plate, a piece of metal approximately 7¼-in. by 4-in. will be needed. Bend ¼-in. of this, at each end, to a right angle, to form a flange for riveting to the tender side sheets. Note: the plate should be tried between the sides of the tender, *close to the back*; then if any error has been made in the width of the tender when bending up the metal for the body, it won't matter, as the sides will still be parallel for their full length. At 1-in. from the bottom, cut a rectangular opening 2-in. wide and 1½-in. high for the coal gate. A runner is riveted at each side of this; it is made by milling a rebate about 1/16-in. deep in the edge of a 3-in. length of ¼-in. by 3/32-in. brass strip, the process being exactly as described for milling axleboxes and other details. This, when cut into two, forms the runners; and bits of domestic pins make fine rivets for such jobs.

Alternatively, to make the runners without milling, cut two strips of metal 1/16-in. in thickness, one ¼-in. wide and one 5/32-in. wide, for each runner; rivet them at each side of the gate, with the narrower one next the front plate, and the outside edges flush, as shown in the detail sketch.

The slide is a piece of 18 or 20 gauge metal, cut to fit easily between the runners, and about 1/16-in. higher than the gate; round off the top corners, and fit a little brass or steel knob to lift it, as shown. The front plate, complete with coal gate, is then placed between the tender sides, flanges inward, and ¾-in. from front edges of tender sides; rivet in position with 1/16-in. brass or copper rivets, heads inside, shanks hammered down into countersunk holes on the outside of tender body, and filed off flush.

At ⅛-in. below the top back edge of the body, rivet a 7-in. length of 1/16-in. by ¼-in. brass angle at each side, and join them by another similar piece across the back; these are to carry the removable tank cover. Rivet similar angles along the bottom, both sides and both ends.

How to Erect the Body

Stand the tender body on the soleplate, with the front edges ⅜-in. from the end of the soleplate, and the sides of tender body and soleplate parallel; tack with solder at two or three places each side. At about 2-in. intervals, all around the body, both sides and both ends, drill No. 51 holes right through angles and soleplate, and put in 1/16-in. roundhead brass or copper rivets, heads inside the tank, and shanks hammered into countersunk holes in the underside of the soleplate. If you don't want to take the soleplate off the frames again, you need not! Instead of drilling No. 51, drill No. 55, and tap the holes 1/16-in. or 10 B.A., using brass screws instead of rivets.

How do you drill and tap so close to the side? Easy enough; put a piece of 3/16-in. brass rod about 5-in. long in your three-jaw, centre and drill it about ½-in. deep with the 55 drill, then solder the shank of the drill into the hole. If you put the rod in the chuck of your handbrace, the chuck will be quite clear of the tender sides whilst drilling. Make an extension for the tap shank, with a bit of copper tube about 5-in. long; this should just fit over the squared end of the tap shank. Hammer it square, so that it will turn the tap, then put your tapwrench on the other end; and go right ahead. After riveting or screwing the body to the soleplate, solder the whole way around, to render the tank watertight.

Coal Space

The bottom of the coal space may now be fitted. For this, a piece of metal approximately 9⅜-in. long is needed, of a width to fit nicely between the tender sides. This is bent to the shape shown in the section of the tender, 1½-in. from the front being horizontal, and 1½-in. from the back, vertical; the intervening part goes up at an angle. A little lip, ¼-in. wide, projects through the coal gate; on a full-sized tender, this is the fireman's shovelling plate.

Nicks are also needed at each front corner, to clear the flanges of the front plate. As there is no heat nor pressure to withstand, and the amount of coal carried is only a few ounces, it is usually sufficient if the plate is placed in position and soldered to the tender sides and front; don't forget to solder under the lip at the bottom of the gate.

If an extra strong job is required, pieces of angle brass can be riveted to the tender sides, under the sloping part, before the plate is finally fixed. They can be located quite easily by first putting the plate in position, and scribing lines on the inner side of the body, close to the plate; remove same, and rivet your angles to the sides, at a distance below the lines, equal to the thickness of the metal. Replace the plate, put a few screws in each angle, through the plate, as described for fixing body to soleplate, then solder up, to make it all watertight. A piece of angle is then soldered at the back of the vertical portion, in line with the two pieces on the tender sides, to form the fourth side support of the detachable tank cover.

Internal Fittings

The hand pump, and the fittings for the eccentric pump and injector feeds, are now installed. The position of the hand pump—already made for testing the boiler by water pressure—is easily found; place the handle vertically, and set the pump on the soleplate, centrally between the sides, with the handle 2-in. from the back of the tender. Drill four No. 30 holes through the soleplate, using those in the pump stand as guides, and secure with four ⅛-in. or 5 B.A. brass screws, nutted underneath. A smear of plumber's jointing under the nuts will prevent leakage.

An inch or so ahead of the pump, drill a ¼-in. hole; and in this, fit a double-ended union. Chuck a bit of 5/16-in. hexagon brass rod in the three-jaw and form a union end to it, like that on top of the pump; then reverse in chuck, and "ditto repeato" on the other end, leaving the screwed part a little longer, say ½-in. Poke this through the hole in the soleplate, and secure by a locknut. Connect it with the union on top of the pump, by a swan-neck of ⅛-in. tube, thin-walled for preference, with a union nut and cone on each end.

Feed and By-Pass Fittings

The feed and by-pass fittings are shown

near the front end, in the drawing, for the sake of clearness, but their exact position does not matter a bean. It would be more convenient to bring them farther back, where you can get at them easier when screwing up the locknuts.

Each one is merely a ½-in. length of $^5/_{16}$-in. brass rod, round or hexagon, drilled right through with No. 30 drill, and turned down and screwed ¼-in. by 40, for a full ¼-in. length. The plain ends of both of them are opened out to ⅛-in. depth with No. 23 drill; and pieces of copper tube, $^5/_{32}$-in. diameter and long enough to reach within 1-in. of the drag beam, are silver-soldered into the lower ends.

A piece of ⅛-in. thin-walled tube, long enough to reach to the underside of the filler hole, is silversoldered into the upper end of the by-pass fitting, which is then put through a ¼-in. hole in the soleplate, and nutted on the upper side, as shown in the sectional illustration.

The feed fitting is put through a similar hole alongside the by-pass, and secured by a nut having a finger of fine copper gauze soldered over it, so that all water going down the fitting, has to pass through the gauze strainer (known as a "strum" among enginemen) and any foreign matter which gets into the tank, cannot get down to the pump and put it out of action by obstructing the valves.

Injector Water Valve

The injector water valve is simply a plain screw-down valve, made similar to the boiler fittings, and put through holes in the soleplate and the tank plate above it. The locknut at the bottom of the coal space may have a jointing washer of Hallite or similar material to keep it watertight, or it may be soldered over. The extended spindle is furnished with a cross handle at the top. A small piece of $^5/_{32}$-in. tube is silversoldered into the bottom of the valve; and when the engine and tender are coupled up, all three pipes (pump feed, by-pass, and injector feed) are connected to the pipes on the engine by small slip-on hoses made from rubber tube.

To avoid getting wrong connections, I use different coloured rubber hoses whereever possible; for example, red for the pump feed, white for the by-pass, and black (as used for the old-fashioned suction-operated automobile screen wipers) for the injector feed, as this is fairly stiff and does not collapse under the suction of the injector, which is more intense than the pump.

Slip-on hoses are O.K. when there is no pressure; but as the delivery from the emergency hand pump has to withstand boiler pressure, something more substantial, but equally flexible, is needed. I find that a length of ⅛-in. thin-walled pipe, coiled as shown, fills the bill nicely. The union at the front end is ¼-in. by 26, instead of the usual 40 pitch; this is because it is used every time the engine is coupled to, or disconnected from the tender. The coarser thread is quick-acting, and resists wear. A finer thread is more suitable for unions which are normally coupled, and only occasionally disconnected, as in the pipe fittings on engine and boiler.

Removable Cover and Filler

No separate drawing is needed for the removable tank top, as it is merely a sheet of metal, same kind of material as used for the rest of the tender, measuring approximately 7-in. by 6⅝-in. Fit it to the open space over the emergency hand pump, so that it just goes in easily, and lies on the angles previously fixed around sides and back of the tender.

Starting at ⅞-in. from the back end, cut an opening 2½-in. long and 1-in. wide, with rounded corners, on the longitudinal centre line; when the hand pump lever is vertical, it should be exactly under the middle of this opening, as shown in the longitudinal section. Now bend a strip of ¼-in. wide brass or copper to the shape of the hole, and solder it in, forming a little "wall" all around the hole; on top of this, put a rectangular lid, same shape as the hole, but overlapping about $^1/_{16}$-in. all around. When cutting it out, leave two small tags about ⅛-in. wide at one end, and about ¼-in. apart; bend these into loops with a small pair of roundnose pliers. Cut a strip of metal to fit between the tags, bend one end of that into a loop, same diameter as those on the tags, and put a small piece of wire through the lot, thus forming a nobby hinge. Bend the strip at right angles just below the loop, and solder or rivet it to the tank top, as shown in the longitudinal section.

To render the lid easy to open and shut, make a wire handle in the shape of a flat-topped arch, and fix it at the other end of the lid. Drill two holes the size of the wire, poke the two ends through about $^1/_{32}$-in., and either rivet them over, or solder them on the underside of the lid.

The completed cover is attached to the angles by 8 B.A. or $^3/_{32}$-in. screws, spaced at about 1½-in. intervals. Drill the clearing holes in the plate with either No. 43 or 41 drill (to suit screws used) about ⅛-in. from the edges; then place plate in position, use the holes to locate the tapping holes in the angles, which can then be drilled and tapped, and the brass screws put in right away. No jointing gasket is required.

Tender Beading

A beading of $^3/_{32}$-in. half-round wire (any metal available) is soldered all around the front edges and top of the tender body. To hold this in place whilst soldering, I use three or four home-made cramps, like small toolmaker's cramps, made in a few minutes from pieces of ¼-in. square brass rod and ⅛-in. screws. Steel cramps rust rapidly when used for holding work to be soldered. The wire, if of hard brass, nickel bronze, or copper, should be softened where it is required to make a bend. Solder along the top, using a liquid flux (not paste), and scrape off any solder running out below the wire, with a scraper made from a worn flat file ground square at the end, and the teeth ground off.

Accessories or "Trimmings"

Little more remains to finish. The tender buffers can be made same as those on the engine; to get clearance for the spindles, in a built-up frame, simply put the drill through the holes in the buffer beam, and let it cut a clearance through the angles. The drawhooks are a simple filing job, needing no detailing; they are made from ⅛-in. flat steel, to the shape and dimensions given in the illustration. After inserting the shank through the square hole in the buffer beam, put a small spring, or a couple of thick rubber washers, between the beam and the retaining washer and nut; this will prevent starting the load with too much of a sudden jerk.

Couplings

Screw-couplings are simple enough to make, and give a nice finish to the engine.

The shackles are made from $\frac{3}{32}$-in. steel wire, bent to shape as shown; the eyes are formed by filing away half the diameter of the wire, and bending the other half into a loop with roundnose pliers. Silver-solder the joints; if the eye gets stopped up in the process, just put a No. 40 drill through. Note—before bending the eyes of the shackle that carries the plain swivel, pass the end through the hole in the drawhook, otherwise you can't get it erected, as the eye won't go through the hole. The swivels are turned from $\frac{3}{16}$-in. brass rod, shouldered down to $\frac{3}{32}$-in. each end, to fit the eyes. One is drilled No. 48, and the other drilled same size, but tapped $\frac{3}{32}$-in. The screw is turned from $\frac{3}{16}$-in. steel rod; one end is turned to fit the plain hole in the shorter shackle, and the other screwed to fit the tapped hole in the longer one. A piece of $\frac{1}{16}$-in. rod, with a ball at the end, is screwed into the enlarged part of the screw, for turning same and tightening the coupling. The complete assembly is shown in the illustration.

If dummy vacuum-brake pipes are required, these can be made by using either $\frac{1}{8}$-in. tube or wire for the pipes, and small rubber tube, or cycle-valve tube, for the hose connections. The stand-pipes are clipped to the buffer beams, close to the couplings, by small clips made from sheet brass, bent to shape, soldered to the stand-pipes, and attached to the buffer beams by 9 B.A. screws.

Handrails are made from 15 gauge wire, nickel-bronze or rustless steel for preference, the knobs being turned from $\frac{3}{16}$-in. round rod. Steps for both engine and tender can be made from 16 gauge sheet steel, with a small flange at the back, bent up at right angles and riveted or screwed to the frames. The size and position of the steps are shown on the general arrangement drawings.

Other Trimmings

Where an engine is intended to do real hard work, such as live passenger hauling, I do not recommend the fitting of too much detail, and have therefore kept the job as simple as possible. Things such as lamps and lamp irons, are prone to get knocked off. If anybody wishes to add all the external "trimmings," the best thing to do is to obtain a good clear photograph of the full-sized engine from any publishers of locomotive literature (e.g., the Locomotive Publishing Co., 88, Horseferry Road, Westminster, London, S.W.1), and copy the required accessories from that.

Should working brakes be desired on the tender, the full brake gear described for "Princess Marina," and shown on the blueprints obtainable from *Mechanics* Publishing Department, can be used on the "Bantam Cock"; but if fitted, do not attempt to use it as a service brake, otherwise you will soon have the tender wheels resembling polysided nuts. Any engine-driver will tell you that the engine pulls the train, but it is the train brakes that stop the engine; when passenger-hauling on a small railway, fit a good hefty brake to the car on which the driver sits, and make that your service brake.

The coupling between engine and tender is a plain link with a hole in each end passing through the slots in the drag beams, and secured by ordinary commercial split pins dropped through holes drilled in the tops of the drag beams. Little bits of angle are riveted to the beams below the slots, to support the bottom ends of the pins. The reproduced illustration shows the whole assembly, and is self-explanatory.

Painting

The big engines are painted light green, lined black and white. The small one need not be lined; plain green looks quite well, with a black smokebox and chimney, black underframe, and green wheels. Top of tender is black, inside of cab grey or stone colour; buffer beams and buffer sockets red. Inside of frames may also be red if desired.

It is essential to remove all grease before painting, and a good wash down in petrol —*do this outdoors*!—will do the needful in that respect. Some folk use an undercoat, but I never do; if one thin coat of the desired colour dries semi-transparent and shows bare metal, a second thin coat is applied, but the first must be perfectly dry.

The boiler requires special treatment, on account of the heat. After much experimenting, I find the method below very effective. The paint — which should be either a good heat-resisting enamel as used for domestic radiators, baths, and so on, or alternatively a good brand of synthetic hard gloss paint—is carefully and evenly applied to the boiler, which is previously cleaned, dried, and filled almost full of cold water. A soft brush is essential; I use artist's sable or camel hair brushes. A small Bunsen gas burner is then put in the firebox, and the water slowly heated to about 200 degrees, just below boiling, and kept at that for a period of about 12 hours, which need not be continuous, though it is better if it is. Then let the boiler slowly cool off, and it will be found that the paint has set hard and glossy. Oil spots which fall on it when the engine runs, can be wiped off whilst hot, and only improve the gloss. Whilst the job is in progress, the engine should be protected by a "tunnel" of brown paper or any other handy material, to prevent dust settling on it.

How to Drive the "Bantam Cock"

Don't forget that the engine-driver's most helpful companion is his oil feeder; so the first job is to oil every moving joint with a good grade of machine oil.

I use the Vacuum Oil Coy.'s "Extra Heavy Medium." Then fill the cylinder lubricator with a heavy superheater oil; Vacuum "600 W.," or "Cyltal," are about the best. Some folk think that because a $3\frac{1}{2}$-in. gauge locomotive is only one-sixteenth of the size of her sister on 4-ft. $8\frac{1}{2}$-in. gauge, she needs thin oil such as used for sewing machines, typewriters, or even clocks; a sad mistake! The little engine needs the same kind of coal as the big one, and the same kind of oil; the temperature of the steam is the same, despite the difference in the size of the boilers, and the little engine actually needs much more oil, in proportion to size, than her full-sized relative, on account of the cylinders being bronze instead of cast iron. Give the lubricator wheel a few turns by hand, to ensure that the oil pipes are filled, and oil will start feeding as soon as the wheels begin to turn.

Water should show about two-thirds up the gauge glass. As there is no natural draught in these small engines, some means of inducing a draught through the firebox will be needed, to get the fire started; and the easiest way of doing this is to rig up an extension chimney with a piece of tube about 8-in. long, to fit in the top of the engine's chimney. A piece of $\frac{1}{8}$-in. tube, with the end of it contracted to about $\frac{1}{32}$-in. and bent to a right angle, is inserted through a hole about 1-in. from one end of the extension pipe, and silver-soldered so that the jet will blow up the middle of same.

The other end of the pipe is soldered into a tin can, which is connected to a motor tyre pump, the tin can acting as an air receiver and keeping a constant flow of air blowing from the jet.

Wet some small knobs of charcoal with paraffin, and spread them over the fire-bars; throw in a lighted match, and start pumping. The air blowing up the extension chimney will cause the fire to burn briskly; add more dry charcoal until you have a good bed of fire, then some coal can be added. Either Welsh steam coal, or anthracite can be used; break up to pea size and sift out all the dust. Steam will appear in three to four minutes; then remove the auxiliary chimney, and open the engine's own blower valve. Keep adding coal at intervals until you have about an inch of fire on the bars—it will burn away fairly quickly at first—and as soon as the steam gauge shows about 60lb., put the reverse gear in full forward position and open up the regulator.

If the wheels appear to lock, shut the regulator and move the engine by hand a turn or two, which will expel the trapped condensate water, due to steam entering cold cylinders. Let the engine run without load until dry steam comes out of the chimney in sharp, snappy puffs; then you can take your seat on the passenger car and reap the reward of your labour.

The engine is a very powerful type, and will not take the least notice of your weight, treating you like a bag of feathers, providing she has been built to the instructions and the workmanship is reasonably good. On a continuous track, as soon as she gets into a good swing, bring back the reversing gear as near to middle as you possibly can, without upsetting the even beating of the exhaust; set the regulator to the speed you require, and the locomotive will "keep on keeping on," as the enginemen would say, as long as there is any water left in the tender and any fire on the bars.

Keep the water well up the glass, by regulating the bypass valve, or use the injector if you so desire; to work it, turn on the water, and when it dribbles from the overflow, turn on the steam valve fully. There will be a "sneeze" from the injector, and the overflow should immediately dry up, all the water going into the boiler. If a dribble persists, close the water valve slowly until the dribble ceases, and note the position of the water valve for future operation, so you can always set it instantly to right position.

Firing

Study well the fireman's side of the job, as well as the driver's. Fire little and often, as needed. The correct time to add more coal, is exactly contrary to what a raw recruit would imagine. You don't wait until the fire burns low before firing up; the correct time to fire, is when the last lot put in has become completely incandescent, and the safety valve is just lifting. Sprinkle enough coal over the top of the clear fire, to make it black; pressure will not fall, because the body of fire in the box maintains it. Keep on firing as above, unless the fire begins to get too thick; it should not be allowed to become thicker than an inch or so. In that case, instead of adding more coal when the boiler begins to blow off, open the firehole door a little, and allow the fire to burn down a bit before firing fresh coal to it, meantime keeping the water well up the gauge glass. A little practice will soon make a perfect fireman.

The rate of firing will, of course, vary with the load. With eight to a dozen passengers on several flat cars, the engine will eat up the fuel almost as soon as you put it in the firebox, and the pump will be feeding full blast all the time. The engine will do the work willingly; but to do it, she needs a requisite amount of "food and drink." The engine will also use more fuel and water on an up-and-down track, as the continual succession of starts and stops, and the resulting heavy blast, takes more steam than a non-stop run.

When the run is finished, drop the remnants of the fire by pulling out the dumping pin, and clean the ashpan out; also take a look in the smokebox, and if there is an accumulation of cinders, clean those out too, taking care to wipe the contact surfaces of smokebox door and ring perfectly clean before screwing up the door fastening again. Wipe all the oil splashes, etc., off the paintwork and motion whilst the engine is still hot; never put her away in a dirty condition. Look after the "Bantam Cock" well, and she will repay you by years of faithful and trouble-free service.

THE END

Bantam Cock items available solely from
A.J. REEVES & CO.LTD.

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