The lever is attached to the eye at the bottom of the regulator rod, by the headed pin, the arrangement being shown in the drawing of the side view of the complete outfit erected.

How to Erect Regulator

Cut two brackets from 1/16 in. x 1/4 in. brass strip, as shown in the illustrations; solder a thickening piece at the boiler end of each, to afford a good hold for the screw threads. The other ends are bent at right angles. In the boiler barrel, a full 1/2 in. behind the front edge of the dome bush flange, and 5/32 in. away from it, drill two No. 34 holes, and countersink them, to take the 6 B.A. screws. Hold each bracket temporarily in place, as shown in the plan drawing, and mark off the location of the screw hole, through the hole in the boiler barrel. Remove bracket, drill the marked place with No. 44 drill, and tap 6 B.A. Also drill a No. 41 hole in the vertical part of each bracket; then replace them, and secure by countersunk-head brass screws. I might mention here, that some of the brass screws on the market at the present time are made of very inferior metal, which corrodes very quickly. For that reason, I always make my own screws for use in boiler work, from drawn phosphor-bronze, and should advise all locomotive builders to do the same. Safety first!

The regulator is set between the brackets as shown, with the top of the stand projecting 3/8 in. above the flange of the dome bush. Run a No. 41 drill through the holes in the upper part of the brackets, making countersinks on the stand; drill these No. 48, and tap 3/32 in. or 7 B.A. Fix with cheesehead screws, putting a smear of plumber's jointing on the threads, to prevent any steam getting through into the column.

The regulator spindle is a 2 5/8 in. length of 5/32 in. round bronze rod with the ends turned, screwed, and squared as shown. Note that the square on the inner end should be a very good fit in the square hole in the end of the inner regulator lever. A collar is made from 1/4 in. brass rod; this acts as a stop, to prevent the rod from coming out of the gland. Chuck the rod in three-jaw, face, centre, and drill about 3/16 in. deep with No. 23 drill; part off a slice a full 5/32 in. long. Put this on the spindle in the position shown. To make the stuffing box, chuck a piece of 1/2 in. brass rod in the three-jaw; face, centre, and drill No. 21 for 5/8 in. depth. Turn down 3/8 in. of the outside to 3/8 in. diameter, and screw 3/8 in. x 26; part off to leave 1/8 in. flange. Reverse and rechuck in a tapped bush held in three-jaw; open out with 7/32 in. drill to 3/8 in. depth, and tap 1/4 in. x 40. The gland is made from 5/16 in. hexagon rod, same as any other spindle gland, and needs no detailing.

Put the regulator spindle through the bush, as shown in the erection drawing, entering the spigot into the hole in the bracket, and the squared part into the squared hole in the little lever. This job can be sighted down the dome hole; and the lever can be lined up by aid of a bit of bent wire. Put in the stuffing-box, and screw it home. There should be just the weeniest bit of end play, not more than 1/64 in. but the spindle must on no account be tight. If it *is* tight, or there is too much end play, take out the spindle, adjust the collar, and have another shot. When O.K. remove the spindle and pin the collar in place; then put the stuffing-box in, with a taste of plumber's jointing on the threads. Pack it with a few strands of graphited yarn, put the gland in, and fit the outer lever. This is made in similar fashion to the inner one, but is of steel, and is secured by a nut on the screwed end of the spindle. The valve should operate easily when the outer lever is moved by hand. No stops are required on the regulator itself, as these will be fitted on the handle inside the cab.

Superheater

THE multiple-element superheater follows full-size practice, having two elements per flue, which gives greater superheating surface, and is far more efficient than larger elements in small flues. Also there is less risk of "birds' nests" forming against the return bends, and choking the flues. The first job is to fit the steam pipe, which is a 7 1/4 in. length of 5/16 in. x 20 gauge copper tube, screwed 5/16 in. x 32 at each end. Put a smear of plumber's jointing on the threads at one end, insert the pipe through the hole in the smokebox tubeplate, and screw it into the regulator boss by aid of a round file jammed in the end. This will release easily by turning it backwards, when the tube is right home.

The steam flange may be made either from a casting, or from 3/4 in. round or hexagon rod. If the latter, chuck in three-jaw, face the end, centre, and drill down to 7/8 in. depth with 1/4 in. drill. Open out 3/8 in. of the end with 9/32 in. or letter J drill, and tap 5/16 in. x 32. Turn down 1/4 in. length to 7/16 in. diameter and screw 7/16 in. x 32. Turn down the next 1/4 in. to 5/8 in. diameter, and part off at 1/4 in. from the shoulder. Reverse in chuck, and face the end truly. Anoint the threads with plumber's jointing, and screw the fitting on to the projecting end of the steam pipe; the outer threads will engage with those in the tapped hole in the tubeplate, and when the flange is screwed home, the lot will be locked solid.

Headers and Elements

The wet header is a 2 1/2 in. length of 3/8 in. copper tube, with the ends plugged by discs of 16-gauge copper. It is attached to a flange made from 3/4 in. round bronze rod, or from a casting. If the former, chuck the rod in three-jaw, centre, drill down with 1/4 in. drill for a bare 5/16 in. depth, and face off truly. Part off at 3/8 in. from the end. Drill another 1/4 in. hole from the side, to meet the one already drilled, and file a shallow groove across this, to take the tube header. Drill four No. 41 holes for the fixing screws, as indicated in the drawing. Drill a 1/4 in. hole in the centre of the header tube, and also drill the six holes for the elements, at the angle and position shown in the drawing, using No. 14 drill. In the front, near one end, drill a No. 23 hole for the pipe leading to the snifting-valve.

The hot header is another piece of 3/8 in. x 20-gauge copper tube, 2 3/4 ins. long, with the ends plugged as before. Six holes are drilled in a line, with No. 14 drill, as indicated by the dotted lines in the drawing, so that they come opposite the flues. Between these, and at right angles to them, 1/2 in. each side of centre, drill two 15/64 in. holes, and open them out with a taper reamer, so that the two steam pipes leading to the cylinders, will fit very tightly. These are 5 in. lengths of 1/4 in. copper tube, bent to the shape of swan-necks, and furnished with 3/8 in. x 32 union nuts and cones on the outer ends. A 6 1/2 in. length of 5/32 in. copper tube for the snifting-valve, is fitted into the hole in the wet header when assembling the parts.

For the elements, six pieces of 3/16 in. x 22-gauge copper tube, 10 ins. long, and six approximately 7/16 in. shorter, will be required. The return bends will need six little blocks of copper, of 3/8 in. x 5/8 in. section, and 3/4 in. long. On one end of each of these, make two centre-pops 5/16 in. apart, and drill these in, using No. 14 drill, at an angle as shown, so that the holes meet. Then file the blocks to the given shape. Fit one longer and one shorter element into each block, and braze the joints. Note, these joints must *not* be silver-soldered, but properly brazed, using brass wire, spelter, or Sifbronze; this only entails heating them up to bright red instead of dull red. The intense heat in the firebox, when the engine is working hard, would destroy a silver-soldered joint. Pickle the jobs, and clean up, removing all burnt flux.

The elements are then assembled as shown in the illustration. The flange above the wet header can be tied in position with a bit of thin iron binding-wire. If the tubes are a tight fit in the holes, as they should be, they will "stay put" during the silver-soldering operation. Cover all the joints with wet flux; for best grade silver-solder, use either Boron compo, or powdered borax, mixed to a paste with water, and for Easyflo, use the special flux sold for use with it. Heat the whole lot to a medium red, and apply the silver-solder or Easyflo to all the joints. When the molten metal has run around every one, let the assembly cool to black, then quench out in acid pickle, leaving it in for about 15 minutes. Take it out, drain out the acid, and well wash in running water, letting the water run through the headers and elements, to make sure all the scale and residue from the brazing and silver-soldering operations has been removed. If any grit or scale should get down into the cylinders, it will do the valves and pistons what the kiddies would call "a bit of no good."

The elements can then be inserted into the flues, and the flanges connected up with four 3/32 in. or 7 B.A. long screws, as shown in the drawings. Put a 1/64 in. Hallite or similar jointing gasket between the faces, and don't forget to punch a hole in the middle, to let the steam pass! Mistakes are easily made, and this particular item has been forgotten, on more than one occasion, by more than one of my correspondents, not being detected until the boiler had been erected and all the joints made. The whole lot had to be taken down again, to rectify matters, to the accompaniment of a copious flow of railroad Esperanto. Experience still teaches!

Cab Fittings

THE arrangement of the cab fittings on this locomotive, are in the nature of a compromise. As the various parts have to be made larger in proportion to the full-size article, to enable them to work efficiently, it is obviously impossible to set them out on the boiler backhead, in the same way as big sister's; so I have arranged for the regulator, screw reverser, and driver's brake valve to get as near full-size practice as possible, set the blower valve low down on the backhead, close to the regulator handle, and arrange the rest of the blobs and gadgets to give a symmetrical layout, which I hope will meet with the approval of those good folk who are building the engine. They are easy enough to make and fit.

The regulator handle is mounted on a bracket attached to the left side of the backhead, and carries a short drop arm which is connected to the operating lever on the boiler barrel, by an outside rod with a fork at each end. A simplified bevel-drive reversing gear actuates a shaft, similar to the propeller-shaft of a motor car, with universal joints at each end, connected to the reversing screw on the left-hand motion bracket. In full-size, the driver's brake valve is mounted on a kind of pedestal, which also carries the blower-valve. On the small engine, the pedestal itself forms the brake-valve, and the blower-valve is separately mounted on the backhead above it. The whistle-valve is mounted at the end of the turret carrying the union for the steam-pipe leading to the blower-valve; this is situated in the usual position on top of the wrapper inside the cab. As there is no regulator handle in the middle of the backhead, this position is ideal for the steam gauge; and a screw-down valve is fitted at either side of it. One regulates the steam supply to the injector, and the other is an isolating valve for the driver's brake-valve. If this is kept closed when the brake is not in use (the brakes on the passenger car should always be used as the service brake) it prevents accumulation of condensate water in the driver's valve, pipes and brake cylinder. The water gauge is large and reliable, but not big enough to be unsightly. Room on the backhead being limited, the clack which takes the feed from the hand-pump is arranged at the side of the wrapper.

There isn't enough room for a sliding firehole door, so the usual pattern of swing door is specified. No blowdown valve nor washout plug is provided at the back end of the firebox, but an "Everlasting" quick-acting blowdown valve will be fitted at the front end of the firebox, as in full-size practice. There is plenty of room for this, between the pump eccentric and the horn-block casting; and a short pipe with a bend in it, allows steam and water to be blown down between the sleepers, clear of the "works." The valve is operated from outside the frame. The position of all the components, is shown in the general view of the cab; and each item is shown separately in the detail drawings, so no trouble should be experienced in making them. As some of the fittings are the same type as I have fully detailed in these notes when describing other locomotives, there is no point in going through the full rigmarole again, so I will run through the construction briefly, as a sort of "refresh-your-memory" interlude, and only go into full detail when the fittings differ from those previously described.

Regulator Handle

Both the main part of the handle, and the short drop arm, are filed or milled up from 5/16 in. x 3/32 in. steel strip; or an odd bit of 3/32 in. frame steel, as used for smaller engines, would do. The dimensions are shown in the drawing. The hole in the top of both arm and handle, should be drilled 3/16 in. To make the sleeve, chuck a piece of 5/16 in. round mild steel in the three-jaw, and turn about 1/2 in. of it to 9/32 in. diameter. Further reduce 3/32 in. length to a tight fit in the hole in end of handle. Part off at 7/16 in. from the end. Reverse in chuck, and turn the other end to a tight fit in the drop arm, for 3/32 in.

length. Centre, drill through with No. 34 drill, and ream ⅛ in. Press handle and drop arm on the ends, setting the latter at about 30 deg. in advance of the handle, as shown in the side view; braze or silver-solder the joints, quench in water (not acid pickle for steel) and clean up. Turn a little grip from ⅛ in. round steel as shown, with a 1/16 in. pip on the end; push this pip through a No. 51 hole drilled in the narrow end of the handle, and slightly countersunk; rivet over, and file flush.

The bracket can be filed up from a piece of 1 in. x ⅛ in. steel angle; a simple kiddy-practice job. The four screwholes are drilled No. 41, and the hole for the spindle drilled No. 48 and tapped 3/32 in. or 7 B.A. The spindle itself can either be turned from a piece of ¼ in. hexagon steel rod held in the three-jaw, another simple turning job, or made from a piece of ⅛ in. round silver-steel, screwed at both ends, the outer end being furnished with an ordinary commercial nut. When the handle assembly is mounted on the spindle, it should move freely when the spindle is screwed right home against the shoulder.

The bracket is mounted on the back-head close to the top (see general arrangement drawing) and 1 1/16 in. from the centre line, so that the drop arm is just clear of the side of the wrapper. Fix it with four 3/32 in. or 7 B.A. screws, round or hexagon head as desired. Make up two little forks to the dimensions shown, by the same process that I have repeatedly described for valve-gear forks. Put the regulator lever on the side of the barrel, in such a position that the regulator valve is closed. This should be when the lever is inclined forward about 30 deg. Set the regulator handle vertical: the drop arm should then be inclined forward, parallel with its "mate" on the side of the boiler. Measure from the centre of the hole in one, to the centre of hole in the other, which gives the exact length of the completed rod between centres of pinholes in the forks. Mount the forks on the end of a piece of 3/32 in. silver-steel, cut to the indicated length, and pin the forks to the drop arm, and short lever, with little bolts made from 3/32 in. silver-steel, nutted at both ends. For neatness sake, the ends could be reduced to 1/16 in. and screwed 10 B.A., and commercial nuts of that size used. The bolts should still be free to turn, when the nuts are tight up against the shoulders. A 1/16 in. stop pin can be fitted in the bracket, as shown, to prevent the handle being accidentally pushed past the "off" position.

Turret and Whistle Valve

THE body is made from a 1 in. length of 5/16 in. round rod, bronze or gunmetal for preference, though brass will do if nothing better is available. This, by the way, applies to all the fittings made from rod material. Centre, and put a No. 34 drill right through. Open out and bottom one end to 3/16 in. diameter, and tap 7/32 in. x 40. Open out the other end likewise, to 7/16 in. depth, and tap same pitch, but don't use the D-bit. Ream the remains of the No. 34 hole with a ⅛ in. parallel reamer. Drill three 3/16 in. holes for nipples as shown; two are drilled at right angles into the D-bitted end, and the other into the longer recess. Note that these holes must be drilled so that when ¼ in. x 40 union nipples are fitted into them, they will occupy the positions shown in the illustration. The nipples are made from ¼ in. round rod, the spigots squeezed into the holes in the body of the fitting; the shouldered stem is turned from ⅜ in. round rod, to the dimensions shown. The spigot of this is also squeezed in, and the three joints can then be silver-soldered. Pickle, wash and clean up.

A 5/32 in. rustless ball is seated on the hole in the D-bitted end, and a cap made to fit, from 5/16 in. or ⅜ in. hexagon rod. This is drilled up with a No. 30 drill, as shown, to accommodate a light spring wound up from thin bronze or hard brass wire, about 28 gauge. A similar cap is made for the other end, but is drilled right through with No. 48 drill; and a slot, a full 1/16 in. wide and 3/16 in. deep, is milled or filed across it. A handle like a weeny reversing lever, is then made from 3/16 in. round rod; nickel-bronze (German silver) is about the best stuff for this. Turn the grip part, in the three-jaw, and file the rest flat; total length should be about 1 in. The push-pin is just a bit of 15 gauge hard bronze wire—rustless steel can be used, but be sure it IS rustless!—rounded off at the ends, and should be long enough to project a full 1/32 in. into the slot, when the other end is resting against the ball. Drill a hole, about No. 56, across the slot at the end of the cap, and a corresponding hole in the end of the handle; assemble as shown, so that when the handle is depressed, it pushes the pin and lets steam past, to the union nipple. The handle should fit close to the bottom of the slot; if too far away, it will swing right around when released, and the pin will blow out.

The stem of the fitting is screwed into a tapped hole in the top of the wrapper, so that the cap with the lever in it, overhangs the backhead. The hole should be made as close to the edge as possible, so that the thread is tapped in the thickness of the backhead flange.

Injector and Brake Shut-off Valves

This is an improvement on the screw-down valves previously described, as it gives a quicker opening, and provides a larger steam passage for the same size of valve; also it doesn't need a D-bit to form the seating. To make the body, part off a ½ in. length of ⅜ in. round rod; chuck in three-jaw, centre, drill through with 7/32 in. drill, and tap ¼ in. x 40. Drill a 3/16 in. hole in the side, in the middle of the length, and silver-solder a ¼ in. x 40 union nipple in it.

To make the valve seating, chuck a piece of 5/16 in. or ⅜ in. hexagon rod in the three-jaw. Face, centre, and drill down about ⅝ in. depth with 3/32 in. or No. 42 drill. Turn down the outside for 5/32 in. length, to ¼ in. diameter, and screw ¼ in. x 40; part off at ⅜ in. from the shoulder. Reverse in chuck, turn down ¼ in. of the other end to ¼ in. diameter, and screw ¼ in. x 40. Open out the centre hole with No. 23 drill for ⅛ in. depth; and in this, silver-solder a piece of 5/32 in. tube about 2¾ ins. long. Screw the short end into the valve body with a smear of plumber's jointing on the threads. For the gland end, chuck the rod again, face, centre, and drill down about ⅝ in. depth with No. 30 drill. Turn down 5/32 in. of the end, to ¼ in. diameter, and screw ¼ in. x 40. Part off at ⅜ in. from the shoulder. Reverse in chuck, turn down ¼ in. of the other end to ¼ in. diameter, and screw ¼ in. x 40. Open out about ⅛ in. of the centre hole with No. 21 drill, and tap the rest $\frac{5}{32}$ in. x 32. Screw the shorter end, into the other end of the valve body.

The valve pin is a piece of $\frac{5}{32}$ in. rustless steel or phosphor-bronze a full $1\frac{1}{8}$ in. long. Turn a blunt cone point on one end, the angle being about 90 deg.: this can be done by slewing the top slide around, or by running the lathe at high speed, and sweeping a fine file across the end, the file being canted at the approximate angle. Next, with a die in the tailstock holder, cut about $\frac{9}{16}$ in. length of $\frac{5}{32}$ in. x 32 thread on the pin; turn away $\frac{1}{8}$ in. of this, next to the cone point, as shown in the section of the fitting. File a square on the other end, about $\frac{3}{32}$ in. across, and fit a little hand wheel, turned up from $\frac{3}{8}$ in. rod. Dural makes very nice hand wheels. A punch for the square hole can be made from a bit of $\frac{3}{32}$ in. square silver-steel, ground off dead square at the end, hardened, and tempered to dark yellow; or a square can be filed on the end of a bit of round silver-steel of larger diameter, and hardened and tempered same way. To use, drill a $\frac{3}{32}$ in. hole in the hand wheel, before parting off the turned rod, while still in the chuck. After parting off, rest the wheel on a bit of flat rod with a $\frac{1}{8}$ in. hole in it, and drive the square punch through the round hole. I have detailed this process again, especially for several beginners who have asked how to produce square holes without filing out round ones. Some say they can file any shape except square!!

Put the wheel on the squared part of the spindle, and slightly burr over the end, to prevent it coming off. All that remains, is to make the gland nut. Chuck the hexagon rod again, face, centre, drill down about $\frac{5}{16}$ in. depth with No. 21 drill, open out to $\frac{3}{16}$ in. full depth with No. 3 or $\frac{7}{32}$ in. drill and tap $\frac{1}{4}$ in. x 40. Chamfer the corners of the hexagon, part off at $\frac{1}{4}$ in. from the end, reverse in chuck, and chamfer the other corners. Assemble as shown in illustration. Drill two $\frac{7}{32}$ in. holes close to top of backhead, at $\frac{11}{16}$ in. each side of centre; tap $\frac{1}{4}$ in. x 40, and screw in the fittings. The bits of pipe should be slightly bent, so that when the fittings are screwed right home, the ends of the pipes are as close to the top of the wrapper as possible. The unions should hang down at the angle shown. The glands are packed with a few strands of graphited yarn.

Steam Pressure Gauge

THE process of making and calibrating a little steam gauge isn't worth the trouble involved, when reasonably accurate and reliable ones are readily obtainable commercially. A gauge $\frac{3}{4}$ in. diameter, reading to 120 lb. will be needed for this boiler. It is attached to the backhead by a flange and syphon pipe. For the flange, chuck a piece of $\frac{1}{2}$ in. round rod in the three-jaw, face the end, centre, and drill No. 50 for $\frac{5}{16}$ in. depth. Turn down $\frac{3}{16}$ in. length to $\frac{1}{8}$ in. diameter; part off at $\frac{3}{16}$ in. full from the shoulder, reverse in chuck, and skim up the face truly, slightly chamfering the edge. Drill a No. 32 hole in the thickness, breaking into the centre hole, and drill three No. 48 screwholes as shown.

Bend a piece of $\frac{1}{8}$ in. copper pipe, to form a U-shape with one leg about $1\frac{1}{8}$ in. long, and the other about $\frac{5}{8}$ in. or to suit the union on the gauge. The longer end is silver-soldered into the hole in the side of the flange; the shorter is furnished with a cone or flat collar, to suit the gauge union, the nut being placed on the pipe before the cone or collar is fitted and silver-soldered. Some purchased gauges are supplied with a tail pipe, which could be silver-soldered into the syphon pipe, but it makes an unsightly joint. It is far neater to open the hole in the union nut, to take the syphon pipe direct, and fit as above. Drill a No. 30 hole in the backhead, close to the top, on the centre line, and fit the spigot of the flange in it, attaching the flange to the backhead by three 9 B.A. brass screws, roundhead for preference. Put a jointing washer of $\frac{1}{64}$ in. Hallite or similar material, between the flange and the backhead.

Blower Valve

The body of the blower valve is made from a piece of $\frac{3}{8}$ in. rod. Chuck in three-jaw, face the end, turn down $\frac{3}{16}$ in. length to $\frac{1}{4}$ in. diameter, and screw $\frac{1}{4}$ in. x 40; Part off at $\frac{7}{8}$ in. from the shoulder. Reverse in chuck, centre the other end, and drill $\frac{3}{32}$ in. for $\frac{3}{4}$ in. depth. Open out to $\frac{5}{16}$ in. depth, bottoming the hole with $\frac{7}{32}$ in. drill and D-bit, and tap $\frac{1}{4}$ in. x 40. Drill two $\frac{3}{16}$ in. holes in the side, at right angles, to take the union nipples as shown in the drawing; the one nearest to the spigot, breaks into the $\frac{3}{32}$ in. hole, and the other breaks into the tapped hole, but be careful to avoid damaging the D-bitted seating. Fit $\frac{1}{4}$ in. x 40 union nipples in each, and silver-solder them. The gland fitting, nut, pin and hand-wheel are made and fitted exactly as given above, for the injector steam valve.

At 2 in. from the top of the backhead, and $1\frac{1}{4}$ in. to the left of the centre line, drill a $\frac{7}{32}$ in. hole, tap it $\frac{1}{4}$ in. by 40, and screw in the blind spigot of the blower valve. The nipple nearest backhead should be vertical when the valve is screwed right home, and the other one should be horizontal, and pointing right. The vertical one is connected to the left-hand union on the turret, by a $\frac{1}{8}$ in. copper pipe with union nuts and cones at each end: the horizontal one is connected to the nipple under the hollow stay, by a similar pipe and union nuts. The whole doings is shown in the view of the cab arrangement.

Firehole Door

The firehole door, and the baffle plate, are both cut from 16-gauge steel: or a casting may be used if available. If so, the hinges will be cast on; if not, make them from $\frac{1}{8}$ in. strip, using 18 or 20 gauge metal. The handle is made from the same material, and bits of domestic pins do very well for riveting. The spacer between the door and the baffle, is just a $\frac{7}{16}$ in. length of $\frac{1}{4}$ in. round mild steel, turned down for $\frac{1}{8}$ in. length at each end, to $\frac{5}{32}$ in. diameter. It is pushed through holes in the middle of the door and baffle, drilled to suit, and riveted over as shown.

The lug for attaching the door to the backhead, is cut from 18 or 20 gauge metal, as shown in the drawing, and the projection bent into a socket, to take a $\frac{1}{16}$ in. hinge-pin. It is attached to the backhead by three $\frac{3}{32}$ in. or 7 B.A. screws. Here is a tip: several readers have complained that the usual commercial brass screws rot and break off. Personally I never use them in boiler work, but make all my own, from drawn phosphor bronze. It is only the work of minutes to chuck a bit of rod the size of the screwhead needed, in the three-jaw, turn it to the length and diameter of the screw, and thread it with a die in the tailstock holder; part off far enough behind the shoulder, to form the head, and slot it with a hacksaw. If hexagon heads are preferred, simply use hexagon rod; it is commercially available in all sizes, even as small as 1/8 in. across flats. I've never found a bronze screw rot and break yet.

The spring catch is made from a bit of thin springy bronze, of the kind used for the brush springs of dynamos and motors. It should be just stiff enough to keep the door closed when running, yet allowing the door to be knocked open with the shovel, when firing on the run. Drill three No. 40 air holes in the door, as indicated.

Hand Pump Feed Clack

The clack or checkvalve through which the water from the emergency hand pump is delivered to the boiler, is one of my "standard" fittings which has been described many times, so no detailing is needed. All the dimensions are given in the drawing. The body is made from 3/8 in. round rod, which may be turned down to 11/32 in. for neatness sake if desired; the ball chamber is 3/8 in. deep, closed by a 1/4 in. x 40 screwed plug turned from 5/16 in. hexagon rod. The screwed fitting at the side, for attachment to the boiler, is made from 3/8 in. rod, and silver-soldered into a 3/16 in. hole drilled in the side of the valve body.

On the right-hand side of the wrapper, and as close to the backhead as possible, drill a 7/32 in. hole, about 1 3/4 in. from the top of wrapper, and tap it 1/4 in. x 40. Screw the clack into this, with a smear of plumber's jointing on the threads.

Water Gauge

THE water gauge differs but little from my "standard" pattern, the variation being that the top and bottom sections are of different lengths, to allow for the slope of the backhead; and the blowdown valve is of an improved quick-acting type, which, incidentally, will form my new "standard." On the older pattern, made in one piece, trouble was sometimes experienced with valve leakage, in districts where the water was "dirty," as the enginemen call it when hard and scaly. Bits of scale became jammed between the pin and the recess in which it worked. The type shown, allows of a bigger recess, and a bigger outlet, without increasing the size of the fitting.

The upper part of the gauge is made in precisely the same manner as a check valve, except that there is no ball seating, the fitting being drilled clearing size for the gauge glass; in this case use a No. 10 drill. Tap the end 7/32 in. x 40, and make a screwed plug to fit, as shown, from 5/16 in. round rod. The top can be filed square, for the sake of variety.

For the bottom fitting, chuck a piece of 3/8 in. round rod, face the end, centre, and drill to 1 3/16 in. depth with No. 30 drill. Turn down 1/4 in. of the end to 1/4 in. diameter, and screw 1/4 in. x 40. Part off at 1 1/16 in. from the shoulder. Reverse in chuck, centre, drill into the opposing No. 30 hole with No. 43 drill, open out and bottom to 5/16 in. depth with 7/32 in. drill and D-bit, and tap 1/4 in. x 40. At 7/16 in. from the shoulder drill a 3/16 in. hole breaking into the No. 30 hole; and 3/8 in. from that, diametrically opposite, drill a similar hole breaking into the tapped recess. Mind the seating! In the former hole, fit a screwed nipple to carry the bottom of the gauge glass. To make it, chuck a piece of 5/16 in. round rod in the three-jaw; face, centre, drill No. 30 for about 3/8 in. depth, open out to 1/8 in. depth with No. 10, screw 1/4 in. of the outside with a 5/16 in. x 32 die in the tailstock holder, and part off at a bare 5/16 in. from the end. Reverse in chuck, holding lightly by the threads, and turn a bare 1/8 in. to a tight fit in the hole in the side of the gauge body. In the other hole, fit a 7/32 in. x 40 union nipple for the blowdown pipe, and silver-solder both nipples at one heating. Pickle, wash off, and clean up. Tip—I always clean and polish my bits as I go along, using a fine wire circular scratch-brush on a home-made spindle which fits in a taper hole which I drilled and reamed in the end of the spindle of my Stanley grinder. As this spins at nearly 3,000 r.p.m. it only takes a few seconds to make small fittings "bobby-dazzle," as the L.B. & S.C.R. cleaner boys used to say.

For the valve-pin carrier, chuck a piece of 5/16 in. hexagon rod, face the end, centre, and drill down to about 7/16 in. depth with No. 30 drill. Turn down 5/32 in. of the end, to 1/4 in. diameter, and screw 1/4 in. x 40. Part off at 1/4 in. from the shoulder, and chuck the other way around in a tapped bush held in three-jaw. Run a 5/32 in. x 32 tap right through, bevel off the outside as shown, for appearance sake, and take a skim off the end, to remove any burring. The valve pin is made in the same way as described for injector valve, but is only 7/8 in. long; and instead of a wheel (which may, of course, be fitted by those who prefer it) a No. 43 cross hole is drilled in the end of the pin, and a short piece of 3/32 in. steel fitted in with the ends rounded off.

The drawing shows how the gauge is erected. At 1 3/8 in. to the right of the centre-line of the backhead, and as close to the top as possible, drill a 7/32 in. hole and tap it 1/4 in. x 40. Directly underneath it, at 1 3/4 in. below, drill and tap another; but watch your step on this operation. At this point, the backhead slopes outward, but the gauge fittings must be parallel; so be careful to hold your drill brace horizontally if drilling by hand. I always do mine on the drilling-machine, with the boiler upended, and the barrel set vertically; and I start the tap by putting it in the drill chuck, and pulling the belt of the machine by hand. The threads should not on any account be slack.

The gauge is erected with a wedge-shaped washer between the shoulder of the fitting, and the sloping backhead, as shown in the sectional illustration; a smear of plumber's jointing on the threads will ensure freedom from leakage, as long as the threads are O.K. The upper fitting is screwed in, in the ordinary way, using the No. 10 drill to line them up. If the drill, put in shank first, with the end resting in the recess in the lower fitting, can be freely twisted with finger and thumb you can pass the erection job as satisfactory, and there won't be any broken glasses caused by the gland nuts binding against them.

The glass is cut to such a length that when in place, resting in the recess, it is just below the upper passageway, as shown in the section. The packing rings are rubber rings cut from 3/16 in. rubber tube. The best way that I know of making these rings is to chuck a piece of 3/16 in. round rod in the three-jaw, and put a short length of the rubber tube on it. Run the lathe at a high speed, and apply a wet discarded safety razor blade to the rubber at about 3/32 in. intervals. When you push the tube off the rod, it just falls into evenly-cut rings. Wet the glass, put it down the top fitting, put on a ring, then the two nuts back to back, then another ring; push the glass down into the recess, slide the nuts into position (they will take the rings with them), tighten up, and Bob's your uncle. Warning—the nuts should be only a little more than finger-tight. The glass must have freedom to expand; and you'd be surprised to know how little gland pressure is needed to prevent leakage. This day, nearly half-a-century after it happened, I bear a scar on my forehead caused by a bad cut from a burst gauge glass, the glands of which had been screwed up too tightly by a careless fitter. It wasn't our regular engine it is hardly necessary to add! Drivers and firemen, in those days, did all their own small jobs on the engine's weekly "shed day," when we washed out the boiler and gave the old girl the "once-over." It was exceedingly "infra-dig" to seek aid from the shed fitters, for anything we could do ourselves. WHAT a different tale it is to-day—no wonder maintenance costs have gone up!

As these little engines have to be driven from the back of the tender, an extension handle, to operate the gauge blowdown valve, is a useful accessory; and one is shown here. It is simply a length of 1/4 in. round mild steel, any length you fancy, one end of which is furnished with a cross-handle, like that on the valve pin, but a little longer, to give more leverage. The other end is drilled down for 1/4 in. or so, with No. 20 drill (an easy fit is needed) and a slot filed across the hole, as shown, to engage the valve pin. If this is carried on the back of the tender, and used as needed, it may save a few new words being added to the dictionary of railroad Esperanto!

"Everlasting" Blowdown Valve

This is the type of blowdown valve used on the British Railways standard locomotives, and on many other types of locomotives in use all over the world. For particulars and drawings of it, I am indebted to Mr. F. S. Lovick-Johnson, the Managing Director of the Patent Everlasting Valve Company. As far as working principles are concerned, the weeny edition is an exact copy of the full-sized article; and the construction is also similar, the principal variation being that I have arranged a boss on the inlet side of the valve casing, which can be screwed direct into the boiler throatplate. The action is simple, like most efficient gadgets; the less complication you introduce, the better. The valve is made in two halves, the inlet half being recessed to accommodate the valve itself, and the actuating arm. The other half forms the portface over which the valve slides, and provides a bearing for the operating lever. When the valve is in the open position, the inlet and outlet holes are in line, forming a straight-through exit for the contents of the boiler, and any foreign matter that might be in the water. When the valve is in the shut position, it covers the outlet hole, and the higher the boiler pressure, the tighter the valve is held to its seating, so that leakage is non est. Opening and closing is instantaneous, merely by moving the lever through a 60 degree angle. It will thus be seen that the "Everlasting" valve is far superior to any valve of the screw-down type, especially one which incorporates a long screwed spindle in the foundation ring itself, and an opening in the ring, both of which would choke with scale after one run and would be utterly useless.

Valve Body

CASTINGS are available for both halves of the valve body; they can also be made from slices of 7/8 in. bronze or gunmetal rod, if desired. The machining is practically the same in either case. Tackle the inlet side first, by chucking the casting, recessed side outwards, in the three-jaw, facing up the contact edge, and boring out the recess to given size. This can be done with a straight-nosed tool set crosswise in the slide-rest toolholder. Make a pop mark in the middle of the cast boss; or if rod metal is used, at the place where the centre of the boss should be. Chuck in four-jaw with this pop mark running truly (easy enough if you bring up the tailstock centre as a guide), open the pop mark with a centre-drill, and put a No. 30 drill right through into the recess. Face the end, so that the overall width of the casting is 7/16 in. then turn down 5/32 in. length to 1/4 in. diameter and screw 1/4 in. x 40.

Chuck the other side in the three-jaw likewise, and clean up the portface with a roundnose tool set crosswise in the rest. Reverse in chuck, and face the back (says Pat) to bring the thickness to 9/32 in. On this boss, mark out the positions of the post bearing, and the outlet hole (see back view in the detail drawing). Chuck in four-jaw with the upper mark, for the bearing, running truly. Open out with a centre-drill, put a No. 34 right through, and follow with a 1/8 in. parallel reamer. Set the other mark to run truly, open with centre-drill, put a No. 30 drill right through, open out for 5/32 in. depth with 5/32 in. drill, and tap 3/16 in. x 40. Remove from chuck, and, pin-drill the bearing hole to a depth of 1/16 in. with a 3/16 in. pin-drill having a 1/8 in. pilot pin. Centrepop the six lugs, and drill them with No. 48 drill. These holes must go through truly, so the job had better be done either on a drilling-machine, or in the lathe, with the drill in the three-jaw and the casting held against a drilling pad on the tailstock.

To get the two halves properly in alignment, clamp them together, bosses outwards, with a piece of 1/8 in. round rod poked through the inlet and outlet holes; the lugs should then coincide as well. Run the No. 48 drill through the holes in the lugs already drilled, and make countersinks on the lugs on the undrilled half; take the halves apart, open the countersinks with a No. 53 drill, going right through the lugs, and tap 9 B.A.

Post and Lever

The post, or spindle, is turned from a piece of 3/16 in. bronze or rustless steel rod, chucked in three-jaw. Face the end, and turn down 15/32 in. length to 1/8 in. diameter, an exact fit in the bearing hole. Further reduce 1/8 in. of the end, to a shade under 3/32 in. diameter, and screw 8 B.A.; the 3/32 in. section in between, is filed to a 3/32 in. square by the method I have described several times, using the chuck jaws both to guide the file, and set the angles. Part off at 3/16 in. from the shoulder. Reverse in chuck, turn down 1/8 in. of the end to 5/32 in. diameter, then file a 7/64 in. square on the end. Face off a shade, to leave this projecting 7/64 in. from the collar, which should be 1/16 in. wide. Both squared parts should be in line, the facets being parallel.

The lever is a simple filing or milling job, made from 1/4 in. x. 3/32 in. steel or nickel bronze. The drawing shows the outline. The smaller end is drilled No. 48, and the larger end has a 3/32 in. square hole in it, which can be made as described for the square holes in the valve wheels, the same punch being used. Note—the square must be offset to 15 degrees as shown in the drawing; if it isn't, the lever won't move to an equal angle either way, when operating the valve.

Valve and Arm

The easiest way to make the valve arm is to form the square hole and the recess, in a piece of $\frac{1}{8}$ in. brass sheet a little larger than the finished arm, and then file the sausage-shaped outline around the holes, which sounds like Pat's way of making a barrel by building it around a bunghole. Mark the position of hole and recess; the square hole can be formed with a punch, or filed from a $\frac{3}{32}$ in. drilled hole by aid of a watchmaker's square file, using the squared part of the post as guide. The recess can be started with a $\frac{5}{32}$ in. drill, and bottomed with a D-bit; be sure that you don't break right through. When the hole and recess are O.K. go ahead and file to outline shown.

The valve is turned from a piece of $\frac{7}{32}$ in. round bronze rod. Face the end, and make a weeny recess in it about $\frac{1}{64}$ in. deep, with a $\frac{1}{8}$ in. D-bit. At $\frac{1}{32}$ in. from the face (watchmaker's job this !) run a parting tool in. to $\frac{1}{32}$ in. depth; then part off at $\frac{1}{32}$ in. from the shoulder, and *don't* follow my bad example and let it drop through a crack in the floorboards, as I did with the first valve I made ! The spring washer, which holds the valve to the face when there is no pressure in the boiler, is a commercial article, used in radio work and small electric fittings, costing a few pence per dozen.

Assembly and Erection

True up the portface and the weeny valve, by the same methods that I have described for slide valves and cylinder portfaces, by rubbing lightly on a piece of fine emery-cloth or similar abrasive, laid on a perfectly true surface. Punch a $\frac{1}{8}$ in. hole in a piece of $\frac{1}{32}$ in. Hallite or similar jointing material, and cut around it to form a washer a full $\frac{3}{16}$ in. diameter. Put this in the pin-drilled recess in the portface, at the entrance of the bearing hole. Push the post through, so that the $\frac{3}{16}$ in. collar on it bears against the washer; then put the lever on, securing with an 8 B.A. commercial nut. The spindle should work freely without slackness. Put the spring washer in the recess in the valve arm, and put the reduced part of the valve in also; mind you don't spill the lot, then put the square hole in the valve arm, over the squared end of the post. Smear a little plumber's jointing on the projecting edge around the recess in the other half of the body, but take care to avoid getting any inside. The two halves can then be placed together, and secured by six 9 B.A. screws.

To erect the valve, drill a $\frac{7}{32}$ in. hole about $\frac{1}{4}$ in. above the foundation ring, at approximately $\frac{5}{8}$ in. from the centre-line of the throatplate. Screw the boss of the valve into this, with some plumber's jointing on the threads, arranging it so that when the valve is right home, the lever is at the top, as shown in the detail drawing. A piece of $\frac{3}{16}$ in. copper pipe, bent as shown, is screwed into the outlet opening, to discharge the contents of the boiler clear of the motion work. In full-size, the blow-down valve is operated from ground level, by a rod attached to the lever, passing to the outside of the frame; we shall follow suit when the boiler is erected, using a similar type of handle, made from steel wire.

Grate and Ashpan

THE grate and ashpan on the little class 4 are arranged in a different manner to any of those hitherto described in these serial stories, for a locomotive having the trailing axle under the firebox. I usually arrange the grate and ashpan as separate items, on a narrow-firebox engine, the ends of the firebar bearers being located in nicks in the lower edges of the firebox side sheets, and supported by the top edges of the ashpan. The latter goes over the trailing axle, slots being cut in the sides to clear same. This allows of easy dumping, but there is a chance of grit getting through the slots into the axle boxes, and most folk find it convenient to turn the engine upside down to replace the grate and ashpan. Personally, I have found, on my own locomotives, that a drop of thick cylinder oil is quite effective in keeping ash and grit from the journals; and as I usually turn the engine upside down, to take a look at the " works," and wipe off the dirt picked up while running, plus the superfluous oil which all locomotives, big and little, take an unholy delight in flinging all over the frames and boiler-bottom, it isn't any extra trouble to replace the grate and ashpan at the same time.

On an engine where the firebox goes down between two axles, usually the driving and trailing, and the bottom of the firebox is unobstructed, it is a simple matter to support the grate on four legs, same being attached to the ashpan; so that when replacing them, the ashpan can be easily pushed up in place from underneath, and the securing pin put through, which automatically locates the grate. I have this arrangement on some of my own engines, and it is very convenient; so I schemed out a plan to adapt it to the little 75000, despite the presence of the trailing axle; and the drawings show how the wheeze can be worked. Complete protection is also afforded to the trailing axle-boxes, which will dispel some of our readers' doubts and fears of ashes getting into the journal boxes.

Instead of the ashpan being bent up from a single sheet, it is made in three pieces; two specially-shaped sides, and a bottom plate which is bent to the contour of the sides, and brazed in. The back is left open, as usual, and there is an extra aperture for admitting air underneath. The front end is closed, to keep ash and grit away from the eccentrics. The firebars are attached to the top of the ashpan, the bearers going right through the ashpan sides; this allows of a cast set of bars being used if desired. Incidentally I recommend a cast grate, as the bars last much longer than those cut from steel strip. The ashpan is made of such a width, that it will just enter the bottom of the firebox; and by virtue of its shape, it can be entered almost vertically, then tilted over, so that the back end of the grate rests on the bracket provided. A stop at the front, locates the position at that end; and when the pin is inserted, the whole bag of tricks is securely held.

How to make the Ashpan

The best material to use for the ashpan, is 18-gauge sheet steel, but brass may be used if desired. Two pieces 5⅝ in, long, and 1⅞ in. wide will be needed. Mark one off; and drill the two holes for the ends of the firebar bearers: use it as a jig to drill the second plate, and temporarily rivet together through the holes. The two plates can then be cut out together like a pair of frame plates. A strip of the same kind of metal, a full 1$^{11}/_{16}$ in. wide, is then bent to the same shape as the lower edge of the plates, and continued up to the top of the front edges, as shown in the perspective sketch. At the bottom of the step, cut an opening 1⅜ in. long and ½ in. wide, to serve as an extra air inlet, as the front end of the ashpan is closed, to keep ash and the grit from the eccentric and pump. Clamp one of the side plates at each side of the shaped bottom, and if steel, braze the joint at either side. If brass, use silversolder. A piece of ½ in. x $^1/_{16}$ in. brass angle, or a piece of 16-gauge or 18-gauge sheet steel, bent to a similar angle in the bench vice, is riveted to the front of the ashpan at the position shown.

Grate

The grate may be a casting, or built up from strip steel. If a casting, all it will need, will be a clean-up with a file, to remove any roughness. The holes at the upper edge of the ashpan, should be drilled No. 30 and countersunk; put the grate in position at the top of the ashpan, as shown in the drawings, temporarily clamp it there, and run the drill through the holes, making countersinks on the outer bars. Remove, open the countersinks with No. 40 drill, tap ⅛ in. or 5 BA, and replace the grate with a thin washer between the side of the pan, and the grate, opposite each hole. Secure with four countersunk-head screws: these must fit flush, or the ashpan won't enter the bottom of the firebox. If they project, either deepen the countersunk holes, or file the screwheads flush with the ashpan sides.

For a built-up grate, seven firebars are needed, each a bare 5½ in. long, cut from $^5/_{16}$ in. x ⅛ in. black mild steel strip. Hold one against the side of the ashpan, level with the top, and mark off the position of the holes with a scriber, or else clamp the bar to the ashpan, and drill the holes through it, using No. 30 drill. The holes in the ashpan will then locate the bearer holes in the bar, and the latter can be used as a jig to drill the rest of the bars. Countersink the holes in the ashpan, and file any burrs off. To make the spacers, chuck a piece of ¼ in. round rod in the three-jaw, face, centre, and drill down for about ¾ in. depth with No. 30 drill. Part off ⅛ in. slices until you reach the end of the hole, then ditto-repeato operations until you have a dozen spacers. The bearers are made from ⅛ in. soft steel rod, each being a little under 2 ins. long. Poke one through the hole in the ashpan, put on a thin washer, then a bar, then a spacer, then another bar, until all seven bars are threaded on, with a spacer between each. A thin washer is put between the last bar and the ashpan side, and then both ends of the bearer can be riveted over into the countersink, and filed flush. Repeat operations for the other end of the set of bars. The grate and ashpan then forms a single unit.

Erecting the Boiler

BEFORE the grate and ashpan assembly can be fitted to the boiler, the latter must be erected on the frames, and this is a fairly simple job. First fit the bracket which will carry the back end of the grate. This is just a bit of angle bent up from a bit of 16-gauge steel, 1½ in. long and ¾ in. wide. Bend it $^1/_{16}$ in. off centre line, so that one side is $^7/_{16}$ in. wide, and the other $^5/_{16}$ in. This is riveted to the projecting lower edge of the firebox doorplate, by three $^3/_{32}$ in. rivets, as shown in the detail drawing. The longer edge goes underneath.

Smear some plumbers' jointing around the projecting part of the smokebox tubeplate flange, and press on the smokebox. Take care to have the chimney up straight. If the fit is reasonably tight, no further fixing will be needed; the smokebox cannot move, being held by screws through the saddle flanges, and the rear end of the boiler is free to slide, but cannot lift. If the fit is too easy, a few $^3/_{32}$ in. or 7 B.A. countersunk screws put through clearing holes in the smokebox shell, into tapped holes in the flange of the tubeplate, will do the needful in preventing the smokebox and boiler parting company.

The boiler can then be dropped into position between the frames, with the blastpipe going through the hole in the bottom of the smokebox shell. This locates the correct position automatically; and if the saddle is placed between the frames first, the height of same, and the level of the boiler, can all be set at what the kiddies would call "one go." The foundation ring should rest on the front edge of the trailing hornblocks, which settles the correct height of the back end of the boiler; then it is a simple matter to adjust the saddle up or down, until the bottom of the boiler, is parallel to the top of the frames. With a bent scriber, mark little circles on the lugs, or bits of angle, attached to the ends of the saddle, through the holes drilled in the frame for the fixing screws.

To make the expansion brackets, cut two pieces of ¼ in. x $^1/_{16}$ in. angle, each 1 in. long; drill three No. 41 holes in them, for screws as shown in the detail illustration. Set the piece of angle midway between the driving and trailing wheels; the side with the holes in, resting against the boiler, and the undrilled side resting on the frames. Holding it so that it cannot shift, run the No. 41 drill through the holes, and make countersinks on the boiler; then lift out the boiler and saddle. Drill the countersinks on the boiler with No. 48 drill, and tap either $^3/_{32}$ in. or 7 B.A.; attach the pieces of angle with brass screws—or better still, with home-made screws of drawn bronze. As mentioned earlier, the commercial kind of "brass" screws, frequently rot and break. If the screws are a good fit, a smear of plumbers' jointing will prevent any water leaking past the threads: but if at all slack, sweat over the complete bracket with soft solder, same as stayheads.

Centrepunch the circles scribed on the lugs at the end of the saddle, drill No. 40, and tap ⅛ in. or 5 B.A. For the screws attaching the smokebox to the saddle, drill three No, 41 holes ⅛ in. from the edge of the flange on each side: one in the middle, and one on either side of it at 1 in. away. Anybody who loves to see a lot of "pimples" adorning the job, could drill a series of No. 51 holes at ¼ in. spacing, all along each flange, and fix the smokebox to the saddle, by using round or hexagon screws, either $^1/_{16}$ in. or 10 B.A., in place of the three $^3/_{32}$ in. or 7 B.A. specified further along. The saddle can then be replaced in the frames, and secured by 1/8 in. or 5 B.A. screws, either round or hexagon heads as desired.

Drill a 7/32 in. hole in the bottom of the smokebox, about 1 1/8 in. in front of the blastpipe hole, to accommodate the snifting valve. The boiler can then be replaced in the frame, with the smokebox in its correct position on the saddle, and the expansion brackets resting on the upper edge of the frame, between the driving and trailing wheels. The smokebox can then be secured to the saddle flange by the three screws at each side, to which I referred above. The boiler is prevented from lifting, but allowed freedom for expansion, by two hook-shaped clips, as shown in the detail illustration. These are cut from 16 or 18-gauge brass or steel, and bent to shape shown: they are drilled No. 40 and attached to the frames by 3/32 in. or 7 B.A. screws, the holes in the frame being tapped to suit. Be careful to avoid piercing the firebox when drilling and tapping, a slip is very easily made.

How to Erect Grate and Ashpan

At 2 ins. from the top edge of the frame, on either side (that is, slightly above the coupled axle centres) and 2 3/4 ins. behind the driving-wheel centre, drill a No. 30 hole through the frame. Take care when setting these out, as the holes must be exactly opposite. Now insert the ashpan, with grate complete, into the bottom of the firebox. If it is held vertically, shallow end upwards, it will go in easily; then let the back end drop until the firebars rest on the ledge at the back, formed by the bit of angle. If the front end is then pushed up until the piece of angle on the front of the ashpan butts up against the projecting bottom edge of the firebox, the assembly will then be in correct position. Hold it there, and put the No. 30 drill through the holes in the frame, making countersinks on the sides of the ashpan; be careful to keep the drill horizontal, and at right angles to the frame. Remove ashpan, and drill through the sides at the places shown by the countersinks, with a 3/16 in. drill.

Cut a piece of thin-walled copper tube to a length of 2 in. This should be a tight fit in the holes in the ashpan, and should allow a piece of 1/8 in. round steel to pass through it easily. Push it through the holes in the ashpan, as shown in the plan drawing, and bell out the ends a little. The pin is just a 3 1/2 in. length of 1/8 in. round steel, with a turned knob screwed on one end, and the other rounded off a little, to enable it to enter the guide tube easily. If the pin is pulled out after a run is finished, the grate and ashpan will drop down, and can be easily removed, and any ash or clinker cleaned out. To replace, simply insert the ashpan as above, and push the pin through the holes in the frame, and the ashpan.

Steam Pipe Connections

TWO 3/8 in. holes are needed in the smokebox, for the steam pipes to pass through. These must be dead in line with the holes in the top of the steam chests, and are 15/16 in. below the horizontal centre-line of the boiler. Carefully mark the location, make centre-pops, and first drill 1/8 in. or No. 30 pilot holes. When enlarging, hold the drill brace so that the 3/8 in. drill slants upwards at an angle of about 30 deg. to the horizontal centre-line of the boiler; it should just clear the top of the cylinder, at right-angles to the part of the smokebox shell that is being drilled.

The connection between the union nut on the superheater pipe and the cylinder, is made by a short piece of 1/4 in. copper pipe with a union nipple at the upper end, and a flange at the lower end. To make the nipple, chuck a piece of 3/8 in. round rod in the three-jaw, with about 7/8 in. projecting from the chuck. Face the end, centre deeply, and drill for about 7/8 in. depth with 7/32 in. drill, screw 3/8 in. length of the outside with 3/8 in. x 32 die in the tailstock holder, and part off at 5/8 in. from the end. Reverse in chuck, and open out for 1/8 in. depth, with letter D drill if you have it; if not, use 1/4 in. Repeat operation.

The flanges for attachment to cylinders may be castings or cut from 1/2 in. sq. brass rod. Castings will only need cleaning up with a file, and smoothing on the contact face by rubbing on a flat file laid on the bench. If making them from bar, saw or part off two pieces a full 13/16 in. long. Saw a "step" at each end, leaving the middle part 5/16 in. wide; then saw or file off both sides to the angle shown in the drawing. File off any roughness in the steps; round the ends, drill the screwholes No. 30, and the steam-pipe hole either with letter D or 1/4 in. drill. In the middle of the contact face, drill a 7/32 in. hole, to meet the hole for steam-pipe; smooth off any burring.

Cut two pieces of 1/4 in. copper pipe, each 1 7/16 in. long. At 3/8 in. from one end, drill a 5/32 in. hole in the pipe; and in the hole, fit a 7/32 in. x 40 union nipple, same as those on the mechanical lubricator, boiler fittings, etc. Fit the large union nipples on the same ends of the pipes as the small ones, and the flanges at the opposite end, setting them to line up with the small nipples, as shown in the illustration. All three joints can then be silver-soldered at one heat; pickle, wash off, and clean up. Push the large nipples through the holes in the smokebox sides, and just start the nuts on the threads. Seat the flanges on the faced bosses on top of the cylinder steam-chests, run a No. 30 drill through the holes, make countersinks on the cylinders, follow up with No. 40, and tap 1/8 in. or 5 B.A. Remove pipe and union, and file off any burr on the seating. Replace, with a jointing gasket, made from 1/64 in. Hallite or similar material, or with stout oiled brown paper, between flange and seating—don't forget to punch a 7/32 in. hole in the middle! —securing the flange with two roundhead screws. The union nuts in the smokebox can then be tightened.

Oil Pipe Connections

On the full-sized engines the oil is atomised by a separate steam spray before entering the steam chests; but on the little one, it is only necessary to introduce the oil supply into the steam pipes, and the flow of steam will do the needful in distributing the oil, in a fine spray, to the moving parts. The connections for this are shown in the drawing. Oil from the lubricator enters an auxiliary upper check valve, from which branch pipes lead to the unions on the steam pipes. To make the check valve, chuck a piece of 5/16 in. brass rod in three-jaw, face the end, turn down about 1/4 in. length to 7/32 in. diameter, and screw 7/32 in. x 40. Centre deeply, and part off at 1/2 in. from the shoulder. Reverse in chuck, centre, drill right through with No. 34 drill, open out to 7/16 in. depth with 3/16 in. drill and D-bit, slightly countersink the end, and tap 7/32 in. x 40. Put a 1/8 in. parallel reamer through the remains of the No. 34 hole.

At 3/16 in. from the top, drill a No. 32 hole clean through the body; and in each side fit a piece of 1/8 in. copper tube approximately 2 in. long, with a union nut and cone on the outer end of each. No need to describe how to make those, as I've done it so many times already! Silver-solder the cones to the pipes, and the pipes to the body, at the one heat. Pickle, wash off, and clean up; then seat a $\frac{5}{32}$ in. ball, either rustless steel or bronze, on the seating, and turn up a cap for the valve body, from $\frac{5}{16}$ in. hexagon rod, drilling same as shown, with No. 30 drill, to accommodate a light spring. This is necessary with a small oil check valve, as the ball, if not loaded, will tend to "float" in the thick cylinder oil, allowing a certain amount of back-flow.

Connect up the union nuts on the pipes, to the nipples on the steam pipes as shown; the exact position of the check-valve doesn't matter a bean, and the pipes may be bent to suit. All that then remains is to connect the union on the check valve with the union on its mate under the lubricator, with a piece of $\frac{1}{8}$ in. copper tube, furnished with union nuts and cones at each end.

Snifting Valve

THIS is a fitting that the big engine doesn't possess. At one time, many full-sized engines had them, the idea being to destroy the vacuum in the steam pipe, caused by the pumping action of the cylinders when the engine was coasting with the regulator shut. Without the valve, grit and ashes were sucked down the blastpipe, and did what the kiddies would call "a bit of no good" to the valves and pistons. In modern practice, the vacuum is now destroyed by an admission of oily steam, by what is known as an anti-carboniser. On the small engine, this fitting would be rather a tricky proposition to make and fit; and as the old snifting-valve, as it was called by the enginemen, is just as effective on a $3\frac{1}{2}$ in. gauge locomotive, I specify and use it.

To make it, chuck the $\frac{5}{16}$ in. brass rod again, face the end, and turn down $\frac{3}{16}$ in. length to $\frac{7}{32}$ in. diameter, a tight fit in the hole in the bottom of the smokebox. Part off at $\frac{3}{8}$ in. from the shoulder. Reverse in chuck, face, centre, drill right through with No. 34 drill, open out and bottom to $\frac{5}{16}$ in. depth with $\frac{7}{32}$ in. drill and D-bit, slightly countersink the end, and tap $\frac{1}{4}$ in. x 40. Put a $\frac{1}{8}$ in. parallel reamer through the remnants of the No. 34 hole, and seat a $\frac{5}{32}$ in. ball on it. Chuck a piece of $\frac{5}{16}$ in. hexagon brass rod in three-jaw, face the end, turn down $\frac{1}{8}$ in. length to $\frac{1}{4}$ in. diameter, and screw $\frac{1}{4}$ in. x 40. Part off at $\frac{7}{16}$ in. from the shoulder. Reverse in chuck, turn down $\frac{1}{4}$ in. of the end to $\frac{1}{4}$ in. diameter, and screw $\frac{1}{4}$ in. x 40. Centre deeply and drill through with No. 40 drill; cross-nick the end of the hole with a thin flat file, so that when the ball lifts, it won't block the hole.

Assemble the valve as shown, with a smear of plumber's jointing on the threads, then put the plain end through the hole in the bottom of the smokebox. Put a $\frac{1}{4}$ in. x 40 union nut on the $\frac{5}{32}$ in. pipe leading from the wet header, and silver-solder a union cone on the end. Connect up to the snifting-valve, as shown in the illustration. When the engine is coasting with the regulator shut, the suction of the cylinders will lift the ball off the seating, and air will be "sniffed" in from underneath the smokebox, and pass through the superheater to the cylinders, thus not only destroying the vacuum and preventing ash and grit being sucked in, but the air being heated in its passage through the superheater, the cylinders are prevented from cooling off.

Combination Blast Nozzle

All B.R. standard locomotives have a blastpipe "tip" in which the blower jets are incorporated, and the one I am specifying for the little class 4, is of this type but slightly simplified. Castings may be available; but if not, chuck a short piece of $\frac{7}{8}$ in. round brass rod in the three-jaw, face the end, and turn down $\frac{1}{2}$ in. length to $\frac{1}{2}$ in. diameter. Bevel off the end for $\frac{3}{16}$ in. length, to about a 30 deg. angle; the exact angle doesn't matter, as long as the top isn't less than $\frac{1}{4}$ in. across. Part off at a full $\frac{1}{16}$ in. behind the shoulder. Reverse in chuck, gripping by the parallel part. Centre, and put a $\frac{5}{32}$ in. or No 22 drill clean through. Open out with an $\frac{11}{32}$ in. drill for $\frac{5}{16}$ in. depth, and tap $\frac{3}{8}$ in. x 40. The point of the drill will form the internal taper shown. Skim the flange truly.

Chuck the $\frac{7}{8}$ in. rod again, and part off a slice a full $\frac{5}{16}$ in. thick. Chuck this truly, centre, drill a hole through it about $\frac{7}{16}$ in. diameter, and open it out with a boring tool until the parallel part of the piece previously turned, will just push in. Continue recessing with the boring tool, until a recess is formed, $\frac{3}{4}$ in. diameter and $\frac{1}{4}$ in. deep, as shown in the section. Drill a $\frac{5}{32}$ in. hole in the side of the cup thus formed; and in it, fit a $\frac{1}{4}$ in. x 40 union nipple. Put the cup over the centre part, see that the edge bears well down on the flange, and silver-solder the joints and the union nipple at one heat. After pickling, washing off and cleaning up, drill four holes with a No. 70 drill, equidistant around the cone, and as close to same as you can get them without breaking into the silver-soldered joint; see the black dots in the plan view.

The completed combination nozzle can then be screwed on to the top of the blastpipe in the smokebox. When tight, the union nipple should be to the left of the blastpipe, looking at it from the open front of the smokebox. Connect it to the end of the thoroughfare nipple on the end of the hollow stay, by a piece of $\frac{1}{8}$ in. thin-walled copper pipe, with union nuts and cones on each end. Check the blast-nozzle for alignment with the chimney liner, by putting a piece of straight rod down it; a piece of $\frac{5}{32}$ in. silver steel should be straight enough, and a good enough fit. The rod should stand exactly in the middle of the top of the chimney; if it doesn't, simply bend the blastpipe until it does, the soft copper allowing for this.

It is important that the smokebox be perfectly airtight, for if it isn't, the engine won't steam. The interstices around the blastpipe, snifting-valve and steampipe unions must be sealed; a few turns of asbestos string wound around the blastpipe and pressed down into the crack, will usually do the trick, especially if some plumber's jointing is smeared over the string, after pressing down, to "make it stick." A fillet of plumber's jointing alone should be sufficient for the unions and snifting-valve. This material, sold under the name of "Boss White," and other brands, sets something like rubber, and will not crack under heat. Put a smear of it around the flange of the smokebox front or ring, and carefully press same home, making sure that the door hinges are perfectly horizontal. The ring is pressed in as far as the radius, which stands just clear of the smokebox shell. We are now ready to fit the feed clacks, connect up the water pipes, and make and fit the injector.

SOME correspondence having reached *Mechanics* offices requesting information as to how and why an injector operates apparently in defiance of the laws of nature, our worthy Editor suggests that before describing how to make the injector for the little Class 4 locomotive, I should give an explanation of the principles of working. At first sight, it certainly does seem ridiculous to expect a jet of steam to force water into a boiler against its own pressure; and the inventor, a French engineer named Henri Giffard, was laughed at, when he asserted that it could be done —incidentally, the same as your humble servant when I asserted that a tiny steam locomotive could be made to burn coal and haul living passengers. We both proved our contentions! It was in 1859 that M. Giffard made some sample injectors, and two of them came into the hands of the Paris representatives of two British locomotive-building firms (Sharp, Stewart & Co., and Robert Stephenson) who sent them over for test; but no instructions as to how they were to be fitted up, were forthcoming. However, as luck would have it, one of Sharp's fitters coupled up the steam and water connections correctly, and was astonished to find that the injector fed water into the boiler. The first injectors were naturally crude and temperamental, but it wasn't long before British engineers turned their attention to making improvements; and the injector of to-day is a sturdy and reliable component, universally used as a boiler feeder. It not only is able to feed the boiler with water, using steam at boiler pressure, but can be operated with exhaust steam, with the advantage of utilising steam that would otherwise be wasted; and it is possible to feed against no less than 180 lb. boiler pressure, with exhaust steam at *one pound* pressure only!

The reason an injector feeds against the boiler pressure is a very simple one; the fact that a jet of water issuing from a nozzle at a given velocity has far more "kick" than a jet of steam at the same velocity. Imagine for one minute that you are heatproof and could walk through a jet of steam without getting scalded. Now imagine two hoses, one carrying steam, and one water, each with exactly the same pressure behind it, and the nozzles of these hoses are directing their jets across a path on which you are walking. You would probably pass through the steam jet without any effort; but when you tried to pass through the water jet you would be what the kiddies call "knocked into the middle of next week" by the force of water coming in contact with your anatomy! In an injector a jet of steam issuing from a small nozzle at high velocity comes into contact with cold water and condenses in it; and in doing so, it gives up its velocity to the water. We now have a jet of water coming from the second nozzle, at approximately the same speed as the jet of steam; and as explained above, this jet, by virtue of having more "kick"—or to be "scientific," more kinetic energy than the jet of steam, it is enabled to bump up the clack valve and get into the boiler.

Some idea of the speed at which water passes through an injector can be gleaned from the fact that all the water needed by the boiler of a full-sized class 4 locomotive, working all-out, can get through a delivery cone, the throat of which is only a little over ¼ in. diameter. What is more marvellous still, is the fact that a jet of water passing through a nozzle only eleven-thousandths of an inch in diameter, not much thicker than a hair, has enough "Sunny Jim" behind it to force up the clack valve and enter the boiler of a little locomotive, when the safety-valve is blowing off at 80 lb. I have made one that size, but it was unreliable for service use, as the slightest speck of dirt or grit getting into the weeny nozzles, effectually "stopped the clock"; and I have found by experiment, that the sizes of nozzles given in the following notes, are the smallest that can be used if a really reliable and trouble-free injector is desired. Small commercially-made injectors have been on the market for many years; around the turn of the century, a type known as the "Vic" was marketed by W. A. Eaton, Bertrand Garside, and others. This was too large for anything below a 5 in. gauge locomotive; and even when fitted to a boiler of that size, it "knocked the steam gauge silly" as the enginemen would say, when feeding water in. It is now some 30 years or so since I first wrote an illustrated description of how to make a small injector; and since that time I have made countless experiments with a view to combining reliability with the lowest possible steam consumption plus efficient working. The injector described below will feed perfectly, running or standing, without loss of water from the overflow; it uses so little steam, that if put on when the engine is running, with the safety valves blowing off, it won't make them shut down, whereas the older commercial injectors, not made to my specifications, would have promptly stopped the engine altogether. It will also lift water, if placed above the source of supply, but I don't recommend this method of fitting. All modern injectors are placed well below the tank level, where they can readily be cooled by turning on the water, if they should by any chance become overheated, due to leaky clack, steam valve, or other cause. Also, they use less steam in that position. Nature won't be fooled, and you can't get power for nothing in this benighted world; it requires more steam to suck up the water, as well as force it into the boiler. So much for the whys and wherefores; now let's get on with the job of making the injector.

WHILST the body of the injector *could* be machined up from a casting, held in various positions in a four-jaw chuck, I find it much easier to build up from rod material, silver-soldering the joints. Saw or part off a piece of 5/16 in. square brass rod, to full ⅞ in. length. Gunmetal or bronze can, of course, be used, but brass will do just as well, as there is no movement, and consequently no wear. Chuck truly in the four-jaw, face the end, centre, drill right through with No. 24 drill, and ream 5/32 in. Turn down 5/32 in. length to ¼ in. diameter, and screw ¼ in. x 40. Reverse end-for-end, rechuck truly, and repeat the turning and screwing operation, leaving the centre part 9/16 in. long.

Make a centre-pop in the middle of one of the facets, and another one, on the centre-line, a bare 3/16 in. to the right of it. Drill out the middle one with a ⅛ in. drill, letting it break right through into the reamed hole; then, with a 3/16 in. pin-drill, counterbore the hole to a depth of 1/16 in. Drill the other centre-pop with a No. 34 drill, letting it go clean through the body, cutting right across the reamed centre hole. Turn the embryo body over, and on the centre-line, at 1/8 in. from the end, centre-pop and drill a No. 21 or 5/32 in. hole, right into the centre hole. Open out the end of the No. 34 hole with No. 30 drill, and tap it 5/32 in. x 40.

For the ball chamber part off a piece of 1/2 in. round rod held in the three-jaw to a length of 3/8 in. full. On one end of this, make a centre-pop a full 1/32 in. off centre. Chuck in four-jaw with this pop mark running truly; open out with centre-drill, drill right through with No. 34, open out and bottom to 1/4 in. depth with 7/32 in. drill and D-bit, slightly countersink the end with 1/4 in. drill, tap 1/4 in. x 40, stopping well short of the ball seat, and run a 1/8 in. parallel reamer through the remnants of the No. 34 hole. Chuck any odd scrap of rod, 3/8 in. diameter or over, in the three-jaw; seating! Then press the spigot on the bottom of the ball chamber, into the counterbore in the injector body, taking care that the slanting hole comes exactly over the corresponding hole in the body. The whole arrangement is shown clearly in the sectional illustration.

The union nipple for the waterpipe connection is made from 1/4 in. round brass rod held in the three-jaw chuck. Face the end, centre deeply with letter E centre-drill to 3/8 in. depth with No. 34 drill. Screw a bare 1/4 in. of the outside, with 1/4 in. x 40 die in the tailstock holder, and part off at a full 5/16 in. from the end. Reverse in chuck, but don't grip tightly enough to damage the threads; then turn down 1/16 in. length to a tight fit in the No. 21 hole in the underside of the body. Press in, and silver-solder the joints. Stand the assembly upside down, nipple pointing skywards, on a bit of asbestos millboard, in the brazing pan, and do the job as described for the boiler fittings; apply a little wet flux, heat to medium red, and touch the joints with a strip of best-grade silver-solder, or Easy-flo. Let cool to black, quench out in acid pickle, wash in running water, and clean up with a scratch brush. I use a fine-wire circular scratch brush with a metal centre, mounted on a home-made taper-shank spindle which is stuck into a taper hole in the end of the spindle of my electric grinder. As this buzzes around at 2,990 r.p.m. it only needs a few seconds' application to make small fittings bobby-dazzle like an Easter bride's wedding ring.

Seat a 5/32 in. ball, either rustless steel or bronze, on the seating in the ball chamber, same as I have described for the pump, and fit a cap to it, made from 5/16 in. hexagon rod. Make a countersink in the cap, so as to allow the ball about 1/16 in. lift; injector valves need more lift than pump valves, as they don't keep bobbing up and down. This one stays open until the jet is established, or as the enginemen say, until the injector "picks up," when the vacuum in the combining cone sucks it down on the seating, where it stays all the time the injector is working. If for any reason the injector "knocks off," such as a surge of water in the tank, water going down the steam pipe, or the various things that happen when the engine hits a bad place in the line when running fast, or clatters through a crossing frog, the ball will lift, and release the mixture of steam, air, and water, enabling the injector to restart "all by itself" as the kiddies would say.

Cone Reamers

Four special reamers will be needed for forming the tapers in the cones. These are easy enough to make, and once you have them, you are all set to make injectors "till the cows come home." The reamers for the combining and delivery cones, and for forming radii, are made from 5/32 in. round silver-steel. That for the steam cone is made from 7/64 in. ditto., or from 1/8 in. slightly reduced. The tapers are turned by holding the rod in the three-jaw, and setting over the top slide; this is a matter of trial and error, the angle of the slide being adjusted until the length of taper is as shown. Use a roundnose tool, with the cutting edge set exactly at centre-height. Don't forget to apply cutting oil.

After turning the tapers, file or grind away half the diameter of the tapered part; then heat to bright red, and plunge vertically into clean cold water. Brighten up the flat part of the taper, on an oilstone, or by carefully holding against an emery-wheel. Lay each reamer on a piece of sheet iron, and hold it over a Bunsen flame, spirit lamp, or a small burner of the domestic gas stove. Have a pan of water handy; watch the brightened part like a cat watching a mouse hole, and when it turns to dark yellow, tip the reamer into the water quickly. Another careful rub on the oilstone, and the reamer is ready for use.

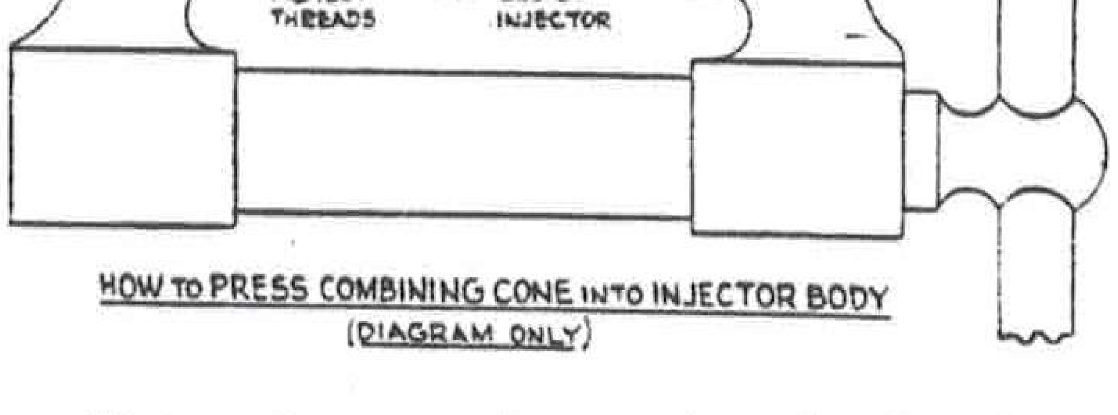
AS the combining cone (middle one) has to be pressed in, make this first. Many beginners are scared of turning to a press fit; well, they needn't be, as nothing is easier. Simply put a taper broach into the injector body at the end carrying the water nipple, and broach the hole slightly taper for about 1/8 in. or so. Now, if the cone is turned to a very tight push-fit in the broached part, which is simply another trial-and-error job, it will be a nice press fit in the rest of the bore.

Chuck a bit of 3/16 in. round brass rod in the three-jaw, and turn down about 3/8 in. length as above. Face the end, centre, and drill down about 3/8 in. depth with No. 72 drill. The ordinary centre-drill is too coarse-pointed for this, so make your own by turning a long cone point on the end of a short length of 3/32 in. silver-steel; or it may be filed, by holding a file at an angle across the end of the steel, and then sweeping it across, with slight downward pressure, with the lathe running very fast. File the point to the shape of a tiny arrow-head, as described for reamers. This, when used in the tailstock chuck, will form a weeny depression, just right for starting a small drill. When drilling, don't let the drill penetrate more than 1/16 in. at a time, before withdrawing to clear chips from the flutes, or it will seize and break; and run the lathe as fast as possible without creating a miniature earthquake. Slightly cut back the end of the rod, to form a very blunt nose, then part off at 9/32 in. full, from the end.

Reverse in chuck, leaving exactly half of the piece protruding from the chuck jaws; then, with the cone reamer with the 3/4 in. taper in the tailstock chuck, carefully ream out the hole in the cone until the point of the reamer just shows through the hole in the other end. I use a stop on my own reamers, to save what enginemen call "overshooting the platform." This is merely a 1 in. length of $\frac{1}{4}$ in. round rod with a No. 21 hole drilled through it; a setscrew is fitted close to one end. It only takes a few minutes to make, and is shown in the drawing of the cone reamers. If this is placed over the reamer blade, with the setscrew at the shank end, and adjusted for the length to be reamed, it will prevent the reamer being pushed in too far, and so spoiling the cone. Don't put the reamer in to the full depth at one go, or the scrapings which is removes, will choke the clearance, and prevent it from cutting correctly; ream a little, and then withdraw. If the reamer is put in the chuck with its round back uppermost, the bits will fall away as the reamer is withdrawn—simple, but quick!

With a fine saw (I use a home-made baby hacksaw frame with double-edged jewellers' blades in it) saw the cone in half, pressing the saw against the chuck jaws while sawing. The lathe may be stopped, or running; I saw them on the run. Withdraw the bit left in the chuck, for about $\frac{1}{16}$ in. and with a knife tool in the slide-rest, face off the saw marks, and form another blunt nose. With the stubby radius reamer, take off the sharp edge of the hole. Chuck the other bit of the cone, and repeat operations, but don't radius the hole.

The cone is then pressed into the injector body, and this is a case of "watch your step," for correct position is vital. Put an old union nut on the threads at the end of the body, farthest away from the water nipple, and insert the nozzle end of the cone into the broached end of the injector body. Make a push rod from a short length of $\frac{5}{32}$ in. round rod, with a countersink in the end, so that it will not damage the ends of the cone; put it against the cone end, hold it in line with the cone and injector body, put the lot between the jaws of the bench vice, and squeeze in the cone by slowing turning the vice handle. Look down through the hole at the bottom of the air-ball chamber while the cone is going in; and when the end of it appears, squeeze slowly until the back end is about $\frac{1}{64}$ in. off the centre of the hole, the front end then being out of sight. Then repeat operations with the other half of the cone; and to avoid pressing this in too far, put a narrow sliver of brass $\frac{1}{32}$ in. thick, down the hole in the ball chamber, and press in the cone until the sliver is just held lightly between the halves. When it is pulled out, the cones will be the correct distance apart, and should appear as shown in the plan view.



HOW TO PRESS COMBINING CONE INTO INJECTOR BODY
(DIAGRAM ONLY)

Put a tapwrench on the shank of the reamer with the $\frac{3}{4}$ in. taper, insert into the injector body, with the blade entering the cone, and carefully take out a few scrapings, until you can just push a No. 70 drill through the end, by holding it in a pin chuck, and twirling it between finger and thumb. Finally, with the stubby radius reamer, take off the sharp edge on the entrance to the taper hole, by putting it in the bore of the injector body and twisting back and forth a few times. The radius should be about $\frac{1}{32}$ in. depth, to give the water an easy passage in, around the nozzle of the steam cone. I have dilated at some length on this cone-fitting job, as I have gathered from correspondence about failure of injectors to feed, is practically always due to incorrect cone making and fitting.

An alternative combining cone is shown in the drawing; this is the type fitted to many American injectors. The cone is turned and reamed as given above; but instead of sawing it in half, a groove is formed in the middle with a $\frac{1}{16}$ in. wide parting-tool. In the middle of the groove, two $\frac{1}{32}$ in. slots are formed with a watchmaker's flat file, these slots cutting into the taper bore. The cone is pressed into the body, so that the groove is central with the hole at the bottom of the ball chamber. The taper bore is finish-reamed as given above. While this type of cone is quite efficient when working, it is slightly slower in "picking up," due to the smaller apertures for escape of steam and air.

The other cones will be found easier to make and fit. Tackle the delivery cone next; chuck a piece of $\frac{1}{4}$ in. round brass rod in the three-jaw, and turn about $\frac{1}{2}$ in. length to $\frac{7}{32}$ in. diameter, and easy fit in the threads of a $\frac{1}{4}$ in. x 40 union nut. Face the end, and turn down $\frac{9}{32}$ in. length, to a tight push fit in the injector body, at the end farthest away from the water nipple; then turn the end to the shape and size shown in the drawings, which can easily be done with a round-nose tool in the slide-rest. Centre the end with the special weeny centre which I mentioned previously, and drill down about $\frac{3}{16}$ in. full depth with a No. 76 drill. This should be held in a jeweller's pin chuck, a commercial article obtained cheaply from any tool-store; the shank of it fits in the tailstock chuck. Use the same "technique" when drilling, as previously mentioned, penetrating not more than $\frac{1}{16}$ in. before withdrawing to clear chippings; this method enables these microscopic drills to drill the full depth of the flutes, without risk of breakage, but it goes without saying, that they mustn't be forced, or something will happen, and pretty quick at that!

With the stubby radius reamer in the tailstock chuck, bell out the end of the cone, as shown in the drawings, then part off at a full $\frac{3}{32}$ in. from the shoulder. Reverse in chuck, and with the long tapered reamer in the tailstock chuck, ream out the No. 76 hole until you can just push a drill the next size larger (No. 75) through the small end of the cone. This method ensures that the taper extends the full length of the cone, and that the throat is the correct size; the importance of the latter can be judged by the fact that a discrepancy of one thousandth of an inch can upset the working of a full-sized injector. A well-known chief mechanical engineer, now retired, referred to this when operating the injector on one of my own engines, and said that it was a marvel to him how I ever got such a tiny squirt to feed the boiler at all! Slightly bell the large end of the taper with the stubby reamer, skim off any burring, and the cone is finished.

For the steam cone, chuck the $\frac{1}{4}$ in. rod again, and turn down about $\frac{1}{2}$ in. length to $\frac{7}{32}$ in. diameter as before. Face the end, then reduce $\frac{5}{16}$ in. length to a tight push fit in the injector body. Turn the end to the shape and length shown; the diameter of the end should be between 0.065 in. and 0.060 in. If smaller, more water regulation will be needed, though the injector will work; if larger, there is a chance that not enough water will pass the annular space, and steam will blow from the overflow. Centre the end, and drill down to about 7/16 in. full depth, with No. 67 drill, taking the same strict precautions as before, to avoid breakage. Next, with the small-shanked reamer, very carefully ream the end of the nozzle, until it is almost knife-edged. Part off at a full 3/32 in. from the shoulder; reverse in chuck, and with a No. 34 drill, drill out the back of the cone to a depth of 1/4 in. Put the small-shank reamer in the tailstock chuck, and very carefully ream at the bottom of the drilled hole, until you can just push a No. 65 drill through with a finger-twirl. The nozzle end should then be the same section as the diabolo toys, which were all the rage among children many years ago, when "fags" were five a penny. This is the double-reverse cone, which was standard Swindon practice on Great Western injectors, and later adopted as standard for British Railways locomotives. I have tried out practically every form of nozzle used in full-size practice, in my small injectors, and so far I have not found one to beat this style for quick pick-up and low steam consumption. Skim off the flange, to remove any burring, insert the cone in the injector body, replace the airball and cap, and the "works" of the injector are complete.

ON the B.R. standard injectors, a clack or check valve is incorporated in the injector body, but it is more convenient in the small size, to make it separately. Chuck a piece of 5/16 in. round rod in the three-jaw, face the end, centre, drill down to 9/16 in. depth with No 34 drill, open out and bottom to 9/32 in. depth with 7/32 in. drill and D-bit, slightly countersink the end, and tap 1/4 in. x 40, stopping short of the ball seat. Ream the remains of the No. 34 hole with a 1/8 in. parallel reamer. At 5/32 in. from the bottom, drill a 3/16 in. hole, breaking into the reamed hole.

Chuck the 5/16 in. rod again; face, centre, and drill with No. 34 drill to a full 7/16 in. depth. Open out and bottom to 7/32 in. depth with 7/32 in. drill and D-bit, and tap 1/4 in. x 40. Part off at a bare 3/8 in. from the end; reverse in chuck, and turn down 3/32 in. of the end, to a tight fit in the hole in the side of the clack body. Press it in, and silver-solder the joint; after pickling and cleaning up, fit a 5/32 in. rustless ball to the seating. Chuck a bit of 5/16 in. hexagon brass rod, face the end, and turn down 1/8 in. of the end to 1/4 in. diameter, screwing 1/4 in. x 40. Part off at 3/8 in. from the shoulder; reverse in chuck, holding either in a tapped bush in the three-jaw, or direct by the hexagon. Turn down 1/4 in. length of the outside to 1/4 in. diameter, and screw 1/4 in. x 40. Centre deeply with size E centre-drill, and drill through with No. 34 drill. Cross-nick the short end with a thin flat file, and assemble as shown, with a smear of plumber's jointing on the threads. Screw the completed check valve on to the end of the injector as shown; if it doesn't stand straight up, parallel with the ball chamber, when screwed right home, take a skim off the flange of the delivery delivery cone, which will allow it to be screwed on a little further. Repeat the treatment if necessary, but if the radius at the end of the delivery cone is cut away in doing so, form a fresh radius with the stubby reamer.

The sides of the ball chamber can be cut away by milling, or careful filing, both for appearance sake, and to reduce the amount of metal in the injector. As the gadget must be cool, to allow steam to condense in it, the less bulk of metal is an advantage, as it doesn't retain the heat. The flat sides are shown in the plan view. The overflow pipe is merely a short length of thin 5/32 in. pipe screwed into the tapped hole at the clack-valve end of the injector. This may be formed in a bend, if desired; on my own engines I sometimes use a bend, which is in full view from the driving car, a convenience when operating the injector on the run. Although most of my engines have feed pumps, operated by an eccentric on the axle, I prefer to use the injector, as it is modern practice. How the injector is erected on the engine will be described along with the pipe work, or "plumbing."

"Mass Production"

Readers of *Mechanics* who follow my locomotive construction notes may be interested to know that I never make any small components singly. During the latter part of the Kaiser's war, I left the footplate temporarily to take charge of a small munition shop, somebody or other having disclosed the fact that I was—well, qualified, shall we say? Anyway, I got so used to seeing things turned out by the gross, that when working my own shop, and having a machine set to do a certain job, it seemed waste of time to make one only, and so I made a dozen or so while at it. I still do! For some years past, around Christmas time, I have made injectors and other fittings, a dozen or more at a time, and distributed them as presents to various folk all over the world, in return for kindnesses shown. Not so long ago, Mr. C. Moore, who is managing director of the Myford Engineering Co. Ltd., visited my workshop and railway, and finding that I didn't possess a Myford lathe, promptly sent me the machine shown in the photograph opposite, a Super-7 (I can it supersonic!) plus nearly all the blobs and gadgets in the accessories list. As an accuracy test, I made eight injectors on it right away; seven of them were shown in the *Mechanics* issue of June 18, the missing one having departed to U.S.A. when the shot was taken.

The other photo, July 16 issue, shows injectors in the making. At the top left is a machined body, with the ball chamber, union, and cap, all ready for assembly. At top right, same are assembled, and set ready for silver-soldering. Below that, are two steam cones, two delivery cones, and four combining cones of various types. Bottom left, shows a check valve in pieces, ready for assembly; next to it, one assembled ready for the silver-soldering job; and beside that, a finished check valve. All the injectors shown in the group photo were tested on one of my own locomotives over a distance of two miles each, and fed the boiler perfectly, running or standing, with no loss of either steam pressure or water; so builders of the B.R. class 4 engine can make and fit the injector described in detail, with every confidence that, given reasonably accurate workmanship, it will do the job as specified.

ON most of the engines described in these notes, which were fitted with top feed connections, the delivery was through plain elbows on top of the boiler barrel, the actual clacks being either on the pumps or injectors, or on the frames below the feed pipes. In the present instance, the top feeds are "the real McCoy," as the actual clacks are mounted near the top of the boiler barrel, as on the full-sized engine. They can be connected to the feed pipes either by flanges, again as on the big engines, or by the more simple union fittings, which are far more convenient in the small size. The choice lies with the builder, both arrangements being shown in the illustrations.*

To make the clack boxes, chuck a piece of 3/8 in. round rod in the three-jaw, and turn down about 1 in. of it to 11/32 in. diameter. Face the end, centre, drill down for about 1/2 in. depth with No. 34 drill, open out and bottom to 5/16 in. depth with 7/32 in. drill and D-bit, and tap 1/4 in. x 40. Slightly countersink the end, to allow the cap to screw right home. Part off at a full 7/16 in. from the end, reverse in chuck, counterbore the end for a full 1/16 in. depth with No. 23 drill, poke a 1/8 in. parallel reamer through the rest of the hole, and slightly round off the sharp edge, like the clacks on the big engine. Drill another No. 23 hole in the side of the body, about 3/16 in. from the top, and fit about 1 1/2 in. of 5/32 in. copper tube in it. Fit another stub of same kind of tube in the counterbore at bottom.

If you are going to use flange joints throughout, make two of the larger flanges shown in the detail illustration * and four of the smaller ones, using 5/32 in. sheet copper. If using the union fitting, make two of the union connecting screws shown inset; there are made from 5/16 in. hexagon rod and need no detailing, as I've described them many times already. Fit the larger flanges to the pipes coming out of the sides of the clacks, and the smaller flanges, or union fittings as the choice may be, to the bottom pipes; the whole lot can then be silver-soldered at one heating. Merely anoint the joints with wet flux, heat to medium red, and touch them with a thin strip of best grade silver-solder, or "Easy-flo." The latter is obtainable in wire form, and I always use this for these "jewellery jobs"; such a wee taste is needed, ye ken, and the joints look exceedingly neat. Quench in acid pickle, wash off, and clean up. Seat a 5/32 in. rustless ball on the reamed hole, and make a cap to fit the top as shown. The ball should have a full 1/32 in. lift on the pump side, and a bare 1/16 in. on the injector side. Tip for beginners: if you aren't very hot at filing hexagons, turn the cap from 3/8 in. rod, leaving the flange flat, and about 3/32 in. thick. Chuck with the flange outwards, holding the screw in a tapped bush in the three-jaw; centre, and drill a 1/16 in. hole about halfway through, skimming off any burr, and rounding the edge of the flange. Chuck a bit of 1/4 in. hexagon rod in the three-jaw, and turn a pip on the end, to a tight fit in the little hole in the cap. Part off at a full 3/32 in. from the shoulder. Square the pip into the hole in the cap, and silver-solder it. Chuck the cap in the tapped bush again, and chamfer the corners of the hexagon; the cap will then look like those shown in the drawings.

At 1 5/8 in. from the end of the boiler barrel, and 1 in. each side of the top centre-line of the boiler, drill a 5/32 in. clearing hole, and slightly countersink it. Bend the pipes coming from the side of the clacks, as shown in the drawings, so that they will shoot the water towards the smokebox tubeplate when the clacks are erected. The clack assemblies can then be put in place, and attached to the boiler barrel by four 9 B.A. screws. I always make bronze screws to attach my fittings to boilers, since I had trouble with commercial brass screws in days now past. Some town water is chemically treated, and the screws rot and break off. It is a simple matter to turn the screws from bronze rod of a diameter suitable for the heads, and put the threads on with a die in the tailstock holder. The heads can be rounded off with the screwed part held in the chuck, and the slots put in with a fine hacksaw. If you have bedded down the flanges to the curve of the boiler barrel accurately, a jointing gasket of 1/64 in. Hallite can be placed between flange and boiler, and the screws put in with a taste of plumber's jointing on the threads; but if there is any doubt about perfect contact between the flange and boiler, just sweat over the lot with ordinary solder. It is doubtful whether the clacks will have to come off again during the lifetime of the engine.

The Plumbing Job

The reproduced diagram shows the starting and finishing points of all the steam and water pipes; the exact route they take is not of much consequence as long as the job is neatly done. My own usual plan, to avoid wasting copper pipe (some of my forbears came fra'over the Borrrrrdererrrr, ye ken!) is to get the exact lengths with a piece of thick lead fuse wire, running the wire along the route to be taken by the pipe, which is then cut to the length shown by the wire, and the flanges or union nipples silver-soldered on. The pipe for the pump feed runs from the right-hand flange or union attached to the top clack, follows the contour of the boiler barrel nearly to the bottom, and then goes in an easy curve to the union on the top of the valve-box of the pump. The bypass pipe goes from the lower union on the pump valve-box, and should run along under the right-hand running-board when that component is fitted, until it reaches the cab, when it drops down to connect to the union of the bypass valve.

The pipe from the left-hand flange or union on the top feed, also follows the contour of the boiler barrel until it drops below the running-board, where it turns back, and runs under the running-board to the cab front. Then it takes a sweep downwards, and is attached to the delivery clack of the injector, which is located as shown in the general arrangement of the engine. The steam pipe to the injector comes straight from the steam valve on the backhead, down through the footplate, and curves around to the union on the back end of the injector, while the water feed to that component is supplied by a pipe passing through the left-hand angle bracket attached to the underside of the drag beam. The union alongside it, is connected to the clack on the side of the firebox wrapper by a pipe going up through the footplate. The drawing of the backhead with the fittings on it, published recently, shows how the pipes should be run above the footplate. The feed pipe from the pump to the bracket under the drag beam, should be bent to one side, so that it doesn't prevent the grate and ashpan being dumped.

Brackets and Bypass Valve

The brackets carrying the ends of the pipes are just simply small pieces of 16-gauge brass or steel, cut to shape and bent, as shown in the illustrations.* The holes for the 5/32 in. pipes can be drilled with No. 21 drill. The hole for the hand-pump union can be drilled $\frac{7}{32}$ in. or drilled $\frac{3}{16}$ in. and tapped $\frac{7}{32}$ in. x 40. Both brackets are fixed to the underside of the drag beam, in the positions shown, by $\frac{3}{32}$ in. or 7 B.A. screws running through clearing holes in the bracket angles, into tapped holes in the thickness of the beam.

To make the bypass valve, part off a $\frac{3}{4}$ in. full length of $\frac{3}{8}$ in. round rod. Chuck in three-jaw, face, centre, and drill right through with No. 43 drill. Open out and bottom to $\frac{7}{16}$ in. depth with $\frac{7}{32}$ in. drill and D-bit, and tap the end $\frac{1}{4}$ in. x 40. Reverse in chuck, open out the centre hole for $\frac{3}{32}$ in. depth with No. 23 drill, poke a $\frac{3}{32}$ in. reamer through the remnant of the No. 43 hole, and turn the outside to shape shown.* At $\frac{3}{8}$ in. from the bottom, drill a $\frac{5}{32}$ in. hole in the side, and fit a $\frac{1}{4}$ in. x 40 union nipple into it. Fit a bit of $\frac{5}{32}$ in. pipe about $2\frac{1}{4}$ ins. long, in the counterbore at bottom, and silver-solder the lot at one heat. Pickle, wash off, and clean up.

CHUCK a bit of $\frac{5}{16}$ in. hexagon rod in the three-jaw, face the end, centre, and drill down about $\frac{5}{8}$ in. depth with No. 30 drill. Turn down $\frac{3}{16}$ in. of the end to $\frac{1}{4}$ in. diameter, and screw $\frac{1}{4}$ in. x 40. Part off at $\frac{3}{8}$ in. from the shoulder. Reverse and rechuck in a tapped bush. Turn down $\frac{1}{4}$ in. of the end to $\frac{1}{4}$ in. diameter, and screw $\frac{1}{4}$ in. x 40; chamfer the hexagon slightly, and skim off any burring. Open out the centre hole for about $\frac{3}{16}$ in. depth with No. 21 drill, and tap the rest $\frac{5}{32}$ in. x 32. Screw the fitting into the body with counterbored end at top, and make a gland nut to suit, from $\frac{5}{16}$ in. rod. The valve pin is a $2\frac{3}{4}$ in. length of $\frac{5}{32}$ in. rustless steel or bronze rod, with one end turned down to a full $\frac{1}{8}$ in. diameter, and finished with a cone point, same as the valves on the backhead. The next $\frac{1}{2}$ in. is screwed $\frac{5}{32}$ in. x 32, to fit the threads in the cap; and the upper end can be furnished either with a little handwheel, like the boiler valves, or with a cross-handle, same as the water-gauge. Please yourselves! The gland is packed with a few strands of graphited yarn, and the tail pipe is bent at right-angles to the body, to go through the end hole in the right-hand bracket. No other support will be needed. The bend should be exactly opposite to the union screw, as shown. When the footplate or cab deck is fitted, a hole is drilled in same, through which the valve pin can project up into the cab, for operation by the driver; see view showing cab front and pipe brackets.

Cab Front

This cab is a rather tricky one to make, on account of the combined tumble-home of the sides, and the angularity of the ends of the front plate, or weatherboard, as old-time enginemen usually called it. The idea of the ends being set at the angle shown, is to give the enginemen a clear view, free from back glare and reflection, which sometimes occurs with a window at right-angles to the centre-line of the engine. Whenever I am making anything of this sort, I always first cut out a pattern in thin cardboard or stiff paper (I learned the value of paper patterns way back in childhood days, when I frequently acted as a living "dummy" for a local dressmaker) and then use this as a guide or jig to mark out and cut the metal one. If you spoil a dozen or more paper or card patterns, the loss—except for valuable time—is infinitesimal; but with metal at present prices, an error in cutting out would be a major disaster! The shape of the firebox wrapper can easily be obtained by running a bit of thin soft copper wire, or lead fuse wire, all around it, and laying the shaped wire on the paper, marking off its outline with a pencil, and cutting slightly inside the marked lines. It is then an easy job to "offer up" the pattern, to the actual boiler, and operate with the scissors until it fits perfectly all around. The outline of the cab front can then be marked off, around the hole, cut to shape, bent to the angle shown, and the lot tried in place. If O.K. mark off the metal from the pattern, cut and bend it, and you're all set. One of my old friends, now, alas! on the other side of Jordan, used to stick his pattern on the metal with gum or liquid glue and cut it out like a kiddy does fretsaw work.

The window openings can either be cut out with a piercing-saw, which is only a glorified fretsaw, or drilled inside the marked lines, the piece being broken out, and the ragged edge filed to outline. The window frames can be cut from thin sheet brass, and should be about $\frac{1}{8}$ in. wide. They are riveted on the outside of the cab front with very fine rivets; I use the snipped-off heads of domestic lill pins, or dolls' pins, which are little more than $\frac{1}{64}$ in. thick. For "glass" I use the transparent mica sold commercially for oilstove fronts, and other places where a heat-resisting material is needed. This is easily cut with ordinary scissors, to the shape of the window-frames, and is sandwiched between the cab front and the window frame, the rivets going through the lot. The full-sized windows are made to open, but this is an unnecessary refinement on the small engine. The cab front is not attached to the boiler, but to the footplate by pieces of angle, when the footplate is fitted later on.

THE cab sides can be cut from the same kind of metal as the front, 18 or 20 gauge brass or steel sheet being a convenient thickness. No pattern is needed, as the sides are plain straightforward jobs, so the outline can be marked direct on the metal, as shown in the drawing, and cut with saw and file. The height of the sides is $4\frac{3}{8}$ in. and the bend for the "tumble-home" is made at $2\frac{5}{8}$ in. from the bottom. The windows can be glazed, either by following the same procedure as for the front windows, or by putting one large sheet of mica on the inside, with a brass frame to match, riveted in place with pin-heads. In the latter case a beading of $\frac{1}{16}$ in. half-round wire should be soldered around the openings on the outside, to add the finishing touch. Don't forget to cut the little projection on the sloping front, to which the running-board valance is attached.

Footplate

The footplate, or cab deck, is made from 16-gauge steel, to the dimensions shown in the illustration. The recess into which the firebox will fit, when the footplate is erected, should be cut to suit the actual job, in case there has been any slight discrepancy in building and erecting the boiler.

The main part of the footplate rests on top of the rear ends of the main frames; and the narrower extension which carries the "balcony" at the back of the cab, is carried by a special bracket, which can be bent up from 16-gauge steel. A separate illustration of this is given, showing it in the flat. Cut to given size, and bend on the dotted lines; a job easily done in the bench vice. The two narrow strips at the top of the bracket are bent inwards, forming ledges on which the footplate extension rests, and to which it can be attached by screws, with nuts underneath. The bracket itself, when bent to shape, is placed between the rear ends of the main frames, going in for a distance of ½ in. so that the overhang will be 1⅛ in. as shown. Four screws are used at each side, to hold it to the frames, as shown dotted in the plan; the upper two at each side, can also be utilised to hold the back ends of the angles by which the footplate is attached to the frames.

Cab Roof

The roof is a simple job, being just a piece of 18 or 20-gauge sheet metal, bent to the curve of the cab front. The exact length is obtained from the actual job; run a piece of soft copper wire, or lead fuse wire, around the upper edge of the cab front, from one cab side to the other. The slope of the front corners should be cut to suit the angle to which the cab front is bent; and the rear corners are cut away as indicated in the drawing. A gap 2 ins. wide and 2½ ins. long, is cut in the back part of the roof. On the full-sized engines, this opening is made in the middle, and is covered by a sliding top made in two sections, which, when open, is equivalent to the "sunshine roof" of a motor car, and is of great benefit to the enginemen in hot weather. On our little engine, as we cannot ride on the footplate, but must get at the "handles" just the same, the opening is made at the back, giving access to the backhead fittings, and covered, when the engine is not in use, by a single sliding section. Note: I have shown the opening equivalent to the width of that on the full-sized engine; but there is not the slightest objection to the gap being made wide enough to get the driver's hand right in, provided that the sliding cover is made wide enough to close it. The cover slides in two runners, one at either side of the gap; these are strips of brass about $3/16$ in. wide and $3/32$ in. thick, with a rebate about $1/16$ in. wide, milled in each. They extend for the full length of the roof, and are riveted at either side of the gap, as shown in the end view. A rain-strip, of $3/32$ in. half-round wire, is soldered to the roof at each side, in the position shown in the side view.

Doors and Draught Shield

At each side of the cab, at the back end, a piece of angle is attached, to support the doors. This can either be ordinary commercial angle, or bent up from 18-gauge strip metal. It should be 2⅜ in. high, and riveted on, as shown in the detail sketch. The doors are just two strips of 18-gauge metal, measuring 2⅜ in. x ⅞ in. The hinges are bent up from bits of thin strip metal about ⅛ in. wide, attached to door and corner brackets by "pinhead" rivets, or by soldering, which is plenty strong enough where there is neither heat nor pressure to withstand. Stops are fixed at top and bottom, as shown in the plan sketch, to prevent the doors from flying open in the wrong direction.

The shape of the back draught shield plate is shown by dotted lines in the end view. It is made from a piece of 18 or 20-gauge steel or brass, approximately 6⅜ ins. long, and 2⅜ ins. wide, ¼ in. of each end being bent at right-angles, to meet the doors, and the back cut away as indicated. The cutaway part is made to same measurements on both sides of the centre-line, naturally; that will amuse our more experienced locomotive builders, but they would be surprised if they read some of the letters that I receive from novices, who call my attention to obvious items on my drawings to which I haven't made any specific allusion. It is quite on the cards that somebody, without bothering to use his noddle, would cut out half a draught shield, fix it, and then write to me asking where he had gone wrong. Anyway, the shield is cut to shape and bent at the ends, it can be attached to the back of the footplate by a full-length piece of ¼ in. x $1/16$ in. angle. The knobs for supporting the vertical handrails will be fixed in the ends, alongside the doors, but we will see about attending to that later on.

Whistle

Unlike the larger standard locomotives, the class 4's are supplied with single-note whistles of the Great Western pattern, so we can fit our little one with a single-note tube-type whistle, which will give a passable imitation of the "voice of Swindon." The barrel is a piece of thin brass tube about $7/16$ in. diameter, squared off at both ends in the lathe, to a length of 4 ins. One end is furnished with a turned brass plug, which should be a tight push-fit, and may be soldered, to make it airtight. If not airtight, the whistle will sound as though it had a cold. The sound slot is filed about ⅜ in. from the other end, to size and shape as shown. The deflector disc is a ⅛ in. slice parted off a piece of brass rod turned to a tight fit in the tube, and the edge cut away for $1/32$ in. to the width of the slot. The end plug has a ¼ in. x 40 union formed on the end, like those on the boiler fittings. When assembling, put a little bead of solder and a taste of liquid flux, between the plug and the round disc, and heat the whistle over a gas or spirit flame until the solder melts and seals the joints; but be careful to wash out all traces of the flux, in running water.

Two small angle brackets, bent up from scraps of 18 or 20-gauge brass can be soldered to the barrel, and the whistle attached to the underside of the footplate bracket by a couple of screws, as shown, nutted on the inside. A ⅛ in. pipe furnished with union nuts and cones, connects the union on the whistle, with the corresponding one on the whistle valve, nearest the handle. Set the opening so that any water blown over with the steam, can drain out of the barrel, or the whistle will do what the kiddies call "bobble" instead of blowing a clear note.

Running-boards

THE running-boards are attached to the boiler, in the manner adopted on American locomotives; but unlike the latter, are provided with valances. Each side is composed of three sections; one extends from the cab to the smokebox, the second drops down to buffer-beam level, and the third is the short "low-level" section of the front platform. The easiest way to get the correct outline of the upper section so that it is close to the boiler for full length, is to make a pattern from stiff paper or thin card. If a dozen pieces are spoiled, the only cost is the time wasted; but spoiling metal means loss o'bawbees, ye ken! When the pattern is correct, use it as a template to cut out the metal; 18 or 20 gauge steel, or brass if desired, would be suitable. The valance is merely a straight piece of ⅜ in. x 16-gauge steel strip. The running-board may be attached to it either by pieces of angle, or by silver-soldering or brazing. Personally I build up these assemblies by aid of an oxy-acetylene blowpipe with a small tip, using Sifbronze; the job is a jolly sight easier than using a soldering-bit, and it certainly is permanent. The assembly can be attached to the boiler-barrel by small brackets bent from ¼ in. x 16-gauge strip metal, to the shape shown in the front end view, by dotted lines. Rivet them to the running-board, but use 3/32 in. or 7 B.A. brass screws to attach them to the boiler. There is not the least objection to screws in the boiler, as long as the threads are good, and a smear of plumber's jointing is put around them before screwing home, to prevent leakage.

The lower section is made in the same way as the upper. The only difference in the sloping section is that the ends are bent to line up with the horizontal sections; and the attachment to the valance is not made at the edge, but in the centre, as shown by dotted lines in the side view. The sections are joined by butt strips, those behind the valence being shown dotted. Rivet them to one section of the valance, and put a couple of 1/16 in. or 10 B.A. roundhead screws, to simulate the rivets on the full-sized engine, in the other. The horizontal sections, and the fixed section under the front of the smokebox, are joined in the same manner. The latter is merely a flat piece of the same kind of metal used for the running-boards, cut to fit in between the frames, the upper part curved to fit the smokebox, and is attached to a butt strip riveted to the underside of the sloping sections of the running-boards, by screws. The steps are bent from sheet metal and riveted on as shown, no detailing being necessary for that simple job. The low-level sections are attached to the top of the buffer-beam by a couple of screws at each side.

The lower part of the front section must be made removable, in order to give access to the lubricator. This is a very easy job, the piece of metal merely being cut to fit between the frames, and bent to the shape shown in the side view, by the dotted lines. It rests on the lid of the lubricator, and the upper edge should be fitted so that it comes flush with the lower edge of the upper fixed section. Two pegs prevent it from slipping forward when the engine is running. To fit them accurately, just temporarily fix the section in place, mark and centrepop the position of the pegs about ½ in. from each side, and drill right through plate and top of beam with No. 48 drill. Remove plate, open out holes in top of beam with No. 40 drill, cut two bits of 3/32 in. wire, about 5/16 in. long, for pegs, round off one end, turn the other to go through hole in plate, insert, and rivet over; see section.

Front End Steps

Might as well finish off the front end whilst on the job! The steps are made up from sheet metal, the drawing being practically self-explanatory. The back plate and the bottom step are all in one piece, the step being bent at right angles to the back; leave a little tag at each side when cutting out, which is bent up as shown, to prevent the driver's foot slipping off sideways, should there be any oil or grease on the metal—there usually is! Incidentally, in my time on the L.B. & S.C. Railway very few of the enginemen wore boots or shoes with nails in the soles, as a precaution against slipping on smooth steel running-boards, or "gangways" as we called them, and when climbing in and out of the cabs on smooth steps.

The upper step is cut from sheet metal (18 or 20 gauge steel) and may either be riveted or brazed to the back plate. The top is bent over for attachment to the underside of the running-board as shown, and an oval hole is formed under the upper step. A stay, made from strip steel, is riveted to the lower part of the back plate, and the complete assembly erected as illustrated, a nutted screw holding the top angle, and a screw, tapped into the frame, holding the stay.

Buffers

The buffer sockets may be cast, or turned from ⅞ in. square rod. Chuck in four-jaw, face the end, centre, and drill to about 1⅜ in. depth with No. 30 drill, turn down the outside to ⅜ in. diameter for ½ in. length, and screw ⅜ in. x 32. Part off at ¾ in. from shoulder. Reverse and rechuck in a tapped bush in the three-jaw; turn the outside to outline shown, and open the centre hole to ½ in. depth with ⅜ in. drill. Castings are machined up in same sequence. The heads are turned from ⅞ in. round steel; chuck in three-jaw, face the end, centre, drill and tap ⅛ in. or 5 B.A. for the spindle, turn down 9/16 in. length to a sliding fit in the socket, part off at 11/16 in., from the end, reverse in chuck, and finish off the head as shown. Make the pin from ⅛ in. round steel, and assemble as per illustration. Fix with nuts behind the beam.

An alternative way of making the socket would be to use ⅝ in. round steel, leaving the screwed shank ⅛ in. longer. Cut the square flange from ⅛ in. plate, drill and tap a ⅜ in. x 32 hole in the middle, and screw it on to the shank. The four little holes in the square flange are optional. They are intended for those good folk who are fond of rivet and screw heads adorning their locomotives. After drilling them, countersink them at the back, poke a 1/16 in. hexagon-headed screw through each, snip off at the back, and rivet flush. When erected, the buffers look as though they were held on by the weeny screws!

Drawhook and Coupling

The drawhook is a simple exercise in filing, needing no description, as it is made from ⅛ in. steel plate, and all dimensions are given in the drawing. Be sure to round off all the sharp edges, as in full-size practice, so that there is no chance of the hook cutting into the coupling shackles.

The coupling shackles are made from 3/32 in. steel wire. File a flat on the ends of each piece, and bend into a loop with a pair of roundnose pliers. Braze the joints and if the brazing material stops up the holes, just put a No. 40 drill through. The swivels are turned from 3/16 in. round steel rod, the pips at each end being made a fairly easy fit in the holes in the shackles. One swivel is drilled No. 48, and the other drilled similarly, but also tapped 3/32 in. or 7 B.A. The shackles can be sprung over the pips by a little careful wangling.

The screw is also turned from 3/16 in. round steel held in three-jaw; just turn down ½ in. length to 3/32 in. diameter, and screw to match the tapped hole in the swivel. Part off at a full $\frac{3}{8}$ in. from the shoulder, reverse in chuck, and turn down $\frac{1}{4}$ in. of the other end, to fit the hole in the plain-drilled swivel. Drill and tap a $\frac{1}{16}$ in. hole in the middle part, screw a bit of 16-gauge steel wire into it, and screw a ball, turned from $\frac{1}{4}$ in. round steel, on the outer end. The reduced end of the screw is poked through the plain-drilled swivel, and riveted over just sufficiently to prevent it coming out, while allowing it to turn freely. The other end is screwed into the tapped swivel. I nearly forgot to mention that before bending the second loop on the first shackle (the one attached to the drawhook) poke it through the hole in the drawhook; then form the loop, braze it, and bend to shape afterwards. The blacksmith at Brighton Works, in my time, was one of the real old craftsmen; he forged the eyes on the shackles of the full-sized couplings by hand, with the shackle in place in the drawhook.

Make two drawhooks, and two screw couplings, while on the job; then you'll be all set when the time comes to fit a coupling to the tender. There is no standpipe for the vacuum brake coupling-hose on these engines; the hose is attached to a short bit of pipe at the bottom of the buffer-beam, in a manner somewhat similar to the Westinghouse pipes on the old Brighton engines. As the hose is just a useless encumberance in this position, I should advise leaving it off altogether.

Reversing Gear

I may state right here, that whatever anybody asserts to the contrary, an exact small replica of the reversing-gear fitted to the full-size engines, is impossible to make in $3\frac{1}{2}$ in. gauge *as a working proposition*; the parts would be like the works of a wrist-watch. I have therefore compromised by specifying a reversing-gear that operates as in full-size, like turning the domestic wringer, in the way you want the engine to go; but open bevel-gears are used, stout enough to do the job, and the bracket and bearings are made to suit.

THE stand for the main bearing may either be cast, or built up. If cast, it will only need drilling for the shaft, facing the ends, and facing off the feet. To build up, cut the ends from $\frac{3}{16}$ in. brass plate. One is as shown in the dotted lines in the view of the back end; and the other as in the full lines, with a squared end, to which the wheel bracket is attached. Drill a $\frac{3}{16}$ in. hole in the middle of each, with the two pieces clamped together; open out and ream to $\frac{1}{4}$ in. The bearing is a $\frac{3}{4}$ in. length of $\frac{1}{4}$ in. round rod, bronze or gunmetal for preference, chucked in three-jaw, drilled No. 34 and reamed $\frac{1}{8}$ in. Press the ends on to this, making sure both feet are parallel. If the fit is tight, no further fixing is needed; but if at all slack, silver-solder the joints.

The bearing for the wheel spindle is made from a piece of $\frac{3}{16}$ in. brass plate $\frac{11}{16}$ in. long and $\frac{3}{8}$ in. wide, rounded off at one end. Drill and ream a $\frac{1}{4}$ in. hole at the rounded end; and in it squeeze a bush made in the same way as the one described above, but only $\frac{5}{16}$ in. long. In the squared end, drill two No. 41 holes for the screws attaching it to the stand, but don't fix it until the gear-wheels are fitted.

Two $\frac{3}{8}$ in. bevel wheels are needed; any pitch will do, as long as they mesh properly. These are mounted on $\frac{1}{8}$ in. spindles, silver-steel for preference, the ends being turned down to fit tightly in the bosses of the wheels. The outer end of the shorter spindle carries the hand wheel. This can be turned from rod, or may be cast. If the latter, it will only need cleaning up, and drilling for the spindle. If turned from solid rod, a short bit of 1 in. will be required; any metal you fancy will do. Dural makes nice-looking wheels. Chuck in three-jaw, and face off, making the face concave; centre, and drill about $\frac{3}{8}$ in. down with No. 40 drill. Run a parting-tool in on an angle, for a $\frac{1}{4}$ in. or so, then round off the edge, finally parting off at the same angle. Reverse in chuck, face the end till the flat surface is $\frac{1}{4}$ in. diameter, then drive a $\frac{3}{32}$ in. square drift through the hole. This is merely a bit of $\frac{3}{32}$ in. square silver-steel, ground off square at the end, and hardened and tempered. The wheel spokes can be formed by first drilling six $\frac{3}{16}$ in. holes between rim and boss, then carefully filing to shape with a watchmaker's file.

THIS grip can be turned from an odd bit of round dural, rustless steel, or nickel-bronze; leave a pip on the end when parting off, drill a hole in the wheel rim, to take the pip, and rivet it in as shown.* The end of the short spindle is filed square to fit the square hole in the wheel boss, and the end turned and screwed 9 B.A., the wheel being held on by a commercial nut.

The end of the longer spindle is furnished with a jaw or fork, which will form one-half of the upper universal joint. Four of these will be needed, all made to exactly the same dimensions, as shown in the plan and elevation views of the complete gear. They are made from $\frac{5}{16}$ in. square rod. Chuck truly in four-jaw, turn and drill the boss part, then part off at a full $\frac{7}{16}$ in. from the end. The rest is a matter of careful filing; if the boss is held in a small hand-vice the job will be found to be quite easy. It would be advisable to drill the cross-hole before filing, both to make certain that both holes are dead in line, also as a guide when filing the rounded end. One of the jaws can then be pressed on the spindle, far enough to prevent any appreciable end-play, but at the same time leaving the spindle free to turn easily; put a pin through boss and spindle, as shown.

The two parts of the reversing-gear can then be assembled, as shown in the plan view, making sure that the wheels mesh correctly. Adjustment can be made by filing the flat face of the stand, if needed, or moving the wheel bracket longitudinally. When the setscrews are finally tightened, the wheel and spindle should turn freely without any tight spots.

How to Erect the Reversing-Gear

The complete reversing-gear is mounted on a sheetmetal or cast stand, which is attached to the cab side, as shown by dotted lines in the illustration. A cast stand will only require cleaning up with a file. To make a sheetmetal stand, cut out a piece of 16-gauge steel as shown in the drawing, and bend it on the dotted lines, brazing the corners to make it rigid. Drill four No. 41 holes in the cab side, at the approximate positions shown (no need for "mike" measurements!) and countersink them. Temporarily clamp the stand in position inside the cab. If the stand is cast, run the 41 drill through the holes in the cab side, making countersinks on the casting; follow through with No. 48, and tap $\frac{3}{32}$ in. or 7 B.A. If the stand is sheetmetal, drill right through with the No. 41 drill. File off any burrs.

Drill four No. 41 holes in the top of the stand, corresponding to the centres of the feet or lugs; put the gear assembly in place, and temporarily clamp it to the top of the stand. Run the 41 drill through from the underside, and make countersinks in the "soles of the feet." Remove gear, drill the holes, using No. 48 drill, tap 3/32 in. or 7 B.A., replace on stand, and secure with screws put in from the underside as shown. Put the stand in place, and fix that by countersunk screws only, if a casting, or screws and nuts, if made from sheet.

Reversing-shaft and Universal Joints

The next item on the programme calls for a little careful measuring. First, mount one of the jaw fittings on the end of the reversing screw, pinning it as shown for the cab gear. Next, take the distance from the holes in it, to the holes in the similar gadget in the cab; this gives the approximate length of the reversing-shaft between centres. The shaft itself can either be a piece of 3/16 in. steel tube, or a piece of rod drilled up a little way at each end; the length is approximately 7/8 in. shorter than the length between centres mentioned above. One end of it has a jaw fitting rigidly attached to it, by a short piece of 1/8 in. rod, pushed partly into the boss of the jaw, and partly into the end of the tube, or drilled rod. It should be a tight fit in both, and pinned, as shown.

The other end is furnished with an expansion fitting, which allows for any variation in the length between centres, when the engine is hot. A short bit of 1/8 in. rod is pinned into the boss of the fourth jaw fitting, with about 3/8 in. projecting; a 1/16 in. cross-pin is driven into a No. 53 hole drilled in it, as shown. The end of the tube or rod is drilled a sliding fit for the 1/8 in. rod, and the end is slotted with a watchmaker's file, or a key-cutter's warding file, to allow the pin to slide in it. This gives endplay without affecting the drive, and is clearly shown in the illustration.

A hole must now be drilled in the cab front, opposite the end of the reversing-gear spindle, to allow the shaft to pass through; and a long slot must also be cut in the running-board. The location of this can be ascertained by sighting with a piece of thin string stretched between points opposite the end of the spindle in the cab, and the end of the reversing-screw on the motion, in the same way as I have described the method of sighting a drill outside the cylinder, when setting it in the machine-vice on the drilling-machine table, to drill the steam passages. The slot can be formed by drilling a series of holes along the marked place, running them into a slot with a rat-tail file, and finishing with a flat file. A hood, bent from sheet brass of about 24 gauge, could be soldered over the slot, corresponding to the hood over the shaft of the full-sized engines; but this is a refinement that is hardly necessary on the small one.

All that is needed to couple up the shaft, are the two centre-pieces for the universal joints. These are 1/8 in. slices of 3/16 in. round rod, cross-drilled No. 55 and tapped 1/16 in. or 10 B.A. The pins are short bits of 1/16 in. silver-steel, screwed to suit. Put one of the slices between the jaws of each fork on the shaft, screw the pins in through the holes, and cut off any projection, just above the jaws. The shaft can then be placed in position between the reversing gear in the cab, and the reversing screw on the motion, and the remaining pins put in. This is a fiddling job, admitted; the way I do it, is to slot the ends of the pins with a jeweller's saw, and use a magnetic screwdriver, the end of which is reduced to fit the slots in the tiny pins. If difficulty is experienced in putting in the pins with the revers'ng-gear in place in the cab, take it out; pull the jaw, with the spigot attached, right out of the end of the shaft, couple it up to its mate on the end of the reversing spindle, and replace, inserting the jaw spigot in the end of the shaft, and securing the reversing-gear stand in place again. It should now be possible to reverse the motion by turning the hand wheel, without any tight places in the whole of the movement, either way. Don't neglect to "ile the jints," as one of my old footplate mates used to say.

ON full-sized engines, the driver's brake valve is mounted on a square stand, just alongside the reversing gear, the stand also carrying the handles for operating the blower and sanding valves. As it isn't practicable to make a working brake valve in such a small size, we can get the effect by using the stand itself as the working part of the valve; the little handle on top, completing the "illusion." This is how to do it. The main part of the stand is made from a piece of 1/2 in. square brass rod a full 1 3/16 in. long; chuck truly in four-jaw, face the end, centre, and drill right through with 1/4 in. drill, opening out to 7/16 in. Reverse in chuck and face off the other end to dead length. On the centre-line of one of the facets, at 3/4 in. from the end, drill a 5/32 in. hole, and fit a 7/32 in. x 40 union nipple in it, silver-soldering the joint.

For the top fitting, chuck the rod again, and turn down 1/4 in. length to a tight fit in the body. Part off at 5/16 in. from the end; chuck in three-jaw by the turned part, centre, drill through with No. 30 drill, open out and bottom to a bare 1/4 in. depth with 7/32 in. dr'll, and tap 1/4 in. x 40. Make a gland to suit, from 5/16 in. hexagon rod. Drill a No. 51 hole in each corner of the square. For the bottom fitting you need a chunk of brass 5/8 in. wide, 3/4 in. long, and 1/4 in. thick, or a casting. Scribe a line across th's, 1/4 in. from the long side, and make a centrepop in the middle of it. Chuck in four-jaw with this pop running truly, and turn down 5/32 in. of it to a tight fit in the body. Face the end truly. Chuck by spigot in three-jaw, and take a skim off the bottom, to true it up. Drill the eight No. 51 screwholes as shown, four for attaching the base to body, and the other four for screwing down to cab floor. Set out and drill the holes for pipe and union screw, but only drill in about 1/16 in. depth. On top of the round blob, set out and drill the two ports, going right through into the larger holes, as shown in the section. Fit a short length of 1/8 in. pipe into one hole, and a 1/4 in. x 40 union screw in the other, silver-soldering both.

For the valve, chuck a piece of 7/16 in. bronze rod, and take a skim off it for about 3/8 in. length, so that it fits easily in the body. Turn down 1/8 in. length to 1/4 in. diameter, and part off at a full 1/4 in. from the end. Reverse in chuck, and take a truing skim off the contact face. Slot the boss as shown, drill the steam port right through, and form the recesses. The middle one is merely a countersink. The sausage-shaped one can be formed by making a countersink at each end with a No. 48 drill, and chipping or scoring a groove between the countersinks. True up both valve and portface by rubbing on a piece of fine emerycloth or other abrasive, laid on the lathe bed or drill table.

The spindle is a piece of 1/8 in. rustless steel or bronze, with a tongue filed or milled at one end, to fit easily in the valve slot. The upper end is squared, reduced and screwed to sizes shown, to fit the square hole in the handle, which is filed up from a bit of 3/32 in. flat steel and needs no detailing out. The collar is a 3/16 in. slice of 1/4 in. brass rod with a No. 32 hole drilled in it.

To assemble, put a smear of plumber's jointing around the boss on the base, press it in, and secure with a screw in each corner hole; see that the pipe and union are arranged in relation to the side union, as shown in the drawing. Put a spot of cylinder oil on valve and portface, and drop the valve into the body. Put the collar on the spindle in the position shown, and insert with the tongue in the valve slot, putting the cap on temporarily. If the spindle has about 1/32 in. endplay, O.K., if not, adjust collar until it has, then pin the collar to the spindle, and attach the cap with four countersunk screws as shown. Pack the gland with a strand of graphited yarn, and fit the handle.

The completed valve is then erected in the cab, in the position shown in the drawing previously published, showing the cab fittings. Attach it to the footplate by four screws, nutted underneath the footplate. Holes must, of course, be drilled in same for the pipes. The bit of pipe on the left side is left open. The union underneath is connected to the union on the brake cylinder by a 1/8 in. pipe furnished with union nuts and cones. The union on the side of the stand is connected to the screwdown valve on the right-hand side of the backhead, as shown in the view of cab fittings mentioned above, by a 1/8 in. pipe with cones and nuts. When this valve is open, there is always steam pressure in the stand. To apply the brake, the handle is turned clockwise until the through port in the valve registers with the right-hand port in the face. Steam then passes through both ports direct to the brake cylinder and operates the brake gear. To release, the handle is returned to its original position, which cuts off steam from the brake cylinder, and brings the sausage-shaped recess over the two ports in the face; steam from the brake cylinder then comes up through the pipe, passes through the recess into the other port, and thus escapes to the atmosphere, the pull-off spring releasing the blocks from the wheels.

Final Engine Details

The cab handrails are made from 3/32 in. nickel-bronze (German silver) or rustless steel wire, the upper end being flattened, drilled, and riveted to the cab roof as shown. It passes through a handrail knob of the usual kind, attached to the side of the draught shield by a nut. The bottom end is bent inwards and passes through a hole drilled at the bottom end of the draught shield; a washer can be placed on it and the lot soldered over.

The handrails along the side of the boiler are shown in the general arrangement drawing and no separate details are needed. The handrails can be made of the material mentioned above, and the knobs either turned with a form tool, as described in detail for previous locomotives in this series, or purchased from our approved advertisers at a cheap rate. They are screwed into tapped holes in the boiler shell with a taste of plumber's jointing on the threads. Tip—to ensure that they are put in straight and level, stand the engine on a level surface, and with a scribing-block having the needle set at the right height, scribe a line along each side of the boiler. Set out and drill the tapping holes for the shanks of the knobs along these lines, and there should be no trouble about their being O.K.

I have shown, as a matter of convenience, the complete arrangement of drawbar between engine and tender, but the engine part might as well be fitted right away. It merely consists of a 1 in. length of steel angle of the size shown, attached by three 3/32 in. iron rivets, under the drawbar slot in the drag beam. A 3/16 in. hole is drilled through the top part of the beam and the angle; and a pin, turned to suit the hole, from 5/16 in. round steel, keeps the drawbar in place. The bar is merely a bit of 1/8 in. x 3/8 in. mild steel bar, rounded at the ends and drilled as shown. Well, that completes the engine part of the business; now we can go ahead and make a suitable tender.

Starting the Tender

WITH the exception of the tender fitted to the new class 8 three-cylinder passenger locomotive, the tenders fitted to the standard B.R. types are all of the same pattern, though differing in size. Personally I think they are ugly; the utilitarian aspect could have easily been retained, with a much more aesthetic outline. However, that is no concern of your humble servant's; we are making a reasonably close copy of the full-sized 75000, so I have shown in the drawing, the type of tender provided, but I have simplified the construction and details, to suit the little 3½ in. gauge engine, although the basic construction is the same. In the usual type of tender, as described in this series for other locomotives, the body is built up on a soleplate, to which all the internal fittings are attached. In this one, there is no soleplate; the two sides, bottom, and the sloping part of the top, at each side, are bent up from a single sheet. Neither is there a coal plate forming the tank top; instead, the coal bunker is made like a hopper, and let into the body, being supported from the upper part of the sides. However, in the simplification process, I have managed to incorporate the usual type of easily-made frame, plus the internal blobs and gadgets which I always specify; so there should be no difficulty in making up a tender which looks right, yet is much simpler than a reduced copy of the original. The reproduced drawing will show that there is not much amiss with the appearance!

Tender Frames

To make the frames, two pieces of 13-gauge (3/32 in.) soft sheet steel will be needed, 16 in. long and 2¾ in. wide. Mark out one sheet as per drawing shown, drill a couple of the rivet holes through both plates, temporarily rivet together, then saw and file them to the given outline, exactly as the locomotive frames were made. The frames may either be secured to the beams by angles, screwed and riveted, or brazed;

and if the latter process is the one you fancy (it is the easier by far!) the four holes at each top corner need not be drilled. The No. 30 holes to the rear of the middle and trailing axlebox openings, are set at the same distance as shown in the dimensioning of the one behind the leading opening: they are for the brake-hanger pins. The 1/4 in. hole ahead of the leading opening, at the bottom of the frame, is for the brake-shaft bush. The easiest way to cut the oval openings between the wheels, is to use a spiral blade, or an Abrafile, in your hacksaw frame. Before parting the frame plates, mark on them, which is the outside, as the horncheeks are fitted outside.

Horncheeks

The horncheeks can either be castings, or made from brass angle. If the former, they only need cleaning up with a file, drilling for rivets, and attaching to frames. Horncheeks made from angle will need filing to shape, naturally, but the ribs are optional. The easiest way to make and fit ribs is to nick right across the outside, on the corner of the angle, to the required depth, using a keycutter's warding file; let in a strip of brass, so that it projects through into the inside corner of the angle, like a rib, and silver-solder it in place. File flush on the outside. If all the nicks are made at one fell swoop, then the strips fitted, and the lot silver-soldered at one heat, the job takes very little time. Built-up horncheeks are drilled same as cast ones, and then riveted to the frames, each side of the axlebox openings by 1/16 in. rivets. When doing this job, I always put a bit of bar, same width as axleboxes, in the opening; set

THE beams can either be made from angle, or cast; if the latter, they will have fixing angles cast on, and should only need cleaning up with a file. The slots for the frames will need cutting as shown, and this can be done by planing or milling. If a regular machine isn't available, the job can be done in the lathe, using a 5/32 in. saw-type cutter on an arbor between centres, and holding the beam at the correct height, in a machine-vice, regular or improvised, on the lathe saddle. If no machine or cutter is available, use a thin flat file, holding the beam in the bench vice in a vertical position, with the marked line of the slot level with the vice jaw. Same will then form a guide. The frames are attached to cast beams with screws, through the clearing holes in frame, engaging in tapped holes in the beam lugs.

If steel angle is used for beams, and the frames brazed into them, no angles are necessary. Just jam the frames into the slots, line up carefully, so that the frame and beams form a perfect rectangle, and clamp lightly in place. Don't put pressure on the frames lengthwise, or the lot will just buckle and distort when redhot. I use a distance-piece across the middle of frames, with a clamp over the lot, which keeps the frame plates in line; the beams are prevented from parting company with the frames, by some binding wire wound around them and the distance-piece. A spot of Sifbronze in each corner, applied by aid of an oxy-acetylene blowpipe, and the job is done in two wags of a dog's tail. If a blowlamp is used, anoint the corners with wet flux, heat the whole beam and adjacent parts of the frames, to bright red, and apply a bit of thin soft brass wire to the joints. This will melt and form a fillet along the slot, and also where the end of the frame touches the beam. Let cool to black, quench out in cold water only, and clean up.

For angle erection, cut four pieces of 3/4 in. x 1/8 in. angle, each a full 7/8 in. long, and rivet them to the beams, alongside the slots, as shown in the plan view of the frames. If a small piece of 5/32 in. frame steel is jammed in each slot, and the angle held to it by aid of a cramp, whilst the rivet holes are being drilled, there won't be any chance of the angles being fixed in the wrong position. Countersink the rivet holes on the outside of the beams, hammer the stems flush, and file smooth. File the bottom edges of the angles level with the bottom of the beam.

To erect, jam the frames in the slots and carefully line up the frames, taking care that the beams are square with them, the whole assembly forming a perfect rectangle. Lay it upside down on the lathe bed, drill table, or something equally flat and true, and make certain that the edges make contact with the flat surface for their full length. Then put a cramp over each angle; run the 30 drill through the holes in the frames, making countersinks in the angles; follow with No. 40 drill, tap 1/8 in. or 5 B.A., and put screws in. Hexagon heads may be used if desired.

Springs

Cast dummy leaf springs are not only easy to fit, but have the correct appearance; and if fitted up with the spring plungers as shown, the action is quite O.K. Castings are available with the spring brackets all in one piece. The contact side of the brackets can be cleaned up with a file; but I do mine on a linisher, or surface grinder, using a medium-grade emery band. They can also be rubbed true on a piece of medium-grade emerycloth, or other abrasive, laid on something flat, as the contact side should bed truly to the frames. The dummy rivet-heads will be cast on, but holes must be drilled for the fixing rivets, using No. 30 drill and countersinking them.

If the face of the casting isn't clean, teach it better manners with a file; then drill the hoop or buckle with a 5/16 in. drill as shown. To make the plunger, chuck a bit of 5/16 in. round rod in the three-jaw, and skim about 7/8 in. length, until it slides easily in the hole in the hoop. Centre, and drill with 7/32 in. or No. 3 drill, to 3/8 in. depth; part off at a full 7/16 in. from the end. Reverse in chuck, and slightly round off the blank end. Put a spring wound up from 19-gauge tinned steel wire (piano wire) in the cup, and assemble as shown; the spring should just start to compress when

$\frac{3}{16}$ in. of the plunger is showing.

To erect, place each spring with the bottom of the hoop level with the top of the axlebox opening, and in the middle of it; the spring must, of course, be exactly level. Clamp in place with a toolmaker's cramp, run the No. 30 drill through the frame, using the holes in the spring brackets as guides, and rivet in place with $\frac{1}{8}$ in. iron rivets, as shown in the plan view of the assembled frames.

CASTINGS should be available for the axleboxes, and will probably come in a stick. If so, and your lathe cross-slide has sufficient traverse, or—better still—a milling machine is available, the grooves at either side can be milled out at one go. On the miller it can be done with a side-and-face cutter, $\frac{1}{2}$ in. wide; but on the lathe, go to work exactly as I described for the engine axleboxes, with the boxes clamped under the lathe tool-holder, or to a vertical slide, at the correct height, so that a $\frac{1}{2}$ in. endmill, or slot-drill, can take out the surplus metal at one cut. Grip the cutter in the three-jaw, set into cut by moving the topslide handle, and traverse it across the cutter by operating the cross-slide. If the latter hasn't enough movement to do the stick of boxes at one go, saw the stick in half, but be careful to machine both halves to exactly the same dimensions.

Failing castings, the boxes can be made from bronze or gunmetal bar, of $1\frac{3}{16}$ in. x $1\frac{1}{8}$ in. section, or nearest larger, a piece about 6 in. long being required. This is grooved in exactly the same way as just mentioned, the groove being made in the narrower side, at $\frac{1}{16}$ in. from the edge. If it can't be done at one setting, cut in half as before. Six $\frac{7}{8}$ in. lengths are then parted off in the four-jaw, or else sawn off to full length, then chucked separately in the four-jaw, and faced both ends to dead length. Each length is then chucked truly in the four-jaw, with the wider flange outwards; the dummy axlebox cover, of domed shape, is then turned to size shown. The full-sized covers are attached by four screws; and if it is required to imitate these on the small boxes, drill four No. 55 holes at the locations shown, tap $\frac{1}{16}$ in. or 10 B.A., and put screws in, using either round or hexagon, as you may fancy. Cast boxes will have the domed covers, with dummy screws, ready cast on, and will only need cleaning up, which can be done with a stiff wire brush, or a file card.

The blind hole for the journal part of the axle must be drilled dead square with the sides of the box; if a drilling machine is available, hold the box in a machine-vice on the table and set the face dead level. Failing that, make a deep centre-pop in the middle of each box, and chuck in four-jaw with the centre-pop running truly; start with $\frac{1}{8}$ in. drill and then open out with $\frac{5}{16}$ in. drill. My pet way of setting jobs truly in a machine-vice is to lay the piece on the drilling-machine table, with the face to be drilled resting on the table. The jaws of the machine-vice are then opened enough to go over it, the vice being upside down, and the jaws are tightened on to the work while they are resting on the table. When turned up the right way, the work will be found dead level with the tops of the vice jaws and O.K. for true drilling. To set work truly in the four-jaw, I just bring up the tailstock with the centre-point in it, hold the work with the centre-pop over the point, and tighten the jaws carefully on to the work. These simple tricks ensure a great saving of time.

Drill a $\frac{1}{16}$ in. oil hole from the top of each box into the journal hole, as shown, and countersink it. The boxes can then be fitted to the horns, slightly rounding off the upper edge of each side groove, to allow the boxes full play, right to the top of the openings. Mark each box on the back with a figure-punch or dots, so that when removed the boxes can always be correctly replaced. They are prevented from falling out of the openings by hornstays made from $1\frac{3}{4}$ in. lengths of $\frac{3}{16}$ in. x $\frac{1}{16}$ in. steel strip, secured to the frames below the horn-cheeks by $\frac{1}{16}$ in. or 10 B.A. roundhead screws.

Wheels and Axles

As the wheels and axles are machined up in exactly the same way as those on the engine there is no need to detail out the whole rigmarole again. Just chuck the wheels, back outwards, in the three-jaw, and face the back and boss, taking a cut over the edge of the flange, to bring it true. Centre, drill through boss with $\frac{19}{64}$ in. drill and ream $\frac{5}{16}$ in. Reverse in chuck, gripping by flange, and turn the face and boss, putting the rebate in at the edge of the spokes with a parting tool. Finally, mount on a screwed peg in a small improvised faceplate held in three-jaw, and turn treads and flanges, finishing each with the same setting of the cross-slide, so that they are all the same diameter.

The axles can be turned from $\frac{3}{8}$ in. round mild steel, held in three-jaw. If the chuck is a shade out of truth, it doesn't matter, as wheel-seat and journal are turned at the same setting. This allows of an easy way of getting a press fit for the axle in the wheel boss. The combined length of wheel-seat and journal is 1 in. Chuck a piece of $\frac{3}{8}$ in. steel, approximately $5\frac{3}{8}$ in. long, in the three-jaw, with about $1\frac{1}{4}$ in. projecting. Face the end and turn down a full 1 in. to a wee bit under $\frac{11}{32}$ in. diameter. Now very carefully reduce $\frac{1}{2}$ in. of this, until it will just slide into the reamed hole in the wheel boss. Note the setting of the "mike" collar on the handle of the cross-slide; or if it doesn't possess a graduated collar, note carefully the exact position of the handle. Now turn the remaining $\frac{1}{2}$ in. of the projecting wheel seat, until the "mike" collar shows the slide to be within one division of the reading previously noted, or until the handle is just short of the position in which it was when the first $\frac{1}{2}$ in. was finished. The second $\frac{1}{2}$ in. should then be a squeeze fit for the wheel boss. It must not be too tight or the boss will split when the wheel is pressed on; these small bosses split very easily. Slightly round off the end.

When all the axles have been turned thus, press on all the wheels by aid of the bench vice, as previously described for the engine; then take a pair of axleboxes out of the frames, put them on the journals outside the wheels, replace the lot, and put the hornstays on. Each pair of wheels should spin quite freely; if they don't, take them out again and ease the holes in the axleboxes with an expanding reamer, or grip one journal in the three-jaw, run the lathe at its highest speed, and apply a fine file to the other journal, which should do the needful. The chassis thus far completed should run very freely if placed on the rails and given a push, the wheels running absolutely true on the axles, with no sign of wobble; we can then proceed with the body or tank.

AS mentioned in the opening paragraph about the tender, there is no soleplate under the body, the bottom, sides, and the upper slope at either side of the body being bent up from a single sheet. This should be of 18-gauge sheet brass or copper, and a piece 14⅜ in. square will be required. Draw a line down the middle of the sheet, and at 3¼ in. at either side of it, draw another; that will locate the bottom bends. At 2¾ in. beyond those, draw two more, which will give the position of the upper bends. The easiest way to bend the sheet to shape, if a bending machine isn't available, is to remove the hard steel jaws of the bench vice, and in their place put two pieces of stout bar, not less than 15 in. long. The edges should be slightly rounded. If the sheet is gripped between these, it can easily be bent at right angles. If the vice is too small to allow sufficient depth of metal to go below the jaws, the alternative would be to use two pieces of bar long enough to project beyond the jaws. To enable the outer ends to grip the metal tightly, a hole about ¼ in. diameter could be drilled through them, and a bolt put through. Before I had my Diacro bending brake, I made a bending-iron from 1 in. square bar, using a piece about 3 ft. long. The middle part was heated and flattened out for about 2 in. and bent into a loop, the bar then looking like an overgrown split-pin. A ⅜ in. bolt was put through the free ends. To bend a sheet, I put it between the bars, tightened the bolt, and gripped the bars in the bench vice with the metal as close to the vice as possible; a piece of hard wood held against the metal, and hit with a hammer, soon made a good bend.

To get the upper bends, which are on a wide radius, put two bits of round rod between the jaws of the vice, with the metal between them. It should be fairly easy to form these radius bends by hand pressure alone, especially in copper.

The end plates are cut from the same kind of metal. Pieces of angle brass are riveted along the bottom and sides as shown, at a bare 1/16 in. from the edge, for the back plate, and at the bottom only, for the front plate. Both plates are cut to the outline shown in the cross sections: and the back one is let in flush with the end of the body, and riveted to the angles, the joint being soldered over to make it watertight. Another piece of angle is riveted along the top, to support the tank cover.

The front plate needs a rectangular hole cut in it, as shown, at 1⅝ in. from the bottom, for the coal gate. It also has a channel at one side, to accommodate the brake spindle. This could be formed in one piece with the plate, by pressing: but it will be found an easier job, for the average home worker, if the trough or recess is made separately, and riveted on in the position shown. A sketch is given, showing the shape and dimensions of the piece of metal needed to make the trough. Cut it out, and bend the middle part around a piece of ½ in. rod, to form the trough, then bend the sides at right angles to form the flanges, by which the trough is then riveted to the back of the plate. Don't cut away the metal at the front yet, as this can be done when the brake spindle is erected, and only enough need be removed, to clear the spindle. A piece of angle is riveted on the back, level with the bottom of the coal gate opening, and the plate can then be inserted, and riveted and soldered.

Coal Hopper

The coal hopper is rather tricky to make, as it is parallel at the top, but not only slopes inwards towards the front, but the bottom is inclined as well. Anybody who had a thousand or so of them to make, would stamp them out of one piece, on a machine with punch and die of correct shape, like fancy tin boxes, or motor car wings; but we shall have to resort to building up, for the one-off job. The piece forming at the back and bottom, is marked off on a piece of 18-gauge brass, and cut out and bent to the shape shown in the illustrations. At 1¾ in. below the top of the curve, rivet a piece of angle-brass, to support the front end of the tank cover; see longitudinal section, also plan. After bending, place temporarily in position in the body, with the front end resting on the piece of angle under the coal gate, and the back jammed between the curved-in sides, which it should fit tightly.

The easiest way to get the exact shape of the sides of the hopper, is to cut paper patterns. Stiff paper is needed, or very thin card. When a child, I acted as living dummy for a local dressmaker, to earn a few coppers (we were very poor indeed) and the woman taught me much of her trade; I have found the paper pattern part very useful in locomotive building, something which poor Dorcas never imagined! If you spoil 50 pieces of paper the cost is negligible, and the only waste is your time; but if you spoil only one piece of brass or copper—nuff sed! Mark off, cut out, and bend your pattern (call it "template" if you happen to be "precise!") as shown in the drawings, for each side of the hopper, and try them in. If they don't fit, you'll see at a glance where they need alteration; and when you get them O.K. simply flatten them out and use them as guides to cut the pieces of sheet brass to correct size. These can then be bent to shape, and should fit properly. One place where the pattern will be found especially useful, is in locating where the side of the hopper has to be cut, to clear the brake-spindle trough.

It is a good wheeze to tack the sides of the hopper to the bottom, with a little solder in several places, so that the whole bag of tricks can be removed in one piece, to rivet or screw the joints, and solder over the lot, to make it watertight. In the cross section, I have shown the bottom edges of the hopper sides bent to form flanges, on which the bottom plate rests, and is attached by screws: but as an alternative, the hopper sides could be cut flush with the bottom, and the joints made with full-length pieces of brass angle, riveted and soldered. The angle should be home-made from strips of soft brass sheet bent in the bench vice to the correct angle of bottom and side of the hopper, 1/16 in. brass or copper rivets should be used for fixing.

Fittings Inside Tank

Before fitting the hopper permanently, there is a little work to do inside the tank. First of all, fit the tank temporarily to the chassis. Drill holes at 2 in. centres, all along the pieces of angle riveted to the top of frames. Set the body on the chassis, in the position shown in the general arrangement drawing, and clamp it temporarily in place, then run the drill through the holes in the angle, carrying on right through the bottom of the body. Use No.

40 drill. The 3/32 in. or 7 B.A. brass screws which will go through these, to fix the body permanently, need not be put in until the body is nearly ready for permanent erection, as the heads have to be soldered over to make them watertight.

Next, drill the 1/4 in. and 3/8 in. holes in the tank bottom, as shown in the plan view. Over each of the 3/8 in. holes, solder a piece of 16-gauge brass about 1 in. square, to thicken up the part where the fixing screws which hold the strainer flanges, are tapped into the tank bottom; run the 3/8 in. drill through these, using the holes already drilled, as guide. The 1/4 in. holes don't need any thickening pieces, but clean off any burring from all the holes. The fittings can then be made, all ready for erection. These consist of two strainers, one for the engine pump and one for the injector; the union elbow for the hand pump and the bypass fitting.

The strainer fittings, which have square flanges, can be made from castings, or from rod material. If the latter, either 5/8 in. square brass rod can be used, or 3/8 in. rod with separate flanges of 3/32 in. sheet brass. The 5/8 in. square rod can be chucked truly in the four-jaw, faced off, and turned to a full 1/4 in. diameter for 3/8 in. length. Part off at a full 1/4 in. from the shoulder, repeating operations for No. 2. Re-chuck the turned part in three-jaw; centre, and drill down for 1/2 in. depth with No. 40 drill. Turn down 5/32 in. of the outside to 3/8 in. diameter, then further reduce 1/16 in. to 1/4 in. diameter. Round off the corners of the square, and drill the four screwholes. At 3/16 in. from the bottom, drill a No. 23 hole in the side, and silver-solder a piece of 5/32 in. pipe into it, approximately 5½ in. long. The strainer is rolled up from a bit of fine brass or copper gauze, and fitted over the 1/4 in. spigot. A touch of soft solder will keep it in place. If 5/8 in. square rod isn't available, chuck a bit of 3/8 in. round rod in three-jaw, and turn down a bare 1/2 in. length to 1/4 in. diameter; part off at 5/32 in. from shoulder. Reverse in chuck, and drill as above, turning a spigot on the end for the gauze strainer. Cut out a piece of 3/32 in. sheet brass, 5/8 in. square, round the corners, drill the screwholes, and drill a 1/4 in. hole in the middle. Press it on to the 1/4 in. neck of the fitting, fit the pipe, and silver-solder pipe and flange at same heat.

For the hand pump elbow, chuck a bit of 3/8 in. round rod in the three-jaw, face the end, centre deeply, and drill a bare 7/8 in. depth with No. 40 drill. Turn down 7/16 in. of the outside to 1/4 in. diameter, and screw 1/4 in. x 40. Part off at 1/2 in. from the shoulder, drill a 5/32 in. hole in the side, and fit and silver-solder a 1/4 in. x 40 union nipple into it, as shown in section. The bypass fitting is made in similar fashion from 3/8 in. rod, but the bottom part is turned down and fitted with a similar pipe to those in the strainer fittings. The upper part is opened out with No. 23 drill for 1/8 in. depth, and a piece of 5/32 in. pipe 7¼ in. long, silver-soldered into it.

THE hand pump shouldn't be needed when an eccentric-driven pump and an injector are fitted, but I always specify one, as a kind of insurance. If the fire is let down, with low water, and steam pressure drops too low either to run the engine or work the injector, the hand pump comes in handy. As the one shown in the drawing is of the usual pattern which I have specified for practically all engines in this series of notes, there is no need to go into full details of construction again; a brief run-through should suffice.

The stand can be a casting, or bent up from a piece of sheet brass approximately 4½ in. long and 1 in. wide. Drill the holes for the barrel with 31/64 in. drill, and carefully ream with the "lead" end of a 1/2 in. parallel reamer, to a tight fit for the barrel, which is a 1 7/8 in. length of 1/2 in. brass tube. If this isn't smooth inside, make it so by running it up and down an improvised lap made by winding a piece of fine emery cloth around a stick, to a loose fit in the tube, and holding same in the three-jaw. Run the lathe as fast as possible while lapping the tube. The valve box is made in the same way as that for the engine pump, from a 1 in. length of 3/8 in. brass rod; but there is no union at the bottom. Just cross-nick the hexagon cap of the bottom valve seat fitting, as shown in the section. Drill a 5/32 in. hole in the middle of the valve box, and tap it 3/16 in. x 40. Chuck a piece of 1/2 in. round brass rod in three-jaw, face the end, centre, and drill down about 1/2 in. depth with No. 40 drill. Turn down 1/8 in. of the end, to 3/16 in. diameter, and screw 3/16 in. x 40. Turn the next 1/4 in. to a very tight fit in the pump barrel, and part off at 3/16 in. from the shoulder. Squeeze the plug into the pump barrel, screw the valve box on to the pip, insert barrel into holes in stand as shown, and solder the joints; this will be quite strong enough, as there is no heat to worry about.

If a piece of 7/16 in. brass or gunmetal rod is an easy sliding fit in the barrel, it may be used without any turning, as the pump ram doesn't have to be such a precise fit as a piston in a cylinder. Otherwise, turn the ram from a bit of 1/2 in. rod held in three-jaw. A groove 3/16 in. wide and about 1/8 in. deep, is turned at 1/8 in. from the end. The other end is slotted 1/8 in. for the pump lever, by the same process as described for slotting valve-gear forks; the pinhole is drilled No. 43. The lever, and the anchor lug, are made from 1/8 in. x 1/4 in. rod, nickel-bronze (German silver) for preference, though brass will do. To make the anchor lug, chuck the rod truly in the four-jaw, and turn down 5/16 in. of the end to 1/8 in. diameter, screwing 1/8 in. or 5 B.A. Part off at 7/16 in. from the shoulder, round the end, and drill a No. 41 hole for the pin. The twin links are cut from 1/4 in. x 1/16 in. brass, drilled No. 43, and pinned to the lever and lug by pieces of 3/32 in. drawn bronze rod. The whole bag of tricks is then assembled as shown. Drill four No. 30 holes in the bottom angles, and attach the pump, in the position shown in the longitudinal section, to the tank bottom, by four brass screws, 1/8 in. or 5 B.A., nutted underneath. The union on top is connected to the union on the elbow fitting, by a swan-neck of 5/32 in. pipe, as shown, furnished with union nuts and cones at each end.

The pump is operated through the filling hole, by an extension handle made from a piece of the same section rod as used for the pump lever, with a socket on the end as shown. The socket may be either a 1½ in. length of commercial rectangular tube, or made by bending a piece of 16-gauge sheet brass around the handle, and silver-soldering the joint. It should be a fairly easy fit on the pump lever.

THE shovelling plate is made from a piece of 16-gauge steel or brass, cut out to the shape and dimensions shown n the detail illustration, and bent on the dotted lines as indicated. To keep the sliding gate in place, rivet a 3/16 in. strip of metal at each side of the uprights, a full 1/16 in. from the back; the complete unit can then be attached to the tender front plate, over the rectangular hole, by three screws as shown, running into tapped holes in the front plate and the inside angle. The gate itself is simply a piece of metal cut to fit between the runners, and furnished with a lifting knob turned from an odd scrap of brass or steel. Leave a pip on the end when turning the knob, drill a hole in the plate to take the pip, and rivet over the end. This is not the same as the full-sized job; but with a tender front made in the same manner as the big engine, you wouldn't be able to get at the handles, nor the firehole. The trouble is that we have to drive from a car behind the engine, as we cannot ride on the footplate; and matters have to be arranged accordingly.

The tank cover is a piece of 16-gauge sheet brass, measuring 4½ in. x 4⅝ in. It is supported at front and back, by the angles already attached. To support the sides, rivet a ⅜ in. strip of 16-gauge brass along each side of the opening, as shown in the plan, and bend the projecting part horizontal, to allow the cover to lie flat. The cover is attached to the angles and strips, by 9 B.A. roundhead screws, which run through No. 48 holes drilled along the edges, into corresponding tapped holes in the angles and strips.

A rectangular filler is provided, through which the hand-pump can be operated if required, and this has a hinged lid. Cut a hole in the cover, 2 in. long and about ⅞ in. wide, as shown in plan; leave the corners rounded. Bend a strip of 18-gauge metal, 5/16 in. wide, to the shape of the hole, with the joint in the middle of one of the short sides. Fit this in the hole with about 3/16 in. projecting above the cover, and solder it around on the underside. The lid is cut out of 16-gauge metal, to the shape shown in the plan; leave two ⅛ in. lugs, ½ in. apart, at one end, which can be bent into loops, to form part of the hinge. The middle section of the hinge is made from a ½ in. strip of metal, with one end bent around to match the loops, a pin being put through the lot. The strip is attached to the tank top, as shown in the section and plan views, by two 9 B.A. screws, which may be nutted underneath, for extra strength.

Erection of Body

The tank can now be erected on the chassis, by standing it in place, and putting brass screws through the holes in the bottom, and the corresponding holes in the angles at the top of the frames, and nutting them underneath. The screwheads should be soldered over, to prevent water leaking through. The complete hopper can then be placed in the tank, and the upper edges set level, with the front end resting on the angle at the back of the coal gate. Scribe a line right along each side of the projecting part of the hopper, level with the tank top; remove hopper, and rivet a length of 5/32 in. angle along each side, level with the line, as shown in the cross section. This angle should be small and neat; as it is obtuse, ordinary commercial angle isn't suitable, but it can easily be bent up from thin sheet copper in the bench vice, if a bending machine isn't available. The hopper can then be replaced, and fixed permanently. The front edge should be attached to the angle at the back of the coal gate, by three countersunk brass screws; and the little angles at the sides, along the top of the tank, can be attached to the tank sheet by a few 1/16 in. roundhead brass screws. All the joints can then be soldered over, to prevent leakage of water; take special care at the place where the trough for the brake spindle projects through the side.

All that then remains is to attach the fittings. The strainers for the engine pump and injector feeds are just pushed through the ⅜ in. holes in the bottom of the tank, setting the pipes parallel; run a No. 43 drill through the holes in the flanges, and make countersinks on the tank bottom. Drill through the countersinks with No. 51 drill, tap 8 B.A., and attach fitting with 8 B.A. brass screws, putting a gasket of 1/64 in. Hallite or similar jointing between the contact faces. The other fittings are simply poked through the ¼ in. holes and fixed with the locknuts, as shown. If preferred, the fittings can be attached before the hopper is put in, which will give more room to get at the nuts, and adjust and bend the overflow pipe, the end of which should be set so that the discharge can be seen through the filler hole.

The engine pump and injector feed pipes, and the bypass pipe below the tank, should be set to the curve shown in the longitudinal section, and prevented from moving about, by little clips made from narrow strips of metal, as shown, which are attached to the tank bottom by screws. Pieces of rubber hose, to fit on fairly tightly, are slipped over the ends, to make connection with the corresponding pipes on the engine. These hoses are known as "feedbags" among the enginemen. As there is no pressure to withstand, the slip-on fit is quite satisfactory. Where possible, I use different coloured pipes to save any error when connecting up "on the quick"; red for pump feed, white for bypass, and black for injector. As the hand-pump pipe has to stand pressure, I usually specify a metal pipe, with a coil in it to ensure flexibility on curves; but in the present instance, a cycle pump connector can be used in place of the coil. A short piece of pipe, about 1 in. long, with a union nut and cone to couple to the pipe on the engine, is screwed and soldered to one end of the connector; and a similar pipe, bent as shown, to the other end, for attachment to the union on the elbow fitting. The length of this must be made to suit the length of the connector. The next item will be the brake gear, and then the final trimmings.

THE tender brake gear on the full-sized engines, is arranged for either hand or power operation; and this is provided for by a link arrangement on the handbrake spindle. On the small engine, this is not necessary, and it is possible to simplify the actuating arrangement, by dispensing with the links and substituting a plain spindle as shown. The actual brake gear is pretty much the same as the full-sized version. Adjustment is provided for, on the leading pull-rod, by a sleeve with right-and-left-hand threads, with lock nuts. There is no compensating gear, pull-rods and brake beams being directly connected by special long forks, which are clearly shown in the plan view. In the opinion of many firemen, the bevel gear at the top of the brake spindle is unnecessary; they say they could get far more leverage with a vertical spindle with the handle directly on top of it, as is usual practice. However, as the full-sized engines have the bevel drive, I have specified it. The construction is fairly simple, and I have shown all details separately.

Brake Spindle and Bracket

The actual brake spindle is a piece of 5/32 in. round steel rod, approximately 5¾ in. long, with about an inch of 5/32 in. x 32 thread at one end; the opposite end is turned down for ⅛ in. length, to a shade under 3/32 in. diameter and screwed 8 B.A. The brake spindle bracket is made in two pieces; the outer one, by which the complete bracket is attached to the tender front plate, is a piece of brass or steel, 3/32 in. thick, measuring 1 1/16 in. x 1 in. It is filed off at one corner, to clear the sloping part of the tender top, and drilled for screws as shown. The piece which carries the brake spindle is made from a 1 in. length of brass bar of 7/16 in. x ⅝ in. section, sawn and filed to the shape shown. It should fit in the trough quite easily. Before drilling the holes for the brake and handle spindles, get a suitable pair of bevel gears; those I have shown are ⅜ in. on their larger diameter, but anything close to that size can be used. A pair taken from a Meccano set, or from an old clock, musical box, etc., could all be worked in, provided that the spindle holes are drilled to allow them to mesh correctly. For the wheels shown, the hole for the horizontal spindle should be drilled 3/16 in. from the top of the bracket; and for the near-vertical spindle, ⅜ in. from the flat face, as shown in the plan. This should slope at 7 degrees from the vertical, and reamed 5/32 in. so as to ensure the spindle fitting without undue slackness. This part of the bracket can then be attached to the front plate by four countersunk screws as shown; run the drill through the upper hole, right through the front plate (use No. 32 drill) and put a ⅛ in. parallel reamer through.

The horizontal spindle itself is a piece of ⅛ in. round silver-steel approximately 9/16 in. long. One of the bevel gears is pinned to the end, as shown. To make the handle, bend up a piece of 3/32 in. round steel to the required shape, and silver-solder it to a boss, which is just a ⅛ in. slice of ¼ in. round steel rod, with a No. 32 hole drilled through it. File a slight depression across the centre with a rat-tail file, and set the handle in it, before silver-soldering. Push the spindle, with wheel attached, through the bracket from the back, then squeeze the boss of the handle on, until there is only the weeniest bit of endplay: then pin the boss to the spindle.

A collar is needed on the brake spindle, to prevent it from lifting; this is a 3/16 in. slice of ¼ in. round rod, with a No. 23 hole drilled through it. Drive it on to the brake spindle, until about 9/16 in. from the end. The hole in the bevel wheel should be reamed to a tight fit on the spindle. Hold the wheel in place, then push the spindle up through the hole in the bracket, through the wheel boss, and put the nut on. Adjust until there is no appreciable up-and-down movement, and the wheels mesh properly, so that the handle turns easily, and operates the spindle; then pin both wheel boss and collar to the spindle, as shown. Drill the holes No. 53, and use 1/16 in. wire for pins, easing the end with a file, to give the pin a start. The whole assembly can then be inserted into the trough in the tender front, as shown in the assembly views, and the plate attached by six screws, as shown. The holes for these should be drilled and tapped through the flanges of the trough, which will give the threads plenty of "hold."

Brake Blocks and Hangers

The brake hangers being merely a simple job of filing and drilling, no detailed instructions should be needed; they can be made from ⅛ in. x ⅜ in. flat steel, and all dimensions are given in the illustration. The brake blocks are the same as those which I specified for the class 7 Britannia, a standard B.R. pattern; and castings for these are already on sale, so time and labour can be saved by their use. They only need the grooves in the back, cleaning out to allow the hangers to fit easily, and holes drilled for the pins. Alternatively, the blocks can be sawn and filed from ½ in. x ¼ in. steel bar, and slotted at the back, either by milling or filing. I have described several times how to mill slots and grooves in the lathe by gripping the work in a machine-vice (regular or improvised) bolted to the lathe saddle and running it under a saw-type milling-cutter on an arbor between the lathe centres. The easiest way of machining the curved part that makes contact with the wheel tread, is to scribe a circle 2 7/16 in. diameter on a piece of brass about ⅛ in. thick; solder the blocks to it, with the ends just touching the circle, spacing them evenly all around it; bolt the plate to the lathe faceplate with the scribed circle running truly, and then applying a boring tool to the inner faces of the blocks, in the same way as for boring out a shallow recess. Feed in until the boring tool starts to cut the brass plate, then remove the lot and melt off the blocks. This process has been illustrated when describing other engines in this series of notes. The brake-blocks, whether cast or machined, can then be pinned to the hangers with pins made from 3/32 in. silver-steel. They should be easy enough to bed themselves to the wheel-treads when the brakes are applied, but not loose enough to lop over and rub against the treads when the brakes are off.

The hanger pins are made from ¼ in. round mild steel rod held in the three-jaw. Face the end, and turn down 9/32 in. length, to ⅛ in. diameter, screwing ⅛ in. or 5 B.A.; part off at 9/16 in. from the shoulder. Reverse in chuck, and turn down 9/32 in. to a nice fit in the holes in the tops of hangers; further reduce a full ⅛ in. to 3/32 in. diameter, and screw 3/32 in. or 7 B.A. Put on the hangers, and secure with ordinary commercial nuts; when these are tight against the shoulder, the hangers should still be free to swing. The other ends of the hangers can then be put through the holes already in the frames, from the inside, and nutted on the outside, as shown in the plan view.

Brake Beams

Each brake beam needs a piece of flat mild steel of ⅜ in. x ⅛ in. section, a full 4⅛ in. long. Chuck truly in the four-jaw, face the end, and turn down ¼ in. length to ⅛ in. diameter, to fit the holes in the lower ends of the hangers. Further reduce a bare ⅛ in. to 3/32 in. diameter, and screw 3/32 in. or 7 B.A. Reverse in chuck, and repeat operation, leaving 3⅝ in. between the shoulders. Each beam can then be filed or milled to the shape shown in plan view, and drilled No. 30 for the pin. A beam is then placed between each pair of hangers (easily done if the outer nuts on the hanger pins are eased off) and the lower ends secured with commercial nuts. It is usual, in full-sized practice, to fix the brake gear with flat split cotters and washers; if anybody tries making an oblong hole in the 3/32 in. end of the brake beam, and making flat split cotters to fit these holes, he will immediately realise why I specify nuts instead!

FOR the brake shaft, you will need a piece of 1/4 in. round mild steel, a full 4 7/8 in. long. Chuck in three-jaw, face the end, and turn down 1/4 in. length to 3/16 in. diameter. Reverse in chuck, and repeat operations, leaving a bare 4 3/8 in. between the shoulders.

The two actuating arms that carry the brake nut are sawn and filed from 3/8 in. x 3/32 in. flat mild steel, and drilled as shown. It is a good wheeze to saw off the two blanks, and solder them together, while filing to shape and drilling, so as to ensure them being exactly alike. The short drop-arm is filed from 1/8 in. x 3/8 in. steel, the shape of all arms being shown in the end view of the shaft.

The brake nut is turned from a piece of 1/4 in. square bronze rod, chucked truly in four-jaw. Face the end, and turn down 1/8 in. length to 1/8 in. diameter; part off at 3/8 in. from the shoulder. Reverse in chuck, and turn down the other end similarly; then drill a No. 30 hole through the middle part, and tap it 5/32 in. x 32. The 40 pitch can be used, of course, but the 32 gives a quicker action.

Press one of the actuating arms on the shaft until it is 3/8 in. from the end; put the nut in place, with the pip on the side entering the hole in the end of the arm, then press on the other arm, just far enough to allow the full diameter of the shaft to project through a bare 3/32 in., as shown in the illustrations. The nut should be just free enough to turn. The drop-arm can then be pressed on at the other end, until the centre of it is 2 5/32 in. from the shoulder. It should be set at right angles to the actuating arms, as shown. All three arms can then be brazed or silver-soldered to the shaft by the process I have described for similar jobs on the engine part.

The bushes in which the shaft turns are turned from 11/16 in. or 3/4 in. round brass rod held in three-jaw. Face the end, centre, and drill down about 5/16 in. depth with 3/16 in. drill. Turn down 3/16 in. of the end to 1/4 in. diameter, and part off at 1/16 in. full from the shoulder. Reverse in chuck, and take a skim off the flange, to true it up. The second bush is made by the same process, but the spigot is only 3/32 in. long, as it fits flush with frame, to allow the actuating arms to come close to frame, as shown in the plan view. File the flanges to shape, and drill the screwholes, as shown. The brake shaft is then put in position, the ends in the 1/4 in. holes in frames, and the screwed end of the brake spindle entered in the nut. Screw up the nut by turning the handle, until it is in the position shown, then put the bushes or bearings on, over the reduced ends of the shaft, as shown in the plan at the bottom, and fix the flanges to the frames by screws running through the clearing holes in the bush flanges, into tapped holes in the frame.

Pull-Rods

All we need to complete are the pull-rods and beam connectors. The two halves of the adjustable rod are made from pieces of 1/8 in. round steel, each a little over 1 in. long. One end of each is threaded for 7/16 in. length with 1/8 in. or 5 B.A. thread, one right-handed, and one left-handed. The other end is either screwed to take an ordinary fork, as used for valve gears, or turned down to 3/32 in. diameter to fit a short fork similar to those on the full-sized engines. I have shown both patterns, so you can take your choice. Either type is made by exactly the same process as described for valve-gear and other forks, by clamping the piece of rod under the slide-rest tool-holder, and running it up to a cutter on a stub mandrel held in the three-jaw chuck; then sawing off to length, chucking in four-jaw to turn, drill, and tap the boss, finally rounding off the ends of the jaws.

To make the adjuster, chuck a piece of 5/16 in. or 3/8 in. hexagon brass rod in three-jaw. Face the end, centre, and drill down to 3/4 in. depth with No. 40 drill. Turn down 3/16 in. length to 1/4 in. diameter and part off at 5/8 in. from the end. Reverse in chuck, and turn down 3/16 in. of the other end to 1/4 in. diameter also; then tap halfway through with a 1/8 in. or 5 B.A. right-hand tap. Reverse in chuck again, and tap the other half with a left-hand tap. The locknuts are merely 1/8 in. slices parted off the hexagon rod, and drilled and tapped as above, one R.H. and one L.H. Don't forget to screw the locknuts on to the pieces of rod, before you screw the rods into the adjuster!

The intermediate and trailing pull-rods are both made from 1/4 in. square steel, with the eyes and forks integral, as in full-size. The connectors are also made from the same material. It would be advisable to make these first, and pin them to the brake beams; the exact length of each pull-rod can then be ascertained from the actual job, so that the brake-blocks will all bear equally on the wheel treads. The end of the piece of rod can be slotted down to the length shown, by the method mentioned above, and sawn off to length, the opposite end to the jaws being thinned down to 1/8 in. thickness, to form the tongue, as shown in the drawing; the ends are rounded. Two only are needed, for the leading and middle beams; push them over the beams until the middle hole coincides with the hole in the beam (see plan view) and pin to the beam by means of a turned pin. These are turned from 3/16 in. round mild steel rod held in the three-jaw, a simple job which needs no detailing out. They should fit easily in the holes, the heads being left about 1/16 in. thick. A 1/16 in. hole is drilled in the stem of each; and a split-pin, which can be made from 1/16 in. brass wire filed half away, and bent to shape with a small pair of round-nose pliers, inserted, to prevent the pins jumping out.

To get the exact length of the pull-rods, hold the brake-blocks tightly against the wheels; and for the intermediate rod, measure from the centre of the hole in the fork at the back of the leading beam, to the centre of the eye in the connector at the front of the middle beam. For the back or trailing rod, measure from the centre of the hole in the fork behind the middle beam, to the centre of the hole in the trailing beam itself, as the trailing rod is directly connected to the beam.

Transfer these measurements to the pieces of 1/4 in. rod, centre-pop, and drill the pin-holes right away; then there will be no error. Now slot the forked end of each, in the manner described above, and then

$\frac{3}{32}$ in. or 7 B.A. After finish-turning the buffer head, centre it, and drill right through with No. 41 drill, opening out to $\frac{5}{8}$ in. depth with $\frac{5}{32}$ in. or No. 21 drill. Tap the end $\frac{3}{16}$ in. x 40. Make two special screws, as shown, from a bit of $\frac{5}{32}$ in. mild steel rod held in the three-jaw; turn down 1 in. length to $\frac{3}{32}$ in. diameter, and put about $\frac{1}{8}$ in. of $\frac{3}{32}$ in. or 7 B.A. thread on the end. Part off to leave a $\frac{1}{8}$ in. head, and slot it with a fine hacksaw. The head should be reduced slightly, so that it will slide in the drilled hole in the buffer head quite easily.

The springs are the same as used on the engine buffers. To assemble, poke one of the screws down the hole in the buffer head, so that it projects through the end, then put the spring over the screw; insert the head into the socket, and with a screw-driver put down the hole in the buffer head, drive the screw tightly home into the tapped hole at the end of the socket. Then screw a stub of $\frac{3}{16}$ in. mild steel into the tapped hole in the buffer head, and file off flush. The head of the spindle screw will prevent the buffer head from coming out of the socket, whilst allowing it to compress the spring in the usual manner. Should it be necessary for the buffer to be taken apart for any reason—very unlikely—it is a simple matter to drill out the $\frac{3}{16}$ in. plug; or drill a small hole in the middle of it, drive in the tang end of a file, and unscrew it.

To erect the buffers on the beam, screw them in so that the square flanges are true with the beam, and not lopsided, as the kiddies would remark; then run a No. 51 drill through the holes in the corners, making countersinks on the beam, follow with No. 55, and tap $\frac{1}{16}$ in. or 10 B.A. Put either round-head or hexagon-head steel screws in, just as you fancy. The screws merely prevent the buffer sockets from turning around, the threads on the spigots holding them in place and taking any stresses.

THE ladders on the tenders of British standard locomotives are far more convenient, from a fireman's point of view, than the little steps usually provided. They have earned the nickname of "fire-escapes." The sides of the ladder on our little class 4 can be made from strips of 16 or 18 gauge mild steel, $\frac{1}{8}$ in. wide, and the rungs $\frac{1}{16}$ in. steel wire. The dimensions of the complete ladder were given in the back view of the tender in the general arrangement drawing. If the two strips are clamped together, and one marked out for the holes to accommodate the ends of the rungs, both can be drilled together, and this will ensure that all the rungs are square with the sides and parallel with each other. It is rather a ticklish job to get the top bends accurately made, as the metal has to be bent on its wider side; if any builder can't manage the bends, there is a very easy alternative, viz., to mark out the side of the ladder on a piece of sheet metal and cut it out complete with the "arch." Allow a little extra below the arch to be bent at right angles, drilled and fixed to the tank top by a $\frac{1}{16}$ in. or 10 B.A. screw at each side, as shown in the view of the back of the tender.

Cut all the rungs to about $\frac{7}{8}$ in. length, then turn a little spigot on the end of each, to fit the holes in the sides; insert, rivet over, and file flush, as shown in the detail sketch. The lower support is made by bending a bit of the same section steel, as used for the sides, to a channel shape, as shown in another detail sketch, and riveting it to the ladder in the position shown in the back view of the tender. To fix the ladder, the top is attached as mentioned above, and the lower support attached to the buffer beam by $\frac{1}{16}$ in. or 10 B.A. screws, put through the clearing holes in the bracket, into tapped holes in the beam. The ladder should be vertical when erected.

Grab Rails and Brake Pipe Stand

The grab rails are made from 15-gauge spoke wire; in case I forget to mention it, plated cycle spokes of several gauges can be purchased cheaply at any cycle dealer's store, and are just the cat's whiskers for handrails, valve gear pins, and various other oddments in small locomotive construction. The length and location of the grab rails are shown on the back view mentioned above; when cutting, allow sufficient for the ends which are bent over. Before bending, turn down each end slightly and screw $\frac{1}{16}$ in. or 10 B.A.; then bend, insert into the holes drilled in the tender body and secure with nuts, as shown. A spot of solder will prevent any water leaking past.

The final job is the brake pipe stand. This can be made from $\frac{1}{8}$ in. copper rod, which is preferable to tube (the pipe being merely a dummy, put on for appearance sake) as it will bend without kinking. Dimensions are given in the illustration. A little collar is soldered just below the bend, as shown, to give a "finish." The clip is made from a short strip of sheet brass or copper, about $\frac{1}{32}$ in. thick, bent to shape and soldered to the "pipe." It also carries the "dolly" or dummy coupling, used in full-size for preventing air from entering the train pipe on the last vehicle. This is simply a bit of $\frac{3}{16}$ in. brass rod, turned to the shape of a baby's "dummy" teat, the lug behind it being filed flat and drilled for a pin, by which it is attached to the clip, as shown. The hose is a piece of ordinary rubber tube, slipped over both the end of the top bend and the dolly; a very narrow bit of brass or copper, bent around the top of the hose to simulate a pipe clip, adds a little touch of realism. The complete assembly is attached to the buffer beam by two $\frac{1}{16}$ in. or 10 B.A. screws. There is no need to describe the drawhook and screw coupling again, as they are exactly the same as fitted to the buffer beam on the engine.

Epilogue

The full-size engines are painted black and lined in a similar manner to the engines of the old London and North Western Railway. If the little engine is well-washed down with petrol (outdoors !) to remove all grease, she can be painted with a good quick-drying enamel, or a synthetic gloss paint, such as "Valspar," "Sol" or similar. Wider lines can be put on with a thin lining brush, and fine lines with a ruling pen, both being guided by a rule. It is a pity that no transfers are available of the hungry lion standing over his wheel, as the symbol would add a finishing touch. Maybe some of our artistic friends will be able to paint one, but personally I'd make him a bit more plump !

The engine is fired and driven in the same manner as other locomotives described in these notes; use an auxiliary blower for steam-raising, start the fire with paraffin-soaked charcoal or wood chips, and use Welsh coal or anthracite, or a mixture of both, broken to pea size, with all dust sifted out. Keep the water well up the gauge glass, never let the fire get low—when note carefully the following. The eye at the front end of the intermediate pull-rod is at right-angles to the fork: the eye at the front end of the trailing pull-rod is in the same plane as the fork (clearly shown in the detail drawings) so don't make both rods alike! The surplus metal between eyes and forks can then be filed or milled away, and the eyes rounded off. The pull-rods can then be erected, and secured by pins, as mentioned above.

To adjust the brakes, slack off the adjuster, and wind the nut up the brake spindle by turning the handle until the actuating arms are almost horizontal. Then screw up the adjuster until the blocks are tight against the wheels, and, tighten the locknuts. If the handle is then turned backwards until the actuating arms are in the position shown in the elevation view, all blocks should be clear of the wheels. Don't forget to give all the joints a spot of oil after erection.

WHEN checking over the sectional drawing of the tender body, I found that the injector water valve had been inadvertently omitted, so I'll proceed to remedy that right away. As a matter of fact, it was my original intention to put it on the engine, as I did on my 3½ in. gauge Britannia, and as it is in full size; but with the injector in the location shown on the general arrangement drawing, which is approximate to its full-size position, there was not sufficient room to operate it easily. The trouble with these little locomotives is that we can't ride on the footplate, but have to drive and fire from a car behind the tender; and our fingers are rather on the large side for easy manipulation of tiny handles! Anyway, it is easy enough to drill a ¼ in. hole in the tender footplate, directly over the injector water pipe, and 5/16 in. ahead of the front of the tender body; the water valve is fitted in this hole, as shown on the drawing, which gives full details of the valve.

To make it, part off a piece of 5/16 in. hexagon brass rod, 1 in. long, and chuck it in the three-jaw. Turn down one end to ¼ in. diameter for ⅜ in. length, and screw ¼ in. x 40. Centre, and drill right through with No. 31 drill; open out to ¼ in. depth with No. 21 drill. Reverse in chuck, open out the hole for 7/16 in. depth with 7/32 in. drill, and tap ¼ in. x 40. Drill a No. 23 hole in the side, halfway between the shoulder and the bottom; the pipe leading from the strainer fitting under the tender body should be cut to such a length that it will enter this hole about 1/16 in. depth when the screwed neck of the valve is inserted in the hole in the tender footplate. The remainder of the No. 31 hole in the valve body is tapped 5/32 in. x 32, to give a quick opening to the valve pin.

Chuck the 5/16 in. rod again, face the end, centre, and drill down for ½ in. depth with No. 40 drill. Turn down 3/16 in. of the end to ¼ in. diameter, and screw ¼ in. x 40; face off any burring, and part off at 7/16 in. from the end. Reverse in chuck, open out the centre hole with No. 23 drill to about 3/16 in. depth, and turn the outside as shown. Make a ¼ in. x 40 gland nut, and a locknut, from the same kind of rod; two simple jobs needing no detailing. The valve pin will need a piece of 5/32 in. rustless steel or phosphor-bronze rod, approximately 4⅛ in. long. Chuck in three-jaw, turn a cone point on the end, to about 60 deg. angle, turn the next 3/16 in. to a full ⅛ in. diameter and screw the next ⅜ in. 5/32 in. x 32. The other end can be furnished with either a handwheel as shown, in the same way as the boiler fittings previously described; or it can be cross-drilled with No. 49 drill, and fitted with a cross-handle made from a bit of 15-gauge spoke wire about ⅝ in. long.

The end of the shortened water-pipe, with the strainer at the other end, can then be silver-soldered into the hole in the valve body, taking care to keep strainer and valve in alignment. Quench in the acid pickle, wash off, and clean up, then replace the strainer, at the same time pushing the screwed neck of the valve body upwards through the hole in the tender footplate, securing same with the locknut, as shown. Silver-solder a piece of 5/32 in. pipe, about ⅝ in. long, into the hole in the underside of the valve seating, and screw the seating tightly home; bend the end of the pipe slightly forward, as shown, to take the connecting hose or "feedbag." Put the gland nut over the valve pin, and push two or three turns of graphited yarn into the nut; screw the pin into the valve, run the gland nut down on to the projecting bit of the screwed neck showing above the locknut, and tighten it until the wheel or handle becomes stiff to turn. Slack it back a shade until the wheel goes easily, and the job is completed.

Tender Steps

The steps are made from 18-gauge steel, and are just a simple exercise in cutting and bending. Mark out as shown, two to each size. Bend the side wings and bottom projections in opposite directions on each pair, which will give the necessary right- and left-handed steps. The ⅛ in. projections at each side of the bottom steps are bent upwards at right angles to the tread, and the front corners rounded off. The separate upper steps are cut out to the sizes shown, bent on the dotted lines, and the corners rounded in similar manner; they can be riveted to the step brackets with 1/16 in. rivets, or may be brazed, just as builders prefer. Drill plain holes at the location of the oval openings, and finish to outline with a half-round file.

The completed steps assemblies are located on the tender, as shown in the general arrangement drawing, and are attached by screws running through holes in the buffer and drag beams, and through the wings of the steps, with nuts on the inside. For neatness sake, countersink the screw-holes in the beams, and use countersunk screws; alternatively, use roundhead screws, which look like the rivets on a full-sized engine when the screwdriver slots are filled up with paint. I don't advise riveting the steps to the beams, as it may be necessary to remove them at some future time.

Tender Buffers

Owing to the width of the tender frames, it isn't possible to use the type of buffer specified for the engine, as the spindles would foul the frames when the buffers were compressed. The accompanying drawing shows a type of buffer that gets over that difficulty. The heads and sockets can be made from castings, or rod material, in exactly the same way as specified for the engine buffers; but the spigots on the sockets are cut very short, as shown, and screwed ¾ in. x 32, to suit the tapped holes in the beam. Each socket is drilled right through with No. 48 drill, and then opened out for ¾ in. depth with ⅜ in. drill, the remainder of the small hole being tapped she is about to blow off is the best time to pop a bit more coal on—and, above all, never let the cylinder lubricator run short of oil, and she will serve you well.

Items stocked for 75000 class:

Drawings set RV30(13 sheets)	6/079
Frame steel	6/080
Buffer beams	6/081
Hornblocks (hot pressed)	6/082
Axleboxes	6/083
Axlepump & stay	6/084
Eccentric straps	6/085
Driving & coupled wheels	6/086
Cylinder castings set	6/087
Piston blanks(H)	6/088
Crossheads	6/089
Valve gear brackets	6/090
Guide bar brackets	6/091
Bogie bolster	6/092
Bogie centre block	6/093
Bogie equalisers	6/094
Bogie axleboxes	6/095
Bogie wheels	6/096
Brake bracket, cylinder & covers	6/097
Buffer heads & step stocks	6/098
Saddle	6/100
Smokebox door & ring	6/101
Chimney	6/102
Petticote pipe	6/103
Dome	6/104
Inner dome	6/105
Dome bush	6/106
Regulator stand	6/107
Reverse gears & handwheel	6/108
Cast grate	6/109
Everlasting blowdown valve castings	6/110
Lubricator eccentric sheave	6/111
Tender frame steel	6/112
Tender buffer beam steel	6/113
Tender horns & cast springs	6/114
Tender axleboxes	6/115
Tender wheels	6/116
Timken axlebox covers (6)	6/117
Tender brake bevel gears	6/118
Handpump casting & tee	6/119
Buffer heads & plain stocks	6/126

To order only:
Boiler flanged plates (5) set
All-copper boiler materials including flanged plates, with barrel in flat, or with barrel rolled with castellated silversoldered seam.
Brass rolled smokebox tube with silversolder seam.

Photo etched name & numberplate sets :
75000, 75028, 75029, 75048, 75078.
75029 The Green Knight (as preserved).

For transfers see Reeves Catalogue and check from photographic research the correct style as appropriate to your model.