Solid Stays

THREE lengths of 3/16-in. copper or bronze rod are needed for the solid stays, all 16¾-ins. long. Each has about 3/8-in. length of 3/16-in. by 40 thread put on each end with a die in tailstock holder; the rod being held in the three-jaw, and projecting back into the hollow lathe mandrel. If your lathe hasn't a hollow mandrel, you will have to screw the rods by hand, and be mighty careful to hold the die-stock exactly at right angles to the rod when screwing.

The holes are already in the smokebox tube plate, as they were drilled along with the tube holes; but we need some in the backhead. Scribe a line across the backhead at 1⅝-ins. from the top; find the centre of it, and at 7/16-in. each side of centre, make a centrepop, also another 7/8-in. farther along each side. Drill them out with 11/32-in. drill, and tap 3/16-in. by 40. Screw one of the long rods into a blind nipple for about three threads, insert it into one of the holes in the backhead, and manoeuvre it through the corresponding hole in the smokebox tube plate. This sounds rather like a conjuring trick, but it can easily be done by aid of an extension, which is simply a few inches of 1/4-in. rod or tube, with the end drilled a fairly tight push fit on the end of the stay rod. With the extension in place, you can easily find the "entrance to the way out." Screw the blind nipple home tightly in the backhead, and pull off the extension, which will be standing out from the smokebox tube plate. There will be a few threads of stay rod showing through the hole; put another blind nipple on them, and screw home. When the outer threads on the nipple meet those in the tapped hole in the smokebox tube plate, they will engage; and when the nipple is screwed right home, the whole bag of tricks will be locked up solid.

The stay on the extreme right, looking at the backhead, is the hollow one. To make the thoroughfare nipple, chuck the 3/8-in. hexagon rod again, and proceed as directed for the blind nipples, but part off ½-in. from the shoulder. Reverse in chuck, gripping by part of the hexagon; turn down 1/4-in. length to 1/4-in. diameter, and screw 1/4-in. by 40. Countersink deeply, and drill right through into the tapped hole with 5/32-in. drill. Chamfer the corners of the hexagon.

Blower Valve

The blower valve can be made from 3/8-in. hexagon or round rod, as you prefer. Bronze or gunmetal is best for working fittings, though brass may be used at a pinch. Chuck in three-jaw, face, centre, and drill down a full 1-in. depth with No. 48 or 5/64-in. drill. Open out to about ½-in. depth with No. 30 drill, and bottom the hole with a 1/8in. D-bit to 5/8-in. depth. Further open out 1/8-in. of the end with No. 21 drill, and tap the No. 30 part 5/32-in. by 32 if you have the requisite tap. Forty-thread pitch will do, but the coarser thread gives quicker operation of the valve, which is desirable. Don't let the tap hit and score the seating. Turn down 1/4-in. of the outside to 1/4-in. diameter, and screw 1/4-in. by 40. Part off at 1-in. from the end; reverse in chuck, turn down 5/16-in. length to 5/16-in. diameter, and screw 5/16-in. by 40. Open out the centre hole with 5/32-in. or No. 22 drill for 1/4-in. depth, and tap 3/16-in. by 40.

At 1/4-in. from the shoulder, drill a 5/32-in. hole in the side of the fitting, breaking into the 5/32-in. tapped hole; see sectional illustration. A 1/4-in. union screw is fitted into this; chuck a piece of 1/4-in. round rod, same kind of metal as the body of the valve. Face, centre deeply, and drill about 3/8-in. down with No. 40 drill. Screw the outside 1/4-in. by 40 for 1/4-in. length, and part off 7/16-in. from the end. Reverse in chuck, turn down 1/8-in. of the plain end to a tight fit in the hole in the side of the valve body; squeeze it in, and silver-solder it. Backhead fittings should be as neat as possible, so be sparing with the silver-solder (I use "Easyflo" in wire form for jobs like these) and clean up well afterwards. Run in the 5/32-in. tap again, to clear any burring off the threads.

Gland Nut

For the gland nut, chuck a piece of 5/16-in. hexagon rod; face, centre, and drill 3/8-in. depth with No. 21 drill; open out to a bare 1/4-in. depth with 7/32-in. drill, tap 1/4-in. by 40, part off 5/16-in. from the end, and chamfer the corners of the hexagon. To make the pin, chuck an inch of 5/32-in. round rod — rustless steel, phosphor or nickel bronze will do—with 1/4-in. projecting from jaws. Turn down 3/16-in. length to 7/64-in. diameter, and form a blunt cone on the end.

I never bother to turn these cone points, but just take a fine file, and make a couple of sweeps across the end of the rod, with the lathe running fast, and the file held at the correct angle for the required taper. The result is a perfectly clean and smooth cone point. Pull the rod another 1/4-in. or so out of the chuck, and screw it to match the thread in the valve body. Reverse in chuck, and file a square 1/8-in. long, on the other end.

Hand Wheel

For the hand wheel, chuck a bit of 7/16-in. round rod (any metal; dural makes nice wheels), face, centre, drill down about 1/8-in. depth with No. 40 drill, form a little recess in the face, so as to show a boss and rim, and run a parting tool in a bare 1/8-in. behind the face, but don't part completely off until the rim is knurled. This can be done simply by pressing a coarse-cut file against the periphery of the wheel whilst pulling the lathe belt by hand, until the teeth bite in and rough up the surface. I find this gives a much better knurled grip, than one formed by the usual circular knurl.

Part off the wheel, drill four little holes in the recess, for appearance sake, and square the centre hole either by filing with a watchmaker's square file or driving a square punch through it. The punch is made from a bit of square silver steel, filed off square at the end, and hardened and tempered; I keep several handy, of different sizes. Drive the wheel on the squared end of the pin, and slightly rivet over at the end. Don't put the pin in the valve "for keeps" yet, as it may get damaged when inserting the stay in the boiler; just see if it fits all right.

Hollow Stay

The stay itself is a 16¾-in. length of 3/16-in. by 16 or 18 gauge copper tube. One end is screwed 3/16-in. by 40 for 3/16-in. length, and the other end for about 7/16-in. length. Screw the shorter end tightly into the end of the blower valve, with a smear of plumbers' jointing on the threads. Poke a piece of wire into the other end of the stay, to act as an assistant in finding the hole at the smokebox end of the boiler; then insert the stay through the last 5/16-in. hole in the backhead, wangle the other end through the hole in the tube plate and screw right home, so that the union nipple is vertical. Screw the thoroughfare nipple on the smokebox end, in the same way as described for the blind nipples. The sectional illustration shows the assembly complete.

Cross Stays in Firebox Wrapper

There are six cross stays in the firebox wrapper, fitted in a manner somewhat similar to the longitudinal rod stays just described. First of all, drill and tap the holes in the wrapper. Set out a horizontal line on each side of the shell of the Belpaire firebox, $1\frac{1}{2}$-ins. below the top at the throat plate end, and $1\frac{1}{4}$-ins. at the backhead end; and starting 1-in. from the backhead, make six centre-pops, 1-in. apart; see longitudinal section of boiler. Drill these out first with a No. 30 drill, and by poking a piece of $\frac{1}{8}$-in. straight wire through each pair, you can see if the holes on the opposite sides line up all right. Then open out the holes with $\frac{5}{32}$-in. drill, but don't hold the brace so that the drill is at right angles to the plate—the rods must be horizontal; see cross section of boiler.

The easiest way for a beginner or novice to do the job, is to use the lathe for drilling the holes. Put the drill in the three-jaw, and hold the boiler between drill and tailstock centre, the latter in the hole opposite the one you are going to drill. As the drill will be pointing straight at the tailstock centre, it is obvious that the holes must line up all right. Don't forget a spot of cutting oil, as used for turning steel, helps a wonderful lot in getting clean holes in soft copper.

After drilling, tap all the holes $\frac{6}{16}$-in. by 40, using a taper tap, and taking the same strict caution as before, to hold the tap horizontal, and not at right angles to the copper sheet.

Wedge Washers

AS the heads of the blind nipples cannot seat home fairly on the sides of the wrapper sheet, owing to the inward slope (or "tumble-home," as the shopmen call it) a dozen wedge-shaped washers will be needed. These should be made from copper rod for preference but gunmetal or brass will serve. Chuck a length of [illegible]-in. diameter rod in three-jaw; face, centre, drill down about 1-in. with [illegible]-in. clearing drill (letter O, 8 mm. or $\frac{21}{64}$-in.) and part off 12 slices each $\frac{1}{16}$-in. in thickness. File these to a wedge shape, the thinner side going to a knife edge. Hold a small block of wood in the bench vice, drive a nail or screw into it, and slip each washer over the head, which should project about $\frac{1}{16}$-in. That will keep the washers still whilst being filed.

The six stay rods are $4\frac{1}{8}$-ins. long, made from the same kind of rod as used for the longitudinal stays, and screwed at each end in exactly the same way. When inserting, screw each into a blind nipple for about three threads, then put a wedge washer on the nipple. Insert into hole in wrapper, wangle it through the other side, and put on another blind nipple with a wedge washer on it, tightening up the whole issue until the nipples are bearing hard against the wrapper, with the wedge washers in the position shown in both the cross section of boiler, and the small detail illustration.

Firebox Stays

There are 66 firebox stays all told, made from $\frac{5}{32}$-in. copper rod. Some of the best stuff I ever used, were unravelled strands from some scrap ends of high-tension cable, as used for the "grid" and similar purposes. This was soft and ductile, excellent material, and took a good clean thread. I also used some scrap ends of $\frac{5}{32}$-in. copper rod taken from the overhead and feeder equipment of a dismantled electric tramway.

If ordinary drawn copper rod is used, it should be softened, by heating to red and plunging into clean cold water. Cut about a dozen pieces, say 6-ins. long, and screw both ends of each $\frac{5}{32}$-in. by 40, for about $\frac{5}{8}$-in. length, using a die in tailstock holder, and the rod in the three-jaw. Keep the die clear of chippings, pull the belt back and forth by hand, use plenty of cutting oil, and you won't get any torn threads.

Set out, drill, and tap all the holes through wrapper and firebox. The first row is approximately $1\frac{5}{16}$-ins. below the centre-line of the wrapper cross stays; start with the first centre-pop at 1-in. from the backhead, then every successive mark is made at $\frac{3}{4}$-in. centres. The whole issue is arranged symmetrically; see longitudinal section of boiler.

Unlike the wrapper stays, all the holes are drilled square with the wrapper sheet, using No. 30 drill, with the exception of the two in the throat plate under the boiler barrel; these are drilled parallel to the bottom of the barrel.

Probably the chuck on your hand brace or drilling machine will foul the barrel when you try to drill the two holes mentioned. Well, don't worry about that; take a piece of $\frac{1}{4}$-in. tube about a foot long, temporarily solder the drill shank in one end and hold the other in the drill chuck. I keep several broken ends of drills permanently fixed in long pieces of $\frac{3}{16}$-in. and $\frac{1}{4}$-in. brass rod, especially for jobs which cannot be reached by an ordinary drill put direct in the chuck. When tapping, a similar piece of tube is used, one end being hammered square to fit the tap shank, and a tapwrench is clamped on the other end.

Tapping Stay Holes

A pilot tap is best for tapping stay holes, as the threads should be continuous in both plates, and they certainly won't be that, if the tap isn't lined up exactly with the hole in the inner plate, when entering the outer one.

I make my own staybolt taps as follows. In the present instance, a piece of $\frac{5}{32}$-in. silver steel, about $2\frac{1}{2}$-ins. long, is chucked in three-jaw, and $\frac{5}{8}$-in. of the end turned down to $\frac{1}{8}$-in. diameter, a sliding fit in the drilled holes. The next inch is screwed $\frac{5}{32}$-in. by 40, same thread as staybolts; three or four flutes are milled along the threads, and the ends of the thread next to the pilot are carefully backed off with a watchmaker's file. The shank end of the tap is squared, to take a wrench, and the threads and pilot hardened and tempered.

The whole of the threaded part, and the pilot, is made red-hot and quenched in clean cold water; the flutes are cleaned up with a piece of fine emerycloth on the end of a thin, flat stick, the tap is then laid on a piece of sheet iron, and the lot held over a gas flame until the brightened parts of the flutes turn to a dark yellow. The tap is then quickly tipped off the iron, into some cold water.

The pilot pin must be softened more than this, or it will break off; that is easily done by holding a red-hot poker against it for a few seconds. Anybody wishing to make a tap as above, and having no means of milling the flutes, can file the tap square at the beginning of the threaded part.

This will serve to start the thread, but a squared tap won't cut such good threads as a fluted one, so an ordinary "second" tap should be run through the holes afterwards. When using the tap, dip it in cutting oil before putting it in the hole; enter the pilot through both the holes (wrapper and firebox) and then work back and forth in the usual way. The pilot in the hole in the firebox, guides the tap whilst the screwed portion is tapping the hole in the wrapper.

An ordinary taper tap can also be used, but the taper should be very long, and great care taken to see that the tap lines up with the inner (firebox) hole whilst the outer (wrapper) hole is being tapped.

Fitting Stays

Clamp a tapwrench on one of your pieces of screwed stay rod, a little above the threads; screw it right home through wrapper and firebox, and snip or saw off the rod about $^{3}/_{32}$-in. from the surface of the wrapper. For the two in the throat plate, where a tapwrench cannot be turned, screw the stays home with a pair of pliers. When all the screwed ends have been used up, put some more lengths of thread on the remaining pieces of rod, and repeat the screwing-in operation until the whole 61 are in.

Making Locknuts

Locknuts are required on the ends of the stays sticking out of the plates inside the firebox. There are no commercially-made brass locknuts tapped $^{5}/_{32}$-in. by 40, so they will have to be home-made, but this isn't a very formidable job.

Chuck a piece of $^{1}/_{4}$-in. hexagon brass rod in three-jaw; face, centre, and drill down about 1-in. depth with No. 30 drill. Tap $^{5}/_{32}$-in. by 40 and part off $^{1}/_{8}$-in. slices until you get to the end of the tapped hole. Repeat operations until you have half-a-gross of nuts; a few spares are always useful.

To chamfer the corners of the hexagons, chuck a stub end of $^{1}/_{4}$-in. rod in three-jaw; turn down $^{1}/_{8}$-in. of it to $^{5}/_{32}$-in. diameter, and screw $^{5}/_{32}$-in. by 40. Don't remove it from chuck, but screw each nut on it, and touch the corners of the hexagon with a square-ended tool, the left-hand corner of which is ground off at an angle of about 45 deg. Sounds a long job, but it isn't when you come to do it.

Screw a nut on to the end of each projecting stay, and tighten up with a spanner. I use a box spanner for this job, home-made; it consists of a piece of round steel rod just over [illegible] long, and [illegible] diameter, with a hexagon-shaped depression in one end and a bent handle of $^{3}/_{16}$-in. steel rod at the other.

Box Spanner

To make it, just chuck the bit of rod in three-jaw, face, centre, and drill a hole about $^{1}/_{4}$-in. deep, to the size of the hexagon over the corners. Put a short bit of the hexagon rod in the hole, and hammer down the sides of the rod on to the hexagon, which will make the round hole into a hexagon socket, an easy fit on the nuts. Rechuck and skim off any burr from the hexagon end, drill a cross hole at the other end with a No. 13 drill, and drive in a bit of $^{3}/_{16}$-in. steel rod, bent as shown in the illustration.

Riveting Stays

Put a piece of stout iron bar in the bench vice, with one end projecting about 6-ins. Slip the firebox over this, and resting each stay on it in turn, hammer down the projecting bit of stay outside the wrapper, until a round head is formed, as shown in the small detail sketch. This operation will burr up the thread outside the nuts in the firebox, which is all to the good; but in case it loosens the nuts as well, go over them all again with the box spanner, and give them a final tighten up. Should any difficulty be encountered in getting the bar to "hold up" the stays in the upper part of the firebox, a thickenning piece can be attached to the bar by a couple of screws or rivets, as shown.

If the bar slips down between the jaws of the bench vice while you are forming the stay heads, take out the two hard-steel jaw plates, which are usually fixed by a couple of countersunk screws, and put the bar on the ledges which supported the separate jaw plates. Lastly—beginners please note, very important this—hit the ends of the stays with your hammer, and not the copper sheet around them!

Sweating up Stayheads and Nuts

If the staybolts are a perfect fit in the tapped holes in firebox and wrapper plates, and the heads are properly formed, also the nuts locked up tightly against the firebox plate, there should not be any fear of leakage; but soft copper is ticklish stuff to deal with, and all amateurs are liable to get imperfect threads, especially if the dies are dull or worn, or the taps not in first-class order. It is therefore advisable to sweat over all the stayheads and nuts, and in some cases the blind nipples also. I always do my own as a "safety-first" precaution, and am never troubled with "Welsh vegetables" in my fireboxes.

The job is easily done; all you need is a one-pint blow-lamp or small gas blow-pipe, a hatchet-shaped soldering bit, some liquid flux, and some solder, preferably plumber's solder, which has a higher melting point than ordinary tinman's solder, though the latter will do at a pinch. Note for beginners—always use a liquid flux for boiler work; never use paste flux under any circumstances, for the simple reason that if you get any inside the boiler (easily done via a bad thread), you'll never get it out, and the boiler will not only have a tendency to prime, or foam, but your water gauge will everlastingly give false readings.

Paste fluxes are all right for soldered joints in electric wiring, or repairing domestic tinware, and suchlike jobs; but for boilers always give it a miss, and never mind what the advertisements tell you. This is another case where experience is the best teacher!

A brush is needed for applying the flux, and this can easily be made in a few minutes by putting the end of a small bunch of fine iron wires into the end of a bit of $^{5}/_{16}$-in. or $^{3}/_{8}$-in. tube, and hammering it flat. A wooden handle can be driven into the other end; just a round bit of wood will do. The copper or brass tube holding the wires becomes too hot for comfort while the job is in progress!

Making Flux

Lay the boiler on its side in the brazing pan, with the firebox horizontal. Brush some of the liquid flux all over the stayheads and nuts that are uppermost.

I use Baker's soldering fluid, but you can make your own flux if desired, either by dissolving bits of zinc in muriatic acid (spirits of salts) until no more will dissolve, and then adding a little powdered salammoniac, or else buying some lump chloride of zinc (sold by manufacturing chemists) and dissolving it in water. The muriatic acid stunt should always be done in the open air, away from house windows, and don't get any of the fumes down your throat.

Get the blow-lamp or blow-pipe going, and heat up the whole boiler evenly until, if you touch a stayhead or nut with the solder, a little will melt off on it. Give each stayhead on the outside of the wrapper, a taste of the solder; but you needn't bother about that inside the firebox. Just melt off a little here and there among the stay nuts. Now, if you play the flame on the outside of the wrapper, and at the same time give each stayhead a dab with the brush dipped in the flux, the melted solder will just flash around each head, and sweat in. The blind

nipples on the wrapper can be treated to a dose of the same medicine, which will effectually seal any interstice or cranny between the wedge washers and the wrapper sheet.

The flame can now be played inside the firebox, and the solder rendered quite liquid. If you dip the brush in the flux and apply it to all the nuts, the solder will sweat between them and the copper sheet, and right through the threads between stay and nut.

Should any of them show signs of being cantankerous, and the solder doesn't appear to "take," give them an extra dab of flux and, apply the copper bit (heated to working temperature) to the nut, keeping the flame going at the same time. This will teach any delinquent good manners, as the bit will guide the solder all around. Whilst the solder is still at molten temperature, brush it over all the joints and rivet heads inside the box as well, applying plenty of flux; then, if there are any pinholes in the brazing, they will be sealed before any trouble occurs.

Turn the boiler completely over, and repeat the process; then do the two ends of the firebox, sweating over the stayheads on backhead and throat plate same time. Last of all, if this is your first boiler, or if you don't fancy your skill too much as a coppersmith, and are doubtful about the brazing, brush the melted solder all over the inside of the firebox, using plenty of flux, so that is tinned like a kitchen utensil. Drain off any surplus solder, let the boiler cool a bit, and then give it a good wash in running water, scrubbing with an old nailbrush or something similar, to get rid of all the flux; otherwise, it will turn green, and corrosion will take place.

Sweating from the Inside

There is another way of sweating up, which can be used by anybody who has a big forge, and plenty of plumbers' solder. The boiler can be heated over the forge, and some liquid flux poured inside, the boiler well shaken up, so that the flux reaches every part. A good ladleful of melted plumbers' solder is then poured slowly into it. The handiest way of doing this is to plug the hole in the smokebox tube plate with asbestos, up-end the boiler, and pour the metal in through the regulator bush, which can then be plugged temporarily in like manner.

Keeping the boiler at the melting temperature of the solder, it is turned about over the forge fire, so that the solder covers every part; a little more flux put in through the safety-valve bush, helps matters a lot. The surplus solder is then drained out, and the boiler given a good wash out with running water.

This makes a very neat job, and seals any brazing pinholes; but it has one drawback, inasmuch as it leaves the stay nuts inside the firebox, loose on their threads, and allows them to stand a chance of working off when the engine runs over a rough road or through points and crossings.

Requirements for Boiler Testing

The boiler can now be given a water-pressure test. For this you will need a pressure gauge reading to 200 lbs. per square inch or over; plugs for the holes in the boiler, and a pump. The gauge I use for boiler testing is a full-sized locomotive pressure gauge with centrally-pivoted needle, reading to 360 lbs., purchased new over the counter of a London engineers' store about 1920, for 12s. I had it tested against a master gauge, and it is as near correct "as makes no odds."

Gauges off old automobile tyre pumps used for the old-fashioned high-pressure tyres, will do for this job, or maybe you could borrow a suitable gauge; but *don't* use one of the little gauges supplied for locomotive boilers, or you will "do it in." The little "clocks" are O.K. for indicating steam pressure, but are not robust enough to stand the overload of a water test.

Two screwed plugs are required, one for the safety-valve bush, and one for the hole in the smokebox tube plate; these are similar to the "thoroughfare" nipple on the blower stay. Chuck a piece of ¾-in. hexagon brass rod, face the end, turn down about ⅜-in. length to ½-in. diameter, and screw ½-in. by 26. Part off at ⅞-in. from the end. Reverse in chuck, turn down ¼-in. of the end to ¼-in. diameter, screw ¼-in. by 40, centre deeply, and drill right through with ⅛-in. or No. 30 drill. Repeat process, but this time screw the larger end ½-in. by 32, to suit the hole in smokebox tube plate.

A plug is also needed for the regulator bush, and for this we can make the regulator gland-and-stuffing-box fitting, leaving it solid for the time being. Castings may be available; but if not, chuck a piece of 1-in. brass rod in three-jaw, face the end, and turn down ¾-in. length to ⅝-in. diameter, a sliding fit in the regulator bush on the backhead. Part off at 1-in. from the end; reverse in chuck, and turn down ⅛-in. length to 7/16-in. diameter. At 3/32-in. from the edge, scribe a circle, and on it drill six holes at equidistant spacing, using No. 40 drill. Now fit this plug to the bush, exactly as described for fitting cylinder covers, and secure it with six 3/32-in. or 7 B.A. brass screws, putting a jointing gasket of 1/64-in. "Hallite" or similar material, between the bush and the flange of the plug.

If you have no pump suitable for pumping up to about 180 lbs. pressure, the deficiency can be remedied by making the emergency hand pump for the tender right away; this can be used for the test, then laid aside until required to instal in the tender tank. No castings are required. The stand is a piece of 1¼-ins. by ⅛-in. brass or copper, approximately 4½-ins. long, bent to the shape shown in the sectional illustration. Drill a No. 30 hole in the corner of each bottom lug, and one in the middle of the top. On the centre-line of each end, and ¾-in. from the bottom, drill a No. 30 pilot hole, and put a bit of ⅛-in. wire through both holes, which will indicate if they are in line; if not, correct with a rat-tail file, and then open out the holes with 35/64-in. drill, finally reaming with a 9/16-in. parallel reamer. Don't put this right through; only enter the "lead" just far enough to make the hole a tight fit for a piece of 9/16-in. treblet tube, a 2-in. length of which forms the pump barrel.

Square it off to dead length in the lathe; and if the inside isn't smooth, polish it up a bit with a piece of fine emery or other abrasive cloth, wound around a stick. This can be held in the chuck; and when running the lathe as fast as possible, run the tube up and down the improvised lap. A couple of minutes of this treatment will make the inside of the tube as smooth as glass.

Chuck a piece of brass rod in the three-jaw, any diameter larger than the bore of the tube. Face the end, centre, and drill down about ½-in. depth with ⅛-in. drill. Turn down 3/16-in. of the outside to ¼-in. diameter, and screw ¼-in. by 40. Turn down a further 5/16-in. or so, to a tight drive fit in the end of the pump barrel, and part off at 7/16-in. from the end. Squeeze this plug into the end of the barrel.

Pump Valve Box

Chuck a piece of 7/16-in. round brass rod in the three-jaw, face the end, and part off a 1⅛-in. length. Rechuck, centre, drill right through with No. 23 drill, open out to ¼-in. depth with 9/32-in. drill, bottom to ⅜-in. depth with 9/32-in. D-bit, slightly countersink the top, tap 5/16-in. by 32 or 40, and skim off any burr at the end.

Reverse in chuck, and repeat process, except that instead of using the D-bit, the hole can be opened out to the full ⅜-in. depth with the 9/32-in. drill. Cross-nick the end of the small centre hole with a little chisel, which can be home-made from a bit of ⅛-in. silver steel, and poke a 5/32-in. parallel reamer through. In the side, midway between top and bottom, drill a 7/32-in. hole, and tap it ¼-in. by 40. This should break into the central passageway.

The valves are 3/16-in. rustless steel balls. Drop one into the D-bitted end of the valve box, and seat it by holding a short piece of 5/32-in. round rod on the ball, and giving it a sharp crack with a hammer. Beginners' warning—don't overdo it; all you need for a tight seating is to take the sharp arris off the edge of the reamed hole. The narrower the seating, within reason, the more watertight the valve will be.

Now take the depth from the top of the ball, to the top of the valve box, with a depth gauge. If you haven't one, take a piece of ¼-in. square rod about 1-in. long, drill a No. 41 cross hole through it, put in a piece of 3/32-in. silver-steel wire about 3-ins. long, and put a 3/32-in. setscrew in the side, to clamp the wire in any desired position. When a child, I used one of mother's hat-pins stuck through a tram ticket.

Chuck a bit of ⅜-in. hexagon brass rod in the three-jaw, face the end, and turn down to 5/16-in. diameter, the length indicated by the depth gauge; screw it 5/16-in. by 32 or 40 to match the valve box. Part off at 9/16-in. from the end. Reverse in chuck; turn down ¼-in. of the end to ¼-in. diameter, and screw ¼-in. by 40. Centre deeply with size E centre drill, drill right through with No. 30 drill, and cross nick the 5/16-in. end with a file, as shown in the sectional illustration, removing any burrs.

The diameter of the hole will allow the ball the requisite amount of lift. Now turn the valve box over, and drop a ball into the other end, taking depth as before. Chuck the ⅜-in. rod again; face, centre, and drill down about ½-in. depth with No. 23 drill. Turn down to 5/16-in. diameter, the amount indicated by the depth gauge, and screw 5/16-in. by 32 or 40, as before; put a 5/32-in. parallel reamer in the hole as far as it will go, take a weeny truing-up skim off the end, and part off to leave a head ⅛-in. wide, which is cross-nicked with a thin flat file, such as key-cutters use for cutting wards. Seat a 3/16-in. ball on the end of the hole, as shown in the illustration.

Assembly

The whole lot can be assembled as shown. Screw the spigot at the end of the pump barrel, into the valve box, and insert the pump barrel into the stand, taking care that the valve box is vertical, D-bitted end at the top, and the box ⅜-in. from the stand. Solder the joint between barrel and valve box, and the points where the barrel goes through the stand; this will be perfectly satisfactory, as the parts are never heated, and the solder thereby weakened.

Put the balls in the valve box, and screw in cap and base with a slight smear of plumbers' jointing on the threads, but take care not to let any get on to the balls or seatings.

Pump Ram

The pump ram is a 2¼-in. length of ½-in. round bronze, gunmetal or rustless steel rod. This should fit the treblet tube exactly, and need no turning to make it fit; but if you have not a piece suitable, use the nearest larger size available, and turn it to suit the pump barrel. A packing groove 3/16-in. wide and about ⅛-in. deep, is formed with a parting tool ⅛-in. from the end; the other end is reduced and rounded off to the shape shown. Drill a No. 32 cross hole through it, and cut a ⅛-in. slot in the end, by the method described for slotting valve gear forks and other parts of the engine.

Pump Lever

The lever is a 2¼-in. length of ⅛-in. by ¼-in. rod, nickel-bronze for preference (the stuff we used to call German silver), but brass will do, if nothing better is available. Round off one end, and slightly bevel the other; drill a No. 30 hole in the rounded end, and another 1-in. above it.

The two anchor links are made from 1/16-in. by ¼-in. rod, and another 1-in. above it.

The two anchor links are made from 1/16-in. by ¼-in. rod, same material as lever, and drill No. 32 at 2-in. centres, the ends being rounded off.

The anchor lug is made from same section as lever; chuck a piece truly in four-jaw, turn down 5/16-in. of it to ⅛-in. diameter, screw ⅛-in. or 5 B.A., and part off a full ⅜-in. from the shoulder. Round off the end, and drill it No. 30. Put one of the anchor links each side of it, and drive a ⅛-in. bronze pin through the lot, slightly riveting same over each side.

Put the lever between the other ends of the anchor links, and repeat the pinning process. The bottom of the lever is then placed in the slot in the ram, and similarly pinned.

Pack the groove in the ram with a few strands of graphited yarn; or better still, if you can get it, some strands from a bit of full-sized hydraulic pump packing. Insert the ram in the barrel; put the screw on the anchor lug through the hole in the top of the stand, secure with a brass nut, and the pump is complete.

Pump Extension Handle

THE pump, when installed in the tender tank, is operated by an extension handle through the filler hole; and this handle will, of course, be needed on the boiler-testing stunt, to get sufficient leverage for the required pressure. It consists of a 5-in. length of ⅛-in. by ¼-in. rod—steel may be used if desired, as the handle does not remain in the water—one end of which is rounded.

The other end carries a 2-in. length of rectangular tube, of a size which will fit the lever; see illustration. This is a commercial section, sold at regular metal merchants' stores; but if difficult to obtain, bend a piece of 16 gauge sheet brass around the extension lever, to the desired shape, and silver-solder the corner. The extension should not be slack on the pump lever, or the socket will bell out; just a nice sliding fit is correct.

How to Test the Boiler

Screw the ¼-in. by 32 adaptor into the hole in the smokebox tube-plate, with a 1/64-in. Hallite or similar washer under the shoulder. Connect this to the pressure gauge by a length of ⅛-in. or 5/32-in. tube, with suitable union nuts and cones on each end. Fill the boiler right up to the safety-valve bush with cold water, and screw in the ¼-in. by 26 adaptor. Stand the pump in a small bowl of water, and connect the union on top of the valve box, to the adaptor in the safety-valve bush, by a pipe and unions as above. Put on the extension handle and give a few strokes. The needle of the gauge will immediately begin to rise. When it reaches 50 lbs., stop pumping, and take a good look all around the boiler, both outside, and in the firebox. Should any leakage develop, correct at once before going any farther. If all O.K., raise the pressure to 100 lbs., and take another look. If still sound, no leakage nor distortion, pressure can be gradually raised to 180 lbs. There is no need to go above this, as if the job will stand 180 lbs. of hydraulic pressure, it is perfectly safe for 100 lbs. steam. Should there be a slight movement of the firebox crown, or the Belpaire wrapper, don't worry; it will only be the copper sheet, softened by the heat of the brazing operations, settling itself to the best position for resisting the working pressure. Should there be any defect which causes any part of the boiler to give way, it will simply part without any explosion; in fact, without any sound, in most cases, simply releasing the pressure, so the operator doesn't run the slightest risk. Beginners may thus be reassured! Anyway, if your boiler reaches the 180 lbs. mark without any casualty, leave the pressure on for a short time (your humble servant usually has a cup of the enginemen's best friend, to celebrate!), after which the pressure can be let off, and the adaptors removed; the next jobs will be the smokebox, saddle and boiler fittings.

Smokebox

In the "1,000" class engines on the G.W.R., the smokebox is carried on a separate saddle; and this is an example of how full-size practice sometimes follows an alteration or innovation in small size. Many years ago, I described in a contemporary journal, how to build a 2½-in. gauge "King" class engine; and later on, first actually built a "Grange" class locomotive, and then described how to build a copy of it. Both these engines had separate smokebox saddles, at the time when the full-sized Swindon products had the saddles cast integral with the cylinders, as in American practice. When Mr. F. W. Hawksworth "took the reins," he adopted the separate saddle.

The smokebox for our 3½-in. gauge "1,000" needs a piece of brass or copper tube 4⅛-ins. outside diameter; steel could be used at a pinch, the only disadvantage being that if any wet cinders or smokebox char should be left in it, rusting will occur.

If tube should be scarce, roll the barrel from a piece of 16 gauge sheet metal; butt the edges, and secure with a butt strip inside, riveted and silver-soldered if brass or copper. If steel, no butt strip need be used, the edges being merely butted together and Sifbronzed.

The barrel should be squared off at each end, holding one end in the three-jaw, with a circular disc of wood, a chuck plate casting, a wheel, or anything else handy and of requisite size, jammed in the end, so that the chuck jaws can grip the barrel firmly without distortion, and without any risk of the barrel flying out of the chuck and causing damage to the workshop window or the builder's personal anatomy.

Use a roundnose tool set crosswise in the rest—not a knife tool, as this would probably "dig in" and tear the edge of the barrel—and take light cuts. Take off the sharp edges by applying the tool whilst the work is still revolving. Sharp edges are first-class skin removers!

Marking out the Smokebox

Scribe a line down the barrel, and halfway along it make a centre-pop. Then make another, diametrically opposite. I usually do mine with a flexible steel rule which can be wrapped right around the smokebox, correctly measuring its periphery, and it is easy enough to mark off half the distance around, which gives the location of centre-pop No. 2.

A substitute for a flexible steel rule is a domestic measuring tape. A bit of copper wire, or lead fuse wire, can be used, cutting a length equal to the circumference of the barrel, and doubling it in half, which will indicate the halfway-around mark when applied to the smokebox.

Drill a No. 30 hole at each pop mark, and put a piece of ⅛-in. straight wire through; this will indicate at a glance whether the holes are exactly opposite. If not, correct with a rat-tail file; then drill one with 13/32-in. drill, and the other with 1⅛-in. drill. If you haven't one this size, drill a circle of ⅛-in. holes 1-in. diameter, break out the piece, and file to finished size, using a piece of 1⅛-in. tube for a gauge.

Smokebox front and door

Both the door and ring, as the front plate is usually termed, may be made up from castings, or from ⅛-in. sheet brass, or stamped brass blanks.

If castings are used, chuck the ring in the three-jaw, using outside jaws, with flange inwards, and the casting projecting a little beyond the jaws. Face the front and round off the edges; then bore out the door hole to 3-ins. diameter. Re-chuck the other way about, with the hole over the appropriate step of the inside jaws, and turn the flange until the ring is a tight fit in the end of the barrel. Bevel it slightly for about ⅛-in. so that it will enter the barrel easily on final assembly.

A cast door will have a chucking piece on the convex side; this is held in the three-jaw, whilst the edge of the door which makes contact with the ring, is truly faced off. That is all the machining you can do to a cast door, as the straps for the hinges will be cast on it, and prevent the front, or convex side, being machined all over. It will have to be finished by hand, first with a file, and then emerycloth or similar abrasive. After facing the edge, centre, and drill a No. 30 hole through; then cut off the chucking piece.

I doubt if any amateur turner—and few professionals!—could get a smooth convex surface by using a roundnose tool in the rest and manipulating both handles of the slide-rest at once, use a hand graver, or a fine file, to remove any ridges, and finish off with emerycloth. Melt the solder and pull out the brass stub, and the door is ready for hinges.

Hinges and Lugs

The cast door will have the hinges on it, and the ends will only need drilling with No. 51 drill to take a 1/16-in. hinge pin. Hinges for the door made from a blank, are merely strips of 20 gauge metal ⅛-in. wide, with one end rounded off, and the other end bent into a loop just big enough to admit a piece of 1/16-in. steel wire. This is easily done by aid of a small pair of roundnose pliers, using the pin for a gauge. The stuff we used to call German silver, which is really nickel-bronze, makes nice hinges, but soft steel, or even brass, may be used as desired.

The hinges are riveted to the door by pieces of domestic pins; the larger variety, known as blanket pins, are the most suitable. Holes for these should be drilled with No. 57 drill, and countersunk; the pin is then driven in, snipped off to leave about 1/32-in. projecting both sides, and hammered flush.

The lugs are turned from 1/8-in. square nickel-bronze, soft steel or brass. Chuck truly in four-jaw, turn about 1/4-in. length to 7/64-in. diameter, and screw 6 B.A. Part off to leave about 3/16-in. of head. Don't drill the pinhole yet; this is done later, with the door in place.

Crossbar and Dart

The crossbar is made from two pieces of 1/8-in. by 1/4-in. flat steel, either bright or black, each 3 1/2-ins. long, riveted together with 3/16-in. spacers between them. Clamp the two pieces together, and drill a No. 41 hole through both, at 5/8-in. from each end. Chuck a bit of 1/4-in. steel rod in three-jaw; face, centre, drill down about 1/2-in. with a No. 41 drill, and part off two 5/16-in. slices. Place them between the bars, opposite the holes, and rivet the lot together with 3/32-in. iron rivets as shown in the illustration.

To make the dart, chuck a piece of 3/8-in. round steel rod in the three-jaw. Turn 1 1/16-ins. length to 1/8-in. diameter; further reduce 1/4-in. of the end to 3/32-in. diameter, and screw 3/32-in. or 7 B.A. The next 5/16-in. is filed square, and I have described how to file true squares on small rods several times already, so need not repeat here. Part off to leave a head 3/16-in. long; file this flat, to the same thickness as the stem of the dart, shaping the flat part as shown in the detail illustration.

The dart is turned by a "key" fitting on the squared part, and the door is pulled up airtight by a locking handle on the screwed section.

For the key, chuck a piece of 5/16-in. round mild steel rod, face the end, centre, and drill down a full 1/4-in. with No. 40 drill; part off a 5/32-in. slice. Either file the hole to fit the square on the dart, or drive a piece of square silver-steel with a hardened and tempered end, through it. Drill a No. 51 hole in the side, tap it 8 B.A. and screw in a piece of 3/32-in. steel wire, slightly tapered, and screwed 8 B.A. at the narrower end, the other end being rounded.

To make the locking handle, chuck a piece of 1/4-in. rod, and turn 1/4-in. of it down to 7/32-in. diameter. Centre, and drill down 1/4-in. depth with No. 48 drill. Part off a slice 3/16-in. long. Tap the hole either 3/32-in. or 7 B.A. to match the thread on the dart, and fit a handle to it, same as the key, only a little shorter, say 1/2-in. long.

Fabricated Smokebox Ring

If no castings are available, make the ring from a disc of 1/8-in. sheet brass, or a stamping (called a "blank" in the metal trade) about 4 3/4-ins. in diameter. This is flanged over the circular former used for the smokebox tube plate, following the flanging instructions given for that component.

Chuck the flanged plate in the three-jaw, flange outwards, and skim off any raggedness around the flange; then re-chuck the other way around, holding by the inside of the flange, on the outside of the top steps of the three-jaw.

Cut the 3-in. hole in the front, by putting a parting tool crosswise in the slide-rest tool-holder, and feeding it up to the plate at 1 1/2-ins. from centre; run at slow speed, use plenty of cutting oil, and the disc will come out nicely, leaving a hole the correct diameter.

Face off the whole of the front with a roundnose tool set crosswise in the rest, then turn down the flange to a tight drive fit in the smokebox barrel, bevelling slightly as mentioned above.

Made-up Door

A 3 1/2-in. disc or blank of 1/8-in. brass, will be needed for the door. Anneal it by heating to red and plunging into cold water; then lay it on a block of lead or soft wood, and hit it with the ball end of the hammer. I usually start from the centre, and work outwards toward the edge in a sort of spiral, and never have any trouble in getting a nice even dish; but some folk prefer to start from the outer edge and work toward centre, like a gramophone soundbox runs over a record.

Having dished the plate, chuck in three-jaw with concave side outwards, holding by the extreme edge and setting to run truly; then take a facing cut across the edge with a roundnose tool set crosswise in the rest, making a flat face about 1/4-in. or so in width. Centre the plate, and drill a No. 30 hole through it; then face the metal around the hole until you have a flat place about 3/4-in. diameter.

Remove from chuck, then turn a pip about 1/8-in. long on the end of a short bit of 1/2-in. brass rod. This pip should be a tight fit in the hole in the middle of the dished plate. Drive it in, on the concave side, the shoulder of metal behind the pip butting up against the turned flat place in the middle. Run some solder around; when set, wash off any flux left from the soldering, and chuck the stub of rod in the three-jaw.

The dished plate soldered to the stub should run quite truly, and the convex side can be machined off, and the door reduced to 3 3/8-ins. diameter, at the one setting. As

How to Assemble

Put the dart through the hole in the door from the concave side, put on a 1/8-in. washer, and the key and locking handle. Place door in position on the ring, or smokebox front; put the crossbar over the dart head, adjust the door so that it is nicely in the middle of the ring, and tighten the locking handle.

Now make two little brackets to support the crossbar; these are bent up from 1/16-in. by 1/4-in. strip steel—a strip cut off a bit of 16 gauge steel sheet will do fine—drilled No. 40, and attach to the inside of the smokebox ring by 3/32-in. or 7 B.A. brass screws.

These brackets are shown in the section of smokebox; and no detail illustration is needed. Always use brass screws for anything inside a smokebox; steel screws become "set" by heat, condensation and other causes, and invariably break off at the heads if you try to get them out after any length of time.

All that remains are the hinge lugs. Mark the position of the eyes at the ends of the hinge straps, on the ring; and 1/16-in. below each, make a centre-pop. Remove the door, drill out the centre-pops with No. 44 drill, and tap 6 B.A. Screw in the lugs; replace door again, seeing that it is perfectly central on the ring, then put the No. 51 drill down the hole in the end of each hinge strap, and carry on right through the lug.

The hinge pin is merely a piece of 1/16-in. or 16 gauge steel wire, a piece of cycle spoke being just the right thing; the upper end is burred over slightly, so that it cannot fall through. Alternatively, it may be screwed 1/16-in. or 10 B.A., and a small

" button " screwed on the end, to serve the same purpose.

Finally, round off the lugs with a fine file, so that they conform to the shape of the ends of the hinge straps. If the locking handle is given a turn backwards, and the key turned one-quarter around, so as to allow the head of the dart to pass between the two members of the crossbar, the door should swing open easily; and when closed, with the handle of the key hanging downwards, and the locking handle screwed up against the boss of the key, the door should fit snugly against the ring and be perfectly airtight.

Don't drive the ring-and-door assembly permanently into the front of the smokebox shell yet; this is done later on, when all the pipe work, or " plumbing " inside the smokebox, has received attention.

Liner and Chimney

The chimney is a small edition of the familiar " fat " type with polished copper top, which is a feature of the Great Western locomotives, and adds to their pleasing personal appearance.

It contains a liner made from brass or copper tube, and this should be made and fitted next. A piece of 18 or 20 gauge tube is needed, 1⅛-ins. outside diameter, and after squaring off both ends in the lathe, the length should be 2⅜-ins. Cut a square of 16 gauge sheet brass or copper, measuring 2½-ins. each way; and in the middle, cut a hole 1⅛-ins. diameter, a tight fit for the tube, by the same method that was used to make the hole in the top of the smokebox. Bend the piece of metal to the same radius as the inside of the smokebox, push the piece of tube through the hole, so that it projects 1$\frac{3}{16}$-ins. above the convex side, and silver-solder it.

Very important, this—apply the silver-solder to the concave side, and let it make a little fillet all around the tube: if any shows on the convex side, the plate will not fit snugly against the smokebox. The silver-soldering operation will soften the tube, and the lower part can be slightly belled out as shown in the illustration, by driving a piece of tapered steel, hardwood, or anything else that may be handy, into the end. I have found an old brass plumbers' bob weight very useful for this job.

Put a smear of plumbers' jointing around the tube on the convex side of the plate, and push it up through the hole in the top of the smokebox, from the inside. Drill four holes with No. 41 drill opposite each corner of the plate, going right through both the smokebox barrel and the plate. Countersink the holes on the outside, put in four $\frac{3}{32}$-in. or 7 B.A. countersunk brass screws, and nut them inside the smokebox, as shown in the sectional illustration.

Cast Chimney

The chimney is turned up from a casting. This, by the good rights, should be copper; but it may be supplied in a grade of gun-metal that assumes the exact hue of polished copper after it has once been heated.

Chuck it in the three-jaw, base outwards, and bore it exactly as described for cylinder boring, until it is an exact sliding fit to go over the outside of the liner. Then mount it on a wood or metal mandrel, or drive it on a stub end of brass rod, as when mounting a cylinder for facing the flange; chuck in three-jaw, and turn the outside of the cap, the barrel, and as much of the base as you can, at the one chucking.

The base must be finished off carefully with a file, and finally smoothed with emery-cloth or other abrasive. The cast-in radius which sits on the smokebox, should be cleaned up with a file (it will be approximately right for the curve of the smokebox shell), and finally " bedded down " by wrapping a piece of thin emerycloth around the smokebox and giving the chimney radius a few rubs on it.

The lip at the top, which is supposed to act as a deterrent to " down draught " when coasting with steam off—whether it does or not, is a point on which may drivers don't agree—is finished off with a file.

The chimney is simply pushed on over the liner, and needs no further fixing. Any time you want to " bob up " the cap, as the old-time cleaners would say, you can lift off the chimney to do it, which was something the before-mentioned cleaners couldn't quite manage on their engines.

Built-up Chimney

A chimney could be turned from solid copper rod 2-ins. diameter, or from a piece of copper tube 2-ins. diameter and ¼-in. in thickness, as used for hydraulic presses, using the method described for machining the casting; but the radius under the base would have to be milled out, or cut with a fly-cutter. In the former case, it would need a cutter same diameter as smokebox. In the latter case, the chimney would be mounted on a stub mandrel, clamped under the slide-rest tool-holder at right angles to the lathe bed, and at centre height.

The fly-cutter is simply a small roundnose tool, made from ¼-in. silver-steel, exactly like a turning tool, and about 3-ins. long. This is put through a cross-hole in a short piece of ⅝-in. or ¾-in. bar, and secured with a setscrew. It must not have any chance of slipping, and the cutting edge must be exactly 2$\frac{1}{16}$-ins. from centre of bar.

Hold the bar in the three-jaw and start the lathe; the cutter will then sweep a circle 4⅛-ins. diameter, and if the chimney is fed up to it with the cross slide, and transversed across the flying cutter with the top slide, it will carve out a radius in the chimney base that will exactly fit the smokebox. Solemn warning: mind your fingers, for if the cutter should happen to catch them, it will be a hospital job. I seldom recommend fly-cutters for that specific reason.

Smokebox Saddle

CASTINGS will be provided for the smokebox saddle. This is of a different type or pattern to the usual kind, inasmuch as it has tapered-in sides, and no flange at the top, whereas most saddles have straight sides and a heavy flange all around the smokebox seating, like that described for " Bantam Cock." An end view and part section of the saddle is shown under the end view of the smokebox, which also illustrates the method of fixing it to the frames.

The casting requires no actual machine work done to it; merely clean it up with a file, the wide part being made to a tight push fit between the frames over the cylinders. The radius, or seating for the smokebox, is also cleaned out with a file.

At the bottom of this will be found two lugs, one at each end. Drill a No. 30 hole through each. Set the smokebox on the saddle so that the chimney is exactly vertical, with equal overhang each end. Hold the saddle to the smokebox by a clamp, or by any other convenient means, and put the No. 30 drill through the holes in the lugs again, carrying on right through the smokebox barrel.

The barrel can then be held down to the saddle by two ⅛-in. or 5 B.A. brass screws, with nuts inside the smokebox, as shown in the broken-away corner of the saddle in the small detail illustration.

Drill three No. 30 holes in the frame each side, above the cylinders, and about 5/16-in. from the top; the middle one above the middle of the cylinder, and the others at about 1-in. each side. Countersink them. Set the saddle between the frames, with the ends flush with the ends of the piston valve liners, and the angle of the saddle level with top of frame. The vertical part of the saddle sides should be 3/8-in. down between frames. Run the No. 30 drill through holes in frame, making countersinks on the saddle; follow up with No. 40, tap 1/8-in. or 5 B.A., but don't put the screws in "for keeps" yet, as this is not necessary until the complete boiler and smokebox has been finished with all fittings and pipe work.

Built-up Smokebox Saddle

In the unlikely event of a casting not being available, the saddle could be built up, using pieces of 1/8-in. brass plate for the ends, and pieces of 1/16-in. or 16 gauge ditto for the sides, the whole issue being silver-soldered together, or joined with small pieces of angle riveted into each corner, just as the builder prefers.

Two small pieces of ¼-in. by 1/8-in. angle brass could be riveted in the centre of each end plate, to serve as the lugs for holding the smokebox to the saddle, which were described earlier; the fixing would be exactly the same, holes being drilled with No. 30 drill through the angles and the smokebox shell, to take the fixing screws.

As the 16 gauge side plates would not be thick enough to take a thread, and it would be difficult to get at the inside and put nuts on, when the boiler is finally erected, a strip of 13 gauge brass could be riveted or soldered along the inside of the vertical part of the saddle, each side. This would thicken it up sufficiently to afford a good hold for the screws, and the saddle could be then erected on the frames in the manner described for the casting.

Regulator

On the full-sized G.W.R. engines the general practice is to collect steam from the highest point of the Belpaire firebox, just behind the throat plate; it enters two bell-mouthed pipes and proceeds via a central pipe to a regulator valve of the slide type, situated in the smokebox. Now that's fine for a big engine, but not so good for a little one; if there is one thing you want to avoid, to keep out of trouble, it is moving parts inside the smokebox, in an inaccessible position. It would be O.K. if we had a few Lilliputian fitters who could get inside the smokebox and do the needful; but as we have not that facility, it is policy to put things where we can get at them ourselves!

For that reason I am specifying a self-contained regulator of the disc-in-a-tube type, which is easy to make and fit, and can be taken out just as easily in the unlikely event of "something going wrong with the works."

The first requirement is a piece of 3/8-in. brass treblet tube 6 1/8-ins. long. Treblet tube is a commercial article, so-called because it is triple-drawn (three times through the dies) and is smooth, hard, and perfectly true, also thin-walled; if not obtainable, use ordinary brass or copper tube, as thin a gauge as you can get. Square off both ends in the lathe, and drill about 20 1/16-in. holes in three rows, starting about ¼-in. from one end, and keeping the holes close together in staggered formation. Scrape off any burrs that are formed inside the tube by the drill.

Throttle-Block

Chuck a piece of 3/8-in. round bronze or gunmetal rod in three-jaw. Face the end, centre, drill down about 5/16-in. with No. 48 drill, and tap 3/32-in. or 7 B.A. Countersink slightly; you can do this with the centre drill, when centring, if you like. Turn down 1/4-in. of the outside to a press fit in the tube, and part off at 3/8-in. from the end.

Reverse in chuck, centre, drill down about 5/16-in. with 9/32-in. or 7 mm. drill, and tap 5/16-in. by 32 or 40. Turn the outside to the shape shown in sectional illustrations. On the port face, about 3/32-in. from the edge, and 1/8-in. apart, make two centre-pops, and drill them out with 7/64-in. or No. 35 drill, putting it in on the slant, so that the holes go into the 5/16-in. tapped recess; see section.

With a little chisel made from a bit of round silver-steel, chip out the division between the holes; or you can mill it out with a dental burr (your dentist will probably give you a few used burrs for the asking; they will cut metal after they have finished work on teeth!), which can be held in the three-jaw, the block being clamped under the slide-rest tool-holder.

Chip the right-hand end of the hole to a point, as shown in view of port face; this allows gradual admission of steam when starting, and prevents slipping of the wheels. Slipping is not caused by high pressure and big cylinders, but by greasy rails and careless enginemen. I wouldn't give two-pennyworth of cold tea for a locomotive that had not the power to slip its wheels, if allowed, when starting; because such an engine would have no reserve of power to sustain its tractive effort at full speed, which is where you want it—ask any full-size driver.

Drill a No. 48 hole for the stop pin at the place indicated on the port face drawing, close to the edge, and about 3/32-in. off centre, and tap it 3/32-in. or 7 B.A. Screw in a little stub of bronze wire, leaving about 3/32-in. projecting, and do the same with the hole in the middle.

Before screwing in the pins "for keeps," it is advisable to rub the face with a twisting motion on a bit of fine emerycloth or similar abrasive, laid, business side up, on your lathe bed or other true surface. This ensures a true face, and the minute scratches hold the oil and make a perfect seal between portface and valve, besides ensuring easy operation.

Throttle Valve

For the valve, chuck a piece of 3/8-in. rod, of a different grade to that used for the throttle-block. Probably our advertisers will supply castings; but if not, and you use rod material, always recollect that dissimilar metals work best together, as one should be a little softer than the other. A valve made from the grade of aluminium used for automobile engine pistons, would work excellently on a bronze port face, for example; you could melt down a scrap piston with your big blow-lamp, and pour it into a tube for a mould, to obtain the necessary casting.

Face the end, centre, and drill down about 3/8-in. depth with No. 40 drill. Turn down 5/16-in. of the outside to 5/16-in. diameter, and part off at 5/16-in. from the end. Reverse in chuck, skim the outside to an easy fit in the regulator tube, and slightly countersink the centre hole, also truing up the face if needed.

Cut a 1/16-in. slot across the boss, with a watchmaker's flat file, or an Eclipse 4 S. slotting blade (the Eclipse 4 S. tool is a useful gadget) and then cut the sausage-shaped steam slot and file out the segment as shown. The former is made by drilling two 7/64-in. holes, same as the portface, and running them into one hole by aid of a rat-tail file. The segment needs no describing, only a file and a little ordinary "gumption." True up the valve face as described above.

Stuffing-box and Gland

You already have a brass fitting used to plug the regulator bush on the backhead when testing the boiler. Chuck this in three-jaw, flange outward; centre; drill right through with No. 21 drill, open out to ½-in. depth with 9/32-in. or 7 mm. drill, and tap 5/16-in. by 32.

Chuck any odd bit of rod about ½-in. diameter, turn down ¼-in. of it to 5/16-in. diameter, and screw 5/16-in. by 32. Don't remove from the chuck, but screw the fitting on to it, which should ensure it running perfectly true: then turn down ⅜-in. length to a tight drive fit in the regulator tube.

The gland is made from ⅜-in. bronze rod, in exactly the same way as described for piston glands, and repetition of details is not necessary; the overall length is 7/16-in.

Spindle

THE regulator spindle is a piece of 5/32-in. round rod—rustless steel, nickel or phosphor bronze, or hard brass—approximately 6¾-ins. long. One end is filed flat on each side, for a distance of about 5/16-in. to form a tongue that fits easily into the slot in the boss of the valve.

Turn down 5/32-in. of the other end to 3/32-in. diameter, and screw 3/32-in. or 7 B.A. The next 5/32-in. is filed square, by same process as used for squared ends of valve pins and other parts.

To repeat briefly, for beginners' benefit, chuck the rod with just the amount required to be squared, projecting from chuck jaws. Set one jaw exactly vertical: then, with a "safe-edge" file (one which has one edge plain, without teeth) file a flat on the rod, holding the file horizontally, with the safe edge rubbing against the chuck jaws. Repeat with the chuck jaw in "3, 6, and 9 o'clock" positions, and there is your square!

Spindle Assembly

Chuck a piece of brass rod, ½-in. in diameter, in the three-jaw; face, centre, and drill No. 23 for about ½-in. depth, and part off two 3/16-in. slices. Drive one on to the regulator spindle about 1½-ins. from the tongued end, and pin it with a bit of 1/16-in. brass wire driven into a No. 53 hole drilled through the lot. Put the other on about 1½-ins. from the other end, but don't pin it yet.

Press the throttle-block into the end of the tube, where the holes are drilled in it, the steam port being just below the holes; put the valve in position, and then insert the spindle, getting the tongue into the slot in the valve. If the tube is held vertically, but lightly, in the bench vice, this will be easy.

Measure the distance between the end of the tube, and the collar on the spindle. It should be ⅜-in. (the amount the boss of the stuffing-box fitting enters) plus 1/32-in. for clearance; if different to this, make the adjustment by shifting the collar on the spindle, and when correct, pin it, same as the other collar.

Wind a bit of 22 gauge hard bronze wire (Dick Simmonds sells it) around the spindle to form a spring, and file the ends square; the spring should be about 2-ins. long uncompressed. Put a drop of cylinder oil on the valve face before inserting it into the tube; this will make it stick to the port face whilst you hold the tube horizontally when inserting the spindle with the spring on it.

Put the stuffing-box fitting over the other end, and press it right home, taking care that the tongue on the spindle enters the slot in the valve; you can feel it by twisting the spindle between finger and thumb, and pressing the spindle toward the valve. When the fitting is right home, the spindle should have 1/32-in. end play, and the valve should work freely between the stops, shutting right off when one end of the segment is against the pin, and being fully open when the other end of the segment hits it.

The gland is packed with graphited yarn, same as the cylinder glands. Note: When pressing in the stuffing-box fitting, make certain that the holes in the tube will be at the top, when the completed regulator is inserted in the boiler; this can be done by making a centre-pop at the top of the flange, before removing it from the boiler after use as a testing plug, and lining up the holes in the tube with the centre-pop.

Regulator Handle

To make the handle, chuck a bit of ¼-in. round rod in three-jaw; rustless steel, nickel bronze, or anything else you fancy—and turn up the handle part, which is a kiddy's practice job needing no description. Cut it off about 1½-ins. from the end, and file it flat on both sides below the hand grip.

Chuck a piece of ¼-in. round rod, centre and drill it No. 30, and part off a ⅛-in. slice; silver-solder this on the end of the handle, run the 30 drill through the lot, and file the hole with a watchmaker's square file to a nice fit on the square on the regulator spindle, securing in place with a 3/32-in. or 7 B.A. commercial nut.

The square should be filed, so that when the regulator is shut, the handle should be in the "5 o'clock" position; pushing it up to about "4 o'clock" should start the engine, and when it is right up to about "1 o'clock" she should be going like—ah, um!

Steam Pipe and Flange

Cut a piece of 5/16-in. by 20 gauge (thicker may be used, but not thinner) copper tube to a length of 10⅜-ins. Screw one end to match the tapped hole in the end of regulator, and the other end 5/16-in. by 32 for about ½-in. length. Screw it tightly into the regulator with a smear of plumbers' jointing on the threads, and set it down ½-in. as shown in the sectional illustration.

Cut a gasket or joint ring from 1/64-in. Hallite or similar jointing material, to go between the flange of the regulator gland and the bush in the backhead; put on, insert regulator complete, and the end of the steam-pipe should then just project through the hole in the smokebox tube plate.

If it doesn't, remove the lot and bend the pipe till it does, and is nicely in the middle, at that; the screws can then be put in the regulator flange, and tightened up well. You already have the holes drilled and tapped, for fitting the plug while testing.

Pipe Flange

Our advertisers will probably be able to supply a casting for the flange. If not, chuck a piece of 1-in. round rod—brass will do, there is nothing to wear; face the end, centre, drill down about ⅞-in. depth with 9/32-in. or 7 mm. drill, and tap 5/16-in. by 32. Turn down ½-in. length to ¾-in. diameter, then further reduce ¼-in. length to ½-in. diameter, and screw ½-in. by 32. Part off at ¾-in. from the end, reverse in chuck, and take a skim off the big face, to true it up. File a couple of spanner flats on the intermediate part between flange and small end.

Castings will probably have this section cast hexagon shape. If held by the big flange, they can be turned, drilled and tapped, same as the rod, and reversed in chuck for facing the flange.

Anoint the threads with plumbers' jointing, and screw the fitting on to the end of the steam pipe; the external threads will engage with those in the tapped hole in the smokebox tube plate, and the whole lot will lock up solid, same as the longitudinal and wrapper stay nipples.

Superheater

Unlike the feeble attempts at superheating, such as "gridirons," or coils in the smokebox, which were more in the nature of condensers than superheaters, the component about to be described, really *does* superheat, bringing the steam temperature to over 600 degs. F.

My experiments have proved that, providing the lubrication is beyond suspicion, you can't have the steam too hot, the efficiency of the engine being raised to an amazing degree.

On a 2½-ins. gauge engine with an oil-fired boiler, I put a coil right in the flame of the blow-lamp, so that it became red-hot when the engine was at work. Result—the engine hauled me at a high speed for no less than 3¼ actual miles without a stop, on one tenderful of water (less than a quart), maintaining steam pressure at 90 lbs. the whole time, the last three laps of my railway being covered after the oil burner had gone out for lack of fuel!

The locomotive had cylinders of good quality gunmetal, with pistons and slide valves of hard phosphor bronze; and on examination after some months of running with "red-hot" steam, the cylinder bores and port faces were in first-class condition, with a glassy surface, but with all the colours of the rainbow, due to the high working temperature. Therefore, nobody need have any fear about the little Great Western engine "burning her fingers" in a manner of speaking.

Wet Header and Flange

THE superheater consists of three sections, viz., the wet header, the elements, and the hot header with its connections to the cylinders. The whole issue is easy to make and fit.

The flange of the wet header may be a casting, in which case it only needs facing on both sides, and drilling for the steam passages, as below. If no casting is available, chuck a piece of 1-in. diameter brass rod, face the end, centre, and drill 7/16-in. depth with ¼-in. drill; part off ½-in. from the end.

With a ½-in. round file, make a groove in the edge about ⅛-in. deep; and in the centre of this, drill another ¼-in. hole, to meet the one in the middle. Drill the four screwholes (indicated by the screwholes in the end view) with No. 34 drill, about ⅛-in. from the edge.

The header itself is a piece of ½-in. by 20 or 22 gauge seamless copper tube 3¼-ins. long. Square off the ends; drill a ¼-in. hole in the middle, and exactly opposite to it, four ¼-in. holes all in a line, at ⅞-in. centres. At right angles to these, and about ¾-in. from the right-hand end of the tube, drill a ⅛-in. hole for the pipe leading to the snifting valve.

Clean out any burring inside the tubes, and plug the ends either with a disc of 16 gauge sheet copper, or a slice turned to a drive fit and parted off the end of a piece of ½-in. rod.

Elements

The four elements are made from ¼-in. by 20 or 22 gauge copper tube (not thinner), eight pieces 10¾-ins. long being required. Four of them have a sharp bend at one end, as shown; and the easiest way to get this, is to bend the tube at approximately 10-ins. from the end, before cutting it off the long piece. If the tube is hard drawn, soften by heating to red and plunging into cold water, before attempting to bend it.

Cut off directly above the bend, and repeat performance for the other three. The lower four are left straight.

The firebox ends of the elements are joined by return bends made from small blocks of copper. Spearheads, as described for other locomotives in these notes, may be used if desired; and if properly made, will be perfectly satisfactory.

My only reason for specifying the block bends, is that I have received many letters, especially from beginners, who have completely blocked the spearheads with spelter when brazing them together. There is no fear of any blockage occurring with the bends illustrated.

Each bend requires a small block of copper about ⅝-in. long, ⅜-in. wide, and ⅝-in. deep; a ⅜-in. slice off a bit of ⅝-in. square bar, would be just right. Drill two holes in one edge, almost touching, using letter D drill if available; if not, use ¼-in. drill. These holes should converge, so that they break into each other just inside the block.

Fit the ends of a bent tube and a straight tube into each hole, and braze the joint; don't use silver-solder, but either brazing strip, brass wire, or "Sifbronze." Fit the elements into the four blocks and do the lot at one heat.

Pickle and wash off, running water through the elements to clear out any internal scale, which would do the piston valves a bit of no good if it got into the steam chests; then bend the two members of the element so that they lie parallel, and file the outsides of the copper blocks to the shape shown in the sectional illustration.

They should fit the flues easily, and leave room at each side for the hot gases from the firebox to pass along between them and the walls of the flues.

Hot Header

This is made precisely the same as the wet header; but on the opposite side to the four holes for the elements, drill two more ¼-in. holes, at about ½-in. from each end, and in each of these fit a piece of ¼-in. copper tube about 4-ins. long, with a ⅜-in. by 26 or 32 union nut and cone on the end. The union nuts are made from 7/16-in. or ½-in. hexagon rod chucked in three-jaw. Face, centre, drill down about ½-in. depth with ¼-in. clearing drill (letter G or 17/64-in.), open out to 5/16-in. depth with letter R or 11/32-in. drill, and tap either ⅜-in. by 26 or 32. Part off a full ⅜-in. from the end, and chamfer the corners of the hexagon both ends.

The cones are made from copper rod; I always use copper, because it always screws up to a steam-tight joint with little pressure on the nut, and there is no risk of melting or distorting the cones when attaching them to the pipes. The angle of the cone can be turned by slewing the top slide around to 30 degs., and using a roundnose tool, or by using a square-ended tool with one corner ground off to 30 degs. angle.

Drill the cone 7/32-in., and after parting off, reverse in chuck and slightly counterbore the back with letter D or ¼-in. drill, to admit the end of the pipe. Silver-solder will do for fixing, as there is not much heat in the smokebox, being so far away from the fire.

First fit the four curved ends of the upper elements into the wet header, then set the flange on top of it, making sure that the holes in header and flange line up. Tie the flange to the header with a bit of thin iron binding wire. Next, fit the four straight ends of the lower elements into the hot header and the two steam pipes complete with unions, as described above. Fit a piece of ⅛-in. copper tube about 5-ins. long, into the ⅛-in. hole in the wet header.

Now cover all the joints with wet flux and the whole bag of tricks can be silver-soldered at one heating; the circular flange, all the ends of the elements into the headers, the ends of the headers, the steam pipes and the snifting valve pipe.

A medium grade of silver-solder will do fine, using Boron compo, or jeweller's borax as flux; or Johnson-Matthey's C4 with "No. 1 Tenacity" flux.

After pickling the superheater assembly, give it another good rinse through with running water, for reasons mentioned above; there is no need to clean it up with steel wool or emerycloth, as it is hidden from sight when erected. Place it in position with the flange of the wet header lining up with the flange on the steam pipe; hold it temporarily, run the No. 34 drill through the screwholes, making countersinks on the steam pipe flange, remove, drill the countersinks No. 44 and tap 6 B.A. It is then all ready for final assembly and erection.

Snifting Valve

A SNIFTING valve, or, to give it its posh title of vacuum relief valve, will be needed to prevent ashes and grit being sucked down the blastpipe into the cylinders when coasting with steam off, and grinding away the pistons and valves; a little refinement that the "old school" never worried about.

Chuck a piece of ⅜-in. hexagon or round rod in the three-jaw; face, centre, and drill down about ½-in. with No. 44 drill. Open out to 3/16-in. depth with 7/32-in. drill, and bottom with a 7/32-in. D-bit to ¼-in. depth; tap ¼-in. by 40, and don't let the tap scrape the seating. Part off at 7/16-in. from the end, reverse in chuck, and turn down ⅛-in. of the other end to ¼-in. diameter. Run a 3/32-in. parallel reamer through the No. 44 hole.

Chuck the rod again, centre, and drill down about ⅜-in. with 5/32-in. drill. Turn down 3/16-in. of the outside to ¼-in. diameter, screw ¼-in. by 40, and then face off 1/16-in., which will ensure that the ⅛-in. spigot left will have a full thread for its full length. Part off at ⅛-in. from the shoulder; reverse in chuck, and open out the centre hole with No. 31 drill to about ⅛-in. depth.

Cross-nick the spigot with a hacksaw or thin file. Silver-solder this to the end of the snifting valve pipe, as shown in the detail illustration. Seat a ⅛-in. rustless steel ball in the cup, by the hammer-and-brass rod trick, and screw it on the cap as shown.

When the engine coasts with the regulator shut, the cylinders, by virtue of their pumping action, suck air out of the superheater and steam pipe. Without this valve, air would go down the blastpipe, and take ash and grit along with it; but the valve prevents it by opening and admitting air to the superheater elements, not only destroying the vacuum caused by the pumping action, but preventing the superheater elements from becoming overheated whilst no steam is flowing through them. Also, the air sucked in by the cylinders is warmed by its passage through the superheater, and prevents them from cooling off sufficiently to cause condensation.

When the boiler is finally erected, a ¼-in. hole is drilled in the bottom of the smokebox, close to the ring (see longitudinal section) and the spigot at the bottom of the snifting valve poked through it, so that it takes air from outside the smokebox; no other fixing is needed. The length and course of the pipe inside the smokebox, doesn't matter a continental.

Connections to Cylinders

The length of the connecting pipes between the superheater unions and the cylinders must be obtained from the actual job; that is where a little fitting skill is called for.

Drill a ⅛-in. hole each side of the smokebox, 1¾-ins. from bottom centre line, and level with the middle of the chimney; open it out with a ⅜-in. clearing drill (letter W). Put the smokebox and saddle on the frames in the position they will occupy when the boiler is finally erected; that is, with the bottom of smokebox ¼-in. above frames, and the holes level with centre of cylinders. Cut two oval flanges from ⅛-in. sheet brass, to the same shape as the bosses on top of the steam chests, and drill them as shown, ¼-in. or letter D drill being used for the steam pipe hole, and No. 30 drill for the screwholes.

For the union fitting, chuck a piece of 7/16-in. or ½-in. hexagon brass rod, in three-jaw; face the end, centre deeply, and drill down about ¾-in. depth with 7/32-in. drill. Turn down ½-in. of the outside to ⅜-in. diameter, and screw ⅜-in. by 26 or 32, to match the union nuts on the superheater. Reverse in chuck, and counterbore slightly with ¼-in. or letter D drill.

Temporarily attach a flange to the steam chest, put the fitting in the hole in the smokebox, and cut and bend a piece of ¼-in. copper tube to connect the two, as shown in the end view. This is a trial-and-error job. When O.K., fit a 7/32-in. by 40 nipple in the bend of each, as also shown; these nipples are exactly the same as fitted to the side of the outlet clack on the underside of the lubricator, so need no further detailing.

Both ends, and the nipple, can then be silver-soldered at one heat; pickle, wash off and clean up. When the boiler is erected, the screwed fittings are held in place by a locknut inside the smokebox, and the superheater unions attached to the fittings as shown.

The idea of the crossed pipes is to make the actual attachment much easier; you have far more flexibility and freedom of adjustment, than with short pipes connected to the hot header on the same side as the fittings. The pipes can easily be bent to miss the blastpipe, and their length does not matter.

The end view also shows the oil delivery; the double-union clack valve was described along with the mechanical lubricator, and the two unions on it are connected by 3/32-in. or ⅛-in. pipes, furnished with nuts and cones on both ends, to the nipples on the steam pipes as shown. It is imperative that these pipes be exactly the same length; I will tell you the easiest way of connecting up, when mounting the boiler after fitting the grate and ashpan.

Safety Valve

THERE are two direct-acting spring safety-valves in the brass casing on the taper boiler-barrel of the full-sized engine. They are not of the "pop" type, because the sudden rush of steam, when a pop valve starts to blow off, would lift the water and cause excessive priming. To prevent priming, a pop valve needs to be placed as high as possible above the normal working level of water in the boiler; and the Great Western Railway does not use them because there is not sufficient space between the working level of the water in the boiler and the position of the valves on the barrel. On the little engine we use one large direct-acting valve only, for the simple reason that there isn't room for two of adequate size; and here is how to make it.

Chuck a piece of 3/4-in. hexagon brass rod in the three-jaw; face the end, turn down 5/16-in. length to 1/2-in. diameter, and screw 1/2-in. by 26, to suit the bush on the boiler barrel. Part off at 5/8-in. from the shoulder.

Put a short bit of 5/8-in. or larger rod in the three-jaw; face, centre, drill 29/64-in. and tap 1/2-in. by 26. Countersink slightly, and skim off any burr. Screw the valve blank into this; face off, centre, and drill right through with a letter C or 15/64-in. drill. Open out the hole to a full 1/2-in. depth with 25/64-in. drill, bottom the hole to 11/16-in. depth with a D-bit, same size as drill, and tap 7/16-in. by 32. Turn down the outside to a bare 5/8-in. diameter, leaving enough of the hexagon to provide a spanner hold for tightening up the valve in the boiler bush.

It is quite possible that our advertisers may be able to supply gunmetal castings for the safety-valve body; if so, they are machined up same way, first turning and screwing the stem that screws into the boiler bush, and then chucking it in a tapped bush for finishing off, as described above. Put a 1/4-in. parallel reamer through the remnants of the small hole at the bottom.

Wing Valve

A wing valve, as in full size, is used on this engine in place of the usual ball. To make it, chuck a piece of 3/8-in. round bronze in three-jaw; face the end, and turn down about 5/16-in. length to 11/32-in. diameter. Further reduce 3/16-in. of the end, to an easy fit in the 1/4-in. reamed hole at the bottom of the valve body; this should be done with a tool with the leading edge ground off to an angle of about 30 deg., which will leave a bevelled valve seat, as shown in the illustration. Part off at 1/4-in. from the end; reverse in chuck, and form a countersink in the end. If you make a shallow hole with the point of a centre drill, and follow it up with a 3/16-in. drill, just letting the cutting edges enter full depth, it will do the trick.

File three flats on the stem, as shown in the view of the underside, taking care not to damage the coned part; and make a couple of nicks with a small chisel, at opposite sides of the countersink, just sufficient to allow a thin screwdriver-point to turn the valve for grinding-in purposes.

Very little grinding-in is required, as the contact between valve and seating does not require to be any wider than that between a ball and its almost knife-edge seating, formed by hitting the ball with a hammer via a bit of soft rod. A spot of oil, with a scraping off your oilstone, applied to the coned part of the valve, and a few twirls back and forth with a screwdriver, will form a perfectly steam-tight contact. Be sure to wipe all the grinding residue off.

Valve Spindle

To make the spindle, chuck a piece of 1/4-in. brass rod in the three-jaw, turn down 1/4-in. length to 1/8-in. diameter, and part off 1-in. from the end. Reverse in chuck, and turn the head to a cone point as shown in the illustration.

For the nipple, chuck a piece of 1/2-in. round rod; face the end, centre, and drill No. 30 for about 1/2-in. depth. Turn down 1/4-in. of the outside to 7/16-in. diameter, screw 7/16-in. by 32, and part off 3/16-in. from the end. Make two nicks for the steam to escape, with a thin flat file, as shown in the illustration.

Valve Spring

The spring is made from a piece of 22 gauge tinned steel wire, wound around a piece of 1/8-in. silver steel held in the three-jaw. If you bend one end of the wire and poke it between the chuck jaws, then pull the belt with your left hand slowly, guiding the wire with your right, the spring will practically form itself. On releasing, it will spring open sufficiently to be an easy fit on the safety-valve spindle.

Touch each end on a fast-running emery wheel, to square them off, and obtain a fair bearing against both nipple and spindle flange. Uneven bearing is a frequent cause of the annoying dribble often seen in small safety-valves. Assemble as shown; the spring should just begin to compress as the nipple enters the threads in the valve body.

Safety Valve Casing

The casing is turned up from a casting, a "kiddy's practice job" requiring no detailing out. The seating had best be finished with a file, and fitted to the taper of the boiler barrel, so that the casing sits vertically. The inside is bored to fit nicely over the valve body. The casing is turned circular at first: the two excrescences on the side are added afterwards, when the top feed pipes have been installed, so there is no need to worry about those yet awhile.

Backhead Fittings

If there is one thing more than another that your humble servant likes to see on a little locomotive, it is a neat arrangement of the footplate. I guess it is because I am used to the lay-outs on the engines of the London, Brighton and South Coast Railway, which were very neat and tidy. Some of the clumsy and badly-arranged fittings I have seen on club and exhibition tracks were just too awful for words, yet there is not the slightest need for it. Most of the trouble was due to the use of ugly and badly-designed commercial fittings, many of which are perpetuated to this day, as can be seen by perusal of certain catalogues, though one or two newcomers to "the trade" have taken my own type of fittings as a guide, and considerably improved matters thereby.

It is quite easy to make your own fittings, and also quite easy to set them out on the backhead in a manner commensurate with full-size practice, as the illustration will show. In this drawing, the outline of the cab front is shown, for two reasons; one, to show that all the fittings are easily accommodated without obstructing the cab windows, and secondly, the dimensions of it are appended, which will save making a separate drawing when we come to the job of making and erecting the superstructure.

Fitting Review

THE fittings are few and simple. At the top is a combined turret and whistle valve with three unions for connection to the steam gauge, blower valve, and whistle, the steam gauge being installed in the position it occupies on some of the full-size G.W.R. engines. The water gauge is of ample length with a 5/16-in. glass, yet the mountings are far smaller and neater than provided for the usual type of 5/32-in. commercial gauge, which has "more brass than glass" in a manner of speaking, and a plug-cock blowdown which either leaks, sticks, or does both.

The regulator and blower valve have already been described; above the latter is a similar valve controlling the steam supply to the injector, and there is plenty of space left on the backhead for the addition of a vacuum brake ejector, if the builder decides on fitting working vacuum brake apparatus at any future date. At the bottom, on the left, is a 3/8-in. washout plug, and on the right, a blowdown valve, by means of which it is possible to blow down the boiler when pressure is low, and so remove a lot of the scale and impurities which collect around the foundation ring in districts where the feed water is none too pure.

The firehole door is of the simple swing type with a spring catch; this is not G.W.R. practice, as they use sliding doors, but not only would sliding doors be over-large and unsightly on this size of engine, but they are more awkward to operate, especially when the runners become choked with coal dust or bits get between the doors. The type shown can be flicked open and shut with the shovel, when you are firing up the engine whilst running.

Turret and Whistle Valve

Chuck a piece of 5/16-in. brass rod in three-jaw, face the end, and part off a piece 1-in. long. Re-chuck, centre, and drill right through with No. 44 drill; open out to 3/8-in. depth with 3/16-in. drill, and bottom to 7/16-in. depth with a 3/16-in. D-bit. Tap the end of the hole 7/32-in. by 40, countersink slightly, and skim off any burr.

Reverse in chuck, and repeat operations, except that the D-bit need not be used; instead, poke a 3/32-in. parallel reamer through the remnants of the No. 44 hole.

At 1/4-in. from the D-bitted end, drill a 5/32-in. hole clean through both sides of the fitting; and another, in line with them, halfway between. Drill another 5/32-in. hole 1/4-in. from the other end, in line with the left-hand hole when the D-bitted end is pointing away from you.

In each side, in the cross-holes, fit a union nipple same as the one described for the blower valve, mechanical lubricator, etc., screwed 1/4-in. by 40; and in the hole at the handle end, fit one screwed 7/32-in. by 40, as shown in plan section.

The little pedestal for attaching the fitting to the boiler, goes in the bottom hole; to make it, chuck a bit of 5/16-in. round brass rod, face the end, centre, and drill down a full 1/4-in. with No. 40 drill. Turn down 3/16-in. of the outside to 3/16-in. diameter, and screw 3/16-in. by 40; part off at 1/4-in. from the end. Re-chuck in a tapped bush held in three-jaw (as described for safety-valve), turn the outside to shape shown, then turn down 1/16-in. of the extreme end to a squeeze fit in the bottom hole of the turret body. Squeeze it in, and silver-solder all four projections in at the one heating; quench in pickle, wash and clean up. Drop a 1/8-in. rustless steel ball in the D-bitted end, seat it with the usual hammer-and-brass wangle, and fit a little hollow cap with a spring, same as previously described for the mechanical lubricator clacks.

Whistle Valve Lever

For the handle fitting, chuck a piece of 3/8-in. hexagon rod in three-jaw; face, centre, and drill to 1/4-in. depth with No. 48 drill. Turn down a bare 3/16-in. of the outside to 7/32-in. diameter, and screw 7/32-in. by 40; part off 7/16-in. from the end. File away two opposite corners of the hexagon, so that the end is rectangular; and across the longer diameter of this, mill, saw or file a slot 3/16-in. deep and 3/32-in. wide.

Make a lever from 5/32-in. round rod—any non-rusting metal will do—turning up the handle end with the rod held in three-jaw, and filing away each side of the rod below it, to form the flat part, which should be an easy fit in the slot. The overall length of the handle should be about 1 1/4-ins.

Round off one side of the flat end, as shown in the plan section; then pin it at the end by a piece of 1/32-in. wire, or a blanket pin snipped off 3/8-in. from the end. I use the latter, and find that No. 57 drill is just O.K. for the holes.

The lever should be perfectly free to move, but close enough to the bottom of the slot to prevent it flying right around when released after being pressed to blow the whistle; the square end of the lever should come up against the bottom of the slot, when the lever it at an angle of about 45 deg. from the fitting.

Put a piece of 15 gauge or 5/64-in. bronze or rustless steel wire 5/8-in. long, in the hole, and screw the fitting home. When the le[ver] is pressed, the ball should be pushed ab[out] 1/32-in. off the seating by the rod, and should have a little play when the ball [is] fairly seated. The correct adjustment [is] easily made on the valve itself, by using longer or shorter push rod, as required.

Fitting Whistle Valve

Drill a 5/32-in. hole in the cen[tre] of the wrapper sheet over the bac[k]head, near enough to the edge to go throu[gh] the backhead flange, which will give you good depth of thread. Tap it 5/16-in. by [40] and screw in the fitting with a taste [of] plumber's jointing on the threads; wh[en] right home, the centre line of the fitti[ng] should be in line with centre of boil[er] and the handle pointing to the right, [as] shown in the illustration of the comple[te] backhead.

The union screw on the right side is con[]nected to the one on the top of the blow[er] valve, by a piece of 1/8-in. copper pipe fu[r]nished with union nuts and cones on eac[h] end, as described for the oil pipe connec[]tions. A similar piece of pipe, with th[e] lower end bent into an inverted swan nec[k] serves as a syphon for the steam gauge.

Whilst steam gauges *can* be home-mad[e] it is a very fiddling job, and I don't recom[]mend making them at home. Apart from the "wrist-watch" work, each one has [to] be separately calibrated along with a [] gauge, and as you would have to get one [of] those anyway, you might as well buy a sma[ll] one ready-made, and save time and troubl[e]. Dick Simmonds and one or two other adve[r]tisers can oblige. Get one about 3/4-in. dia[]meter, reading from 0 to 120 lbs. per sq. in[.] which is a standard size, or 0 to 150, which will retain its accuracy over a longer period though the indications are much closer spaced. The illustration of the complete backhead shows where to put it. The thir[d] pipe is not attached to the turret until th[e] whistle is made and fitted, after the boile[r] is erected on the frames.

Water Gauge

THE next job is the "old reliable"; I've had one similar on my old 4-4-2 "Ayesha" for 26 years, and it has never, as the enginemen would say, "sold me a pup" yet. It has just had to be reliable, at that, because I have made dozens of injectors (I usually make six at a time) and every one has been tested on that particular old locomotive, the water gauge registering the exact amount of feed whilst running.

Kick off with the upper fitting; chuck a piece of 5/16-in. round brass rod, face the end, and part off a piece 1-in. long. Rechuck, centre, drill right through with 3/16-in. clearing drill (No. 11) and screw the end 5/16-in. by 32, only about four threads being needed. Reverse in chuck, tap the other end 7/32-in. by 40, slightly countersink the end, and skim off any burr.

Drill a 3/16-in. hole in the side, and in it, fit a doings exactly the same shape as the pedestal of the whistle valve, and drilled No. 30. Silver-solder it in; then make a little cap for the top, same as described for oil clacks and so on, but instead of using hexagon rod, use round rod, and file a square on the top to take a spanner.

The plug has to be taken out frequently for cleaning the inside of the glass, in districts where the water is not as pure as it might be: and you are less likely to knock the corners off a square than a small hexagon.

Water Gauge Bottom Fitting

For the bottom fitting, chuck a piece of 3/8-in. brass rod in the three-jaw, face the end, centre, and drill down 11/16-in. depth with No. 30 drill. Turn down 3/16-in. of the outside to 1/4-in. diameter, and screw 1/4-in. by 40; part off 1-in. from the shoulder.

Rechuck in a tapped bush, as for the safety-valve; centre, drill down with No. 48 drill until it breaks into the No. 30 hole, open up to about 5/16-in. depth with No. 30 drill, and bottom with a 1/8-in. D-bit to 3/8-in. depth. Tap 5/32-in. by 32 if you have this pitch, as it gives a quicker blow-down action; if not, use 5/32-in. by 40; turn the outside to the shape shown.

At 3/8-in. from the shoulder, drill a 3/16-in. hole, breaking into the No. 30 central hole; at 5/16-in. farther along, and exactly opposite, drill another. In the latter, fit a 7/32-in. by 40 screwed union nipple, same as on the whistle turret; in the former goes the bottom support for the glass tube.

Chuck the 5/16-in. rod again, face the end, centre, and drill No. 30 for about 5/16-in. depth; open out with No. 11 drill for a bare 1/8-in. depth. Part off at 1/4-in. from the end, reverse in chuck, and turn the end down for 3/16-in. length, to a tight fit in the upper hole in the fitting.

Squeeze it in, and silver-solder it and the union nipple at the one heat. Pickle, wash off and clean up. I clean up all my small fittings, after silver-soldering, on a small wire-brush wheel mounted on a short taper shank spindle which fits a hole reamed to suit, in a taper socket screwed on the end of the spindle of my electric grinder, the socket taking the place of the nut which held the emery wheel in place. All I have to do, is to stick the taper into the socket, switch on, and the wire brush buzzes around to the tune of 2,990 revolutions per minute. A few seconds' application of the fitting to the flying tips of the wires, doesn't half make them "bob," as the engine-cleaner boys used to say.

Water Gauge Valve

The valve pin is made exactly as described for the blower valve, except that it has a piece of 15 gauge spoke wire or 5/64-in. silver-steel, driven through a No. 49 hole drilled through the outer end of the pin, as shown in the sectional illustration. The gland nuts are made from 3/8-in. hexagon brass rod chucked in the three-jaw. Face, centre, drill No. 11 for about 3/8-in. depth, open out with 9/32-in. or letter J to 5/16-in. depth, tap 5/16-in. by 32, part off at 1/4-in. from the end, and chamfer the corners.

Fitting Water Gauge

Drill a 7/32-in. hole up in the left-hand corner of the backhead, tap it 1/4-in. by 40, and screw in the top fitting, with a smear of plumber's jointing on the threads. Exactly 2-ins. below it, drill and tap a similar hole, and screw in the bottom fitting; you can easily see if they line up fair and square, by putting the shank end of the No. 11 drill down the top fitting, and letting it fall into the bottom one. The gland nuts should be put on whilst making the test. If the drill goes right to the bottom of the recess in the lower fitting, the lining-up is O.K.; if not, adjust one or the other, or both, until it does.

Gauge Glass

The glass is a piece of 3/16-in. tube with fairly thick walls; no special quality is needed. I used to get some bits of ordinary soda-glass tube from a firm in Hatton Garden who made laboratory apparatus, and it worked out about three feet (*feet*, not inches!) for one penny.

Packing Rings

The packing rings are made from rubber tube; red, black or grey, it doesn't matter which. The easiest way of making them is to slide a bit of rubber tube of the nearest approximate size to 3/16-in. bore and 5/16-in. outside diameter, on to a piece of 3/16-in. rod, and try the gland nut on it.

If it won't fit, chuck the rod in the three-jaw, run the lathe as fast as possible, and hold a bit of fine glass paper to the rubber tube, which will soon thin it down until the gland nut will go on. Then get an old safety razor blade, which is no use for its legitimate purpose; wet it (don't forget that) and apply it to the rubber tube on the mandrel, at about 1/8-in. intervals, still keeping the lathe running. Push it off when you reach the end, and instead of a tube, it will fall off in clean-cut rings.

Cut a piece of the glass tube to a length of approximately 1 11/16-ins., and try it in the gauge fittings to see that the upper hole is clear when the glass tube is bottoming in the lower fitting. If O.K., wet a couple of the rings, and the glass; put the latter through the top fitting, then a ring, then the two nuts back to back, then another ring. Let the tube down in the recess in the lower fitting, and screw the gland nuts home.

They should be little more than finger-tight, as the glass must be free to expand; any driver or fireman will tell you that one of the most frequent causes of broken gauge glasses, is excessive tightening of the glands. Put a smear of plumber's jointing on the threads of the top cap.

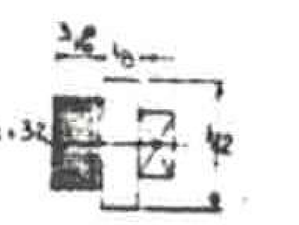
The blowdown pipe is merely a piece of 1/8-in. copper tube with a 7/32-in. by 40 union nut and cone on one end, attached to the nipple under the blowdown valve and led down to a point below the footplate. On a big engine, the blowdowns are frequently allowed to discharge into the ashpan, as on the locomotives of the old L. B and S.C. Railway, but on a little one, it can blow down between the rails.

No detailed instructions for making the injector steam valve will be needed, as the *modus operandi* is exactly the same as given for the blower valve, the only difference being in the dimensions which are given on the accompanying drawing. A piece of 5/32-in. copper tube, thin-walled for preference, say about 22 gauge, is pushed into the end of the valve and silver-soldered. This should be about 6-ins. long, and the end should be bent up as indicated, so that when the valve is screwed right home, with the nipple underneath and pointing a little to the right (see illustration of complete backhead), the end of the pipe practically touches the top of the Belpaire wrapper.

Injectors *must* have dry steam, or they won't work, for the simple reason that their action depends on the condensation of steam in cold water; and if there is already water in the steam, it can't condense any further, and so there is " nothing doing." The valve is screwed into a 1/4-in. by 40 hole, drilled and tapped as near to the top right-hand corner of the backhead as possible.

THE washout plug is made from 1/2-in. round brass rod. Chuck in three-jaw, face the end, turn down 5/16-in. length to 3/8-in. diameter, screw 3/8-in. by 32, and part off 1/4-in. from the shoulder. File or mill a head 1/4-in. square and 1/8-in. long for a spanner hold, leaving 1/8-in. of the flange full diameter, and that's that.

For the blowdown, chuck the rod again, and turn down 3/16-in. length to 3/8-in. diameter, screwing 3/8-in. by 32. Centre, and drill down a full 1-in. with 7/32-in. drill; part off at 1-in. from the end. Rechuck in a tapped bush as previously described; open out the hole with letter J or 9/32-in. drill, to about 3/8-in. depth, and bottom with a D-bit to 1/2-in. depth. Tap the end 5/16-in. by 26 or 32, and turn down the outside to shape shown. At 3/8-in. from the shoulder, drill a 1/4-in. hole, for the pipe socket, which is made from 3/8-in. round rod. Chuck in


WASHOUT PLUG

three-jaw, face, centre, and drill down about 3/8-in. depth with 7/32-in. drill; tap 1/4-in. by 40 for about 5/16-in. depth. Part off 1/2-in. from the end; reverse in chuck, and turn a " pip " on the end to a tight squeeze fit in the hole in the side of the fitting, silver-soldering it in.

The valve pin is made from a bit of 5/16-in. round rod, rustless steel or bronze for preference, by the method given for the blower-valve pin; but the end is squared to take a small box-spanner, and no wheel nor handle is needed.

Fitting Blowdown

At 1/2-in. from the bottom of backhead, and 15/16-in. each side of centre, drill a 1/8-in. pilot hole, and open it out with a letter R or 11/32-in. drill; tap 3/8-in. by 32, screw the washout plug in the left side hole, and the blowdown valve in the right, with the socket pointing downwards. Don't forget that a drop of cutting oil, as used for turning steel, helps the drills and taps to " do their stuff " in soft copper without tearing it; beginners especially note.

Firehole Door

Little detailed instructions are needed fo the firehole door, as castings will be avai able, and the only work necessary will

to rivet an oval baffle plate of 16 gau steel to the boss on the inside of the do This should measure approximately 3/4-in. 1 1/4-ins., so that it easily fits the fireho ring.

Hinge straps and lugs will be cast and only need drilling for the pin. Th hinge lug is a piece of 18 gauge steel wi a tongue bent into a loop for the pin, it may be filed up from a bit of scrap bra It is attached to the backhead by thre 8 B.A. or 3/32-in. brass screws. The com bined handle and catch is riveted to door, and the retaining spring merely a of springy brass or bronze, bent to a ri angle, with a kink in it to engage the of the handle. It is attached to the bac head by a single 3/32-in. brass screw.

If a built-up door is preferred, cut it fro 16 gauge blue steel, fit a baffle plate described above, with a 1/4-in. spacer be tween it and the door, and make the hin straps by the same method as describ for the smokebox door.

Grate

The grate on the full-sized engine is m in two sections, one horizontal and inclined, each with a straight set of b but on the little one, there is no need go to that trouble, particularly as it is de able that the grate should be instantly movable for cleaning out the residue of fire after every run. We therefore us one-piece grate, with the bars bent to angle of the bottom of the firebox.

Seven pieces of 1/8-in. by 5/16-in. black strip steel are required; this is a commercial article obtainable at any iron and steel merchants' store. Cut the bars to a length of 5 1/2-ins. full, and bend each one at 2 1/8-ins. from one end, to the same angle as the bottom of the firebox. Drill a No. 30 hole in one of them, at 1-in. from each end, and use it as a jig to drill similar holes in one of them, at 1-in. from each end, and use it as a jig to drill similar holes in the other six. File off any burrs left after drilling.

Grate Bearers and Spacers

Two pieces of 1/8-in. drawn rustless steel rod, each 2 1/8-ins. long, are used for the bearers; put a few threads on each end, either 5 B.A. or 1/8-in.

A dozen spacers are also needed; for these, chuck a piece of 1/4-in. steel rod in the three-jaw, face the end, centre, and drill down about 1-in. with No. 30 drill. Part off 1/8-in. slices until you get to the end of the drilled hole, then " ditto repeato " until you have the dozen.

Screw an ordinary commercial 1/8-in. or 5 B.A. steel nut on to one end of a bearer, thread on the bars and spacers alternatively as shown in the drawing, and after putting them all on, the nuts are tightened, so as to have the same amount of screw projecting beyond the nut, at both sides of the grate.

Beginners might note that rustless steel bearers are specified, because on my own engines I find that ordinary mild steel rod soon rots away; and on one of my 2 1/2-ins. gauge engines with a wide firebox, the grate collapsed in the middle while the engine was running, and decanted the fire in the ashpan. Incidentally, that wasn't quite such a calamity as one which I once saw at Bromley South in the old steam days. A train bound for Holborn Viaduct via the Catford loop, hauled by an 0-4-4 tank engine running bunker first, was just pulling away from the platform, when the whole blessed lot dropped out—ashpan, grate, and fire complete! Needless to add, there was an "emergency stop," the driver remarking with dry humour that it wasn't much good trying to go to town without any fire.

On the little engines, the bearers are invisible, once the grate is assembled; and when the engine is cold, moisture condenses on the cold plates, and everything in the firebox becomes damp, just as in full-size practice. When a big engine is lit up to raise steam from all cold, and the water gets well heated, a cloud of steam can be seen coming from the chimney; the shed staff would tell you she is "drying out." The accumulated moisture in firebox and tubes is evaporating, as the water in the boiler nears boiling point. However, mild steel rod will have to do for the bearers if for any reason the rustless material is not available.

To locate the grate at the bottom of the firebox, turn the boiler upside-down, and place the grate on the projecting ¼-in. of firebox below the foundation ring. Mark the spots where the ends of the bearers rest; then remove grate, and file nicks, as shown in the assembly drawing, deep enough to allow the grate to sink in flush. Trim up each end of the grate with a file, to leave about ⅛-in. clearance between the ends of the bars and the tube and door plates.

THE full-sized engine's ashpan is a fixture, with a kind of tunnel in it, to allow the trailing axle to pass through; but, as our ashpan must be detachable, for reasons mentioned above, we cannot follow full-size practice, and substitute an ashpan specially made for "dumping."

This is made in one piece, from 18 gauge sheet steel, cut to the shape shown, and bent to the shape of a box with one end open. The front corners should be brazed, or else have little pieces of angle riveted in, to prevent as much as possible any fine grit or ash blowing over the eccentrics and other valve gear parts. The contents of the ashpan, mixed with the oil on the "works," makes a lovely grinding paste which would play havoc with the eccentric straps, pin joints, and so on, if allowed to carry out its fell work!

It might be pointed out that the trailing axle passes through the ashpan, and the points where the axles enter the axleboxes are unprotected, and therefore liable to be affected by the grinding mixture. This is correct to a certain extent, but I find, on my own engines having a similar ashpan, that if all grit, etc., is wiped off the axle after each run, and the axleboxes oiled with a heavy grade of oil such as is used for cylinders, that this forms a seal at the point where the axle enters the axlebox, and no grit can get in.

Cylinder oil would not be suitable for the motion; it would "stick it up" instead of lubricating it; but the proximity of the fire to the trailing axleboxes, keeps them warm enough to keep the thick oil fairly fluid, and lubrication does not suffer.

A permanent shield could not be atta[ched] to the axleboxes, in the form of a tu[nnel] with the axle inside it, on account of independent movement of the boxes either side of the engine; but a short [sep]arate shield over the axle, on each [axle]box, something after the style of the vi[sors] on the "stop-and-go" traffic lights, c[ould] be fixed up by anybody who cares to ta[ke] the trouble.

It could be made of sheet brass bent [to] shape, and either silver-soldered direct [to] the axlebox, or flanged, and fitted with [a] couple of screws running through clear[ing] holes in the flange, into tapped holes [in] the axlebox. The openings in each side [of] the ashpan would have to be made w[ide] enough to clear the shields.

The tube for the retaining pin, and [the] nicks that engage with the supporting bo[lts], cannot be put in the ashpan until the boil[er] is erected on the frames, as their locati[on] has to be marked off from the holes [in] the frames.

How to Erect the Boiler

First of all, put the smokebox saddle [on] the frame, and fix it according to the [in]structions already given when describing [the] smokebox; also connect up the superhea[ter] to the wet header, if this has not alre[ady] been done, putting a jointing gasket ma[de] from 1/64-in. Hallite, or similar jointing, [be]tween the contact faces. Soften a p[iece] of ⅛ in. copper tube about 4½-ins. lo[ng] and fit a ¼-in. by 40 union nut and co[ne] on each end. Screw one of the nuts on the thoroughfare nipple on the end of [the] blower stay, which can easily be done wh[ile] the smokebox is off.

Smear a little plumber's jointing arou[nd] the end of the boiler barrel, and push [on] the smokebox, taking care to have the chi[m]ney up straight. The smokebox shou[ld] overlap the boiler barrel about ¼-in.

Take the cap off the blastpipe, and dr[op] the boiler into position on the chassis, [the] blastpipe locating its longitudinal position [by] virtue of the hole for same in the bottom [of] the smokebox, and the radius of the saddle locating its centre height above rails. The foundation ring should just rest on [the] front ends of the trailing hornblocks, and the bottom of the boiler should be parallel with the top line of frames.

If it isn't, temporarily pack it up, by a [bit] of rod between barrel and frame, until it is; then cut two bits of 9/16-in. by 3/32-in. brass angle, about 1-in. long, and file away one side to about 5/16-in. Drill two No. 30 holes in the wider side of each, near the ends, and put them at each side of the firebox between the coupled wheels, with the narrow part of the angle resting on the frames; then fix them by ⅛-in. or 5 B.A. brass roundhead or cheesehead screws tapped into the wrapper. A smear of plumber's jointing on the threads should be sufficient to stop any leaking past the threads, but if the screws are at all slack, lift the boiler off the chassis again, and sweat over the whole issue—screwheads and angle—same as the stayheads.

If you hold a hot soldering-iron against the angle, with a blob of solder and a dose of flux, and direct the flame of a small blow-lamp on the bit of angle at the same time, the solder will run clean through in two wags of a dog's tail. Don't forget to wash off the flux afterwards.

Replace the boiler, and make two little clips out of 3/32-in. sheet brass, about ¼-in. wide, as shown in the detail sketch. These are attached to the frame by ⅛-in. or 5 B.A. screws, through clearing holes in the clips, the holes in the frame being tapped. The sketch, showing the side view of the clip, explains the whole proceeding. The attachment of the smokebox to the saddle, has already been dealt with in the description of those components.

Replace the blastpipe nozzle, and connect the other union on the ⅛-in. pipe, to the screwed nipple at the side of the cap, thus allowing steam to pass from the hollow stay to the blower ring.

Drilling Steam Pipe Holes

If you haven't already drilled the holes in the sides of smokebox for the steam-pipes, do it now, locating the holes from the actual job, by putting the outside steam connecting pipes temporarily in place, and noting where the unions touch the smokebox. These pipes can then be permanently attached to cylinders, putting gaskets of $\frac{1}{64}$-in. Hallite, or similar jointing, or even thick brown paper soaked in oil, between flange and cylinder.

The locknuts are put on inside the smokebox; and the unions on the ends of the pipes coming from the hot header, are connected up. A little fillet of plumber's jointing around the bottom of the blastpipe, and around the steam pipe fittings where they pass through the smokebox, will complete the job; beginners especially remember that any air leakage into the smokebox, will prevent the free steaming of the boiler.

Finally, put a smear of plumber's jointing around the inside of the front end of the smokebox, and press in the complete front assembly, taking great care that the door hinges are exactly horizontal.

If the smokebox fits tightly on the boiler barrel, and the front is a good tight fit in the smokebox shell, no further fixing is required; I never fix mine. However, if they aren't, make doubly sure by putting about four countersunk brass screws through each joint; simply drill No. 48 holes through smokebox and barrel at the overlap, and through smokebox and flange of front ring, countersink the holes, tap $\frac{5}{32}$-in. or 7 B.A., and put in the screws.

How to Fit Grate and Ashpan

Follow this carefully; at 3-ins. ahead of the centre of trailing axle, and $\frac{1}{4}$-in. above bottom of frame, drill a No. 30 hole each side of frame. At $1\frac{15}{16}$-ins. behind trailing axle, and $\frac{1}{4}$-in. above bottom, drill a No. 40 hole each side.

Now turn the engine upside-down on the bench, drop the grate in the nicks in the bottom of the firebox, and place the ashpan in position, the axle being in the centre of the openings in each side of the ash-pan.

Holding the pan tightly against the grate, and level all ways with bottom of firebox, poke the drills horizontally through each of the four holes, and make countersinks on the ashpan sides. Remove the pan, and drill out the countersinks at the shallow end with a $\frac{3}{16}$-in. clearing drill, say No. 11. The countersinks at the deep end will be right at the extreme edge, so file a nick at each, big enough to accommodate a $\frac{1}{8}$-in. bolt, as shown in the illustration.

THE next requirement is a piece of thin-walled copper tube, with a hole through it big enough to take a $\frac{1}{8}$-in. pin; if you can push the No. 30 drill into it, the size is O.K. Cut a piece $2\frac{1}{4}$-ins. long, put it through the holes in the shallow end of ashpan, and bell out the ends with your centre-punch or anything else handy, so that the tube cannot come out.

The two No. 40 holes in the frame are now tapped $\frac{1}{8}$-in. or 5 B.A., and two $\frac{1}{8}$-in. supporting bolts made to suit, as shown. Chuck a bit of $\frac{1}{4}$-in. hexagon rod in three-jaw, face the end, and turn down $\frac{5}{8}$-in. full to $\frac{1}{8}$-in. diameter. Screw the end $\frac{1}{8}$-in. or 5 B.A. for $\frac{1}{8}$-in. length, and part off to leave a head about $\frac{3}{32}$-in. wide. Reverse in chuck, chamfer the head, and screw the bolts tightly into the tapped holes, from inside the frame.

Put the ashpan in position again, and it will be found that when the tube is in line with the No. 30 holes ahead of the axle, the nicks at the back will engage with these bolts.

The front end of the ashpan is held up by a pin passing through the No. 30 holes in frame, and the tube in the ashpan. This is simply a $2\frac{1}{2}$-ins. length of $\frac{1}{8}$-in. steel wire, rounded off at one end, and furnished with a screwed-on knob at the other; the knob may be turned up out of any odd scrap of brass or steel, drilled No. 40, tapped $\frac{1}{8}$-in. or 5 B.A., and the end of the pin screwed to suit.

After a run, when it is desired to clean out the ashes and residue, the pin is pulled out; grate and ashpan will then fall out of the engine, and the remnants of the fire, plus "muck," as the enginemen call it, comes with them, leaving the firebox clear. The whole issue is replaced in a matter of seconds only.

Whistle

Once the boiler is erected on the chassis, it doesn't take long to put on the rest of the accessories, and prepare for the great day when she takes the road for the first time.

The whistle is of a type new to these notes, a compromise between the "organ pipe" and "bell" types. The trouble with the former is that the note is not clear unless the whistle is hot. Steam condenses in a cold whistle, and the result is either a "bobble" or a screech until the water is blown out; and for this reason, organ-pipe whistles on my own engines are either placed where they keep hot, or furnished with superheated steam.

The bell type whistle, which has an all-round opening, only blows properly if the tube is dead in line with the annular steam opening; and unless the stem in the centre is very stout, a slight knock will throw out the alignment, and the note sounds something like a cow with bronchitis trying to sing.

One of our readers had trouble in getting an ordinary organ-pipe, whistle to give the note he required, trying various tube lengths, steam slots and sound openings without success. He has a daughter on the office staff of the L.M.S. locomotive depot at Rugby, and this young lady is a proper "locomotive fan," with an excellent knowledge of the "ins, outs, whys and wherefores"; she often has lively discussions with drivers about valve gears and other technical matters, to their great astonishment and admiration. Well, one day when our friend was busy trying to improve his whistle "Miss Loco" chimed in (literally!) with "Why don't you try another slot on the other side, Dad?" She had not heard of, nor seen, a small two-slot whistle, neither had "Dad"; but he took her advice, and hey presto!—the trick was done.

Making the Whistle

To make the one illustrated, a piece of brass tube 4-ins. long and $\frac{1}{2}$-in. diameter, about 22 gauge or slightly thinner, is squared off in the lathe at both ends; and a plug about $\frac{1}{8}$-in. in thickness is turned to a press fit in one end. At $\frac{1}{2}$-in. from the other end, file two openings, to the shape shown, at opposite sides of the tube. Turn another disc to a press fit in the tube (chuck a piece of $\frac{1}{2}$-in. rod in three-jaw, turn about $\frac{3}{8}$-in. length to diameter required, and part off a slice), then file a couple of "reliefs" in each side of it, corresponding to the width of the openings in the tube. Press this in so that it is level with the openings, and the gaps between disc and tube line up with them.

Chuck the $\frac{1}{2}$-in. rod again, and turn $\frac{5}{16}$-in. length to a press fit in the tube; centre, drill down with $\frac{1}{8}$-in. drill for $\frac{1}{2}$-in. depth, and part off $\frac{9}{16}$-in. from the end. Drill a

$\frac{3}{16}$-in. hole from the side, into the central hole; and in this, silver-solder a ¼-in. by 40 union nipple, same as on the whistle turret and other boiler fittings. Press this in the open end of the whistle tube, and the gadget is complete.

You should not be able to get a note by blowing into it with your mouth, as the lungs of a human being are a poor substitute for generating pressure when compared to the boiler of the little G.W.R. locomotive; but by connecting an automobile tyre-pump to the nipple, and giving a sharp push, a clear note should be obtained, a fairly deep tone similar to the call of a full-sized G.W.R. engine.

Mounting the Whistle

The whistle is mounted crosswise below the frames of the engine at the trailing end, just ahead of the drag beam. It is secured by two little clips made from strip brass, bent to shape, and secured to the frame by $\frac{3}{32}$-in. or 7 B.A. screws. The union nipple on the whistle is connected to the union on the turret by a ⅛-in. pipe with appropriate nuts and cones on each end, the length of pipe being best obtained by measuring on the actual job.

The pipe should run as close to the backhead as possible, so that it keeps hot, and minimises the amount of water reaching the whistle when operating the valve whilst the whistle is cold. The whistle cannot be placed under the ashpan to keep hot, or it would prevent the latter from being "dumped," and there is no more convenient place to put it, other than that mentioned above.

Injector

The boiler of the full-sized engine is fed by two injectors, one of which is operated by exhaust steam, and one by live steam. I have made, and could describe, a working exhaust steam injector; but there is one great drawback to its use, which up to the present I have not been able to overcome.

A little engine uses much more cylinder oil than its full sized relation, in proportion to size; this is necessary to protect the non-ferrous cylinders and steam-chest liners from the effects of highly superheated steam. This oil naturally goes out with the exhaust steam, and if it were made to operate an exhaust injector, would get into the boiler, coat the heating surface and upset the steaming, and give false indications of the water gauge. The big engine's exhaust is nothing near so oily, and passes through a grease separator; but up to the present, I have not been able to find any form of tiny grease separator suitable for a 3½-ins. gauge engine, the excessive amount of oil that has to be removed, choking all that I have tried, after a couple of runs.

Therefore, as we are not using the vacuum pump for its legitimate purpose, we can make it pump water instead, and feed the boiler in place of the exhaust steam injector, using the live steam injector as "opposite mate."

How it Works

Small injectors, in the past, have been regarded as "kittle cattle"; difficult to make, and unreliable in action. This is far from the truth; if carefully made, and kept clean, they are just as reliable as their full-size relations. A lot of other nonsense has been written and spoken, regarding their working, but I need not go into that here. For beginners' benefit I may add that the idea of a jet of steam forcing water into a boiler against its own pressure, is not a dream of perpetual motion, but the effect of a simple law of nature.

If a jet of steam and a jet of water issues from two identical nozzles at the same speed, the jet of water will have ever so much more "punch" behind it, by virtue of being a kind of "solid body" instead of a vapour. In the injector, a jet of steam issues from the steam cone with all the "kick" the boiler can put behind it. In the combining cone, it mixes with cold water and condenses; and in doing so, transfers its initial speed to the water, giving it such a "kick in the pants," in a manner of speaking, that it can jump the gap between combining and delivery cones, lift the clack and enter the boiler.

The only requirement is, that steam and water must be correctly proportioned to insure perfect condensation instantly; this is achieved by having the cones the right size, and your humble servant found the sizes by actual practical experimenting. Anyone following instructions explicitly, can make a successful injector.

Making the Injector

No castings are required, the body of the injector being made from square brass rod, either $\frac{5}{16}$-in. or ⅜-in. being suitable, the latter size being shown on the drawing. This is the outside dimensions only, and does not affect the working parts.

Chuck a length of either size in the four jaw, set to run truly, and face the end. Centre, drill down about ⅞-in. depth with No. 24 drill, turn down ⅛-in. of the outside to ¼-in. diameter, screw ¼-in. by 40, and part off a full $\frac{13}{16}$-in. from the end.

Reverse in chuck; if you slack Nos. 1 and 2 jaws to release the stock rod, and retighten the same two when rechucking, the body will run truly again. Turn down and screw for ⅛-in. length, same as the other end, then put a $\frac{5}{32}$-in. parallel reamer through; if you haven't one, use a drill, of the same size.

In the centre of one of the sides, drill a ⅛-in. hole, breaking through into the centre passageway; and at a distance of $\frac{3}{16}$-in. full, towards the end, drill a similar hole. There must not be less than $\frac{1}{16}$-in. of metal between the two holes, a shade more is very desirable. Find the centre of the opposite side; and at $\frac{5}{32}$-in. each side of it, drill a $\frac{5}{32}$-in. hole. The one at the same end as the hole on the other side, is tapped $\frac{3}{16}$-in. by 40; the other has a ¼-in. by 40 union nipple fitted to it, same as described for the whistle valve and other fittings. Poke the $\frac{5}{32}$-in. reamer through again, to remove any burr left by the drilling.

Injector Valve Box

The valve box, containing the air release valve, is made from ½-in. round brass rod. Chuck in three-jaw, turn down about ⅜-in. to $\frac{15}{32}$-in. diameter, face the end, and part off a piece $\frac{5}{16}$-in. long.

The tool marks will show the true centre; at $\frac{1}{16}$-in. away from this, make a centre-pop, and chuck the piece in four-jaw with this pop mark running truly. Open it with a centre drill, then drill right through with No. 34 drill, open to about $\frac{3}{16}$-in. depth with $\frac{7}{32}$-in. drill, and bottom with a D-bit, same size, to ¼-in. depth. Slightly countersink the end of the hole; tap ¼-in. by 40, taking care not to let the tap spoil the D-bitted seating, then run a ⅛-in. parallel reamer through the remains of the small hole.

Now, on the underside, make a centre-pop well clear of the reamed hole, say about $\frac{3}{32}$-in. from the edge of the box; and from this, drill a 1/8-in. hole on the slant, so that the drill breaks into the ball chamber well clear of the ball seating: see sectional illustration.

Set the valve box on top of the injector body, so that the ball seat is exactly over the centre hole, and the diagonal hole is over the one in the injector body nearest the end; tie in place with a bit of iron binding wire, and silver-solder the valve box to the body, and the nipple into its hole, at the one heat. Pickle, wash off, and clean up.

Seat a 5/32-in. rustless ball on the D-bitted hole, by holding a bit of brass rod on it, and giving the rod one good sharp crack with a hammer; then make a little cap, similar to the water gauge cap, but with a countersink on the underside, to allow the ball a good 1/32-in. lift. The sides of the valve box may be milled or filed flush with the body, as shown.

Cone Reamers

Before starting on the cones, we need reamers to form the tapers in them, and these are quite easy to make. Chuck a bit of 5/32-in. silver steel rod in the three-jaw, and turn a cone point on the end 3/4-in. long from point to base. If your slide rest has a graduated scale, set it over to about 4 degs., which will do the doings.

Repeat operation on another bit of steel same diameter, this time making the cone 1 1/8-ins. long, setting over the rest to about 3 degs.; and for the third shot, turn a curved cone as shown, 5/16-in. long. File away all three cone points to half diameter, as shown; heat to red, and plunge in clean cold water. Rub up the flat faces on a bit of fine emery-cloth laid on something flat, but don't destroy the cutting edges; just brighten the flats.

Hold the lot on a bit of iron or steel sheet, over a gas or spirit flame. Have the cold water handy, and as soon as the bright part turns yellow, tip the reamers into the water quickly. Give the flat parts a rub up on a smooth and flat oilstone, and the reamers are ready for use.

To prevent the reamer going too far into the cone, I use a stop on all my cone reamers. This merely consists of a 1-in. length of 5/16-in. round rod, with a 5/32-in. clearing hole drilled lengthwise through it —chuck in three-jaw, centre, and use No. 21 drill in the tailstock chuck—and a 5/32-in. setscrew at one end. If this stop is clamped on the reamer, with the end at the distance it is required for the reamer to penetrate, it is quite an impossibility to "overshoot the platform," as the enginemen say.

Combining Cone

It is easiest to make and fit the combining cone first, as this goes in the middle of the injector, and the steam and delivery cones can be made to suit. Chuck a piece of 1/4-in. round brass rod in the three-jaw, and turn down about 3/8-in. of it to a tight squeeze fit in the injector body.

Beginners especially note that the easiest way of ensuring a real steam-and-water-tight press fit, is first to broach out the nipple end of the injector body with an ordinary broach as used for large taper pins, so that the extreme end of the hole is a couple of thousandths of an inch or so larger than the rest of the reamed hole. The enlarged part should not be more than about 1/8-in. long. Now, if you turn the brass rod so that it just—and only just—enters this enlarged part, you are certain of the tight squeeze when the cone is pressed into the injector body.

Face the end, centre, and drill down about 5/16-in. depth with No. 71 drill. An ordinary centre-drill makes far too big a hole for this size, so you must make a special one for yourself, which is easy. Turn a cone point on the end of a piece of 1/8-in. round silver steel, then file a flat at either side of the point, so that it is converted into an arrow head. Harden and temper as described for cone reamers, and rub each flat on your oil stone after tempering. This gadget will cut a weeny centre, just right for the very small drills needed for injector cones.

Small Hole Drilling

The correct way to drill these minute holes without fatalities among the drill tribe, is to keep withdrawing the drill and clearing the chips; don't let it penetrate more than 1/16-in. at each bite. Personally, I use a lever or sliding tailstock barrel, and work it back and forth like a piston-rod working in a cylinder; the chips fall away of their own free will and accord, at each withdrawal, resulting in a clean hole, true to size. It isn't the actual drilling that causes drill casualties; it is the flutes becoming choked with chips, and causing the drill to seize in the hole.

Face off the end of the rod again, in case the drill has cut oversize as it entered (they often play that trick!), then slightly cut the metal back from the orifice, to form a very blunt nose, as shown in the section. Part off at 1/4-in. from the end.

Using the Reamers

Now try your cone reamer with the 3/4-in. taper, in the hole, and note how far it goes in; then set your stop on the reamer shank, so that the taper part projects from it 1/4-in., plus a shade less than the amount the point entered the hole.

Chuck the cone, back outward, in the three-jaw, put the reamer in the tailstock chuck, and ream out the hole until the stop touches the end of the cone. The point should just be protruding from the other end. Put the stubby reamer in the tailstock chuck, and just take the sharp edge off the hole with it.

Remove from chuck, and try a No. 70 drill in the hole, from the wide end. You should not be able to push it through, but should just be able to see the point practically level with the small end of the reamed hole. If so, the taper is O.K.; chuck the cone again, and put the No. 70 drill through it, which will enlarge the end of the cone to the exact size needed.

The cone can be finished off to the full-size Holden and Brooke pattern (the makers who originated the completely-divided combining cone) or to a modification of the American type made by Sellers.

In the former case, chuck the cone again in the three-jaw, with a little more than half projecting, and saw it completely in half with a fine hacksaw as used by jewellers, keeping the blade pressed against the chuck jaws. Pull the stub a little farther out of the chuck, face off the sawn part, and cut it back a little as shown in the section. Rechuck the other half, and give it a dose of the same medicine. With the stubby reamer, very slightly radius the entrance to the smaller half; merely take off the sharp edge.

The two halves are then pressed separately into the injector body, to the location shown in the sectional illustration, so that the halves are exactly under the ball seat, and 1/32-in. apart at the centre. Use the vice as a press, and a piece of 5/32-in. brass rod faced off at the end and slightly countersunk, as a "ramrod." Finally insert the 3/4-in. tapered reamer and give it a twirl or two with your fingers, to remove any burring, and check the alignment of the two halves of the cone.

For the Sellers type of cone, chuck the unfinished cone in three-jaw, and turn a groove 1/16-in. wide and a full 1/32-in. deep, in the centre of it; then, with a fine flat file, such as jewellers use, file a couple of slots across the bottom of the groove, breaking into the reamed taper hole. Clean out any burr with the cone reamer, and press home as above, locating the groove under the ball seat in the valve box.

Delivery Cone

CHUCK the 1/4-in. rod again, and turn down about 1/2-in. length to 7/32-in. diameter. Face the end, and turn down quarter length to an easy push fit in the delivery end of the injector; it must not be slack, but just easy.

Reduce the extreme end, with a round-nose tool, to 5/32-in. diameter, cutting the end to the contour shown in the drawing. Centre it, using the special centre, and drill down 3/8-in. depth with No. 76 drill, using the method described above. Then, with the stubby reamer in the tailstock chuck, bell out the end as shown in the section, and part off to leave a flange 3/32-in. wide.

Reverse in chuck, and with the long tapered cone reamer, open out the hole, same as given for combining cone. The stop should be set roughly 5/16-in. from the reamer point. Try a No. 75 drill in the flange end, and you should just be able to see the tip of it showing at the bottom of the bell mouth: if not, the cone reamer wants to go in a shade farther. When you can just see it, but not push it through, re-chuck the cone, flange outwards, and put it through with the lathe running, and the drill in the tailstock chuck.

Incidentally, these small drills cannot be gripped by the ordinary tailstock chuck. I use them in jewellers' pin chucks — the ordinary type, cross slotted with a taper nut and 3/16-in. shank; this is gripped in the ordinary tailstock chuck, and the drill put in the pin chuck with only the required amount projecting from the jaws. Slightly bell the larger end of the tapered hole with the stubby reamer.

When placed in the injector body, there should be a bare 1/32-in. between the end of the combining cone and the entrance to the delivery cone; you can see it through the overflow hole.

Steam Cone

Chuck the 1/4-in. rod again, and turn down about 1/2-in. to 7/32-in. diameter. Face the end, and turn down 5/16-in. length to an easy push fit in the nipple end of the injector body. Centre, and drill to 7/16-in. depth with No. 66 drill. Now put the 3/4-in. taper reamer in the tailstock chuck, and ream the hole just a little, until a No. 68 drill will enter to a full 3/32-in. depth. Turn the outside to the shape shown, making the end of the nozzle almost parallel where it will enter the combining cone. If you have a "mike" the correct diameter is approximately 0.055-in., but it doesn't matter if you haven't; just turn down to a knife edge around the hole.

Part off to leave a flange 3/32-in. wide; reverse in chuck, and put a 1/8-in drill down, to a depth of 1/4-in. The inside of the No. 66 drill hole should then be broached with the 3/4-in. taper reamer until you can just see the end of a No. 65 drill put into it, by looking down the nozzle; then chuck the cone; flange outwards, and put the 65 drill through it.

The above methods of drilling should ensure the nozzle apertures being the exact size, which is a vital factor to correct operation. When the steam cone is in place in the injeector body, it should enter the combining cone a bare 1/32-in.

Delivery Clack or Check Valve

Chuck a piece of 3/8-in. round brass rod in three jaw, and turn down about 3/4-in. length to 11/32-in. diameter. Face the end, centre, and drill down 9/16-in. depth with No. 34 drill. Open out to 1/4-in. depth with 7/32-in. drill, and bottom with same size D bit to 5/16-in. depth. Slightly countersink the end, and tap 1/4-in. by 40, keeping clear of the seating. Ream the remains of the 34 hole with 1/8-in. reamer, and part off 5/8-in. from the end. Drill a 3/16-in. hole at 5/32-in. from the blind end, breaking into the 1/8-in reamed hole.

Chuck the 3/8-in. rod again, and turn down 1/2-in. length to 11/32-in. diameter. Face, centre, and drill to 1/2-in. depth with 1/8-in. drill. Open out with 7/32-in. drill, and bottom to 3/16-in. depth with D bit of same size; tap 1/4-in. by 40, and 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 squeeze fit in the hole in the side of the valve body; press it in, and silver-solder it.

After pickling and cleaning up, fit a 5/32-in. rustless steel ball, and a union valve cap, to the valve box, exactly the same as you did for the top of the tender hand pump for testing the boiler; but work to the dimensions given on the accompanying drawing, and allow the ball more lift, say, a bare 1/16-in.

Whereas a pump valve keeps bobbing up and down all the time the pump is working, an injector clack goes up and stays up until the injector ceases to feed, then flops down again, so a good lift is an advantage.

Screw the valve on to the delivery end of the injector as shown; if it doesn't stand vertical when right home, take a skim off the end of the delivery cone, until it can be screwed home to that position.

That completes the actual gadget, and the pipe connections will be given along with those of the pump, as it is easier to do all the "plumbing" at one fell swoop, including the fittings for the top feed delivery.

Crosshead Pump

Just over the guide bars on the right-hand side of the full-sized engines, attached to the running-board valance, you will see a long thin cylinder, with a piston-rod attached to the upper end of an arm on the main crosshead. This is a double-acting air pump, which maintains a vacuum in the train brake equipment whilst the engine is running, and dispenses with a small steam-operated ejector; the old London and North Western engines had a similar gadget between the frames, and the peculiar "ticking" noise made by this when running, earned them the nickname of "clockwork engines" among the L.B. and S.C.R. enginemen.

We used to see them very frequently, as through services were run into both East Croydon and Victoria, before electric tramways, and later, motor buses, took away all the "through" passengers. Well, on our little "1,000" we don't need the pump for its legitimate purpose, but as it is a well-known G.W.R. characteristic accessory, we might as well fit one and utilise it to pump water into the boiler; the following notes explain how this can easily be done.

The water version differs somewhat from the air pump, as it is single-acting and needs no piston; also a valve box of the usual type is needed on the end, in place of the simple air flap valves on the barrel.

The valance on the little engine's running-board would not be sufficiently stout to stand the racket of pumping water into the boiler against 100 lbs. pressure when the engine is travelling at a good fast clip; so the pump is mounted on a bracket located over the leading coupled wheel, attached to the frames fore and aft of it. It is, however, quite a simple job to make and erect, and there is no eccentric to bother about.

Barrel

It is quite possible that our enterprising advertisers will be able to supply a little gunmetal or bronze casting comprising barrel, valve box and supporting lug in one unit; if not, it can easily be built up.

For the barrel, saw or part off a piece of 3/8-in. round bronze or gunmetal rod, to a length of 2 3/16-ins. full. Chuck in three-jaw, face the end, centre, and drill clean through with a No. 21 drill. Open out to 1/4-in. depth with 7/32-in. drill, tap 1/4-in. by 40, and make a gland to suit, from a bit of the same kind and size of rod, by the same process as you used when making the piston glands. The other end of the barrel is filed out semi-circular, with a 3/8-in. round file, to fit snugly on the outside of the valve-box.

Valve Box

To make the valve box, part off a 7/8-in. length of the same kind of rod as used for the barrel. Chuck in three-jaw, centre, drill right through with No. 24 drill, then open out and bottom to a depth of 5/16 in. with 9/32-in. drill and D bit. Tap 5/16-in. by 32 or 40, and don't run the tap in far enough to spoil the valve seat formed by the D bit.

Reverse in chuck, and repeat process, except that the D bit need not be used; then run a 5/32-in. parallel reamer through the remnants of the 24 drill hole. Fit a 1/4-in. by 40 union nipple to the D-bitted end.

Cut a piece of 5/32-in. sheet brass, 1 1/2-in. long and 9/16-in. wide; attach this temporarily to the side of the pump barrel, in the position indicated in the drawing, by a couple of 1/16-in. brass screws, put through clearing holes in the plate, into tapped holes in the barrel.

It doesn't matter if you pierce the bore; the most important thing is that the plate should be parallel to the valve box when the latter is placed in the half-round recess in the end of the barrel. Clean the outside of the valve box, set it in the recess, and tie it in position with a bit of thin iron binding wire; take care to have the union nipple parallel with the pump barrel. The joints between valve box, nipple, barrel and plate, can then be silver-soldered at one heat, same as described for boiler fittings and other small gadgets. After pickling, washing off and cleaning up, poke the No. 21 drill down the barrel again, and carry on right through the side of the valve box until the drill makes a slight countersink in the opposite side of the central passageway.

The drill should pass about 1/16-in. below the D-bitted seating, which, of course, must not be distorted; but it would be an advantage to cut away the little bit of metal between the end of the hole, and the ball chamber which is directly under it. This can be done with a little chisel made from the tang eng of a file, or from a bit of silver steel. This will enable water to pass the ball and enter the pump barrel when the ball is fully lifted as it will be when the engine is running fast, and ensure the pump working to its full capacity.

Fit a 3/16-in. rustless ball, and a valve cap, to the upper chamber by the methods described for the hand pump. A fitting is also made for the bottom chamber, in the same manner as described for the hand pump; but instead of being drilled right through, it is drilled "blind," as shown in the sectional illustration, and a 1/4-in. by 40 union nipple silver-soldered into the side of it. Note that it is essential that the lift of the balls must not exceed 1/32-in., for the simple reason that if they do, water will flow back through them as they close, and reduce the efficiency of the pump to a great extent.

Pump Ram

The pump ram is a 3-ins. length of 5/32-in. rustless steel or phosphor bronze, or nickel bronze (what we used to call German silver), one end of which is slightly rounded off, and the other end turned down for 1/4-in. length to 1/8-in. diameter, and screwed 1/8-in. of 5 BA.

Crosshead Arm

To make the crosshead arm, saw and file a piece of 3/32-in. steel plate to the shape shown, finished size being 1 3/8-ins. long, 7/16-in. wide at the bottom, and 5/32-in. at the top. The bottom part is thickened up to enter the recess at the side of the crosshead between the upper and lower shoes, but a piece of 1/16-in. or 16 gauge steel 7/32-in. wide and 7/8-in. long; file it to an easy fit in the recess in the crosshead, then temporarily rivet it to the crosshead arm by a couple of 1/16-in. rivets, or bits of domestic pins, locating it to 1/16-in. from the bottom.

To make the eye at the top, chuck a bit of 1/4-in. round mild steel; face, centre, drill down about 3/16-in. in. depth with No. 30 drill, and part off a 5/32-in. slice. If the upper end of the crosshead arm is slightly recessed longways with a rat-tail file, the eye will "stay put" by aid of a bit of binding wire wound around longitudinally; the joint can then be brazed, and the thickening piece brazed on to the arm, at the one heat. Use either a bit of soft brass wire, or a bit of Sifbronze, for this job; silver-solder is not quite suitable.

Beginners should recollect that iron and steel brazing jobs should never be put into acid pickle; just quench in clean cold water, and clean up. Drill a 1/4-in. hole on the centre line, 1/2-in. from bottom, and the arm is complete.

We made one of the crosshead pins longer than the other, and this should be put in the right-hand crosshead. Place the arm over it, with the thickening piece bedding down in the recess, the pin passing through the hole in the middle; secure with a 1/8-in. steel nut on the outside.

Steel spring washers are now available, right down to 1/16-in. or 10 BA. size; and in places where a nut has any tendency to slack, such as in the present case, it is advisable to use them. They are very handy also for spring pin nuts, which very often begin to move when an engine is running, and upset the axle load adjustments.

6 3/4-ins. long. Bend it to the shape shown in the plan view of the complete pump assembly; the distance from outside the lugs to the outside of the bolting face, should be exactly 1/32-in. If you are slightly "out" either way, the top of the crosshead arm could be bent slightly to suit, but it wouldn't look very engine-like, so try

keep the exact measurement.

Drill a No. 30 hole in each lug, for the fixing screws. The bracket is then placed centrally over the leading coupled wheel $\frac{5}{16}$-in. from the top of frame as shown. See that it is parallel with top of frame, then hold it temporarily in position with a tool-maker's cramp; run the 30 drill through the holes, making countersinks in the frame, follow with No. 40, top $\frac{1}{8}$-in. of 5 B.A., and put screws in.

Now follow very carefully: put the pump ram through the eye in the crosshead arm and secure with a nut. Slide the pump barrel over it, then put the connecting-rod on that side of the engine, on back dead centre, so that the piston rod is fully extended. Slide the pump barrel forward on the ram, until the latter hits the end of the hole, and is entered as far as it will go. Now draw the barrel back $\frac{1}{32}$-in., and put a toolmaker's cramp over the bracket and the plate at the side of the pump barrel, to hold it securely in position while testing for alignment.

Turn the wheels slowly by hand, and watch the pump ram; if it moves easily in and out of the barrel without any tendency to bind or run hard, and keeps in perfect alignment with the barrel, the adjustment is O.K., and all you have to do, is run the No. 34 drill through the holes in the plate, make countersinks on the bracket, follow with No. 44 drilling right through the bracket, tap 6 BA and put screws in.

If there is a slight tendency to bind, it may be overcome by slightly slacking off the nut holding the end of the ram to the crosshead and re-tightening; or the hole may be slightly enlarged by putting a No. 28 or $\frac{9}{64}$-in. through it. It does not matter in the least, about the end of the ram being slightly eccentric to the boss at the top of the cross-head arm.

When all set, and the screws tightened, the ram should slide in and out of the long barrel perfectly freely, and the gland may be packed with a few strands of graphited yarn, or better still, a few strands from a bit of hydraulic packing as used for presses, jacks and other water-driven machinery. Thin lock-nuts on the projecting ends of the screws inside the bracket, would be an advantage in keeping the pump perfectly lined up. I will describe the pipe connections when dealing with the complete plumbing.

Feed Check Valves

On the big engines, the feed water enters the boiler by way of a couple of top feed clacks, one at either side of the safety-valve casing. On the small engine, we can't put the clacks up there, because they would look unsightly; as Nature cannot be scaled, we have to use bigger valves, in proportion to size, than those on the full-sized job. A compromise is called for, as the clacks, or check valves, must be placed somewhere between pump and delivery point; and plain flanged elbow fittings are used where the pipes are attached to the boiler.

On the left hand side of the engine, a horizontal valve, the ball of which is kept seated normally by a very light spring, takes the delivery from both the injector and the emergency hand pump, and passes it on to the top feed fitting. On the right side, a vertical clackbox with a long body, is attached to the inside of the frame. The water from the crosshead pump is delivered into a union fitting at the side, and from there it can pass either to the boiler, via the ball valve immediately above the union, or back to the tender by way of a pipe connected to the lower union and the bypass valve under the footplate.

Check Valve Horizontal

To make the horizontal check valve, chuck an inch of $\frac{5}{16}$-in. hexagon brass rod in the three-jaw; face the end, centre deeply, and drill right through with No. 34 drill. Turn down $\frac{1}{4}$-in. length to $\frac{1}{4}$-in. diameter, and screw $\frac{1}{4}$-in. by 40.

Reverse in chuck; open out to $\frac{9}{16}$-in. depth with $\frac{7}{32}$-in. drill and D-bit, and ream the remains of the 34 hole with a $\frac{1}{8}$-in. parallel reamer.

Tap $\frac{1}{4}$-in. by 40, and make a little cap to suit, same as the top of the tender hand pump. Screw it $\frac{1}{4}$-in. by 40, and countersink for union nut and cone; slightly counterbore the inner end with a No. 21 or $\frac{5}{32}$-in. drill. Seat a $\frac{5}{32}$-in. rustless ball on the D-bitted seating, and put a very light bronze, rustless steel, or hard brass wire spring between the ball and cap as shown.

This only needs to be sufficiently strong to keep the ball on the seat, as the valve is erected in a horizontal position, and the ball will not normally seat by gravity, yet must not be overloaded.

Vertical Check Valve

For the vertical check valve, on the right side, chuck a piece of $\frac{3}{8}$-in. round brass rod, 2-ins. long, in the three-jaw. Face, centre and drill right through with No. 34 drill, open out and bottom with $\frac{7}{32}$-in. drill and D-bit, to $\frac{5}{16}$-in. depth, tap $\frac{1}{4}$-in. by 40, and put the end of a $\frac{1}{8}$-in. parallel reamer in the No. 34 hole for about $\frac{1}{2}$-in. or so, to form a true seating for the ball.

Reverse in chuck, turn down $\frac{1}{4}$-in. of the other end to $\frac{1}{4}$-in. diameter, screw $\frac{1}{4}$-in. by 40, and countersink for union cone.

At $\frac{1}{2}$-in. from the other end, drill a $\frac{3}{16}$-in. hole in the side, and fit a $\frac{1}{4}$-in. by 40 union nipple in it, made as described for boiler fittings. At the union end, fit a plate similar to that on the barrel of the crosshead pump, but $\frac{1}{8}$-in. thick and $\frac{3}{4}$-in. long, temporarily securing it with a $\frac{1}{16}$-in. brass screw. Silver-solder this and the union nipple at one heat; then pickle, wash off, clean up, and fit a valve ball and cap, same as described for the top of the tender pump. This ball should not have more than $\frac{1}{32}$-in. lift. Drill two No. 34 holes in the plate, as shown. The position of both these check valves, and the method of connecting up, will be shown and explained when dealing with the whole of the pipe connections.

Top Feed Fittings

For reasons already explained, these are simply flanged elbow fittings, and contain no valves; they have, however, internal pipes arranged to divert the incoming feed water towards the front end of the boiler.

To make them, chuck a piece of $\frac{3}{4}$-in. brass rod in three-jaw; face, centre, and drill down $\frac{5}{16}$-in. only with a No. 23 drill. Turn down $\frac{1}{8}$-in. length to $\frac{1}{4}$-in. diameter, and part off a bare $\frac{1}{2}$-in. from the end.

Reverse in chuck, and turn the other end to $\frac{1}{4}$-in. diameter, leaving a flange $\frac{3}{32}$-in. in thickness. File this to an oval shape, as shown in the plan view, and drill a couple of No. 40 holes in it for the fixing screws.

Drill a No. 23 hole in the boss above the flange, breaking into the blind hole in the middle, and round off the top as shown. Soften an inch of $\frac{5}{32}$-in. copper tube, drive it into the hole in the lower boss, and bend it into a curve as shown. Note, you need one right and one left hand.

Drill a $\frac{1}{4}$-in. hole in the boiler barrel at each side of the safety-valve bush, the edge of the hole being about $\frac{3}{32}$-in. away from the bush. File off any burrs, then put one of the fittings into each hole, with the bends pointing forward, and the holes in the upper bosses facing outwards.

Run the No. 40 drill through the holes in the flanges, making countersinks on the boiler barrel; follow with No. 48, tap 3/32-in. or 7 BA., and put screws in temporarily. Don't fit any jointing, as the fittings have to come out again to have the pipes fitted, after their length has been measured, as described in following notes.

BEFORE connecting up the pipes, we need two more valves, a screw-down valve for the by-pass, and a check valve or clack box for the hand pump feed, to enable it to discharge into the boiler through one of the top feed fittings, which is preferable to having an extra clack in the backhead. This valve is very similar to the screwdown valves for the boiler fittings.

Chuck a bit of ⅜-in. round brass rod in the three-jaw; face the end, centre, and drill down ⅞-in. depth with No. 48 drill. Open out to ½-in. depth with No. 30 drill, and bottom to ⅝-in. depth with a D-bit same size. Further open out about ⅛-in. of the end with No. 21 drill, and tap the No. 30 section either 5/32-in. by 32 or 40; I use 32 pitch for these valves because it gives a quicker action. Be careful not to spoil the D-bitted seating. Turn down ¼-in. of the outside to ¼-in. diameter, and screw ¼-in. by 40; part off at 1¼-ins. from the end. Reverse in chuck, and turn down the other end to ⅛-in. diameter for ¼-in. length; screw ⅛-in. or 5 B.A.

At 3/16-in. from the shoulder, drill a 5/32-in. hole, breaking into the blind end of the No. 48 drill hole; and another at right angles to it; then diametrically opposite, but ⅛-in. from the screwed end, drill another hole, using No. 23 drill. This should break into the tapped hole, just above the D-bitted seating.

Two ¼-in. by 40 countersunk union nipples, made in the same way as described for the boiler fittings, are squeezed into the two bottom holes, and an inch of 5/32-in. copper tube, thin-walled (say about 24 gauge) fitted in the upper hole.

Both nipples and the pipe are then silver-soldered into the body of the valve at one heat. After pickling and cleaning up, the gadget should look like the plan view given here.

The valve pin is made from 5/32-in. rustless steel, or bronze rod (either nickel or phosphor) by the same process described for the injector steam valve, blower valve, etc., and same applies to the gland nut, which is made from 5/16-in. hexagon brass rod.

The overall length of the valve pin is approximately 3½-ins., which will allow it to project about 1½-ins. above the footplate in the cab. Drill a No. 53 cross hole in the top, and force in a bit of 16 gauge steel wire (ordinary will do, if rustless isn't available) to form the handle. Pack the gland with a few strands of graphited yarn, or unravelled hydraulic pump packing.

Check Valve or Clack for Tender Pump

This is very similar to the injector clack. Chuck a bit of ⅜-in. round brass rod in three-jaw; face, centre, and drill down a bare 11/16-in. with No. 34 drill. Open out to a bare 5/16-in. with 7/32-in. drill, and bottom with a D-bit same size, to ⅜-in. depth. Slightly countersink the end of the hole, and poke a ⅛-in. parallel reamer into the remnants of the No. 34 hole. Tap the large end ¼-in. by 40. At 3/16-in. from the top, drill a 5/32-in. hole into the ball chamber; at 3/16-in. from the bottom, diametrically opposite, drill a 3/16-in. hole into the blind ⅛-in. reamed hole.

Fit a ¼-in. by 40 countersunk union nipple into the upper hole. The lower hole carries a longer nipple with a coarser thread, for quick attachment of the union on the tender feed pipe.

To make it, chuck a piece of ⅜-in. hexagon brass rod in the three-jaw; face the end, centre deeply with size E centre drill, and drill down about ⅞-in. depth with No. 40 drill. Turn down ¼-in. of the end to ¼-in. diameter, and screw ¼-in. by 26.

Part off ¾-in. from the end; reverse in chuck, and turn down a bare ⅛-in. of the other end, to a tight squeeze fit in the bottom hole in the clack body. Press it in, and silver-solder both top and bottom nipples at the one heat; pickle, wash off, clean up, and then fit a 5/32-in. rustless steel or bronze ball, and a little cap, similar to that described for the upper valve of the cross-head pump.

Pipe Brackets

In full-size practice it is found convenient to arrange the connections between engines and tenders, so that any tender can be attached to any engine. This is also my own practice, and the tender of my old 2½-ins. gauge 4-4-2 "Ayesha" has been used for testing every 2½-ins. gauge locomotive I have built, before the engine on test had a tender of its own.

The reproduced illustration of the drag beam for the little "1,000" shows the layout I have adopted for 3½-ins. gauge, for locomotives having both pump and injector. The connection for the pipe coming from the tender hand pump, needs a union, as the water in that pipe is under pressure; but for the injector feed, pump feed and by-pass pipes, similar slip-on hoses of rubber tube (known as "feed-bags" by enginemen) are all that are required.

The pipes are brought to the drag beam in the usual way, and carried by brackets or clips attached to the beam. In the illustration, brackets are shown; but clips can, of course, be used by any builder who prefers them, as shown in the detail sketch.

If the frame has been attached to the beam by pieces of angle, an angle-shaped bracket must be made, and this can either be made from a piece of ¾-in. by 3/32-in. brass angle 1¼-ins. long, or bent up from a piece of 3/32-in. sheet brass measuring 1¼-in. by 1⅛-ins. Bend over ⅜-in. of the longer side; and round off the bottom corners, and drill two holes at ¾-in. centres as shown.

Holes for the pipes are drilled No. 21, and the hole for the hand pump union, drilled ¼-in. Slots are filed in the brackets to clear the frame plates, and the brackets attached to the underside of the drag beam by three 3/32-in. or 7 B.A. screws, running into tapped holes in the thickness of the beam. Cheesehead screws are shown in the illustration, as they are not conspicuous, but hexagon heads may be used if desired. The brackets are set approximately 1½-ins. apart, measured between adjacent edges.

If the frame has been brazed, and there are no angles attached to the beam, the brackets can be made as shown on the right side of the beam in the drawing.

Simply cut a piece of 3/32-in. brass sheet to 1¼-ins. length and 1⅛-ins. depth, drill it for the pipes, round off the corners, slot it to clear frames, and attach to the inside of the beam by two ⅛-in. or 5 B.A. countersunk screws. If preferred, these may pass through clearing holes in the bracket, and have nuts on the inside, instead of being screwed into the bracket.

Pipe Clips

If clips are preferred, these can be made by bending the end of a strip of 16 gauge brass, ¼-in. wide, into a loop just big enough to carry the pipe; the other end is attached to the frame as shown in the detail sketch.

Two screws suffice for both clips; these pass through clearing holes in the clips, and are nutted on the outside of the frame, allowing for easy dismantling if needed. Clips, as shown, alter the spacing of the pipes a little; but this will not matter, as the rubber hoses on the tender have enough flexibility to allow for it.

If a clip is used for attachment of the hand pump clack box, the ¼-in. by 26 nipple must be made with the screwed part ¾-in. long, to allow for passing through the clip and accommodating the lock nut, as well as the union nut.

THE lengths of copper pipe needed for connecting up both pump and injector, are best obtained from the actual job; I use a bit of thick lead wire, which can be readily bent to any shape by finger pressure, run around corners, or wherever desired, and then easily straightened out. When measured, this gives the exact length of copper pipe needed, so that not an inch may be wasted.

If you haven't already temporarily attached the left-hand top-feed fitting, do it now, by drilling a ¼-in. hole close to the safety-valve bush, inserting the curved pipe, and securing the flange to the boiler barrel by a couple of 5/32-in. or 7 B.A. brass screws. Now bend the "down" pipe so that it lies close to the boiler barrel, then turns back towards the footplate end of the engine just above the level of the tops of the driving wheels.

Remove the whole assembly, cut the pipe short at the end of the bend, and fit a union nut and cone, ¼-in. by 40 thread; attach this to the outlet end of the horizontal check valve. The assembly can then be replaced; be sure the pipe leading from the check valve to the top feed fitting lies snugly against the boiler barrel, with no kinks nor dents in it, to spoil the appearance. Sweat over the flange and screwheads with solder, same as you did for the stayheads and nuts.

Now hold the injector temporarily in place between the trailing wheel on the left side and the drag beam, the top of the injector body being about level with bottom of frame, and ½-in. or so away from it. Make a mark on the frame, level with the union screw on the injector delivery clack. Take the measurement from this, to the inlet side of the horizontal check valve, and cut a length, 5/32-in., of copper pipe to suit.

If you take a look at the general arrangement drawing of the engine, published when this serial started, or preferably the full-sized blueprint, you will see a pipe apparently emerging from the running-board, following the curve of the wheel splasher, and disappearing behind the nameplate. This is the joker we are now fitting; it is also shown on the diagram of injector connections.

Fit a union nut and cone on each end (¼-in. by 40 in both cases); screw the union on the straight end, on to the horizontal check valve, and screw the curved end union nut, on to the injector delivery clack.

If the injector sags down when you let go of it, just prop it up temporarily with a bit of wood, or anything that happens to be handy on the bench; then take the distance from the steam cone end of it, to the injector steam valve on the boiler backhead, and cut a length of 5/32-in. copper tube to suit.

Union nuts will be needed to connect this pipe both to the steam valve and injector; but, whilst an ordinary cone is required for the union on the steam valve, a small flat collar is needed for the injector end of the pipe. This is silver-soldered on, same as the cones; and when in place, it butts up against the injector steam cone and is held tightly against it by the union nut, thereby preventing any escape of steam. The injector, now being supported by pipes at both ends, needs no more assistance to maintain its position, and will "stay put."

Finally, make a little inverted swan neck of 5/32-in. copper pipe, with a ¼-in. by 40 union nut and cone on one end; attach this to the water inlet of the injector, with the straight end of the pipe going through the right-hand hole in the left-hand bracket under the drag beam, protruding about ½-in. or so. See diagram of connections. Screw a little bit of pipe about ½-in. long, into the overflow hole in the injector, and the job is complete.

Have the steam pipe as close to the boiler backhead as possible, so that it keeps hot, and supplies dry steam to the injector; because if any water goes over to the gadget, whether by priming or condensation, the injector will not work. As it depends on its action for the steam condensing in the water, and giving up its velocity to the water in the process, it should be obvious that if water goes down the steam pipe, it cannot condense any further, and there will be "nothing doing" in the way of boiler feed. Priming is always indicated by a spluttering of nearly-boiling water from the injector overflow pipe.

Connecting the Pump

First of all, attach the vertical check valve and bypass fitting, to the inside of the right-hand frame, in line with the safety-valve bush. It will be found that this will fit in very nicely, just in front of the hornblock; the top of the upper union should be about level with the top of frame, though the exact position doesn't matter, as long as you have room enough to get the union nut on.

The screws can be put in between the spokes of the driving wheel; the holes in the frame should be drilled No. 34 and countersunk, and countersunk-head 6 B.A. steel screws put through both frame and flange of the valve, with nuts on the inside. To ensure the screwholes lining up, the holes in the flange should be drilled after those in the frame, the valve being held temporarily in position by a toolmaker's cramp; their exact position doesn't matter.

If already drilled in the flange, take the centres of the holes with a pair of dividers, and transfer the measurement to the frame. When transferring hole locations in childhood days, I used to get a strip of paper, lay it over the holes, and rub my small oily fingers over it; this showed the holes as little grubby circles. I then laid the bit of paper on the metal where I wanted to drill the holes to same measurement, and carefully centre-popped the middle of the little dirty rings. Simple, but very effective, as the holes never failed to line up.

Put the right-hand top feed fitting temporarily in place, same as mentioned for the left-hand one; set the down pipe to lie close to the boiler, and cut it off level with the top of the union screw on the vertical clack. Remove pipe and fitting, fit a union nut and cone, replace, and connect up the union to the fitting. Sweat over the flange and screwheads as before, to ensure steam-tight joints.

THE next item is to connect up the top union on the crosshead pump *outside* the frame, to the union on the side of the vertical clack *inside* the frame; and here you will have to be mighty careful, because the pipe has to clear the coupling and connecting rods, and this necessitates fairly sharp bends, which must be made very carefully, to avoid kinking the pipe and obstructing the flow of water. This is one instance where the bit of lead wire comes in very handy, to get the exact length of the copper pipe.

Run the pipe first from the union on the pump, in towards the frames, then down between the leading coupled wheels and the driving wheels, under the frame, and up to the union on the vertical clack, attaching by the usual union nuts and cones.

Alternatively, the pipe could be run over the top of the frames, between the wheels, the upper bend being hidden from view by the continuous long splasher. Anyway, please yourselves—it doesn't matter which way the pipe goes, as long as the water gets into the boiler.

The pipe from the bottom union on the pump valve box can either go downwards and turn in under the frame between the leading coupled and driving wheels below the coupling rods, or it can follow the course of the delivery pipe, if over the top of frame, turning downwards alongside the clack.

In either case, it then goes along below the bottom of the frame, well to the side, and clear of the ashpan, till it reaches the back of the latter; then it turns slightly inward and upward, and goes through the left-hand hole in the right-hand bracket, projecting the same amount as the injector feed pipe. A pendant clip should be attached to it between the driving and trailing wheels, to keep it clear of the ashpan, and prevent it sagging down; this clip is similar to those illustrated in the detail sketch, but is attached to the bottom edge of the frame by a single screw.

Bypass Valve and Hand Pump Clack

Put the pipe on the bypass valve through the right-hand hole in the right-hand bracket, so that it projects ½-in. or so; then, holding it in a vertical position, measure up for a $\frac{1}{16}$-in. sheet metal supporting bracket, as shown in the illustration.

This can be made from a piece of sheet brass 2-ins. long and ¾-in. wide; bend at right angles ⅝-in. from the end, and cut away the parts not wanted. Drill a No. 30 hole in the foot, put the screw at the bottom of the bypass valve through it, and secure with a nut; then attach bracket to frame as shown, so that the valve is vertical, one bottom union pointing ahead, and the other across the engine. Screws can be put in either as shown, or clearing holes drilled through both bracket and frame, screws poked through from inside, and nutted outside, which is easy, as the valve stands clear of the vertical part of the bracket.

The lower nipple of the hand-pump clack is pushed through the ¼-in. hole in the left-hand bracket, and secured with a ¼-in. by 26 locknut, as shown in the diagram, leaving enough screw threads projecting behind the locknut, to allow of easy attachment of the union on the tender pipe.

The upper union is then connected to the bottom union of the bypass valve pointing across the engine, by a piece of $\frac{5}{32}$-in. pipe with appropriate nuts and cones on each end; see diagram.

The final bit of plumbing is about the easiest of the lot, and merely consists of connecting the forward-pointing union on the bypass valve, to the bottom union on the vertical clack, by a piece of $\frac{5}{32}$-in. copper pipe with a union nut and cone on each end.

This pipe should parallel the feed pipe, and be set to clear the ashpan. If it shows any tendency to sag, fit a clip; about the easiest way of securing both pipes is to make one clip, with the looped part big enough to take both pipes.

As some beginners seem rather hazy about the operation of the pumps and the circulation of the water, maybe I had better explain for their benefit, that to prevent airlocking, irregular pump action, water-hammer, and other ills that sometimes occur in small hydraulic apparatus, the pump is always pumping to full capacity, whether it is delivering to the boiler or not.

This is in accordance with full-size practice on the Stroudley tank engines. When the bypass valve is open, the water takes the line of least resistance, and returns to the tender via the connecting hose ("feed-bag") and an internal pipe leading to the top of the tank.

When the bypass valve is closed, the water has to force the delivery clack and enter the boiler. By partially opening the bypass valve, delivery of water to the boiler may be regulated to any desired quantity; and a little practice will enable a driver to keep a constant level in the gauge glass, all the time the engine is running.

When using the tender hand pump while standing, or in emergency, the bypass valve is closed. Water then passes through the pipe going from the hand pump clack to the bottom of the bypass valve, out through the other union, and along the bypass pipe to the vertical clack, which it pushes up, and enters the boiler via the top feed fitting. It cannot get into the crosshead pump, being stopped by the upper valve of same. On the other hand, when the crosshead pump is operating, and the bypass valve is closed, water cannot get back to the tender via the cross pipe, as it is arrested by the hand pump clack. The above explanation, plus a couple of minutes' study of the diagrams, should "clear the air" (or water!) for any beginner.

Road Test

If a track and a passenger-carrying flat car is available, the locomotive may now be given its first trial run. Fill the boiler through the safety-valve bush, until the water shows about two-thirds up the gauge glass.

Fill the lubricator tank with a good quality steam cylinder oil, suitable for high-temperature steam. Ordinary grades of oil sold for automobile engines are not very effective, as they do not cling to the rubbing surfaces in the same way that proper "superheater oil" does; being intended for high-speed work, they merely "wash faces" instead of "staying put," in a manner of speaking.

What is needed, is an oil that will form a tenacious film between piston and cylinder bore, and piston-valve bobbin and liner, forming a steam seal as well as a lubricant. At present I am using Cyltal 80-S, a product which has the consistency of black treacle (molasses) when cold; but Vacuum 600 W, Wakefield's and Price's superheater oil, or any other good reliable firm's cylinder oil will do.

Give the ratchet wheel of the lubricator a few turns by hand, so that the connecting pipes between lubricator and steam pipes are filled with oil, and a few drops has entered the cylinders to help starting from cold. Oil every moving part of the engine's "works" with a good grade of machine oil; a small force-feed oiler, as sold for motor cycles, is about the most handy tool for the amateur engine-driver. Maybe at some future date I'll describe how to make a small edition of a proper locomotive oil-feeder.

The flat car needs a small tin fixed on the front end, to carry water. This should have a stop cock soldered into it near the bottom, and two bits of 5/32-in. copper pipe, one at the bottom and one at the top.

The cock should be connected to the injector feed pipe by a bit of rubber tube; and the bottom and top pipes just mentioned, are likewise connected to the pump feed and bypass pipes respectively.

A small box to carry some coal is also required. The coal should be either Welsh steam coal, a mixture of Welsh and anthracite, or anthracite peas. If the first two, break up to the size of small beans, and sift all the dust out.

Draught

For beginners' benefit, I might mention here that there is no natural draught in a little locomotive (in fact, there is none on full-sized modern engines with short chimneys), so an artificial draught must be provided until there is enough steam to work the engine's own blower.

If an extension chimney and auxiliary blower or fan (described earlier in these notes) are not available, connect up an automobile tyre pump to the hand-pump union on the left-hand pipe bracket, and get some willing helper to pump it for you whilst you attend to the fire.

To start the fire, put some charcoal or wood chips in a big tin lid, and wet them well with paraffin. Shovel enough into the firebox to form a layer all over the bars, then throw in a lighted match, and start the blower or fan, or get your helper to work the tyre pump, turning on the engine's own blower, so that the air pumped into the boiler takes the place of steam, and creates a draught. The fire will soon start roaring; add more charcoal or wood until you get a good red fire bed, then you can shovel in some coal, but not too much at a time.

Steam should be showing in four minutes or so, and then the auxiliary blower or fan can be taken off, and the engine's own blower used, so you can "pay off" your helper, as the boiler will now do its own blowing.

As soon as the steam gauge indicates about 50 lbs., open the cylinder cocks, put the reverse gear in full forward position, and open the regulator. If your workmanship is O.K., there will be a terrific hissing of steam and water from the cocks, and the engine will slowly move off.

Don't attempt to ride on the car yet; wait until she is warmed up, and dry steam is issuing from the cocks; then shut them, take your seat on the car, open the regulator a little, and you'll be well rewarded for all your patient labour.

As the engine gets into her stride, bring the reverse gear back until the nut is almost in the middle of the screw, and open the regulator a little more; by this time you'll be travelling like the "Cornish Riviera" in a hurry, and the safety-valve will be blowing off.

Firing

Look after your fire and water. Contrary to what a beginner might expect, the proper time to pop a bit more coal on is when the fire is fully incandescent—nearly white all over—and the safety-valve is either blowing off, or just going to; if you let the fire die down before using the shovel, you'll lose steam badly before it burns up again, probably have to do what enginemen call "stop and have a blow-up."

Don't let the water fall much below half-a-glass, either; as soon as it drops to the halfway mark, put the pump or injector to work. To use the pump, close the by-pass valve. To start the injector, open the cock on the temporary water-can fully, wait until a stream of water runs out of the injector overflow, then open the steam valve. The injector will then give a splutter and a "sneeze" and "pick up" right away.

Should there be any dribbling from the overflow pipe, shut off the water a little until the dribble ceases; the injector will then make a noise like a linnet chirruping, whilst the water steadily rises in the gauge glass. When shutting off the injector, close the steam valve first.

Very little practice will enable a driver of average "savvy" to regulate running speed, maintain steam pressure, and keep up the water level for an indefinite time. My old 2½-ins. gauge "Ayesha" once made a non-stop run of over five actual miles, hauling my weight—equal to pulling a 27-coach train from London Bridge to Brighton—by taking a jug of water on the flat car, and refilling both tender and lubricator on the run.

When your run is finished, pull out the ashpan pin and dump the residue of the fire, plus clinker and ash; give the engine a good wipe down—it is a "crime" to put an engine away in a dirty condition—have a good look round her, same as a full-size driver would do, to see that nothing is loose, broken or missing. If all is O.K., then we are all set to go ahead, and fit the superstructure (running boards, cab, splashers, etc.), which will be the next job.

THE running boards, or side platforms (usually known as "gangways" among enginemen) may be made in one piece each side, or in three separate sections; I usually make mine in the former way; but beginners may get better results with the three-piece construction.

One-Piece Construction

If you want to try the one-piece method, get a piece of 16 gauge sheet brass or steel, 1¾-ins. wide and about 2-ft. 5-ins. long. At approximately 1¾-ins. from the end, bend it over a bit of ⅞-in. round bar held in the bench vice until the metal each side of the bend is at right angles. Then at ¾-in. above the bottom of the bend, make another in the opposite direction, at a sharp right angle. At 21-ins. from this, make another right-angle bend downwards, easing out into another curved bend similar to that at the front end.

See that the "high-level" piece of metal between the bends, is parallel to both the "low-level" pieces at each end; then trim off each end to the dimensions given on the drawing.

Three-Piece Construction

For the three-piece construction, cut a piece of metal, same kind as mentioned above, 1¾-ins. wide and 1-ft. 9-ins. long; this forms the centre piece. Each end section is then made separately, from short pieces of 1¾-ins. wide strip, bent to shape and dimensions shown in the illustrations; these may be attached to the centre section at either end, by brazing, Sifbronzing, or riveting, putting a small piece of 1/16-in. by ¼-in. angle in each joint.

Regular angle is not needed for this; you can make up these odd bits of angle by bending over scrap bits of metal in the bench vice. I often make bits of angle out of scrap cuttings, instead of throwing them away, and they come in mighty useful.

The next job is to cut out the segments to clear the wheels and rocker gear. The approximate positions of the openings are shown in the plan drawing, but check up from the actual engine, so as to avoid getting an opening in the wrong place, or cutting away needless metal.

If the plates are gripped in the bench vice with the marked line just showing, an "Abrafile" will remove the surplus in a jiffy, using the vice top as guide for the long horizontal line. Alternatively, you can saw down the vertical lines with an ordinary hacksaw, break out a bit of the metal long enough to admit a hacksaw blade on its side, then put the blade in the frame sideways, and cut along horizontally, keeping the side of the sawblade pressed down on the jaws. Trim up with a file.

Valances

The beadings or valances under the running-boards can be made partly from 1/16-in. by ¼-in. angle, and partly from 16 gauge sheet metal. My own usual plan is to use angle for straight runs and easy bends, and cut any intricate curves from sheet. In the present instance, the straight piece under the long top run, could be made from angle, riveted to the underside of the running-board 1/16-in. from edge.

The 3-ins. odd of straight run, at the cab end, could be made from angle; but the fairly sharp bend, also the reversed-curve "twiddley bit" at the front end, can be marked out on a piece of 16 gauge sheet metal, sawn and filed to shape, and attached to the underside of the running-boards, by brazing, soldering, or two or three short bits of angle at the back of each, either riveted or screwed.

Sifbronze Joints

Any lucky person who owns or has the use of a small oxy-acetylene blow-pipe, can build up the whole issue in a very short time, by using steel for the running-boards, 1/16-in. by ¼-in. steel strip for the straight parts of the valances, and 16 gauge sheet for the curves, Sifbronzing the whole bag of tricks.

When building the original "Maisie," I used that method, also made the cab and tender body in the same way; the joints were very neat, and the job a jolly sight easier than soft-soldering.

Ordinary toolmaker's-type clamps, homemade from ⅜-in. square steel with 3/16-in. stove screws, were used to hold the bits together whilst performing the blow-pipe act.

Incidentally, the firm supplying Sifbronze (Suffolk Iron Foundries Ltd., Stowmarket, Suffolk) issue a quarterly publication to all Sifbronze users, called "Sif-Tips," and in it is a comic character named George, who Sifbronzes everything that needs repairing—grandmother's spectacle frames, the baby's pram axle, mother's wringer, the family lawn-mower—in fact, about the only thing he doesn't Sifbronze up, are the holes in his utility socks. Well, your humble servant is another one of the same kidney, and although I've no shares in the firm, I'll say right here that their commodity has never let me down yet.

Attaching Running-boards

After fixing the valances, the running-boards can be attached to the chassis by a couple of ⅛-in. countersunk holes at each end, running through No. 30 countersunk holes in the plates, into tapped holes in the top part of the buffer and drag beams. Support will, of course, be needed in between; and this can be provided by small sheet-metal or cast brackets located between the coupled wheels. These may be riveted to the underside of the running-boards, and attached to the frames below them, by a single screw in each one.

Sheet metal brackets should be cut from 16 gauge material, to the shape shown in the detail sketch, and bent on the dotted lines; these brackets are exceedingly stiff, and will never "give" of their own free will and accord; in fact, I prefer them to castings.

Splashers

The long continuous splashers are an innovation in Great Western practice; hitherto all the engines have had separate splashers with round tops arranged to suit the wheel diameter. The single one is, of course, an easier job to make and erect.

In the present instance, the side plate of the splasher can be cut from 18 or 20 gauge hard-rolled brass or steel sheet, to the dimensions given in the illustration.

Tool Stowage

On the left-hand side of the engine, there is a short upward extension where the splasher joins the cab, and in full-size this forms the entrance to the "pricker box," where the fireman keeps his long tools, instead of laying them on the tender; a good idea, that, because on the Brighton engines, we had to carry them on top of the tender, and several cases occurred of a pricker, clinker shovel, rake or dart slipping, projecting out from the tender side, and being caught by an engine coming the opposite way.

A case occurred of a clinker-shovel slipping just as another train was passing; and after smashing a couple of carriage windows and cutting passengers' faces with flying glass, it swung right around and knocked the fireman clean off the footplate, causing serious injuries, which luckily did not prove fatal.

On the little engines, the worst that could happen is tools falling off the tender and hiding themselves in the grass (they serve me that trick!), so, unless you are a relation of Inspector Meticulous, and have to have every detail "just so," the top of the long splasher may continue in a straight line right to the cab front, as shown by the dotted line in the illustration.

The top of the splasher is simply a strip of the same kind of metal 11/16-in. wide. If brass, it may be soldered to the side, two or three bits of angle being riveted in the joint, at each end and in the centre, to stiffen it up. Alternatively, a piece of angle can be used the whole length, instead of soldering, as in full-size practice, 1/16-in. brass rivets being used for attaching the angle to both side and top of splasher.

This construction can also be used for steel splashers, or the latter may be Sifbronzed, as mentioned above: and a steel splasher may also be Sifbronzed to a steel running-board, forming a handy self-contained unit easily removable for servicing the engine or doing any small repairs. Brass splashers may be soldered to brass running-boards, with strengthening pieces of angle on the inside, as shown in the detail sketch: or again, soldering may be dispensed with, and a piece of angle riveted on full length, as in full size.

A cover is required for the rocker gear at each side; this does not require any detailing out, as it is merely a box made from 20 or 22 gauge sheet brass, one side being straight and the other rounded, with the outer end closed in. It is merely soldered to the running-board, over the hole cut to clear the rocker.

Cab Sides and Front

My own pet way of making a cab for an engine of this type, is to cut one side and half the front from a single piece of 18 or 20 gauge sheet metal, either brass or steel, bend it at the corner of the cab, and attach the two halves by a lap plate in the middle, riveted to one half, and screwed to the other.

If the cab front is made as a single sheet, with separate cab sides, it is usually an awkward job to get the front to fit nicely over the firebox wrapper, and takes some getting into position. The drawing gives the dimensions needed, and also indicates where the bends are made. Note especially, the ⅜-in. strip along the cab side, at the top. This is bent inwards, so that when the corner bend is made, and the side and front are at right angles, the top bend lies flush with the curve of the upper edge of the cab front. When the roof is made and fitted, it is attached to this turned-in flange by three countersunk screws and nuts each side, passing through clearing holes in both roof and flange.

The dimensions of the cut-away part where the driver leans out when he can't see signals through the cab window; also, the side and front window openings are indicated on the drawing. They may either be fretsawed out, with a metal-piercing saw, or coping saw—merely a glorified fretsaw—or a fretsaw machine if available, or by the ancient but easy method of drilling holes all around the outline, breaking out the piece of metal, and trimming with a file. My "Driver" jig-saw machine does jobs like this in double-quick time!

To get the correct outline of the firebox, there are two easy wrinkles. One is to get a bit of stout lead wire and bend it halfway around the wrapper, pressing it into close contact with same; remove it without spoiling its shape, lay it on the sheet metal, and carefully trace its outline with a scriber. This line, when cut out with snips or saw, should fit the firebox outline.

The other wheeze is to lay the former used for flanging the plates, on a piece of cardboard, and mark the outline with a pencil. Cut out with scissors, and "offer it up," as the shopfitters say, to the firebox. If it doesn't fit closely all around, the places where it doesn't are marked, and the card trimmed up with the scissors until it fits closely to the firebox; this cardboard template is then used to mark out the metal, and check the opening after the surplus metal has been cut away.

Don't forget that when making up the two sides of the cab, one front section is bent right-handed and one left; errors are easily made, and you might find, after an hour or two spent on careful fitting, that you have two right or two left-hand cab sides, instead of one of each.

Glazing Windows

Both front and side windows should be "glazed." I hate to see gaping holes where there should be proper windows; so cut out window frames from thin sheet brass, to the same shape as the openings in the cab sides and front, and about 5/32-in. wide.

These are riveted over the openings, on the inside of the cab, using the ends of domestic pins for rivets, and sandwiching a thin bit of mica or cellophane between. These make far better windows than glass, being thinner, and not liable to crack or break.

To put a finish on the job, a bit of 3/32-in. half-round nickel-bronze wire can be soldered on all around the side window openings, to form a beading. Similarly, a piece of flat stuff, nickel bronze or steel strip, about 18 gauge and 5/32-in. or 3/16-in. wide, can be soldered around the cut-away opening, being extended at the lower end, and drilled to take the 3/32-in. handrail pillar, which passes through it. The upper end of the pillar can be screwed into a tapped hole in the upper part of the beading, whilst the bottom end is flattened, turned inwards, and riveted to the cab side by a piece of domestic pin.

Rivet a piece of angle, say 1/16-in. by ¼-in., along the bottom edge of the cab, on the inside, for the fixing screws, which may be put through clearing holes in the angles, into tapped holes in the running-board, or vice versa, as you prefer. The latter will probably be the best for the side where the reversing gear stand is located.

The opening where the wheel projects through the running-board inside the cab, can be closed by a plain box cover, bent up from 20 or 22 gauge sheet brass, and soldered to the cab side. The joint plate, at the top of the meeting edges of the cab front, is a piece of 16 or 18 gauge brass, riveted to one half of the front, on the inside, and attached to the other by two 3/32-in. or 7 B.A. brass countersunk screws, so that the halves can be instantly separated, if required: see drawing.

Cab Roof

The roof is cut from a piece of 18 or 20 gauge sheet brass or steel, 7¼-ins. long and 5-ins. wide, a 1-in. "bite" being taken out of each back corner, as shown in the illustration.

Two sliding ventilators are formed in the roof; the openings for these are 1-in. square, located 1-in. each side of centre line, and 1 5/16-ins. from front edge of roof. A runner is fixed at each side of each opening; these are 2-ins. lengths of 3/32-in. by 5/16-in. strip, with a rebate milled or planed in each, about 1/16-in. wide, and deep enough to take a piece of metal of 20 gauge.

THE rebates can be milled in the lathe, process being as described for axleboxes. Alternatively, the runners can be built up by riveting or soldering together two 2 ins. strips of 18 gauge brass, the top one 5/16-in. wide, and the lower ⅛-in. wide, and attaching to cab roof with the narrower one downwards.

The cab roof is then bent to suit the outline of the cab front plate, and put in place, being attached to the bent-in part of the cab sides, by three 3/32-in. or 7 B.A. countersunk

screws at each side, passing through clearing holes in both plates, and nutted on the inside.

If the roof won't "sit down" properly on the cab front, but persists in coming up and leaving a gap, two or three bits of brass angle can be riveted to the inner side of the cab front, and screws put through the roof, into these angles. They will hold the roof down securely.

The ventilator sliding shutters can then be fitted; they are merely pieces of sheet metal 1⅛-ins. long, cut to a sliding fit between the runners, not loose enough to shake open when the engine is running, nor tight enough to prevent sliding between the runners by finger pressure.

The back edge of the roof may be finished off by having a beading of 3/32-in. nickel-bronze wire soldered all around it, and a rain strip of the same material may be soldered along each side, close to the edge, to prevent the driver getting water down the back of his neck when he looks out for signals in a rainstorm.

Footplate

The actual footplate, or cab deck, as our Transatlantic cousins call it, is just a piece of 16 gauge steel, or brass, cut to fit between the sides of the cab, with clearances for the pipes and other impedimenta.

No drawing is needed for it, the best way being to cut out a piece of cardboard, as I do myself, as a pattern, and when this fits nicely, use it as a guide to mark out and cut the piece of sheet metal. No need to screw it down, merely make it a tight fit, so that it will "stay put" when resting on the upper edges of the frames inside the cab.

A make-up piece is also needed between the frames at the leading end, to close the gap ahead of the smokebox. This also should not be fixed, as it must be instantly removable for the purpose of filling the lubricator. It should be a fairly easy push fit between the frame plates, and follow the contour of the top line, butting up against the front of the smokebox saddle.

To prevent the plate sliding forward, rivet a small peg in the centre, close to the front, on the underside of the plate, and drill a corresponding hole in the top of the buffer beam, so that when the plate is in position, the peg fits into the hole, and thus prevents any slipping of the plate. The smokebox saddle will prevent it slipping down.

The engine part is now practically completed, except for such details as handrails, drawbar and couplings, steps, and one or two other trimmings; and some of these (couplings, for example) are common to both engine and tender. Therefore, we will now go on to the construction of the tender, and then finish off the lot at one fell swoop.

Tender

With the tenders supplied to the "1,000" class engines, an age-old tradition in tender design came to an end on the Great Western Railway. Gone were the flared coping and distinctive frames, also the comparatively low-sided body; in place of them, Swindon came into line with the other three main-line groups, and started to produce tenders with conventional deep slotted frame plates, and straight high side sheets. This is all to the good, from the viewpoint of small locomotive builders, as the new type of tender is considerably easier to build than the old pattern. Even "raw recruits" who have succeeded in making a job of the engine part, have now some experience of machining, fitting and erecting; therefore, there should be no need to go into every little detail, in the matter of building the tender.

Frames

It is quite possible that one or two of our advertisers may supply cast frames, complete with horncheeks and dummy springs all cast on; if so, a very considerable amount of work will be saved. Failing that, the frames can be cut from steel plate in the usual way, and cast horncheeks and dummy cast springs attached to them.

Alternatively, real working leaf springs may be fitted; I will give the necessary drawing and notes, all being well. As there are no tractive stresses to withstand, and the frames only have to carry the weight of the tender tank and its contents, plus a little coal, there is no need to use steel as thick as the engine frames, and two pieces of 3/32-in. blue steel (13 gauge) 17-ins. long and 2¾-ins. wide, will be needed. One of these is marked out, and a couple of the rivet holes drilled; the two plates are then temporarily riveted together, and cut out in exactly the same way as described for the engine frames. Mark which is the outside of each, before parting them.

If the builder decides to attach the frames to the buffer and drag beams by angles, screws and rivets, the horncheeks, and inside angles for attaching the soleplate, may be fitted right away to each frame; but if brazed construction is adopted, leave this job until the brazing has been done. Cast separate horncheeks can be obtained from any of our advertisers selling the necessary material for this locomotive, and only need cleaning up with a file.

The horncheeks are 1⅛-ins. long, 5/16-ins. wide on the face which butts against the frame, and ½-in. wide on the axlebox contact face. To locate them in the proper position, I usually jam a bit of bar in the frame slot, hold the horncheek against it, and secure it with a clamp in that position. The rivet holes are then drilled, and the rivets put in.

I have only shown two in the illustration, as two 3/32-in. charcoal-iron rivets will hold the castings quite securely; but if anybody likes a lot of small rivet heads showing, they can easily emulate full-size practice and secure each horncheek with six 1/16-in. rivets, putting two in each space between ribs, one above the top rib, and one below it. The holes should be countersunk on the inside of the frame, and the stems of the rivets hammered down into the countersink and filed off flush.

A piece of 5/16-in. by 1/16-in. angle, brass or steel (you can bend it up in the bench vice, if you like, from a scrap bit of sheet metal) and 1½-ins. long, is riveted to the top edge of each frame plate, on the inside, midway between each pair of wheels. Use 1/16-in. brass or iron rivets. These angles are shown dotted in the frame drawing.

THE tender beams are made from ⅛-in. steel or brass angle, 1¼-ins. on the wider face and 1-in. on the narrower. If odd angle cannot be obtained, get 1¼-ins., and mill, plane or saw off the unwanted part. Note: whilst both the engine beams were the same shape, the tender drag beam differs from its "opposite mate" in having a bite taken out of each end. This gives the driver and fireman a little more knee-room when climbing up the flush steps. Don't forget that the frame slots are only 3/32-in., instead of ⅛-in., as on the engine; the mistake is easily made! They are also spaced at 4½-ins. between the inner edges, instead of the engine's

$2\frac{7}{8}$-ins. The holes in the buffer beam for the buffer shanks, are tapped $\frac{3}{8}$-ins. by 32 instead of being plain holes; you'll see the reason for this when fitting the buffers later on.

If angle fixing is adopted for the frames, rivet a piece of $\frac{1}{8}$-in. brass or steel angle to the inner side of each frame slot, as shown in the detail drawing, using the method described for the same kind of job on the engine beams. These are not required for brazed-up frame assemblies. As with the engine frame assembly, drive the frames into the slots in the beams, and lay the whole issue upside down on the lathe bed, or something else that has a perfectly flat and true surface, and see that both beams and both frames are in full-length contact with it, before putting any screws in.

If cast frames are available, probably cast beams will be sold to match; and all these will need is a clean-up on the lugs provided for attachment of frames. The only machining the frames will need, will be the inner faces of the horncheeks, between which the axleboxes slide; and if the frames are clamped back to back, and mounted on the slide-rest tool-holder at right angles to the lathe bed, the job can be done with an end-mill in the three-jaw.

The process is exactly similar to that described earlier in the notes, for axleboxes and other jobs of like nature. If the castings are clean, it is probable that milling may not be necessary at all, the faces being merely smoothed off with a hand file. Use a bit of $\frac{5}{8}$-in. bar, as a gauge; it should slide in easily, but without being slack.

Brazed Frame Assembly

For some time past, I have put all my frames together by aid of an oxy-acetylene blow-pipe and a bit of Sifbronze. No angles are needed on the buffer and drag beams, the frames being driven into the slots, and trued up on the lathe bed as mentioned above. I happened to have a bit of channel iron the right width to fit between frames, and this was placed between the frames amidships, and a big cramp placed over the lot, which effectually prevented anything getting out of plumb.

The frame thus assembled, is up-ended in the brazing pan, and a dab of wet "Sifbronze" flux applied to the junction points between frame and beam. The blow-pipe, with a 150-litre tip in it, is then brought into action, and the joint heated to bright red, a matter of a few seconds only. A stick of No. 1 "Sifbronze," $\frac{1}{8}$-in. diameter, is then applied to the red-hot metal, a little bit melting off and running between the beam and frame, in a neat fillet. If allowed to cool to black, quenched in water, and the residue of the flux brushed off, the resulting joint is neat enough to need no further cleaning, the metal lying in the joint quite free from "almond rock."

Exactly the same preparation does for a brazed frame, the only difference being that with the diffused flame of an ordinary paraffin blow-lamp, or air-gas blow-pipe, the whole of the buffer or drag beam, and the adjacent part of frames, has to be heated up to make the brazing material flow.

For brazing iron or steel jobs, brass wire is a good brazing medium, but any good easy-running brazing strip is quite suitable. May I once more remind beginners that steel and iron jobs should never be put into acid pickle after brazing; use water only. Horncheeks, and angles for attaching soleplate, are then attached to the brazed assembly as described previously.

Springs and Axleboxes

Either cast dummy or working leaf springs may be used; if the former, a spring plunger, like a headless buffer, is fitted into the hoop or buckle, as shown in the sectional drawing.

The first job is to fit the brackets for the spring pins, which are the same for either type of spring. Chuck a bit of $\frac{5}{16}$-in. by $\frac{3}{8}$-in. steel truly in the four-jaw, and turn down about $\frac{3}{16}$-in. of it to $\frac{1}{8}$-in. diameter, to fit the No. 30 holes in the frames. Part off at a good $\frac{5}{8}$-in. from the end, "ditto repeatoing" until you have a dozen pieces. Then mark off the hole, $\frac{1}{4}$-in. from shoulder; drill No. 40, tap $\frac{1}{8}$-in. or 5 B.A., and round off the ends with a file.

Push the stems through the holes marked "A" on the frame drawing, and rivet over at the back; warning—don't make the heads too clumsy, or they will foul the wheels. On the full-sized engine, the spring brackets are of angle shape, and riveted to the frame plates; but this entails a lot of work quite unnecessary on a small engine.

To Querists

In view of some recent correspondence received from new readers of these notes, on the subject of this particular locomotive, I wish to emphasise once more that the engines I describe are NOT "models," but small-power locomotives intended for a real job of work, same as in full-size practice. Where the little engine is a copy of an existing full-size one, as in the present instance, the outline and general dimensions are correct in appearance and proportion; but the *details* are designed in exactly the same way as the full-size C.M.E. goes to work, that is, by making them suitable for their particular purpose in relation to the size of the engine.

The spring pins can easily be turned from $\frac{1}{4}$-in. round mild steel held in the three-jaw, to a diameter of $\frac{1}{8}$-in., and screwed at the end; part off at $1\frac{3}{16}$-ins., reverse in chuck, and turn the head to the shape shown. Alternatively, they can be made from $1\frac{3}{16}$-ins. lengths of $\frac{1}{8}$-in. round steel, screwed both ends. On the upper end, screw a washer or boss $\frac{1}{4}$-in. diameter and about $\frac{1}{8}$-in. thick, like a firebox spacer, and turn it to the shape of the head shown, with the stem held in three-jaw.

Cast Dummy Springs

If cast dummy springs are used, clean up with a file if necessary, then drill the spring-pin holes in the top plate at $2\frac{3}{4}$-ins. centres, using No. 31 drill. The pins should be a good fit in the holes.

Next drill the hoop or buckle almost through, with $\frac{3}{8}$-in. drill (see illustration) and make a headless plunger to fit, from either brass or steel rod $\frac{3}{8}$-in. diameter. Chuck in three-jaw, and take a skim off the outside, so as to render the plunger an easy (but not sloppy) fit in the hoop. Face, centre, drill down for $\frac{1}{4}$-in. depth with $\frac{1}{4}$-in. drill; part off $\frac{5}{8}$-in. from end, reverse in chuck, and slightly round off the sharp edge.

The springs are wound up from 19 gauge tinned steel wire; they should just start to compress when the plunger enters the hoop, and the axleboxes should be in the position shown, when the tender is three-parts full of water, and the coal space half full.

If working leaf springs are desired, they should be made on Mr. Tom Glazebrook's system, which for realism combined with resiliency—very important, that!—cannot be

beaten. Each "plate" is composed of two or more laminations, according to the thickness of spring steel available. On my 2½-ins. gauge "Tugboat Annie," I used 28 gauge strip steel, a commercial size sold for gramophone governor-springs and similar purposes, and each leaf was made up of three thicknesses. In the present instance, use sufficient pieces to bring each plate to a thickness of 1/16-in. as shown in the detail illustration.

The top plate is double thickness. The holes for spring pins may be punched with a home-made punch; chuck a bit of ¼-in. round silver-steel in three-jaw, turn ¼-in. of it to the size of a No. 31 drill; carefully square off the end, and taper it backwards slightly from the cutting edge. Harden and temper as described for injector cone reamers. To use, place the bit of spring steel on a block of lead; hold punch quite vertically on it, and give just one hefty crack with a hammer. The result will be a clean-cut hole through the steel.

The hoops are made from ½-in. square steel held truly in the four-jaw. Face, centre, and drill about ⅜-in. depth with No. 30 drill; tap 5/32-in. by 40, turn down 3/16-in. length to 5/16-in. diameter, and part off ⅞-in. from the end. Drill a ⅜-in. hole through the middle of the square part, and file it out to a rectangular hole measuring approximately ½-in. by ⅜-in. to accommodate the nest of plates.

Turn up a screw from 5/16-in. round rod held in the three-jaw; same process as for spring pins. Leave the head flattened, as it bears on the axlebox; assemble spring plates and hoop as shown in the detail sketch, making the screw grip tightly enough to prevent any side movement of the nest of plates.

Axleboxes

Axlebox castings supplied by our advertisers will be in a stick, and the channel in each side can be milled before the stick is cut up, in exactly the same way as described for engine axleboxes, so we need not go over all that ground again.

If you haven't a milling machine, and your cross-slide hasn't sufficient traverse to end-mill the stick at one fell swoop, cut the stick in half, and do each half separately. If the cast boxes are not too close together in the stick, part them off after channelling, with the stick held in the four-jaw, which saves separate facing of each end; otherwise, saw them off, and face each end truly with the box chucked in the four-jaw.

If for any reason you can't get a casting, use a piece of ⅞-in. square brass rod, end-milling a channel ⅝-in. wide and ⅛-in. deep down each side, as described for engine axleboxes. Leave the back flange full width, but reduce the front flange to ¾-in. width; see plan drawing.

The ¼-in. hole for the axle journal is drilled plumb in the middle of the back; if you haven't a drilling machine, use the lathe. Centre-pop the back of the box, chuck in four-jaw with the pop mark running truly, and use drill in tailstock chuck. This applies to both cast and bar material.

Cast boxes will, of course, have the ornamental dummy lid cast on; for bar material boxes, cut the ornamental front from a bit of 1/16-in. brass sheet, and either solder it on, or attach by a couple of weeny screws. Don't forget to drill a 1/16-in. oil hole, as shown by dotted lines in the side view of the axlebox.

The hornstays are simply 1⅜-in. lengths of 3/16-in. by 1/16-in. steel strip, drilled No. 40 and attached to the frame below the axlebox openings, as shown, by 3/32-in. screws.

The tender wheels are shown as 2⅞-ins. on tread, and are machined up exactly as described for the engine wheels, but here is a tip which may save delay. What with the export craze and the endless restrictions on non-essential supplies, castings may be scarce, or delivery very slow.

One of our advertisers informed me that he had very few 2⅞-ins. wheels in stock, but upwards of 2,000 castings that would finish to 2¾-ins. diameter. The latter can easily be used on this tender, by drilling the journal holes 1/16-in. lower in the axleboxes, to maintain the tender at correct height. The difference in wheel diameter cannot be distinguished from the outside.

Axles

Each axle needs a piece of ⅜-in. round mild steel 5 5/16-ins. long; and if chucked in the three-jaw, wheel seat and journal can be turned at the same setting, so they are bound to be concentric. Slightly round off the ends, as a sharp edge scores the axlebox. Both wheels can be pressed on to the axle right away, as the axleboxes are outside the wheels; press by method described for engine wheels, but as there is ½-in. of journal projecting from each wheel when same is right home, a bush not less than ⅝-in. long, should be placed between vice-jaw and wheel boss, when pressing.

Erection

Fit the spring pins to the springs, then screw the pins into the brackets, putting a locknut under each as shown, adjusting so that the bottoms of the hoops are approximately ¼-in. above the axlebox slot.

Turn the chassis upside-down on the bench, and if cast dummy springs have been used, put the spiral springs and plungers in the holes in the hoops. Put an axlebox on each end of each axle, and drop each pair into the horn slots; see that you have the axleboxes in the proper way, so that they won't be upside-down when the chassis is standing on its wheels.

Finally, attach the hornstays to the little bits of projecting frame at the ends of the axlebox slots, using 3/32-in. roundhead or hexagon screws for appearance sake.

Soleplate

No separate drawing is needed for the soleplate or tender bottom. This is a piece of 16 gauge hard-rolled brass or copper sheet, 17⅜-ins. long and 6¾-ins. wide. It must be perfectly flat. Lay it on top of the tender chassis, and drill three No. 40 holes through the plate and the top of the buffer and drag beams at each end; the exact position doesn't matter, but they should be about ⅝-in. from the front and back ends of the tender, one on the centre line, and the others about 2½-ins. each side of it. Put a couple of screws in, with nuts underneath, to hold it in place; then drill two more No. 40 holes through the soleplate and the bits of angle riveted to each side frame.

Valance

For the valances, two pieces of ¼-in. by 1/16-in. brass angle are needed, each 16⅞-ins. long. These are riveted to the underside of the soleplate, so that they will fit between the buffer and drag beams, and are located ⅛-in. from the edges of the soleplate. Use 1/16-in. brass rivets spaced at about 1-in. centres. They don't show, and as they are not subject to any stress, not many are needed.

The soleplate can then be attached to the chassis by 3/32-in. or 7 B.A. brass screws, any shaped head, and nutted underneath. This allows the complete body to be taken off the chassis quite easily in emergency, simply by removing the nuts.

THE best material for the tender body is hard-rolled sheet brass, either 20 or 18 gauge, this material giving nice smooth panels at each side, and not being very easily dinted. However, if this is not available, soft brass sheet can be used, or sheet copper. If expense is a consideration, galvanised iron is a good substitute, 20 gauge sheet being a suitable thickness. Ordinary sheet steel isn't much good, as it rapidly rusts; and rusty water entering the boiler is not only going to leave a deposit in it, but will cattle up the pump valves and the injector. The only way to avoid trouble with a steel tank, is to line it with thin sheet copper, so that the water cannot touch the steel at all. My old 26-year-old "Ayesha" has a steel tender with a brass water tank in it.

The body is built up on a soleplate of 16 gauge metal, measuring 17½-ins. long and 6⅝-ins. wide, attached to the tops of the beams and side angles by screws. These pass through clearing holes in both soleplate and angles, and are nutted underneath. Any suitable screws you have, may be utilised, but they must be brass, and between 5 and 7 B.A., or ⅛-in. and 3/32-in. Three at each end, and one or two in each side angle, will do quite well, as they only have to prevent the body falling off the chassis.

Warning: don't use one kind of metal for the soleplate and another for the body, or trouble may ensue. If, for example, you mount a brass or copper body on a galvanised soleplate, the zinc coating of the latter will combine with the brass or copper to form a jolly fine electric battery, and the joints will corrode and be "eaten away," so that the tender will grow a nice crop of Welsh vegetables. Soleplate and body should be made of the same kind of metal.

Sides and Ends

Wherever possible, I make the sides and ends of my own tenders in a single piece, cut to outline and bent at the corners; but in the present case, this would entail using a piece of metal 4⅞-ins. wide, and approximately 30⅝-ins. long, and it may not be available. If not, use two pieces half the length, each piece forming one side and half the back. The two ends are butted together, the joint coming in the middle of the back, and a butt strip is riveted to the inside.

After the butt strip has been sweated over, and the crack between the two halves filled up and smoothed off with a file, the result is practically as good as the single sheet construction, the joint becoming invisible when the tender is painted. This allows the corners to be very slightly rounded; if the joints are made right at the back corners, the angles are too sharp. Whether one-piece or two-piece construction is used, mark out the sheet metal and cut to outline; then bend the corners, and make the joint last of all.

Front Plate

A piece of metal approximately 7-ins. long and 3¾-ins. wide, is required for the front plate. Bend over about ⅜-ins. at each end, to a right angle, so that the total length over the angles is 6 5/16-ins. less twice the thickness of the metal forming the tender sides.

At 1⅛-ins. from the bottom, cut a rectangular hole 2-ins. wide and 1½-ins. high, for the coal gate. At each side of this, rivet a runner, made as described for the cab roof ventilators; these may be riveted on either with rivets made from 18 gauge copper wire, or pieces of domestic pins. A piece of metal is cut to fit between the runners, and furnished with a knob for lifting; this kind of coal gate is not the same as found on full-size Great Western tenders, but is about the easiest kind to make, looks all right, and does the job. It is the same as we had on the old L.B. and S.C. Railway engines.

The front plate, complete with gate or slide, is placed between the front ends of the tender body, at a distance of 1¼-ins. from the front edges, with the angled ends pointing backwards, and riveted in place with 1/16-in. brass or copper rivets, heads inside the tender. The outside heads can either be flush, or finished cup fashion; many folk love to see lots of cup-headed rivets adorning their platework, but it is a matter of taste. Personally, I prefer the perfectly smooth sheet, and probably you would, too, gentle reader, if you had ever cleaned a full-sized engine.

Erection of Tender Body

Before mounting the body on the chassis, the angles for carrying the top portions of the tank should be attached. Cut two 5¾-ins. lengths of ¼-in. by 1/16-in. brass angle, and rivet them to the back ends of the side sheets at ⅜-in. from the top, as shown in the sectional illustration. Cut another piece to fit between them, and rivet it across the back, at the same level, filing a clearance in it to make room for the butt strip, if one has been used.

In the illustration I have shown broken pieces of angle supporting the bottom of the coal compartment, for the sake of clarity; but builders can either rivet pieces of angle the full length of both sloping and horizontal sections of the bottom plate, or fit a couple of short pieces only at each side.

Only a small weight of coal is carried in the tender; and even if the plate were only soldered in, it would not be in danger of collapsing, but it is best to provide it with a little extra support. Rivet a length of ¼-in. by 1/16-in. angle along the bottom, at each side, and also along the back, and the bottom inside edge of the front plate; drill No. 41 holes all along these, at intervals of about 2-ins., for fixing screws to hold the body down to the soleplate.

Now place the body on the soleplate, midway between the sides, and with the back ¼-in. from the back edge. Tack it in position with a couple of blobs of solder each side; run the 41 drill through the holes in the angle, making countersinks on the soleplate. Follow up with No. 48 drill, tap 3/32-in. or 7 B.A., and put brass screws in. As the drill chuck on the hand brace is too big to allow a drill to enter the hole direct, by virtue of fouling the tender sides, put the drills in 5-ins. lengths of 3/16-in. brass rod, and hold the end of the rod in the chuck.

I don't often have the misfortune to break a drill, but when I do, I always utilise the broken piece by drilling a hole one size smaller in the end of a piece of 3/16-in. rod, and forcing in it the bit of broken drill. This not only gives it another lease of life, but provides extension drills without the trouble of utilising new ones. An extension tapwrench can be made in a jiffy by knocking the end of a piece of tube square, to fit on the tap. An ordinary tapwrench is fixed on the other end of the tube, and there is your extension, ready for use.

Either roundhead or cheesehead brass

screws may be used. When all are tightened, solder all around the inside of the tank body where it sits on the soleplate, seeing that the solder "sweats" under the angles, and completely covers all screw and rivet heads, so that the tank is perfectly watertight. A good heavy soldering bit is an asset on this job; for many years I used a home-made one, made from a scrap copper stay from a full-sized locomotive boiler. Use a liquid flux, same as mentioned for boiler staybolts, and be sure to wash the tank out well after finishing. It is important that all traces of flux should be removed.

THE sloping part of the tank top which forms the bottom of the coal compartment is a fixture; the shorter horizontal part at the back, in which is fitted the filler, is removable, for access to the hand pump, and for cleaning out the interior of the tank occasionally. For the former, you need a piece of 18 or 20 gauge sheet metal (same kind as used for tank body) 12-ins. long and just wide enough to fit nicely between the side sheets; this will be 6⁵⁄₁₆-ins. less two thicknesses of the metal used.

Bend as shown in the drawing. The upper end is rounded off to a radius of 8¾-ins.; the horizontal front end is cut back each side by about ¼-in., leaving a tongue 2-ins. wide in the middle, which projects through the coal gate at the bottom, and forms a "shovel plate" for the fireman.

Fit this plate as shown in the sectional drawing; but before screwing it down "for keeps," mark off on the back of vertical portion, the place where the side angles touch it, and then rivet on a piece of ¼-in. by ⅟₁₆-in. angle, to complete the four sides of the "square" on which the removable top rests. The coal plate can then be screwed down to the angles on which it rests, using ³⁄₃₂-in. or 8 B.A. countersunk brass screws, running through clearing holes in the plate, into tapped holes in the angles. Then solder all around to make it watertight, covering all the heads of the screws, and not forgetting to solder along underneath the tongue projecting through the coal gate.

The removable part of the tank top is made from a piece of the same kind of metal used for the fixed part, and should be cut to fit easily in the back of the tender, resting on the four pieces of angle already fitted.

At ⁵⁄₃₂-in. from the edge, all around, at 1-in. spacing, drill holes with No. 43 drill. Starting at ¾-in. from the back end, cut a rectangular hole, 2½-ins. long and 1⅛-ins. wide, with rounded corners.

Cut a strip of metal ⅜-in. wide, bend it to the shape of the hole, insert it and solder it in place.

Cut out a lid ⅟₁₆-in. larger all around, and leave two tags at one end. Bend these into loops with a small pair of roundnose pliers, so that a piece of ⅟₁₆-in. brass wire is a tight fit. Cut another small strip of metal to fit between the loops; bend that likewise, place it between the loops and put a short piece of ⅟₁₆-in. wire through the lot, to form a hinge. Solder the "tail" to the end of the filler, in the position shown in the sectional drawing; fit a wire loop handle to the other end of the lid, and there's another item done.

Place the tank top in position; run the No. 43 drill through all the holes around the edge, making countersinks in the angle beneath. Follow up with No. 51 drill, and tap 8 B.A., but don't put the screws in yet, as the fittings inside the tank must be put in first.

Installing the Hand Pump

The hand pump was made and used for testing the boiler, so bring it out again, set the handle vertically, and place it in the tank, on the centre line, with the middle of the handle 2-ins. from the back of the tank; see sectional illustration. Using the holes in the bottom lugs of the pump as guides, drill four No. 30 holes through the soleplate, and secure the pump by four brass ⅛-in. or 5 B.A. screws, with nuts underneath the soleplate.

Next make a double-ended union for the pipe connection through the soleplate. Chuck a piece of ⁵⁄₁₆-in. or ⅜-in. hexagon brass rod in the three-jaw; face, centre deeply, turn down ⁷⁄₁₆-in. length to ¼-in. diameter, screw ¼-in. by 40, and part off ¹³⁄₁₆-in. from the end. Reverse in chuck, turn down ¼-in. of the other end to ¼-in. diameter, and screw ¼-in. by 40; centre deeply, and drill right through with No. 40 drill. Make two union nuts to suit—you know how to do that!—and also an ordinary nut about ⅛-in. or so in thickness.

At a point just ahead of the pump, the exact spot doesn't matter, drill a ¼-in. clearing hole, and poke the longer end of the double union through it, putting the nut on underneath the soleplate. Be careful to scrape or file off any burr around the hole, or water will leak out. Connect the upper end of the double union, with the union on top of the pump, by a piece of ⁵⁄₃₂-in. pipe bent to a swan-neck and furnished with cones and union nuts, as described in previous "plumbing" jobs. The lower end of the union is connected to the ¼-in. by 26 union on the engine, when engine and tender are coupled up, by a ⁵⁄₃₂-in. pipe which must be made flexible, to allow for any movement between engine and tender when passing around curves.

The best way of doing this is to coil the pipe like a spring. The usual method of a couple of horizontal turns, permits side-to-side movement, but doesn't allow of "come-and-go," which is necessary, as the engine and tender beams move to and from each other on the curve. Soften a length of ⁵⁄₃₂-in. pipe by heating to red and plunging into cold water; then put a piece of round rod, about ¾-in. diameter, vertically in the vice, and wind the pipe around it about six turns, in the form of a spring.

Bend the two ends as shown in the illustration, showing inside of tender, put a ¼-in. by 40 union nut and cone on one end, and a ¼-in. by 26 ditto on the other. The former is connected to the underside of the double union, and the other projects about ¾-in. beyond the front beam, being set to line up with the union under the engine beam.

Pypass Pipe

Fitting the bypass is a simple job. Chuck a bit of ⅜-in. round brass rod in three-jaw; face, centre, and drill No. 23 for about ⅝-in. depth. Turn down ¼-in. of the outside to ¼-in. diameter, and screw ¼-in. by 40. Part off at a full ¾-in. from the end. Drill a No. 23 hole in the side, meeting the one in the middle, and make a ¼-in. by 40 ordinary nut to fit the screwed part.

In the screwed end, fit a piece of ⁵⁄₃₂-in. tube about 6¼-ins. long; in the side hole fit another piece roughly same length, and silver-solder them both. Make an easy bend in the upper one; see sectional illustration. Drill a ¼-in. clearing hole in the soleplate, close to the double union, poke the bent pipe through, run the nut over it, and screw it on to the fitting.

The pipe underneath the soleplate should be bent to line up with the bypass pipe on the engine. Incidentally, if the tender wheels are temporarily removed whilst the pipe fitting is in progress, it will be found easy enough to get the pipes in.

Feed Pipe for Crosshead Pump

As both the pump and injector feeds need strainers, or "strums," as the enginemen term them, make two at one go. Chuck a bit of ¾-in. round brass rod, face off, and turn down 3/8-in. length to 5/16-in. diameter. Part off 5/8-in. from the end. Drill a hole half-way through the middle of the turned-down part, with No. 23 drill, then chuck again, holding by the turned-down part. Centre, and drill No. 23 until you break into the cross-hole. Turn down ⅛-in. of the end to 5/16-in. diameter, leaving a ¾-in. flange ⅛-in. wide. Drill three No. 41 holes equidistant around the flange, for the fixing screws.

In the side hole of one, fit a piece of 5/32-in. copper pipe about 1¾-ins. long, and in the other, another piece about 6-ins. long; silver-solder them both. Roll up two fingers from fine brass or copper gauze, 5/16-in. diameter, one about 1-in. long and the other about 1½-ins. Bend over the tops, to close them, then put them on the little projections above the flanges, and solder in position, also soldering the seam and top so that they cannot unroll and let dirt through. The long finger goes on the flange with the long pipe.

Drill a 5/16-in. clearing hole in the soleplate, about 8½-ins. from the front beam, and put the long finger through it; then drill and tap the soleplate for three 3/32-in. brass screws, using the holes in the flange as guides or jigs. If a jointing gasket or washer of 1/32-in. Hallite or similar material is placed between flange and soleplate, no water will leak from the joint. Bend the long pipe to line up with the feed pipe under the engine beam.

THE feed to the injector is controlled by a handle similar to a brake handle, and is easily regulated by anyone driving the engine from a car behind the tender. The valve itself is very similar to the screw-down valves in the boiler fittings. To make it, chuck a bit of ⅜-in. round brass rod in three-jaw. Face, centre, drill down to a depth of about 1¼-ins. with 7/64-in. drill, open out to ⅞-in. depth with No. 23 drill, and bottom the hole to 1-in. depth with a similar-sized D-bit. Further open out the end of the hole to ¼-in. depth with No. 11 drill, and tap the remains of the 23 section with 3/16-in. Whitworth tap, taking care not to spoil the seating. Turn down ¼-in. of the end to 5/16-in. diameter, and screw 5/16-in. by 32. Part off at 1¼-ins. from the end, reverse in chuck, and counterbore about ⅛-in. with No. 23 drill. Drill another No. 23 hole in the middle of the plain part, breaking into the longitudinal hole just above the D-bitted seating; see section.

The valve spindle is a piece of 3/16-in. round rustless steel, or nickel or phosphor-bronze, 4½-ins. long. Chuck in three-jaw and put about ⅞-in. of thread on it, with a 3/16-in. Whitworth die in the tailstock holder. I use this pitch for valves, as the coarse thread gives a very quick action; but, of course, a finer thread may be used if you don't object to a lot more turns of the handle!

Turn away the thread for ¼-in., and put a cone point on the end, as described for boiler fittings. For appearance sake, turn down 3-ins. of the stem to ⅛-in. diameter. The way I do this job, for quickness, is to put the spindle in the three-jaw with about ¾-in. sticking out beyond the jaws, turn down that bit (which needs no steady), then pull out another ¾-in., turn that, and "ditto repeato" until the required length has received treatment.

Make a gland nut for the top of the valve, and also a locknut about ⅛-in. thick. Make also, a little angle bracket about ¼-in. wide, to go over the spindle and screw to the front plate of the tender, to steady the long spindle; see sectional illustration again, also front view. Slip it on, then screw or silver-solder a boss 3/16-in. diameter on the end; cross-drill this with No. 43 drill, squeeze in a bit of 3/32-in. steel wire (rustless for preference) and bend it to the shape of a conventional brake handle as shown.

Now, looking at the front of the tender, as shown in the end view, mark a spot 1½-ins. to right of centre line, and ⅜-in. ahead of the end plate. Drill a 5/16-in. clearing hole, and remove all burr. In line with it, and about 1⅞-ins. behind, drill another similar hole; this one, of course, pierces the bottom of the tank, and must be large enough to clear the strainer. Put the pipe attached to the strainer in the hole in the side of the valve, and fit a little tail-pipe to the bottom of the valve, as shown. Silver-solder them both; pickle, wash, clean up, and then poke the top of the valve through the hole ahead of the front plate, and the strainer in the back one, as shown in the drawing.

The valve is retained in place by the locknut on its neck, and the flange is attached to the soleplate, same as the one previously described. Any slight difference between centres of holes and centres of fittings, can easily be adjusted by bending the pipe a little. Put the gland nut on the spindle, screw the spindle into the valve, packing the gland with a few turns of graphited yarn, attach the little bracket to the tender front plate by a small screw and nut, and that's that. Short pieces of rubber tube are slipped over the ends of the tail-pipe on the injector valve, the feed pipe, and the bypass pipe, just long enough to go over the corresponding pipes on the engine for ¼-in. or so, leaving a little "slack" in between, to allow for movement between engine and tender on curves.

That completes the interior fittings of the tender, and the removable top can now be screwed down, using 8 B.A. roundhead brass screws. Wheels may also be replaced.

A beading of 3/32-in. half-round wire (commercial article) is soldered all around the top edge of the tender. To hold it in position whilst soldering, I use a few small home-made toolmaker's cramps; for soldering work, these may be made of brass, so that splashes of liquid flux may be readily washed off without causing rusting-up, as is the case with steel cramps used for the same purpose. Clamps made from 3/16-in. square rod with 3/32-in. or 7 B.A. screws, are quite strong enough for light work such as above.

At the front end of the tender, the beading wire projects beyond the end of the side sheet, and is looped around the upper end of the vertical grab rail, which is made from 3/32-in. wire, nickel-bronze for preference. A touch of solder on the top prevents the wire slipping in the loop. The grab rails at the back end may be merely bent over at each end and pushed through clearing holes drilled in the tank side sheets, and soldered. They stand no stress, and are only for appearance sake, anyway!

Steps

The steps can be bent up from 16 gauge sheet steel. Mark out as shown in the illustration, cut to outline, and bend on the dotted lines as indicated. The wider step does for the engine, and the front end of the tender; the narrower one for the rear end of tender, so you will need four of the former—two right-hand and two left—and two of the latter, one for each side. The bottom step is formed by bending up the projecting metal at right angles; and bending up again the little ⅛-in. tags at each end, to protect the enginemen from side-skidding off a greasy step. The upper steps are bent up from odd scraps of 1/16-in. steel, and may either be brazed on, or riveted. The complete steps are attached to the inner faces of the beams by countersunk screws and nuts, the screws passing through the side ribs of the steps, as indicated by the holes shown in the illustration of the side of the finished step.

Engine and Tender Coupling

There is no need to rig up an elaborate coupling between engine and tender. I always specify a simple bit of flat steel held by a couple of commercial split pins. In the present case, the coupling link itself is a piece of ⅛-in. by ⅜-in. flat steel rod, 2⅞-ins. long, with two 3/16-in. holes drilled at 2-ins. centres; and the ends of the link are rounded off. Two pieces of ½-in. by 3/32-in. angle, brass or steel, and 1-in. long, are needed for supporting it; if the size isn't available, bend up two bits of 3/32-in. sheet to make angles, a job of a couple of minutes only, aided by hammer and bench vice. These are attached to the inner side of the beams, level with the bottom of the slots, by two ⅛-in. or 5 B.A. countersunk screws in each, as shown. You can, if you desire, drill clearing holes through both beams and angles, and use nuts instead of tapping the angles.

In the centre of the top of each beam, and ¼-in. from the edge, drill a 5/32-in. clearing hole (say No. 19 drill) and carry on right through the piece of angle as well. Assemble as shown, with two 5/32-in. split pins. Open out one a little, so that the link is retained always in position either on the engine or tender, as you prefer. Leave the other removable, for coupling and uncoupling.

THE drawbar hooks are filed up from ¼-in. by ⅛-in. flat steel, a job that needs no detailing out; don't forget to round off the sharp corners of the hooks, or the coupling-links of the passenger cars may be cut and broken. The end of the stem is rounded off, easily done with a file, and threaded to take a nut. When put through the hole in the beam, after fitting the coupling, put a fairly stiff spring between the beam and the nut and washer on the screwed section, to ease the pull if the engine tries to "snatch at the load."

Screw couplings are easy to make, and attractive adornments. The shackles are made from 3/32-in. steel wire, the ends being filed half-round, bent into loops with a small pair of roundnose pliers, and brazed or silver-soldered. Don't forget to put one shackle through each drawhook before bending the eyes to shape! If the eyes become filled up with silver-solder, don't worry, just put a No. 40 drill through. After silver-soldering and cleaning, bend carefully to shape so that the eyes line up O.K., easily tested with a bit of 3/32-in. wire.

The swivels are turned from 7/32-in. round steel rod, two ¼-in. lengths being needed for each coupling. Chuck in three-jaw, and turn down ⅛-in. length to 3/32-in. diameter, each end. Drill No. 48 holes through the middle of each; leave two as they are, and tap the other two 3/32-in. or 7 B.A. The eyes of the shackles can be sprung over the reduced ends of the swivels, which should be free to turn.

Each screw is made from an inch of 5/32-in. or 3/16-in. round steel. Turn 5/16-in. of one end down to an easy fit in the No. 48 hole in the plain swivel; reverse in chuck, turn down ¼-in. of the other end to 3/32-in. diameter, and screw to suit the tapped swivel. Drill a No. 53 hole in the middle part and tap 9 B.A. Turn up a ball 3/16-in. diameter from brass or steel, drilling and tapping it 9 B.A.; doesn't matter about it being a perfect sphere—you should see some of them in full size! Put a few threads of 9 B.A. pitch on both ends of a bit of 15 gauge spoke wire about ⅝-in. long; screw the ball on one end, screw the other into the centre part of the screw, and put the plain end of the latter through the hole in the plain-drilled shackle, slightly riveting over the end, so that it is free to turn but can't come out. Finally, screw the tapped swivel on to the threaded part as shown, and there is your coupling.

Brake Pipes

These are for appearance only, as no vacuum-brake apparatus is required on a

Screw Coupling

small locomotive intended for "active service," though I am specifying a tender handbrake as the final job. The dummy brake pipes may be made either from ⅛-in. copper tube or wire bent to the shape shown, a little clip made from thin sheet brass, like a plumber's pipe clip, being soldered to the upper part of the stand pipe. The lugs of this are drilled No. 48; and the stand-pipe is attached to the buffer beam, alongside the coupling, on the driver's right hand, by two 9 B.A. screws. The hose is a bit of 5/32-in. rubber tube slipped over the elbow on the standpipe, and has a clip made from a 1/16-in. strip of thin brass, squeezed around the rubber pipe with a small pair of pliers. In the other end is a brass socket drilled No. 40; this is merely a scrap of 7/32-in. brass rod reduced to fit the rubber tube, and parted off to leave about 3/32-in. of full diameter.

The dummy coupling, or "dolly," as enginemen call it, looks like a baby's "dummy," and is turned from 7/32-in. or ¼-in. rod, the part below the flange being filed flat both sides. It is mounted on a little sheet-metal bracket which is secured to the buffer beam by two 1/16-in. or 10 B.A. screws, and on G.W.R. engines is set to one side of the stand-pipe. The socket is slipped over the dolly; and on a full-sized engine, prevents air being drawn in when the hose is not coupled to a carriage.

All that remains are the tender brakes, and a bit of painting up; I left the brakes till last, as they are optional, and the engine works just the same whether fitted or not. They cannot be used for service stops, as the tender is not heavy enough to stop a load of passengers; in full size, the engine pulls the train, but it is the train that stops the engine, brakes being applied to all the carriage wheels. However, the addition of a working tender brake, kind of "finishes the job," and I fit them to my own 3½-in. gauge tenders.

ON the full-sized Great Western engines, a special arrangement of the tender brake rigging is necessary in order to avoid the water scoop and its actuating mechanism. As we have not fitted the scoop, the brake rigging can be simplified, and the reproduced drawings show how this can be done. All we need is a simple arrangement of pull rods and cross beams; no compensating gear is fitted. This is in accordance with full-size practice on many classes of locomotives; it was found that if there was any inequality in brake-block pressure when the blocks or shoes were new, a very few applications rubbed down the shoes so that each one pressed on its particular wheel with a force equal to the others.

Brake Shoes and Hangers

The first items needed will be shoes and hangers. By rights, the shoes should be of cast iron and in the ordinary course of events supplies could be obtained. However, under present conditions, it is difficult enough to get wheels and cylinders cast, let alone tiny items like brake shoes, so they will probably have to be made. This is not a difficult job. First cut six pieces of ¼-in. by ⅝-in. steel bar to a length of 1¼-ins. full. If a milling machine is available, the six pieces can be gripped in a machine vice on the miller table, and run under a 3-ins. diameter side and face cutter, which will take out the radius in a jiffy; that is how I do my own. If no miller is available, they can be done in the lathe, by the following method. Get a piece of thick sheet brass, copper, or steel, not thinner than ⅛-in., and about 4-ins. square. Make a centre-pop approximately in the middle; and from this, scribe a circle 2⅞-ins. diameter with a pair of dividers. Now solder the blanks for the brake shoes, all around the circle, with the ends of one side of each piece just touching the marked line. Drill a couple of ¼-in. holes in the brass plate, clear of the shoes (in the corners will do fine) and bolt it to the faceplate by ¼-in. bolts through the holes, and the faceplate holes or slots. The centre-pop must run truly; and to get it true, run the tailstock up to the faceplate, and adjust the plate until the tailstock centre will enter the pop mark. Then tighten up your clamping bolts; put an ordinary boring tool in the slide rest, and bore the ring of brake shoes until the sides touching the scribed line are scalloped out to 2⅞-ins. radius. Then remove the brass plate from the faceplate, melt off the shoes, and the most important part is done.

I forgot to mention that the small extra radius formed by milling with a 3-ins. cutter, doesn't matter, because it cannot be detected by eye, and makes no difference to the operation of the brake.

At 7/16-in. from the tip of each curved side, drill a No. 43 hole, as shown in the illustration; the shoes can then be filed to shape. A slot, ⅛-in. wide and approximately 5/16-in. deep, is milled, or sawn and filed in the back of each shoe, to accommodate the hanger. I used to cut these by gripping each shoe in a small machine-vice bolted to the boring table of my old 3½-ins. Drummond lathe, and running it under a ⅛-in. slotting cutter mounted on an arbor between centres. I do them now on the milling machine; but they can be done by clamping each one on its side under the slide-rest tool-holder, and traversing across a home-made slotting-cutter held in the three-jaw. I have already described how to make these cutters. The slots could also be formed on a planing or shaping machine, using a ⅛-in. parting tool in the clapper box. Failing any method of machining, it isn't such a difficult job to make a slot in the back of each shoe with two hacksaw blades side by side in the saw-frame, finishing with a key-cutter's warding file, or an ordinary thin flat file.

The hangers are a simple practice job, merely needing to be filed up from 5/16-in. by ⅛-in. strip steel, and drilled as shown in the illustration. Put a hanger in the slot in each brake shoe, and drive a 5/16-in. length of 3/32-in. silver-steel through the lot. The shoes should be fairly stiff on the pins, so that when the brake is off, the shoes should not be able to tilt forward and rub on the wheels all the time.

Hanger Supports

The supports carrying the hangers are turned from ¼-in. round steel rod held in a three-jaw chuck. Face the end, turn down ¼-in. length to ⅛-in. diameter, and screw it either ⅛-in. or 5 B.A.; the thread need not go right to the shoulder. Part off at a bare ⅞-in. from the end. Reverse in chuck, and turn down 11/32-in. length to ⅛-in. diameter, leaving the ¼-in. diameter section 9/32-in. long. Turn down a full 3/16-in. of the end to 3/32-in. diameter, and screw it 3/32-in. or 7 B.A.. Put the larger end of the hanger over the plain part at the 3/32-in. end, and secure with a nut. Put the ⅛-in. end of the hanger support through the hole provided for it near the top of the frame, at 1⅞-ins. behind the wheel. Poke it through from the inside, and put an ordinary commercial nut on the outside; the hanger should be free on the support, and hang down so that the brake shoe is in line with the tread of the wheel. Brake gear fittings are subject to vibration, and small nuts frequently work off and get lost, so the use of spring washers is advised.

Beams and Pull Rods

The lower ends of each pair of hangers are connected across the engine by a brake beam made from ⅛-in. flat steel, the first and second being ½-in. wide, and the third ⅜-in. wide. They are shown in the accompanying drawings. Each one requires a piece of steel strip 4 7/16-ins. long, which is chucked truly in the four-jaw. Face the end and turn it down to ⅛-in. diameter for a full ¼-in. length; then further reduce a full ⅛-in. of the end, to 3/32-in. diameter, screwing it either 3/32-in. or 7 B.A. In the wider ones, drill two No. 30 holes at ¼-in. centres, as shown; in the narrower one, one hole only. The beams can then be filed to shape. Push one end through the hole in the bottom of a hanger, and it will be found that the other hanger can be sprung over the other end easily; ordinary commercial nuts are used to prevent the hangers coming off. In full-size practice, brake gear is usually erected with washers and flat split cotters; but these are a nuisance on a small locomotive due to the difficulty experienced in fitting them.

Six small forks or clevises are needed to connect up the pull rods. They are made from ¼-in. square steel. Saw or part off three pieces about 1½-ins. long; drill a No. 30 cross hole at about 3/16-in. from the ends of each, then slot them as described for valve gear and other forks, by clamping under the slide-rest tool-holder, and running up to a ⅛-in. slotting cutter on a stub spindle held in a three-jaw. Part off a full ⅜-in. behind the hole; chuck in four-jaw, set to run truly, then turn the round boss.

Centre, drill No. 40, and tap ⅛-in. or 5 B.A. Round off the slotted ends as shown.

The pull rods are pieces of ⅛-in. round steel, screwed to suit the bosses of the forks. The first one, between the brake shaft and the first beam, will be approximately 2¾-ins. long; the others, between the first and second, and second and third beams, are approximately 5⅛-ins. long. The actual sizes are easily obtained from the job itself; I always measure rod lengths from the actual engine, the forks being adjusted on the rods until, when the end rod is pulled, all six shoes touch the wheels at the same time. The forks may be attached to the beams either by small bolts, or turned pins, as desired. The bolts may be made from short pieces of ⅛-in. silver steel, turned down to 3/32-in. at each end, screwed 3/32-in. or 7 B.A., and fitted with commercial nuts. The ⅛-in. part of the bolt should be a full ¼-in. long, so that when both nuts are well tightened up, the bolt is free to turn in the fork. All brake gear parts must be quite free; "precision" fits are not only unnecessary but undesirable, as the joints pick up dirt and dust from the line when running, and if too good a fit, they simply jam up and are rendered useless.

THE brake shaft is a piece of ¼-in. round steel rod a bare 5-ins. long. Chuck in three-jaw and face the ends; turn down ⅛-in. length of each end to 3/16-in. diameter. The shaft carries two arms, one for actuating the pull rods, and the other to connect with the vertical brake spindle. The drop arm is made from a piece of ⅛-in. by ⅜-in. flat steel, filed to the pear shape shown in the drawing. The upper hole is reamed to a tight fit on the shaft; the lower one is drilled No. 30. The arm is driven on the shaft, and located exactly in the middle.

The forked arm is made from a piece of ⅜-in. square steel 1¼-ins. long. Scribe a line down the centre of one side, and make two centre pops on it, ¾-in. apart; drill them out with No. 40 drill. Slot out the ¼-in. jaw as previously described, then file the holes through each side of it, into oval slots as shown. File or mill the shank to a thickness of 3/16-in., and round off the jaws to the profile given; finally, drill out the shank end with letter C or 15/64-in. drill, and ream to a tight fit on the brake shaft, rounding off the end as illustrated. The shank end is driven on to the brake shaft at 2-ins. from centre (see plan of complete assembly) and set at right angles to the drop arm, the average workman's "eye setting" being sufficiently accurate. Both arms are then brazed to the shaft by the method adopted for other arm-and-spindle jobs previously described. May I remind beginners that steel jobs should never be quenched in acid pickle after brazing; use water only. Any traces of burnt flux can be scraped off and the shaft and arms nicely cleaned up with emerycloth.

The bearings are made in a manner somewhat similar to glands. Chuck a bit of 7/16-in. hexagon brass rod in three-jaw; face the end, centre, and drill down about ½-in. depth with No. 11 drill. Turn down ¼-in. of the outside to ⅜-in. diameter, and screw ⅜-in. by 32. Part off to leave a head ⅛-in. wide; reverse in chuck, and chamfer the corners of the hexagon.

Brake Spindle and Column

The brake spindle is a piece of ⅛-in. round silver-steel (or rustless steel, if you have any), 6⅝-ins. long. One end of it is screwed ⅛-in. or 5 B.A. for ¾-in. length; the other end is furnished with a small boss and a cross handle, exactly the same as the upper end of the spindle of the injector water valve, the boss being made from ¼-in round steel, and brazed or silver-soldered on. Two collars are also made from ¼-in. round steel; simply chuck in three-jaw, face, centre, drill No. 32 for about ½-in. depth, turn about ½-in. length to 7/32-in. diameter, and part off two slices a little over ⅛-in. thick. Drive one of these on to the brake spindle, to approximately 1½-ins. below the handle, and take care not to damage the threads at the bottom.

The brake column is turned from a piece of 7/16-in. hexagon brass rod held in the three-jaw. Face the end, centre, and drill down with a No. 30 drill to the full depth of the drill flutes, withdrawing the drill several times to clear the flutes from chippings. Now turn down 1⅞-in. of the outside, to 7/32-in. diameter; if you run the lathe at a good speed, and take three or four light cuts with a roundnose tool, you should get a nicely - finished column. If you like, you can set over the top slide and turn the column to a taper, 7/32-in. diameter at the top, and about 5/16-in. at the bottom; some locomotives have tapered brake columns. Part off at 2-ins. from the end; reverse in chuck, turn down ⅜-in. of the end to 5/16-in. diameter, and screw 5/16-in. by 32. If the No. 30 drill hasn't come through, and there is no hole showing, centre, and put the No. 30 drill in until it meets the other hole. Make a 5/16-in. by 32 nut from a bit of 7/16-in. hexagon brass, to fit the part just screwed.

Put the spindle through the column as shown in the sectional illustration, and drive on the other collar, so that it is 2⅜-ins. from the screwed end; then bring the other collar down on the upper end of the column, adjusting it so that the spindle can turn freely in the column, but cannot move up and down. Drill No. 55 holes through collars and spindle, and drive in small pins made from steel wire. If a bit of 1/16-in. silver-steel is held in the three-jaw, the lathe run at its highest speed, and a fine file applied to the steel, same can be filed in a few seconds to a nice drive fit in the 55 holes. It isn't advisable to use larger pins, as even a 1/16-in. hole would unduly weaken the spindle.

Brake Nut

This is an "artful dodger." Chuck a bit of ¼-in. round bronze rod in the three-jaw; use good quality metal. Face, centre, and drill down about ⅜-in. with No. 48 drill; part off at a full ¼-in. from the end. Chuck the piece again, and tap it 3/32-in. or 7 B.A., working the tap right through very carefully. Now follow carefully: drill a No. 40 cross-hole cutting clean through the tapped hole. Cut two short pieces of 3/32-in. round silver-steel, square off one end of each, and put ⅛-in. of thread on it; this is best done in the lathe, with the rod in the chuck, and the die in the tailstock holder, the thread matching that in the embryo nut. Now put the nut between the jaws of the forked arm on the brake shaft (see plan of brake gear assembled) and screw the pieces of silver steel into it, through the oval holes at each side of the jaws, until they meet in the middle. Cut off the superfluous bits of steel, and trim the ends with a file, so that they just show clear of the oval holes in the jaws. Now put the 40 drill through the cross-hole in the nut, drilling away the bits of the side pins projecting into the hole, and tap the latter ⅛-in. or 5 B.A., to match the bottom end of the brake spindle. This dodge effectively prevents the pins coming out and getting lost on the road, because when the brake spindle is screwed through the nut, it is impossible for the pins to turn.

Assembly and Erection

The brake shaft is erected first. At $1^{11}/_{16}$-in. ahead of the centre of the leading wheels, and ¼-in. above the bottom of the frame, make a centre pop each side, and drill them out with a No. 30 drill. Put a straight piece of ⅛-in. silver-steel through them both, to see if both holes are O.K. for position; if they are, the silver-steel will be at right angles to both frames, and will lie level. If it isn't, the holes can be corrected with a rat-tail file. When they are correct, open out with letter R or $^{11}/_{32}$-in. drill, and tap ⅜-in. by 32.

Now put the brake shaft in position, with the centre arm hanging down, and the forked arm to the right of the engine (see plan of assembled gear), the journals on the ends of the brake shaft going through the tapped holes. Owing to these being much larger than the journals, it will be easy enough to get the shaft in position. Then screw a bearing in at each side, over the journals and into the tapped holes in the frames, as shown in the plan. When the bearings are right home, the shaft should be quite free to turn, and have just a small amount of end play. The short pull rod can then be connected to the drop arm and the leading beam; the fork on the latter must be horizontal, and as the pull rod is slightly inclined, a very slight bend just beyond the fork will be called for. When all the brake shoes are touching the wheels, the forked arm should be inclining just a little.

The last job is to mount the brake spindle and column, and that is only the work of minutes. On the soleplate at the front end of the tender, mark a spot 2-ins. to the right of the centre-line (that will be to your left, if you are looking at the front end of the tender) and ¾-in. ahead of the vertical centre-line of the brake shaft. If the soleplate overhangs the drag beam by $^{1}/_{16}$-in., this point will come ¾-in. from the front edge of the soleplate. Drill a No. 30 hole at the marked place, and drop a piece of ⅛-in. silver-steel through it for a test: when the steel is vertical, it should line up with the tapped hole in the brake nut. If it doesn't, file the hole to correct its position, as mentioned above. When O.K., poke a ⅜-in. clearing drill (letter W or $^{25}/_{64}$-in.) through; file off any burrs, insert the brake spindle and put the ⅜-in. by 32 nut over the bottom end. Then screw the end of the spindle through the brake nut until the screwed part of the column enters the hole in the soleplate, and seats home. Screw the nut on the projecting threads of the column under the drag beam, and the job is complete. Turning the handle clockwise applies the brake; turning in the opposite direction releases it. No pull-off springs are needed, because the brake spindle cannot move up and down in the column, so is able to pull on or push off according to direction of rotation.

Final Notes

That ends the actual job of building the G.W.R. "1,000" class engine. If anyone wishes to "doll it up," to resemble its full-sized sisters in all details, the easiest way is to visit a station where they are frequently to be seen, and also obtain a photo or two. The Locomotive Publishing Co., of 88 Horseferry Road, Westminster, S.W.1, could supply pictures. Personally, I never decorate any engine intended for real hard work with a number of (to it) superfluous accessories; but other people may have different ideas, and I would not decry such decorative work. The only thing I do emphasise, however, is the fault of spending much time and energy on outside show and neglecting the working parts. Full-size locomotives are built to work, and a little one should be built with the same object in view; not as a useless ornament. I practise what I preach, and I have a fleet of engines. Although their personal appearances wouldn't gain a prize in a beauty show, they can all "do their stuff" on my little railway in no uncertain manner. Only a few evenings ago, time of writing, 26-year-old "Ayesha," the 2½-ins. gauge "Atlantic" which is the respected patriarch of every little coal-fired passenger-hauling engine working at the present time, was steaming merrily around with three adult passengers, despite her years and condition!

Two or three realistic refinements could easily be added to your engine without going to extremes. Footboards for the engine cab and the front of the tender could easily be cut from thin wood, such as is used for cigar boxes, or three-ply would do. Pieces of angle could be screwed to the underside, to raise them to "working" height; note the front end of the general arrangement of the tender, which indicates this.

THE END

Items stocked for 1000 class:-

Drawings set RV2 (12 sheets)	8/044
Frame steel	8/045
Buffer beam steel	8/046
Hornblocks (hot pressed)	8/047
Axleboxes (main)	8/048
Frame stays	8/049
Driving/coupled wheels	8/050
Cylinder castings set(piston valve)	8/051
Piston blanks	8/053
Guide bar brackets	8/054
Crossheads	8/055
Crosshead pump	8/056
Eccentric straps	8/057
Pendulum shaft brackets	8/058
Reverser box stand	8/059
Bogie bolster	8/060
Bogie centre	8/061
Bogie horns	8/062
Bogie axleboxes	8/063
Bogie spring pockets	8/064
Bogie wheels	8/065
Buffer heads & plainstocks	8/066
Saddle	8/067
Smokebox door & ring	8/068
Chimney	8/069
Petticote pipe	8/070
Safety valve cover	8/071
Tender frame steel	8/072
Tender buffer beam steel	8/073
Tender horns & cast springs	8/074
Tender axleboxes	8/075
Tender wheels	8/076
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Cylinder castings set(slide valve)	8/079

To special order:
Boiler flanged plates
All-copper boiler materials set including flanged plates & barrel mtl in flat.
Rolled taper barrel with castellated seam.
Rolled brass smokebox tube with silver-soldered seam.

Photo etched name & numberplate sets etched on 1.6mm brass sheet. Set includes all plates on prototype loco in both GWR and BR periods. To special order and delivery only.

No.	Name.
1000	County of Middlesex
1004	County of Somerset
1005	County of Devon
1006	County of Cornwall
1009	County of Carmarthen
1010	County of Caernarvon
1012	County of Denbigh
1015	County of Gloucester
1019	County of Merioneth
1020	County of Monmouth
1021	County of Montgomery
1022	County of Northampton
1027	County of Stafford.
1028	County of Warwick.
1029	County of Worcester.

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

NOTE:
The copy pages from which the "paste-up" for this book were taken from volumes of "Mechancis" which proved impossible to put flat down onto the photo-copier. We apologise for edge distortion in various sections, but hope that all the words are readable.
