VIRGINIA

This week L.B.S.C. begins instructions for building the tender of this old time American locomotive.

Now that the little reminder of days gone by has reached the stage at which she can run, most builders will be anxious to reap some of the reward that sweetens labour; they certainly will if they are anything like your humble servant! To enable this to be done, I thought it would be as well if I described how to build the tender before giving details of the trimmings, such as bell, headlight, boiler cleading and bands, which can be added at any convenient time.

The tenders of most of Virginia’s full-size relations were weird and wonderful boxes of tricks. Though a few of them ran on six wheels, following British practice, the vast majority were furnished with two four wheeled trucks, with built-up bar frames, disc wheels made from chilled cast-iron, with no separate tyres. And equalized springing.

The main frames were built up either from channel-section girders, or bars of rectangular section, with no separate beams, the side members being rounded at the corners and joined to two separate stiffening girders which ran down the middle of the frame, and to which the drawgear was bolted. Instead of a soleplate, the top of the frame was, covered with wooden planks, like the floor of a room, placed transversely and attached to the frame girders.

The tender body was entirely separate and was erected “on the floor.” The tender body followed contemporary British practice, inasmuch as it had straight sides with a flared coping at the top and rounded rear ends. The front ends were also rounded, and the coal was carried in a recess between them. This recess extended about halfway into the tender tank and was wider at the front than at the back.

Needed stamina
The fireman had the backbreaking job of shoveling all the coal from floor-level. This might not seem a very arduous job but when you consider that this involved lifting several tons of black diamonds to a height of three or four feet and throwing them into the firebox during a single journey, on an engine that was anything but a steady rider, it will be realised that the fireman needed both physical strength and good stamina.

However, nobody in those days seemed afraid of a spot of hard work! The toolbox was usually placed at the back of the tank, over the drawbar, as on many British engines. The brake gear was at first operated by hand, and the blocks were placed between the wheels, the beams being of wood. A compensating device was fitted and the pull-rods were connected to a vertical brake-shaft on the fireman’s side of the tender; this had a cross-handle with both ends turned up like a cow’s horns and a ratchet gear underneath like that used on the brake shafts of street tramway-cars.

This also provided the unfortunate “tallowpot” with additional exercise, until the advent of the Westinghouse automatic air brake. When watertroughs, or track-panst as they are called in America, came into vogue the tenders were fitted with waterscoops and the internal pipe was turned over at its upper end to discharge downwards.
The tanks were long and shallow and were well stayed with sheet-metal stays, which also acted as anti-surge plates.

**The 3-1/2in. gauge tender**

In designing the tender for the 3-1/2 in. gauge locomotive I tried-as with the engine-to simplify matters for ease of construction, while keeping the outward appearance as correct as possible.

The main frame is made from two pieces of flat steel, the ends being bent around to form one sill and half the beam, the two being joined by a plate which carries the drawgear. No central members are needed. The truck bolsters are made from two wider strips of steel, bent to shape, riveted to the side sills and furnished with pins on which the trucks are mounted, a circular rubbing-plate being fitted between the bolster and the truck frame.

The trucks themselves can either be cast or built up. If the latter, the pieces are very simple to make and can be temporarily pinned or screwed together, the whole assembly being afterwards brazed at a single heating. The springing is precisely the same as on the engine truck.

The wooden floor is dispensed with and a metal soleplate substituted, to which the tender body is attached; and as the soleplate is fixed to the frame by angles and screws. Removal of the screws, which are accessible at the sides of the frame, allows the whole tender body to be instantly taken off the frame if this should be required. Accidents happen even on small railroads!

The sides and the coal recess can be bent up from a single sheet of brass, if a piece long enough is available the joint being made at the back of the recess; otherwise it can be made in two pieces with the second joint in the middle of the tender back. This allows for the rounded ends both front and back. The top can be made from one single sheet and the coping can be made from a strip attached to it. The big rectangular casing which houses the upper end of the pipe from the water-scoop on the full-size article comes in just right for a filler, as it is big enough to allow the handle of our emergency hand pump to be operated through it for the full stroke.

The detachable handle can be carried in the toolbox at the back, nice and handy when somebody lets both fire and water down and there isn’t enough steam to operate the injector. The fittings inside the tank are to the usual L.B.S.C. standards.

**Frame construction**

Two pieces of soft mild steel, 1/2 in. wide, 1/8 in. thick, and approximately 22-1/2 in. long, are required for the frame. These are bent around at each end to form right angles with a 9/16 in. radius, as shown in the plan drawing, so that the overall length is 16-3/4 in.

The easiest way to do this is to put a piece of 1/2 in. round bar in the bench vice, with about 1-1/2 in. projecting from the side of the jaws. Mark the piece of steel, then put a piece of gas pipe or something similar, over the end of the steel to give extra leverage. Place the steel with the marked spot on the bar in the vice jaws, then a good hearty press down on both ends will form the desired bend.

Although the piece of bar is 1/2 in. dia. the slight spring in the strip will form the bend to the given radius. Before I had a bending machine I made all my bends in the above manner and had no
Anybody of average strength will find the bending easy.

Check off the ends with a trysquare to make certain that they are exactly at right angles with the sides, then lay them on the bench with the ends touching and measure across from side to side. Note how much needs taking off the ends to bring the sides 5-1/8 in. apart and reduce them.

Now cut two pieces of 3/32-in. steel to 3/4-in. width, one 1-1/4 in. long and the other 1-3/4 in. Round off the edges of the longer one as shown. The semicircular sockets for the coupling-pins can easily be milled up from a piece of 7/16in. x 3/8in. steel bar, about 2-1/4in. long; 7/16 in. square will do at a pinch.

Mill a groove in this, 3/16 in. wide and 5/16 in. deep.

If a regular miller is available it is only a few minutes work with the steel in the machine-vice on the table and a 3/16-in.-slotting cutter on the arbor. It can be done in the lathe with a similar cutter on an arbor between centres and the steel in a machine-vice (regular or improvised) on the saddle, setting the steel in the vice at such a height that the full depth is taken out at one cut.

Any Myford or similar lathe will do this quite well with the backgear in and plenty of cutting oil applied by drip-can or brush. Feed very slowly with the cross-slide handle. Alternatively, clamp the piece of metal under the slide-rest tool-holder and end mill the groove, as I have described for other similar jobs.

After the groove is formed cut the piece in half and round off the grooved side to the shape shown in plan. Next cut away the metal at the bottom of the groove for about 1/2-in. width to clear the end of the drawbar or coupling-link when coupled up; this can be done by drilling and filing. Then drill the hole for the pin.

Finally drill a No 41 hole at each side of the clearance and rivet the socket to the plate in the position shown. The front one is fitted level with the bottom of the plate to line up with the drawbar or link on the engine; the back one is fitted in the middle of the plate to bring the slot to the correct height to couple on to a passenger car.

**Against-the-clock method**

Put the two halves of the frame together on the bench (which must be level), clamp the coupler assemblies at each end over the joints, drill No 41 holes through plates and frames and rivet up with 3/32 in. charcoal-iron rivets. To make the job extra strong, I advise brazing or silver-soldering the lot; and if this is done only 1/16 in. rivets need be used to hold the parts together.

Incidentally, as I’m always running against the clock, I shall make both my sockets from a 3/8 in. slice parted off a 1-1/8 in. offcut of steel shafting, milling a groove 5/16 in. deep and 3/8in. wide on opposite sides of it. This will be sawn across the middle, the sawn parts run under a 1/2-in. cutter on the miller to true them up and the clearances at the bottom of the groove formed with a Woodruff key-seat cutter. Drill the pinholes, and there we are!

**Truck bolsters**

The truck bolsters may be cast, or bent up from 1-1/4 in. x 1/8-in. steel. If they are cast, the pin for attachment of the truck and the rubbing plate will be cast integral, and there should also be a chucking-piece cast on opposite the pin. If this is held in the three-jaw the pin can be turned and
screwed and the contact surface faced off at the same setting. All that then remains will be to smooth off both ends with a file, set the bolsters between the frames at the positions indicated and rivet up.

For the bent-up bolsters, two pieces of steel, of section as mentioned above, and 6-1/4 in. long, will be required. Mark off the centre and at 1 in. each side of it make a slight bend to the angle shown in the cross-section. Place this across the frame and mark off where the vertical bends will have to be made to bring the overall width to 5-1/8in. which is the correct distance between the sides of the frame.

The bends can be made in the bench vice. Should the steel be hard, make it red hot at the bends, otherwise it will crack on the outside of them. Check for correct width then set each bolster in position shown and make sure that the bottom is exactly 9/16 in. below the bottom of the frame. Fix temporarily in position with toolmakers cramps then drill three No 41 holes through frame and bolster and rivet up. File off any of the bolster side, which projects above the top edge of the frame.

On the centre line of the bolster, and exactly midway between the sides of frame, drill a 1/4 in. clearing hole. For the pins, chuck a piece of 3/8 in. round mild steel in the three-jaw, face the end, and turn down 1/4in. length to 1/4 in. dia. and screw 1/4 in. x 40. Part off at 13/16in. from the shoulder, reverse in chuck and turn down the other end to 1/4 in. dia. sufficient to leave 13/32 in. length the full 3/8 in. dia.

**Test for accuracy**
Screw 1/4 in. x 40. Put this end through the hole in the bolster and secure with a nut made from 3/8-in. hexagon rod; either steel or brass will do. The complete frame assembly should then be laid on something flat and true, such as the lathe bed, to test it for accuracy. If both sides do not touch the flat surface for their full length, carefully twist the frame until they do; a little careful manipulation will do the trick.

Warning to beginners-when setting the bolsters in the frame do not get mixed as to which is front and back of the frame. The front is the end with the low coupler socket and the centre line of the bolster should be 4-1/2in. behind this. The other one is set only 4-1/2in. from the back end, the distance between the truck pins being 8 in. Not that it matters a great deal if they are reversed, but we might as well have things right!

**Soleplate**
The soleplate on which the tender body is mounted can be cut from a piece of hard-rolled sheet brass of 16-gauge, 6-3/4 in. wide and 16-7/8 in. long after the ends have been cut square. The back corners should be rounded off with a file to 3/4-in. radius. Nick a piece 5/8 in. square-out of each front corner and then file the resulting double corners to similar radii, as shown in the plan of the tender body.

Lay the finished soleplate on the bench and put the frame on top of it, upside down-naturally!-adjusting same until the soleplate projects an even distance all around the frame. Hold it there firmly and then run your scriber all around the inside of the frame, making a deep scratch on the soleplate. Now remove the frame and at the places indicated on the frame drawing by dotted lines rivet four pieces of 3/8in. x 3/32 in. angle. Either commercial brass angle can be used, or the pieces can be bent up from sheet brass of 13-gauge in the bench vice.
Making it watertight
Two similar pieces can also be riveted on, midway between the others. They should all be set close to the scribed line indicating the frame outline; and after riveting, sweat them over with solder so that no water can leak through from the tank.

After the tender body is mounted on the soleplate and the whole bag of tricks erected on the frame these angles will project down inside the frame and will be attached to it by two 3/32 in. or 3/48 in. screws passing through clearing holes in the frame into tapped holes in the angle. Removal of the screws will allow the complete tender body to be lifted off the frame if required.

While the principle of the tender trucks for Virginia is the same as that of the engine truck, the frames are outside the wheels, and this calls for a different method of construction. It would be sheer waste of labour and material to cut the top frame-bars and centre-piece from a single plate, so separate components are used and the complete assembly brazed at the joints.

It is possible that castings comprising centre section, rubbing plate, top bars, and pedestals all cast integral, may be available from our advertisers, and the use of these would save a lot of work. The castings would only need cleaning up with a file, the pedestal jaws truing up, and the rubbing-plate facing off and drilling; operations which do not need any detailing out.

The top frame bars on a built-up truck will need two pieces of 1/4 in. x 3/16 in. mild steel, squared off at the ends to a length of 5-1/4 in. The centre piece is a 4-1/2 in. length of 1-5/8 in. x 3/16 in. mild steel; this must also be dead square at the ends. If a milling machine is not available it can be held truly in the four-jaw chuck and the ends faced off with a round nose tool set crosswise in the rest.

Simple method
Drill a 1/2 in. hole exactly in the middle. To hold it in position For brazing to the frame bars use two 1/16 in. or 1/72 screws put through clearing holes in the thickness of the frame bars (No 51 drill) into tapped holes in the ends of the centre-piece, about 1 in. apart.

If the pedestals are cut from 3/8in. x 1/4in. mild steel, no machining will be required on the sliding faces. Eight will be needed for each truck and all must be exactly the same length. Tip for beginners who want to do the job quickly and accurately; chuck a length of above section steel in the four-jaw and set to run truly. No need for absolutely accurate setting; approximate is good enough.

Put a piece of round rod, any convenient size, in the tailstock chuck and run it up until it touches the end of the rod in the four-jaw. Set your parting-tool to part off carefully a 7/8 in. length, setting the tool at such a height in the tool-holder that it parts off without leaving a pip.

Slack jaws 1 and 2 of the four-jaw chuck, pull out of the bar until it touches the stop in the tailstock chuck, tighten jaws, part off, and repeat operation until you have 16 pieces. They should all be the same length with nicely squared ends if neither the rod in the tailstock chuck, nor the slide-rest, have been moved during the operation.

Spacing inner pedestals
Drill a No 51 hole in the frame bar directly above the location of each pedestal then clamp a pedestal at the end with a toolmakers clamp, lining it up with the end of the top bar and keeping it flush with the sides. Run the 51 drill through the hole in the bar, making a countersink on the top of pedestal, remove, drill the countersink with a No 55 drill for about 1/4in. depth, and tap 1/16 in. or 1/72.

Replace the pedestal and fix with a steel screw. When attaching the inner pedestals put a piece of bar 1/2 in. wide between inner and outer, as a spacer, and clamp the lot together while running the drill through the hole in the frame; this will ensure correct spacing.

Cover all the joints between frame bars, pedestals, and centre-piece with wet flux, lay the assembly on its back on some small coke in the brazing pan, heat the lot to bright red, and apply a piece of thin soft brass wire or easy running brazing strip to each joint. If the heat is sufficient the brazing material will melt and penetrate right through the joint. Run a fillet between centre-piece and frame bar at each corner. Let it cool to black, quench in water, clean up, and file off all the screw heads.

The combined pedestal-tie and staybar is a 5 in. length of 1/4 in. x 3/32 in. mild steel. Drill four No 41 holes at the spacing shown in the underside view, then clamp the piece of strip steel temporarily in place, locate the screw holes through those in the strip, mark the strip so that it can be replaced the same way, drill the marked places on the bottoms of the pedestals with No 48 drill, tap 3/32 in. or 3/48 and attach tie-bars with screws to suit.

Chuck a piece of 1-1/4 in. round bar - bronze or gunmetal for preference, but brass will do if nothing better is available-face the end, centre, drill to 3/8in. depth with 23/64in. drill, turn down 3/16 in. length to a press fit in the hole in the middle of the centre piece and part off at a bare 1/8 in. from the shoulder. Reverse in chuck, gripping by the spigot, face off the disc to 3/32in. thickness, and put a 3/8 in. parallel reamer through the hole. Press the spigot into the hole in the centre piece.

AXLEBOXES AND SPRINGING
The axleboxes may be made from drawn bronze or gunmetal bar of 3/4 in. x 9/16 in. section, or nearest larger, or from castings. If the latter, they will be cast in a stick, with the fancy fronts (representing the lids of the full-sized boxes) cast on. The sides of either the drawn bar or he cast sticks are milled off in exactly the same way as those described for the engine truck, so repetition is unnecessary. The lengths can be either parted off in the four-jaw, or sawn off, and the ends faced in the chuck to 5/8 in. length. The boxes should be an easy sliding fit between the pedestals, but not slack.

Drill a 1/4-in. hole 7/16-in. deep in the back of each box. If a drilling machine is not available, chuck the boxes truly in the four-jaw and centre and drill with the tailstock in the usual way, as the holes must be perfectly square with the back and sides. It will be noticed that only one flange is shown, and that is on the inside of truck frame; this is to allow the boxes free movement to tilt on an uneven track,

Drill a 1/16-in. oiling hole in the front of each box near the top, sloping down to the journal hole. If the fancy fronts are fitted, this can be just below the dummy hinges. Personally I shouldn’t bother about the dummy lids, but should just bevel off the edges of the boxes where they project beyond the pedestals.
I have done this with British pattern tender axle boxes, and they look quite all right. However, some folk worry ‘more about a little detail like that than they do about the efficiency of the engine—there is no accounting for tastes!

The arrangement of equalizers and springs is precisely the same as on the engine truck, the equalizers being cut from 16-gauge steel to the dimensions shown in the drawing. The same applies to the hangers, which are attached to the equalizers by 1/16-in. iron rivets. Dummy cast springs are drilled 1/4 in. in the hoop to take a spiral spring, which bears against the underside of the frame bar, when the springs are erected.

The springs are fixed in the inverted position shown between the hangers either by long 1/16-in. rivets through the bottoms of the hangers and the holes in the ends of the springs, or by bolts made from 1/16 in. silver steel, screwed and nutted at each end, according to the desire of the builder of the locomotive.

Should anybody wish to fit working leaf springs, proceed exactly as described for the engine truck as the spring sizes are the same for both engine and tender trucks and they are erected in the same way.

WHEELS AND AXLES
The wheels are of the disc pattern, spokeless, and are 2 in. dia. on thread with 1/8in. flanges, and the bosses are drilled 19/64in. and reamed 5/16 in. Again, there is no need to repeat the instructions for turning them.

The axles can be turned from 5-1/4in. lengths of 3/8 in. round steel (silver steel or drill-rod are most durable) which can be held in the three-jaw chuck, and both journal and wheel seat turned at the same setting so that it doesn’t matter if the chuck is a wee bit out of truth as the wheel seat must of necessity be true with the journal. Both wheels can be pressed on to each axle right away.

How the trucks are erected
Assembly and erection is very easily done. To assemble a truck, lay the frame upside-down on the bench and take off the tie-bars. Wind up four spiral springs exactly as described for the engine truck. Put one in the hole in the spring hoop, and insert the assembly of spring and equalisers between the pedestals, the ends of the equalisers going over the outsides of the framebars and pedestals, and the spring bearing on the frame bar.

Put an axlebox on each end of the axle and carefully fit the axleboxes to the pedestal jaws. If the boxes are made to instructions, and the jaws are correctly spaced, the boxes should be interchangeable. Note if the boxes bear evenly on the ends of the equalisers, and if O.K. all that remains is to replace the tie-bars and screws.

A rubbing-plate is needed between the bushing in the top of the centrepiece and the bottom of a truck bolster bent up from l-1/4in. x 1/8in. steel. This is merely a disc of brass 3/32-in. thick, 1-1/4 in. dia. with a 3/8 in. clearing hole in the middle. It may be cut from sheet or parted off from a piece of the same kind of bar used for the bushing.

Put it over the pin in the bolster, put on the truck, and secure it with a steel washer and a nut made
from 3/8 in. hexagon steel. The truck should swivel quite freely on the pin, with about 1/32 in.
clearance between the bottom of bushing, and the retaining washer. To prevent the nut slacking off
when the engine runs at a high speed over a rough track (and she will be able to do just that, as you
will see) drill a No 50 hole right through nut and screwed end of pin and put a 1/16 in. split-pin in
it. That will do the trick.

Now, if the tender chassis is tried on the track, it should run quite freely. Try it with some weights
on the soleplate and note if the springs and equalisers function all right before fitting the body and
tank.

Variations for casting-built trucks
If a small boss is cast on the underside of a cast truck frame,. on the opposite side to the bearing face
which takes the place of the turned centre flange on the built-up truck, it could be held in the
three-jaw and the flange faced off and drilled for the 3/8 in. pin at the same setting to Otherwise,.
the frame would have be held m the four-jaw for this operation. The axleboxes, equalisers and
springs are made and fitted exactly as described for a built-up truck and a similar tie-bar is fitted at
the bottom of the cast-on pedestals at each side.

Regarding cast truck bolsters, I have included here a drawing of one of suitable pattern. The main
part of it looks something like a river punt, and no rubbing-plate is needed between the underside
and the centre of the truck, as a substitute for it is cast integral, below which is a boss which is
turned and screwed to serve as the centre-pin.

Again, if a chucking-piece is cast on the inside of the “punt,” opposite to the above-mentioned
excrescences, this could be gripped in the three-jaw and the facing, turning, and screwing done at
the one setting. Otherwise, the casting would have to be chucked in the four-jaw with the boss for
the pin running” truly. The assembly and erection of the whole bag of tricks is carried out in the
same way as just described for the built-up arrangement.

While this serial has been running I have received some letters asking if the locomotive could be
built to halfsize to haul a train of old-fashioned wooden cars on a “scenic” line, as a pleasing
variation to the usual-type of British locomotive used for this purpose. Also some of our American
friends want to build a bigger edition to run on a 4-3/4in. gauge track, and they are asking about
the boiler. Virginia could easily be adapted to any size within reason, taking the 3-1/2in. gauge
dimensions as a basis, and varying the details to suit the size of the required engine.

For 1-3/4in. gauge, the principal dimensions should be halved, as near as possible, but the distance
over outside of frames should be 1-7/16 in. and the distance between the backs of the wheels 1-9/16
in. The wheels themselves should be 1/4 in. wide on the treads, with 3/32 in. flanges about 3/64 in.

If sprung coupled axles are desired, underhung spiral springs should be used, one under each
axlebox. Cylinders should be 9/16 in. bore and 3/4 in. stroke, with loose-eccentric gear set to cut-off
at about 60 per cent. A simple displacement lubricator would serve.

The boiler could be of the simple water-tube type, fired by a spiritlamp or one of my small
oil-burners. The outer casing should be half the size of the 3-1/2in. boiler; made from 20-gauge
steel with a lining of 1/16 in. asbestos millboard around the firebox wrapper. The inside barrel
could be made from 1-1/4 in. seamless copper tube about 22-gauge, not thicker than 20-gauge, with 16-gauge ends and backhead and two 5/32 in. watertubes, all joints being silver soldered.

No pump under the boiler would be needed, water being supplied by a hand-pump in the tender. The amount of water in the boiler would last quite a while on a non-stop run with a normal train, and it could be replenished in a matter of a ‘minute or so while the train stopped at a station. With cylinders of the size mentioned, even-fired with a spirit lamp the baby Virginia would have no difficulty in making enough steam to haul quite a big kiddy.

With an oil-burner, it would pull an average adult; a 2-6-0 with similar size cylinders and wheels, which I built as a present for a friend now, alas in the land beyond Jordan, hauled my weight around my own little railway for over 20 min. nonstop, and would have kept going indefinitely if the tender had held enough water.

I kept up the level by operating the hand-pump every time she started to blow off at 80 lb. Anybody who wishes to build a half-size American tea-kettle can follow the general construction of any of the similar size jobs I have described, such as the Dot (half-sized Doris) and so on.

An enlargement to 4-3/4 in. gauge is a different sort of proposition. While the general dimensions can be increased in the proportion of 4 to 3 certain details like the cross-sections of the motion rods, valve gear, etc., can be made more proportionate to those of a full-size locomotive.

The boiler, too, would need a separate design for this size, as it would be no good just to use the same number of tubes, but of larger diameter, to cite just one variation.
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It is possible that castings comprising centre section, rubbing plate, top bars, and pedestals all cast integral, may be available from our advertisers, and the use of these would save a lot of work. The castings would only need cleaning up with a file, the pedestal jaws truing up, and the rubbing-plate facing off and drilling; operations which do not need any detailing out.

The top frame bars on a built-up truck will need two pieces of 1/4 in. x 3/16 in. mild steel, squared off at the ends to a length of 5-1/4 in. The centre piece is a 4-1/2 in. length of 1-5/8 in. x 3/16 in. mild steel; this must also be dead square at the ends. If a milling machine is not available it can be held truly in the four-jaw chuck and the ends faced off with a round nose tool set crosswise in the rest.

**Simple method**

Drill a 1/2 in. hole exactly in the middle. To hold it in position For brazing to the frame bars use two 1/16 in. or 1/72 screws put through clearing holes in the thickness of the frame bars (No 51 drill) into tapped holes in the ends of the centre-piece, about 1 in. apart.

If the pedestals are cut from 3/8in. x 1/4in. mild steel, no machining will be required on the sliding faces. Eight will be needed for each truck and all must be exactly the same length. Tip for beginners who want to do the job quickly and accurately; chuck a length of above section steel in the four-jaw and set to run truly. No need for absolutely accurate setting; approximate is good enough.

Put a piece of round rod, any convenient size, in the tailstock chuck and run it up until it touches the end of the rod in the four-jaw. Set your parting-tool to part off carefully a 7/8 in. length, setting the tool at such a height in the tool-holder that it parts off without leaving a pip.

Slack jaws 1 and 2 of the four-jaw chuck, pull out of the bar until it touches the stop in the tailstock chuck, tighten jaws, part off, and repeat operation until you have 16 pieces. They should all be the same length with nicely squared ends if neither the rod in the tailstock chuck, nor the slide-rest, have been moved during the operation.

**Spacing inner pedestals**

Drill a No 51 hole in the frame bar directly above the location of each pedestal then clamp a pedestal at the end with a toolmakers clamp, lining it up with the end of the top
bar and keeping it flush with the sides. Run the 51 drill through the hole in the bar, making a countersink on the top of pedestal, remove, drill the countersink with a No 55 drill for about 1/4 in. depth, and tap 1/16 in. or 1/72.

Replace the pedestal and fix with a steel screw. When attaching the inner pedestals put a piece of bar 1/2 in. wide between inner and outer, as a spacer, and clamp the lot together while running the drill through the hole in the frame; this will ensure correct spacing.

Cover all the joints between frame bars, pedestals, and centre-piece with wet flux, lay the assembly on its back on some small coke in the brazing pan, heat the lot to bright red, and apply a piece of thin soft brass wire or easy running brazing strip to each joint. If the heat is sufficient the brazing material will melt and penetrate right through the joint. Run a fillet between centre-piece and frame bar at each corner. Let it cool to black, quench in water, clean up, and file off all the screw heads.

The combined pedestal-tie and staybar is a 5 in. length of 1/4 in. x 3/32 in. mild steel. Drill four No 41 holes at the spacing shown in the underside view, then clamp the piece of strip steel temporarily in place, locate the screw holes through those in the strip, mark the strip so that it can be replaced the same way, drill the marked places on the bottoms of the pedestals with No 48 drill, tap 3/32 in. or 3/48 and attach tie-bars with screws to suit.

Chuck a piece of 1-1/4 in. round bar - bronze or gunmetal for preference, but brass will do if nothing better is available-face the end, centre, drill to 3/8 in. depth with 23/64 in. drill, turn down 3/16 in. length to a press fit in the hole in the middle of the centre piece and part off at a bare 1/8 in. from the shoulder. Reverse in chuck, gripping by the spigot, face off the disc to 3/32 in. thickness, and put a 3/8 in. parallel reamer through the hole. Press the spigot into the hole in the centre piece.

AXLEBOXES AND SPRINGING
The axleboxes may be made from drawn bronze or gunmetal bar of 3/4 in. x 9/16 in. section, or nearest larger, or from castings. If the latter, they will be cast in a stick, with the fancy fronts (representing the lids of the full-sized boxes) cast on. The sides of either the drawn bar or he cast sticks are milled off in exactly the same way as those described for the engine truck, so repetition is unnecessary. The lengths can be either parted off in the four-jaw, or sawn off, and the ends faced in the chuck to 5/8 in. length. The boxes should be an easy sliding fit between the pedestals, but not slack.

Drill a 1/4-in. hole 7/16-in. deep in the back of each box. If a drilling machine is not available,, chuck the boxes truly in the four-jaw and centre and drill with the tailstock in the usual way, as the holes must be perfectly square with the back and sides. It will be noticed that only one flange is shown, and that is on the inside of truck frame; this is to allow the boxes free movement to tilt on an uneven track,
Drill a 1/16-in. oiling hole in the front of each box near the top, sloping down to the journal hole. If the fancy fronts are fitted, this can be just below the dummy hinges. Personally I shouldn’t bother about the dummy lids, but should just bevel off the edges of the boxes where they project beyond the pedestals.

I have done this with British pattern tender axle boxes, and they look quite all right. However, some folk worry ‘more about a little detail like that than they do about the efficiency of the engine—there is no accounting for tastes!

The arrangement of equalizers and springs is precisely the same as on the engine truck, the equalizers being cut from 16-gauge steel to the dimensions shown in the drawing. The same applies to the hangers, which are attached to the equalizers by 1/16-in. iron rivets. Dummy cast springs are drilled 1/4 in. in the hoop to take a spiral spring, which bears against the underside of the frame bar, when the springs are erected.

The springs are fixed in the inverted position shown between the hangers either by long 1/16-in. rivets through the bottoms of the hangers and the holes in the ends of the springs, or by bolts made from 1/16 in. silver steel, screwed and nutted at each end, according to the desire of the builder of the locomotive.

Should anybody wish to fit working leaf springs, proceed exactly as described for the engine truck as the spring sizes are the same for both engine and tender trucks and they are erected in the same way.

WHEELS AND AXLES
The wheels are of the disc pattern, spokeless, and are 2 in. dia. on thread with 1/8in. flanges, and the bosses are drilled 19/64in. and reamed 5/16 in. Again, there is no need to repeat the instructions for turning them.

The axles can be turned from 5-1/4in. lengths of 3/8 in. round steel (silver steel or drill-rod are most durable) which can be held in the three-jaw chuck, and both journal and wheel seat turned at the same setting so that it doesn’t matter if the chuck is a wee bit out of truth as the wheel seat must of necessity be true with the journal. Both wheels can be pressed on to each axle right away.

How the trucks are erected
Assembly and erection is very easily done. To assemble a truck, lay the frame upside-down on the bench and take off the tie-bars. Wind up four spiral springs exactly as described for the engine truck. Put one in the hole in the spring hoop, and insert the assembly of spring and equalisers between the pedestals, the ends of the equalisers going over the outsides of the framebars and pedestals, and the spring bearing on the frame bar.
Put an axlebox on each end of the axle and carefully fit the axleboxes to the pedestal jaws. If the boxes are made to instructions, and the jaws are correctly spaced, the boxes should be interchangeable. Note if the boxes bear evenly on the ends of the equalisers, and if O.K. all that remains is to replace the tie-bars and screws.

A rubbing-plate is needed between the bushing in the top of the centrepiece and the bottom of a truck bolster bent up from 1-1/4in. x 1/8in. steel. This is merely a disc of brass 3/32-in. thick, 1-1/4 in. dia. with a 3/8 in. clearing hole in the middle. It may be cut from sheet or parted off from a piece of the same kind of bar used for the bushing.

Put it over the pin in the bolster, put on the truck, and secure it with a steel washer and a nut made from 3/8 in. hexagon steel. The truck should swivel quite freely on the pin, with about 1/32in. clearance between the bottom of bushing, and the retaining washer. To prevent the nut slacking off when the engine runs at a high speed over a rough track (and she will be able to do just that, as you will see) drill a No 50 hole right through nut and screwed end of pin and put a 1/16 in. split-pin in it. That will do the trick.

Now, if the tender chassis is tried on the track, it should run quite freely. Try it with some weights on the soleplate and note if the springs and equalisers function all right before fitting the body and tank.

**Variations for casting-built trucks**

If a small boss is cast on the underside of a cast truck frame, on the opposite side to the bearing face which takes the place of the turned centre flange on the built-up truck, it could be held in the three-jaw and the flange faced off and drilled for the 3/8 in. pin at the same setting. Otherwise, the frame would have to be held in the four-jaw for this operation. The axleboxes, equalisers and springs are made and fitted exactly as described for a built-up truck and a similar tie-bar is fitted at the bottom of the cast-on pedestals at each side.

Regarding cast truck bolsters, I have included here a drawing of one of suitable pattern. The main part of it looks something like a river punt, and no rubbing-plate is needed between the underside and the centre of the truck, as a substitute for it is cast integral, below which is a boss which is turned and screwed to serve as the centre-pin.

Again, if a chucking-piece is cast on the inside of the “punt,” opposite to the above-mentioned excrescences, this could be gripped in the three-jaw and the facing, turning, and screwing done at the one setting. Otherwise, the casting would have to be chucked in the four-jaw with the boss for the pin running” truly. The assembly and erection of the whole bag of tricks is carried out in the same way as just described for the built-up arrangement.
While this serial has been running I have received some letters asking if the locomotive could be built to halfsize to haul a train of old-fashioned wooden cars on a “scenic” line, as a pleasing variation to the usual-type of British locomotive used for this purpose. Also some of our American friends want to build a bigger edition to run on a 4-3/4in. gauge track, and they are asking about the boiler. *Virginia* could easily be adapted to any size within reason, taking the 3-1/2in. gauge dimensions as a basis, and varying the details to suit the size of the required engine.

For 1-3/4in. gauge, the principal dimensions should be halved, as near as possible, but the distance over outside of frames should be 1-7/16 in. and the distance between the backs of the wheels 1-9/16 in. The wheels themselves should be 1/4 in. wide on the treads, with 3/32in. flanges about 3/64 in. thick.

If sprung coupled axles are desired, underhung spiral springs should be used, one under each axlebox. Cylinders should, be 9/16 in. bore and 3/4in. stroke, with loose-eccentric gear set to cut-off at about 60 per cent. A simple displacement lubricator would serve.

The boiler could be of the simple water-tube type, fired by a spiritlamp or one of my small oil-burners. The outer casing should be half the size of the 3-1/2in. boiler, made from 20-gauge steel with a lining of 1/16 in. asbestos millboard around the firebox wrapper. The inside barrel could be made from 1-1/4 in. seamless copper tube about 22-gauge, not thicker than 20-gauge, with 16-gauge ends and backhead and two 5/32in. watertubes, all joints being silver soldered.

No pump under the boiler would be needed, water being supplied by a hand-pump in the tender. The amount of water in the boiler would last quite a while on a non-stop run with a normal train, and it could be replenished in a matter of a ‘minute or so while the train stopped at a station. With cylinders of the size mentioned, even-fired with a spirit lamp the baby *Virginia* would have no difficulty in making enough steam to haul quite a big kiddy.

With an oil-burner, it would pull an average adult; a 2-6-0 with similar size cylinders and wheels, which I built as a present for a friend now, alas in the land beyond Jordan, hauled my weight around my own little railway for over 20 min. nonstop, and would have kept going indefinitely if the tender had held enough water.

I kept up the level by operating the hand-pump every time she started to blow off at 80 lb. Anybody who wishes to build a half-size American tea-kettle can follow the general construction of any of the similar size jobs I have described, such as the Dot (half-sized Doris) and so on.

An enlargement to 4-3/4 in. gauge is a different sort of proposition. While the general dimensions can be increased in the proportion of 4 to 3 certain details like the
cross-sections of the motion rods, valve gear, etc., can be made more proportionate to those of a full-size locomotive.

The boiler, too, would need a separate design for this size, as it would be no good just to use the same number of tubes, but of larger diameter, to cite just one variation.
VIRGINIA

By L.B.S.C.

Though outwardly a museum piece, this old American locomotive will put up a modern performance

In response to many requests for a description of an old-type American locomotive—typical of her period but capable of real work—I have pleasure in presenting Virginia. But before going into any details of construction I would like to address a few remarks to prospective builders, both in this country and the United State.

Now anyone with average skill could obtain a set of drawings of such a locomotive, reduce them to one-sixteenth of full size and go ahead and build the engine in accordance; but the result, while maybe very nice to look at, would be about the biggest disappointment ever as far as working was concerned. As I have so many times tried to emphasize, Nature will not submit to being scaled and proportions which are quite all right for 4 ft. 8½ in. gauge are more or less useless for 3½ in. gauge.

The reason why I stress this point, especially for the benefit of newcomers to our craft, is just this: When I set out to design a small locomotive, the object I have in mind is the same as that of a designer of a full-size one, namely, to produce an engine that will perform in the manner ex-
pected of it, with the greatest efficiency and the least trouble. To get this result the various parts must be arranged to suit the size of the engine and this is what I have done in the case of Virginia.

It would merely be a waste of time to make a complaint that certain parts are not the same as in full-size practice because they are not intended to be. Another point I always consider is ease of construction for those builders who are either tackling their first locomotive or have little in the way of equipment and workshop facilities. This engine can be built by the aid of a lathe of not less than 3 in. centres—or 6 in. swing as it would be termed in the U.S.A.—a small drilling machine and the usual assortment of hand tools found in an average amateur's workshop. Naturally, the less facilities available the more patience is required and the longer the job will take; but the main thing is it can be done. Now let us take a look at what we shall have to do.

Representative 4-4-0

Virginia is not an exact copy of any particular full-size engine, but she is representative of the usual type of 4-4-0 turned out by Baldwin, Rogers, Hinkley, Grant and other locomotive builders during the latter part of the last century. These were coal-burners—hence the type of smokestack shown. But she can be made to represent an earlier wood-burner by fitting a balloon stack, of which I will show a drawing later.

These engines had wooden pilot beams and, as a little wood beam would lack strength, I have substituted a metal one with rounded ends to look like the full-size job. The frames were built up of bars bolted together—I have substituted frames cut from the solid but having the same appearance. As the single bar or rail between driving wheels and cylinders would be too frail if made of proportionate size, I have shown it much deeper but it does not look out of place. The pedestals and pedestal ties are similar to full-size, but the axleboxes are simple one-piece reamed blocks, the same as I specify on British engines.

In full size the cylinders were cast with half the smokebox saddle integral with each, and the steam and exhaust ways were cast in. In 3½ in. gauge this would be a rather tricky job and special castings would have to be made which, of course, would send up the cost. I have a set of cylinders of this type, but they have no cored passages and it would be quite a job to drill the steam and exhaust ways in them.

I have therefore substituted separate cylinders bolted to the side of the frames which are enlarged at the front end to accommodate them. The smokebox saddle is a separate casting which rests on the frames and gives
the same appearance as if the lot were in one piece. This does away at once fell swoop with much awkward machining and fitting, the steam and exhaust connections being simple pipes and tee-pieces. Room is also obtained for a mechanical lubricator— a refinement never dreamed of by Virginia's not-so-big sisters! This arrangement of cylinders does not affect the leading truck which is of the sliding type with a central block and pivot. It has bar frames cut from solid, like the main frames, and equalised springing.

The alligator crossheads run between cantilever guide bars which are supported at the outer ends by a guide yoke going across the frames and forming a stay. The valve gear is Stephenson link motion of the typical American type in which the cut-off and the lower end of a rocking-shaft lever inside the frame, the outside lever being attached to the valve spindle by a suitable link. The weighbar shaft is carried by separate brackets screwed to the frame. The connecting rods are main rods as our cousins call them—are of the correct pattern but outside the coupling-rods or side-rods as in British locomotives, which avoids cramping the cylinders up against the frames.

Boiler and superstructure

The boiler is of the typical wagon-tops type giving a large steam space over the firebox. On this is mounted an outsize in steam domes containing the throttle-valve, which is operated by a push-and-pull lever as in full size. This dome carries a safety-valve of the direct-acting open-spring type and a dummy whistle, the real one being concealed or rather camouflaged as it takes the place of the Westinghouse air reservoir.

The dome on the barrel is a sandbox. The bell is too small to ring, but the big oil headlight on the top of the extended smokebox can be made to light up. Internally, the boiler is pure 1956—new wine in old bottles!—the tubes, superheater and pipes being arranged to my pet "standard" pattern. There is no trouble in fitting the firebox and tubes in the wagon-top shell and the sharply-angled section of the barrel presents no difficulty in construction.

The cabs of the full-size oldtimers were usually made of wood, and this one could very well be made from the thin cedar as used for cigar boxes, which does not warp. Personally I prefer a metal cab—there is little visible difference when painted. The running-boards and the rest of the adornments call for no comment. The tender will be of the usual double-truck type with bar-framed trucks and solid disc wheels and a long and low body, which is convenient when driving from a car behind the tender.

As stated in a recent note the engine can also be built in modern form, with a larger boiler and outside valve gear. Anyone wishing to build the engine thus is invited to go right ahead, and I will give the variations as we arrive at the appropriate stages. The frames, running-gear, wheels and cylinders are the same in either case. Now to construction.

Engine frames

To make the frames two pieces of mild steel plate 23 in. long, 1½ in. wide and ½ in. thick are required. Coat one of these with marking-out fluid and mark out the outline shown in the drawing. Builders who are on the muscular side and do not object to pushing a hacksaw through ½-in. steel can go ahead and cut both frames together in the usual way. For the less hearty fraternity I suggest cutting out the first plate roughly to size and shape, then repeating operations on the second. The two plates can then be temporarily riveted or bolted together and finished by filing.

Readers from time to time have suggested cutting out frames with a jigsaw, but even my Driver jigsaw runs too fast— even on the lowest speed—for cutting steel although it is a champion at cutting brass and copper. Anyone with a milling machine could mount a ½ in. saw-type cutter on the arbor and cut the frames like cutting wood with a circular saw.

I used this method by way of variation on the last pair of frames that I cut for an experimental locomotive instead of roughing them out with my little Jerry oxygen cutter and finishing them on the miller. This cutter, by the way, is a Lilliput and cuts ½ in. steel very nearly as clean as a hacksaw would, leaving soft edges easily machined or filed.

The bolt holes for the cylinders, the exhaust hole and the hole in the hump (which will accommodate the rocking-shaft bearing) must be drilled with the frames clamped together; the slots for the axleboxes can be finished at the same time. Use a piece of steel bar ½ in. wide and not less than ½ in. thick as a gauge when filing these to a finish, as the axleboxes run direct in them. With frames ¼ in. thick there is no need for separate hornblocks.

The pilot beam is made from a piece of ½ in. x ½ in. mild steel with the ends bent to a half circle as shown, so that they represent the rounded ends of the wooden pilot beams on the full-size engines. The bends are easily made by bending over 2 in. longer than required, the location of the bends marked, the metal heated to bright red at the marked spots and then bent round a piece of ½ in. rod held in the bench vice. When cool, saw off the unwanted parts and butt with a file. Two pieces of 3 in. x ½ in. angle are then riveted to the beam—at 1½ in. each side of the centre-line—using 3/32 in. iron rivets countersunk on the outside of the beam; four in each. The front ends of the frames are attached to these by four 6 B.A. (or their American equivalent 4-36 A.S.M.E.) screws, taking great care to have both frames exactly parallel. Lay them on edge on something completely flat (American builders cannot use the lathe owing to the runners being angles instead of flats but the drill-press table would do). Drill No. 34 clearing holes in the angles, but the beam in position, hold it in place with a toolmaker's clamp over each angle, run the drill through holes in the angle—making countersinks on the frame—drill through with No. 44 drill, tap 6 B.A. or equivalent and put the screws in.

Carrying the drawbar

The rear ends of the frames are joined by a piece of ½ in. square bar, faced off at each end in the four-jaw chuck, to 24 in. length. A bracket is attached to this to carry the drawbar; this is a piece of 1 in. x ½ in. steel bar ½ in. long, filed or milled to the shape shown and drilled ½ in. for the drawbar hole in the angle—making countersinks on the frame bar by two screws, as in the plan and the bar is then put between the back end of the frames, a cramp placed over the outside of the frames to hold them tightly in place. The screws are put in by the same method as described for the front end.

The truck bolster is simply a piece of ½ in. steel plate 1½ in. wide and 3½ in. long. Drill three No. 34 holes at ½ in. from each shorter edge and countersink them; then attach the bolster plate to the underside of the frames with its centre-line 3½ in. from the back of the pilot beam, using 6 B.A. countersunk screws running through the clearing holes in the plate into tapped holes in the frames. These screws will miss the cylinder bolt holes. Drill a ½ in. hole in the middle of the bolster for the pivot pin.

The axleboxes are made in the same way as those for British locomotives, but no spring pins are needed as the
springs will be overhead and will be described in the next installment. A piece of 1 in. × \(\frac{1}{2}\) in. good hard bronze or gunmetal bar about 4\(\frac{1}{2}\) in. long will make the four boxes. If a milling machine is available the groove at each side can be formed with a \(\frac{1}{2}\) in. cutter on the arbor, the bar being held in a machine vice on the table.

To do the job in the lathe, clamp the piece of bar under the slide-rest tool holder, packed up to centre height and at right angles to lathe centres. A quick way of doing the latter setting, is to put on the faceplate and check the distance at each end of the bar from the faceplate with a pair of calipers. When both ends tally the bar is set correctly. Then put on the three-jaw chuck with a \(\frac{1}{2}\) in. end mill or home-made slot drill in it, feed the bar into the cut with the topslide and traverse across the cutter with the cross slide. Set your slide gauge to \(\frac{1}{2}\) in.—same width as the axlebox openings in the frame—and mill the grooves \(\frac{1}{2}\) in. deep, so that the gauge will just slide over the grooves. The boxes should fit easily in the openings in order that the wheels can follow an uneven track, but they should have no appreciable endplay or they will knock badly when running.

The four mouldings can be parted off in the four-jaw or sawn to full length and finished to dead length in the chuck. Fit each box to a slot and number both for future replacement. Centre both boxes on one side, drill each No. 30, clamp each to its opposite mate and drill through. Put all the boxes in the frame and check each pair for correct drilling with a piece of \(\frac{1}{4}\) in. silver steel, which should lie dead square across the frames. If all right remove the boxes, clamp each pair together again and drill through both with the 31/64 in. drill, using either drilling machine or lathe. Finally, drill the oil holes, replace the boxes in the frames and run a \(\frac{1}{4}\) in. parallel reamer through each pair.

The hornstays, or pedestals are as they are called in the United States, are \(\frac{1}{4}\) in. lengths of \(\frac{1}{4}\) in. × \(\frac{1}{2}\) in. mild steel with a No. 34 hole drilled at \(\frac{1}{4}\) in. from each end. They are attached to the underside of the frames across the axlebox openings by two 6 B.A. screws in each, as shown in the frame drawing.

To be continued

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An interesting MODEL STEAM ENGINE

**T**HERE IS ALWAYS some satisfaction to be gained in making a critical examination of a model where, as in the present instance, the quality of the design and workmanship is clearly outstanding.

The engine illustrated was built in 1902 by the late A. G. Berry, who in his time was a well-known jeweller and watchmaker in Salisbury. The special purpose for which the engine was made was for driving a model of the Ferris wheel that was one of the attractions of the Paris Exhibition of 1900.

The model as a whole is a typical example of jeweller's work; for all the steel parts are highly polished, including the one-piece crankshaft, the connecting rod and the slidebars.

As to the size of the engine, the cylinder has a bore and stroke of \(\frac{1}{4}\) in. and 1 in. respectively and the flywheel is 3 in. in diameter. Although the cylinder covers, the steam chest and the caps of the main bearings are secured with hexagon-headed screws, elsewhere watchmaker's screws have been fitted. But the latter appear in no way obtrusive or unsightly as they are so minute—for example, the screws holding down the caps of the governor shaft bearings are only 39 thou. in. in diameter.

As the model was required to drive the Ferris wheel without constant attention, the governor gear was included in the design. This governor is of particular interest because of its working efficiency and the delicate workmanship involved in the construction of a mechanism of such small size.

The drive for the governor is taken from the crankshaft through bevel gearing to a shaft that is carried in two ornamental bearing pillars fitted with loose caps. From the shaft a second pair of bevel gears conveys the drive to the vertical governor shaft.

The centrifugal governor itself is of conventional design and consists of two polished steel balls attached to pivoted levers that serve to raise a spring-loaded sleeve as the engine speed rises. From this point, a system of levers and links conveys the movements of the governor sleeve to a small rotary throttle valve housed in an extension of the steam chest cover and the packing gland of the valve spindle is adjusted by means of two screws of only 28 thou. in. in diameter.

The link and lever components of the governor connections are made from \(\frac{1}{4}\) in. square steel rod and, as an example of the painstaking workmanship involved, the vertical link connecting the governor lever to the cross-lever is forked at either end and fitted with small clevis pins. The remainder of the rod has been turned circular in section and belled in the middle.

In general, the fine finish of the well-proportioned fittings gives the engine an appearance suggestive of a full-sized prototype.—N.H.
American locomotives make extensive use of equalised springing.

Alternative methods of fitting this are described by L.B.S.C.

A little American locomotive without the familiar equalising bars would certainly appear to have something missing, so I have included two alternative methods of equalised springing for this engine.

The first is very simple, it employs cast dummy springs and equalising bars with spiral springs concealed in the spring hoops. The second has working leaf springs and a working equalising bar between them. Both give the correct appearance and both are O.K. as far as working properties are concerned, but the second is more tricky to make and erect. However, it is worth the trouble where the builder wants the "real McCoy" as our cousins would say.

The arrangement is clearly shown in the drawing. The equalising bar is carried on a bracket midway between the coupled wheels and a spring is located over each axlebox, one end of this being attached to the frames by a long hanger and the other end to the equalising bar by a short one. A slotted block is fitted to the top of each axlebox, straddling the frame bar, and the weight is transmitted by this from the spring to the axlebox.

The two methods

Taking the simple type first, two pieces of $\frac{1}{2}$ in. x $\frac{3}{4}$ in. steel bar will be needed, each about 2 in. long. Square off the ends in the four-jaw chuck and cut a slot in each end, longways, $\frac{1}{4}$ in. wide and $\frac{1}{8}$ in. deep. Builders who own a milling machine can do this job with the bits of rod held in a machine vice on the table, using a $\frac{1}{4}$ in. side-and-face cutter on the arbor.

To do the job in the lathe, proceed exactly as described for axleboxes, clamping the bar under the slide-rest tool-holder at centre height, or holding it in a machine vice on a vertical slide, then traversing across a $\frac{1}{4}$ in. endmill or slot drill held in the three-jaw. When all four ends are slotted, cut the pieces in half. Clean up the spring castings with a file, drill the lugs at the ends with a No. 34 drill and drill up the hoops or buckles with a 9/32 in. drill, taking care to avoid breaking through the top.

Chock each slotted piece in the four-jaw, setting it to run truly; turn down the solid end—to within $\frac{1}{8}$ in. of the slot—to a diameter which will just slide in the hole in the spring hoop. Face this off to $\frac{1}{8}$ in. length, centre, and drill to a bare $\frac{1}{8}$ in. depth with a 7/32 in. drill. The spring can be wound up from 20-gauge tinned steel wire around a piece of $\frac{1}{4}$ in. rod held in the three-jaw. Bend an inch or so of the spring wire at right angles and push it between the chuck jaws, then pull the lathe belt by hand and guide the spring wire on to the mandrel rod with the other hand. Cut off four $\frac{1}{4}$ in. lengths and touch the ends on a fast-running emery-wheel. The springs should just start to compress when the plunger enters the hole in the spring hoop.

The equalisers can be cast or built up, the bar being made from $\frac{1}{4}$ in. x $\frac{3}{4}$ in. mild steel and the stand from 1 in. x $\frac{1}{4}$ in. bar. The top of the stand can be slotted in the manner described above and the bar may be silver soldered into the slot or secured by a rivet through the middle. Two No. 34 bolt holes are drilled in the foot.

Cut the four short hangers from 7/32 in. x $\frac{3}{4}$ in. steel, or from 16-gauge sheet steel, drill them and the ends of the equaliser bar as shown and rivet the hangers at each end of the bar, putting $\frac{1}{8}$ in. washers at each side of the bar so as to spread the hangers far enough apart to fit over the end of the spring. The springs can then be attached, a short bit of $\frac{7}{64}$ in. steel rod being put through hanger and spring eye and riveted over at both ends.

Attaching longer hangers

The longer hangers can be cut as shown and attached to the outer ends of the springs in similar fashion. At $\frac{1}{4}$ in. ahead of the centre of the driving axle drill a No. 34 hole from the side through the top bar of the frame; at $\frac{1}{2}$ in. behind the centre of the trailing axle, drill another. Midway between the axleboxes drill two vertical holes $\frac{1}{4}$ in. apart in the top bar to correspond with those in the foot of the equaliser.

The whole bag of tricks can then be erected as shown, using 6 B.A. bolts to attach the equaliser foot and spring hangers to the frame bar. The cast dummy springs and equaliser will
Alternative types of springs and equalisers

be held rigid, the rise-and-fall movement of the axleboxes being controlled by the coil springs in the hoops.

If working leaf springs are used, which I recommend, the slotted part that fits over the frame bar and bears on the axlebox can be made in one piece with the spring hoop. Saw off four pieces of ½ in. x ¾ in. mild steel and face the ends in the four-jaw to a dead length of 1½ in. One end of each is slotted ½ in. wide and 7/16 in. deep by the method previously given; the other end is milled or filed in square, the little neck in between being turned to ½ in. dia. with the piece chucked truly in the four-jaw, slotted end outwards.

Before removing from the chuck, centre the bottom of the slot with a thin centre-drill, drill down about ½ in. depth with a No. 44 drill and tap 6 B.A. Drill a ½ in. hole through the squared end, in line with the slot, and file it to a ½ in. x ½ in. rectangular shape to accommodate the spring plates.

Building up springs

The springs are made on the Glazebrook principle, each leaf being built up from three or four laminations which are merely strips of thin steel used for gramophone governor springs and similar purposes. The hangers pass through slots cut in the top plate, just as they do on some of the latest British Railways locomotives; so some of the old-time locomotive engineers designed details which have stood the test of time!

The top plate should be cut to an overall length of 3 in. and the slots can be cut by aid of a punch. This is made from a piece of ½ in. round silver steel about 2½ in. long. Square off the ends in the lathe, then file one end to a “screwdriver edge” a full ⁷⁄₈ in. across. Round off the ends as shown and back off the metal slightly from the cutting edge. Harden and temper to dark yellow—or use Mr. Proctor’s tip as given in these notes in the June 28 issue.

To use, lay the spring plate on a block of lead, hold the punch vertically on it in correct location, then give the shank one good heavy crack with a fairly heavy hammer. A series of light taps will merely split the steel. The punch will cut a clean slot if it is properly made and used as stated.

The bottom plate of the spring should be approximately ½ in. long, and the others in proportion, as shown in the illustrations. The completed spring should fit tightly in the rectangular hole in the hoop. Clamp it tightly by a grub-screw in the tapped hole, the Allen type of screw being best for this purpose.

The threads should fit tightly to avoid any chance of coming loose on the road. If you have any doubt about the thread’s tightness fill the end of the tapped hole with solder and file flush with the end of the slot, which will certainly teach it good manners. In my time, the eccentric set-screws on the Brighton engines were sealed in by filling up the hole with white metal, and I never heard of one coming loose.

Working equaliser

The stand for the working equaliser can be made from 1 in. x ½ in. steel bar, as before, to the same cross section as shown in the detail drawing, but the centre part is slotted out ¾ in. deep and ¼ in. wide. The little top piece, which carries an oval cotter bearing on the bar in the full-size job but is merely ornamented in the small one, can be made separately and just soldered on when the equaliser is assembled.

The bar itself is filed or milled from a piece of ½ in. x ¼ in. mild steel to the dimensions shown. Each end has a slot in it, similar to that in the ends of the spring. You can't very well punch these through ¼ in. of mild steel, but they can easily be formed by aid of a dental burr. A dental burr is used to clean out the cavity of a hollow tooth before filling it; your dentist would probably give you a few for the asking as they are only thrown away after use.

Mark out the location of the slots on the ends of the equaliser bars and

Spring and equaliser details

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drill a No. 50 hole at each end. Clamp the bar on its side under the lathe toolholder, lever in the centres; put a 
\( \frac{1}{4} \) in. burr in the three-jaw and cut away the metal between the two holes by using the burr as an endmill, the same as if slotting axleboxes or similar jobs. Take fine cuts, naturally, and use plenty of cutting oil applied with a brush and you will get a perfect slot; incidentally, the way the little burr cuts steel will explain why you get sundry twinges in the dentist’s chair! I use them for all sorts of jobs, cutting steam and exhaust ports, and so on.

**Right: Details of the coupled wheels**

**Below: Running gear details**

Drill a No. 30 hole through the middle of the slotted part of the stand and counterstrik slightly both sides. Drill another through the middle of the equaliser bar, insert the bar into the slot and pin it with a short piece of \( \frac{1}{4} \) in. silver-steel slightly riveted over both sides and filed flush. The bar should tip easily without being slack.

Only one short hanger is required at the end of each bar, and this is a plain strip as shown. The hangers on the outer ends of the springs must be forked at the bottom to straddle the frame bar; the upper ends pass through the slots in the spring plates. They are made from \( \frac{1}{4} \) in. \( \times \) \( \frac{1}{4} \) in. mild steel. The quickest way to form the forks is to mount a small saw-type milling-cutter, \( \frac{1}{2} \) in. wide, on a stub arbor held in the three-jaw. Clamp the piece of steel under the slide-rest toolholder at centre height and at right angles to the lathe centres. Feed it straight onto the cutter with the cross-slide, applying some cutting oil with a brush, then cut off the steel to the full length of the hanger and file or mill away the surplus above the fork so as to fit the slot in spring.

To assemble, put a short hanger through the slots in one end of the spring and equaliser bar and squeeze a short pin in each hole in the hanger to prevent the parts coming adrift. Push the thin end of each of the forked hangers through the other ends of the springs and pin similarly. The forks are then fitted over the frame bar and secured by 6 B.A. bolts, the stand of the equaliser being bolted to frame as shown.

The four coupled wheels are \( 3 \frac{3}{4} \) in. dia., on tread, with \( \frac{1}{4} \) in. flanges. The easiest way to machine the castings is as follows. Chuck each casting by the tread, back outwards, in the three-jaw, setting to run as truly as possible with the flange just clear of the chuck jaws. Use a roundnose tool with the end bent at about 45 deg. to the shank so that it will both turn and face without being shifted in the rest. Face off the boss, centre, drill through with a 27/64 in. drill, ream \( \frac{3}{16} \) in., then face off the back of the rim, taking a final cut right across and bringing the rim and boss flush. Take a small roughing cut off the flange to true it up.

Reverse the wheel in the chuck, gripping by the flange, and face off the rim and boss, leaving the boss standing out \( \frac{3}{16} \) in. above the rim. Note the position of the handles, or reading of micrometer collars, so that all four wheels can be finished to the same thickness. With a parting-tool set crosswise in the rest cut a \( \frac{3}{4} \) in. rebate where the spokes join the rim; this shows the joint between the tyre and wheel-centre in full size.

**Finishing tread and flange**

To finish the tread and flange, chuck an odd casting or disc of metal a little smaller than the back of the wheel. Face it off, recessing at the middle for about 1/32 in. depth and 1 in. or so dia. Centre, drill 15/32 in. and tap \( \frac{1}{4} \) in. any fine thread; screw in, very tightly, a short piece of \( \frac{1}{4} \) in. rod threaded to suit. About 1 in. of the rod should project. Turn this to \( \frac{1}{4} \) in. dia. so that the wheels will just slide on it, then turn the end to \( \frac{3}{4} \) in. dia. to within \( \frac{1}{16} \) in. of the plate. Screw it any fine thread and fit a nut to suit.

Mount a wheel on the stub and tighten the nut sufficiently to hold the wheel without straining anything. Using an ordinary roundnose tool, turn the tread and flange to within 1/64 in. of the finished size. Serve the other three similarly then, when the last one is on, touch up the cutting edge of the tool with an oilstone slip without taking it out of the rest; finish-turn the last one to size.

Remove it, and finish-turn the other three with the cross-slide handle at the same setting; they will then be exactly the same diameter, which is essential with coupled wheels. The edges of the flanges can be rounded off with a file while the lathe is running. Tip for beginners: a speed of about 60 r.p.m. is plenty for this size wheel; if the tool chatters, the lathe is running too fast.

Mark off the position of the crankpin hole on one wheel. Drill it 13/64 in., either on the drilling-machine or lathe (not by hand) and it can be used as a jig to drill the rest. Put it on top of the wheel to be drilled, put a short piece of \( \frac{1}{4} \) in. rod through the axle holes in the bosses to line them up, set the wheel so that the pear-shaped bosses are in line, then put the drill through the hole in the boss in the upper wheel and drill through the lower. Repeat this process with the other two wheels and no separate jig will be needed. All four crankpin holes can then be reamed 7/32 in. on the drilling machine or lathe.

The crankpins are turned from silver steel ("drill-rod") to our friends in U.S.A.) as the finished surface of this is very resistant to wear. If the three-jaw chuck is reasonably true the stock may be held direct in same; but if not, use either a split bush or a collet. The spigots should be a press fit in the wheel bosses but they should

\* Continued on page 214
Orthon (Blackheath) attaining 61.25 m.p.h.

About thirty craft contested the straight events—comprising the usual nomination and steering—and some excitement was created by the running of several of the faster boats by the new steering makers. These markers consist of iron rods mounted on a heavy base and fitted with a round float which is free to move up and down the rod according to the water level. When a fast boat hit one of the floats, however, its round shape allowed the boat to ride up it, and several craft were overturned.

The steering at first resulted in a tie between J. Clay (Blackheath) and J. Clarke (Welling) but following a re-run the verdict went to the latter, whose petrol-engined launch was running very reliably.

**RESULTS**

**C RESTRICTED RACE**
1. W. Everitt (Victoria) Non 2 65.92 m.p.h.
2. K. Hyde (St. Albans) Slipper 4 65.08

**CLASS C RACE**
1. R. Phillips (St. Albans) Foz 2 69.47 m.p.h.
2. C. Stanworth (Bournville)
   Cezetta
   59.39

**STEERING COMPETITION**
1. J. Clarke (Welling) 9 points
2. J. Clay (Blackheath) Elizabeth 9 0.0

**NOMINATION RACE**
1. J. Clay (Blackheath) Elizabeth Error .3 sec.
2. J. Cleary (Blackheath) Via Media

**King’s Lynn speed regatta**

The King's Lynn event is an informal regatta for speed only. The venue is attractive, being a farm pond in the village of Watlington near King's Lynn.

There was one event only open to all classes of racing hydroplanes irrespective of size, but provided a very interesting race. Dick Phillips repeated his fine performance by topping the list with a run of 66.19 m.p.h. with Foz 2. This boat is running really well and must be regarded as favourite for the Hispano-Suiza race to be run at St. Albans on August Bank Holiday week-end.

**RESULTS**

1. R. Phillips (St. Albans) Foz 2 66.19 m.p.h.
2. K. Hyde (St. Albans) Slipper 4 63.92
3. G. Lines (Victoria) Big Sparky 61.6
4. J. Benson (Blackheath) Orthon 58.78

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**VIRGINIA ... continued from page 208**

not be tight enough to split the bosses when pressing in. It is easy enough to turn a correct press fit. Just ease the end of the hole in the wheel boss with a taper broach; only a scrape, for about 3 in. depth. If the spigot is turned so that it will just enter the enlargement very tightly it will be the exact size for a correct press fit.

After turning the spigots part off the pins to the overall length shown in the drawing; reverse in chuck and turn the ends to 5/32 in. dia. for 7/16 in. length, screwing 5/32 in. X 40, or A.S.M.E. equivalent. Before pressing into the wheel bosses put a brass nut on the thread to prevent damage. The bench vice can be used for the squeezing operation. Don't forget that the bigger pins are pressed into the wheels with the bigger balance-weights!

Each axle needs a piece of 1/2 in. round mild steel (our American friends call it "cold-rolled") the ends of which are turned to a press fit in the big holes in the wheel bosses by the same method described for crankpin spigots. If the chuck is not true, and a collet is not available, turn the axle between centres, using steel slightly larger. This will ensure that the wheel seats are concentric with the axle.

Have the steel long enough to allow for a carrier at the headstock end, so that the full length of the axle can be turned without removing it from the lathe. The surplus can be parted off with the axe held in the chuck, for which job a true chuck is not essential. Press one wheel on each axle only; the other must be left until the eccentrics for the valve gear are made and fitted.

To be continued
L.B.S.C. details this week, the making and fitting of the eccentrics, coupling rods and the leading four-wheel truck

Many of the engines similar to Virginia had crosshead pumps for boiler feeding arranged between cylinders and frame. As this would entail close work and fragile parts in the small size, an eccentric-driven pump between frames is substituted, so we have to make and fit five eccentrics on the driving axle if link motion is used.

Builders who propose to fit outside valve gear need only the pump eccentric. They are all made by the same process though the pump eccentric is a little larger than those for the valve gear.

For the latter chuck a piece of 1½ in. round mild steel in the three-jaw—preferably the #8ft easily-machined quality as used for shafting. Face off the end, then run a parting tool in for about ½ in. depth at ½ in. intervals until you have four blanks showing each a full 8½ in. wide. In the centre of each cut a groove 7/32 in. wide and ¼ in. deep with the parting tool which—very important this—must have its cutting edge dead square with the work, so that the groove is of even depth for its full width.

Aim at an exceptionally smooth finish or there will be excessive wear on the straps; then repeat the four pieces. Some folk may prefer to turn each separately. This is quite in order, especially if the lathe is not in good trim and inclined to chatter. Use slow speed and plenty of cutting oil.

The piece which was faced off first will have the true centre shown on it by the tool marks. Make a deep centrepop at ¼ in. from this, then chuck in the four-jaw with the pop mark running true.

Open the pop mark with a centre drill, follow with 9/32 in., open out with 31/64 in. and ream ½ in. to a fairly tight fit on the axle. If Nos. 1 and 2 jaws are then slacked, the drilled eccentrics removed, an undrilled one inserted and the same two jaws tightened again, the process can be repeated without any further marking out and all four will be exactly alike. If the parting tool has left a poor finish on the sides, they can be faced off at the same time.

At the bottom of the groove—in the thickest part of the eccentric—drill a hole with No. 40 drill right through into the axle hole. Open this out to half its depth with 3/32 in. drill and tap the rest ½ in. or 5 B.A., or its A.S.M.E. equivalent. Remove any burring with the reamer and fit set screws, turning the heads to fit easily in the counterbore. Allen screws might be used with advantage.

The pump eccentric is made in the same way from 1½ in. steel, reduced to 1½ in. before grooving. The whole lot can then be threaded on the driving axle in the order shown—but don’t forget to put the axlebox on first! After fitting put on the other axlebox and the other driving wheel, setting the cranks as near as you can at right angles by eye. Lots of ways of setting the cranks exactly at right angles have been advocated by folk at various times, but I always use the following and it has never failed.

Stand the assembly on something flat, such as the lathe bed or driller table, either on V-blocks or "scotched" each side so that they can be turned. Set your index square against the wheel already pressed on, so that the edge of the blade passes over the centres of both axle and crankpin. Then set the needle of a scribing block to the centre of the axle and adjust the crankpin on the other wheel by turning the wheel on the axle slightly until the centre of the pin is "spot on" to the scribe point. Take a final look at the other side to make sure that the setting there is still all right and if so, the wheel can be pressed home in the sure knowledge that the cranks are set exactly at 90 deg. The whole business takes only a few minutes and no special jig or other apparatus is called for.

The trailing wheels can be set in the same manner. Sometimes when setting cranks on a multi-coupled locomotive, I check with a pair of dummy coupling-rods before pressing the coupled wheels home. The rods are merely strips of ½ in. x ½ in. metal with holes drilled in them at
correct centres, of a size to suit the crankpins.

The coupling rods

Some of these old tea-kettles had straight coupling rods, as shown on the general arrangement drawing, and some had fish-bellied rods, as shown by the dotted line in the detail drawing. Please yourselves which you make.

Two pieces of mild steel ¾ in. wide, ¾ in. thick and 7¾ in. long, will be required. Coat one with marking-out fluid and carefully mark out as shown; dot the centres of the bosses, drill ½ in. then use it as a guide to drill the other. Fix them together with bits of ½ in. rod driven through the holes. When I mill out long rods on my milling machine I have to take precautions to prevent springing, as the jaws of the machine vice are only 4 in. wide. So I grip a hefty bit of bar 1 in. square or thicker in the vice and clamp the rod blanks to it instead of holding them direct.

Sometimes I use pieces of mild steel an inch or so longer than necessary and drill holes in the ends so that they can be held down to the supporting bar by setscrews. The surplus metal can then be taken out in one cut each side, using a small slabbng-cutter on the arbor and applying plenty of "juice" by clipping a small can to the overhead arm with a cock and pipe leading down to the cutter.

Rods can be milled in the lathe by using a cutter on an arbor between centres and holding the blanks in a machine vice (regular or improvised from two bits of angle and two bolts) attached to the lathe saddle. The disadvantage of no-height adjustment can be got over by filing a gap at the end in which the cutter can start at required height. The blanks must be well supported at each end. They can also be turned between centres; this leaves the top and bottom rounded, naturally, but they can easily be made flat by a little judicious filing.

If machining is entirely ruled out, grip the rods in the bench vice with the marked line showing just above the jaws. File a gap at the end wide enough to take a hacksaw blade on its side. Put a blade sideways in the saw frame, insert in the gap and saw along, using the vice top as guide. A drop of cutting oil works wonders; apply it with a brush to the blade. Finish the job with a file.

To round off the bosses, separate the rods and open out the holes with ¼ in. drill. Turn a piece of square bar—anything from ¼ in. to ½ in. across facets—for about ½ in. in length to a good fit in the holes. Clamp this parallel with the lathe centres in the sliderest tool holder and slip the end of a rod over the pip. Put an endmill, about ¼ in. diameter, in the three-jaw. With the lathe running at moderate speed grip the free end of the rod tightly in your left hand and feed the end on the pip to the cutter by turning the cross-slide handle. Then swing slowly the free end of the rod round, the pip acting as fulcrum, and the revolving cutter will round off the end of the rod very nicely. Warning: don't swing the rod far enough around to cut off the bit that forms the oil box!

All that then remains is to finish off carefully with a file; open out the hole in the front boss to ¹/₄ in. and the back to 3/₃2 in. Fit a bush turned from bronze rod in the front hole and a flanged one in the back. Put the reamers through after squeezing in the bushes. An oil hole can be drilled in each boss.

Truck simplified

The leading truck is rather different to the British type. It is representative of full-size practice, but I have simplified it a lot to make the job easy. A piece of ½ in. steel plate 6 in. long and 2¾ in. wide is needed for the top section. Two rectangular openings 2¾ in. × 2¾ in. are cut in this at ¾ in. from each edge; the easiest way to do this would be to drill a ¾ in. hole at each corner and cut away the metal between with a piercing saw (which is merely a glorified fretsaw) using a metal-cutting jigsaw blade in it or a spiral file, such as the Abratile. The slot for the wheel.
centre pin can be formed by drilling a \( \frac{1}{8} \) in. hole at each end and taking out the metal between with a round file.

The pedestals, between which the axleboxes are fitted, can be bent from 3/32 in. \( \times \) \( \frac{1}{8} \) in. mild steel strip and either riveted or brazed to the top surface as shown in the illustration. Brazing is preferred using a small screw in each to hold the pedestals in position while brazing. Fit the end pieces first, then use a piece of \( \frac{1}{8} \) in. bar as a spacer while fitting the inner ones. The lower ends are held in place by a single tie bar of \( \frac{1}{4} \) in. \( \times \) \( \frac{1}{8} \) in. steel strip attached to the pedestal feet by screws or bolts as preferred. This takes the place of the separate horn stays on British bogies.

The axleboxes are milled from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. bronze rod, by the process described for the main boxes, and are drilled and reamed in the same way. Note that there is only one flange, and that is a thick one—on the outside. The reason is that the double equalisers bear on top of the boxes—one inside and one outside the top frame bar—and allowance has to be made for this. The wheels and axles are also turned to the instructions given for the coupled wheels and axles, so repetition is unnecessary. The dimensions are all shown in the drawings.

The springing may look rather tricky to the uninitiated, but it isn’t difficult to fit up. Either cast dummy springs can be used, with spirals in the hoops, or real leaf springs may be installed—whichver the builder prefers. In either case the top part of the truck frame bears on the spring hoop. The outer ends of the spring are attached to the equalisers by short links, which then hang down to them, and the ends of the equalisers transfer their burden to the axleboxes.

Should a box lift on an uneven piece of line the equaliser just lifts and bears a little harder on the other box. Both equaliser and short link alike are sawn and filed, or milled, from \( \frac{1}{8} \) in. or 16-gauge mild steel, a simple job needing no detailing.

If cast dummy springs are used just clean them up with a file, and drill the hoop for the spiral spring as shown. Drill the ends of the spring and the links with No. 51 drill; put a link at each side of the spring eye and run a piece of \( \frac{3}{8} \) in. steel rod, drilling it from 1/8 in. silver steel through the lot, riveting it over at each side. As the length of the spring castings may vary slightly, measure the distance between the eyes and drill the holes in the equaliser bars accordingly; then put an equaliser at each side of the spring, outside the short links, and rivet the latter to the inside of the equalisers. The spiral springs in the hoops should be fairly strong, as they carry the weight of the whole front end of the engine. Tinned steel wire of 19 gauge should do the trick nicely.

To erect: take off the bottom tie bars and lay the truck frame upside down on the bench. The spring- and equaliser assembly can then be dropped in place. Be sure the spiral spring doesn’t fall out and get lost. Then put in the axleboxes, flange outward, and put on the tie bars; the springs should just start to come up when the boxes are at the bottom of the pedestals. Press one wheel on an axle, push the axle through the boxes and press on the other wheel. The truck should run quite freely.

**Working leaf springs**

First make up the two springs by the method described for the coupled-wheel springs, working to the dimensions given and punching the oval slots in the long plates. Then file up a set of short hangers from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. steel rod, drilling them as indicated. The tongues of the hangers are then put through the slots in the ends of the springs and secured by a pin—like those in the coupled-wheel springs. These pins must be a press fit in the hangers, so that they will not come adrift on the road. If they are at all doubtful, solder them.

The assembly is erected in the way already illustrated with an equaliser at each side of the spring, the pins securing the hangers to the equalisers going through the thick part of the hanger. With the cast dummy springs it doesn’t matter if the hangers are riveted up tightly as the cast spring does not flex. But with the working leaf springs the hangers should be free enough to swing to allow for the working spring lengthening as it straightens out a little when the engine goes over a rough bit of road.

As mentioned earlier I discarded the swing-link arrangement in favour of a sliding movement, as it is not only easier to fit up but is much freer on the curves of the usual back garden or club track. The friction between the top plate of the truck and the bolster under the main frame will prevent any hunting or what the children call “wobbilation.” A pin is attached to the bolster by a nut on top, the middle part being a nice sliding fit in the slot of the truck plate. It is prevented from dropping off by a nut and washer underneath.

The chassis thus far assembled and erected should be tried for freedom of working parts by pushing it over a piece of track. It should run perfectly free, especially as far as the coupling rods are concerned. If there is any sign of tightness correct it before proceeding to the next stage. All my locomotives have power and to spare, but there is no sense in mopping up the power in internal friction—you want it all at the tender drawbar!

To prevent any likelihood of the coupled wheels shifting on their seats drill a No. 43 hole about \( \frac{1}{8} \) in. deep in the joint between the wheel seat (end of the axle) and the wheel boss and squeeze in a little piece of 3/32 in. silver steel to form a round key.

A box lift on an uneven piece of line the equaliser just lifts and bears a little harder on the other box. Both equaliser and short link alike are sawn and filed, or milled, from \( \frac{1}{8} \) in. or 16-gauge mild steel, a simple job needing no detailing.

If cast dummy springs are used just clean them up with a file, and drill the hoop for the spiral spring as shown. Drill the ends of the spring and the links with No. 51 drill; put a link at each side of the spring eye and run a piece of \( \frac{3}{8} \) in. steel rod, drilling it from 1/8 in. silver steel through the lot, riveting it over at each side. As the length of the spring castings may vary slightly, measure the distance between the eyes and drill the holes in the equaliser bars accordingly; then put an equaliser together.
This week's article explains how "period" cylinders can be made to operate with modern efficiency.

Most of the not-so-big American locomotives of Virginia's day had small slide-valve cylinders, the bodies of which were cast integral with the two halves of the smokebox saddle, and the steam chests had the appearance of being added as an afterthought. They were very small, and were usually attached by outside bolts. The ports were small by modern standards, and the valve travel short.

I have endeavoured to retain the ancient appearance as much as possible by keeping the steam chests clear of the frame, but I have had to lengthen them in order to get in big ports and allow for a fairly long valve travel. The job of machining and fitting the cylinders is rendered much easier by making them separate from the saddle, while the appearance is not spoiled in the least.

The machining is pretty much the same as specified for the cylinders of British type locomotives which have been described in these notes. Should there be any roughness on the portface, smooth it off with a file, also clean up one end of the casting and check position of corehole. If this is fairly true, no marking-out is needed.

If it is much out plug the end of the hole with a disc of wood, and mark the true centre on it; this can be got from the drawing showing the section through the exhaust port. Coat the end with marking-out fluid, and scribe a circle on it, showing the exact location of the bore. Mount the casting, port face down, on an angleplate attached to the faceplate and set it parallel with the lathe centre-line by applying a try-square, stock to faceplate, and blade to the bolting-face of the cylinder, the casting being held securely with a bar across its back with a bolt at each end.

If the slots in the angleplate do not happen to come right for the bolts, drill holes in the angleplate to suit. Many years ago I made a fine angleplate from a piece of 3 in. angle iron about 4½ in. long, without any slots in it. Holes were drilled and tapped in it to suit various lengths of bar used for clamping down cylinder castings. It was a real time-saver.

Adjust the angleplate on the faceplate until the corehole or marked circle runs truly, then tighten all the bolts. The casting should overhang the angleplate by about ½ in. to allow for facing the flange. Start the lathe and note if there is any vibration; if there is, a counterweight must be bolted to the faceplate opposite the angleplate so as to restore balance. Counterweights can be made by pouring melted lead into a tin lid and drilling a bolt-hole through the middle. Personally I use anything handy.

First face off the flange with a roundnose tool set crosswise in the rest; take off half the difference between the length of casting and the length of the finished cylinder. Then put a boring-tool in the rest—with its cutting edge slightly above centre so that the lower part does not rub against the metal—and take a fairly hefty cut right through the corehole to remove the hard skin. Most small lathes now on the market have a saddle and leadscrew, and the feed should be the finest that the change-wheels will permit.

If the lathe has no leadscrew, the topslide must be set to turn parallel before boring is begun. Chuck any odd bit of rod in the three-jaw, with about 2½ in. projecting, and take a fine cut along it. Check the diameter at each cut, with micrometer or calipers. If measurements do not tally, adjust the topslide and have another go. When measurements are within slightly less than 0.001 in. the slide is set near enough for the cylinder-boring job. When boring by hand feed, turn the topslide handle very steadily and maintain even speed; this is important.

If a 1½ in. parallel reamer is available, continue boring until the leading end will just enter. If not, bore to size, taking the last two or three traverses through the casting without altering the position of the cross-slide. This allows for any spring in the tool and it should give a parallel bore with a good finish.

Unless the lathe has a hole through the mandrel large enough to admit the reamer (seldom found in a home workshop) reaming will have to be done by hand. Face off the other end of the casting by mounting it on a stub mandrel held in three-jaw; this is just a short piece of rod, turned to a tight fit in the bore. Then grip the casting in the bench vice, and carefully put the reamer through with a big tapwrench on the shank.

The cutting edges of the reamer should be rubbed with an oilstone slip before commencing operations.
and a few drops of cutting oil will help the reamer to cut easily and give a smooth finish. Avoid bearing down on the reamer while operating—usually done inadvertently—or the bore will be stpped, or else tapered, both of which ruin the job and would necessitate reboring to restore parallelism.

Stand the bored casting end-up on the anagleplate, putting a piece of soft copper or aluminium sheet between the faced flange and the angleplate to prevent damage, and fix with a long bolt through the bore, with a big washer and another bit of soft metal under the nut. Adjust the angleplate so that the casting is approximately in the middle of faceplate, to preserve balance. Set the portface right for machining by applying a try-square to the job, stock to faceplate and blade to bolting-face.

Machine off with a roundnose tool set crosswise in the rest until the distance from edge of bore to portface is exactly 11/32 in. then slew the casting around a quarter-turn, bringing bolting-face right for machining, check for correct setting with the try-square applied to portface, and repeat faceting operation until the bolting-face is 15/32 in. from edge of bore. No further measurement is necessary.

Ports and passageways

Coat the portface with marking-out fluid, and set out the ports as shown. Set the casting end-up on the topslide or saddle, with the portface at right angles to lathe centre-line. This can be checked by running it up to the faceplate, or to a rule held edgewise to the faceplate. If a vertical slide is available, mount the casting on the centre and fix it to the slide, which gives height adjustment and allows all ports to be cut without removing the casting for readjustment, otherwise height will have to be adjusted by packing.

Set one port level with lathe centres, put a ¾ in. endmill or slot-drill in the three-jaw, feed the work into the cut with either topslide or headstock handles, and traverse across with the cross-slide. Bring the handle to the same position at each end of every cut, to avoid over-running, or, better still, fix a temporary stop on the slide. Cut to ¾ in. depth. The exhaust port can be cut with two "bits" side by side to get the necessary width, or a ¾ in. cutter may be used. This method leaves rounded ends, which is of no consequence and does not affect the efficiency of the cylinder.

Ports may be cut by hand. Drill a row of holes, ¾ in. deep, in the marked spaces and cut them into rectangular slots by aid of two small chisels—one ½ in. wide, the other ¾ in.

made from short lengths of silver-steel. File to shape, harden and temper to dark yellow, and finish the cutting edges on an oilstone; just a few minutes’ work.

File a bevel about ¾ in. long at the mouth of each bore, opposite the ports; make three centre-ops on it at a little over ¾/32 in. centres, and drill holes from these with a 7/32 in. drill, then drill a slanting 7/32 in. hole from the bottom of the exhaust port to meet it, as shown in the section.

Cylinder covers

Chuck front cover by spigot provided, face off, and turn the register to a push fit in the cylinder bore, making it ¾ in. deep. Face off the flange and turn to 1¼ in. dia. Reverse in chuck, holding either by the edge in the chuck jaws, or in a stepped bush held in the chuck, and saw or part off the chucking-spigot. Face off, slightly rounding the outer edge, which gives the appearance of the lagging cap usually found on the full-size engines, especially if tinned over before final assembly.

Proceed in the same way with the back cover, but before reversing in the chuck, centre and drill right through with a 1/32 in. drill. After reversing and facing off gland boss, open out the hole with an 11/32 in. pin-drill to ¾ in. depth, and tap ¾ in. x 32. Use of a pin-drill for opening out ensures concentricity, and the gland should not bind on the piston-rod in any position.

For the gland, chuck a piece of ¾ in. round bronze rod in the three-jaw, face, centre, and drill to ¾ in.
screwing each to a block of metal, holding them in a machine-vice on the lathe saddle at correct height and traversing past each side of a side-and-face cutter on an arbor between centres; or clamping against a vertical slide, and traversing above and below an endmill held in three-jaw.

In either case, the cover, if the seatings are machined separately, would have to be set truly on the cylinder by aid of a try-square with its stock to bolt-face and blade to seating. Failing facilities for machining, the seatings could be hand-filed if carefully marked off and checked with a try-square as above.

**Pistons and rods**

The pistons are turned from round rod, a little larger than finished size; bronze, rustless steel, or the alloy used for i.c. pistons will be suitable. Chuck in three-jaw, face the end, centre, drill to 1 in. depth with 1/8 in. drill, turn down 1 in. length of the outside to 1/64 in. bigger than finished diameter, and run a parting-tool in for about 1/16 in. depth at a full 1/4 in. from the end, also at a full 1/4 in. farther along.

In the middle of each blank cut a groove 1/8 in. wide and 7/32 in. deep, then part them off. Chuck each separately, face off any marks left by the parting-tool, open out the centre hole to 1/8 in. depth with a No 3 drill, and tap the rest 7/32 in. x 40. Put a piston-rod (which is just a length of 7/32 in. rustless steel or bronze with 1/8 in. of 7/32 in. x 40 thread on the end) in the tailstock chuck, run it up to the piston, enter it in the hole, and screw it home by pulling the lathe belt by hand.

To finish, hold the piston-rod in a collet, or a split bush in the three-jaw, and carefully turn the piston to a sliding fit in the cylinder bore, using the cylinder itself as a gauge.

The steam chest can be faced truly on both sides by holding it in the four-jaw chuck, using a roundnose tool set crosswise in the rest. Smooth off the outside with a file, then chuck in the four-jaw with the boss run true; centre, put in a No 30 drill through, open out to 1/16 in. depth with a 7/32 in. drill, and tap 1/4 in. x 40.

**Buckle and spindle and the tallow cup**

Turn the outside of the boss, and face off to 1/16 in. length. The holes for the tallow cup and the steam pipe can be drilled and tapped on the drilling-machine if desired.

Set out and drill the 16 screwholes as shown, then cut a piece of brass plate for the cover to the same size as the steam chest. Clamp it to the chest and put the drill through the lot. Temporarily clamp the chest to the portface of the cylinder, flush with the outer edge; run the drill through screwholes, making countersinks on the portface; remove chest, drill countersinks No. 48, and tap same thread as used for cylinder flanges. The steam-chest gland is made by the same process as that adopted for the piston gland from 1/8 in. round bronze or gunmetal rod.

The slide-valves can be machined up by 1/4 in. x 1/8 in. bronze bar, by the same process described for axleboxes, the recess being formed by drilling a 1/4 in. countersink in the face and finishing with a small chisel. Cast valves may be used, in which case the recess would be cast in. The buckle may also be cast, cut from 1 in. x 1/4 in. brass bar. It should fit easily on the valve, but with no slackness.

The spindle is a 1 1/4 in. length of 1/4 in. rustless steel with a few threads at each end. The fork or crosshead is made from 1/4 in. square steel; drill the crosshole before slotting. To slot truly, clamp the rod under the slide-rest toolholder at centre height and run up to a 1/4 in. saw-teeth cutter on a stub mandrel held in three-jaw. Round the end with a file, part off to length, and chuck in four-jaw to turn boss, drill, and tap. Assemble as shown.

Use 1/4 in. square braided graphited yarn in the piston grooves and Parnelto or similar packing in the glands; gaskets of Hallite, or oiled brown paper, will be O.K. for the steam chest and cover joints. The big engines carried tallow cups on the chests, so I have shown a section of a simple one which needs no explanation. This can be made from either a casting or from brass rod.

*To be continued*
L.B.S.C. describes how to make and erect the guide bars, crossheads, main rods, and combined guide yoke and pump bracket.

The best material for the guide bars would be silver steel, owing to its wear-resisting properties, but mild steel is a good second-best. Four pieces of $\frac{3}{16}$ in. $\times \frac{3}{8}$ in. section are required, squared off at each end to $3\frac{1}{4}$ in. length. Chuck each in the four-jaw with one wider face 1/32 in. off centre, and turn a $\frac{1}{8}$ in. pip on the end, $\frac{1}{4}$ in. long.

This pip should come in the middle of the wide face when seen in plan; but viewed from the side, it should be flush, as is shown in the drawing. It fits into a hole drilled in the guide yoke and forms the outer support for the guide bar; a simple arrangement which has proved very satisfactory on some of my own engines.

The guide bars are left full thickness at the part where the greatest stress comes, which is at 2 in. from the cylinders. From that point they are tapered off each end to a $\frac{1}{4}$ in. thickness, and this can be done either by milling or careful filing. The last $\frac{1}{2}$ in. at the cylinder end is left parallel and two No 41 holes are drilled in it for the screws attaching it to the seating on the gland boss. When attaching, check with a try-square to make absolutely certain that the bars are square with the covers.

Alligator crossheads are used, and they may be either steel or bronze. Bronze shoes work with very little friction on silver-steel guide bars, and they can be tinned over by any builder who objects to the colour. The easiest way to make the crossheads is to build them in three pieces, a centre and two shoes.

**Making the centre**

A piece of bar of $\frac{3}{8}$ in. $\times \frac{3}{8}$ in. section is needed for the centre. If a milling machine is available, square off each end of the bar and slot it lengthwise for $\frac{1}{8}$ in. depth with a $\frac{1}{4}$ in. side-and-face cutter on the arbor. If not, clamp the bar under the slide-rest tool-holder, same as for end-milling axleboxes, and cut the slot with a $\frac{1}{4}$ in. end-mill or slot-drill in the three-jaw. Saw or part off at a full $\frac{3}{8}$ in. from the end; then chuck each piece in the four-jaw with the blank end outwards, and set to run truly.

Face the end, centre, drill No 4— it doesn’t matter if the drill breaks right through into the slot—and put the end of a $7/32$ in. parallel reamer in, just far enough to make the hole a tight fit for the piston-rod. Turn $\frac{1}{4}$ in. of the outside to $\frac{1}{8}$ in. dia. and at $\frac{3}{8}$ in. from the shoulder, drill a No 14 cross-hole and ream it $\frac{1}{8}$ in. for the wrist pin.

**Home-made cramps**

Two pieces of $\frac{1}{4}$ in. $\times \frac{1}{4}$ in. bar each 2$\frac{1}{2}$ in. long will make all four shoes. Mill a $\frac{1}{4}$ in. $\times 3/32$ in. groove in each, exactly as described for axleboxes, then cut each piece in half and square off the ends to 1$\frac{1}{2}$ in. length. File each end to shape shown and bevel off the plain side; then clamp one at top and bottom of the centre-piece. For jobs like this I use rough home-made cramps made from odd bits of square steel rod, about $\frac{1}{4}$ in. section, and $\frac{1}{4}$ in. commercial stove screws. They only take a few minutes to make. Hold the job quite firmly; it doesn’t matter a bean about their getting red hot when the brazing is in progress.

If the crossheads are steel, apply a little Boron compo paste to the joints, heat to bright red, and touch them with a bit of soft brass wire, which will melt at once and flow in, but be exceedingly sparing with it. Only just
The main or connecting rods

sufficient is needed to run between the centre and shoes. Too much will partially block the recess, and it will be a Dickens of a job to get it cleared out.

For bronze crossheads, use best grade silver-solder with powdered borax mixed with water for flux, or Easyflo and its special flux, taking the same strict caution to avoid blocking the recess. Only a dull red heat is needed, and the job can be quenched in acid pickle, washed in running water and then tinned. Dip in liquid soldering flux, heat to melting point of solder, apply a little solder, spread it with a small wire brush or a soldering bit, and wipe off any surplus. Bronze crossheads treated thus look just like steel.

Fitting the crossheads

To fit the crossheads to the bars, make a temporary spacer for the ends. This is just a piece of $\frac{1}{8}$ in. x $\frac{1}{8}$ in. steel with two No 30 holes drilled in it at 1 in centres. Put the crosshead between the bars, and put the spacer over the pins on the ends to hold them at the right distance apart. The crossheads should slide freely from one end to the other; if tight, ease the grooves slightly with a narrow fine-cut flat file.

When O.K. push them right back on to the ends of the piston rods so that the latter just enter the bosses. They should still work freely between the bars, with the piston rods in the bosses, the only extra resistance being that of the pistons.

The connecting rods, or main rods as they are known in the land of the dollar, are made in precisely the same way as the side or coupling rods. Two $\frac{1}{8}$ in. lengths of $\frac{1}{8}$ in. x $\frac{1}{8}$ in. mild steel are required, one of which is marked out, the two temporarily fixed together, and the centre part milled, or sawn and filed to shape shown, by the methods previously described. It would add to the working life of the little end, and not weaken it, if the hole for the crosshead pin, or wrist pin is drilled No 14, reamed $\frac{7}{32}$ in. and then casehardened.

Heat to bright red, roll in some good casehardening powder (Kasenit, Eco-site, or any other good brand), filling up the hole, then reheat until the yellow flame dies away and the powder has all fused. Finally quench in water. The pins are turned from $\frac{1}{8}$ in. hexagon steel to a nice fit without shake (a simple job requiring no detailing out) and casehardened in the same way.

The stress on the little end and the wrist pin, when starting heavy loads, is relatively enormous. If bushed, there would be little metal left around the bush; the little end itself cannot be made any bigger as its size is limited by the crosshead.

The big-end looks exactly like those on Virginia's not-so-big sisters, but actually it is what our American friends would call phoney; what appears to be a pair of brasses is simply a bush with a rectangular face, the joint between rod and strap being just a couple of deep scratches, the bolts doing nothing at all! Open out the hole to $\frac{1}{4}$ in. dia, and turn a bush to fit from a piece of $\frac{3}{4}$ in. round bronze held in the three-jaw. Leave the flange a full 3/32 in. thick and after parting off file it to a rectangle measuring $\frac{3}{8}$ in. x $\frac{3}{4}$ in.

Use of watchmakers' file

Before pressing in the bush make the two marks representing the joint; deep scratches with a hard-pointed scriber will do the trick. Personally, for jobs like this, I use a fish-bellied, fine-cut Swiss file of the kind used by watchmakers. It has very sharp edges and is exceedingly hard. When pressing the bush home, be sure it is fair all ways with the big-end itself, parallel top and bottom as shown. Drill a No 40 hole in the thickness of the big-end, right into the bush, and tap it $\frac{3}{4}$ in. or 4/36, then turn up a little oil cup to fit, to shape shown, from any odd scrap of steel that may be handy.

When screwed home this locks the bush and prevents it from turning. Another deep scratch right across the face of the bush, made vertically, represents the joint between full-size brasses. Finally drill two No 51 holes through the thickness of the big-end at the spacing shown, and fit two bolts, which can be made from bits of $\frac{1}{4}$ in. silver-steel, or drill rod, screwed at each end and furnished with commercial nuts.

Guide yoke and pump bracket

Mention was made earlier in this serial about the need for one relatively large pump to take the place of two crosshead pumps for which there was insufficient room. I thought it might

Combined guide yoke and pump bracket

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be a good wheeze to incorporate the stay or bracket for this with the guide yokes, provided that the pump didn't run foul of the valve gear and a little contriving, produced the desired result. A first glance at the drawing may give the impression that it is rather complicated, but it is nothing of the sort; all it needs, is careful setting out, and sawing and filing to outline.

The combination of yoke and bracket is made from a piece of \( \frac{1}{2} \) in. steel \( \frac{5}{6} \) in. long and \( \frac{1}{6} \) in. wide. The two rectangular slots at either end are for the main rods to pass through, and the No 30 drilled holes above and below them accommodate the pins on the ends of the guide bars. The two \( \frac{1}{8} \) in. slots fit over the frame bars and are attached to them by \( \frac{1}{4} \) in. lengths of \( \frac{1}{6} \) in. \( \times \frac{1}{2} \) in. angle riveted to the bracket and fixed to the frame by long bolts passing through both angles and the frame.

**Powerful little locos**

The inside support is necessary to take the back thrust when the pump is feeding the boiler when the engine is running fast; otherwise there would be a tendency for the bracket to twist at the points above the frame where the bracket is narrow. It would surprise the unintimated to know what tremendous power these little locomotives can exert for their size. The pump barrel will pass through the hole in the middle of the bracket and will be attached to it by a circular flange.

No detailed instructions are needed for marking out the yoke and bracket, all dimensions being given on the drawing. The cutting-out is done in a manner similar to that on the frames. Take particular care to mark out and drill the holes for the guide-bar pins exactly as shown, otherwise there may be a spot of trouble when erecting which will result in crossheads binding and other little items, and cause fresh words to be added to the dictionary.

**Brass or steel angles**

Steel should be used for the angles if possible, but commercial brass angle will do at a pinch. I often make bits of steel angle by milling a square bar with a side-and-face cutter of suitable size. The result gives a beautifully true angle.

When riveting the angles to the yoke jam a bit of \( \frac{1}{4} \) in. bar in the slot, but the angle up tightly around it and hold it there with a toolmakers' cramp while drilling the rivet holes. Note that the rivets are countersunk on the back of the yoke; there must be no projections that side.

The rectangular holes for the rods may be cut in the same way as those in the leading truck. Drill the holes for the bolts in the two outside angles, using a No 41 drill, as they can then be used as guides to drill the corresponding holes in the frame and inside angles.

First set the combined guide-yoke and pump bracket across the frames with the back of it \( \frac{1}{4} \) in. from the centre of the hole which will carry the rocker bearing. Check with try-square to make sure it is dead square across the frames, then put a toolmakers' clamp over the two angles on each side, about halfway down, so that the angles are clamped tightly against the frame.

Next, with a No 41 drill entered into the bottom hole in the outer angle, drill right through the frame and the inside angle; clean off any burring and secure with a bolt made from 3/32 in. silver steel or drill rod, screwed at both ends and nutted tightly. Repeat this process on the other side of the frame, then remove cramps and drill the two upper holes, bolting likewise. The yoke should then be perfectly firm and rigid.

Now take a cylinder, with guide bars and crosshead attached, enter the pips on the guide bars into the holes in the bracket, and set the cylinder against the frame; the bolting face of the cylinder should line up exactly with the enlarged part of the frame which contains the bolt holes. Set the cylinder horizontal, then hold it tightly against the frames with a big cramp over the lot.

**Improvised drill**

A drill is now required which is long enough to reach the bolting face of the cylinder when put through the holes in the opposite side of the frame. Such drills are made commercially (I have some) but there is no need to buy one especially for the job. One can be made from a drill which has become too short for normal use, or from a broken and reground stub.

Just file a step about \( \frac{1}{4} \) in. long on the end of the Shank; file a corresponding step on the end of a piece of \( \frac{1}{4} \) in. silver steel or drill rod about 3 in. long, fit them together and braze the joint. Put this in the hand-brace, poke it through the bolt holes in both frames, and make countersinks on the bolting face of the cylinder.

Remove the cylinder, drill the countersinks with a No 40 drill, tap \( \frac{1}{8} \) in., 5 B.A., or corresponding A.S.M.E. thread, repeat the whole process on the other cylinder, then both can be erected, using hexagon-headed screws. Although these are out of sight they are easier to tighten up between the frames than slotted screws would be; but take care to avoid over tightening and stripping the threads.

**Erecting main rods**

The main or connecting rods can then be erected, putting the big-ends over the crankpins and securing with 3/32 in. \( \times \) 40 nuts home made from \( \frac{1}{4} \) in. hexagon steel rod with washers under them. The rods should pass through the openings in the guide yoke, and the crossheads can then be connected up to them by the pins through the holes in crosshead and the little ends and secured by 4 B.A. nuts.

The final job of this stage is to pin the crossheads to the piston rods. To set them in the correct position for equal clearance at each end of the stroke, take off the front cylinder covers. With the piston rod entered a little way in the crosshead boss put the crank on front dead centre, then carefully tap the piston, using a bit of soft metal rod between hammer and piston and holding the rod centrally so that it bears against the end of the piston rod until the piston is just \( \frac{1}{4} \) in. from the end of the cylinder.

Drill a No 43 hole through the crosshead boss and piston rod and squeeze in a \( \frac{1}{8} \) in. piece of 3/32 in. silver steel or drill rod. When the covers are replaced the assembly should be tested by turning the wheels by hand; there should be no tight places at any point in a complete revolution.

**To be continued.**

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*Method of erecting the guide bars*
Difficulties are sometimes encountered when trying to fit an eccentric-driven pump between the frames of a locomotive with an inside valve gear as there is usually insufficient space between the links for the end of the pump barrel and the gland. I got over that by specifying a long-barrelled pump in which the gland is clear of the links; otherwise it is of my standard pattern.

Normally it should operate without trouble for an indefinite period, but as it is the unexpected that usually happens (Ayesha's pump once failed through the body of a defunct ant becoming jammed between the suction valve and the seating !) this pump can be taken out, in an emergency, in a matter of minutes. It is attached to the combined guide yoke and pump stay by a circular flange and four screws; removal of these, unscrewing three union nuts and the gland nut, and pulling out the wrist pin, frees the whole issue.

The pump can be made from castings, or built up. A cast pump body comprises barrel, flange for attachment, and valvebox, plus a chucking-spigot on the valvebox, opposite the barrel. This should be not less than \( \frac{3}{8} \) in. dia.

Grip this in three-jaw and set the barrel to run as truly as possible. Centre the end with a size E centre-drill, then bring up the tailstock with a centre-point in it to support the barrel while same is turned to \( \frac{1}{4} \) in. dia. to fit the hole in the stay. Face off the flange with a knife tool, at the same setting.

Put about \( \frac{1}{4} \) in. of \( \frac{7}{8} \) in. \( \times \) 32 thread on the end, with a die in tailstock holder. Drill for about 2 in. depth with \( \frac{3}{16} \) in. drill, open out to a full \( \frac{1}{8} \) in. depth with \( \frac{3}{8} \) in. drill, and face the end so that the distance from flange to the end of the barrel is \( \frac{3}{4} \) in. Tip to beginners—the end is screwed before drilling so as to avoid squeezing in the end of the barrel.

One end of the valvebox should be cast a little longer than the finished length so that it can be gripped in the three-jaw, the free end being set to run truly. Face the end, drill right through with No 24 drill, open out and bottom to \( \frac{1}{8} \) in. depth with \( \frac{3}{16} \) in. drill and D-bit, tap \( \frac{1}{8} \) in. \( \times \) 32 and slightly countersink the end. Chuck a short piece of rod about \( \frac{1}{2} \) in. dia. in the three-jaw, turn down about \( \frac{3}{16} \) in. of it to \( \frac{1}{8} \) in. dia. and screw \( \frac{3}{8} \) in. \( \times \) 32.

Screw the tapped end of the valvebox on to this, then repeat operations on the other end after facing it off sufficiently to bring the length of valvebox to \( \frac{3}{4} \) in. The D-bit is not used for this end. Make a little chisel from a piece of \( \frac{1}{2} \) in. silver-steel or drill rod and nick the bottom of the hole with it, as shown in the section. Finally put a \( \frac{3}{16} \) in. parallel reamer through, which can be done by hand, with a tap wrench on the shank. Saw off the chucking-piece and trim with a file.

The built-up pump body can be made from bronze or gunmetal rod of...


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\( \frac{3}{8} \) in. dia. Chuck a length in three-jaw, face the end and form the recess exactly as described above for the cast job. Part off at 1\( \frac{1}{2} \) in. from the end, reverse in chuck and repeat operation. Drill a 7/32 in. hole in the side, midway between ends, breaking into the central hole between the recesses. Chuck the rod again, and part off a piece 1\( \frac{1}{2} \) in. long.

If the chuck is reasonably true, re-chuck with about 1/4 in. projecting. Screw 1/4 in. length with 1/8 in. x 32 thread, face the end, drill right through with 5/32 in. drill, and open out to 1\( \frac{1}{8} \) in. depth with 1/16 in. drill. Reverse in chuck and turn down 1/4 in. of the end to a tight fit in the hole in the side of the valvebox. Should the chuck be out of trueness, and a collet is not available, use a split bush held in the three-jaw when rechucking; I described how this is made in a previous instalment.

For the flange, chuck a piece of 1 in. rod—ordinary brass, or even screw rod—would do, as there is nothing to wear on the end of this drill 27/64 in. for about 1/8 in. depth and part off a 1/4 in. slice. Hold this in three-jaw, setting to run truly, then put a 1/8 in. parallel reamer through it so that it will fit tightly on the pump barrel, level with the end of the pipe.

Squeeze the pipe into the hole in the valvebox, with the flange tight up against it, and silver-solder the lot. Pickle, wash off and clean up, then put a 5/32 in. parallel reamer through the hole in the middle of the valvebox, to remove any burring and true it up. Heating for the silver soldering job will probably have distorted it slightly.

Tee and elbow fittings

These may be cast or made from rod. If cast, both pieces will have chucking spigots cast on, making them look like crosses. First drop a 1/8 in. rustless steel ball into the D-bitted recess, and seat it by putting a piece of brass rod on it and giving the end just one sharp crack with a hammer. Take the distance between the ball and the top of the valvebox with a depth gage. Chuck the tee casting by one of the side projections, the other to run truly, face off, centre deeply with a size E centre-drill, and drill right through with No 40 drill. Turn down the outside to 1/8 in. dia. and screw 1/4 in. x 40. Rechuck the other way about, in a tapped bush held in three-jaw, and turn and screw the other projection likewise, countersinking the hole with a centre-drill. Now chuck by top spigot, and turn the body part to 1/8 in. dia., facing the end to 1/4 in. from centre of screwed nipples.

Centre and drill No 30 until drill breaks into the cross-hole. Turn down the end to the depth indicated by the depth gage to 1/8 in. dia., and screw it 1/8 in. x 32. Take a 1/64 in. skim off the end, and cross-nick it with a fine file. Screw it into the valvebox so that when tight the nipples are parallel with the barrel. The chucking spigot could be parted off with the body held in three-jaw; but keep the tool clear of the nipples!

For the elbow, chuck by one of the projections, and turn, screw and drill the nipple as above, running the drill to the middle of the casting. Then grip by the other projection, face the opposite end, centre, and drill with No 24 drill until it breaks into the previously drilled hole. This part forms the suction-valve seating, so drill a 1/8 in. ball into the recess in the valvebox and take depth as before, turning the seating to the length indicated, to 1/8 in. dia., screwing 1/4 in. x 32.

Put a 5/32 in. parallel reamer down the centre hole as far as it will go, take a 1/64 in. skim off the end to true it up, saw or part off the chucking-pieces, and assemble as shown in the section. The ball should be placed on the seating and given just one crack as above, before screwing the seating right home. The nipple should be parallel with the barrel.

A built-up tee is made from a 1 in. length of 1/8 in. round rod with a 1/8 in. cross-hole drilled 1/4 in. from one end. This end is held in the chuck, while the other end is centred and drilled No 40 until the drill breaks into the cross-hole. The part that screws into the valvebox is turned, screwed and cross-nicked as described for the cast tee. For the nipples, chuck a piece of 1/8 in. rod, face, centre deeply and drill No 40 for 1/4 in. depth.

Screw 1/4 in. length with 1/8 in. x 40 die, part off at a bare 1/8 in. from the end, reverse in chuck, turn 3/32 in. of the other end to a tight fit in the cross-hole, squeeze in, and silver solder the joints. For a built-up elbow, turn the seating part from 1/8 in. rod held in three-jaw, as described for the casting, drilling to 1/4 in. depth. Part off at a full 1/8 in. from shoulder. Drill a 1/8 in. hole in the side, breaking into the one previously drilled, and in this, fit and silver solder a 1/4 in. x 40 nipple made as above described.

Pump ram

The ram or plunger is made from a 2\( \frac{1}{2} \) in. length of 1/8 in. round rustless steel or drawn bronze rod. This should fit the drilled pump barrel without any turning. Pump rams should fit easily, they do not need precision-fitting like steam pistons. Slightly bevel off one end and slot it to 1/8 in. depth by gripping it under the slide-rest tool-holder and running

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it up to a ¾ in. saw-type cutter on a stub mandrel in three-jaw; beginners should drill and ream the ⅜ in. hole for the wrist-pin before slotting.

Reverse in chuck, and turn the anti-airlock pin to ¾ in. dia. as shown. A well-known designer, now passed on, stated in his books that axle-driven locomotive pumps were not satisfactory. The reason why his were not was because they trapped air in the barrel, and this was simply compressed and expanded by the action of the pump ram.

I found that out when rebuilding a locomotive of his design for a friend, and completely cored it by fitting a new ram with an anti-airlock pin, as specified here, which renders air-trapping impossible.

The gland is turned from ½ in. round or hexagon rod. Chuck in three-jaw, face the end, and drill ⅛ in. for ⅜ in. depth. Open out for ⅛ in. depth with 13/32 in. drill and tap ⅛ in. × 32. Part off at ⅛ in. from the end, and slightly chamfer both ends. If round rod is used, file, saw, or mill four C-spanner slots as shown.

The best stuff for packing is a few strands of hydraulic packing which can be unravelled from a bit of the full-size braided material; failing that, use graphited yarn. Avoid hemp or flax; a plumber friend tried it, as he used it in his profession, and his pump ram soon grooved like corduroy.

The wrist pin is a piece of ¾ in. silver steel or drill-rod, a full ⅛ in. long, turned down at each end to 3/32 in. dia. for ½ in. length, screwed, and furnished with commercial nuts.

**Eccentric strap and rod**

The casting for the eccentric strap can be cleaned up on the outside with a file; centre-pop the lugs, and drill them right through with No 44 drill. Saw across them with a fine hacksaw, using the vice top as a guide to get the sawcut across the middle; then open out the holes in the plain half with No 34 drill, and tap those in the other half with 6 B.A. tap or its A.S.M.E. equivalent. Smooth off any sawmarks on the lugs, and screw the two halves together.

Chuck in four-jaw with the hole running as truly as possible. Face the side of the strap and bore out with an ordinary boring-tool to an easy fit on the middle eccentric. Enginemen of my time usually called eccentrics "tumblers." A piece of round rod turned to the same diameter as the eccentric, should be used as a gauge. The strap can then be reversed and held on the smallest step of the chuck jaws, for facing the opposite side.

If the step is too big, chuck the piece of rod (used as a gauge) in three-jaw and clamp the strap on the end of it by its own screws, using a strip of paper between strap and gauge for packing, so that the screws will hold it tightly enough to prevent its shifting while turning is in progress. The slot for the rod in the side lug can be end-milled as described for axleboxes, or by holding the strap in a machine vice (regular or improvised) on the lathe saddle and running it under a ⅛ in. saw-type cutter on an arbor between centres.

The rod can be milled or filed from a 1½ in. length of ¼ in. × ¾ in. mild steel, the larger end being inserted in the slot in the strap and secured by two ¾ in. rivets. It can be soldered as well if desired. Leave the drilling of the hole in the little end until the pump is erected.

**How to erect the pump**

Take out the combined guide yoke and pump bracket and drill four No 34 holes around the ⅜ in. hole for the pump barrel, in the position shown in the end views. Unscrew the pump gland and pull out the ram, then insert the pump barrel through the hole in the bracket from the angled side. Set it vertically, as shown in the end view; then turn the No 34 drill through the holes in the bracket, making countersinks on the pump flange.

Remove the pump, drill the counter-

sinks No 44 and tap 6 B.A. or the A.S.M.E. equivalent. Replace the pump and secure the flange to the bracket with four screws as shown in the plan view. The bracket, with pump attached, can then be replaced in the engine frames.

Put the eccentric strap on the middle tumbler and see that it is quite free to turn when the screws are tightened. Push the ram into the pump barrel as far as it will go, then set the little end of the eccentric rod in the slot. Hold it there, and with a bent-ended scriber put through the wrist-pin hole in the ram scribe a little circle on the end of the eccentric rod.

Remove the strap and rod, and make a centrepop on the rod 1/32 in. nearer the strap than the middle of the little circle. Drill this with a No 34 drill and ream ⅛ in., taking great care that the hole goes through dead square with the side of the rod. Try the wrist-pin in it and if it fits nicely without shake round off the eye, and caseharden it as described for the little-end of the main rods. After cleaning up, replace the strap and connect up the ram to the rod with the wrist pin.

The pump gland should not be screwed up tightly enough to require effort to turn the wheels by hand. It only needs to be tight enough to prevent leakage of water, and this can be done when the engine is first tried under steam.

In fulfilment of a recent promise, here is the picture of Bill Van Brocklin's 4-4-0. It was taken by Al Milburn, who certainly knows how to "shoot" little locomotives. The modernised version of Virginica should be very similar in appearance, and all being well I will give details of the necessary variations as the description proceeds.

Space prevents further details of Bill's engine this week but later I hope to say more about her. She has put up some fine performances on the Pioneer Valley Lines club track.

*To be continued.*

*Bill Van Brocklin's 4-4-0 locomotive, to which the modernised Virginia will bear resemblance*
L.B.S.C. describes the type of link motion fitted to most American locomotives before outside valve gears were adopted.

Chuck the piece of 1\(\frac{1}{2}\) in. rod that you used for a gauge when boring the straps; centre, drill No 30 for \(\frac{1}{8}\) in. depth, and part off a \(\frac{1}{8}\) in. slice. Drill the other centrepop on the jig with a No 40 drill, tap \(\frac{1}{4}\) in. and attach the disc to the jig with a \(\frac{1}{8}\) in. screw.

To use the jig, put the strap over the disc, rebate upwards. Put the fork over the pin and set the larger end of the rod in the rebate. The rods should be made full length at first, so that the end can be squared off to an exact length to fit the rebate. Then sweat the rod to the strap with solder, after which the job is removed from the jig, the three rivet-holes drilled No 52 and countersunk both sides; drive in little bits of \(\frac{1}{16}\) in. iron wire, rivet into the countersinks, and file flush.

The expansion links can be machined, but I certainly don't see any sense in spending hours to set up a job for machining when it can easily be done by hand in far less time. It would be a different case if there were a gross of links to be made, but as there are only two, proceed as follows. Coat a piece of \(\frac{1}{8}\) in. bright steel (ground cast steel for preference) with marking-out fluid and carefully

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Left and bottom left: Elevation and plan views of the link motion.

Below: End view of the r.h. valve gear erected.

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set out the outline of the expansion link as shown. Cut the slot first; then if you are unlucky enough to spoil it, there isn’t as much harm done as would be the case if the outline of the link had been cut out.

Drill a few 5/32 in. holes along the centre-line of the slot, as close together as possible, then run them into one with a rat-tail file. Then, with a watchmaker’s fine file, ease the sides of the slot until a piece of 3/8 in. silver-steel can be run from one end to the other easily but without shake. I use a 4 in. fish-bellied Swiss file for this job and have no trouble whatever. It just needs care, that’s all! Then drill and ream the two pinholes and file the link to outline.

The bar, or saddle, by which the link is supported, is made from a piece of 3/8 in. x 1/2 in. steel 3/16 in. long, with a recess 1/8 in. long and a full 3/16 in. deep, milled or filed in it. Round the ends and drill two No 52 holes in it as indicated, then clamp it to the end of a toolmaker’s clamp, put the 52 drill through the slot, and drive in two pins made from 3/16 in. iron wire. At 3/16 in. from the middle of the slot, drill another 3/16 in. hole and in this fit the lifting pin, which is turned from 3/16 in. silver-steel to the dimensions shown.

Jewels in the workshop

Squeeze the pip into the hole in the bar and braise or silver-solder the bar and pin. Use only the tiniest amount of brazing material to avoid getting any in the link slot—my few personal friends call these “jewellery jobs.” Before the redness has died away, quench the lot in cold water; this will harden the link and it will last the lifetime of the locomotive without appreciable wear.

A body who doesn’t fancy their skill at “jewellery” should countersink the hole in the bar on the recess side and rivet the pip of the lifting-pin into it, filing flush with the bottom of the recess. The holes at each end should be countersunk both sides, the pins riveted over and filed flush. No brazing is then required.

The dieblock, or link-block as they called it when Virginia was a young girl, is made from the same material as the link. Drill the hole first and file the outline of the block around it. The radius of the sides should, of course, correspond to the link slot, and it should fit easily without shake. Harden it right out by heating to red and dropping into water. The bolt is turned from round silver-steel or drill-rod a little over 3/16 in. dia. and the plain part should fit a reamed 1/8 in. hole exactly.

The bearing for the rocking-shaft is turned from a piece of drawn bronze or gunmetal, any size over 1/4 in. dia.

Chuck in three-jaw, face the end, centre off, and drill to 1 1/4 in. depth with a letter C or 15/64 in. drill. Turn down about 1 in. length to a tight fit in the 1/8 in. hole drilled in the frame, part off at 1 in. from the end, rechuck, and poke a 1/4 in. parallel reamer through. Drill and tap the top of the "arch" on the frame for a 1/4 in. or 5/32 setscrew, then fit the bearing into the hole with 1/8 in. projecting through the frame. Don’t fit the setscrew yet.

The rocking-shaft

The shaft is a 1/4 in. length of 1/4 in. silver-steel or drill-rod, one end being turned down for 1 in. length to 1/8 in. dia. and the other end to 1/4 in. length. The outer rocker can be made from 1/4 in. mild steel with a boss brazed on. I make all my bosses levers and arms in the same way. Mill off the rocker arm to the shape shown, drill small end No 34 and the large end 3/16 in. Chuck a piece of 1/8 in. round steel in three-jaw, face, centre, and drill No 40 for about 1/4 in. depth. Turn 1/4 in. of the end to a tight fit in the 1/8 in. hole in the arm and part off at 1/8 in. from the shoulder. Squeeze the pip into the hole in the arm and braise the joint. Simply coat with wet flux, heat to bright red, and touch the joint with a bit of 1/8 in. soft brass wire; quench in clean cold water. Clean up, then chuck the boss in three-jaw, and open out the hole with 1/8 in. drill. The end of the shaft should fit tightly in it.

Drill and tap the side of the boss for a 3/32 in. or 3/48 setscrew. This is used while valve-setting; when the final adjustment is made, the boss is pinned to the shaft. The pin for attachment of the valve-rod is a 1/8 in. in length of 1/4 in. silver-steel or drill-rod, with a bare 1/8 in. turned down to 3/32 in. dia. and screwed 3/32 in. or 3/36 in. Put on the thread to protect it while squeezing the pin into the hole in the end of the arm.

Dimensions of the rocking shaft

The inner rocker arm is made in the same way, but the boss is only 1/4 in. dia. and 1/8 in. long, the hole being reamed 1/32 in. to take the die-bolt. The hole in the larger end is drilled 1/32 in. Fit to shaft and braise the joint as before. If the hole in the arm is countersunk on the face, the brazing can be done from that side, and there will be no risk of the brazing material spreading on the shaft, as it will just fill up the countersink and can be filed off flush when the job is cleaned up.

Push the shaft through the bearing from inside and put the outer arm on temporarily. A countersunk oil hole can be drilled in the bearing close to the outside of the frame; or better still, a little fancy oil cup could be turned from a bit of 1/8 in. brass rod and screwed into a tapped hole in the bearing.

The valve rods, which look like baby coupling-rods or side-rods, are milled or filed up from 1/4 in. x 1/4 in. steel, and need no detailing.

Reversing or weighbar shaft

To make the reversing-shaft, or what British enginemen call the weighbar shaft, a piece of 1/4 in. silver-steel or drill-rod 3/32 in. long is required. Chuck in three-jaw and turn down 3/32 in. length to 1/8 in. dia. then reverse in chuck and turn down 3/32 in. length to same size. The two lifting arms are

Left: Components of the expansion link

Below: Dimensions of the reversing arm and lifting links
milled or filed from ¼ in. x ⅛ in. steel, the holes in the larger ends being reamed a tight fit for the shaft, on which they are mounted ⅛ in. apart, as shown.

The small ends must be dead in line and this is easily settled by putting a short piece of ⅛ in. silver-steel or drill-rod through the holes in both of them and leaving it there while the brazing job is being done, by the process described. Quench in water and clean up.

The reversing arm which fits on the end of the shaft and is operated by the reach-rod connected to the lever fitted in the cab (American enginemens call this a "Johnson bar") is made in the same manner as the outer rocker. A section of it, with dimensions, is shown separately. The two bearings which carry the shaft are milled, or swaged and filed from ⅛ in. x ⅛ in. mild steel. As the shaft must be quite level across the frames, it is essential that the holes in the bearings are central and exactly the same distance from the bottom so after forming them to shape, stand them side-by-side on the lathe bed or drilling-machine table, clamp temporarily together with a toolmakers' cramp, and drill and ream the holes together. After that, drill the screw-holes in the base and smooth off any burring, so that the bearings will bed down truly on the frame.

The lifting links can be made from ⅛ in. square steel. As they are so short, it isn't worth while building them up from ⅛ in. strip with brazed-on blocks for the forked ends. The easiest way to make them is to take a piece of ½ in. square steel about 3 in. long, first mark off and drill a cross hole with a No 34 drill about 5/32 in. from each end, then clamp the piece under the slide-rest tool-holder and form the slots by running the work up to a saw-type cutter on a stub mandrel in the three-jaw.

The centre part between the slotted ends is then milled, or swaged and filed away, like forming a coupling-rod. Drill another No 34 hole exactly 1 in. away from those in the slotted ends; cut of the two ends about ⅛ in. from the holes, and finish to shape shown, with a file.

**Tip for tyros**

For beginners' benefit I will repeat that they should always finish off rounded ends by aid of a button jig. This is simply a bit of round silver-steel about ⅛ in. long, the same diameter as the required end, with a pip turned on the end, a tight fit in the hole. Put the pip in the hole, grip the rod and button jig together in the bench vice, and file down the end of the rod until the file touches the jig.

If this is first hardened by heating to red and dropping in water, the file won't cut it, so you cannot file the rod out of shape. It is a good wheeze to make a dozen or so of different sizes; they come in handy. A ¼ in. parallel reamer put through the holes in both ends of the lifting links, completes the job.

**How to erect the valve gear**

First pin the forks on the eccentric rods to the expansion links with pieces of ⅛ in. silver-steel or drill-rod, which should be a press fit in the holes in the forks, but free in the holes in links. File flush each side. Be careful to assemble each pair as shown in the plan and elevation drawings; rods together, forks crossed, and straps right way up with the oil-holes on top. Put the straps over the eccentric sheaves and put the screws in. The expansion links should now lie against the inside rockers.

Put a die-block on a die-bolt and, with the upper part of the link opposite the hole in the rocker arm, insert the bolt, pushing the die into the link slot. Secure the bolt with a nut at the back of the rocker as shown in the end view; when this is tight against the shoulder on the bolt, the die and bolt should still be free to turn.

Put the brackets on the ends of the reverse shaft and set them on the frames so that the centre of shaft is 1 in. behind the centre of rocker shaft (see plan). Make certain that the shaft is dead square across the frames and the longer end of shaft is on the right; then attach brackets to frame by two 3/32 in. or 3/48 screws in each, locating the holes for tapping, through those in the brackets.

The lower ends of the lifting links are then slipped over the pins in the link bar and secured by nuts; the upper ends are attached to the lifting arms by bolts made from pieces of ⅛ in. silver-steel or drill rod, turned down to 3/32 in. at each end, screwed, and nutted. The valve rods are attached to the valve-spindle forks in the same way. We will set the valves after fitting the reach-rod and lever.

**Simple substitution**

Beginners who are doubtful about fitting up the link motion as described could easily substitute a simple loose-eccentric gear. On a continuous track where constant reversing is not needed, the loose-eccentric gear with fixed early cut-off is perfectly satisfactory. Only one eccentric is used for each cylinder, the end of the rod being directly connected to the inside rocker-arm.

The eccentric is left free to turn on the axle, a ⅛ in. pin being fitted in the widest part midway between axle and edge, driven by a stop-collar. This is a disc of metal ⅛ in. dia. and ⅛ in. thick, cut away to half its thickness for half its diameter less ⅛ in. A setscrew attaches it to the axle. All being well, I will give a drawing of this arrangement when describing the valve-setting.

*To be continued.*
It is always a ticklish job to adapt a modern type of valve-gear to a locomotive not designed for it, as British Railways found out when starting to rebuild the Bulleid Pacifics. Before I got out a satisfactory arrangement for Virginia I tried several different layouts, all more or less satisfactory, but the one illustrated is easiest to make and erect.

In the case of our Virginia it involves the minimum of alteration to the components in the original design. It will be necessary to offset the valve spindles by \( \frac{1}{2} \) in. Cut off the central boss on the steam chest, and at \( \frac{1}{2} \) in. away from it toward the outside drill a \( \frac{1}{16} \) in. hole. Turn up a new boss from \( \frac{1}{8} \) in. rod with a spigot \( \frac{1}{4} \) in. long to fit the hole. Drill and tap this for the spindle and gland, squeeze it into the hole and silver-solder it.

**Lap-and-lead movement**

The gland should be made with a \( \frac{1}{8} \) in. lead instead of \( \frac{1}{4} \) in. Cut the boss off the valve buckle and silver-solder on a fresh one \( \frac{1}{4} \) in. more toward the edge, as shown in the dotted lines in the plan drawing. Then we can go ahead.

A wider valve crosshead or fork will be required and this is made in the same way as that previously described, but to dimensions given. When chucking in the four-jaw to turn, drill and tap the boss, set it \( \frac{1}{4} \) in. out of centre, which will result in the boss being turned to the offset shown.

The combination lever is made from \( \frac{1}{4} \) in. square mild steel. The slot at the top is made by clamping the piece of rod under the slide-rest toolholder at centre height and feeding up to a saw-type cutter \( \frac{1}{4} \) in. wide on a stub mandrel in the chuck. All the forked ends in the gear are formed in the same way. The side of the rod can be milled or filed away to the shape shown and the ends rounded as described for rounding ends last week in the notes on link motion. The union link is just a midget version of the combination lever made from \( \frac{1}{4} \) in. square steel.

The drop arms which are attached to the bottom of the crosshead can be filed or milled from \( \frac{1}{4} \) in. steel, the odd cutouts coming in handy. Use a No 32 drill for the hole, and squeeze in it a pin which is just a piece of \( \frac{1}{4} \) in. silver steel with the end turned down and screwed for the retaining nut. Put a nut on the threads while the pin is being pressed in to protect them from damage. The arm is attached to the bottom shoe of the crosshead by three \( \frac{1}{4} \) in. or 1/72 screws—or better still, if the crossheads have not yet been made, put just one screw to hold the arm temporarily in place and braze it while brazing the shoes to the centre section.

**Expansion link and radius rod**

The expansion links can be made from \( \frac{1}{16} \) in. steel (cast ground kind for preference) by the process described for the Stephenson links. To make the trunnion, chuck a piece of \( \frac{1}{8} \) in. square steel in the four-jaw, set to run truly and turn a full \( \frac{3}{16} \) in. length to \( \frac{1}{16} \) in. dia. squaring off the end. Turn this to a gauge, drill a No 14 hole in a piece of metal about \( \frac{1}{8} \) in. thick and ream \( \frac{1}{8} \) in. then turn the trunnion to fit it exactly, without the slightest vestige of shake. Part off at \( \frac{1}{16} \) in. from the shoulder, file the flange slightly as shown in the side view of the link, then set it exactly in the middle of the slot and braze it in position. Be exceedingly sparing with the brazing material in order to avoid getting any in the slot.

To hold the trunnion flange to the link while brazing use one of the rough home-made cramps which I

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*Left: Arrangement of the Walshaerd gear*

*Below: The combination lever*
The expansion link

recently mentioned, with one jaw on the end of the pin and the other against the opposite side of the link. Apply the brazing material (brass wire or coarse-grade silver-solder), to the outside of the joints. Don’t put it close to the slot. If the heat is right, it will flow between the flange and link and leave the slot perfectly clear.

To make the die block chuck a piece of \( \frac{1}{2} \) in. square silver steel truly in the four-jaw. Face the end, centre, and drill about \( \frac{1}{2} \) in. depth with No 33 drill. Pin-drill a recess \( \frac{1}{8} \) in. dia. and \( \frac{1}{16} \) in. full depth, part off at \( \frac{1}{8} \) in. from the end and repeat the process for the other die block. Ream the holes \( \frac{1}{16} \) in., then file two opposite sides to an exact sliding fit in the slot of the expansion link. Finally, heat to medium red and quench in cold water. The die pin is turned up from \( \frac{3}{8} \) in. silver steel to the dimensions shown and needs no detailing. Slightly reduce the head to an easy fit in the recess of the die block.

The radius rod is made from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. mild steel, and is a simple rolling or filling job, the slot being formed in the same way as those in the expansion links but being straight they are much easier. Be careful to get the right amount of offset, with the eye parallel with the rod otherwise the latter will bind on the pin and cause friction and wear at the top of the combination lever. The eye can be casehardened with advantage by the process described for the little ends of the connecting-rods. A casehardened eye working on a “natural” silver-steel pin takes a long time indeed to wear to any appreciable extent. In my own engines they run for years.

Brackets for expansion links

Now we come to another little alteration. Instead of the ends of the guide yoke being made as for the link-motion engine, they will need extending to carry the brackets for the Walshaert’s links. If builders have not made the yoke yet this will not cause any extra work; but if they have the most satisfactory course will be to cut out a fresh yoke.

Lay the original one on a piece of steel long enough to include the extension and run a scriber all round it. This will save a lot of marking out. Then, at each end, add the extra bit shown in the accompanying drawing and cut to the complete fresh outline. Each bracket is then cut from \( \frac{1}{4} \) in. steel to the shape and dimensions in the drawing and brazed to the ends of the guide yoke.

My pet way of doing this sort of job is to drill two No 51 holes in the edge of the bracket and attach it temporarily to the edge of the yoke by two \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. steel screws. The yoke is then laid in the brazing tray, a fillet of wet flux laid along the joint, the whole lot heated to bright red and a piece of soft brass wire applied. This melts and runs into a clean fillet between the yoke and bracket. Quench out in water, clean up, and file off the screwheads. The result is a neat and strong component.

For the bushes chuck a piece of \( \frac{1}{8} \) in. bronze or gunmetal rod in the three-jaw, face the end, centre, and drill No 14 for about \( \frac{1}{4} \) in. depth. Turn \( \frac{1}{8} \) in. length to \( \frac{1}{8} \) in. dia. and screw \( \frac{1}{2} \) in. \( \times \) 32 or 40. Part off at a full \( \frac{1}{8} \) in. from the shoulder. Reverse in the chuck, skew the end true and run a \( \frac{1}{8} \) in. parallel reamer through the hole. The nut is made from \( \frac{1}{8} \) in. hexagon rod and the bushes are inserted with their heads on the inside of the brackets. If the link trunnions fit these bushes properly, without shake, the wear will be negligible. My experience is that one long bearing is more resistant to wear than two short ones; provided that the fitting is correct.

The eccentric rod

The return cranks, or eccentric cranks, as they are usually known in America, can be made from \( \frac{1}{4} \) in. \( \times \) \( \frac{1}{4} \) in. mild steel in the same way as the crosshead arms, the pin being also similar. If the driving crankpins have not yet been made turn the outer ends to \( \frac{1}{8} \) in. dia. and don’t screw them; the hole in the larger end of the return crank should fit very tightly. If they have been made and the ends screwed, tap the return cranks to fit.

Reversing shaft

The reversing shaft is a piece of \( \frac{1}{8} \) in. round steel squared off to \( \frac{1}{2} \) in. length, with \( \frac{1}{16} \) in. of each end turned down to \( \frac{1}{8} \) in. dia. The reversing arm has a plain hole in the end and is pinned to the shaft at \( \frac{1}{8} \) in. from the end. Drill a No 43 hole through boss and shaft and squeeze in a pin made from a \( \frac{1}{8} \) in. length of 3/32 in. silver steel.

Both the lifting arms carry a little die block at their smaller ends. Chuck a piece of \( \frac{1}{8} \) in. square silver steel truly in the four-jaw; face, centre, and drill No 30 for \( \frac{1}{8} \) in. depth. Countersink the end and part off a \( \frac{1}{8} \) in. slice, repeating the process. The screws are turned up from \( \frac{1}{8} \) in. round silver steel held in the three-jaw, the plain part being an easy fit in the die block and of such a length that when the screw is tight home in the lifting arm, the die block is still free.

Before attaching, ease the opposite sides of each die block sufficiently to allow it to slide freely in the slot in the radius rod. Pin one lifting arm to the end of the shaft which carries the reverse arm and set the two arms at right angles. This end of the shaft goes on the right-hand side of the engine. The other arm is not fitted.

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until the shaft is erected.

The brackets are made in exactly the same way as described for those carrying the shaft for the link motion, but to the dimensions given in the reproduced detail drawing.

How to erect the valve gear

Screw the valve crosshead on to the spindle, with the offset away from the frame as shown in plan. Put the lower end of the combination lever in the fork of the union link and pin it with a piece of ¼ in. silver steel squeezed through the holes in the fork filed flush each side. The end of the combination lever should be quite free in the fork.

Put the small end of the radius rod in the fork at the top of combination lever and pin through the lower hole in similar manner. Insert the trunnions on the expansion links in the bushes in the brackets, then put the top of each combination lever between the wide jaws of the valve crossheads, the ends of the union links fitting over the pins in the crosshead drop arms. Attach the combination levers to the valve crossheads by pins made from ½ in. silver steel turned down at each end to 3/32 in. screwed 3/32 in. or 3/48 and furnished with nuts. When the nuts are tight against the shoulders the bolt should still be quite free. Don’t forget to put nuts on the crosshead pins.

The radius rods should now lie close to the expansion links. Lift each to the upper end of the slot and attach the die block to it through the slot in the link. Put the die block on the pin and screw the pin home in the tapped hole in the radius rod; the head of the pin should have a sawcut in it for this purpose. When right home the die block should be flush with the sides of link, but quite free to turn on the pin.

Put the two brackets on the reversing shaft, then add a collar, which is just a ½ in. slice of ⅜ in. round rod with a ¼ in. hole through it. Put on the other lifting arm, setting as near as you can by eye, parallel to its opposite mate on the other end. Now set the assembly on the frames as shown, with the centre of the shaft at 1 ½ in. behind the centres of link trunnions. See that the shaft is dead square across the frames and screw the brackets to the tops of frames as described for the link motion job.

The lifting arms should now be lying against the inner sides of the radius rods, the die blocks being in the straight slots. Set the right-hand one (which has already been fitted to the shaft) so that it is supporting the radius rod with the die block in the middle of the expansion link, and temporarily clamp the shaft in that position. Then adjust the left-hand lifting arm until exactly parallel and the left-hand die block in the middle of the other expansion link. This ensures that both sides are always exactly “in step.”

The lifting arms can then be pinned to the shaft, likewise the collar, which is run up against the left-hand bracket and prevents any side movement of the shaft towards the right. The shaft should be free to turn, but should not have any side play.

Put a return crank on the end of the main pin, with its own pin approximately ½ in. from the centre of axle. To get exact setting, set the expansion link in such a position that the die block can be run up and down the slot in it without any movement of the valve spindle and temporarily fix it there. Put the main crank on front dead centre and take the distance from the centre of the hole in the link tail—to the centre of the return crankpin—with a pair of dividers. Shift the main crank to back dead centre and check with the dividers as set. If the distance between the centres is not the same, shift the return crank to half the difference and try again.

When the measurement tallies on both dead centres, the return crank is correctly set and the distance between the divider points is the exact length between the centres of the eccentric rod. Pin the return cranks to the main crankpins by drilling a No 53 hole through the thickness of the crank and pin, squeezing in pins made from ⅛ in. silver steel. The eccentric rods can then be made in the same process as the other rods to the measurement between the centres as indicated by dividers.

The crankpin end is bronze-bushed, with the flange of the bush on the straight side of the rod. The forked end is attached to the link tail by a similar bolt to that at the top of the combination lever. The valve gear should work perfectly freely when the wheels are turned by hand and reverse with the links at any angle. I will give instructions for fitting the valves, together with those for doing the same job on the Stephenson link motion.

To be continued.
The use of separate cylinders instead of combined cylinder and smokebox saddle castings with steam and exhaust ways cored in—a difficult job in 3½ in. gauge—calls for separate steam and exhaust pipe connections.

The simple arrangement illustrated is the same as I use on my own outside cylinder engines. It has proved easy to make and fit and perfectly satisfactory in service. The layout is the same both for steam and exhaust, the only differences being dimensions, the addition of an oil check valve to the steam pipes and the fittings at the tops of the vertical pipes.

The exhaust should be fitted first. Chuck a piece of ½ in. square brass rod in the four-jaw and set to run truly. Face the end, centre, and drill to 1 in. depth with 7/32 in. drill, and part off at ½ in. from the end. Re-chuck, and run a ½ in. x 40 tap right through. In the middle of one of the facets drill a 19/64 hole and ease it with the “lead” end of a 3/16 in. parallel reamer until the end of a 5/32 in. tube will fit tightly. Cut a piece 3 in. long, put about 2/5 in. of 5/32 in. x 32 thread on the end, and fit it in the hole, silver soldering the joint.

Cut two pieces of ⅛ in. copper tube of about 20-gauge, about 1½ in. long, face off to a dead length of 1 ¼ in. in the chuck, screwing one end for ⅛ in. length and the other for ⅛ in. length, with ¼ in. x 40 thread. Make two locknuts to fit from ⅛ in. hexagon brass rod, and two more from ½ in. rod, with a plain hole; all about ½ in. wide. The plain ones are silver soldered to the pipes at ½ in. from the short-screwed ends. The tapped nuts are screwed on the longer-screwed ends to the end of the threads and the pipes and then screwed into the centrepiece until they touch in the middle.

Smear a little plumber’s jointing (Boss White or similar) on the threads at the shorter ends, hold the assembly with the ⅛ in. pipe vertical between the cylinders opposite the exhaust holes, and screw the pipes out of the centrepiece into the cylinders, using a spanner on the smaller nuts. Put another taste of plumbers’ jointing on the threads between the locknuts and centrepiece, then screw both locknuts tightly up against it.

The blast nozzle is made exactly the same as a union nut, but the end is tapered off as shown to allow the blower ring (to be described later) to fit over it.

Steam pipe assembly

The centre may be built up, or a casting, in which case a chucking piece will be cast on opposite the boss for the oil check valve. To build up, saw the tee shown in the plan from a piece of ⅛ in. x ⅛ in. brass bar. Chuck in the four jaw with the head of the tee running truly, centre, drill right through with 5/32 in. drill and tap ⅛ in. x 40. Then drill a 15/64 in. hole right across the stem of the tee (see plan) and drill a ⅛ in. hole up the stem, breaking into the tapped hole as shown by the dotted lines. Plug the end of this with a slice of brass rod about ¼ in. thick, driving in tightly. Open out one side of the cross hole to take a ⅛ in. pipe and fit a piece 1½ in. long in it; this should have a few ⅛ in. x 40 threads on the end.

Chuck a piece of ⅛ in. round brass rod in the three jaw, turn a ⅛ in. pipe on the end—a tight fit for the hole opposite the pipe—and part off ⅛ in. from the shoulder. This will form the body of the oil check valve. Squeeze it into the hole, then silver
solder the pipe, boss and plug at one heating. Pickle, wash off and clean up, then chuck the assembly by holding the pipe in the three jaw. The boss opposite it should run truly. Centre this, drill it \(\frac{1}{4}\) in. until the drill breaks through into the communicating hole, open out to \(\frac{1}{8}\) in. depth with \(\frac{1}{8}\) in. drill and tap 7/32 in. x 40.

For the valve seating chuck a piece of \(\frac{1}{4}\) in. hexagon rod in the three jaw. Face off, turn \(\frac{3}{8}\) in. length to 7/32 in. dia. and screw 7/32 in. x 40. Centre deeply and drill to \(\frac{1}{8}\) in. depth with a No 44 drill; part off at \(\frac{3}{8}\) in. from the end. Reverse in the chuck, turn and screw as above for 5/32 in. length, put a 3/32 in. parallel reamer through the hole and face off about 1/32 in. to form a true seat for the ball, which should be \(\frac{1}{16}\) in. dia. rustless steel. Seat it with a tap as described for the pump balls and assemble as shown with a light spring made from 28 or 30-gauge wire (hard bronze for preference) to keep the ball seated on the suction stroke of the pump. Uninitiated folk would hardly credit that these little balls would float, but they will—in the thick cylinder oil—if given half a chance.

To make the steam pipe union chuck a piece of \(\frac{1}{4}\) in. hexagon rod in the three jaw, face, centre deeply, and drill to \(\frac{1}{8}\) in. depth with a \(\frac{1}{8}\) in. drill. Turn down \(\frac{1}{8}\) in. length to \(\frac{1}{8}\) in. dia. and screw \(\frac{1}{4}\) in. x 32. Part off at \(\frac{1}{8}\) in. from end, reverse in the chuck, open out the centre hole for \(\frac{1}{16}\) in. depth with 7/32 in. drill and tap \(\frac{1}{4}\) in. x 40. Chamfer the corners of the hexagon. This fitting is not permanently attached until the smokebox is fitted.

The cross-steam pipes are made from \(\frac{1}{8}\) in. copper tube and fitted up in exactly the same way as described for the exhaust pipes. All dimensions are shown on the drawing.

**Mechanical lubricator**

Old-time American enginemen would have been mighty glad if their tea kettles had been provided with this gadget, especially the firemen. Part of their duties when running on a down grade or other place where the engine was coasting with steam off was to go along the running board with a can of melted tallow and pour a quantity into the tallow cups on the steam chests. A pleasant job on a dark night with half-a-gale blowing and raining or snowing! This was how the nickname of "tallowpot" came to be applied to American firemen. Drivers rejoiced in the nickname of "hoggars."

To make the oil tank cut a piece of 18-gauge sheet brass \(\frac{1}{4}\) in. long and \(\frac{1}{4}\) in. wide, bend to a rectangle measuring \(\frac{1}{2}\) in. x 1 in. and stand it in the brazing pan on a piece of 16-gauge brass about \(\frac{1}{2}\) in. x \(\frac{1}{2}\) in. Silver solder all around the bottom and along the joint, which should be in one corner. Pickle, wash and clean up, file the projecting parts of the bottom flush with the sides, drill a \(\frac{1}{8}\) in. hole in the middle of the bottom and another at \(\frac{1}{8}\) in. from the top on the centre line of one of the shorter sides. The lid can either be flanged over a former plate of the...
same size as the tank top, or made from a piece of 18-gauge brass 3/8 in. × 1/4 in. with a 1/4 in. nick taken out of each corner and 1/4 in. of each edge bent up to form a tray. The corners can be silver soldered, but use very little, otherwise there will be a hole in each corner and the lid will not go on to its full depth.

The pump stand is made from a piece of 3/8 in. square brass rod faced off at each end to a dead length of 1 3/4 in. Chuck truly in four jaw, centre, drill 5/32 in. for 3/16 in. depth and tap 1/8 in. × 40. File or mill the 3/16 in. rebates shown in the drawing, then in the middle of the lower recess, at 13/32 in. from the bottom of the stand, drill a No 41 hole. At 1/16 in. from the top drill a 5/32 in. hole, and tap it 1/8 in. × 40. Both these must go through dead square with the face, so use either a drilling machine or the lathe—not a hand brace.

Pin-drill out the back of the smaller hole to 3/16 in. dia. for 1 3/4 in. depth. The ports are set out at 1/4 in. from the pivot hole at 1/4 in. centres. The right-hand port is drilled right through into the tapped hole in the bottom of the stand. The left-hand port is drilled in to 1/16 in. depth only and a groove is milled or chipped with a little half-round chisel (easily made from a bit of 1/8 in. steel ground away to half its diameter, or diagonally, and hardened and jumpered) from the port to the bottom of the stand.

For the pump cylinder square off a piece of 3/16 in. rod to 3/16 in. length, make a deep centre pop on it at 1/16 in. from one of the facets, chuck in the four jaw with the pop running truly and drill right through with a No 34 drill. Open out to 5/32 in. depth with a 3/16 in. drill and tap 7/32 in. × 40. Put a 1/8 in. parallel reamer through the remains of the hole. For the gland chuck a piece of 3/16 in. brass rod, face, centre and drill No 34 for 1/4 in. depth. Turn down 1/4 in. of the outside to 7/32 in. dia. and screw 7/32 in. × 40. Part off at 3/32 in. from the shoulder, reverse and chamfer the corners and make a 1/8 in. locknut to suit from the same size rod.

To make the check valve chuck a piece of 1/16 in. round rod, face the end, turn down 1/16 in. length to 3/32 in. dia. and screw 7/32 in. × 40. Part off at 1/8 in. from the shoulder. Reverse in the chuck, centre, and drill right through with a No 43 drill, open out and bottom to 1/16 in. depth with 1/16 in. drill and D-bit and tap 7/32 in. × 40. Put a 3/32 in. reamer through remains of hole. Drill a 5/32 in. hole in the side and silver solder a 7/32 in. × 40 union nipple in it.

For the cap chuck a bit of 1/16 in. hexagon rod, face, centre and drill 3/32 in. × 40, with a No 30 drill; turn down a full 1/8 in. of the end to 7/32 in. dia. and screw 7/32 in. × 40. Part off at 1/8 in. from the shoulder. Seat a 1/8 in. ball in the recess and assemble with a spring similar to the one in the upper valve.

See that the port and cylinder faces are perfectly clean and attach the cylinder to the stand; place the assembly in the tank and screw the check valve loosely into the stand through the hole in the bottom of the tank. Put the bearing through the hole in the tank side, put on the locknut, enter the bearing in the tapped hole at the top of the stand and screw in until the head of the bearing touches the side of the tank; then run the locknut back and tighten it against the inside of the tank. Tighten up the check valve under the tank. Enter the crankpin into the hole at the top of the pump ram, hold the crank at the opposite end of the bearing between the pump ram and the stand, and clamp the crank into the bearing and screw home into the crank.

The crank lever is filed up from 3/32 in. × 3/4 in. steel and drilled as shown. The paws are filed up either from cast steel and hardened or from mild steel and case hardened. The (Continued on page 538)

Left: Mechanical lubricator
Below: Rocking shaft; oil check valve; stationary pawl assembly; crankshaft and bearing
Making a crankshaft

I have rough turned a four throw crankshaft for an outboard i.c engine (all journal diameters 1 1/2 in.) Material used: flame cut mild steel billet. I intended having the rough turned shaft case hardened—finally ground, but have been advised that case hardening is unnecessary. The suggested finish is normalising and grinding. I am aware that motor crankshafts are normally produced from hard specification steel and are not hardened, but I feel rather doubtful as to a soft ground finish being adequate on mild steel.—H.R.P., Enfield, Middx.

If this is a relatively low-efficiency engine for which neither the speed nor the bearing load has to be extremely high, a mild steel crankshaft, unhardened and running in white metal or soft bronze bearings, would be fairly satisfactory—though an alloy steel having greater resistance to wear would, of course, be an advantage. It would be very risky to attempt case-hardening a mild steel crankshaft, owing to the great danger of distortion and possibly cracking as well. For normalising mild steel, it should be uniformly heated to a red heat and allowed to cool naturally.

Working by hot air

I fail to see how a hot air engine works and would be obliged if you could enlighten me on the subject. —R.E., Birmingham.

Several types have been made, working on different principles. But the most common type is the closed circuit engine as originally invented by Stirling. In this type of engine the air is alternately heated and cooled, causing it to expand and contract. This is done by using a closed chamber, one end of which is heated and the other end kept as cool as possible. Inside the chamber is a moving piston, or, strictly speaking, a displacer which does not touch the sides, but it is used to displace the air from one end of the chamber to the other. A communicating pipe from this chamber leads to the working cylinder, which has a piston alternately forced out and drawn in by the changing pressures. The displacer piston is usually timed about 90 deg. out of phase with the power piston. Numerous articles on the hot air engine have been published in MODEL ENGINEER, with diagrams showing working principles.

Inside-cylinder castings

I am proposing to build an 0-6-0 tender locomotive in 2¼ in. gauge with inside cylinders. Can you inform me where I can obtain castings for the inside cylinders?—P.M.J., Horsforth.

Drawings and all necessary castings and materials should be obtainable from Kennion Bros (Hertford) Ltd, 7, Greenways, Hertford, Herts.

Virginia

Continued from page 526

The outer rocker is connected to the side of the valve-spindle fork, the pin of which is made long enough for this by a short connecting rod bent to the angle shown in the plan. The inner rocker is connected direct to the ratchet arm by a 3/32 in. rod screwed at both ends. The rocker end carries a brass boss filed up from ⅛ in. × ⅛ in. brass rod and screwed on. The other end carries a fork made from ⅛ in. square steel—made in the same way as the valve-spindle forks—and attached to the ratchet lever by a 9 B.A. or 2/56 screw. The exact length of this rod is easily obtained from the actual job with lever and rocker arm hanging straight down. The pawl should ratchet one tooth at each revolution of the driving wheels when the valve gear is in the notched-up position. If it does not do this when the fork is connected to the bottom hole of the ratchet lever try one higher up. In the case of the Walschaerts gear the back end of the driving rod is connected to the wrist pin of the feed pump, the pin being extended sufficiently to allow this to be done without the rod fouling the side of the pump barrel. It should be bent to clear the underside of the guide yoke.

To be continued.
In Virginia's Day the "pole" lever was practically the only means provided on American locomotives for "hooking-up" and reversing. Power reversers had not been invented and there were only a few isolated examples of the wheel-and-screw type.

The kind of "Johnson bar"—as it was called by the old American enginemen—most commonly in use was a very long lever pivoted to the frame, standing almost as high as the top of the boiler. The upper part passed between a couple of narrow sector plates plentifully provided with notches, and the lever carried a trigger and latch to engage with them. One end of the sector was carried by a support on the frame, and the other on a bracket attached to the boiler.

The valve gear was usually balanced by a coiled spring on the weighbar shaft (called a "rumper" shaft in the United States) enclosed in a case at the left-hand end; but like those on the earlier C class goods engines on the L.B. and S.C.R. the springs frequently broke and then, despite the leverage, it took the engineman all his time to get the lever over.

The lever I am specifying for Virginia is typical of the old Johnsons, but both ends of the sector are supported from the frame, and the lever is pivoted in a slotted bracket screwed to the top bar. The locking gear is also rather more substantial, a copy of the full-size arrangement being far too flimsy for 3½ in. gauge and unsuitable for serious work.

**Sector and supports**

The two sector plates are cut from 3/32 in. or 13-gauge soft mild steel sheet. Do not attempt to bend them from strip, but mark them out and saw and file to outline. Note that the back part is 3/16 in. longer than the front, as the latch is at the back of the lever. Don't cut any notches, but drill a No. 33 hole at each end as shown.

The supports or legs are made from 1 in. x 1 in. strip steel. Before bending the lugs at the bottom, heat to red and let cool slowly, otherwise the metal may crack. A rebate is filed or milled at each side of the upper end to act as a spacer for the sector plates and support them. The sectors are first attached to the supports by 3/16 in. iron rivets or pieces of 16-gauge iron wire driven through. Set them parallel, then braze the joints; just apply a little wet flux, heat to bright red and touch the joints with a piece of thin soft brass wire. Quench in water and clean up. Drill a No. 30 hole in each lug for the fixing screws.

Continuing the instructions for building this old-time 3½ in. gauge American locomotive, L.B.S.C. describes a component that not only reverses the engine, but provides a good test of the driver's strength.

The lever can be machined from solid or built up. If the former is preferred chuck a piece of 1/4 in. x 1/4 in. mild steel truly in the four-jaw and turn the grip; the pole can then be milled or file to shape and the end rounded and drilled for pivot bolt. To build up, use the same kind of steel for the flat part of the lever, but turn the grip from round steel and brace it on. If the engine has link motion drill the hole for the reach-rod pin at 1 1/8 in. above the pivot hole —for Walschaerts gear, at 1 1/8 in. above the pivot hole. Use a No. 44 drill and tap 6 B.A. or 4/36. The pin is turned from 3/8 in. silver steel or drill rod, screwed into the lever and lock-nutted.

The bracket can be filed from a piece of 1/4 in. x 1/4 in. mild steel. The slot can be cut by gripping the bracket in a machine vice on the lathe saddle and running under a 1/4 in. saw-type cutter on an arbor between centres, or by end milling. The lever should be a snug fit. One side of the hole for the pivot bolt or fulcrum pin is countersunk. The pin is turned from 3/8 in. silver steel or drill rod to the dimensions given. Note that the bracket must not pinch the lever when the bolt is screwed right home and nutted.

The trigger is filed up from 3/8 in. x 3/8 in. steel and slotted by the same manner.

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*Left: Reversing lever or Johnson bar*

*Below: Sector plates and sector supports*
Means as used for the bracket. The latch is also a plain job of filing, \(\frac{1}{2}\) in. \(\times \frac{3}{8}\) in. steel being used. I keep all my offcuts in a small box and usually find a bit for jobs such as the one just described which needs little filing or milling. The latch block is a \(\frac{3}{4}\) in. piece of \(\frac{1}{2}\) in. \(\times \frac{3}{16}\) in. steel, slotted as shown.

My pet way of making it is to mill the slots in the end of a longer piece of rod of correct section, which is easy, as you have plenty to grip in the machine vice on the milling machine or the lathe. Then the rod is chucked in the four-jaw and the slotted piece parted off to correct length.

**How to Erect**

First screw the lever bracket to the frame in the position illustrated, using two \(\frac{3}{4}\) in. or 5/36 screws running through the clearing holes in the bracket into tapped holes in the frame bar. Next put the lever between the sector plates and stand the lot with the lever in the slot in the bracket. Put the bolt in—see that the lever is exactly vertical—then attach the lugs at the bottom of the supports to the frame, making sure that the lever is central. Turn up two \(\frac{1}{16}\) in. pins from \(\frac{3}{4}\) in. round steel, leaving the heads a full \(\frac{1}{2}\) in. long and slightly grooving them. With one of these pins the latch to the trigger, leaving the joint quite free to move.

Now put the latch block over the latch and try the assembly against the lever, setting the latch block so that it just clears the top of the sectors. Mark the exact position, then remove the lever and attach the latch block at the marked spot with the other headed pin. Attach the other end of the trigger to the lever, using a piece of \(\frac{1}{8}\) in. steel wire for a pin; drill the hole in the lever with No. 51 drill, so that the joint is perfectly free.

Hook a light spring—wound up from 30-gauge steel wire around a \(\frac{1}{8}\) in. mandrel—over the heads of the pins in the trigger and latch block. Replace the lever between the sector plates and put the pivot bolt and the reach-rod pin in. Don't cut any notches yet.

The reach rod is made from \(\frac{1}{8}\) in. \(\times \frac{1}{2}\) in. mild steel and is a plain filing or milling job, the fork at the front end being made by brazing on a little block of steel—same section—and forming the fork as described for valve-gear forks.

Check off the exact length of the rod between centres of holes as follows. Set the lever exactly vertical and file a \(\frac{3}{4}\) in. notch in the sector, so that the latch will drop into it and hold the lever in that position. A key-cutter's warding file will do the trick. Next set the die-blocks in the middle of the links, either Walschaerts or link motion, and temporarily fix the reverse arm so that they stay there. Now measure from the centre of the hole in the reverse arm to the centre of the reach-rod pin in the lever—and that is the dimension required.

When marking out the rod don't forget to allow for the bends; I simply bend a bit of copper wire to the shape of the rod and then straighten it out, which gives me the exact length of the steel rod needed. The forked end is attached to the reverse arm by a similar bolt to those in the valve gear, viz. a bit of \(\frac{1}{8}\) in. silver steel or drill rod turned down at each end to \(3/32\) in. screwed and nutted.

Push the lever forward until the link-motion die blocks are in line with the fore-gear eccentric strips; note the position of the latch and file a notch in the sector to suit. Pull the lever back until the die blocks are in line with the back-gear strips and file a notch at that end. The other notches are then filed at \(\frac{3}{16}\) in. spacing. For the Walschaerts notches push the lever forward as far as it will go and turn the wheels by hand in a forward direction. The lever will move back slightly to allow for die-slip. File the notch to suit that position, repeating the operation for the reverse direction. Space the other intermediate notches as described. Avoid cutting the notches too deep; the latch should still be

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**The reach-rod**

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engaging in the latch block when bottoming in the notches in the sector.

Take off the steam chest covers and put the lever in full forward gear. For link motion take off the back half of the fore-gear eccentric strap and adjust the setscrew so that the eccentric can just be moved on the shaft by hand. Replace the strap, then turn the wheels by hand in a forward direction and watch the valve. If the ports do not open an equal amount at each end of the valve travel, adjust the outside rocker until they do, then tighten the setscrew.

Now put the main crank on the front dead centre and turn the eccentric in a forward direction until the valve first closes the port, starts to reopen it, and the edge of the port appears against the valve as a thin black line. Turn the wheels until the crack is on back dead centre, when the back port should show a similar crack. If it does not the valve is a shade too long; take a tiny bit off both laps and try again. The exhaust cavity must remain exactly in the middle. When the crack appears on both the front and back dead centres the valve is set correctly and the eccentric setscrew can be permanently tightened.

Tyre pump test

Repeat the operation on the other eccentric, with the lever in back gear, turning the wheels backwards; then finally both centres on the other cylinder. Test by connecting it to an air supply—a motor-tyre pump coupled to the steam pipe with a temporary adapter is quite satisfactory. It should be impossible to hold the wheels by hand when pumping hard.

The Walschaerts gear is easily set; simply put the lever in mid-gear and adjust the rocker until the black line of the port shows at each end of the valve travel. The gear itself will attend to the rest if made to instructions. On either gear the rocker can, if desired, be permanently pinned to the shaft after the valves have been correctly set, as there is no need to alter it again.

The loose-eccentric valve gear is the only type of valve gear that gives even port openings at both ends of the cylinder in both forward and reverse directions. The eccentric strap and rod are made as described for one of the link-motion eccentric assemblies, but the rod is fitted into a slot cut in the lug of the strap, as illustrated. The smaller end has no fork, simply a plain eye which fits over the pin in the end of the inside rocker.

To keep the eccentric in line with the rocker a distance-piece is required between the tumbler and the axlebox. Chuck a piece of \( \frac{3}{4} \) in. round rod in the three-jaw, face the end, centre and drill to about \( \frac{1}{4} \) in. depth with \( \frac{3}{4} \) in. drill. Part off two \( \frac{5}{32} \) in. slices, one for each eccentric. To make the stop collars for driving the eccentrics chuck a piece of \( \frac{1}{4} \) in. round rod; face, centre and drill with \( 31/64 \) in. drill to about \( \frac{3}{8} \) in. depth. Part off two slices \( \frac{1}{4} \) in. wide, rechuck each, skim off any irregularities left by the parting-tool and put a \( \frac{1}{8} \) in. parallel reamer through. Drill a No 40 hole in the thickness and tap it \( \frac{1}{4} \) in. or 5/36 for a setscrew.

Opposite this cut away a segment 5/32 in. deep to within \( \frac{1}{4} \) in. of the centre; this can be sawn and filed or milled by the process described for axleboxes. Drill a No 32 hole in the eccentric—in the thickest part opposite the axle hole—and squeeze in a \( \frac{1}{4} \) in. pin made from silver steel or drill rod, leaving \( \frac{1}{8} \) in. projecting. The hole in the eccentric must be reamed large enough to allow the eccentric to turn freely on the axle without being slack.

The distance-piece goes next to the axlebox, then the eccentric is fitted and the stop collar adjusted so that the eccentric can turn freely but not move endwise. The shoulders, formed by the edges of the collar where the segment was cut away, engage with the pin and drive the eccentric—in either direction as desired.

To set the valves correctly take off the steam chest covers, and turn the wheels by hand, watching the valve. The stop collar may be in any position. If the ports do not open equally at each end of the valve travel, adjust the outside rocker until they do. Next put the crank on front dead centre and turn the stop collar in a forward direction until the valve first closes the front port, then starts to open it again. As soon as the crack shows tighten the setscrew in the stop collar and turn the wheels to back dead centre, when the crack should appear at the back port. If it does not, shorten the valve slightly—keeping the cavity in the middle—and try again.

Curing minor faults

When the crack shows at both ends on the dead centres turn the wheels backwards. If the crack still shows on the dead centres, the setting is satisfactory for both directions. If the crack appears before dead centre, the shoulder of the stop collar needs a little taking off it where it makes contact with the pin in the eccentric. If the crack does not appear until after the crank has passed dead centre, the shoulder needs building up a little at the contact point with the pin—this can be done by soldering a little bit of brass of requisite thickness to the shoulder.

The thickness required can be ascertained by setting the crank on the dead centre, then advancing the eccentric itself (not the collar) until the crack is seen. The thickness of the packing piece required will be indicated by the distance between the shoulder on the collar and the pin in the eccentric.

With the size of eccentric shown the travel of the valve will ensure a cut-off that will provide easy starting at the same time giving low steam consumption without affecting the power of the engine—and on a continuous line the absence of a means of reversing from the cab is no drawback whatever.

To be continued.
In those far-off days when Virginia's full-size sisters scorned up the grades of the Blue Ridge Mountains, and raced merrily along the Trail of the Lonesome Pine, the kind of boiler favoured by most American locomotive makers was the wagon-top type; the reason for the nickname is obvious.

British locomotive engineers had long recognised the advantage of ample steam space over the firebox and one of the earliest examples was Edward Bury's Liverpool, which was tried out on the Liverpool and Manchester Railway. She had a D-shaped firebox casing with a big hemispherical top. Rothwell, Rennie, Stephenson and others built locomotives with similar boilers, and other versions appeared, one of which was the hay-stack pattern such as I described for the Tisfield Thunderbolt.

The American engineers obtained their steam space by raising the firebox casing much higher than the boiler barrel and connecting it to the barrel with a steeply-inclined cone, and finished the job by adding a huge dome. Virginia has both; but the way I have arranged things, it will be quite easy for any beginner to build.

The barrel is parallel, right from the smokebox to the firebox casing, which is made in the manner I usually specify for a Belpaire firebox, except that the top is rounded instead of being flat. The throatplate has a large hole in it, into which the barrel fits. The joint is hidden, and the correct shape of the boiler maintained by simply forming the cleading plate into the shape of the cone, and filling up the space, if desired, with felt or asbestos flock. A thin cleading plate is fitted over the firebox casing to hide the stayheads; none is needed around the barrel.

An outside in bushes will be required to accommodate the big dome, and this calls for a variation in the shape of the crownstay girders. They are, however, just as easily made and fitted. Two blind bushes will be needed in the top of the barrel to carry the studs for bell and sandbox. A tapped bush will be required at each side of the barrel to carry the check valves for boiler feeds.

No bushes will be wanted in the backhead as this will be thick enough to allow the fittings to be screwed straight in. The well-known saying that "things are not always what they seem," applies to this boiler; despite its ancient appearance, it is actually as modern as any that I have described in these notes, and will be a fast and highly-efficient steamer, one of the contributing features being the multiple-element super-heater.

The boiler barrel is a piece of 16-gauge seamless copper tube squared off at each end in the lathe to a length of 9 1/2 in. This is plenty thick enough; the bursting pressure of a seamless tube of this diameter and gauge provides an ample safety margin, and with materials at present price levels there is no need to use unnecessarily heavy stuff.

Tip to beginners—put a disc of wood, or a wheel casting, or anything of right diameter in one end of the tube and grip it in the three-jaw; if you try to hold it without anything inside it will fly out as soon as turning is begun. To support the end being turned, if you haven't a steady, screw two pieces of wood together in the shape of an L.

Fretsaw out a hole 3 1/2 in. dia. in the vertical part at lathe centre height and bolt or clamp the horizontal part to the lathe bed so that the barrel-

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Longitudinal section of the boiler

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tube will project through about ¼ in. or so. The end can then be faced off easily with a roundnose tool set crosswise in the rest; a drop of cutting oil helps matters considerably. Two forming plates will be needed for throatplate, backhead, and ends of firebox. Some folk manage with hardwood formers, but for really good flanging metal ones are much to be preferred. With a good hacksaw, plus a drop of cutting oil, the formers can be cut from ¼ in. mild steel or iron plate with surprising ease, especially if an obliging mate, such as an interested kiddy, can be persuaded to hold the oil-can and feed oil on to the saw-blade while you cut. As a hacksaw won’t cut round sharp corners, saw as close to the marked lines as possible and finish with a file. Round off the edge on one side of the former.

Since the firebox former is also used as a jig for laying off the tube holes, mark them out very carefully, as shown, and drill them with No 30 drill. Next, lay the throatplate former on a piece of ¼ in. (10-gauge) sheet copper and draw a line all round it ¾ in. away, except at the bottom. Cut round the line with a piercing-saw which is just a glorified fretsaw; again, a drop of cutting oil is a wonderful help. Alternatively, use a hacksaw with a blade about 32 teeth per inch, sawing as close to the line as possible and finishing with a file.

Soften the copper by heating to red and plunging into clean cold water, then clamp the former and copper together in the bench vice and beat down the projecting edge of the copper on to the former. Note to beginners—if the copper “goes hard” under the hammer re-anneal it at once before proceeding or it will crack; also, don’t forget to have the side of the former with the rounded edge next to the copper.

File off any raggedness, also file the flange all round to clean up and remove hammer marks; don’t be afraid of making plenty of file scratches as they form an excellent key for the brazing material. Then, on the centre line and 2½ in. from the top of the flanged plate, make a centrepin and from that strike a 3½ in. dia. circle with dividers.

Either cut out the piece with a piercing-saw (I do jobs like this with a Driver jigsaw, a wonderful time-and-labour saver) or drill a circle of holes all round just inside the line, break out the piece and clean up with a file until the barrel fits tightly. A similar plate can be flanged up for the backhead while on the job, but don’t cut any hole in it.

For the wrapper sheet, a piece of 13-gauge (3/32 in.) copper 42 in. wide will be needed. To get the exact length, and avoid waste of costly material, run a piece of soft copper wire or lead fuse wire right round the throatplate flange; this, when straightened out, will give the exact length needed. If the sheet copper is hard, soften as previously mentioned and then bend it to the shape of the throatplate. The round back can be bent over the barrel, as drawn tube is usually hard and true, and the sharper bends at the lower part can be formed over a piece of bar held in the bench vice with about 5 in. projecting from the side.

Soft copper bends very easily by hand pressure only. Clean all round inside one end, then attach the shaped wrapper to the throatplate flange with a few 3/32 in. copper rivets, to hold it in position while brazing. Insert the barrel into the hole and carefully line it up with the sides and top of the wrapper sheet. It should fit very tightly and project ⅛ in. through.

May I reassure beginners that there is nothing to be afraid of in brazing...

**VIRGINIA...**

Extreme left: The front end of boiler

Left: Section view through the firebox
up a locomotive boiler; it is just a question of knowing how (these notes tell you), having the necessary materials and plenty of heat.

A good brazing forge can be improvised with an old tray and a piece of sheet iron bent into a curve so that it will stand up at the back of the tray, which should be covered with a layer of small coke or blacksmith's breeze. The tools required are a blowlamp (5-pint for this size of boiler) or equivalent air-gas blowpipe blown by fan or foot-belows; large and small tongs; piece of \( \frac{1}{2} \) in. iron wire about 2 ft long, pointed one end.

Materials needed are some flux, which may be Boron compo or powdered borax mixed to a paste with water, and some easy-running brazing strip, plus some coarse-grade silver solder.

To clean the work after brazing, a pickle-bath is advisable. All I ever used was a wooden box big enough to take the boiler, lined with thin sheet lead. The pickle consists of diluted sulphuric acid, one part acid to about 16 of water. Stale accumulator acid will do, weakened by adding three times its bulk of water.

Stand the boiler shell in the coke, barrel upwards, and pile more coke round the firebox until nearly level with throatplate; put some inside as well. Cover the joints with wet flux. See that the blowlamp has plenty of paraffin in the tank, and get it going strong.

Heat the whole bag of tricks until the surrounding coke glows red and the flux starts to fuse. Concentrate the flame on one bottom corner and when it glows bright red apply the end of a length of brazing strip, which should be dipped in the flux. If the heat is sufficient the end of the strip will promptly melt and run into the joint. Move the flame very slowly along, feeding in more strip as the metal glows bright under the flame, and before you realise it you'll be up to the barrel.

Carry straight on—the flame will have to play on the double thickness of metal—for a little longer so as to bring the lot to the melting temperature of the strip, but perseverance does it and the molten strip should run into both the joint between throatplate flange and wrapper, and between barrel and throatplate, forming a fillet as shown by the black triangles in the drawing.

Go very slowly right round the barrel, until you reach the place where the wrapper and barrel part company. Pause here, then restart at the other bottom corner, repeating tactics as before. This time, when the barrel is reached at the point where you left off, give an extra blow up to make certain that the strip is properly melted and a perfect junction is made, then turn inwards and finish the

(Continued on page 608)
MAY BE BOUGHT

Sir — With reference to the paragraph Novel Chuck Backplate [Readers' Hints, October 4] may I point out that the type of backplate described and illustrated can be obtained from Charles Taylor (Birmingham) Ltd., Birmingham 3, who offer it as a standard pattern in a number of sizes from 4 in. dia. upwards for use with their self-centring chucks.

These chucks incidentally are actuated by a spiral rather than by a scroll, and are common enough in machine shops but rarely if ever seen on a model engineer's lathe. This may be due to their weight since the smallest (4 in.) weighs about 9 lb. without backplate.

It provided the bolt hole spacing is somewhere near the same, there seems no reason why these Taylor backplates should not be used with the conventional three- and four-jaw chucks that are usually fitted to model engineers' lathes.

F. SEWARD.

FAIR'S FAIR

Sir,—May I point out to Mr. Ballenby, [Postbag, October 8] that I did not claim the contractor's engine as an Emmett type, I said it might delight Roland Emmett. The caption on the photograph was not mine.

Your correspondent says this engine is better proportioned than the G.W.R. How does he know? He does not, for the reason that he can have no conception of what prototype, if any I had in mind. If I told him it was an exact scale copy of a locomotive in use upon the Twadlington Steam Tramway he would be none the wiser.

I said I am not a model engineer, and I mean just that. Mr. Ballenby would do well to read several articles upon the subject of scale and non-scale model locomotives which were from the pen of the late E. W. Twinning in MODEL ENGINEER and Locomotive Magazine 1939-40. I endorse all the writer said.

Before making so free with his opinions upon other people's work, what about a few photographs of some of the engines he has built.

Fair is fair.

Bishop's Stortford. G. WOODCOCK.

VIRGINIA

joint between the underside of the barrel and the throatplate. When arriving at the other end, have a good final blow-up at the junction point to make certain of an unbroken fillet of melted strip and if any bubbles appear, due to the flux "boiling up," use the pointed wire to break them up.

Let the job cool to black, then carefully immerse it in the pickle bath, taking care to avoid getting splashed. The garden rake makes a good "reacht-rod." Leave it in for about 20 minutes, then fish it out, well wash under the domestic tap, and clean up with a handful of steel wool, or some scouring powder. Never handle dirty copper if it can possibly be avoided; besides, clean copper makes a much better job of the subsequent operations.

Firebox and tubes

Both ends of the firebox are marked out on 13-gauge copper, and flanged in exactly the same manner as the throatplate, so repetition is needless. Before taking the firebox tubeplate off the former, put the No. 30 drill through the copper plate, using the holes in former as guide. After removing, open out the three upper holes with a 3/4 in. drill and ease with a 3/4 in. reamer until the end of a 3/4 in. tube will fit very tightly. Open out the rest with 23/64 in. drill and ease with 3/4 in. reamer to take a 3/4 in. tube tightly. Countersink all the holes on the side opposite flange.

Next, fit the firehole ring to the doorplate. The ring is simply a 3/4 in. length of 13/4 in. copper tube 1/4 in. thick, with a step turned at each end, 3/8 in. long and 1/4 in. deep. Soften it, then squeeze it oval in the bench vice until approximately 1 1/4 x 1 1/4 in. Lay it on the doorplate, with its centre 1 1/4 in. from the top. Scribe a line all round it, cut out the piece, fit one of the flanges of the ring in the hole on the side opposite flange, and beat down the projecting lip until the plate is tightly gripped against the shoulder of the ring.

The sides and crown of the firebox are in one piece, made from 13-gauge sheet copper in exactly the same manner as the outer firebox wrapper. The exact length of the piece of copper, which is 43/4 in. wide, is ascertained with a bit of wire first run round the flange and then straightened, as before. The corner bends can easily be made over a piece of 3/4 in. round bar held in the bench vice with about 5 in. projecting from side of jaws.

Well clean both ends of the piece of copper before riveting it to the tubeplate and doorplate flanges. Use 3/32 in. copper rivets spaced about 1 in. apart. These rivets are solely for the purpose of holding the sides and crown close to the flanges of the end plates while brazing and play no part whatever in keeping the boiler to withstand pressure. Even 3/16 in. rivets would do, but the joints must be close between flanges and sheet.

The crown stays are cut to shape shown, the single ones from 13-gauge copper and the double from two pieces of 16-gauge copper riveted back to back, all the lot being riveted to the firebox crown with 3/32 in. rivets at 3/4 in. centres. Don't forget to clean the contact surfaces before riveting.

The firebox can then be brazed up, using precisely the same technique as described for the shell. Do the doorplate end first, and run a fillet right round the firehole ring. When doing the tubeplate be careful to avoid playing the full force of the blowlamp on the metal between the tube holes or you'll suddenly find that there is one big ragged hole where there were a lot of little round ones, and the job, thus far, will have to be repeated. Copper is expensive! To do the crown stays, stand the firebox right way up in the coke, making sure the joints are well fluxed, and before applying the brazing strip run a little of the coarse-grade silver-solder under all the flanges. This not only seals the rivets, but helps the brazing strip to flow easily, and it also makes a neater joint. Pickle, wash off, and clean up as before, and the firebox will then be ready for tube fitting.

FOWLER IN AFRICA

Sir.—You might be interested in the enclosed picture of roller 16632, built by Fowler in 1926 and still in use by a road building contractor in the Nolsen district of N. Rhodesia. The roller is in the charge of an African driver.

Bristol. W. B. HUGHES.

MODEL ENGINEER 608 25 OCTOBER 1956
Continuing instructions for building the boiler, the author describes alternative methods and adds some items of interest from personal experiences

Continued from 25 October 1956, pages 595—597

By L.B.S.C.

A

N AMERICAN correspondent, after passing some amusing comments on the recent suggestion that my boilermaking methods should be submitted to a committee of welding experts, asks if I personally recommend the methods of brazing and bronze-welding described in the various textbooks when dealing with the use of oxy-coal-gas and oxy-acetylene blowpipes. As others have written to me on the same subject, maybe a little dissertation on the matter may be opportune, with special reference to Virginia's boiler.

Being a seeker after information, with the firm belief that many ideas are better than one, I have read several books on this subject, but they all dealt with bronze-welding and brazing methods applied commercially; such as the plumber's work, jointing copper pipes, attaching fittings and so on; or else with the making of copper utensils for various purposes. The various processes described are of course perfectly sound; but I have found that certain variations are needed in the case of building small locomotive boilers.

The oxy-coal-gas blowpipe is in effect a more powerful version of the air-gas blowpipe, blown by foot-bellows or fan, and is much quicker in action, but the same technique can be used. For example, when doing the first brazing job on Virginia's boiler, viz. the joints between barrel, throatplate, and firebox wrapper, the assembly is just placed on the coke or breeze, barrel upwards as before, but there is no need to pile any around it, nor put any inside.

Apply plenty of wet flux and heat the whole evenly until the flux has dried out and started to glaze. Then concentrate the flame on one bottom corner, but watch it carefully because the extra power of the pale-blue flame heats it to red in a matter of seconds and if the flame plays on one spot too long it will melt the copper. As soon as it glows bright red apply the brazing-strip, or Sifbronze rod (I use ½ in. Sifbronze No. 1 rod for a job like this), which will not only melt but run like water, filling up the interstice between wrapper and flange. Then move the flame slowly along, feeding in the brazing material as you go; keep dipping it into dry flux.

Carry on right round the barrel, feeding in the brazing material to the two joints between barrel and throatplate, and throatplate flange and wrapper, so that an unbroken fillet runs right from the barrel to the edge of the wrapper sheet, looking just like one joint. Continue right to the bottom of the throatplate, then go back and do the part remaining under the barrel. With the powerful flame, it is simplicity itself to make sure that the joint at each end merges perfectly with the one around the barrel.

Textbook method

The advice given in the textbooks for using an oxy-acetylene blowpipe in bronze-welding is to flux the joint, then concentrate on one point, and when that glows bright red apply the Sifbronze or other welding-rod in the flame and drop one spot in the joint. Then move the flame along a little and repeat process, dropping another spot of welding-metal in the joint so that it overlaps the first.

This process is continued until the end of the joint is reached, and it should then present a rippled surface. This method is quite all right for "straight" single joints, such as the joints between the firebox sides and crown, and the flanges of the tube and door plates. I have done plenty this way, and they have been perfectly successful. I find, however, that the job can be done far quicker by running instead of rippling the metal on boiler joints, and I do this by using a far bigger blowpipe tip and a lower gas pressure than recommended by the writers of the bronze-welding textbooks.

For example, one of the experimental jobs I have in hand has a boiler similar to Maisie; I finished this last May. The barrel and wrapper are in one piece, being made from a piece of 43 in. × 14-gauge seamless copper tube, split and opened out at the firebox section. It has the usual short throatplate, bronze-welded in by the ripple method; but I am everlastingly running against the clock, and when I made the firebox and combustion-chamber assembly I decided to get a move on.

I used a tip just twice the capacity of the recommended size, with a lower gas pressure, and got a big diffused flame. The joints were well flared, with the material sold by the Sifbronze people, and by aid of the big diffused flame I was able to heat enough of the firebox at each "bite," to make the Sifbronze run like ordinary easy-running brazing strip and penetrate the joint. It also ran clean around the firehole ring.

For this kind of antic the copper has to be a little hotter than for ordinary brazing, but it is still well below burning point, and the resulting joints are extraordinarily strong and leakproof for-ever-and-a-day. The tubes and foundation-ring joints were done with the same blowpipe tip and lower gas pressure, using Johnson-Matthey's B-6 alloy, and the result was one of the neatest and strongest boilers I have ever made.

During the period of the M.E. exhibition the managing director of the Myford Engineering Co., Mr Cecil Moore, along with Mr A. J. Reeves, paid me a friendly call and they closely examined the boiler, so they can confirm the above.

The above information may be
useful to builders of Virginia who have oxy-acetane or oxy-acetylene equipment. I recommend the ripple method for the ends of the firebox as there is no risk of burning or melting out the metal between the tube holes if the smaller flame is used and kept well away from that part. The other joints I will deal with as we come to them, if all's well.

Tubeplate and tubes

An iron or steel former 3 1/2 in. dia. will be needed for flanging up the smokebox tubeplate; an old wheel casting, discarded chuck back or anything similar would do, as it comes to no harm. The tubeplate itself requires a disc of copper, either 3/32 in. or 1/8 in. thick, and about 4 1/2 in. dia. This is softened, and flanged over the former, as described for the other flanged plates.

Chuck in three jaw, flange outwards, and turn on the rugged edge of the flange. Next, chuck by the inside of the flange on the top step of the outside jaws, and turn the outside of the flange to a tight fit in the boiler barrel.

Clamp the firebox former to the side of the tubeplate opposite flange, with the lower row of holes in the position shown in the illustration of the front end last week, making sure that the former is central. Drill through the tubeplate, using the holes in the former to guide the drill, then open them out as described for the firebox tubeplate, but this time run the reamer in to full depth of flutes and countersink the holes on both sides of the plate. Lastly, drill and tap the holes for stay nipples and steam flange.

Three 1/4 in. x 20-gauge flues, and 12 of 3/8 in. dia. x 22-gauge (our American friends call them all flues, irrespective of size) will be required. These are square off in the lathe to 9 in. length. Most lathes have a 1 in. hollow mandrel, so the small tubes will go through the chuck far enough to be faced off without support.

The outer ends of the larger ones can be supported by an improvised L-shaped wooden stay—as mentioned for the boiler barrel—while being faced off. If beginners try to face them without a support they will soon come to grief! Before removing from the chuck, clean the ends with coarse emerycloth.

In one operation

Old hands at the game can silver solder the whole nest in at one heating. Insert them in the holes in the firebox tubeplate so that they just project through about 1/8 in. Put the smokebox tubeplate temporarily on the other end to act as a support and spacer while the silver soldering is being done. Set the tubes parallel with the firebox sides and at right angles to the tubeplate.

Set the assembly in the brazing pan with the tubes vertical, pile coke or breeze all around to the level of the tubeplate, and put some inside to within 1 in. of it. Cover the whole surface of the tubeplate around and between the tubes with wet flux; make sure that it touches every tube. Cut some little squares of best-grade silver solder or Easy-flo and drop them among the tubes.

Now carefully heat up the firebox tubeplate until the surrounding coke glows red, keeping the flame off the tubes as much as possible; then direct the flame partly outside and partly inside the box, the idea being to heat both tubeplate and tube ends evenly to a dull red. The little bits of silver solder will then melt and flow around the tubes in the countersinks.

Apply some more, direct from the strip, to the outer tubes. Keep up the heat until quite sure that the silver solder has flowed around every tube and formed a fillet; molten silver solder flows readily wherever the surface has been fluxed. Let it cool to black, but before dumping the assembly in the pickle, pull off the smokebox tubeplate and make the outer ends of the tubes red hot. This will soften them ready for expanding. Leave the assembly in the pickle for about 15 minutes before washing off.

Beginners or otherwise inexperienced coppersmiths should do the job in two stages; first, the three big tubes and the upper row of smaller ones, using method described. After pickling the first lot insert the rest of the small tubes and repeat operation. The reason will be apparent when doing the job! I should not recommend using oxygen equipment for the above as the thin tubes are very easily burned, or even melted by the powerful flame. It is safest to use either blowlamp or air-gas blow pipe, with a big diffused comparatively mild flame.

First stage of assembly

Cut a piece of 1/4 in. square copper rod to fit between the flanges of the throatplate at the bottom; this forms the front section of the mudring. Clean it well, also the inside of the throatplate at the bottom, and rivet it in place with two 3/4 in. rivets to hold it while fitting the firebox. Now lay the boiler shell on its back and slide in the firebox and tube assembly. Incidentally it would be an advantage to cut the big hole for the dome bush before starting assembly, using the method described for the big hole in throatplate.

Bend the front end of the firebox against the section of mudring, setting it midway between sides, and clamp it there with a toolmakers' cramp. The flanges of the crown stays should touch the top of the wrapper for their full length. Put a
cramp at the end of each, to hold them in place, and then drill a No 1 hole through wrapper and flange about 1/8 in. from the end. Remove cramp and rivet flange to wrapper with a 3/32 in. roundhead copper rivet.

For supporting the rivets while doing this job, put a piece of iron or steel bar in the bench vice with sufficient projecting from the side of jaws to reach the full length of the flanges. There is no need to countersink the holes in top of wrapper sheet as the cleading plate will hide the rivets. Serve the second flange in same way then drill four more holes through wrapper and each flange at the same spacing and put rivets through the lot. The rivets farther away from the end can easily be inserted with a notched strip of metal.

Now drill four No 1 holes through the throatplate, piece of mudring, and firebox tubeplate, and rivet up. Pieces of 3/32 in. copper wire can be used if long rivets are not available; fancy heads are not needed. Next, clean around the front end of the barrel and insert smokebox tubeplate, flange first, making sure that it is quite vertical.

Drive it down until it almost touches the tube ends then line up each tube and its respective hole with a wooden skewer or similar object, finally driving the tubeplate farther in until the tubes project through about 1/8 in. and the tubeplate is square with the barrel. The ends of the tubes may then be expanded into the tubeplate by driving a drift into the end of each.

The tapered end of a worn-out or broken taper-shank drill makes an excellent drift or one can be turned from steel of suitable diameter to approximately the same taper, and polished with emery cloth. Smear the drift with grease, insert in the tube end, and give it two or three good cracks with a hammer, which will expand the tube into close contact with the hole. A hit sideways will free it if it sticks.

Next stage

Cut a hole the size of the barrel in a big tin lid, small tray or something similar. Stand the boiler, barrel upwards, in the brazing pan, put the tray over it with the barrel projecting about 3 in. through the hole, and prop up the tray with a brick or some other fireproof object at each side.

Pile some small coke or breeze around the barrel to the level of the tubeplate. Plug each tube with a wad of asbestos flock or string. Put a layer of wet flux all around between edge of tubeplate and barrel and round each tube.

First heat the whole boiler end until the coke glows red, then concentrate on one point farthest away from tubes and heat to begin to flow. Apply the strip of brazing material and when it melts and starts to flow in between tubeplate flange and barrel work your way right round as previously described.

Next, blow direct on the tube ends and heat them and the surrounding part of tubeplate to medium red. The tubes will not burn, although they are thin, as the asbestos wads protect them. Apply a strip of best-grade silver solder or Easyfuse direct to each tube, and if the heat is right this will melt readily and flow right around in a neat fillet.

Don’t “boil” solder

Note to beginners—if an oxy-coal-gas or oxy-acetylene blowpipe is used for the circumferential joint, direct the flame more to the outside of the barrel than on the tubeplate as otherwise the projecting edge of the barrel may start to melt. Don’t use it at all on the tubes, as apart from the risk of burning off or melting the tube ends, too much concentrated heat causes the silver to go to “boil” and turn spongy and porous. The heat of a blowlamp or air-gas blowpipe is ample for this job.

Lift off the holed tray and lay the boiler on its back with the firebox shell overhanging the edge of the pan. Put one of the bricks on the barrel to prevent it tipping up. Smear a good layer of wet flux at each side of each crownstay, where it is riveted to the wrapper sheet, and lay a strip of silver solder in the flux.

Heat the lot to dull red by blowing partly outside and partly inside. As soon as the silver solder starts to melt direct the flame underneath, full force, on what would be the top of the boiler when right way up. As the copper and the flange riveted to it grows brighter the silver solder will run and “sweat” right through between flange and wrapper, making a sound joint and sealing the rivets.

Let the job cool to black, then carefully immerse it in the pickle, standing well clear of splashes, as the boiler is now getting heavy and may slip off the rack, or whatever you are using as a reach rod. Leave it in for about 20 minutes then wash off and clean up as before.

Another tip to beginners: don’t use any of the silver solder substitutes on boiler joints that are not close-riveted as they usually have a phosphorous content and are very brittle and liable to crack open under stress.

● To be continued.
For those building this old-style American engine who wish to give their loco a more modern appearance, L.B.S.C. gives details of an alternative boiler

Continued from 1 November 1956, pages 630—632

The job of arranging a modern-looking boiler to suit the old-fashioned chassis of Virginia proved easier than adapting the more modern valve gear. As there was, of course, only the same available space for the firebox, owing to the limitations of frame and axles, I decided to utilise the original arrangement of firebox and tubes and fit them into a larger straight-topped boiler shell.

This scheme of things worked out very well, as the drawing shows clearly, and it also eliminated the need for further detailed instructions in building up the firebox and tube assembly.

The principal difference in the construction is the method of making up the boiler shell, and this one is easier, if anything, than the wagon-top pattern. The barrel is a piece of seamless copper tube as before, but 4½ in. dia. and 3/32 in. (13-gauge) thick, squared off to 9 in. length by the process previously described. In one end of this fit a copper "piston-ring" ½ in. wide, which can be made by bending a strip of 16-gauge copper into a ring which will fit tightly inside the barrel tube. Insert for half its width, and fix it with about six 3/32 in. copper rivets.

The wrapper

The firebox wrapper is made from a piece of 13-gauge sheet copper 4½ in. wide and approximately 16½ in. long. Soften this and bend it round the barrel, opening out at the bottom to 24 in. wide, as shown in the drawing. Fit this to the projecting part of the "piston-ring" and rivet it in position likewise. The space between the bottom of the barrel and the bottom of the wrapper is filled in by a short throatplate which can be flanged up over the lower part of the backhead former.

The former is made from § in. iron or steel as before, and no separate drawing is needed for the size. Just make it 3/32 in. narrower all round (except at the bottom) than the inside measurement of the shaped wrapper. The short throatplate is flanged over for ½ in. at each side, but not at the curved top, which just butts against the end of the barrel.

No flange is needed here, because the pressure inside just tends to force the throatplate into closer contact with the barrel. The projecting part of the "piston-ring" should be filed away flush with the barrel for the full width of the throatplate. The side flanges of the throatplate can then be riveted to the sides of the wrapper and the assembly brazed or bronze-welded.

For brazing, proceed as described for the wagon-top boiler shell, but while the boiler is upright braze both sides, from the bottom to the junction of barrel and throatplate; then go along the underside of the barrel from one side of the throatplate to the other, running in a good fillet of brazing material, as shown by the black triangle in the drawing.

Now lay the boiler on its side and play the flame direct on the outside of the "piston-ring" joint; this, by the way, should have been well fluxed before starting on the brazing job. As soon as it reaches medium red, run in a little coarse-grade silver-solder. This will penetrate right through the joint and seal the rivets.

Keep up the heat and then apply the brazing strip, which will fill up the crack and finish off the joint. Work your way right round the barrel, feeding in first the silver solder and then the brazing strip until the short throatplate is reached on the other side. Make quite certain that the brazing materials melt and run into an unbroken mass at both points where the circumferential joint meets the throatplate.

Oxy-acetylene method

Let the job cool to black, then quench in pickle, wash off, and clean up. If the crack has been properly filled up there will probably be a little of the brazing material standing above the surface and this should be filed off right away, so that barrel and wrapper form an unbroken surface.

Users of oxy-acetylene equipment should make this joint by the ripple method previously described. Start at one bottom corner and when reaching the barrel, carry straight on instead of going along under the barrel. Take great care to see that the drops of molten metal falling off the welding-rod, penetrate the crack, and well overlap. Go right on to the other bottom corner of the throatplate;

Front end of the boiler and cross-section through the firebox, with a perspective sketch of the throatplate

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then finally do the joint between barrel and throatplate.

The firebox and tube assembly can then be made and fitted in the same way as described for the wagon-top boiler, the only difference being in the shape of the girdler crown stays. As the large bush for the dome is on the barrel instead of the wrapper sheet, the ordinary type of crown stays can be used, made to the dimensions given in the drawings. The rest of the boilmaking instructions apply to either type of boiler.

**Backhead and mud ring**

The only difference between the backheads of the two boilers is that the one for the wagon-top boiler is flattened at the sides.

Clean around the inside of the wrapper for about ½ in. from the edge and also clean the inner side of the backhead between flanges for about ¼ in. up from bottom. Cut a piece of ¼ in. square copper rod to fit between the flanges at the bottom and put a couple of ½ in. copper rivets through the lot to hold the square rod in place.

Next, measure from the top and sides of the wrapper to the flange of the oval firehole. Transfer the measurements to the backhead, and from them mark out and cut the oval hole for the flange of the ring to pass through. Cut it rather smaller than necessary at first, then if the backhead is "offered up," as full-size boiler-makers would say, to the boiler it can be seen at a glance if the hole is correctly located and, if not, which side needs filing to let the flange pass through.

File the hole just large enough to let the flange of the ring come through easily then put the backhead in place with the flange through the hole and the piece of square rod at the bottom, butting up against the firebox.

Put a piece of stout iron bar in the bench vice, with a little over 4 in. projecting from the side of the jaws. Rest the inner side of the firehole ring on this and beat down the bit of flange projecting through the backhead in the same way as the other end of the ring was treated, so that it lies close against the backhead and securely clamps the backhead against the shoulder of the ring. Then drill four holes with a No 41 drill through the backhead, square bar, and firebox doorplate, and rivet up with 3/32 in. copper rivets or pieces of 3/32 in. copper wire.

**Don't use brass!**

Hammer the edge of the wrapper against the backhead flange so that it makes very close contact all the way around; if it tends to spring away drill a few No 48 holes through wrapper and flange at about 1 in. centres, tap them 3/32 in. or 3/48 and screw in stubs of 3/32 in. copper wire screwed to suit. Tip to beginners—don't think you will save time by using brass screws instead or there will probably be a lot of little holes instead of screws after the blowlamp has been on the job! I know of several cases where that has happened.

Finally, fit the two side sections of the mud ring. These are made from ½ in. square copper rod, the ends being filed to fit up tightly against the flanges so that there are no gaps between the side and end sections of the ring. Anybody who makes a slip and files off a little too much can remedy matters by driving in a splinter of copper after the pieces have been riveted in place.

This job is done by drilling six No 41 holes through wrapper, rod, and firebox side, and putting in 3/32 in. copper rivets. Again, no fancy heads are required, as they would only have to be filed off after brazing up to allow the firebox to fit between the frames.

**Bushes**

All the bushes should be made from copper or bronze; brass should be avoided. I turn my small boiler bushes from either solid copper rod (cast or drawn, according to size) or thick-walled copper tube. The big ones are either turned from weldable cast flanges used by plumbers in welded copper-pipe installations, or from copper or bronze castings. The little blind bushes in either boiler, for bell bracket and sand-dome stud, can be made from ½ in. copper rod.
The safety-valve bushes for the bigger boiler can be turned from % in. copper rod, or thick tube, and castings for the big dome bushes will be available from advertisers. All are simple turning jobs needing no detailing, the dimensions being shown on the drawings. The bushes should be a tight fit in the holes in the boiler; the big hole for the dome bush being cut in the same way as for the firehole ring in the door plate and backhead. Take care to avoid distorting the big bush when fitting it.

Final brazing job

The great Thomas A. Edison once remarked that invention was partly inspiration and partly perspiration: I forget the exact percentages. Well, the job now ahead is partly perserverance and partly perspiration, the percentages being about equal; and beginners have nothing whatever to fear.

First cover every joint with wet flux, putting plenty round the bushes and plenty round the firehole ring. Lay the boiler upside down in the brazing pan and pile up the coke around it to the level of the mud ring, but leave the backhead clear.

Put some asbestos tubes, or bits of asbestos flock or millboard, in the firebox to protect the tubes, filling it nearly to ring level. If you can get a mate to hold another small blowlamp while you operate the fivepinter it will make the job much easier. An interested kiddy would probably feel a very important person if asked to assist in such an important job!

Either easy-running brazing strip can be used, or a coarse-grade silver solder, such as Johnson-Matthey's B-6 alloy; but avoid anything with a phosphorous content.

First heat up the whole lot gradually until the surrounding coke begins to glow and the wet flux has dried out and started to "fuse." Then concentrate on one corner of the mud ring. When this attains medium red for silver solder, or bright red for brazing strip, dip the strip in the flux and apply it to the joint in the flame. If the heat is sufficient it will start to melt, and run right into the joint.

Feed in sufficient to form a fillet against the firebox plate, then very slowly move the flame along, feeding in more brazing material as the copper reaches the required heat. A little practice will enable the job to be done non the slower. Keep dipping the tip of the spelter or silver solder in the flux before applying it to the copper.

If the suggested mate is assisting, the second blowlamp flame should be directed on the same place as the first, but from the inner side of the firebox, so that the two flames meet at an angle with the mud ring in the middle. If this is done there will be no question about the brazing material flowing, as it will probably run in an unbroken fillet all around the ring.

On "completing the course" and arriving back at the starting point be sure to have a good blow-up so that perfect continuity is ensured at that spot, otherwise a leak might start. Next, as quickly as possible, up-end the boiler in the pen and stand it on the end of the barrel, backhead upwards. Get the blowlamp flame playing on the bottom corner of the backhead and as soon as that glows red repeat the ritual, moving the flame slowly along and feeding in the brazing material.

Converge flames

If two lamps are used, the big one should blow direct on the backhead and the smaller one should be aimed from the side, the two flames meeting at an angle as before so that the joint is literally between two fires. After going right round the backhead, play direct on the firehole flange; inexperiencedoppersmiths will make a better job of this if they use silver solder only, as it flows easier and penetrates more freely between flange and backhead.

Finally, stand the boiler right way up and play the flame direct on each bush in turn, using silver solder only. There is no particular need to lay the boiler on its side to do the two side bolsters for the check valves; if the strip of silver solder is dipped in the flux and applied to the bushes it will—if the heat is O.K.—just flash round the bush and form a fillet without running down into a blob.

Let the boiler cool to black in the pen then lower it, very carefully, into the pickle and stand well clear, for when the acid enters the boiler and meets the hot firebox and tubes it will blow out again with great acrality before finally settling. The boiler can safely be left in the pickle for half-an-hour or so to get the scale and brazing residue loosened.

Then give the whole lot a good wash with running water. I use a hose with a small nozzle that will enter the bush holes, and as our mains pressure is very high the insides of my boilers get a really good sluicing. Clean up the outside with a handful of steel wool, or some domestic scouring powder, and the boiler will be ready for the next use.

Users of oxy-acetylene apparatus will find the job easier. I tried both the ripple method and the running method and found the latter was the better and quicker. No coke packing was required, for that the two flames meet merely laid on its back in the pan after fluxing the joints.

For the Virginia boiler I should use the 750 tip in my Alida set (recommended for welding % in. steel) and a low gas pressure giving a long, diffused flame. The water outlet would be practically the same as before, but the copper heats up quicker under the greater temperature of the oxy-acetylene flame, and the jointing material used should be Sifbronze or any other good welding-rod with a similar melting temperature.

Pinholes test

The backhead joint could be done by the ripple method if the operator preferred it, but I like to have the jointing material penetrate the full depth of flange and this does not happen with the ripple way of making the joint, the metal only penetrating to the bottom of the groove. I should use coarse-grade silver solder for the bushes, either changing over to my oxy-acetylene blowpipe which is always handy to my brazing-forgie, ready coupled up, or else I should further reduce the gas pressure of the oxy-acetylene blowpipe to avoid any chance of the silver solder "boiling" and become porous.

Before starting to stay the boiler it should be tested for "pinholes" which sometimes form in the joints through bubbles in the flux and do not show up until all traces of flux are removed by the pickling. Plug up all the bushes and other holes with temporary wooden plugs; an ordinary cork bung will do for the dome bush, if a length of thin wire is wound round the boiler and over it.

Rig up an adapter by soldering or screwing a motor-tyre valve into a brass plug that will fit one of the tapped holes or bushes. If the boiler is then immersed in a bath of water and about 20 lb. of air pressure pumped in with a tyre pump any pinhole will at once be indicated by a stream of bubbles, like a puncture in a tyre. Mark the spot, drill a No. 55 hole, tap % in. or 1/72, and screw in a stub of threaded copper wire with a smear of plumbers' jointing on the threads. This will effect a permanent repair.

To be continued.

STABLE PASTE

The retail prices of Fluxite soldering paste have been pegged for a period of six months. Fluxite has not increased in price since 1951 and a 2-ounce tin costs Is.
Both larger and smaller boilers are stayed in the same manner. One of the two longitudinal stays is hollow and carries steam for the blower, the blowoff valve being attached to one end. The other end carries a throughfare nipple with a union for the pipe leading to the blower ring. The second stay is a copper or bronze rod with a blind nipple at each end.

The firebox stays are of the usual pattern—made from copper rod screwed through both plates—nursed inside the firebox and riveted over outside the wrapper sheet, as used on some British Railways locomotives.

First make the blower valve. Chuck a piece of \(\frac{3}{8}\) in. round or hexagon rod in the three-jaw, face the end, turn down \(\frac{1}{2}\) in. length to \(\frac{1}{4}\) in. dia. and screw \(\frac{3}{8}\) in. \(\times\) 40. Part off at a full \(\frac{1}{2}\) in. from the shoulder. Reverse in the chuck, centre, drill right through with \(\frac{3}{32}\) in. drill, open out and bottom to \(\frac{3}{16}\) in. depth with a \(\frac{7}{32}\) in. drill and D-bit, and tap for about half the depth with \(\frac{1}{4}\) in. \(\times\) 40 tap. Reverse again and open out the hole with a No 14 drill to \(\frac{7}{32}\) in. depth.

Drill a \(\frac{5}{32}\) in. hole in the side at \(\frac{1}{4}\) in. from the shoulder and fit a \(\frac{1}{4}\) in. \(\times\) 40 union nipple into it. Cut a piece of \(16\) or \(18\)-gauge copper tube \(\frac{1}{8}\) in. dia. and \(\frac{15}{32}\) in. long (check this length from the boiler) chuck in the three-jaw and put \(\frac{1}{4}\) in. of \(\frac{3}{8}\) in. \(\times\) 40 thread on one end and fit the plain end tightly into the counterbored end of the valve. Both joints can then be silver soldered at one heat.

For the gland fitting chuck a piece of \(\frac{3}{8}\) in. hexagon rod, face the end, centre, and drill to \(\frac{1}{8}\) in. dia. with a No 30 drill. Turn down \(\frac{5}{32}\) in. of the outside to \(\frac{1}{4}\) in. dia. and screw \(\frac{1}{2}\) in. \(\times\) 40. Part off at a bare \(\frac{1}{4}\) in. from the end, reverse and re-chuck in a tapped bush held in the three-jaw, turn down \(\frac{3}{16}\) in. of the end to \(\frac{1}{4}\) in. dia. and screw \(\frac{1}{4}\) in. \(\times\) 40. Open out the hole to about \(\frac{3}{16}\) in. depth with a No 21 drill and tap the rest \(\frac{5}{32}\) in. \(\times\) 32. The nut is made from \(\frac{3}{8}\) in. hexagon rod and is exactly the same as a union nut. The pin is a \(\frac{1}{2}\) in. length of \(\frac{5}{32}\) in. rustless steel or drawn bronze.

Chuck in the three-jaw, turn a cone point on the end about 90 deg. angle, turn down \(\frac{3}{16}\) in. length to a full \(\frac{1}{4}\) in. dia. and screw the next \(\frac{3}{16}\) in. with a \(\frac{5}{32}\) in. \(\times\) 32 die in the tailstock holder. On the other end file a square and fit a handwheel turned from \(\frac{3}{8}\) in. rod on it, riveting over the end to keep the wheel on tightly. The assembly is shown in the drawing.

The throughfare nipple is made from \(\frac{3}{8}\) in. hexagon rod. Chuck, face off, centre deeply with a letter E centre drill and drill to \(\frac{1}{4}\) in. dia. with \(\frac{3}{32}\) in. drill. Turn down \(\frac{1}{4}\) in. of the outside to \(\frac{3}{8}\) in. dia. and screw \(\frac{3}{16}\) in. \(\times\) 40. Turn down \(\frac{1}{6}\) in. of the other end to \(\frac{1}{8}\) in. dia. and screw \(\frac{3}{32}\) in. \(\times\) 40. Open out the hole to a full \(\frac{1}{2}\) in. depth with \(\frac{5}{32}\) in. drill and tap \(\frac{3}{32}\) in. \(\times\) 40.

For the blind nipples chuck the \(\frac{3}{8}\) in. hexagon rod again, face, centre and drill to \(\frac{1}{4}\) in. dia. with \(\frac{5}{32}\) in. drill; tap \(\frac{3}{32}\) in. \(\times\) 40. Turn down \(\frac{1}{6}\) in. of the outside to \(\frac{3}{8}\) in. dia. in. dia. and screw \(\frac{3}{8}\) in. \(\times\) 40. Part off to leave a head full \(\frac{1}{2}\) in. thick, reverse in chuck and chamfer the corners of the hexagon. No separate drawing of the backhead showing the location of the holes for stay nipples is given, as the backhead is exactly the same shape and size as the throat plate of the smaller boiler and that for the larger is the same shape as the cross section—so builders will have to locate the position of nipples, but this is easy enough, as the location of the stays themselves can be seen in the cross section through the firebox. All you have to do is to transfer the measurement to the backhead, centrepop, drill 9/32 in. and tap \(\frac{3}{8}\) in. \(\times\) 40. The holes should correspond to those in the smokebox tubeplate, the location of which is given.

The solid stay is a piece of \(\frac{3}{8}\) in. copper or bronze rod (don’t use brass) the same length as the hollow stay, with a few \(\frac{3}{8}\) in. \(\times\) 40 threads on each end. Screw a nipple on for two or three threads, insert in left-hand hole in the backhead, push through until it projects through the corresponding hole in the smokebox tubeplate, put the other nipple on that end and screw both right home. Insert the hollow stay in the right-hand hole, push through and screw the thoroughfare nipple on the other end. All threads should be smeared with plumbers’ jointing before fitting.

A piece of stiff wire put in the end of the hollow stay will help towards guiding it to the hole in the smokebox tubeplate, sighting it through the hole for steampipe. When the blower valve is screwed home the nipple should be vertical.

Firebox stays

Beginners often ask why I specify a large number of small firebox stays instead of a few thicker ones. The answer is that they support the plate much better. No matter how thick the stays are, if they are widely spaced the plate will bulge between them like an old-fashioned buttoned cushion. Not only is this avoided with close spacing, but the stays themselves may be made thinner with perfect safety, as they have far less plate surface to support. There is also no need for excessively-thick firebox plates, which reduce efficiency. I know of a professional boilermaker who used two \(\frac{1}{4}\) in. copper rivets to stay a \(\frac{1}{2}\) in. gauge firebox at each side—but the plate was nearly \(\frac{1}{2}\) in. thick!

Set out the location of the stays on the outside of the firebox wrapper as shown, centrepop them and drill the holes with a No 40 drill at right angles to the plate. The outer hole will guide the drill to the inner firebox plate if the job is done on a drilling machine. A little cutting oil, as used for turning steel, is a great help both.
n drilling and tapping soft copper; if tapped dry the result is usually torn threads. As the threads in both plates must be in line and the thread itself continuous in pitch so that the stay engages properly in the inside plate, a pilot tap should be used. If supplies are not immediately available they can be made.

The pilot pin must be long enough to bridge the gap where the outer wrapper is farthest from the inner firebox—which needs a pin 1 in. long in the case of the larger boiler. Chuck a 3 in. length of 1/2 in. silver steel or drill rod with about 1/2 in. projecting from jaws and turn down 1/4 in. length very carefully until it enters a No 40 drill hole easily. Then pull the rod out of the chuck for another 1 in. and screw that with a 1/4 in. die in the tailstock holder.

If a tap-fluting cutter is available mill three or four flutes for the full length of the thread. If not, file four flats on the threads, tapering them off so that a few full threads are left at the shank end. File two flats or a square on the end of the shank to take a tap wrench, then harden and temper as described for pin drills. To avoid the chance of the pin breaking off soften it by applying a red-hot poker to the end, keeping it there until the blue colour travels right down the pin to the start of the threads; then let it cool naturally.

This improvised pilot tap will not cut a thread good enough to screw the stay into, but it will form one good enough to guide an ordinary 1/4 in. commercially-made tap through the holes—so put one of the latter through before inserting stays to clean up the thread to size.

A good way for beginners to fit stays is to cut off several lengths of 1/2 in. copper rod about 6 in. long; the copper must be soft. Chuck in the three-jaw and put a few threads on the end of each long enough to go through both plates (the distance varies from top to bottom of firebox) plus a full 1/4 in. for a locknut. Put a tap wrench in the middle and screw the stay home right to the end of the thread, snipping it off about 3/32 in. from the boiler. Repeat the operation until all the pieces of copper rod are used.

Screw a brass locknut on the projecting end inside the firebox, then put a piece of stout iron bar in the bench vice so that it projects from the sides. Put the firebox over it with the nut resting on the bar, and rivet over the plain bit of stay on the outside of the wrapper. When all the stays have been put in, all the nuts inside the firebox can be given a final tightening—but not sufficient to strip the threads, which is easily done owing to the softness of the copper.

For the nut tightening I use a homemade box spanner. This is made from a piece of mild steel rod a little larger in diameter than the width of the nuts over corners and about 1 in. long. Chuck in the three-jaw, face, centre and drill to about 1/4 in. depth with a No 30 drill. Open out to a full 1/4 in. depth with a drill the same size as the width of nut over corners; drive a nut into the recess and hammer the edge of the metal on to the flats of the nut. Drill a No 32 cross hole near the solid end of the bit of steel; and in it drive a piece of 1/32 in. steel rod about 4 in. long. With this gadget every nut in the firebox can easily be tightened. To get at the upper rows simply bend the handle a little.

Making stays leakproof
If the threads in the tapped holes and on the stays are perfect, they should be steamtight when the nuts are tightened; but there is a chance of this not occurring, especially with beginners who usually manage to get a good proportion of torn or distorted threads. This, however, is of no consequence, as Stephenson cured leaky tubes in the Rocket by "sodding 'em oop"—and the same remedy will cure leaky stayheads and nuts in a little locomotive.

First make up a wire brush by putting a bunch of thin iron wires into the end of a couple of inches of 1/4 in. tube and flattening the tube to hold the wires tightly. Fix this into a wooden handle or a piece of fibre tube—anything which won't become too hot to handle. Lay the boiler
on its side in the brazing pan and brush some liquid soldering flux all over the stayheads on the outside of the wrapper and the nuts inside the firebox.

Heat the boiler evenly with a blowlamp to the melting point of solder—plumbers' solder for preference, as it has a higher melting point than ordinary tinsmiths' solder, but the latter will do if the former is not available. Melt a little off a stick on to the stayheads on the outside of the wrapper, keep it liquid by the aid of the blowlamp and brush the melted solder over all the heads, applying more flux to any place where the solder does not "take." Repeat this process inside the firebox, brushing the melted solder over all the locknuts. Turn the boiler over to do the opposite side and up-end it for the stays in the backhead and throatplate.

When you are quite certain that every stayhead and locknut has been well covered shake off any superfluous solder from the wrapper and firebox; let the job cool off and then give the boiler a thorough washing inside and out to remove all traces of the soldering flux. If any is allowed to remain a greenish deposit will form and this doesn't do cuts and scratches any good. Besides which it is detrimental to the boiler.

The next job is to give the boiler a hydraulic pressure test; all the holes except two should be closed by temporary metal plugs screwed to fit. The dome can be made and fitted right away. It may either be a casting or built up. If cast, it will only need chucking in the three-jaw and the flange faced truly to fit over the bush in the boiler. If built up, the same method of construction applies to either size of boiler.

The flange can be cut from 1 in. brass sheet to a little over the outside diameter of the bush.Chuck in the three-jaw and, with a parting tool set crosswise in the rest, cut a hole the same size as the internal diameter of the bush. In this fit a piece of 16- or 18-gauge copper tube as shown, with a ½ in. brass disc driven into the top. Silver solder both the disc and flange, then chuck again and skim the flange true. The flange is attached to the dome bush by a ring of 3/32 in. brass screws as shown (in the same way as a cylinder cover) with a gasket of jointing material between.

Connect a big pressure gauge to one of the holes left open by an adaptor which can be turned from any suitable odd end of brass rod. I use a full-size locomotive steam gauge reading to 360 lb. per sq. in. connected to the adaptor by a ½ in. pipe. The other hole is used for an adaptor and similar pipe—at the other end of which is a pump. An ordinary tender handpump will do very nicely for this. Fill the boiler with cold water, then pump more in until the gauge shows 50 lb. pressure, then take a look to see if there are any leaks or bulges. If any leaks appear they should be attended to before proceeding further. Don't take any notice of a slight movement of the firebox crown, as it will only be caused by the copper settling itself in the best position to resist pressure.

If all is satisfactory pressure can gradually be increased to 160 lb. keeping a sharp lookout for any trouble which may develop. There is not the slightest need to go beyond 160 lb. which is twice the working pressure, giving the required degree of safety; anything higher would only have the effect of unduly straining the boiler, so if it stands up all right to that amount without leakage or distortion it can be passed for service with every confidence.

**Camouflaging the tender!**

My picture shows a locomotive built by Bill Treadway of Bristol, Connecticut, U.S.A. with an uncommon sort of tender. She was built to the Carl Purinton design for a 3½ in. gauge 0-4-0 tank engine—similar to my *Juliet*—but has the American Southern valve gear and she performs very well.

At one time she didn't carry enough coal and water for a long nonstop run. Bill, therefore, decided to add a tender and, as the engine is more British than American in appearance, he made the tender to represent a typical British four-wheeled wagon—with the pleasing result shown. The picture was taken by Al Milburn when Bill took the locomotive for a run on his track last year.

*To be continued.*

**Railway Facts**

The British Transport Commission has just issued their 1956 edition of "Facts and Figures About British Railways". This is a 48-page booklet, free on application to the British Transport Commission Office. It gives the principle facts and figures for every aspect of the British Railways.

1955 is regarded as an important year since a 15-year modernisation and re-equipment was launched, the biggest ever undertaken by British Railways. On the list for modernisation are the line, passenger carriages, diesel trains, signalling and telecommunications, and staff welfare.

*Bill Treadway's 3½ in. gauge tank engine with disguised supplementary tender*
As the smokeboxes of both the ancient and modern boilers differ but little in actual construction, one description will do for the two of them. The front is made from a casting which is turned to a tight push fit in the end of the barrel, which in both sizes is a piece of 16-gauge brass tube.

This need not be seamless; the ordinary commercial quality with a brazed joint is quite satisfactory. It need not even be brass, although non-ferrous metal is more satisfactory when the engine is not run very frequently and ash which collect moisture are left in the smokebox. A piece of steel tube, or rolled-up sheet steel or iron with a brazed joint, makes a serviceable smokebox shell.

Unless the builder desires, the door need not be made to open; the front can be cast with the door and all the ornaments integral, and the whole lot pulled out like removing a lid from a can when the smokebox requires cleaning out, or there is anything to be done inside it. No liner or petticoat is needed for the long chimney or stack on the smaller smokebox. Both sizes are supported by cast or built-up saddles screwed to the frames between the cylinders.

BARRELS AND FRONTS

The smaller smokebox requires a piece of tube 3½ in. dia. and 4½ in. long, and the larger, a piece 4¼ in. dia. and 4¾ in. long, both ends being squared off in the lathe. If a disc of wood or metal is driven into the end held in the three-jaw, the outer end can be faced off without further support, and without risk of the work flying out of the chuck or becoming distorted.

Before removing it from the chuck, hold a scriber against the barrel at 2½ in. from one end and scribe a ring on it. Make a centrepop on this, then bend a bit of wire completely around the barrel, butting the ends together. Either cut this in half, or bend it double, then lay it around the barrel on the scribed line with one end against the centrepop. Make another at the other end of the wire. The two will then be exactly opposite.

Drill a No. 30 hole through each and put a bit of ⅛ in. wire, which must be straight, through both of them to check if they are exactly opposite. If O.K. open out one to ⅛ in. dia. and the other to ⅛ in. on the smaller barrel and 1 in. on the larger.

Our “precise” friends will at once comment that this is a childish way of going to work, but it makes certain that both chimney and blastpipe holes are exactly opposite, and that is vital to the draughting. The simplest way is often the best. At ⅛ in. ahead of the blastpipe hole, on the same centreline, drill a ⅛ in. hole for the steam-pipe.

If the one-piece pull-and-push smokebox front is adopted (I shall make my own that way, time being precious now) grip it either by the edge, or by a chucking-piece which may be provided; set it to run as truly as possible, and turn the spigot to a tight push fit in the smokebox barrel.

Reverse in chuck, and turn the flange to size; part off the spigot, if any, and face off any stub left. The rest of the front can be cleaned up with a file, if required—some castings come out exceedingly clean and need no titivating—the dummy door-clamps or dogs drilled No. 55 and tapped ⅛ in. or 1/72, and hexagon-headed screws put in for appearance sake.

The smaller front will require a pin put through the dummy hinges, but the larger one has the modern forked hinge supports and no pin is needed. Note that both doors are the same size, although the barrels differ; modern smokeboxes being self-cleaning in full size, a large door is not required.

To make a door that opens, turn

Smokebox for the wagon-top boiler, and details of the door-clamp
Smokebox for the straight-top boiler

the spigot as described, then reverse in chuck and face off the complete front, which will have the hole cast in (says Pat). Grip the separate door by the spigot provided on the front of the casting, set to run as truly as possible, and face off the contact edge. Reverse in chuck, and part off the chucking-piece, trimming the stump flush.

The door cannot be turned on the outside as this would remove the cast-on hinge straps. If, however, a dished brass blank is used, of the type which I have described for British type smokebox doors, chuck it concave side inwards, face the rim, centre and drill a No 30 hole through and face off the middle to about 1/8 in. dia.

Finishing the rod

Turn a 1/4 in. pip on the end of a bit of brass rod about 1/2 in. dia., drive this into the hole, see that the rod butts up truly against the face-off circle, and solder it. The piece of rod can then be gripped in the three-jaw and the convex side turned, the blank turned to diameter, and the contact edge skimmed up truly.

Melt the door off the piece of rod, wipe off all superfluous solder, and rivet on a pair of hinge straps made from 1/2 in. strips of 18-gauge nickel-bronze or steel. Bend the ends into a loop and silver solder them; if the hole is filled up by the silver solder, just put a drill through. Tap the centre hole 5/32 in. and screw in a brass plug, filing off flush.

Clamp the door temporarily in place and mark off the position of the hinge lugs on the smokebox front, then drill and tap the holes for the stems of the lugs, which are made from brass rod, 1/8 in. square for the larger door and 1/4 in. square for the smaller.

The rod is chucked truly in the four-jaw for turning and screwing the stems. The larger lugs are slotted like a valve-gear fork by the same process; for holding them under the slide-rest tool-holder while this is being done, screw them into the end of a short piece of square rod with a hole drilled and tapped in the end. The smaller door has one long pin passing through both hinges, as on British engines, but the larger one has a short pin in each fork, slightly riveted over at the top and the underside to prevent their coming out.

The door-clamps or dogs are filed up from 1/4 in. square rod to size shown (tedious job this!) and drilled No 51 for the screws. The big engines have studs, but on the little ones it is more convenient to use hexagon-headed screws. Set out the location of the screws all round the door, carefully centrepop, then drill No 55 and tap 1/8 in. or 1/72 and attach the dogs as shown.

SMOKESTACKS

The long, capped stack for the smaller engine can either be made from a casting or from a 4/8 in. length of 1 1/2 in. brass tube with a cast cap and base bored to fit on tightly, then silver soldered. If cast, it can be gripped in the three-jaw by the long barrel, cap outwards, bored by the same process as described for cylinders, and the cap turned at the same setting.

Reverse in chuck, turn as much of the base as possible, and finish with a file. It could also be turned from a piece of cored stick 1 3/8 in. dia. as used for turning bushings, but this is rather a waste of metal. Incidentally one of my few friends always turns square-based chimneys, such as the old L.N.W.R. pattern, from square rod; some job! The long stack is attached to the smokebox by four screws, say 3/32 in. or 3/48 with countersunk heads, put through the corners of the square flange and nutted inside the smokebox.

Turning the stovepipe stack

The stovepipe stack can be turned from a casting in the same way, gripping in the chuck to bore it, but a piece of emerycloth should be wrapped round the narrow end to give the chuck a grip at that end; another primitive dodge that always works! To finish the outside of this one, it should be mounted on a mandrel between centres, and the top-slide set over to give the necessary degree of taper.

That part of the base which cannot be turned is finished off with file and emerycloth while still on the mandrel. Cast stacks of both sizes will have the

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bases cast to fit the radius of the smokebox barrel, and a slight clean-up with a file will be all that is needed to bed them down.

Owing to the larger diameter of the smokebox the stovepipe stack will need to be fitted over a liner to get the correct height above blast nozzle for proper draught. The liner, or petticoat as it is usually called by old American enginemen, is a piece of 1 in. thick brass or copper tube squared off in the lathe to a length of 23 in. and belled out at one end to 1½ in. dia.

Making the stack

I usually do this job by first annealing the tube, then holding it against the rounded-off edge of a block of steel or hardwood, like plumbers use for belling out the ends of compo pipe; or it can be spun out by holding in the three-jaw and easing out the edge with a burnishing tool, which should be greased.

Cut a piece of 16- or 18-gauge copper 2 in. square, and in the middle of it cut a hole into which the tube will fit tightly. Bend the piece of copper to the radius of the inside of the smokebox, push the liner through the hole from the concave side until ¾ in. from the copper, and silver solder it, taking care to avoid getting any silver solder on the convex side.

After pickling and washing off, push the liner through the hole in the smokebox from the inside and secure the flange to the shell by a 3/32 in., 0 or 3/48 countersunk screw in each corner, nutted inside the smokebox. A smear of plumbers' jointing round the liner before inserting will make sure of an airtight joint. The stack should be a tight push fit on the liner and will need no other fixing.

SMOKEBOX SADDLES

Both smokebox saddles are the same pattern, varying only in size; they can be cast or bought up. If cast, the only "machining" that they should need is a clean-up with a file, as the seating for the smokebox will be cast to correct radius. If built up, five pieces of 16-gauge metal will be needed; a built-up saddle need not be needed at all.

Two endplates are cut to the shape shown; two sideplates, bent to the same radius as the sides of the endplates; and a saddleplate bent to the same radius as the smokebox shell. This should have a hole about 1½ in. square cut in it for the fit-up.

If brass or copper, silver solder the assembly; if steel, braze it. To set up for brazing or silver soldering I usually set the sideplates between the ends and hold them together with a light cramp. It is a bit of a conjuring trick to make them stay put; I freely admit, unless one is used to it, and beginners might find it better to rivet a small bit of angle in each corner at the waist.

Making the joints

The flange is placed in the brazing-pan, convex side up, and the saddle assembly set on it in the correct location. All joints are fluxed, the whole lot heated evenly to dull red for silver solder, or bright red for brazing, and the silver solder or brazing strip (soft brass wire about 16-gauge makes fine brazing-strip for jobs like this) applied to the joints.

I never have any trouble in getting it to flow; it only needs the right heat illustration how this can be done. Two ½ in. spring pins ½ in. long are screwed into the bottom of each axlebox at ½ in. centres, the holes for them being located through No 30 holes drilled in the hornstay or pedestal tie.

The springs are wound up from 21- or 20-gauge tinned steel wire round a ½ in. mandrel, and kept in place by a spring plate made from 3/32 in. steel strip, similarly drilled, this in turn being secured by ordinary commercial nuts.

Where the springs are located above the frame, as in the original arrangement, the reversing lever should be fitted as shown in the amended drawing; but it cannot be permanently attached until the boiler is erected because the front support must be fixed to the backhead, which was done on the full-size engine.

For the time being, temporarily remove the front support of the quadrant and attach the pivot-block of the lever to the top of the frames so that the fulcrum pin is approxi-

Amended arrangement of the reversing lever; and alternative springs

mately 1½ in. from the rear end of the frame.

Quadrant support

The back support of the quadrant should then come flush with the end, as shown. In this position, the lever will clear the top of the spring hanger easily. The reach rod will need to be another ½ in. long, and the bend should be slightly eased to keep clear of the wheel flange. When the boiler is erected, the length of the front support, which will have to be fixed in the horizontal position as shown, can easily be ascertained from the actual job.

There is an alternative for those good folk who would rather support the front end of the quadrant from the frame instead of the boiler; the double hanger supporting the back end as cast, spring could be made long enough to reach up to the quadrant, the end of which could be bolted to it in the ordinary way.

To be continued.
American locomotive designers of the Virginia period favoured the balanced throttle, similar to the Ramsbottom double-beat regulator still used in this country on the Gresley and Bulleid Pacifics, and various other types. The stem of this valve has two heads like i.c. poppet valves, the upper one being slightly larger than the lower, and there are two matching seatings in the regulator head.

As steam pressure takes effect on top of one, and underneath the other, the only resistance against opening is the difference in the valve area, and theoretically this should be a nearly-perfect throttle; but there are two very practical faults. One is that an exceedingly small lift of the two valves lets a lot of steam pass, and this is why locomotives with this type of regulator are prone to excessive slipping; secondly, both valves being rigid on the spindle, and both seatings being fixed in the head, it is difficult to keep them both steamtight.

Even if carefully ground in, so that both are tight at the start, the least difference in expansion of either valve spindle or seatings will cause one of them to leak; and for these reasons I am not specifying a small copy for the little locomotive, but have substituted a well-known tried-and-tested type which has proved O.K. on my own engines. As it has to be operated by a push-pull handle, it is erected sideways.

The stand

The stand is either cast or built-up. If cast, it will only need drilling for ports, steam-passage, and pipe, and drilling and tapping for the pin on which the valve works, and the screw for the bell-crank. It is finished off as described for the built-up version. The main part of this is a piece of 3/8 in. square brass rod, faced off at each end in the four-jaw to 1 1/2 in. length.

After facing, offset it in the chuck 1/3 in. then centre and drill to 1 1/2 in. depth with 3/8 in. drill. Tap the end 7/32 in. x 40. On the centre-line of the facet nearest the hole drill a 3/32 in. hole 3/8 in. from top and another 3/16 in. from bottom. Level with the latter, drill a 3/16 in. hole for the steam-pipe in the side as shown, breaking into the 3/8 in. hole down the middle.

For the portface, chuck a piece of 1/16 in. round bronze or gunmetal rod, face it off, and part off a slice a full 1/16 in. thick. Rechuck the other way around, face off, centre, and drill a 3/32 in. hole right through. For the boss at bottom, repeat operation on a piece of 3/16 in. brass rod, parting off to 3/32 in. thickness.

Put a little stub of 3/32 in. copper wire in each, leaving about 3/32 in. projecting, like a dowel, and poke these in the 1/16 in. holes in the stand. This trick will locate both the portface and the boss correctly. Put a piece of 3/16 in. copper pipe, about 2 in. long, into the hole in the side of the stand and silver solder the lot at one heat.

Quench in acid pickle, wash off, clean up, and drill the ports as shown, running the drill right through into the centre hole in the stand. Open out the hole where the copper dowel pin went in with No 48 drill, tap it 3/32 in. or 3/48, countersink a shade, and fit a trunnion pin, as shown, made from 3/32 in. bronze or hard brass wire. Before screwing this in permanently true up the portface by the same method as described for slide-valves.

The hole in the boss at the bottom is drilled No 44 and tapped B.A. or 4/36, and a screw which forms the bell-crank pivot is made from 3/16 in. round bronze or hard brass rod, as shown. Don't use steel for any pins or screws inside the boiler, as it is only asking for trouble.

Plug the top of the stand with a bit of screwed rod cut off level with the top, filed flush and soldered over. Chuck a bit of 1/16 in. brass rod, face, centre, drill to a bare 3/8 in. depth with 1/16 in. drill, part off at 3/8 in. from the end, reverse in chuck, and open out the other end to 9/32 in. for 3/8 in. depth, tapping 3/8 in. x 40.

Bend the short pipe as shown, setting it down 1/8 in. and sideways to 11/32 in., which will bring it to the centre-line of the steam-pipe inside the boiler barrel when same is erected. Fit the tapped bush to the end, cutting the pipe if necessary, to bring the tapped end of the bush 2 in. from the centre of the stand; then silver solder it. The valve is filed up from a piece of 1/4 in. hard brass plate and drilled as shown. Face it off truly as described for slide-valves. The bell-crank can be cut from the same kind of material.

As the bell-crank moves in a straight line, and the end of the bell-crank moves in an arc, the pinhole must be slotted as shown. A bit of nickel-bronze (German silver) is the best material for the link, but hard brass is a good substitute; same applies to the pins. The fork is made exactly the same as a valve-gear fork, so no detailing is necessary; the material should be bronze or hard brass.

To assemble, smear the valve face with cylinder oil, place on trunnion pin, and fit a spring wound up from a 22-gauge bronze or hard brass wire, plus a brass nut. Put the bell-crank on the plain part of the pivot screw, which it should fit easily but without slackness, and screw it home into the boss. Then attach the link to the bell-crank and the lug at the side of valve.
by the shouldered screws the threads of which should fit tightly for obvious reasons.

When the bell-crank is operated the valve should move easily over the portface. It can easily be tested for steamtightness by sucking at the steam-pipe bush with the valve in the closed position.

The method of erecting the completed throttle is clearly shown in the back view and plan. The bracket is bent up from a strip of 3/32 in. brass or copper 3/4 in. wide, to shape shown; drill four No 41 holes at 1/4 in. centres, close to the dome bush, and countersink them. Hold the bracket in position and make a mark on it through one of the holes with a scribe.

Remove the bracket, drill and tap it for the screw at the marked spot, replace and put a screw in; then if the No 41 drill is put down the other holes, and countersinks made on the bracket, the exact position of the other screws will be correctly located and the bracket can be fixed with brass countersunk-head screws.

Before permanently fixing, drill the three No 41 holes in the upper part, for attaching the throttle stand, and countersink them. Hold the throttle in position, mark off one screwhole on it through the hole in the bracket, drill and tap for screw, then temporarily attach to the bracket by that screw while locating the others as described above. It does not matter about the screwholes piercing the passageway, if the brass screws are put in tightly with a smear of plumbers' jointing compound on the threads.

For the gland fitting, chuck a piece of 5/16 in. brass rod, face the end, centre, and drill to 1/4 in. depth with No 30 drill. Turn down 5/32 in. of the end to 5/32 in. dia. and screw 5/32 in. x 32. Part off at 1/16 in. from the shoulder, reverse in chuck, holding in a tapped bush for preference, open out with 7/32 in. drill for 1/4 in. depth and tap 5/32 in. x 40.

The gland is made from 5/16 in. hexagon rod, in the manner described for valve-spindle glands. On the centre-line of the backhead, at 1/8 in. from the top, drill a 13/32 in. hole, tap it 5/32 in. x 32, and screw in the fitting, anointing the threads with plumbers' jointing.

The throttle-rod is a 3/4 in. length of 5/32 in. rustless steel or hard bronze rod with a few threads on each end. One end is furnished with a fork the same size as the brass one, but made of steel; the hole in one side of the jaws is drilled No 41 and the other tapped 3/32 in. or 3/48. Attach the brass fork to the bell-crank by a piece of 7/64 in. bronze rod squeezed through the holes in the fork and filed flush at each side; this should be done before the throttle is permanently erected.

Put the gland on the rod and push it through the stuffingbox, then if the throttle valve is set in the "open" position the brass fork can be held by a wire with the end bent hook-shape and the throttle-rod screwed into it. The gland can then be packed with a few strands of graphited yarn.

The throttle lever is made in the same way as the reversing lever, to the sizes shown, the holes being drilled No 41. The anchoring lug is made from a piece of 5/16 in. rod turned down at the end for 3/8 in. length to 1/4 in. dia. and screwed 5/32 in. or 5/36. Part off at 11/32 in. from shoulder, file the end flat as shown in the detail sketch, round off the end, drill a No 41 hole through the tongue, and attach the two links to it with a pin made from 3/32 in. silver steel.

The links are filed up from 1/8 in. x 5/32 in. steel strip and drilled No 43. The other ends are pinned to the throttle lever in similar manner, the joints being left free but not slack. At 1/8 in. to the left of throttle centre, and 5/32 in. below it, drill and tap a hole in the backhead to suit the anchoring lug and screw it in, with some plumbers' jointing on the threads.

Put the lever through the fork on the throttle rod and attach it by a screw with 5/32 in. of "plain" under the head. When the lever is operated the throttle should work easily. No stops are needed as the throttle lever will come up against the end of the slot in the fork and prevent too much movement.

SUPERHEATER

The superheater is a simple three-element affair, easily built up. First
fit the steam-pipe, which is a piece of \( \frac{1}{4} \) in. tube of 20-gauge copper, with \( \frac{3}{4} \) in. of \( \frac{3}{4} \) in. \( \times 40 \) thread on one end, and about \( \frac{3}{4} \) in. \( \times 32 \) thread on the other. Apply a little jointing to the fine threads, and insert into boiler through hole in the smokebox tubeplate, which should be drilled \( \frac{1}{4} \) in. \( \times 32 \) and tapped \( \frac{3}{8} \) in. \( \times 32 \), screwing it into the bush on the drop-pipe from the throttle. I usually do this sort of job by jamming the end of a round file into the end of the pipe, which holds it tightly enough to screw home but releases when turned backwards.

Chuck a piece of \( \frac{1}{4} \) in. brass rod in three-jaw, face, centre, and drill to about \( \frac{3}{4} \) in. depth with No 3 or \( \frac{3}{4} \) in. drill. Open out to about \( \frac{3}{8} \) in. depth with \( \frac{3}{4} \) in. \( \times 32 \) drill, and tap \( \frac{3}{4} \) in. \( \times 32 \). Turn down \( \frac{3}{8} \) in. of the outside to \( \frac{1}{2} \) in. dia. and screw \( \frac{3}{8} \) in. \( \times 32 \). Turn down the next \( \frac{3}{4} \) in. to \( \frac{3}{8} \) in. dia. and part off at \( \frac{1}{4} \) in. from the end. Reverse in chuck, and turn the face truly. "Dope" the threads, and screw this on to the projecting end of the steam-pipe. The external thread will engage in the tapped hole and the fitting can be screwed tightly home.

Chuck the \( \frac{1}{4} \) in. rod again, face, centre, and drill to \( \frac{1}{4} \) in. depth with No 3 or \( \frac{3}{4} \) in. \( \times 32 \) drill. Part off at \( \frac{1}{4} \) in. from the end. Drill another \( \frac{3}{4} \) in. hole in the thickness, breaking into the centre hole, and across this file a groove \( \frac{3}{4} \) in. deep with a \( \frac{1}{4} \) in. round file. Drill four No 34 holes for fixing screws as shown in end view.

Next cut two lengths of \( \frac{1}{4} \) in. \( \times 20 \) or 18-gauge copper tube a little over \( \frac{3}{4} \) in. long, and square off the ends in the lathe. In each of these drill three \( \frac{7}{32} \) in. holes at 1 in. centres, for the ends of the elements. In one of them drill a \( \frac{7}{32} \) in. hole in the middle, at the angle to the element holes shown in the section; and at right angles to this, at \( \frac{1}{4} \) in. from the end, another 23 hole for the snifting-valve pipe. This forms the "wet" header.

In the other drill a \( \frac{1}{4} \) in. hole at \( \frac{3}{4} \) in. from the end, nearly at right angles to the element holes. This one will be the "hot" header. Plug the ends of both with discs of 16-gauge copper, or \( \frac{1}{4} \) in. slices parted off a piece of brass rod turned to fit tightly in the tube ends.

The upper elements are 8 in. lengths of \( \frac{7}{32} \) in. \( \times 22 \) gauge copper tube, and the lower, \( \frac{4}{8} \) in. lengths. The block bends are \( \frac{1}{4} \) in. lengths of \( \frac{1}{8} \) in. \( \times 1 \) in. copper bar, in the shorter ends of which two \( \frac{7}{32} \) in. holes are drilled close together, the drill being run in on the slant so that the holes meet in the block (see section).

Round off the sides and ends of the blocks, drive one longer and one shorter element into each, and braze the joints. Use brass wire or Sif-bronze No 1 rod \( \frac{1}{4} \) in. dia. for this job; not silver solder, which is unsuitable as the blocks are too close to the fire. It only entails heating to bright red instead of dull red. Quench in pickle and wash off, then fit the elements into the headers as shown in the section.

The \( \frac{1}{4} \) in. steam flange is then set in position over the hole in the top header, the groove in the flange lying on the tube; tie it in place with a piece of thin iron binding-wire. Fit a \( \frac{3}{4} \) in. length of \( \frac{1}{8} \) in. copper tube into the small hole in the top header, and a \( \frac{3}{8} \) in. length of \( \frac{1}{4} \) in. copper tube into the vacant hole in the bottom header.

The whole bag of tricks can then be silver soldered at the one heating; best-grade silver solder, or Easyflo, can be used on this job as it is away from the fire. Just cover all the joints and the end plugs with wet flux, heat the lot to dull red, and touch each joint with the strip of silver solder. After quenching in the pickle, well wash in running water, letting the water run through the tubes until there are no signs of any scale or dirt being left in them.

Bend the \( \frac{3}{4} \) in. pipe into a swan-neck, as shown, and fit a \( \frac{3}{4} \) in. \( \times 32 \) union nut and cone on the end, silver-soldering the cone to the pipe; this is best done separately. Push the elements into the flues, and line up the flanges, clamping temporarily in place; put the 34 drill through the holes in the outer flange, making countersinks on the inner.

Remove the outer flange, drill the countersinks No 44 and tap 6 B.A. or 4/36, but don't attach the superheater permanently yet. This will be done in due course when all the fittings are attached to the boiler and the snifting-valve attached to the pipe provided.

To be continued.
Owing to the dome on the larger boiler being smaller and situated in a different place to that on the smaller boiler, the throttle arrangement described last week cannot be fitted in. So I have taken the opportunity to scheme out an entirely different arrangement on the lines of the Stanier regulator, which was first fitted to some of the L.M.S. engines.

This is a slidevalve working on a horizontal portface, operated by twin levers controlled by a small crank on the regulator rod, the footplate end of which carried a drop handle and small quadrant. For the American push-and-pull operation I have rearranged the whole bag of tricks and set the valve to move in a fore-and-aft direction connecting the bottom of the twin links (now made up as a bridle) direct to the operating rod with a wide-jawed clevis.

Incidentally, anyone building the smaller boiler but preferring this type of throttle can use it without alteration, as it will, of course, fit the larger dome; but the short drop pipe and tapped bush for connecting to the dry pipe must be fitted owing to the difference in level between the throttle rod and dry pipe. On the larger boiler they line up as illustrated.

The stand can either be cast or built up. If cast, clean up both sides with a file to allow the bridle free and easy movement. Set out the steam port on the top face and drill down on the slant with a 3/16 in. drill, as shown in the section. Next, drill another 5/32 in. hole from the bottom of the stand to meet the first one. Centre and drill the dry-pipe boss with a 3/16 in. drill until the drill breaks into the vertical hole: open out with 9/32 in. drill to 1/4 in. depth and tap 1/8 in. x 32. Tap the bottom of the vertical hole 7/32 in. x 40 and screw in a stub of brass rod as indicated. File flush and solder over it to ensure that no steam leaks through. The rest of the job is the same as on a built-up throttle.

The main part of a built-up stand is a piece of 5/16 in. x 3/4 in. bar—brass or gunmetal for preference—squared off in the lathe to a length of 2 in. The horizontal part is filed up from a piece of 5/16 in. square brass rod 5/32 in. long, which should be faced off in the chuck at the rebated end. The boss is a 3/32 in. length of 3/16 in. round brass rod. File or mill the larger piece of bar to the size and shape shown. Attach the boss to the bottom by a 3/32 in. brass screw through the middle and the horizontal part directly above it by a similar screw. Silver solder the joints, pickle, wash and clean up, file off the screwheads, then drill the assembly in the same way as specified for the cast version.

After plugging the bottom of the vertical hole drill a No 30 hole for the fulcrum bolt at 7/16 in. from top as shown, making sure that it goes through dead square; then true up the portface in the manner described for the cylinder portface. When rubbing it on the emerycloth avoid tilting it but hold it as close to the portface as possible.

The throttle valve is made in exactly the same way as for locomotive slidevalves, the quickest way being to chuck a piece of 5/16 in. square rod in the four-jaw, set to run truly and face off, then make a very shallow depression in the middle with a 3/32 in. D-bit and part off at 5/32 in. full from the end.
The slot can be formed by endmilling, clamping the valve on its side under the slide-rest toolholder and traversing across a ¼ in. endmill in the three-jaw or it may be just filed—it doesn’t matter if the bottom of the groove is round or flat. Bevel the sides with a file and true up the face, as with the cylinder slidevalves. The valve keeps streamtight much better with the little depression in the face than it would if left perfectly plain. Remember to use a different grade of metal for the valve. I have used both rustless steel and bearing metal for these jobs, and good quality brass does the job satisfactorily.

The two levers forming the sides of the bridge can be made from nickel bronze (German silver), brass, or rustless steel; but if the latter be sure that it is rustless! Two 2½ in. lengths of ½ in. × 3/32 in. section will be required, drilled as shown, and the ends rounded off. Mark off and drill one, then use it as a jig to drill the other, as both must be exactly alike. (Note that the countersinks are on opposite sides.)

The pin at the top and the stub pins at the bottom should be made from ¼ in. drawn bronze rod. For the pin chuck in the three-jaw and turn the end for a full ¼ in. length to a tight fit in the drilled hole; part off at a full ¼ in. from the end, reverse in the chuck and turn the other pip. For each stub turn a similar pip and part off at ¼ in. from the shoulder.

The clevis, which is just a wide-jawed fork, is made from a piece of ½ in. × ⅛ in. brass bar. Chuck truly in the four-jaw, face the end, centre, drill No 40 for about ⅛ in. depth and tap ⅛ in. or 5/36. Turn ⅛ in. of the end to ⅛ in. dia. with a knife tool, and as the cut is intermittent look out for flying chips when feeding into cut; they come off with considerable force. Part off at ⅛ in. from the shoulder, taking the same strict caution as before—not only to dodge chips, but to save the parting-tool from premature decapitation.

The jaw opening can be milled out by the same process as described for ordinary narrow jaws, using the widest cutter available and taking sufficient “bites” to cut the proper width. Judicious use of a file will also do the trick. The best way of making sure that the holes at each side line up is to drill right across the blank before cutting the jaw opening. To assemble, push the pins on the stubs into the holes, rivet into the countersinks and file flush; do the same with one end of the long pin. Then push the stubs through the holes in the clevis jaws from the inside, spring the other end of the free lever over the long pin and rivet up.

When the bridge is in place on the stand the clevis cannot come off the stubs. The joints should be free, but not too slack. The end of the bridge moves in an arc, but the length of the throttle rod provides enough flexibility to allow for this and no slotting is required.

**HOW TO ERECT THE THROTTLE**

On the centre-line of the top of the boiler, ahead of the dome bush, drill two No 30 holes at the spacing shown in the plan and countersink them. Insert the throttle stand through the dome bush, push it forward and then bring the horizontal part up against the boiler top under the holes. Wedge it there temporarily, then put the No 30 drill down the holes and make countersinks on the bracket. Remove the stand, drill the countersinks No 40, tap ⅛ in. or 5/36, replace the stand and secure with countersunk brass screws. Smear the portface with cylinder oil, put the valve on it and place the bridge
over the stand with the long pin resting in the slot in the valve. Line up the holes in the bridge levers with the hole in the stand and put the bolt in. This is made from a piece of 1/4-in. bronze or rustless steel rod, a full 1/4 in. long, turned down to 3/32 in. at each end for 1/4 in. length, screwed 3/32 in. in 3/48, and furnished with brass nuts. When the nuts are tight against the shoulders the bridge should be quite free to move, without sideplay.

The gland fitting on the backhead is the same as described for the smaller boiler—but the throttle-rod is longer, being 6 1/2 in. overall. Make up the fork for the throttle lever and screw it on to one end, put a few threads on the other end to suit the clevises, insert in the gland, and screw into the boss on the clevis, which can be held in position by a piece of hooked wire put down the dome bush.

When the throttle rod is operated the valve should slide easily on the portface. No stops are needed, as the clevis comes up against the stand and prevents the bridge pushing the valve off the end of the portface, and the dome itself acts as a stop at the other end. As the throttle lever on the backhead is made and fitted exactly as shown for the wagon-top boiler I need not go over that part of the ritual again. The required movement from shut to full open is a bare 1/4 in. No spring is required to keep the valve on the face, as the steam pressure attends to that part of the business.

THE SUPERHEATER

If a "wet" header of the kind specified for the smaller boiler were used, attached to the steam flange, it would blanket the union for the blower pipe and prevent the nut from being taken up. I have therefore shown an alternative arrangement which has proved satisfactory on other locomotives. In this the upper elements of the superheater are directly connected to the steam flange, and the pipe from the snifting valve coupled to a union formed integral with the flange.

The dry pipe is a piece of 3/8 in. copper tube not thinner than 20-gauge and 6 1/2 in. long. One end has 1/4 in. length of 3/8 in. x 32 thread cut on it and the other 1/8 in. same pitch. Insert into the boiler and screw home, as already described, and fit a similar steam flange, as indicated in the section drawing. To make the outer

flange chuck a piece of 1/2 in. brass rod, face off, centre and drill to 1/2 in. depth with 1/2 in. drill. Part off at 1/4 in. from the chuck. Machine and turn 1/2 in. length to 1/2 in. dia., screwing 1/2 in. x 40. Centre deeply with size E centre drill and drill No 40 until the drill breaks through into the 1/2 in. hole. Then drill three 1/8 in. holes in the thing, the breaking into the hole in the middle at the angle shown in the front view; open out the ends of these to take a 7/32 in. pipe a tight fit.

The upper elements are of 7/32 in. x 22-gauge copper tube, the two outer being approximately 9 1/2 in. long, and the middle one 9 1/2 in. All three lower elements are 8 1/2 in. long. The block bends and the "hot" header are made exactly the same as for the wagon-top boiler—so is the swan-necked pipe to the cylinders, with the union nut and cone. I have heard from several correspondents in the U.S.A. and Canada that 7/32 in. copper tube is either very scarce or non-existent in some parts of those countries. In that case use 1/8 in. which should be obtainable anywhere.

Fit the block bends on to the elements and braze them as before; then bend the other ends as shown and insert into the holes in the steam flange and header. Attach the swan-necked pipe and silver-solder the whole batch of joints at one heating. Afterpickling, don't forget to give the whole issue a good wash in running water, letting the water run through the pipes to remove all traces of dirt, scale and burnt flux.

The completed superheater is then erected by the same method as described for the smaller boiler, using three 6 B.A. or 4/36 screws to connect the flanges, but it should not be permanently connected up until all the fittings are on.

Castings not recommended

From time to time I receive requests for information as to whether certain parts of a boiler can be cast. Recently an American reader suggested that the whole rear part of the wagon-top boiler could be made as a casting, the unit comprising the tapered part of the barrel, throatplate, wrapper sheet, backhead and dome seating. Even if a cast back end was advisable this suggestion is impracticable because the firebox could not be inserted.

If the backhead is left out and the rear end of the casing left open for insertion of the firebox it could be done, but the only gain over a boiler made in one piece would be the elimination of the throatplate joints._offsetting that would be the extra thickness and weight of the casting compared with sheet metal, and the

same staying would be needed to support the inner firebox.

One firm in the United States markets a complete cast rear-end boiler unit comprising wrapper, throatplate, backhead and firebox. All that were needed to complete the boiler were the barrel, tubes and smokebox tubeplate. The moulding was not so very difficult, as the boiler was of the wide-firebox type. Information has reached me that boilers made with these cast units are not in the same street as those made from sheet metal in the usual way, being slow in raising and maintaining steam, but as I have never seen one I cannot offer first-hand information. While I was over there about 26 years ago I saw a 3 1/2 in. gauge 4-6-2 with a cast copper firebox ribbed to form staying, but she was a poor steamer.

Not so long ago our Scottish friend W. McWilliam tried the cast-iron business. The boiler of his 3 1/4 in. gauge Schools class 4-4-0 developed trouble and, being a dab hand at pattern-making, he thought he would try the cast rear-end experiment as it would probably be quicker than making a fresh boiler from sheet metal.

He states that he had three shots at it, and on the third attempt produced a perfect bronze casting comprising throatplate, wrapper, backhead, firebox and foundation ring complete with staying. It only required tubes, barrel and smokebox tubeplate, and was finished in a few hours.

It does not leak, he avers, and has stood the test pressure all right, but takes a long time to get up steam. It was certainly some achievement—seeing that the boiler has a long narrow firebox—and is a tribute to his core making.

To be continued.

FOR STEAM LOVERS

You will enjoy reading The Live Steam Book by L.B.S.C. It is an invaluable work of reference for all who are interested in building small steam locomotives—and in making them work. Price 12s. 6d. net. Add 1s. postage if ordered direct from Percival Marshall and Co. Ltd., 19/20, Noel Street, London, W.1. (U.S.A. and Canada $3.00).

BELT DRIVES

Belt Drives in the Small Workshop by Duplex is a small useful book dealing with light transmission belts in all forms suitable for small power. It costs 3s. 6d. plus 3d. postage if ordered from Percival Marshall and Co. Ltd., 19/20, Noel Street, London, W.1. (U.S.A. and Canada $1.00).
The wooden cabs in vogue on American locomotives when Virginia was a young girl resembled in one respect the legendary cupboard of Old Mother Hubbard inasmuch as they were rather bare.

There was the big Johnson bar on the right-hand side, the throttle lever across the backhead and a big firehole door of the universal oven type usually operated by a chain. The only other backhead adornments were a little water-gauge on the left and three small try-cocks of the screwdown type in a bunch on the right, with a cast-iron cup underneath to catch the drips, which were led away underneath the cab deck by a small pipe. A small steam gauge was usually situated on top of the wrapper close to the backhead and a chain across the inside of the cab roof was connected to the whistle valve.

Very few locomotives had injectors, or even blowers, and the water-valve controlling the pump feed was usually on the tender. The handles controlling cylinder drain cocks and ashpan dampers—and a lever for operating the rocking grate, when one was provided—usually protruded through the cab deck.

As you will see from the drawing, the cab of our little engine is better furnished, but I have tried to retain the old-fashioned look. "Massa Johnson" is present, and the long inclined throttle lever, the "oven door," the water gauge and one try-cock keep him company, as they did in full size; but there are newcomers in the shape of an injector steam valve, blower valve, and a combined whistle valve and steam turret (also known as a fountain or manifold) to which the steam connections and the pressure-gauge syphon are attached. There is also a check valve to take the feed from the emergency hand pump which will be fitted in the tender. A boiler blowdown valve will also be required, and this goes below the cab deck, being located just above the mud-ring at the side of the firebox.

The cab itself would have seemed strange to British engimen of the period. Apart from the two rectangular windows above the boiler there were two front doors leading out on to the running board, with windows in the upper panels. The "hoger," otherwise the driver, or engineer as he is called in America, and the "tallowpot" or "ashcat," alias the fireman, worked at different levels in a literal sense. The driver had a seatbox perched up at running-board level close to the right-hand side of the cab, from which he could operate the throttle and reverse lever and, later, the Westinghouse brake valve.
He could also take a look at the track ahead when necessary by leaning out of the side window.

The safety valve does his shovelling lower down on the cab deck—which we call the footplate—and on these old engines he was rather cramped for space.

**SAFETY VALVES**

Before starting on the backhead fittings it would be advisable to make the safety valves. That for the wagon-top boiler is a small copy of the type used on the full-size engines, in which the valve was held down by a spring-loaded spindle, the spring being retained by a pressure plate supported on two pillars which were screwed into the seating. There are two on the larger straight-top boiler, modern pop valves of the Coale type.

The seating of the former is made from ½ in. hexagon rod. Chuck in the three jaw, face, centre, drill with No. 14, ½ in. length to ¼ in. dia. and screw in ½ in. × 26 or 32. Part off at a full ½ in. from the shoulder. Reversal and rechuck in a tapped bush held in the three jaw. Put a ½ in. parallel reamer through the hole, very slightly countersink it, and take a skim over the face to true it up. At ¾ in. each side of the seating drill a No 48 hole and tap it 3/32 in. or 3/48. These holes must be square with the face of the seating.

The pillars which screw into them are made from 1/16 in. lengths of 3/32 in. steel rod, screwed as shown. The pressure plate is made from a ¼ in. length of 1/32 in. steel with three No 41 holes drilled in it at ½ in. centres; round off the ends.

**Making the valve**

For the valve chuck a piece of ½ in. round bronze, face the end, and turn down 1/16 in. length to an easy fit in the hole in the seating. Bevel the next 1/16 in. with a pointed tool, letting the tool go far enough to undercut the bevel a little, as indicated. Part off at 1/16 in. from the end, reverse in the chuck, and make a countersink in the head as shown. An ordinary centre drill will not form a depression this shape, so turn a cone point on the end of a piece of 1/16 in. silver-steel rod, file half away, harden and temper, and give the flat face a rub on an oilstone. This will come in handy also for centring the injector cones. File three flats on the stem to let steam get by.

Chuck the 1/16 in. rod again and turn down 1 in. length to 3/32 in. dia., parting off at 1/16 in. from the shoulder. Reverse in the chuck and turn down 1/16 in. of the end to a cone point, the exact angle of which doesn’t matter as long as it is a little sharper than the angle of the countersink. The point must press in the countersink at a lower level than the valve seat. The valve must be ground into the seat—and this is easily done by cutting a screwdriver slot across the head of the valve with a fine hacksaw, taking care to avoid cutting into the bevel.

A very small amount of pumice powder and water is about the best grinding medium for tiny non-ferrous valves or a scrape off the edge of your oilstone will also do the trick. Proceed just the same as grinding in the valves of an I.C. engine—but it won’t take a fraction of the time! A very few turns back and forth with light pressure will render the valve steam-tight.

Note that the tapped hole in the dome is not in the middle, but offset a full ¼ in. so as to leave room for the stem of the dummy whistle, which projects from the bell mouth of the outside dome on the full-size engines. Incidentally, the real whistle will be located under the running board on the right-hand side. If any builder has a yen for a chime whistle he can make another whistle two tones lower and fix it on the other side, with a separate pipe to the union on the turret. My 2-6-6-4 Mallet Annabel has this arrangement, and the effect is real Casey Jones!

Mark off and drill and tap the hole in the inner dome top, to suit the thread on the valve seating, and screw in tightly with a smear of plumbers’ jointing on the threads. Assemble the valve as shown, with a spring wound up from 22-gauge tinned steel wire on the valve spindle, securing the pressure plate with a couple of commercial nuts. The valve can be adjusted to lift at 80 lb. when the boiler is first put in steam. To save making a separate drawing I have shown the outer dome section, and the casting should be bored so that it is a tight push fit on the bush flanges. It will then require no fixing and is instantly removable to get at the safety valve, or for any other purpose.

**POP SAFETY VALVE FOR LARGER BOILER**

Although I don’t recommend pop safety valves on small boilers as a general rule on account of their tendency to lift water (the one I fitted to Ayesha for experiment was a champion at providing free showers—baths they are characteristic of American locomotives, so I am specifying them for the straight-top boiler.

Provided that the water isn’t allowed out of sight in the top of the gauge they should behave themselves on a barrel of ⅝ in. dia. The first item needed will be a special pin drill to form the pop seating, but this is easily made from a piece of ⅞ in. silver steel or drill rod. Chuck in the three jaw, face the end and turn ¼ in. length to a bare 3/32 in. dia. and the next 3/32 in. long to 3/32 in. dia. Then grind or file the end for about 3/32 in. length until it is 3/32 in. thick.

With a small fine file back off the steps as shown and slightly undercut them; the sides of the 3/32 in. and ⅛ in. sections should also be slightly backed off for clearance. Harden by heating to bright red and immersing into water, then rub the flattened parts on an oilstone until bright. Put the pin drill on a piece of sheet iron and hold over a gas or spirit flame until the bright part turns medium yellow, then tip off into cold water and it will be ready for use.

Chuck a piece of ⅛ in. hexagon rod in the three jaw, face the end, and turn down ½ in. length to ⅛ in. dia. Centre and drill to about ⅛ in. depth with a No 24 drill. Open out to ⅛ in. depth with ⅛ in. clearing drill (letter W), then make a mark such as a file nick or deep scratch on the shank of the pin drill at exactly ⅛ in. from the bottom step, and feed it in until

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**The safety valve for the wagon-top boiler and parts of the safety valve**

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MODEL ENGINEER
the mark is level with the end of the turned rod. This will form the valve seating and the pop recess at one fell swoop. Screw the outside for about 1 in. down, with the finest thread for which you have a die and tap (screwcut if you like) and part off at 1/8 in. from the end. Reverse in the chuck and turn down 1/8 in. of the end to 1/8 in. dia., screwing 1/4 in. x 26. Put a 3/32 in. parallel reamer through the hole.

Chuck a piece of 1/4 in. round rod and turn a full 1/4 in. length to 3/32 in. dia., parting off at 1/8 in. from the shoulder. Reverse in the chuck and countersink the end with a 1/8 in. drill—just enough to take a 1/8 in. ball nearly to half its diameter. Take a very slight skim off the outside of the cup, say about 1/64 in.

For the cap chuck a piece of 1/4 in. rod and turn 1/4 in. length to 1/8 in. dia. Face the end square, and drill No 40 to 1/8 in. depth. Open out to 1/8 in. depth, drilling and tapping to suit the thread on the column. Part off at 1/8 in. from the end, reverse in the chuck, round off the end and drill for No 41 holes in it as shown in the plan. Seat the ball with the usual hammer blow via a piece of brass rod, and assemble the valve as indicated with a 22-gauge spring.

I test pop valves on a small air reservoir which is connected to a full-scale steam gauge, pumping air in with an ordinary tyre pump. The reservoir is only a short length of 2 in. brass tube with silver soldered ends and a few bushes of different sizes, those not in use being plugged. Screw down the cap until the valve pops off at 80 lb. It should shut down at 75 lb. If it doesn’t and hangs up, take another slight skim off the outside of the cup, repeating until it does.

The clearance between cup and recess regulates the difference in pressure between lifting and shutting. I have got them as close as 2 lb.

WHISTLE VALVE AND TURRET

Chuck a piece of 1/8 in. round rod, face the end and part off a 1 in. length. Re-chuck, centre and drill right through with a No 43 drill. Open out and bottom to 1/8 in. depth with a 7/32 in. drill and D-bit, tapping the end 1/8 in. x 40 and slightly countersinking. Reverse in the chuck and open out to 1/8 in. depth with 7/32 in. drill, tapping 1/8 in. x 40 and countersinking. Put a 3/32 in. parallel reamer through the remnant of 43 hole. At 1/8 in. from the D-bitted end drill a 3/32 in. hole right across, and another at right angles to it, fitting 1/8 in. x 40 union nipples into them. Then at 1/8 in. from the other end drill another 3/32 in. hole in line with the right-hand lower nipple as shown, and fit a 7/32 in. x 40 nipple in it.
If a chime whistle is to be used fit another similar nipple on the opposite side. Silver solder the lot at one heat, then quench in acid pickle, wash off and clean up.

Chuck a piece of 1/4 in. hexagon rod, face, centre and drill No 40 for a full 1/8 in. depth. Turn down 1/8 in. length to 7/32 in. dia. and screw 7/32 in. x 40. Part off at 1/8 in. from the end. Reverse in the chuck and turn down 5/32 in. length to 1/8 in. dia. and screw 1/8 in. x 40. Open out hole to 1/8 in. depth with a No 30 drill. Seat a 1/8 in. rustless ball in the body, wind up a light spring from hard brass or bronze wire around a 3/32 in. mandrel (a bit of drill rod will do), put it in the cap and screw home with some plumbers’ jointing on the threads.

Chuck a piece of 1/4 in. x 1/8 in. brass rod truly in the four jaw, face off, centre and drill No 48 for 1/8 in. depth. Turn down 5/32 in. length to 1/8 in. dia. and screw 1/8 in. x 40. Part off at 1/8 in. from the shoulder. Cut a slot by milling or filing a full 1/8 in. wide and 1/8 in. deep down the centre of the longer dimension. File up a bell crank to the shape illustrated (from a piece of 16-gauge brass) and pin it in the slot with a piece of thin brass wire. Use bits of domestic blanket pins for jobs like this; they are a nice sneeze fit in a No 57 drilled hole.

Put a piece of 15-gauge hard brass or rustless steel wire 1/8 in. long in the hole and screw the assembly into the end of the valve body, so that the wire touches the ball. The horizontal arm of the bell crank should push the ball off the seating when the vertical arm is pulled forward.

On the centre line of the top of the wrapper sheet—and as close to the backhead as possible—drill a 1/8 in. hole through the wrapper sheet and backhead flange and tap it 7/32 in. x 40. Screw the fitting into this, with a smear of plumbers’ jointing on the threads. When tight it should be in the position shown in the illustration of the complete cab arrangement.

When the cab is fitted a piece of fine chain, such as used in jewellery work, is attached to the eye in the bell crank and the other end to a hook at the back of the cab roof, so that pulling on the chain will open the ball valve and sound the whistle. The lower right-hand union is connected to the union on the blower valve, which is already attached to the hollow stay, by a 1/8 in. pipe with cones and union nuts at each end. This pipe must be bent to clear the throttle lever when in the “shut” position.

To be continued.
\( \frac{3}{8} \) in. from the tapped end drill another diametrically opposite. In each of these fit a \( \frac{3}{8} \) in. \( \times 40 \) union nipple and silver solder them.

Chuck a piece of \( \frac{3}{8} \) in. hexagon rod, face, centre, and drill to \( \frac{3}{8} \) in. depth with No 30 drill. Turn down \( \frac{7}{32} \) in. length to \( \frac{1}{8} \) in. dia. and screw \( \frac{1}{8} \) in. \( \times 40 \). Part off at \( \frac{1}{8} \) in. from the shoulder, reverse and rechuck in a tapped bush. Turn \( \frac{3}{64} \) in. length to \( \frac{1}{8} \) in. dia. and screw \( \frac{1}{8} \) in. \( \times 40 \). Reverse again in tapped bush, open out the hole with No 21 drill to \( \frac{1}{8} \) in. depth and run a \( \frac{5}{32} \) in. \( \times 32 \) tap through the rest of it. Screw this fitting into the valve body, tapped end first.

For the valve pin, chuck a piece of \( 5/32 \) in. rustless steel or drawn bronze. Turn the end to a blunt cone— the exact angle isn’t of any importance— reduce the next \( \frac{3}{64} \) in. to \( \frac{1}{8} \) in. dia. then screw the next \( \frac{1}{8} \) in. with \( 5/32 \) in. \( \times 32 \) die in tailstock holder. Part off at \( \frac{1}{4} \) in. from the end.

Chuck a piece of \( \frac{3}{8} \) in. rod and turn the handwheel, recessing the face between rim and boss as desired. Centre and drill \( \frac{1}{16} \) in. for about \( \frac{3}{8} \) in. depth, run the parting-tool in about \( \frac{1}{16} \) in. depth and, failing a proper knurling-tool, press a second-cut file hard against the edge of the wheel, letting it run along as the wheel revolves, repeating until there is a deep knurl. I do all my wheels that way.

A piece of \( \frac{1}{8} \) in. square silver steel with the end hardened is driven through the hole to square it and the end of the pin filed square to fit, the end of the square being slightly riveted over. I usually drill four small holes in the wheel between the rim and boss, for appearance’s sake, as shown in the drawings.

The gland nut is made from \( \frac{3}{8} \) in. hexagon rod and is the same as a union nut; the whole valve is assembled as shown. It is located on the boiler backhead at \( \frac{1}{2} \) in. from the top and \( \frac{1}{8} \) in. to the left of the centreline (see view of the cab) which keeps it clear of the water-gauge. At this position drill a \( \frac{5}{32} \) in. hole in the backhead and tap it \( \frac{3}{8} \) in. \( \times 40 \), screwing in the fitting with the usual taste of the plumber’s best friend on the threads.

When right home, the union nearest the backhead should stand vertically; if it doesn’t come right and a little gentle persuasion will not help don’t strain the threads but put a washer between the fitting and the backhead; the thinnest that will do the trick. Then connect up the upper union to the bottom left-hand union on the turret by a \( \frac{5}{32} \) in. pipe with nuts and cones at each end.

A suitable \( \frac{3}{4} \) in. steam-gauge reading to 120 lb. can be purchased from our advertisers. They can be home-made but it is a fiddling job and requires the services of a full-size gauge for calibrating, so it is really cheaper in the end to buy a ready-made one. It is connected to the remaining bottom union on the turret by an inverted swan-neck of \( \frac{3}{4} \) in. pipe, as shown in the illustration of the inside of the cab.

- To be continued.

FOR STEAM LOVERS

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MAKE YOUR OWN CLOCK.

You can equip every room in your house with accurate and inexpensive timepieces if you follow the instructions in Electric Clocks and How to Make Them by F. Hope-Jones. It gives details for building the Synchronome master clock, and it also contains a number of full working instructions in line with current practice. Price 10s. 6d., postage 8d., from Percival Marshall, 19, Noel Street, London, W.1. (U.S.A. and Canada $2.50).
This week L.B.S.C. completes the description of the boiler fittings for the old-style 3½ in. gauge American locomotive

Continued from 3 January 1957, pages 25 to 27

Many of the old American engines had a sloping water-gauge at the opposite side of the backhead to the three try-cocks, and canted to a matching angle; but the reason—if any!—for this has disappeared along with the old Red Indian legends.

I prefer the straight-up kind and I have specified one for Virginia. It fits in nicely on the backhead between the throttle and injector steam-valve; and the large steam and waterways render it perfectly reliable. It is also easy to make and fit.

For the upper fitting, chuck a piece of ⅛ in. rod in three-jaw, face, centre, and drill to ½ in. depth with No 12 drill. Screw 5/32 in. of the outside with ⅛ in. × 32 die in tailstock holder and part off at a full ¼ in. from the end. Reverse in the chuck, tap 7/32 in. × 40 for 5/32 in. depth, slightly countersink the end, and skim true. Drill a ¼ in. hole in the side, halfway down.

Chuck a bit of ⅛ in. rod, face, centre, drill for a full ½ in. depth with No 30 drill, turn down ¼ in. of the outside to ⅛ in. dia. and screw ⅛ in. × 40. Part off at ¼ in. from the end, reverse and hold in a tapped bush, turn the outside to contour shown, and turn ¼ in. of the end to a tight fit in the hole in the body part. Squeeze it in and silver solder it. The plug is turned up from a bit of ⅛ in. rod and needs no detailing. The top is filed square.

Bottom fitting

The bottom fitting is turned from ⅛ in. rod. Chuck in the three-jaw, face, centre, and drill to ½ in. depth with No 30 drill. Turn down ¼ in. length to ¼ in. dia. and screw ¼ in. × 40, parting off at 1 in. from the shoulder. Reverse and rechuck in a tapped bush. Turn down the outside to a full ⅛ in. dia. to within 3/32 in. of the shoulder. Centre and drill No 43 until the drill breaks into the No 30 hole. Open out and bottom to ⅛ in. depth with 7/32 in. drill and D-bit, tap the end ½ in. × 40, and slightly countersink.

Chamfer the end, drill a No 43 cross-hole through it and squeeze in a piece of 3/32 in. steel to form the handle. Round off the ends as shown. The two gland nuts are made from ⅛ in. hexagon rod and are the same as union nuts, but only 7/32 in. long so as to leave as much of the glass showing as possible.

To fit the gauge to the backhead scribe a vertical line on the backhead at ⅛ in. to the left of the centre line. On this, at ⅛ in. from the edge of the backhead, make a deep centre-pop; and another at ⅛ in. below it. Drill these 7/32 in. and tap ⅛ in. × 40. Screw in the top and bottom fittings of the gauge with a smear of plumbers’ jointing on the threads.

To get them exactly in line, put the shank end of the No 12 drill through the top one and adjust them until it will drop into the counterbore of the bottom one. If they don’t come right within a quarter-turn when tightened up, a little gentle coaxing may do the trick, as soft copper will “stretch,” but be careful to avoid overheating and stripping.

Details of the water-gauge, water-level test valve and the boiler blowdown valve.
the threads. My own pet trick is to use one or more thin copper washers punched out of a bit of foil between flange and backhead.

Cut a piece of \( \frac{3}{8} \) in. glass tube 1\( \frac{1}{2} \) in. long; nick with a three-cornered file and break it with your fingers. Then the packing was slide a short length of \( \frac{1}{4} \) in. rubber tube with a \( \frac{1}{8} \) in. bore on to a piece of \( \frac{1}{8} \) in. rod, hold in chuck, run the lathe fast and apply a wet discarded safety-razor blade at 3/32 in. intervals. When the rubber tube is pushed off the rod it will fall into rings.

Put the wetted glass tube down the top fitting, slide a wet ring on to it, then put the two gland nuts on, back to back, then another ring. Let the glass drop into the counterbore in the bottom fitting, push down the gland nut—it will take the packing-ring with it—and screw it finger-tight. Push the other one up against the top fitting and screw that finger-tight also; then give each another half-turn with a spanner.

The glass should be free to expand so the nuts should be just tight enough to prevent leakage, and no more. Screw in the top cap and the job is done.

WATER-LEVEL TEST VALVE

Chuck a piece of \( \frac{1}{4} \) in. round rod, face, centre, and drill to \( \frac{1}{2} \) in. depth with 3/32 in. or No 43 drill. Open out and bottom to \( \frac{5}{32} \) in. depth with 7/32 in. drill and D-bit and tap the end \( \frac{1}{4} \) in. \( \times \) 40. Part off at a full \( \frac{1}{2} \) in. from the end, reverse in the chuck, turn down \( \frac{1}{32} \) in. of the other end to \( \frac{1}{32} \) in. dia. and screw \( \frac{1}{32} \) in. \( \times \) 40.

At \( \frac{1}{2} \) in. from the shoulder drill a No 32 hole and silver solder a short piece of \( \frac{1}{8} \) in. thin-walled tube into it. The cap and pin are made exactly the same as those at the bottom of the water-gauge but a little hand-wheel may be fitted, like that on the injector steam valve. At \( \frac{1}{8} \) in. to the right of the backhead centre line and \( \frac{1}{2} \) in. from the top drill a 7/32 in. hole, tap \( \frac{1}{32} \) in. \( \times \) 40 and screw in the valve with the pipe hanging down.

The boiler blowdown valve is merely a glorified edition of the above, made by the same process, to the dimensions shown on the drawing. The \( \frac{1}{8} \) in. blowdown pipe may be screwed in if desired. The end of the plug is squared so that the valve can be operated with a box-spanner from the back of the engine, out of the way of boiling water which comes out with considerable force when the boiler is blown down with about 20 lb. pressure left in it. This usually removes scale and sludge after long periods of running and saves much washing-out when hard water is used. Practically all the old tea-kettles had the swing firehole door. Castings will probably be available for Virginia and, if so, will only need drilling and fitting with hinge-lug and handle. Otherwise, cut the door and baffle from 16-gauge sheet steel and turn the distance-piece from a bit of \( \frac{1}{8} \) in. round steel, making the pipes 3/32 in. dia. and 3/32 in. long. Drill the holes in door and baffle with No 41 drill and assemble as shown.

The hinge straps and handle can be cut out of strips of 18-gauge steel and riveted on with bits of domestic pins, the ends being bent to a circle to accommodate the \( \frac{1}{8} \) in. hinge-pin. The hinge lug is also cut from 18-gauge steel, with a bent end for the pin.

Drill three No 40 holes in the door, as shown in the cab view, to let a little air in over the fire when smoky coal is used, otherwise the engineer will need a gas mask.

I usually make my spring catches from the strip bronze used for holding down electric-motor brushes; this is just the stuff for the job, being nice and springy. Alternatively, thin hard brass strip can be used or the thin steel used for gramophone governor springs. Both the spring catch and the hinge lug are attached to the backhead with home-made screws turned up from \( \frac{1}{16} \) in. bronze and threaded 3/32 in. or 3/48. Commercial "brass" screws usually rot away and break off when used in boiler work due to electrolytic action set up by the zinc in the alloy used.

INJECTOR

The injector is one of my "standard" types, the dimensions of which were obtained after much experimenting, and is similar to that specified for Ivy Hall, but the water inlet is at the side and the overflow pipe is curved and long enough to reach to the side of the engine as the injector is located centrally and close to the drag beam.

The first job is to make the cone reamers, which are turned from 5/32 in. silver steel or drill rod. Chuck in the three-jaw and turn the tapers very carefully to the length shown. For the very short one turn a straight taper for \( \frac{1}{16} \) in. then very slightly radius it with a half-round file while the job is running in the lathe. File away half the diameter of the taper, then harden and temper as described for pin-drills and other items.

When running the munition shop in the latter part of the Kaiser's war I did a lot of the toolmaking myself—had to, as really skilled toolmakers were scarce—and made lots of little reamers. I used to harden and temper at one operation by using a small pail with water in it, on top of which I...
poured a layer of sperm oil. The reamers were made bright red and plunged vertically through the sperm oil into the water. They neither distorted nor cracked and kept their edges very well. Rub the flats on an oilstone after tempering.

The stop is simply a brass bush which screws in tightly. When placed on the reamer shank at the right spot it prevents the tapered part going too far into the cone and enlarging the throat above the correct drill size.

For the injector body, saw or part off a piece of \( \frac{1}{4} \) in. square brass rod a full \( \frac{3}{4} \) in. long. Chuck truly in the four-jaw, face, centre, drill through with No 23 drill and ream 3/32 in. Turn down 5/32 in. length to \( \frac{1}{4} \) in. dia. and screw \( \frac{3}{4} \) in. X 40. Reverse in the chuck and turn and screw the other end to same size, leaving distance between shoulders \( \frac{1}{8} \) in.

In the middle of one of the facets drill a \( \frac{1}{8} \) in. hole and pin-drill it to \( \frac{3}{16} \) in. depth with a \( \frac{1}{8} \) in. pin-drill. At \( \frac{1}{16} \) in. drill another hole clean through the body, and where the drill comes out tap it 5/32 in. X 40. At \( \frac{1}{8} \) in. from the shoulder at the opposite end drill a No 23 hole on the side shown in plan and fit a \( \frac{1}{8} \) in. length of 5/32 in. copper tube into it. This will be the water inlet.

Chuck a piece of \( \frac{1}{2} \) in. round brass rod in the three-jaw, face the end and part off \( \frac{1}{2} \) in. length. At \( \frac{1}{8} \) in. from the centre indicated by tool marks make a centrepunch and chuck in the four-jaw with this running truly. Drill through with No 34 drill, open out and bottom to \( \frac{1}{8} \) in. depth with 7/32 in. drill and D-bit, and tap \( \frac{1}{4} \) in. X 40. Run a \( \frac{1}{2} \) in. parallel reamer through the remains of the 34 hole.

Chuck any odd bit of brass rod, turn \( \frac{1}{2} \) in. length to \( \frac{1}{8} \) in. dia., screwing \( \frac{1}{4} \) in. X 40, and screw the \( \frac{1}{4} \) in. piece on to it, then turn down \( \frac{1}{2} \) in. length to a tight fit in the pin-drilled recess on the body. At \( \frac{1}{16} \) in. from the reamed hole, in the wider part, drill a \( \frac{1}{8} \) in. hole on the slant, breaking into the tapped hole as shown.

Fit the projection into the pin-drilled recess with the holes lining up as shown, then silver solder the joint and the side pipe at the same heating. Pickle, wash, and clean up, then poke the 5/32 in. reamer through again to remove any burring. Fit a ball and cap, as described for top of check valves, and file or mill a flat each side.

The combining cone must be a press fit and the easiest way to ensure this is to take a scrape out of the end of the reamed hole through the body, water-pipe end, with a taper broach. I keep a few taper broaches mounted in file handles in the tool-rack at the back of my bench and find them mighty handy.

Chuck a piece of \( \frac{3}{16} \) in. rod and turn down \( \frac{3}{32} \) in. of it until it will just enter the broached end tightly. Face, centre, and drill to \( \frac{3}{16} \) in. depth with No 72 drill. Cut back the end very slightly, until it will not go in nose and part off at 9/32 in. from the end. Reverse in the chuck and ream the hole with the \( \frac{1}{8} \) in. tapered reamer until the point just shows through; if the stop is put on the reamer at \( \frac{1}{8} \) in. from the point you won't "overshoot the platform."

With 5/32 in. of the cone projecting from the chuck jaws, saw it in two, using a very fine saw kept pressed against the jaws; then pull the "left-in" piece out a little way, skim off the saw marks, bevel it a shade and slightly radius the hole with the short reamer. Chuck the other half, skim off and bevel that likewise, and slightly radius the large end.

If the slotted cone is preferred, the Sellers type being true American, cut a groove \( \frac{1}{4} \) in. wide and \( \frac{1}{32} \) in. deep with a parting-tool. Take care that the weeny cone doesn't fly out of the jaws while this is being done. Cut two 1/32 in. slots across the bottom of the groove with a watchmaker's flat file. This cone can be pressed straight in; the groove should come right under the hole at the bottom of the ball chamber.

To fit the divided cone, press in the nozzle half first, using the vice-jaws, with pieces of soft copper sheet over them as a press, to prevent damage to the injector body and cone. Use a piece of \( \frac{1}{8} \) in. brass rod as a pusher, between vice-jaw and end of cone, and press in until the piece of cone is just past the middle of the hole at bottom of ball chamber. Then press in the other half likewise; and to prevent it going in too far put a sliver of brass 1/32 in. thick down the hole in the ball chamber and press in until the second half of the cone just touches it. Now poke the \( \frac{1}{4} \) in. taper reamer into the cone and turn it gently with a tapwrench on the Shank until a No 70 drill can just be pushed through.

For delivery cone, chuck a piece of 7/32 in. rod, face, centre, and drill No 76 to the depth of the drill flutes. Hold the drill in a pin chuck in the tailstock, chuck, and keep the sawing fluid on the drill very light so as to clear chips. Turn \( \frac{3}{16} \) in. length to a tight push fit in the injector body, then shape the end as shown and countersink it with the short reamer.

Part off at 3/32 in. from the shoulder, reverse in chuck, drill No 60 until you meet the first hole then ream with the \( \frac{1}{8} \) in. taper reamer until a No 75 drill can just be pushed through the throat. Countersink the end with the short reamer and skim true. The steam cone is made by same process, drilling No 66.

After turning nozzle to size and shape given, put the \( \frac{1}{8} \) in. taper reamer down it until the hole is opened out almost to a knife edge. Reverse in chuck, centre and drill No 34 drill to 7/32 in. depth. Drill No 54 drill, open out and bottom to \( \frac{1}{8} \) in. depth with 7/32 in. drill and D-bit and tap \( \frac{1}{8} \) in. X 40. At 5/32 in. from bottom, drill a \( \frac{1}{8} \) in. hole breaking into the centre hole. Chuck a piece of \( \frac{1}{8} \) in. rod, face, centre, drill No 30 for \( \frac{1}{8} \) in. depth, open out and bottom to \( \frac{1}{8} \) in. depth with 5/32 in. drill and D-bit, and tap \( \frac{1}{8} \) in. X 40.

Part off at 11/32 in. from the end, reverse in chuck and turn down 3/32 in. length to a tight fit in the \( \frac{1}{8} \) in. hole in the valve body. Press it in and silver solder it. Pickle, wash and clean up, then put a \( \frac{1}{8} \) in. parallel reamer down the remains of the 34 hole. Seat a 5/32 in. rustless ball on it and fit a union cap.

Chuck a piece of \( \frac{1}{8} \) in. hexagon rod, face and centre deeply, drill No 40 for \( \frac{1}{8} \) in. depth, turn down \( \frac{1}{8} \) in. length to \( \frac{1}{8} \) in. dia. and screw \( \frac{1}{8} \) in. X 40. Part off at \( \frac{1}{8} \) in. from the end, reverse in chuck, turn down and screw the other end likewise for 5/32 in. depth, and cross-nick with a thin flat file. Assemble as shown.

If the valve doesn't line up with the injector when screwed right home take a slight skim off the flange of the delivery cone. The overflow pipe can be fitted when erecting.

To be continued.
As both ancient and modern boilers are erected in similar manner there will be no need to separate the instructions, so I will just point out the difference in the attachment of the smokeboxes to the boiler barrels.

The smokebox on the smaller boiler is 3/4 in. less in diameter than the boiler barrel. In full-size practice they were actually the same diameter, but the apparent extra size of the boiler barrel was explained by the fact that the boiler was lagged—not the smokebox, the lagging making up the extra diameter as can be seen from the outside.

On the more modern boilers the smokebox was made to the diameter of the boiler over the cleading plates, which American engineers call the "boiler jacket." This brought the smokebox apparently flush with the barrel. As the only lagging needed by the small engine is a bit of thin sheet metal over the firebox wrapper, to hide up the staysheads, I specified the actual boiler barrels to be full diameter and this calls for a different method of attachment to that used on the full-size job.

This is really an advantage, as the smokeboxes are easily detachable, which is more than can be said for the full-size articles!

The smokebox on the smaller boiler fits inside the end of the barrel, the difference in the outside diameter of the smokebox and inside of barrel being filled up by a brass ring. This should be 1/4 in. wide and 1/8 in. thick.

If a piece of 16-gauge tube 3/4 in. outside dia. is available, chuck it in the three-jaw with a wood disc or something solid inside to take the jaw pressure and prevent its collapsing, then face the end and round it off for about 1/4 in. Part off at 3/4 in. from the end.

Put a smear of plumbers’ jointing around the inside of the barrel and press in the ring, leaving the rounded-off end just projecting. This will represent the polished brass lagging-band which was a conspicuous feature of Virginia’s ancestors. They were a gay lot of lasses with their polished brass and steel, colourful painting, and ornamentation, in striking contrast to the sombre and funereal plain black which was adopted in later years.

However, history is repeating itself; some of the American diesel locomotives are inclined to be gaudy!

If the ring is a tight fit it will require no further fixing, but if slack enough to slide, four small countersunk screws put through the boiler-barrel and ring will hold it. Put another taste of the plumbers’ best friend around the inside of the ring and press in the smokebox to about 3/4 in. depth. Be sure to have the smokestack dead in line with the dome so that it will stand quite vertically when the boiler is on the frames.

A similar ring is fitted to the end of the larger boiler barrel, but this does not need to be rounded off and is only pressed into the barrel for half its length. Fix by screws as above if slack, then smear some of the jointing paste on the outside and press the smokebox over it, taking the same strict caution to have the stack vertical.

The ends of the barrel and smokebox should butt up flush, the joint being covered by an ordinary flat and narrow boiler-band of the usual type when the job is finished off. If brass tube is not available to make the joint rings, they can be rolled up from strip brass of 16-gauge and the joint bedded and silver-soldered.

Tip to beginners—fit the strip ring to the barrel before silver-soldering to ensure an exact tight fit, then pull it out and get busy with the blowpipe, putting the butt piece on the inside (it need not be more than 3/4 in. long) and fixing it with a couple of 3/8 in. rivets. File the outside smooth after silver-soldering.

HOW TO ERECT BOILER

If the smokebox saddle has not yet been fitted to the chassis, do this now, lining it up with the cylinders and attaching it to the top of the frame by screws as shown in the drawings.

Before fixing it permanently, drill four No. 41 holes through the top of the flange at each side about 3/4 in. from the edge for screws to hold the

Diagram of the pipe connections
smokebox to the saddle. Take off the blast nozzle and the steam-pipe union and put the complete boiler and smokebox in place with the steam and exhaust pipes going through their respective holes in the bottom of the smokebox.

The firebox should just clear the trailing axleboxes nicely and leave plenty of room for the pump eccentric-strap to clear the throatplate on the back dead centre. There should be just room enough for the boiler to sit level without fouling the springs at each side of the frame.

Pack up the barrel at the throatplate end with a piece of wood placed across the frame top and adjust until the bottom of the boiler barrel is exactly level and parallel to the top edges of the frames.

On full-size engines the rear ends of the boilers were supported by two cantilever-like beams attached to the backhead and frames, and lifting was prevented by two brackets at each side of the firebox wrapper ahead of and behind the support of the equalising lever. They embraced the top bar of the frame and were attached to the wrapper by studs and nuts.

We don’t need anything so elaborate as that for the little engine. All that will be required are two plain brackets, one on either side, at the rear of the equaliser support. They can be made from commercial brass angle or bent up in the bench vice from 13-gauge sheet brass to the size given in the drawing, and drilled as shown.

With the boiler in position as mentioned above, put a bracket on top of the frame, close to the equaliser support, with the drilled side against the boiler. Run the drill through the holes in the bracket and make counter-sinks on the wrapper sheet, remove bracket, drill the holes No 48, tap 3/32 in. or 3/48 and fit screws.

These should be home made from drawn bronze rod, as I mentioned in a previous note. When both brackets are screwed on lift off the boiler and sweat over brackets and screws with solder, same as stayheads, which is the best insurance against leakage that you could wish for.

To prevent the boiler lifting, and at the same time allowing it freedom for expansion—very important that it —fit a couple of clips made from angle or bent from sheet metal. These simulate the frame clips on the full-size engines. The horizontal part of the angle rests on the boiler bracket but doesn’t grip it tightly enough to prevent the boiler moving under expansion.

The vertical part of the clip is attached to the frame by a couple of 3/32 in. or 3/48 in. screws as shown. The smokebox is attached to the saddle by similar-size screws with round heads put through the clearing holes already drilled in the saddle flange into tapped holes in the barrel of the smokebox. Don’t bother about connecting up the pipes inside the smokebox for the time being in case there should be any need to lift the boiler while doing the “plumbing.”

FITTING THE WATER PIPES

Although our water pipes must of necessity be much larger than “scale” size, which would be useless, there is no need to fit them so that they look clumsy. I am including what our radio and television friends would call a “schematic diagram” of the whole outfit; and as long as the pipes start and finish at the right places their exact location will not affect the working of the engine in any way, so neatness is the watchword.

The right-hand check-valve on the boiler barrel takes the feed from the pump, so all that is required for that will be a piece of 5/32 in. copper tube with a union nut and cone at each end. To get the exact length, measure with a piece of thick lead wire which is easily bent to the shape of the pipe. When straightened out, it will give the exact length to which the actual copper pipe will be cut.

When silver soldering on the cones make the whole length of pipe red hot and quench the lot in the acid pickle, rinsing away all traces of the pickle under the kitchen tap; then rub it with a bunch of steel wool and the result will be a delight, just like the old American engineers liked to see their pipe work.

Bend to shape with finger-pressure only; don’t use pliers or any other kind of grip or the pristine beauty of the pipe will be completely destroyed. Anybody of average strength can bend 5/32 in. pipes without effort. These remarks apply to the whole of the pipe-fitting. The lower end of the above-mentioned pipe is attached to the front union on the pump delivery tee.

The back union is connected to the bypass valve by a long pipe which is brought out over the left-hand frame and runs along to the bypass valve which is attached to the frame at the rear end. This pipe should be set at approximately 1/4 in. above the top of the frame so that it will lie under the running-board when same is erected.

The delivery pipe from the injector keeps it company until it turns in-

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**Arrangement of pipes at rear beam and sectional view of the bypass valve**

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**MODEL ENGINEER**
wards to the pump, while the injector pipe goes on in the shape of an in-
verted swan-neck and is connected to the left-hand check-valve, as can be
seen in the general arrangement of the engine published with the first
instalment.

The injector itself is supported by the water-pipe passing through a
hole in a sheet-metal bracket screwed to the underside of the rear beam.
The full-size engines had their pipes suspended by long hanging pipe-clips;
again, these would be useless on the little engine; much too fragile.

The steam-pipe to the injector is also 5/32 in. dia. and runs from the
bottom union on the injector steam-valve to a little below frame level
where it is bent into a half-circle and connected to the steam inlet on the
injector by a union nut. Note, a plain collar, not a cone, is needed on
this end of the pipe to butt against the end of the steam cone.

The feedpipe to the water-pump and the pipe from the bottom of the
bypass valve are supported by another sheet-metal bracket at the right-hand
end of the drag beam. The feedpipe can be run along under the right-hand
frame and then bent inwards to connect to the union at the bottom of the
valve-box.

A small clip can be bent up from 1/4 in. strip metal and attached to the
underside of frame, about half-way along, to prevent the pipe from
sagging. Keep it clear of the ashpan, so that the latter is free to drop.

As the bypass valve is made in exactly the same way as the other
screwdown valves there is no need to go through the whole ritual again,
the sectional drawing giving all the necessary dimensions. For the sake
of clarity I have shown both the bracket and the union nipple at the
side, in the same plane in the section, but actually they are set at right
angles, as is plainly indicated in the drawing showing the arrangement of
pipes at the rear beam.

The bottom union is made a little longer than usual, the hole in the
bracket tapped 3/8 in. x 40, and the union nipple screwed into it, which
dispenses with a separate locknut, as space is rather at a premium at this
point. Be careful to avoid kinking the pipe from the bottom union to the
bracket under the beam when bending it.

Another tip to beginners—soft lead wire can be purchased in various
gauges from 1/16 in. upwards (I keep a stock of several sizes) and if a piece
is poked through the pipe before bending, bends of quite small radius
can be made without any danger of kinking.

You can't pull out the wire, naturally, after making the bends but if
you make the pipe red hot the wire melts and runs out of its own free
will and accord, and usually with

great acclivity! This tip doesn't seem to be generally known.

Contrary to the way I arrange the connecting pipes between engine and
tender on British locomotives, the injector feed is set low down, which is
beneficial to that gadget as it keeps cool and starts as soon as water and
steam are turned on. The union for connecting up the feedpipes for the
emergency hand-pump is placed di-
rectly above it.

A union is needed here as the pipe
is under pressure when the pump is
operated; the other connections are
not under pressure and slip-on hoses
will suffice. Chuck a piece of 3/8 in.
hexagon rod, face, centre deeply and
drill to 1 in. depth with No 41 or
3/32 in. drill. Turn down a full
3/8 in. of the outside to 1/4 in. dia. and
screw 3/8 in. x 40. Part off at 3/8 in.
from shoulder, reverse in chuck, turn
down 1 in. length to 1/4 in. dia. and
screw 3/8 in. x 26.

The coarser thread is more handy for
choosing up the tender pipe. Countersink the end, and chamfer the corners of the hexagon. Make a
1/4 in. x 40 locknut and union nut from the same sized hexagon rod.
Put the longer end of the double
union through the bracket, secure with the locknut, then connect it up to
the check valve at the side of the
wrapper sheet inside the cab with a
5/32 in. pipe furnished with union
nuts and cones at each end.

If the plumbing job has gone off
O.K. without having to take off the
boiler any more, the connections in
the smokebox can now be finished
off, coupling up the swan-neck from
the superheater to the vertical steam-
pipe and fitting the bottom of the
smoothing-valve into the hole provided.

See that the blower ring sits well
don top of the blast nozzle so that the steam from the jets all goes up
the stack, and line up the nozzle itself by putting a straight piece of
drill-rod down it, which should be a
good fit in the hole in the nozzle,
bending the blastpipe, if required,
until the piece of drill-rod stands up
exactly in the middle of the stack.

Make quite certain that the unions
are tight, because if any steam escapes into the smokebox it will destroy the
vacuum and the boiler won't steam.

By the same token, as Pat would
remark, the holes where the pipes
pass through the smokebox barrel
must be sealed so that no air can be
drawn in.

• Continued on page 184.
WHEN the Liverpool Overhead Railway opened to the public in 1893 one of its first passengers was George Williams, a boy of 11. Before the line closed for ever on the last Sunday evening of 1956 Mr Williams, now 74, travelled on it again, for the last time.

There were many who made this sentimental journey. Although the greater part of the staff were accommodated in other work, all of them were sorry to see the old Overhead close. It says much for the private management that it could earn the loyalty of a veteran like Signalman George Bowers who began on the Overhead as a porter in 1913 and remained for 43 years, if we include his service in the First World War.

Even with modern machines it will take quite a time to remove the Dockers' Umbrella. Meanwhile the Liverpudlians are thinking of happier events in the programme for 1957.

This year is the 750th anniversary of Liverpool's first charter. Such an occasion asks to be celebrated by all the organised bodies in this great port. But the 750th year of the charter also happens to be the hundredth year of a key institution, the Mersey Docks and Harbour Board.

Among the organisations which have a direct reason to celebrate the centenary is the Liverpool Nautical Research Society, and so the society's open meeting in February is being devoted to "Liverpool's Dockland One Hundred Years Ago." H. A. Taylor of the Liverpool Record Office, who is also a member of the L.N.R.S., is to speak on the relevant pictorial and written records in the possession of the Liverpool libraries.

"This will not be a highly technical or detailed study," writes chairman R. B. Summerfield, "but an attempt to recall something of the atmosphere and customs, just as they were felt and recorded by artists and journalists, or typified by advertisements and other commercial records."

Naturally, the members are also keenly aware of the larger celebration this year, and will enlist all of its history to the sea, and what could be closer to that history than a society immersed in nautical research?

ANY MORE FOR TEA?

At four o'clock on the afternoon of February 16 members of Sussex Miniature Locomotive Society foregather in the Tea Room at Beech Hurst for the society's annual meeting. They will also enjoy the more normal amenities of a tea room. Because of this, secretary S. R. Botzel is anxious not only to have a large attendance but to know who is coming so that the right number of high teas will be ready.

In future the second Sunday in each month will, as far as possible, be visiting day. The choice of a definite date makes it unnecessary for the members to be notified whenever visitors are coming, but the arrangement is by no means like one of the laws of the Medes and Persians.

If a club finds the date unsuitable the Sussex M.L.S. will try to cooperate accordingly. One visit is already in the diary: Maidstone Society on the second Sunday in May.

There are also hopes of a visit from Birmingham at a later period.

Although June seems a long way off many traction engine enthusiasts will be glad to mark off a couple of June dates in their diaries before they forget.

The occasion is the Rempstone Steam Traction Engine Rally of 1957. Mr J. Byers is holding it at the Steam Plough Works, Rempstone, on June 29 and 30.

As in 1956, the local vicar will lead a service at the field on the Sunday afternoon (June 30) and the proceeds from the two days will be devoted to the Blind.

This announcement comes to me from N. Ayres, a member of the committee, whose address is 1, Cameron Avenue, Leicester.

M.E. DIARY


February 1.—J.I.E. Pepys House, "Trans-ocean Deep Sea Submerged Repeater Systems," E. F. S. Clarke, 7 p.m.

February 2.—S.M.E.E. rummage sale, 28 Wanless Road, London, S.E.24, 2.30 p.m.

February 6.—J.I.E. Midland Section, film evening and meeting with Institution of Water Engineers, Birmingham 7 p.m.

February 7.—Eltham and District S. "Boiler Brazing," chairman A. L. Hutton.

February 8.—J.I.E. Pepys House, "Kinematic Design," R. J. Herbert, 7 p.m. Institution of Mechanical Engineers, "Economics of Plant Replacement and Renewals," C. W. Griffiths, headquarters 6 p.m. Welling and District M. and E.E.S. "Bits and Pieces," 8 p.m.

February 11.—J.I.E. Sheffield, "Power Station Construction," S. S. Ellam, 7.30 p.m. Clyde S. and M.M.S. Nautical quiz, Hugh Lauder and William Forth (illustrated) Kelvingrove Museum, 7.30 p.m.

February 12.—Bristol Ship Model Club, "Mediaeval Ships," N. H. Poole, Legion House, Portland Square, 7 p.m. Institution of Mechanical Engineers, Automobile Division general meeting, papers, headquarters 6 p.m.

February 13.—Birmingham S.M.E. film show, King's Arms.


VIRGINIA...

continued from page 172

If a few scraps of asbestos millboard are kneaded up to a kind of putty with a little water and a fillet of this put around each pipe, pressing it well into the annular space between pipe and smokebox, it will set hard after the first steam-up and form a perfect seal.

If a tender or a flat car is available the engine can now be tried on the road. Although I have made many locomotives during my long life I still get the same thrill when trying out a new engine as I did when a child of 10 when my first "home-made" locomotive, with a coffee-can boiler and four lugs for wheels, got out of control, dashed off up the passage, tried to climb up on to the doormat, overturned, and set fire to the mat.

I thought mum was going to be well, annoyed—shall we say?—but she wasn't; she was pleased that my effort had been successful. Space has run out, so I'll have to defer some hints on making a test run until the next installment.

To be continued.
The first thing I do when about to give a new locomotive its first trial run is to see that every moving part is lubricated.

After going around with the oil feeder fill the mechanical lubricator with a good grade of superheater cylinder oil and turn the ratchet wheel by hand until you feel a definite resistance on the forcing stroke of the pump, indicating that oil is pushing up the spring-loaded check valve and entering the steam pipe. See that the smokebox front is pushed in airtight.

To make sure that the dummy door hinge strips lie horizontally, put a 3/32 in. countersunk screw through the smokebox barrel, close to the front edge, and file a nick in the push in part of the smokebox front to engage with it. Put enough water in the boiler to reach about three quarters up the gauge glass.

A temporary tender

If a spare tender is not available and the builder has not yet made up a flat car for riding on, a temporary tender can be rigged up with a piece of board mounted on four flanged wheels; a tin can can be used as a water tank. It should have a cock and a piece of tube soldered in it near the bottom and another piece of tube near the top. Connect the former to the injector and pump feeds, and the latter to the bypass by pieces of rubber pipe. A piece of stout wire with twisted ends can be used for a temporary coupling between engine and car or range tender.

Beginners should note that it needs a strong artificial draught to start the fire and keep it going until there is sufficient steam to operate the blower. There is no natural draught in a full-size locomotive unless it has an exceptionally long chimney, so there isn’t much hope of any in a small one.

The easiest way to create enough draught to start the fire in Virginia’s little firebox is to rig up an adapter, one end of which is screwed to fit on the union for connecting up the tender hand pump and the other to fit the union of an ordinary automobile tyre pump. When this is coupled up it is easy enough to pump air into the boiler with one hand while stoking up with the other. Of course, the proper thing to do is to make up an auxiliary blower, either fan or pressure operated. But most beginners will be too impatient to see the wheels turn for the first time under steam to wait until that job is done.

Now another tip to beginners about coal. Ordinary house coal is hopeless . . . good quality steam coal should be used. Before nationalisation, when branded Welsh steam coal could be obtained, I used Graigola, Navigation, Calorite and other brands which lit freely, didn’t cake, made very little ash, no clinker, and lots of steam. The last lot delivered just recently for my domestic boiler is nameless but supposed to be Grade A. It suits the boiler very well, but is no use for my little locomotives as it smokes, cakes badly, chokes the firebars with ash, and clinkers as well. Luckily I still have some good anthracite peas left!

That Pocahontas barrage!

American readers who are unable to obtain good Welsh coal can use Pennsylvania anthracite, or Ford briquettes. I got excellent results from both when I was over there. I remember trying old Ayesha on Pocahontas steam coal. She burnt it all right—she would steam on a mixture of granite chips and tarmac !—but put up a smoke barrage all over the landscape, and just above the top of the chimney it looked thick enough to cut with a hacksaw. I note from a recent number of The Call Boy that our Californian friends have been using some Welsh coal for their little locomotives, and, indeed to goodness, I hope that they get the right quality.

To start the fire, wet some charcoal or wood chips with kerosene (paraffin) or alcohol (methylated spirit) and well cover the firebars with it. Throw in a lighted match and start pumping, with the blower-valve open. Throw in some more as soon as the first lot is well alight, then some coal can be added. This should be broken up to pea size and all the dust sifted out. Steam should be up in about three minutes, when the adapter and tyepump can be disconnected and the boiler will do its own blowing.

When the steam gauge shows about 60 lb. “put the Johnson down in the corner,” which is the old American engineer’s way of saying put the lever in full forward gear, and open the throttle a little. Stand clear of the stack, for when the hot steam goes into the cold cylinders it will condense, and for the first few revolutions of the driving wheels, Virginia will be unladylike enough to spit out some dirty water. However, she will soon remember her manners and start to purr along with a clear exhaust, while the steam pressure will rise and the pressure will start to blow off. Now fill up the water tender, and, if you have made the flat car, take your seat on it.

He didn’t look ahead . . .

Open the throttle very steadily, for the power will amaze any uninitiated beginner. I remember once at Norbury a very talkative and super-confident overseas visitor came to see me. He was desperately anxious to see if an engine would really haul a living load on my little straight line, so I got up steam on one and invited him to drive it. He sat on the flat car facing me, not looking ahead like a good engineer should, and—yak-yakking all the time—he opened the throttle wide. The engine was blowing off, the steel rails were dry, and she gave one mighty jerk and yanked the flat car from right under him. He hadn’t taken his feet right off the ground, but all the same over he went, while...
I made a frantic grab at the car and luckily caught it—or there would have been a spectacular buffer-stop collision at the far end of the line. It was a very quiet and crestfallen merchant who picked himself up and begged for another try, with a solemn promise to be more careful!

If your workmanship is satisfactory and the valve setting correct, the engine will move off with no apparent effort, and the exhaust beats should be quite even and very snappy without the least sign of wheezing or "syncopating." As she gathers speed pull the lever back to next notch to middle. The beats should immediately soften, but still remain even and distinct.

Now look at that engineman’s nightmare, the water-gauge. The water will be near the bottom nut, so open the bypass valve until water shoots from the upper pipe (denoting that the pump is working) then close it, so that the water will go into the boiler. Leave it closed until the level rises near the top of the glass, then open the bypass a little, letting just enough go into the boiler to maintain the level.

Yet another warning to beginners: don’t in any circumstances wait until the fire begins to die down before putting more coal on or you will do what our American friends call "kill her"—that is, lose all the steam. The right time to fire is when she is just going to blow off and the fire is fully incandescent. Then pop a little over the top of the fire. This will prevent her blowing off, and the process is repeated until the run is finished, when the fire can be allowed to die down. If, however, the fire is getting too big open the firehole door a little when the safety-valves lift, and wait a little before putting any more on. A little practice and experience will soon make the perfect fireman.

To operate the injector first open the water cock, and when water runs freely from the overflow pipe open the steam-valve fully. If the cones are properly made the injector will immediately "pick up" and start feeding. Should there be any dribble from the overflow when feeding adjust the water cock until it ceases.

The engine will keep going as long as the boiler is fired and supplied with water. The mechanical lubricator should be topped up every ½ miles. When the run is finished dump the residue of the fire and the ashes by pulling out the pin and letting the grate and ashpan drop. Clean out, replace, and before putting the engine away, wipe off all oil while she is hot and fill the tallow-cups on the steam chests with cylinder oil in readiness for the next trip. This ensures that there is plenty of lubrication while the mechanical lubricator is getting under way.

If the engine fails to steam freely look for an air leak in the smokebox or a steam leak inside it, either of which will destroy the vacuum and prevent the blast taking effect on the fire. If the engine has little power and the beats are wheezy or slurred, steam is blowing past valves, pistons, or both. If the beats are the valve gear requires adjusting, and the valves are not set correctly; the same applies if the engine goes better in one direction than the other.

The gentlemen who complained about this fault in Mr. Bleydon’s letter (Postbag, 27 December 1956) might do well to check their own workmanship before blaming the design—and speaking of design I have heard of very successful locomotives designed and built by other good folk who incorporated in them the principles and components described in these notes. Nuff sed!

**RUNNING-BOARDS AND CAB**

Making up the running-boards and cab are simple jobs needing little detailed instruction. The running-boards are similar for both the larger and smaller-boiled engines, the only difference being that the brackets supporting the running-board on the latter, are set back to meet the lesser diameter of the boiler-barrel, as shown in the end view.

The running-boards themselves are merely pieces of 16-gauge sheet steel, 1½ in. long and 1½ in. wide. They are attached to the boiler by brackets bent from strips of 16-gauge steel ⅛ in. wide, riveted to the underside of the running-boards and attached to the boiler by brass bands. All the threads are tight and treated with plumbers’ jointing before the screws are inserted, there should be no leakage; personally I have no hesitation in screwing both these, and handrail pillars, direct into the boiler shell, and I have no leakage trouble. However, for anyone who objects there is an alternative; the brackets could be extended downwards to the frame and screwed to that instead of the boiler.

Yet another alternative would be to make the brackets of brass, screw...
and sweat them to the boiler shell and attach the running-boards to the brackets by countersunk screws nutted underneath. It does not matter which way you go, as long as you get there! Any builder of the small-boilered engine who wants to go the whole hog and make a wooden cab should obtain a couple of large-size cigar boxes. Naturally a piece of 1/2-in. cedar would be preferable, but I should imagine that the former are easier to acquire, and probably cheaper. If the size of the box doesn't allow of making the cab-front in one piece, it can be made in two pieces with the join in the middle. The sides could be joined under the cab windows.

**Thoughts on wood**

I know little about woodwork, but were I on the job I should cut the openings on my jigsaw; a hand fret-saw would also do the trick. The outline would be sawn with an ordinary fine-toothed saw. The butt joint, if required, would be made with Cedro, or some similar glue sold in tubes, and reinforced with a small strip of thin brass at top and bottom, secured by small brass woodscrews.

The sides of the cab could be glued to the front and reinforced by pieces of thin brass angle screwed into each corner. Pieces of similar angle could be used to attach the cab to the running-board, using woodscrews to fix the angle to the cab side and ordinary screws and nuts to attach the angle to the running-board. Personally I should make the doors dummy, with the upper panels "glazed" with mica or Perspex, and the lower panels solid, and then attach them to the cab with pattern-makers' pins or gimp pins. The upper windows and those in the cab sides, could be glazed in similar fashion, the mica or Perspex being held in place by window frames made from thin brass sheet, secured by very small brass roundhead screws.

A beading of half-round brass or nickel-bronze wire could be fixed around each window outside, if desired, for appearance sake.

As to the roof I understand that the usual method of "bending" wood to a curve, is to make a series of longitudinal sawcuts about halfway through the thickness on the concave side, which close up when the "bend" is made. The roof can be attached to the sides and front of the cab by pieces of thin brass angle and small roundhead woodscrews. I might mention here that the rear ends of the running-boards will be supported by the cab apron when both the cab deck, or well, are fitted.

The modern type of cab can be made from 18- or 20-gauge sheet steel. The easiest way of making it would be to mark out the front and both sides on one sheet, leaving a strip about 3/4 in. wide along the top and bottom of each side. After cutting out the openings for the boiler and the windows the sheet should be bent at right angles along the corner lines. The marked strip at the bottom edge of each side is then bent inwards at right angles to form the attachment for screwing to the running-board, and the strip at the top bent to line up with the curve of the cab roof, as shown in the drawings. If a piece of steel sufficiently large for the one-piece job is not available the cab can be made in two pieces, each comprising one side and half the front, as I described for *Ivy Hall*; or sides and front can be made separate and joined at the corners by angles and screws or Sifbronzed.

The windows are glazed in the same way as mentioned for the wooden cab, the window frames being made from thin sheet brass.

**Cutting the "glass"**

The mica or Perspex (ordinary glass is too thick) is cut to the size of the frame and sandwiched between the frame and the cab-side or front, the frames being riveted to the cab by bits of thin domestic pins. I use doll pins, which are less than 1/32 in. thick, and have neat little heads; one of my few friends uses 16 B.A. screws.

The roof is made from same kind of metal as the sides, and bent to the radius of the front sheet. A gap is cut in it and runner riveted to each side; a cover-plate is cut to slide between the runners and cover the gap when the engine is not at work. The complete roof is attached to the bent-in strips at each side by 3/32 in. or 3/48 roundhead screws which may be nutted inside. Alternatively, a 3/4 in. strip of brass about 13-gauge can be soldered to the underside of the bent-over part and the screwholes drilled and tapped in it. This enables the screws to be put in without fiddling about with a lot of little nuts.

When erecting the single-unit cab, the steam turret and the check valve at the side of the wrapper will have to be temporarily removed, but that is only the work of a few minutes.

With the *Ivy Hall* construction, each half fits without removing anything, and the two halves are joined by a butt strip riveted to one half and screwed to the other.

*To be continued.*
L.B.S.C. describes some of the accessories for the old-time American engine.

The footplate, or cab deck as our American friends call it, differs from British practice inasmuch as on locomotives of the Virginia type, it is not arranged level with the bottom of the cab sides, but drops to frame level in a kind of well. In the days before mechanical stokers were fitted, the fireman spent most of his time “on the deck” although our nautical friends will probably disagree with that and substitute “down the stokehold.” Curious how terms differ, isn’t it?

In the case of our little engine, the deck itself, with sides and supports, can be made from a single piece of 18-gauge steel, measuring 3¾ in. × 5¼ in. Check the latter dimensions from the engine, measuring from the backhead to the end of the frame, in case of any slight variation in the position of the boiler on the frames. First bend this into a channel measuring 2½ in. wide on the inside; then bend each of the sides outwards, at 1½ in. from the bottom. This will leave a horizontal ledge at each side approximately 1½ in. wide.

If the reversing lever is temporarily removed this can be slid into position, as shown in the drawing, between the trailing spring hangers; and the places which require filing to clear the pipes and the position of the slot to clear the reversing lever can be marked on it. Remove it, file the clearances, cut the slot, and replace, holding it in position with a toolmaker’s cramp, to the underside of each running-board. Drill four No 41 holes at about ½ in. centres through both thicknesses of metal (see back view) and secure with four 3/32 in. or 3/48 screws nutted underneath at each side. The lever can then be replaced. The deck should fit closely to the backhead, otherwise there will be enough draft to blow the engineer off his perch and choke the fireman with coal dust!

Builders have the choice of fitting a sheet-metal apron or cast brackets to support the rear of the running-boards and cab. For the apron a piece of 16- or 18-gauge sheet steel is required, 6 in. × 2½ in. First cut a piece out of the middle, the same width as the well, leaving ¼ in. at the bottom. Then mark off the angles at each side and cut away the surplus metal, leaving the bottom edge ¾ in. long. Next, at ½ in. from the bottom, bend over the upper edge of each side at right angles, as shown in the side view. Offer this up in position, and mark off the amount to be cut away to clear the side wings of the well.

After cutting drill the four No 34 screws as indicated by the “banner signals” in the back view, at ¼ in. centres. Put the apron in position and hold it temporarily with a cramp over the bottom of it and the drag beam; then drill a couple of No 41 holes each side, through the running-board and the bent-over flange. Fix with screws and nuts, and secure the lower part to the drag-beam by four 6 B.A. or 4/36 screws with round or hexagon heads as desired.

If the alternative cast brackets are preferred they will only need cleaning up with a file and drilling for screw and step pillar. Take care to get the two holes for this dead in line. 1, personally, lay the casting on its back on the drilling-machine table or something equally level, and mark off the position of each hole with a scribbling-block or surface-gauge, then make centre-pops dead in the middle of each scribed line. The lower hole is drilled No 30, and the upper is drilled No 40 and tapped ⅛ in. or 5/36. To fit the bracket take out the two hexagon-headed screws holding the frame to the drag-beam nearest the end of frame. Countersink the top hole and put a countersunk screw in place of the hexagon-head one. Drill a hole in the lug under the bracket, corresponding to the position of the lower hole, put the bracket in place, and fix it with a screw about ¼ in. longer than the one taken out.

Put a No 40 drill through both holes in the bracket and drill upwards through the running-board, following with ⅛ in. or 5/36 tap. The step pillar is a piece of ⅛ in. round steel with ¼ in. length of ⅛ in. or 5/36 thread on one end, the overall length being 3½ in.

The other end is turned down for ⅛ in. length to 3/32 in. dia. and screwed 3/32 in. or 3/48. Push it through the lower hole in the bracket and screw it tightly into the upper
hole and running-board, locknutting it on top. The step is bent up from a little piece of 18-gauge steel and needs no detailing out. Drill a No 41 hole in it and attach to the bottom of the pillar by a nut as shown. This pillar and step is not suitable for use with the apron, but that can wait until we fit the tender steps.

**COWCATCHER OR PILOT**

In *Virginia*’s day the triangular gate affair that every American locomotive (with the exception of a few switchers or shunting engines) carried attached to its front beam was called a cowcatcher because it was a protection from wild cattle straying on the unfenced tracks. Some of the “cows” were bull buffaloes! In Matthis Forney’s book *Catechism of the Locomotive* the designation cow-catcher is always used; but the modern term is “pilot,” so call it what you like! However, I’ll tell you right here that it is a dickens of a tantalising job to build one up for our little engine—and if you can buy a casting, don’t hesitate. The time saved will be worth the price. It should only need cleaning up with a file, attaching to the pilot beam with screws through the angles, which will be cast on, and reinforced against collision shocks by the two plate angles about to be described for the built-up version. The same type of coupling is also fitted.

The full-size cowcatchers were made of wood, reinforced at the joints with bolt-on metal strips, but it would be hopeless to make a wooden one for a 3¼ in. gauge engine. It would be smashed to splinters the first time that the engine hit anything. Brass or steel can be used; the former is the easier to work on.

The top beam is a 4½ in. length of ½ in. × ½ in. bar, the ends being squared off at the lathe. The two side members are 1½ in. lengths of similar material, also squared off with both chucked together in the four-jaw, so that they will be exactly alike. The triangular base is cut from ½ in. plate in one piece. Mark it out to given dimensions, then saw and file to the outline. After this the middle part can be cut away to leave a triangular frame ½ in. wide. If a piercing saw is available this is an easy cut. A piercing saw (like a glorified hand fretsaw) or an Abrafile or similar gadget will also do the trick. Failing these, the only way is to drill holes all round inside the marked line, break out the piece, and file the ragged edges to shape. The bars or slats can be made from the same material specified for firebars, or from ¼ in. × ½ in. brass strip. The middle pair are spaced a full ½ in. apart to allow the coupling to be fitted; the others are spaced ¾ in. apart. If a milling-machine is available the top beam can be slotted at ½ in. intervals to take the slats a tight fit; but I once made one up in the following way, which is similar to the method of assembling firebars.

One of the middle slats was drilled No 51, close to the upper end, and used as a jig to drill similar holes in all the rest of the bunch. They were then assembled on a piece of ½ in. silver steel, with ¾ in. spacers between, and nutted at both ends, just like a grate. The lower ends were filed off at the correct angle to match the base, the whole issue placed in position on the frame, and some iron binding-wire tied around the lot to prevent movement. The ends of the slats were then silver soldered to beam and base at one heating.

To assemble the slats temporarily attach the ends to the base by screws put through clearing holes in the base, into tapped holes in the thickness of the end pieces; the beam is attached to the slats in similar manner, and the joints brazed if steel has been used or silver soldered if brass. The slats can then be fitted to the frame. If they are a tight fit in the slots in the beam, they should “stay put” when inserted; the lower end of each will need filing separately to bed down properly on the base.

Pieces of ½ in. asbestos millboard can be placed between the slats to keep them apart at the proper distance and when the whole lot has been fitted some thin iron binding-wire can be tied around the assembly to keep everything in position while brazing or silver soldering the ends of the slats to the frame. The screws previously put in the frame will prevent that part from becoming unstuck while the second operation is in progress.

After quenching and cleaning up the screwheads can be filed off. Anybody who has used the firebar-assembly method has only to remove the pin and pull out the spacers. The little hole in each end slat can be tapped and plugged with a stub of screwed wire by anyone who objects to its presence, but you wouldn’t notice it unless you looked especially for it.

Drill a No 30 hole in the middle of the beam; this should come out between the middle slats. Then fit a ⅛ in. length of ⅛ in. × ⅛ in. angle at each end by two countersunk screws. These bits of angle can be bent up in the bench vice from pieces of 16-gauge sheet; if preferred they could be fitted before the slats are assembled and brazed or silver soldered to the beam at the same heat. Two stiffening brackets are also needed and these can also be bent up from 16-gauge sheet; the shape and size are shown in the side and back views. They are attached to the inner sides of the frame by three screws in each. The whole bag of tricks can then be attached to the pilot beam; be sure that it is located centrally. Two screws are needed in each end angle—either round or hexagon heads as you fancy—running through clearing holes in the angles, into tapped holes in the beam. One screw will suffice in the top of each stiffening bracket, as
shown, a hole being tapped in the frame to receive it. The whole lot should be quite rigid. Finally drill a No 30 hole through the pilot beam, using the one between the two middle slats as guide; this is for the shank of the coupling.

Locomotives and rolling-stock in *Virginia*’s time had the primitive link-and-pin couplings, as automatic couplers had not then been invented; and the link at the leading end of the engine had to be long enough to allow room for the cowcatcher. According to the drawing in Forney’s book, the end of the link was put through the eye of the drawbar and then closed to form a ring; but I have shown an open hook which is easier to make and cannot come off the drawbar when in place.

The link is a simple filing job, made from \( \frac{4}{8} \) in. \( \times \frac{1}{8} \) in. steel, to the shape and dimensions shown. The drawbar is turned from \( \frac{3}{8} \) in. round steel. Chuck in three-jaw, face the end and turn \( \frac{3}{16} \) in. length to \( \frac{1}{8} \) in. dia., screwing the end \( \frac{1}{8} \) in. or 4/36. Turn the next \( \frac{1}{4} \) in. to \( \frac{1}{4} \) in. dia. and part off at \( \frac{1}{2} \) in. from the shoulder.

File each side flat, leaving a tongue a full 3/32 in. thick; round this off and drill a No 30 hole in it to take the hook on the link. Push the shank through the beam as shown in the plan view and secure with a nut behind the pilot beam. The front end of the link lies between the middle slats and the end rests on the base when not in use.

**Domes and Sandboxes**

The domes and sandboxes are turned up from castings, and if a chucking-piece is cast on the top of each it would facilitate the machining, as this could be held in the three-jaw while the inside of the casting is bored. The domes should be bored to fit over the flange of the dome bush, as I mentioned when describing the fitting of the inner domes; the internal diameter of the sandboxes doesn’t matter much. If no chucking-pieces are provided, the castings can be chucking truly in the four-jaw for boring.

To turn the outsides of my own pet antic is to mount them on a stub mandrel made from a piece of hard wood, as I find that this gives a better grip on the inside of the casting; the wood is held in the three-jaw. They can be centre-drilled for tailstock support.

It requires a lot of practice to manipulate both handles of the slide-rest at once to turn the curved portions. I usually finish mine off with a hand graver, which is just a piece of square tool steel about 6 in. long and furnished with a handle. The end is ground off at an angle, corner-wise, so that the end is diamond-shaped. For a rest, if I feel too lazy to fit a half-round file to the tool proper, I cut into the stock and drop the part out of the tool. I put a bit of iron bar crosswise in the slide-rest, letting it project far enough from the side nearest the headstock for the tool to rest upon. With this rig-up it is easy enough to round off the top of a dome or anything similar. The parallel parts of the old-type dome and sandbox—and the more modern version— can be turned in the ordinary way with a roundnose tool, using right- and left-hand knife tools to form the sharp corners of the old-timers.

The bases cannot be turned in the ordinary way owing to their contour, so the only thing to do is to finish off with a half-round file. Personally, I do this while the dome is still chucked, putting the back-gear in to hold the mandrel still, and then carefully filing away any surplus metal until the shape is approximately correct—which isn’t all difficult.

When both sides are done I wind a bit of emery-cloth around my finger and with the lathe running fairly fast the emery is applied to the filed part of the casting, pressing toward the headstock. As the emery-cloth follows the irregular outline of the base there is naturally plenty of vibration on my finger, but it doesn’t hurt—and the result is quite satisfactory. Of course, I’m quite aware that it is “all wrong” like everything else that I do, but somehow—like my locomotives—it always works!

Before taking the big dome off the mandrel, drill the hole in the top for the safety-valve and dummy whistle, with a \( \frac{3}{8} \) in. drill in the tailstock. If one that size is not available, use the largest that you have, and finish with a boring-tool in the slide-rest. The tops of the sandboxes should be finished flat and drilled No 30, the excrement on top being turned separately from a piece of rod of the size shown and used as a nut to hold the sandbox in position.

When the boiler barrel, at the location of the sandbox drill a No 40 hole and tap it \( \frac{1}{4} \) in. or 4/36, screwing in a piece of \( \frac{1}{8} \) in. brass rod with a few threads on each end. The sandbox is placed over the rod, and the ornamental top—tapped to suit—is screwed on to retain it in position.

*To be continued.*

**Virginia Sheets Ready**

The first three sheets of *Virginia*, the 3/4 in. gauge old-time American locomotive, are now ready in the Percival Marshall Plans Service. The sheets are 40 in. \( \times \) 28 in.; every one contains a great deal of detail and costs 7s. 6d. each ($1.50). Main contents are:

**Sheet 1:** Arrangement side view.


NOW THAT the little reminder of days gone by has reached the stage at which she can run, most builders will be anxious to reap some of the reward that sweetens labour; they certainly will if they are anything like your humble servant.

To enable this to be done, I thought it would be as well if I described how to build the tender before giving details of the trimmings, such as bell, headlight, boiler cladding and bands, which can be added at any convenient time.

The tenders of most of Virginia's full-size relations were weird and wonderful boxes of tricks. Though a few of them ran on six wheels, following British practice, the vast majority were furnished with two four-wheeled trucks, with built-up bar frames, disc wheels made from chilled cast-iron, with no separate tyres, and equalised springing.

The main frames were built up either from channel-section girders, or bars of rectangular section, with no separate beams, the side members being rounded at the corners and joined to two separate stiffening girders which ran down the middle of the frame, and to which the draw-gear was bolted. Instead of a sole-plate, the top of the frame was, covered with wooden planks, like the floor of a room, placed transversely and attached to the frame girders. The tender body was entirely separate and was erected "on the floor."

The tender body followed contemporary British practice, inasmuch as it had straight sides with a flared coping at the top and rounded rear ends. The front ends were also rounded, and the coal was carried in a recess between them. This recess extended about halfway into the tender tank and was wider at the front than at the back.

**Needed stamina**

The fireman had the backbreaking job of shovelling all the coal from floor-level. This might not seem a very arduous job but when you consider that this involved lifting several tons of black diamonds to a height of three or four feet and throwing them into the firebox during a single journey, on an engine that was anything but a steady rider, it will be realised that the fireman needed both physical strength and good stamina. However, nobody in those days seemed afraid of a spot of hard work! The toolbox was usually placed at the back of the tender, near the drawbar, as on many British engines.

The brake gear was at first operated by hand, and the blocks were placed between the wheels, the beams being of wood. A compensating device was fitted and the pull-rods were connected to a vertical brake-shaft on the fireman's side of the tender; this had a cross-handle with both ends turned up like a cow's horns and a ratchet gear underneath like that used on the brake shafts of street tramway-cars.

This also provided the unfortunate "tallowpot" with additional exercise, until the advent of the Westinghouse automatic air-brake. When water-troughs, or track-pans as they are called in America, came into vogue the tenders were fitted with water-scops and the internal pipe was turned over at its upper end to discharge downwards.

The tanks were long and shallow and were well stayed with sheet-metal stays which also acted as anti-surge plates.

**The 3-1/2in. gauge tender**

In designing the tender for the 3-1/2 in. gauge locomotive I tried-as with the engine-to simplify matters for ease of construction, while keeping the outward appearance as correct as possible.

The sides and the coal recess can be bent up from a single sheet of brass, if a piece long enough is available the joint being made at the back of the recess; otherwise it can be made in two pieces with the second joint in the middle of the tender back. This allows for the rounded ends both front and back. The top can be made from one single sheet and the coping can be made from a strip attached to it. The big rectangular casing which houses the upper end of the pipe from the water-scoop on the full-size article comes in just right for a filler, as it is big enough to allow the handle of our emergency hand pump to be operated through it for the full stroke.

The detachable handle can be carried in the toolbox at the back, nice and handy when somebody lets both fire and water down and there isn't enough steam to operate the injector. The fittings inside the tank are to the usual L.B.S.C. standards.

**Frame construction**

Two pieces of soft mild steel, 1/2 in. wide, 1/8 in. thick, and approximately 22-1/2 in. long, are required for the frame. These are bent around at each end to form right angles with a 9/16in. radius, as shown in the plan drawing, so that the overall length is 16-3/4 in.

The easiest way to do this is to put a piece of 1/2 in. round bar in the bench vice, with about 1-1/2 in. projecting from the side of the jaws. Mark the piece of steel, then put a piece of gas-pipe or something similar, over the end of the steel to give extra leverage. Place the steel with the marked spot on the bar in the vice jaws, then a good heavy press down on both ends will form the desired bend.

Although the piece of bar is 1/2 in. dia, the slight spring in the strip will form the bend to the given radius. Before I had a bending machine I made all my bends in the above manner and had no trouble. Anybody of average strength will find the bending easy.
Check off the ends with a try-square to make certain that they are exactly at right angles with the sides, then lay them on the bench with the ends touching and measure across from side to side. Note how much needs taking off the ends to bring the sides 5-1/8 in. apart and reduce them.

Now cut two pieces of 3/32 in. steel to 3/4 in. width, one 1-1/4 in. long and the other 1-3/4 in. Round off the edges of the longer one as shown. The semi-circular sockets for the coupling-pins can easily be milled up from a piece of 7/16 in. x 3/8 in. steel bar, about 2-1/4 in. long; 7/16 in. square will do at a pinch. Mill a groove in this, 3/16 in. wide and 5/16 in. deep.

If a regular miller is available it is only a few minutes work with the steel in the machine-vice on the table and a 3/16 in. slotting cutter on the arbor. It can be done in the lathe with a similar cutter on an arbor between centres and the steel in a machine-vice (regular or improvised) on the saddle, setting the steel in the...
vice at such a height that the full depth is taken out at one cut. Any Myford or similar lathe will do this quite well with the backgear in and plenty of cutting oil applied by drip-can or brush. Feed very slowly with the cross-slide handle. After nattively, clamp the piece of metal under the slide-rest tool-holder and endmill the groove, as I have described for other similar Jobs.

After the groove is formed cut the piece in half and round off the grooved side to the shape shown in plan. Next cut away the metal at the bottom of the groove for about 1/2 in. width to clear the end of the drawbar or coupling-link when coupled up; this can be done by drilling and filing. Then drill the hole for the pin.

Finally drill a No 41 hole at each side of the clearance and rivet the socket to the plate in the position shown. The front one is fitted level with the bottom of the plate to line up with the drawbar or link on the engine; the back one is fitted in the middle of the plate to bring the slot to the correct height to couple on to a passenger car.

**Against-the-clock method**

Put the two halves of the frame together on the bench (which must be level), clamp the coupler assemblies at each end over the joints, drill No 41 holes through plates and frames and rivet up with 3/32 in. charcoal-iron rivets. To make the job extra strong, I advise brazing or silver-soldering the lot, and if this is done only 1/16 in. rivets need be used to hold the parts together.

Incidentally, as I'm always running against the clock, I shall make both my sockets from a 3/8 in. slice parted off a 1-1/8 in. offcut of steel shafting, milling the 3/32 in. blade quite wide on opposite sides of it. This will be sawn across the middle, the sawn parts run under a 1/2 in. cutter on the miller to true them up and the clearances at the bottom of the groove formed with a Woodruff key-seat cutter. Drill the pinholes, and there we are!

**Truck bolsters**

The truck bolsters may be cast, or bent up from 1-1/4 in. x 1/8 in. steel. If they are cast, the pin for attachment of the truck and the rubbing plate will be cast integral, and there should also be a chucking-piece cast on opposite the pin. If this is held in the three-jaw the pin can be turned and screwed and the contact surface faced off at the same setting. All that then remains will be to make a slight bend off both ends with a file, set the bolsters between the frames at the positions indicated and rivet up.

For the bent-up bolsters, two pieces of steel, of section as mentioned above, and 6-1/4 in. long, will be required. Mark off the centre and at 1 in. each side of it make a slight bend to the angle shown in the cross-section. Place this across the frame and mark off where the vertical bends will have to be made to bring the overall width to 5-1/8 in., which is the correct distance between the sides of the frame.

The bends can be made in the bench vice. Should the steel be hard, make it redhot at the bends, otherwise it will crack on the outside of them. Check for correct width then set each bolster in position shown and make sure that the bottom is exactly 9/16 in. below the bottom of the frame. Fix temporarily in position with toolmakers' clamps then drill three No 41 holes through frame and bolster and rivet up. File off any of the bolster side which projects above the top edge of the frame.

On the centre line of the bolster, and exactly midway between the sides of frame, drill a 1/4 in. clearing hole. For the pins, chuck a piece of 3/8 in. round mild steel in the three-jaw, face up to the end, turn down 1/4 in., length to 1/4 in. dia. and screw 1/4 in. x 40. Part off at 1/3 in. from the shoulder, reverse in chuck and turn down the other end to 1/8 in. dia. sufficient to leave 1/32 in. length the full 3/8 in. dia.

**Test for accuracy**

Screw 1/4 in. x 40. Put this end through the hole in the bolster and secure with a nut made from 3/8 in. hexagon rod, either steel or brass will do. The complete frame assembly should then be laid on something flat and true, such as the lathe bed, to test it for accuracy. If both sides do not touch the flat surface for their full length, carefully twist the frame until they do, a little careful manipulation will do the trick.

Warning to beginners—when setting the bolsters in the frame do not get mixed up as to which is front and back of the frame. The front is the end with the low coupler socket and the centre line of the bolster should be 4-1/2 in. behind this. The other one is set only 4-1/2 in. from the back end, the distance between the truck pins being 8 in. Not that it matters a great deal if they are reversed, but we might as well have things right!

**Soleplate**

The soleplate on which the tender body is mounted can be cut from a piece of hard-rolled sheet brass of 16-gauge, 6-3/4 in. wide and 16-7/8 in. long after the ends have been cut square. To make the ends of the frame, and at the places indicated on the frame drawing by dotted lines rivet four pieces of 3/8 in. x 3/32 in. angle. Either commercial brass angle can be used, or the pieces can be bent up from sheet brass of 13-gauge in the bench vice.

**Making it watertight**

Two similar pieces can also be riveted on, midway between the others. They should all be set close to the scribed line indicating the frame outline, and after riveting, sweat them over with solder so that no water can leak through from the tank.

After the tender body is mounted on the soleplate and the whole bag of tricks erected on the frame these angles will project down inside the frame and will be attached to it by two 3/32 in. or 3/48 in. screws passing through clearing holes in the frame into tapped holes in the angle. Removal of the screws will allow the complete tender body to be lifted off the frame if required.

*To be continued.*

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**USEFUL BOOKS**

**FITTING BEARINGS**

Plain, ball and roller bearings are described fully in *Bearings and How to Fit Them* by Ian Bradley and Norman Hallowes.

The authors give details of the best materials and methods for constructing bearings, and describe their various applications, particularly with regard to the small workshop.

The book is obtainable from Percival Marshall and Co. Ltd, 19-20, Noel Street, W.1, price 3s. 9d. post paid (U.S.A. and Canada $1.00).

**GEAR CUTTING**

*Gear Wheels and Gear Cutting,* by Alfred W. Marshall, explains the principles which govern the formation and numbers of the teeth for a given mechanism and describes the types of gears in general use.

There are numerous illustrations in this 92 page book, price 3s. 9d. post paid, which can be obtained from Percival Marshall and Co. Ltd, 19-20, Noel Street, London, W.1. Rate in U.S.A. and Canada is $1
While the principle of the tender trucks for *Virginia* is the same as that of the engine truck, the frames are outside the wheels, and this calls for a different method of construction. It would be sheer waste of labour and material to cut the top frame bars and centre-piece from a single plate, so separate components are used and the complete assembly brazed at the joints.

It is possible that castings comprising centre section, rubbing plate, top bars, and pedestals all cast integral, may be available from our advertisers, and the use of these would save a lot of work. The castings would only need cleaning up with a file, the pedestal jaws truing up, and the rubbing-plate facing off and drilling; operations which do not need any detailing out.

The top frame bars on a built-up truck will need two pieces of 1/4 in. x 3/16 in. mild steel, squared off at the ends to a length of 5-1/4 in. The centre-piece is a 4-1/2 in. length of 1-5/8 in. x 3/16 in. mild steel; this must also be dead square at the ends. If a milling-machine is not available it can be held truly in the four-jaw chuck and the ends faced off with a roundnose tool set crosswise in the rest.

**Simple method**

Drill a 1/2 in. hole exactly in the middle. To hold it in position for brazing to the frame bars use two 1/16 in. or 1/72 screws put through clearing holes in the thickness of the frame bars (No 51 drill) into tapped holes in the ends of the centre-piece, about 1 in. apart.

If the pedestals are cut from 3/8in. x 1/4in. mild steel, no machining will be required on the sliding faces. Eight will be needed for each truck and all must be exactly the same length. Tip for beginners who want to do the job quickly and accurately: chuck a length of above section steel in the four-jaw and set to run truly. No need for absolutely accurate setting; approximate is good enough.

Put a piece of round rod, any convenient size, in the tailstock chuck and run it up until it touches the end of the rod in the four-jaw. Set your parting-tool to part off carefully a
7/8 in. length, setting the tool at such a height in the tool-holder that it parts off without leaving a pip.

Slack jaws 1 and 2 of the four-jaw chuck, pull out of the bar until it touches the stop in the tailstock chuck, tighten jaws, part off, and repeat operation until you have 16 pieces. They should all be the same length with nicely squared ends if neither the rod in the tailstock chuck, nor the slide-rest, have been moved during the operation.

**Spacing inner pedestals**

Drill a No 51 hole in the frame bar directly above the location of each pedestal then clamp a pedestal at the end with a toolmakers' cramp, lining it up with the end of the top bar and keeping it flush with the sides. Run the 51 drill through the hole in the bar, making a countersink on the top of pedestal, remove, drill the countersink with a No 53 drill for about 1/4 in. depth, and tap 1/16 in. or 1/72.

Replace the pedestal and fix with a steel screw. When attaching the inner pedestals put a piece of bar 1/8 in. wide between inner and outer, as a spacer, and clamp the lot together while running the drill through the hole in the frame; this will ensure correct spacing.

Cover all the joints between frame bars, pedestals, and centre-piece with wet flux, lay the assembly on its back on some small coke in the brazing pan, heat the lot to bright red, and apply a piece of thin soft brass wire or easy-running brazing strip to each joint. If the heat is sufficient the brazing material will melt and penetrate right through the joint. Run a fillet between centre-piece and frame bar at each corner. Let it cool to black, quench in water, clean up, and file off all the screwheads.

The combined pedestal-tie and stay-bar is a 5 in. length of 1/4 in. x 3/32 in. mild steel. Drill four No 41 holes at the spacing shown in the underside view, then clamp the piece of strip steel temporarily in place, locate the screwholes through those in the strip, mark the strip so that it can be replaced the same way, drill the marked places on the bottoms of the pedestals with No 48 drill, tap 3/32 in. or 3/48 and attach tie-bars with screws to suit.

Chuck a piece of 1-1/4 in. round bar-bronze or gunmetal for preference, but brass will do if nothing better is available-face the end, centre, drill to 3/8 in. depth with 23/64 drill, drill down 3/16 in. length to a press fit in the hole in the middle of the centre-piece and part off at a bare 1/8 in. from the shoulder. Reverse in chuck, gripping by the spigot, face off the disc to 3/32 in. thickness, and put a 3/8 in. parallel reamer through the hole. Press the spigot into the hole in the centre-piece.

**AXLEBOXES AND SPRINGING**

The axleboxes may be made from drawn bronze or gunmetal bar of 3/4 in. x 9/16 in. section, or nearest larger, or from castings. If the latter, they will be cast in a stick, with the fancy fronts (representing the lids of the full-sized boxes) cast on.

The sides of either the drawn bar or the cast sticks are milled off in exactly the same way as those described for the engine truck, so repetition is unnecessary. The lengths can be either parted off in the four-jaw, or sawn off, and the ends faced in the chuck to 5/8 in. length. The boxes should be an easy sliding fit between the pedestals, but not slack.

Drill a 1/4 in. hole 7/16 in. deep in the back of each box. If a drilling machine is not available, chuck the boxes truly in the four-jaw and centre and drill with the tailstock in the usual way, as the holes must be perfectly square with the back and sides. It will be noticed that only one flange is shown, and that is on the inner side of truck frame; this is to allow the boxes free movement to tilt on an uneven track.

Drill a 1/16 in. oiling hole in the front
of each box near the top, sloping down to the journal hole. If the fancy fronts are fitted, this can be just below the dummy hinges. Personally I shouldn't bother about the dummy lids, but should just bevel off the edges of the boxes where they project beyond the pedestals.

I have done this with British pattern tender axleboxes, and they look quite all right. However, some folk worry 'more about a little detail like that than they do about the efficiency of the engine—there is no accounting for tastes.'

The arrangement of equalisers and springs is precisely the same as on the engine truck, the equalisers being cut from 16-gauge steel to the dimensions shown in the drawing. Same applies to the hangers, which are attached to the equalisers by 1/16 in. iron rivets.

Dummy cast springs are drilled 1/4 in. in the hoop to take a spiral spring which bears against the underside of the frame bar when the springs are erected. The springs are fixed in the inverted position shown between the hangers and the holes in the ends of the springs, or by bolts made from 1/16 in. silver steel, screwed and nutted at each end, according to the desire of the builder of the locomotive.

Should anybody wish to fit working leaf springs, proceed exactly as described for the engine truck as the spring sizes are the same for both engine and tender trucks and they are erected in the same way.

### WHEELS AND AXLES

The wheels are of the disc pattern, spokeless, and are 2 in. dia. on thread with 1/8in. flanges, and the bosses are drilled 19/64in. and reamed 5/16 in. Again, there is no need to repeat the instructions for turning them.

The axles can be turned from 5-1/4in. lengths of 3/8 in. round steel (silver steel or drill-rod are most durable) which can be held in the three-jaw chuck, and both journal and wheel seat turned at the same setting so that it doesn't matter if the chuck is a wee bit out of truth as the wheel seat must of necessity be true with the journal. Both wheels can be pressed on to each axle right away.

### How the trucks are erected

Assembly and erection is very easily done. To assemble a truck, lay the frame upside-down on the bench and take off the tie-bars. Wind up four spiral springs exactly as described for the engine truck. Put one in the hole in the spring hoop, and insert the assembly of spring and equalisers between the pedestals, the ends of the equalisers going over the outsides of the framebars and pedestals, and the spring bearing on the frame bar.

Put an axlebox on each end of the axle and carefully fit the axleboxes to the pedestal jaws. If the boxes are made to instructions, and the jaws are correctly spaced, the boxes should be interchangeable. Note if the boxes bear evenly on the ends of the equalisers, and if O.K. all that remains is to replace the tie-bars and screws.

A rubbing-plate is needed between the bushing in the top of the centre-piece and the bottom of a truck bolster bent up from 1-1/4in. x 1/8in. steel. This is merely a disc of brass 3/32 in. thick, 1-1/4 in. dia. With a 3/8 in. clearing hole in the middle. It may be cut from sheet or parted off from a piece of the same kind of bar used for the bushing.

Put it over the pin in the bolster, put on the truck, and secure it with a steel washer and a nut made from 3/8 in. hexagon steel. The truck should swivel quite freely on the pin, with about 1/32 in. clearance between the bottom of bushing, and the retaining washer. To prevent the nut slacking off when the engine runs at a high speed over a rough track (and she will be able to do just that, as you will see) drill a No 50 hole right through nut and screwed end of pin and put a 1/16 in. split-pin in it. That will do the trick.

Now, if the tender chassis is tried on the track, it should run quite freely. Try it with some weights on the soleplate and note if the springs and equalisers function all right before fitting the body and tank.

### Variations for casting-built trucks

If a small boss is cast on the underside of a cast truck frame, on the opposite side to the bearing face which takes the place of the turned centre flange on the built-up truck, it could be held in the three-jaw and the flange faced off and drilled for the 3/8 in. pin at the same setting.

Otherwise, the frame would have to be held in the four-jaw for this operation. The axleboxes, equalisers and springs are made and fitted exactly as described for a built-up truck and a similar tie-bar is fitted at the bottom of the cast-on pedestals at each side.

Regarding cast truck bolsters, I have included here a drawing of one.

*Continued on page 331*
OVER OILING

Sir,-With all due respect to the opinions of Vulcan, [Smoke - Rings, January 3] I have found by experience that cutting down the oil supply to the bare minimum in any kind of engine or mechanism is very dubious economy.

The slogan "oil is cheaper than engines" has been found sound by many motorists, and provided always engines "has been found sound by the bare minimum in anv kind of possible harm done by over-oiling is negligible compared to that which will certainly be caused by oil starvation. It should be remembered that in addition to actual lubrication, oil is called upon to serve also as a heat conducting medium and a corrosion inhibitor.

The latter property is more important than is often realised. Three or four years ago I was called upon to examine a batch of cyclemotor engines which had failed in service; they had been working on the manufacturers' recommended petrol-oil mixture of 32 to 1 and in at least 75 per cent. of them traces of rust were visible on ball-races and other working parts. In a 125 C.C. engine which I run regularly I stick to what is now regarded as unnecessary concentration -16 to 1-and I have never had the least trouble traceable to excessive oil-touch wood.

In the early days of two-strokes one had to be careful with oil, mainly because sparking plugs were very choosy and a plug which would stand up to oil would not stand up to heat, and vice versa. Nowadays plugs have much more tolerance and the type recommended by the engine makers can generally be relied upon to give good results.

Modern engines run much cooler than they did, thanks to good design; and it may be observed that troubles such as sticking of piston rings and heavy carbon deposit are usually caused by poor quality oil, in conjunction with the overheating which results-not to over-oiling, as such.

No doubt with the progress of lubrication research, oils will continue to improve, so that less quantity will go further, and there are also great possibilities in entirely new lubricants such as molybdenum disulphide, not to mention new bearing materials with self-lubricating properties. But until these are fully established, I advise engine users who are not looking for trouble, to play safe by using good and appropriate oil in adequate but not excessive quantity.

Perhaps I should add that I do not possess shares in any lubricating oil producing or selling organisation.

Edgar T. Westbury.

DOGMATISM

Sir.-In the 1870s there was an American bishop who was visiting the principal of a college with which he (the bishop) was connected. The principal remarked that in 50 years time men would have learnt to fly. Whereupon he was rebuked by the bishop, who replied: "Flight is reserved for angels and you have been guilty of blasphemy."

The bishop was the father of Orville and Wilbur Wright.

The wider a man's knowledge and outlook, the less will he be inclined to dogmatise, and the converse of this also holds good.

K. N. Harris.

VIRGINIA...Continued from page 320

of suitable pattern. The main part of it looks something like a river punt, and no rubbing-plate is needed between the underside and the centre of the truck, as a substitute for it is cast integral, below which is a boss and no rubbing-plate is needed. The main part of the casting would have to be chucked in the four-iaw with the boss for the pin running truly. The assembly and erection of the whole bag of tricks is carried out in the same way as just described for the built-up arrangement.

"Virginia" in other sizes

While this serial has been running I have received some letters asking if the locomotive could be built half-size to haul a train of old-fashioned wooden cars on a "scenic" line, as a pleasing variation to the usual-type of British locomotive used for this purpose. Also some of our American friends want to build a bigger edition to run on a 4-3/4in. gauge track, and they are asking about the boiler. Virginia could easily be adapted to any size within reason, taking the 3-1/2in. gauge dimensions as a basis, and varying the details to suit the size of the required engine.

For 1-3/4in. gauge, the principal dimensions should be halved, as near as possible, but the distance over outside of frames should be 1-7/16 in. and the distance between the backs of the wheels 1-9/16 in. The wheels themselves should be 1/4 in. wide on the treads, with 3/32in. flanges about 3/4 in. thick. If sprung coupled axles are desired, underhung spiral springs should be used, one under each axlebox. Cylinders should be, 9/16 in. bore and 3/4in. stroke, with loose-eccentric gear set to cut-off at about 60 per cent. A simple displacement lubricator would serve.

The boiler could be of the simple water-tube type, fired by a spirit-lamp or one of my small oil-burners. The outer casing should be half the size of the 3-1/2in. boiler, made from 20-gauge steel with a lining of 1/16 in. asbestos millboard around the firebox wrapper. The inside barrel could be made from 1-1/4 in. seamless copper tube, about 22-gauge not thicker than 20-gauge, with 16-gauge ends and boiler of two 5/32in. water-tubes, all joints being silver soldered.

No pump under the boiler would be needed, water being supplied by a hand-pump in the tender. The amount of water in the boiler would last quite a while on a non-stop run with a normal train, and it could be replenished in a matter of a 'minute or so while the train stopped at a station. With cylinders of the size mentioned, even-fired with a spirit lamp! the baby Virginia would have no difficulty in making enough steam to haul quite a big kiddy.

With an oil-burner, it would pull an average adult; a 2-6-0 with similar-size cylinders and wheels, which I built as a present for a friend now, alas! in the land beyound Jordan, hauled my weight around my own little way for some time before stopping, and would have kept going indefinitely if the tender had held enough water.

I kept up the level by operating the hand-pump every time she started to blow off at 80 lb. Anybody who wishes to build a half-size American tea-kettle can follow the general construction of any of the similar-size jobs I have described, such as the Dot (half-sized Doris) and so on.

An enlargement to 4-3/4in. gauge is a different sort of proposition. While the general dimensions can be increased in the proportion of 4 to 3 certain details like the cross-sections of the motion rods, valve gear, etc., can be made more proportionate to those in a full-size locomotive.

The boiler, too, would need a separat edesign for this size, as it would be no good just to use the same number of tubes, but of larger diameter, to cite just one variation.

To be continued.
American locomotives carry accessories not found on their British cousins. L.B.S.C. describes some of them in this further article on an American old-timer.

Continued from 28 February 1957, pages 318 to 320

If I wanted to get the inside and outside to the same shape I should just turn a piece of steel to the same shape as the bell, less the desired thickness. This would be filed or milled half away and hardened, forming a bell-shaped D-bit. The bell would be rough-drilled to the required depth and the cutter fed in by the tailstock to bring the hole to the proper shape.

After parting off, reverse the bell in chuck to finish off the top; leave a \( \frac{1}{4} \) in. flat in the middle, centre it, and drill through with No 51 drill for the stem of the clapper fork. This is turned from a piece of \( \frac{7}{16} \) in. square rod chucking truly in the four-jaw, the stem being a full \( \frac{1}{4} \) in. long and \( \frac{7}{16} \) in. dia. screwed at the end as shown.

Part off at \( \frac{7}{16} \) in. from the shoulder, cut the slot with a hacksaw and cross-drill No 57. The clapper is made from a piece of \( \frac{7}{16} \) in. wire \( \frac{15}{32} \) in. long; screw a \( \frac{3}{32} \) in. ball on one end, flatten the other end with a hammer to fit the slot in the fork, round it off, drill a No 55 hole in it and pin it to the fork with a bit of thin wire.

The bell yoke and brackets should be castings and will only need cleaning up with a file. The lugs at the ends of the yoke, which should fit nicely between those on the brackets, are drilled No 53 and tapped 9 B.A. or 2/56. The holes in the ends of the "cow's horns" are drilled No 48. Drill a No 51 hole through the block in the middle of the yoke, put it on top of the bell and poke the stem of the clapper-fork through the lot, securing with a nut on top of the yoke.

One side of the yoke is attached to the bracket by a little setscrew turned up from a piece of \( \frac{1}{4} \) in. hexagon rod with \( 3/32 \) in. of "plain" under the...
VIRGINIA...

head. The other side has a pin made from 15-gauge spoke wire. On the outer end of this is fitted the lever by which the bell is rung. It is filed up to the shape shown from a piece of 3/32 in. steel, and if the boss is drilled No 49 it can be pressed on the end of the pin and will need no further fixing. The illustration shows the complete assembly. The base is attached to the boiler barrel by two 3/16 in. of 1/22 screws.

If castings are not readily available the bracket can be bent to shape from 1/8 in. X 1/8 in. metal and filed approximately to shape shown. The yoke can be made with a little block of brass for the boss and two pieces of 3/32 in. X 1/8 in. strip bent to shape and silver soldered to it, afterwards being filed to shape. The bracket can be silver soldered to a circular piece of 16-gauge brass about 1/2 in. dia. and curved to the radius of the boiler-barrel. Assemble as above and attach to boiler in same way.

The bells on the full-size engines were rung by a rope from the cab (steam and air bell-ringers had not been invented then) and a cord can be fixed to the wee bell likewise; but don't expect a terrific clang from it! Anybody who wants to hear the sound can fix an alarm-clock gong under the tender, fit a clapper to it and attach the other end of the cord to that. I've been going to fit a steam-operated bell under the tender of my 2-6-6-4 Annabel (an' her bell!) for a long time past, but I haven't found time yet.

I puzzled my brain a long time over the simplest way to make the oil headlight a working proposition, and I think that the arrangement shown should fill the bill. The oil tank forms part of the stand and the lamp fits over it. The general arrangement drawing published with the first instalment shows the platform on which the lamp is mounted, supported by four legs as in some full-size engines; this can be followed if desired. However, the one-piece job with bent legs is easier and simpler.

Cut a piece of 18- or 20-gauge brass 3 1/2 in. X 1 3/4 in. and bend down each short side to leave a 2 in. platform in the middle. In the middle part of the bent portions, as shown in side view, and bend outward at the bottom to form lugs for attachment to smokebox. Drill the lugs with No 41 drill.

The oil tank

To make the oil tank, cut a piece of 20-gauge brass 1 3/4 in. X 2 1/2 in. and snap a 1/2 in. square out of each corner; then bend over 1/2 in. of each side to form a tray 1 1/2 in. X 1 3/4 in. and 1/2 in. deep. In the middle of this drill a 1/2 in. hole and solder a 1/2 in. X 40 tapped bush in it; then put the tray in the middle of the platform and solder it down. The burner part is turned up from 1/2 in. hexagon rod to shape shown, screwed to fit the bush and drilled 7/64 in. for the wick.

It is probable that a casting will be available for the lamp body, and if so, all it will need is a clean-up with a file, a glass fitted and a sheetmetal cowl put on top to prevent water going down the vent and putting the light out.

The reflector is optional, but finishes the job. It could be spun up from a disc of aluminium 1 3/4 in. dia. and attached to the back of the lamp case by a screw and nut. Small reflectors are commercial articles and used for a variety of purposes, and a suitable one could probably be found in a toy store or electrical dealers, or in a chain store. I have two here now, used in dental work.

The lamp case can also be built up from sheet brass of about 20-gauge in exactly the same manner that I described for making the oil tank of the mechanical lubricator. The strip should be 6 in. long but wide enough to allow for bending inward at the top to form the upper part of the lamp body.

Divide the strip to form the four sides and draw a line right along it at 1 1/2 in. from the bottom. Above this, over each panel, set out the outline of the top of the lamp body; cut away the superfluous metal and bend the strip into a rectangle measuring 1 3/4 in. X 1 3/4 in. and bend the top serrations inwards until they meet. If desired the curves can be dispensed with and the top shaped like a simple pyramid. The top piece can be turned from 1/2 in. brass rod.

The bezel can be made by bending a piece of 1/2 in. square brass rod into a circle 1 3/4 in. inside diameter and attaching it to the lamp case by a few 1/32 in. rivets (pieces of domestic pins would do) over a hole of that diameter cut in the front of the case. The whole bag of tricks could then be silver soldered, and if the lamp body is then chucked in the four-jaw with the bezel ring running truly, same can be turned to the outline shown. Be careful to take fine cuts for if the tool caught up and knocked the lamp body out of the chuck, you've had it.

A cowl and reflector would be fitted in the same way as mentioned for the cast body. The glass, in either case, is fitted inside, over the front opening, and the corners are cut away as shown by the dotted lines in the front view. It is kept in contact with the case by four dog clips, just like those on the dinning room, except that the clips are tapped and the screws go through plain holes in the case, as shown in the detail sketch.

The lamp body should be a tight push fit over the oil reservoir, and no further fixing will be required. This allows for instantaneous removal for trimming, filling and lighting. The flame cannot burn without a supply of air, so just above the level of the oil

Method for installing electric light

13 March 1937
tank, in the back of the lamp body, drill a row of 5/32 in. air holes right along, as indicated in the side view.

Ordinary lamp wick should be used, a few strands being unravelled from a piece of the usual flat variety; they should be tight enough to prevent slipping down when the engine is running, but not tight enough to prevent the oil coming up. As the lamp will naturally get hot, being on top of the smokebox, don't use kerosene or any other oil liable to vaporise; rape oil, or colza, should be suitable. The bracket is attached to the smokebox by four 3/32 in. or 3/48 round-head screws as shown, tapped direct into the smokebox barrel.

Electric headlight

A more modern type of headlight will be needed for an engine with the larger boiler and we have one readying in the shape of the front end of a "pencil" torch. The drawing shows a section of one that I have here at the present minute. The bulb screws into a pressed-metal reflector with a knurled edge and the outside of the thread in the reflector engages with a nut in the barrel of the torch. A spring at the outer end of the barrel keeps the battery tight against the contact at the back of the lamp, the return being through the case.

Cut off the torch barrel 1 in. from the end, plug it up, and secure a bit of fibre or ebonite to a tight fit in the barrel. Centre and drill it No 48, tap 3/32 in. or 3/48, and part off at 3/4 in. from the end. Before pressing it into the barrel solder a 5/32 in. length of 3/4 in. X 3/32 in. brass to the barrel for attachment to the bracket.

Press in the plug and fit a countersunk setscrew in the side as shown to prevent it from coming out when the lamp is screwed home. Screw in the lamp and reflector, then screw a piece of threaded brass wire through the plug until it bears hard against the lamp contact; cut it off about 3/8 in. from the plug and fit a brass nut and washer.

To make the bracket, cut out a piece of 18-gauge steel to the shape shown and bend it on the dotted lines to the shape of the bracket. Put some wet flux along the joints, heat to bright red, and touch the joints with a piece of soft brass wire, or a 3/8 in. Sifbronze or similar rod, running in just enough to form a neat fillet.

Quench in water as soon as the job cools to black and file off any brazing material that has seeped through. Drill three No 51 holes in one flat face at the points indicated and two in the other; attach the lamp to the bracket by two 3/4 in. or 1/72 screws through these. The complete assembly can then be mounted on the smokebox front just above the door by three screws put through the clearing holes in the bracket into tapped holes in the smokebox front.

Current is supplied by a flat torch battery carried in two clips under the tender, the battery case being earthed to the tender frame and an insulated contact arranged for the positive contact of the battery to press against when in place. From this, an insulated wire is taken to a switch in the cab; and from that another insulated wire is taken to the nut on the back of the lamp case. I hope to show a diagram of this when describing the modernised form of tender body.

Other blobs and gadgets

The flag sockets are turned up from 3/8 in. round rod to the shape shown, and drilled No 48 to receive the hand of the flag; they are screwed into tapped holes at each end of the pilot beam. The handrail pillars can be turned from 3/8 in. rod. I usually turn mine with a form tool shaped to the outline of the pillars but as there are so few of them it is hardly worth while making one.

They are drilled No 41 for 3/32 in. handrails and screwed straight into tapped holes in the boiler shell. If anointed with plumbers' jointing there should be no leakage; I have no trouble.

To get them all level, and both sides at the same height, I just set the needle of a scribing-block or surface-gauge to the desired height, stand the engine on a level surface and scribe a line along both sides of the boiler with the gauge, setting off the distances apart, from the smokebox.

The smokebox side stays are merely pieces of 3/4 in. brass or iron wire 4 in. long. One end is flattened and attached to the top of frame by two screws. The other end is bent at right angles and screwed. Drill a No 30 hole in the smokebox, put a washer on the screwed end, poke same through the hole and secure with a nut inside the smokebox. The exact angle of the stay can be obtained from the actual job.

The steps on the side of the smokebox are bent up from 22-gauge metal in a similar manner to the bracket for the electric headlight and attached by 3/4 in. or 1/72 roundhead screws. There will be two or three more additions to fit when the tender is completed.

To be continued.
L.B.S.C. now gives instructions for making up the tender tank and the fittings that go inside it.

Compared with the average British tender body of contemporary vintage, Virginia's tender tank may seem rather awkward to make and erect...the way I managed to get the exact shape of the last one I made to this pattern many years ago was to mark out the plan of the tank on a piece of cardboard, cut it to outline and bend my strip of metal, using the cardboard as a gauge. As I had a strip long enough for the whole job I made the joint in the middle of the narrow end of the coal recess. The ends were butted together and secured by a butt strip on the water side of the joint.

If builders of this engine find that their strip of 18- or 20-gauge brass, 2½ in. wide, isn't long enough, make the tank in two halves, with the second butt joint in the middle of the back. Both halves will be identical and the curves can still be bent to the cardboard template. To form the radii just bend them by hand around a piece of 1 in. round bar held horizontally in the vise jaws.

Both butt strips should be about ½ in. wide, and they can be held in place with toolmaker's cramps, tacked with soft solder and then riveted up with ½ in. brass or copper rivets. They can be finally sweated watertight with the rest of the tank joints.

Pieces of ½ in. × ⅛ in. angle are riveted for nearly the full length of the tender—top, bottom, back end—and along the straight part of the end of the coal recess. Those at the bottom should be flush with the edge, but those along the top should be a bare ½ in. below the edge so that the top-plate, when screwed down to them, does not project above the sides. Drill a series of holes about 2 in. apart in all the bottom angles, using a No 48 drill, but put an extra one in the bit of angle at the end of the coal recess.

The body can now be erected on the soleplate, and be mighty careful to locate it as shown so that the body curves tally with those on the sole-plate. If you haven't any cramps big enough to hold it tight with solder at each end. Then, using the holes in the bottom angles as a guide, make countersinks with a No 48 drill in the soleplate. Drill these through with a No 55 drill, tap 9 B.A. or 2/56 and put brass screws in. Beginners will probably wonder how they are going to get a No 48 drill to the holes in the angles when they are almost touching the tank sides. Well, just chuck a piece of ⅛ in. brass or steel rod in the three-jaw, say about 3 in. long, face the end, centre and drill to about ⅛ in. depth with a No 49 drill. Drive the fluted piece of the last No 48 drill you broke into the hole, business-end outwards, and use it by holding the rod in the hand-brace. You not only reach the holes, but save money in the bargain. Incidentally, it is a good idea to mount all bits of broken drills in this manner, as they can be used right up in drilling-machine, lathe, or hand-brace.

The next job is to sweat up the tank to make it watertight. Do this as far as possible from the inside for neatness. I just brush some liquid soldering flux (don't use paste) along the bottom, all around and over the angles and use two bits, working with one while the other is heating in the fire. This makes the job practically no-stress and the solder runs easily and covers all rivet and screwheads. Sweat up the butt strips as you come to them. But do not be tempted to warm up the job with a blowlamp or blowpipe before applying the soldering-bits; if you do the chances are that the brass sheet will distort and you will never get it flat again. Wash away all traces of the flux with hot water, and if any solder has seeped through to the outside scrape it off. The best tool for this is an old flat file with the teeth ground off at the end. I use one of my old worn-out 8 in. files for jobs like this.

EMERGENCY HANDPUMP
The fittings required inside the tank are a hand-pump for use in emergency, a water valve to regulate the supply to the injector, a feed-water strainer for the eccentric-driven pump, a flange fitting for the bypass pipe and a union elbow for the hand-pump feedpipe. I have shown these separately in full detail.

The handpump can be made from a casting or built up. The bottom of a casting, if clean, can be trued up by rubbing it on a big flat file laid on the bench otherwise chuck it in the four-jaw and face off the bottom. Drill a No 40 hole at each corner. Chuck the end of the barrel in the three-jaw, set it to run truly, face off the outer end, centre, drill through with 27/64 in. drill and ream ½ in. Mount it on a stub mandrel for facing the other
Seat a 3/8 in. rustless steel ball on the seating and take the depth as described for the engine pump. Chuck a piece of 7/16 in. hexagon rod, face, centre deeply with size E centre drill, drill No 40 for 3/8 in. depth, turn down 3/8 in. length to 1/4 in. dia. and screw 1/8 in. X 40 and part off at 1/8 in. from the shoulder. Reverse in the chuck, holding in a tapped bush, turn down the length indicated by the depth gauge to 1/8 in. dia. and screw 1/32 in. X 32, skim 1/32 in. off the end and cross-nick it.

Drop a ball in the other end and take the depth. Chuck the hexagon rod again, face, centre, drill No 23 for 1/8 in. depth, turn down the length indicated by the depth gauge to 1/8 in. dia. and screw 1/32 in. X 40. Face 1/32 in. off the end and part off at 1/8 in. from the shoulder. Reverse in the chuck, turn the end as shown, cross-nick it and put a 5/32 in. parallel reamer through. Seat a ball on the screwed end and assemble the lot as shown.

The ram is a piece of 7/16 in. rustless steel or phosphor-bronze 2 1/4 in. long and, if a good sliding fit, needs no turning. Round off one end and cut a 1/8 in. slot in it 1/8 in. deep by the method described for valve-gear forks and similar slots. Cross-drill it with a No 31 drill. At 1/16 in. from the other end turn a groove 1/16 in. wide and deep, and pack it with a strand unraveled from full-size hydraulic pump packing if available; if not, use graphitized yarn.

The lever is a 2 1/2 in. length of 1/4 in. X 1/8 in. rod, nickel-bronze for preference, drilled No 30 at points shown. The twin links are made from 1/16 in. X 1/16 in. similar material, but brass will do if nothing better is available. The pins are 1/16 in. drawn bronze rod. They should be a drive fit in the links and easy in the lever, but if slack in the links just rivet the ends over a shade. The extension is simply a piece of rod of the same section as the lever, any length desired, with a socket on the end, 1 1/2 in. long, to fit over the lever. This may be a piece of rectangular brass tube (commercial article) or bent up from 16-gauge sheet, the joint being silversoldered.

**INJECTOR WATER-VALVE**

Chuck a piece of 1/4 in. round rod in the three-jaw, face the end, centre and drill to 1/8 in. depth with a No 40 drill. Open out and bottom to 1/16 in. depth with 7/32 in. drill and D-bit and tap 1/8 in. X 40 for half the depth.
Right: The emergency hand-pump

Below, left: The section and plan of the tank, with fittings

Turn down \(\frac{1}{8}\) in. length to a bare \(\frac{1}{4}\) in. dia., and part off at a full \(\frac{1}{8}\) in. from the shoulder. Reverse in the chuck and turn down a full \(\frac{1}{2}\) in. length to \(\frac{5}{8}\) in. dia. At \(\frac{1}{2}\) in. from the shoulder on the long side, drill No 30 right through as shown. At \(\frac{1}{4}\) in. from the shorter end, drill a No 40 hole, breaking into the central hole, open out with a No 23 drill for about \(\frac{7}{8}\) in. depth and silver-solder a piece of 5/32 in. copper tube about \(\frac{3}{4}\) in. long into it. Drill three No 40 screw-holes in the flange.

Chuck a piece of \(\frac{1}{4}\) in. hexagon rod, face, centre, drill to \(\frac{1}{4}\) in. depth with a No 31 drill, turn down \(\frac{1}{4}\) in. of the outside to \(\frac{1}{4}\) in. dia. and screw \(\frac{1}{4}\) in. \(\times\) 40. Part off at \(\frac{1}{4}\) in. from the shoulder, reverse in the chuck, bevel off the end and run a No 40 cross hole \(\times\) 32 tap through.

The valve spindle needs a piece of 5/32 in. round bronze or rustless steel, \(\frac{3}{4}\) in. long. Chuck in the three-jaw and turn a blunt cone point on the end. Screw 5/32 in. \(\times\) 32 for 1 in. length, then turn away the threads for about \(\frac{1}{4}\) in. as shown. Reverse in the chuck, face off the other end and slightly bevel it. Drill a No 50 cross hole about \(\frac{1}{2}\) in. from the top and squeeze in a \(\frac{1}{4}\) in. long 15-gauge spoke wire, with the ends rounded off to form the handle. For the bush chuck a piece of \(\frac{1}{4}\) in. rod, face, centre and drill No 21 for \(\frac{1}{4}\) in. depth. Turn down \(\frac{1}{4}\) in. length to \(\frac{1}{4}\) in. dia. and part off at \(\frac{1}{4}\) in. from the shoulder.

The other fittings

To make the strainer for the engine-pump feed chuck a piece of \(\frac{1}{4}\) in. brass rod, face, centre, and drill to a bare \(\frac{1}{4}\) in. depth with a No 40 drill. Turn down 3/32 in. length to a bare \(\frac{1}{4}\) in. dia. and part off at \(\frac{1}{4}\) in. from the shoulder. Reverse in the chuck, holding only a bare \(\frac{1}{4}\) in. of the rod in the chuck jaws, setting the piece to run truly and then turn the jaws up well; then turn \(\frac{1}{4}\) in. length to \(\frac{1}{8}\) in. dia. Drill the boss and fit a piece of 5/32 in. copper tube to it, exactly the same as the bottom of the injector water-valve. Roll up a piece of fine-mesh copper or brass gauze into a finger \(\frac{1}{4}\) in. dia. and about \(\frac{1}{4}\) in. long, fit it over the drilled end of the fitting and silver-solder it.

The bypass fitting is very similar. Chuck the \(\frac{1}{4}\) in. rod again and drill it No 40 for \(\frac{1}{4}\) in. depth. Turn down \(\frac{1}{4}\) in. length to \(\frac{1}{4}\) in. dia., then counterbore the hole for \(\frac{1}{4}\) in. depth with a No 23 drill and part off at \(\frac{1}{4}\) in. from the shoulder. Reverse in the chuck and repeat the operation described for the bottom of the strainer. Both this and the bypass fitting need three No 48 holes drilled in the flange for the screws.

In the side hole at bottom of fitting, silver-solder a piece of 5/32 in. copper pipe 7 in. long. In the upper hole fit a 5 in. length and silver-solder that at the same heat.

For the union elbow chuck a piece of \(\frac{1}{4}\) in. round rod, face, centre deeply and drill No 40 to \(\frac{1}{2}\) in. depth. Turn down \(\frac{1}{2}\) in. length to \(\frac{1}{2}\) in. dia. and screw \(\frac{1}{2}\) in. \(\times\) 40. Part off at \(\frac{1}{2}\) in. from the shoulder. Drill a \(\frac{1}{4}\) in. hole in the side at \(\frac{1}{4}\) in. from the bottom and in that silver-solder a \(\frac{1}{4}\) in. \(\times\) 40 union nipple. Make a locknut for the stem from \(\frac{1}{4}\) in. hexagon rod, which needs no detailing out.

THE TANK TOP

The top of the tank can be made from a single sheet of 18-gauge brass — it can be thinner, but not thinner otherwise it may sag — and to get it an exact fit trim up the cardboard template used to get the correct shape of the body until it fits nicely in the tank, resting on the top angles. Then take a leaf from the fretsaw worker’s book; stick the pattern on the sheet of brass and cut it to the outline of the pattern with a metal-cutting fretsaw or a piercing-saw. I do this kind of job on my Driver jigsaw, which goes through 18-gauge brass at an amazing speed. Smooth off the sawmarks with a fine file and the brass top should be a perfect fit in the tank. This method is far better than cutting with shears to a marked line, as there is no distortion of the metal and the minimum of waste.

At \(\frac{1}{4}\) in. from the back end on the centre line, cut an opening \(\frac{1}{4}\) in. wide and not less than \(\frac{3}{4}\) in. long, with slightly rounded corners. It may be longer if desired. This can also be cut out with a piercing-saw. Cut a strip of sheet brass \(\frac{1}{4}\) in. wide and approximately \(\frac{1}{4}\) in. long and bend it to the shape of the hole into which it is fitted, with the joint at the front end. It should project through about \(\frac{1}{4}\) in. and be silver-soldered in place on the underside. A lid with about \(\frac{1}{4}\) in. overlap can be cut from the same kind of metal; leave two \(\frac{1}{4}\) in. tags at one end when cutting out, about \(\frac{1}{4}\) in. apart, and bend them into loops with rounded ends and a similar loop at the end of a short strip \(\frac{1}{4}\) in. wide, fit it between the loops on the lid, put a piece of wire through for a pin — and there is your hinge. The strip is riveted to the front end of the filler, as shown in the section of the tank.

Drill a series of No 48 holes along each side of the tank top, 5/32 in. from the edge at about \(\frac{1}{4}\) in. centres. Do this also at the back of the coal recess. Put the tank top in position and run the drill through all the holes, mark the countersinks on the soleplate. Remove the top, drill the countersinks No 53 and tap 9 B.A. or 2/56.

ATTACHING THE PUMP AND FITTINGS

Set the pump lever vertical and stand the pump in the tank so that the lever will come exactly under the centre of the filler, as shown in the section. Run a No 40 drill through the holes in the base and make countersinks on the soleplate. Remove the pump, drill the marked spots with a No 35 drill, tap the holes in the pump base for 9 B.A. or 5/36, and fix the pump with brass screws to match put in from underneath.

At \(\frac{1}{4}\) in. from the front of the left-hand water leg of the tank and \(\frac{1}{4}\) in. from the side (see plan) drill a \(\frac{1}{4}\) in. hole. At the corresponding place on the tank top drill a \(\frac{1}{4}\) in. hole. Remove the spindle from the water-valve and take out the screwed top. Insert the valve body from underneath.

*Continued on page 478*
POSTBAG

Austin-Walton's notes on Twin Sisters. Finally, he should join a model engineering society where there is a strong locomotive section; there he will find all the help and advice he requires.

Hull, Yorks.

G. I. HELM.

WRITING IT UP

Sirs,—It was with considerable interest that I read Mr Powell's letter and your footnote [Postbag, February 28] concerning the difficulties of writing about the activities of model engineers.

There must be many who would be willing to tell the story of their modelling activities, even if they were not prepared to write about them. Indeed, there must be numerous model engineers who are capable of recording those stories in the form of an article. I, for one, would be happy to cover an area within a reasonable distance of Chard—petrol restrictions would, of course, tend to hamper movement at present.

Now if volunteers would communicate their willingness to be the subject of articles, it would only remain for a mutually convenient date to be arranged and all these unrecorded activities would be gathered in.

Chard, Somerset.

J. HANDEL.

GRINDING OF MOWER

Sirs,—I was glad to read F. C. Atkinson's letter [Postbag, February 21] and I hasten to assure him that I not only wrongly omitted mention of the essentiality of grinding the bottom plate, but also my loathing, on principle, of grinding in the lathe! However, with me this is only perhaps an annual job, and I think even Duplex's attitude to grinding in the lathe is that it is permissible, given reasonable protective precautions.

I am interested to learn that the grinding is quite satisfactory when the cylinder is continuously rotated, provided the axis of the cylinder is above that of the grinding wheel, but this presupposes sufficient clearance between the centres and bed. In any case, with an ML7, this is not so, and the use of false centres and raising the height of the cylinder axis above the lathe axis are necessary, even if the cylinder is ground blade by blade.

Fawaham, Kent.

K. STOCKER.

Sirs,—Mr Atkinson [Postbag, February 21] cannot expect one seriously to take his statement that if the cylinder of a mower is placed above the centre of the grinding wheel and that they are both revolved on their own axes, there will be ample back off. I contend that the whole depth of edge of each blade will be part of a perfect cylinder, it cannot be otherwise.

To get "back off" each blade must be acted upon separately, setting the mower axis either above or below axis of grinding wheel according to way the mower cylinder is placed on its axis.

The method of grinding cylinder blades and bottom blade as suggested is very bad, as one is producing an arc in the bottom blade to that of the cylinder blade which will in use tend to cause jamming.

King's Lynn.

J. D. ELM.

SHADING LINES

Sirs,—In his interesting article on mechanical drawing aids Duplex describes a method of ensuring equal spacing of shading lines. I thought readers might like to hear of another method which perhaps is a little less complicated.

The 45 deg. setsquare merely needs scribed lines parallel to its edges, at a distance from the edge equal to the distance between the shading lines. I find two lines per edge quite sufficient and provided the square is reasonably transparent it is very quick and easy to line up the line first drawn with that scribed on the square. Thus the square is moved over the drawn lines instead of away from them. Inking cannot be done this way but pencilling the shading first takes very little time.

Asheatal, Surrey.

A. K. POTTER.

SELF-SUFFICIENT

Sirs,—Some time ago I contemplated buying a bungalow in the wilds of Dorset, and inspection failed to reveal mains of any sort. As I intended to make one room into a workshop everything would centre round this, so light, heat and power were required. Internal combustion engines were ruled out as fuel is expensive.

I thought a slow combustion Torotive stove would take care of the heating; then I thought the same stove could also produce power and light if I put a small steam coil inside the stove to drive a suitable engine and dynamo.

The final scheme is: the above steam generator coupled to a double Tangye driving a 14 kw d.c. generator (which I have). If a.c. is taken from the generator it can be transformed to 230 volt for motors and fluorescent lighting.

Imagine being invited to an engineer's home with everything run by one of these lovely engines.

Bath.

R. A. GARRAD.

VIRGINIA

Continued from Page 469

neath, bending the pipe to the shape shown in the drawings, and attach to the soleplate by 3/32 in. or 3/48 screws through the holes in the flange, tapping the soleplate to suit. Put a 1/64 in. Hallite or similar gasket between the flange and soleplate. Solder the small bush for the spindle into the corresponding hole in the tank top and replace the screwed cap. The spindle can be let out until the tank is permanently attached, when it is screwed into the valve through the bush as shown.

On the opposite side, at the corresponding position in the other water leg, drill a 7/6 in. clearing hole and fit the pump strainer to the soleplate in similar manner, with the gauze finger projecting up inside the tank. Use 9 B.A. or 2/56 brass screws for attaching, with a gasket between the flange and soleplate as before. Bend the feed pipe as shown in the drawings.

The bypass fitting is attached in like manner to the valve box by a swan-neck of 5/32 in. pipe, with a union nut and cone at each end. As the delivery pipe from the hand-pump has to withstand boiler pressure, slip-on hoses, as used for feed and bypass connections, would be useless so a cycle-pump connector can be used.

One end has a short piece of 5/32 in. pipe with 7/6 in. x 26 union nut and cone for connecting to the union on the engine attached to it. The other end a longer pipe with 7/6 in. x 40 union nut and cone for connecting to the union on the elbow. The length of this is determined by the length of the connector. The joints may be soldered or screwed as desired.

To be continued.
L.B.S.C.'s article on the old-time American locomotive this week deals with a suitable tender for the engine with the larger boiler

When I first erected a little straight railway line in the back garden of my old home at Norbury it proved of great interest to three schoolboys who lived next door.

Once when I was trying a partly-finished engine with a tender which belonged to another one, one of the boys called out, "Lummy, don't she look scatty!" and that non-U but very true remark would just about apply to a Virginia with the larger boiler and modern type of cab if it were coupled to the old-fashioned type of tender. I am, therefore, offering some notes and drawings for a tender of more modern vintage.

There is no need to make any alteration to the frame, tender trucks or any of the running-gear; they will suit the alternative tender body quite well. The soleplate of this one can be made from a piece of 16-gauge sheet brass, 10 in. wide and 8 in. long, which is bent at right angles at a bare 4 in. from each end so as to fit Nicely between the side sheets of the tank, and keep them parallel.

Before fixing this, cut a gap in it 2 in. wide and 1½ in. deep for the coal gate opening. At each side of this rivet a runner, made in the same way as the runners described for the sliding roof of the cab. The gate itself is just a piece of sheet metal (steel will do) cut to slide between the runners and furnished with a knob so that the fireman can lift it easily.

The completed front plate can be riveted in position, butting it up tightly against the semicircular front ends of the side sheets as shown in the plan. If the builder happens to be one of those good folk who delight in seeing a rass of pimplies all over a tender he can put in as many rivets as desired and snap the heads on the outside of the tank sheet. This applies to all the riveting.

Personally I prefer a smooth sheet, like those on the old Brighton engines, and the cleaner-boys certainly liked to wipe smooth sheets instead of knobbly ones!

TANK AND BUNKER

Pieces of ½ in. × ¼ in. brass angle are riveted along the full length of the tank body at the bottom edges and also along the back. Similar pieces are also needed to support the bottom of the coal bunker and the removable part of the tank top. To make certain that the "floor" is level my usual dodge is to cut out a piece of card-board showing its height from the tank bottom and the upward slope to the partition. This is placed in the tank body at each side and a line scribed along the upper edge of the template on the brass sheet.

These lines must of necessity be the same height from the tank bottom, and the pieces of angle are riveted flush with them. The pieces of angle for supporting the removable part of the tank top are riveted along the top and back at 2½ in. from the upper edge. Another piece of angle is riveted to the back of the partition, as shown in the section, to support the front end of the removable tank top.

The bottoms of the coal bunker and the partition are made in one piece from 16-gauge brass full 6½ in. wide, to fit nicely between the tank sides, the length being 9½ in. Cut this away at each side at one end, for ½ in. depth, leaving a tongue in the middle 2 in. wide to fit the bottom of the coal gate opening. At 5½ in. from the shoulders bend the sheet upwards at 45 deg. angle, and at 2½ in. above that, bend it again vertically; see section of tank body. The angle for supporting the front end of the tank top is riveted just above the second bend.

Before screwing this down permanently, erect the tank body on the soleplate. First drill a series of No 41 holes at about ¾ in. centres, right along the bottom angles, both sides and back. Stand the body on the soleplate in the position shown, with ½ in. of the soleplate projecting at
each side and the front curves 1 in. from the front edge. Tack it in this position with a few blobs of solder along the bottom; say one at front and back, and two at each side.

Fix up a couple of extension drills, Nos 41 and 48, driving them into holes drilled in the ends of pieces of 3/8 in. rod about 6 in. long. All broken ends of drills should be saved for making these very useful extensions; in fact a broken end is far better for the purpose than a new drill as there will only be a short piece projecting from the extension rod.

Using the holes in the angles as guides, make countersinks through all of them on the soleplate; drill through with the long-necked No 48 and tap 3/32 in. or 3/48. To drive the taper, take a piece of tube about 6 in. long, of a diameter that will just go over the square on the shank of the tap and hammer the end down on to the flats so that the tube becomes a square-holed box-spanner. Put your tap wrench on the other end, and the tapping becomes a piece of cake. A taste of cutting oil on the tap will make it cut wonderfully easy.

When all are tapped, put in brass screws—any heads will do—and then solder all round the bottom and over the angles and screws, just as described for the smaller tender. The bottom of the coal bunker can then be fitted. Place it in position temporarily and make any adjustment that may be needed to the bends and width; remove it and drill a series of holes at about 2 in. centres, 5/32 in. from the edge, along the level part and up the sides of the slope. Use No 48 drill and countersink the holes.

Replace the plate, see that the tongue goes through the coal-gate opening right at the bottom so that the shoulders at each side of it fit tightly against the front plate, then make countersinks on the angles with the No 48 drill through the holes in the plate; follow through with No 53 drill, tap 9 B.A. or 2/56 and put countersunk brass screws in.

These are necessary in the present case as cheese or roundheads would catch the shovel. Sweat over all the joints and screws so that solder and don’t forget to do the piece under the tongue where it projects through the front plate.

The vertical section at the back of the coal-bunker which forms a division-plate can either be soldered to the sides or fixed with a small piece of angle close to the top, at each side.

REMOVABLE TANK TOP

The cover over the rear part of the tank is made from a piece of 16-gauge brass sheet measuring approximately 6½ in. × 7½ in. It should be trimmed to fit nicely between the sides and ends. At 1½ in. from the back end cut a rectangular hole 2½ in. long and 1 in. wide, with rounded corners; and in it fit a filler with hinged lid, as described for the smaller tender.

At 5/32 in. from the edge, all around the plate, drill a series of holes at about 3 in. centres with No 48 drill. Put the plate in position, make countersinks through the holes with the 48 drill on the angles, drill through with No 53 drill and tap 9 B.A. or 2/56. Don’t put any screws in yet as the top has to come off to fit the emergency hand-pump.

The internal fittings of the larger tender tank are exactly the same as described in the previous instalment and may be fitted in approximately the same position in each case. There is, however, a slight variation in the fitting of the injector water valve. The spindle of this passed through a plain bush in the top of the smaller tank, which was all right as it was well above water level; but in the present instance it passes through the bottom of the coal bunkers, and a plain bush would let water escape all the time the level was above the bush.

A gland will, therefore, be required here and a section of a suitable one is shown in the detail sketch. Chuck a piece of 3/8 in. brass rod in the three-jaw, face, centre, and drill to a bare 1 in. depth with No 21 drill. Turn down 3/8 in. length to 3/8 in. dia. and screw 1/2 in. × 40. Part off at 3/8 in. from shoulder; reverse in the chuck, holding in a tapped bush, and turn 3/8 in. length down to 3/8 in. dia. Make a gland nut to suit from 3/8 in. hexagon rod, the same as a union nut.

When drilling the hole in the soleplate for the insertion of the water-valve, let the drill carry right on until
it goes right through the bottom of the bunker. The holes will then be in alignment—they couldn't very well be otherwise!

After fitting the valve, solder the bottom part of the gland into the hole in the bunker bottom and before inserting the spindle through it don't forget to put the gland nut on the spindle, with a few strands of graphitized yarn inside it. Screw the spindle home, tighten the nut just sufficiently to compress the packing and there won't be any leakage.

**COPING FOR THE SMALLER TENDER**

The flared coping which is fitted around the top of the smaller tender is made from a strip of 18-gauge brass ⅛ in. wide and should be in one piece if a sufficient length is available. If not, the joint can be made in the middle of the back, same as the body. Most amateur metal workers find difficulty with the corners. If they were square, like many of the British tenders of the same period, it would be easy enough to mitre them, making the coping in three pieces with the joints at the flared corners, but *Virginia*’s full-size relations had rounded corners to the coping.

About the easiest way to reproduce these in the small size is first to bend the strip to the shape of the tender top, then put a piece of round rod in the bend vice with an inch or so projecting at the side of the jaws. Lay the bend over this and beat the edge nearest the vice with a hammer. This will stretch the brass sheet, and as the beaten edge will be longer than the unbeaten one the strip will acquire quite a noticeable appearance. It only needs a little practice to make a neat job without any hammer marks.

As a matter of fact I don’t bother to make separate coping strips at all. I make the coping in one piece with the tender, one example being the tender for my Webb compound. The upper part of each side and back was bent over to the desired flare to within about ⅛ in. of the corners, and these were then splayed out in the above way until they lined up with the straight sections.

Another way would be to get a piece of hardwood about 3 in. square and 1 in. thick, plane off two adjacent sides to the required angle and file the corner to match. The strip could then be placed on this carefully and hammered into contact with it. The brass would need well softening before commencing operations, and reannealing if it “went hard” during the process.

After forming the corners, the coping can be attached to the tank top by either of the methods illustrated. Small brackets made from ⅛ in. brass may be attached to the inside of the coping at about 2 in. intervals, either by riveting or soldering, and the lower ends of these can either be attached to the top plate of the tank or to the inner side of the tank sides.

In the former case the coping comes away with the tank top if same is removed. In the latter, it is a fixture, and small clearances would need filing in the top plate to clear the brackets. A beading of 3/32 in. half-round wire, nickel-bronze (German silver) or brass can be soldered around the top edge and another at the joint between the coping and the tender sides, as shown in the general arrangement drawing of the tender. A similar beading can also be soldered at the top edge of the larger tender.

Beginners may find the following tip useful when doing the last-mentioned job. It needs neat soldering to preserve a good appearance, and the beading must be kept tightly in position when soldering. If it isn’t, immediately the hot soldering-bit is applied it will expand and pull away from the tender sheet or coping. I got over this trouble by making some weeny cramps from ⅛ in. square rod and 3/32 in. screws.

**Soldering the beading**

The end of the beading was set in position and secured by one of the cramps, then three more were attached at about 1½ in. intervals, holding the beading tightly to the tender side in line with the top edge. Some liquid flux was applied along the top edge so that a line of soldering would be obtained between the beading and the tender side, and then the hot bit with some solder on it was applied to the same places.

The solder sweated down between beading and metal, and when the spaces between the cramps were done the cramps were shifted along and the process repeated until the end of the beading was reached. The places where the cramps had been attached were then soldered, thus making a continuous run.

Any traces of solder along the top edge were filed off and any that had seeped through and were showing below the beading were scraped off with the ex-file scraper mentioned last week. When I use nickel-bronze half-round wire for beading I always heat it first; the effect is pleasing, whatever the colour of the locomotive.

BOILER CLEADING

Uninitiated folk usually get mixed up with “lagging” and “cleading.” Lagging is the wood strips, felt, asbestos mattress, or other material used to prevent dissipation of heat from a locomotive boiler, and cleading is the term used for the plates and bands which keep the lagging in place. At least, that was the way of things in my time on the L.B. and S.C.R. — maybe they have other terms in use now in the “motive power depots.”

Anyway, all the covering that the *Virginia* boilers need will be a thin brass or copper plate over the firebox wrapper to hide the stayheads, and this can be fixed at the bottom edges by three or four ⅛ in. or 1/72 roundhead screws tapped into the boiler. In addition, the smaller boiler needs a coned section to simulate the wagon-top between barrel and firebox wrapper.

To get the exact shape of the piece of metal required, cut out a paper pattern and wrap it around the boiler so that it touches both the barrel and the top of the wrapper. Run a pencil around it and where it needs cutting, get the ends square, then take it off and cut it at the marked lines.

The result will give you the exact shape and size of the piece of metal. Cut this to the shape and size indicated, bend it around the boiler, and secure it with three or four small screws underneath. Alternatively, bend the edges at right angles like a clip and put two ⅛ in. bolts through the angles.

I make all my boiler bands from what is known in the metal trade as “ticket wire.” This is thin brass strip about ⅛ in. wide. The bands are made by simply bending a length of this around the barrel, cutting it at the overlap, bending the ends at right angles and size indicated, putting a ⅛ in. bolt through. When attaching a band to a firebox I just fix it with a screw at the bottom on each side.

*To be continued.*

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**WIN A MYFORD SUPER SEVEN LATHE**

Only a matter of hours are left for you to send in that entry for the competition in which you can win a Myford Super Seven lathe. The competition closes tomorrow, Friday, April 5.
As the wooden-beamed brake gear on the tender of the full-size old timers is unsuitable for reproduction in 3½ in. gauge, L.B.S.C. describes a working modification which retains the original characteristics.

The brake gear fitted to the tenders of Virginia's full-size relations was a really nobby box of tricks, reminiscent of the brakes on the old horse-drawn tramway cars.

The brake shoes were cast with three openings in each, like miniature wheel spokes, and were supported on each end of a huge wooden beam reinforced by tie-rods. These were hung from brackets bolted to the centre part of the tender truck frames—two beams per truck—and the compensating gear was arranged diagonally, the upper end of each actuating lever being inclined toward the left side of the tender. These ends were connected by a long pull-rod which extended toward the front end of the tender, terminating in a length of chain which was wound around the lower end of the brake spindle. The upper end of this carried a large ratchet wheel level with the tank top.

A hand-operated pawl, pivoted to the tank top, engaged with the ratchet teeth. To apply the brake the fireman had to wind up the chain by aid of the cow's horn handle, and to hold the brakes in the "on" position he had to knock the pawl into engagement. But how he did this with both hands gripping the brake handle history doesn't tell us.

This arrangement would be useless as a working proposition on a 3½ in. gauge job, so I have had to rearrange it. However, I have retained the general characteristics. Solid brake blocks are used, with slotted backs to accommodate the hangers which are slung from brackets bolted to the centre part of the truck. The beams are of steel bar, with turned-down ends which serve as brake-block pins. A fork is attached to the centre of each beam; the front-end one carries the compensating lever, the upper end of which is anchored to a bracket also screwed to the truck centre. The back-end one carries the longer actuating lever. These two levers are connected near the bottom by a torque-rod with a fork at each end for attaching to the levers.

The upper ends of the actuating levers are coupled together by a long pull-rod. Another pull-rod goes from the front one to a vertical arm on a brake shaft which is worked by a vertical brake spindle. It is screwed at the bottom to engage a nut which works between two horizontal arms at the end of the brake shaft. The latter is supported by a sheet-metal bracket attached to the underside of the soleplate.

The action is as follows: When the brake handle is turned clockwise the nut rises and pulls up the horizontal arm on the shaft, causing the vertical arm to move forward. This pulls the actuating arm on each truck towards the front of the tender, and the torque-rod at the lower part then pushes the front beam forward, applying the brake to the front wheels of the truck. When the torque-rod can move no further the rear end of it becomes a fulcrum for the actuating lever, the lower part below the torque-rod fork moving backwards. This takes the beam with it and thus applies the brake to the rear truck wheels.
When the brake handle is turned the other way the action takes place in reverse, and the springs which connect the beams pull the blocks clear of the wheels. No ratchet gear or chain will be needed as the nut cannot slip on the screw.

**BRAKE BLOCKS, HANGERS AND BRACKETS**

It is possible that cast-iron brake blocks will be available, with the slots for hangers cast in. If so, they will only need a slight clean-up with a file and drilling for the ends of the beams, which take the place of the usual hanger pins. The blocks can also be cut from mild-steel bar of \( \frac{1}{4} \) in. \( \times \) \( \frac{1}{8} \) in. section, the slots being formed by the same method as used for slotting forks. File the end of the piece of bar to the shape of the back of the block, then clamp under the slide-rest toolholder and slot it with a \( \frac{1}{8} \) in. cutter while running it on a stub arbor in the chuck. Saw off sufficient to allow for the radius, then repeat operations until you have eight blocks.

To form all the radii at one fell swoop scribe a circle \( 2 \) in. dia. on a piece of paper about \( \frac{3}{8} \) in. thick. Solder all the blocks to this, with the edges to be radiused, touching the circle. Bolt the assembly to the faceplate with the circle running truly, then put a boring tool in the slide-rest and proceed as before if you were boring an eccentric-strap. Melt the blocks off the plate, wipe off any superfluous solder, and there are your finished brake blocks. The hangers are filed up from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. mild steel and need no detailing. The brake hangers can be made from \( \frac{1}{8} \) in. \( \times \) \( \frac{3}{8} \) in. rod, brass or steel. Each pair is in one piece, \( 1 \) in. long. Slot the narrow edge \( \frac{1}{4} \) in. wide and \( \frac{1}{4} \) in. deep by the method described for slotting crosshead shoes and similar jobs. File to the shape shown and drill for the pins and fixing-screws, then put the hangers in the slots and secure with pieces of \( 3/32 \) in. silver-steel or 13-gauge spoke wire driven through the lot and filed flush each side.

The hangers should be free to swing. Each bracket is attached to the underside of the truck frame, level with the centre line of the wheel treads, and secured by two 6 B.A. or 4/36 screws run through clearing holes in the bracket into the tapped holes in the truck frame.

**BRAKE BEAMS AND COMPENSATING GEAR**

The brake beams are made from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. mild steel, each needing a piece a full \( \frac{3}{4} \) in. long. Chuck truly in the four-jaw and turn down \( \frac{3}{8} \) in. of each end to \( 3/32 \) in. dia., screwing \( 3/32 \) in. or \( 3/48 \) just far enough to leave a full \( \frac{1}{4} \) in. of 'plain' between the thread and shoulder. The distance between the shoulders should be \( 3\frac{1}{8} \) in. File to the shape illustrated.

- The forks for attachment of the levers are made from \( \frac{1}{8} \) in. square steel. Each is \( 2 \) in. long, one end being flattened, drilled and rounded off just like a valve-gear fork. The other end is slotted at right angles and to \( \frac{3}{8} \) in. depth; this end is fitted to the brake beam, pinned to hold it in place, and then brazed. Opposite the fork drill a No. 48 hole in the beam for the end of the pull-off spring. Both actuating and compensating levers are filed up from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. mild steel and drilled as shown. A bracket is required to hold the fulcrum pin which supports the upper end of the compensating lever. This is sawn and filed from \( \frac{1}{8} \) in. \( \times \) \( \frac{3}{8} \) in. mild-steel bar to the shape and dimensions given in the detail illustration. Alternatively, it could be built up, the forked section being made from \( \frac{1}{8} \) in. square steel and the end piece from \( \frac{1}{8} \) in. \( \times \) \( \frac{1}{8} \) in. steel, the two parts being permanently screwed together and the joint brazed. The bracket is attached to the centre of the truck frame by two \( 3/32 \) in. or \( 3/48 \) screws (see drawing of the compensating gear). The torque-rod is a piece of \( \frac{1}{8} \) in. round steel, with a fork made from \( \frac{1}{8} \) in. square steel screwed on to each end.

The assembly and erection are very simple. Pin the middle hole in the compensating lever to one end of the torque-rod and the actuating lever to the other by pieces of \( 3/32 \) in. silver-steel or 13-gauge spoke wire pressed through holes in the forks and levers, and filed flush outside. The pins should be a press fit in the forks and free in the levers, but if they are at all slack in the forks rivet the ends over just sufficiently to prevent their coming out. Put the top of the compensating lever in the slot in the fulcrum bracket and pin that too. The lower ends of both levers may then be attached to the forks on the brake beams, either by pinning as stated or by little bolts made from \( 3/32 \) in. silver-steel or 13-gauge spoke wire screwed and nutted at both ends.

The assembly should then present the appearance shown in the drawing of the compensating gear. To erect, all that is needed is to screw the fulcrum bracket to the centre part of the truck frame. The rear tender truck is furnished with an exactly similar assembly.

The final job is to put a brake block on the end of each hanger, lining up the hole in the hanger with those in the block; then slide the lot into position, with the screwed ends of the brake beams going through the holes in the brake blocks and hangers. Attach the hanger brackets to the truck frame and put nuts on the projecting ends of the turned-and-screwed parts of the beam outside the block. These nuts are tight the blocks should be free enough to adjust themselves to the wheel treads, but not slack enough to flop over and rub against the wheel treads when the brakes are off.

An alternative way of assembling, which doesn't involve interfering with the springs and equalisers, is to attach the block-and-hanger assemblies to the beams before screwing the fulcrum bracket in place. If the truck is laid upside-down on the bench a little judicious jerking will get the whole piece into place, and it will only need the screws putting into the brackets to keep it there. Connect the two beams by a pull-off spring wound up from about 20-gauge tinned steel wire around a piece of \( 3/8 \) in. rod and looped through the holes in the beams. If the top of the actuating lever is moved in the direction of the arrow, both pairs of brake blocks should press evenly against the wheel treads, releasing immediately the lever is let go. Don't forget to "tie the jints" as one of my early footplate mates used to say; but keep the "tie" off the blocks and wheel treads!

**BRAKE COLUMN AND SHAFT**

The brake column and shaft, being self-contained items, can be used on both the ancient and modern types of tender. The arrangement illustrated here is for the old one.
make the column chuck a piece of 
\( \frac{1}{4} \) in. round rod (brass or steel as preferred) in the three-jaw, face the end and drill as deeply as you can with a No 30 drill. Turn a bare \( \frac{1}{2} \) in. length to \( \frac{3}{4} \) in. dia. and screw \( \frac{3}{8} \) in. \( \times \) 40; part off at \( \frac{1}{2} \) in. from the shoulder. Reverse and rechuck in a tapped bush held in the three-jaw. Centre the other end and drill down with a No 30 drill until you meet the previous one. Bring up the tailstock with a centre-point in it to support the job while the column is turned to the shape illustrated. The exact angle of taper doesn't matter a bean, but leave a full-diameter flange at the bottom. Then make a \( \frac{3}{4} \) in. \( \times \) 40 locknut to fit the screwed part.

The brake spindle is a piece of \( \frac{1}{2} \) in. steel rod \( 4 \frac{1}{2} \) in. long, with \( \frac{1}{4} \) in. of \( \frac{1}{6} \) in. thread at one end. A little boss turned from \( \frac{1}{2} \) in. rod is screwed or pressed on to the other end and No 49 hole drilled through the lot, into which is squeezed a \( 2 \) in. length of 15-gauge spoke wire. Bend up both ends of this to form the cow's horns, and round off the ends so that the fireman won't cut his hands on them. Incidentally, the handle on the modern tender should have only one end turned up.

Make two collars from round rod, one \( \frac{1}{2} \) in. dia. and the other a bare 7/32 in., drilling both No 31. Push the \( \frac{1}{2} \) in. one on the spindle just over halfway up, insert the spindle into the column and put on the other collar just above the end of the thread. Bring down the upper collar until it touches the top of the column, leaving the spindle just free to turn, then pin both collars in position with bits of thin wire, such as domestic pins, which will not weaken the spindle. Drill a \( \frac{1}{4} \) in. clearing hole in the soleplate.

Above: The hanger support, hanger and brake block.

Right: The compensating gear 2 in. from the front end and 1\( \frac{1}{2} \) in. to the left of the centre line, insert the screwed end of column and secure with the locknut.

The bracket carrying the brake shaft is bent up from a piece of 16-gauge steel, \( \frac{1}{4} \) in. wide and about 2\( \frac{1}{2} \) in. long. If bent over a piece of \( \frac{3}{8} \) in. bar it will come out just the right size. Round off the sides with a file and drill a No 14 hole in each, \( \frac{3}{8} \) in. from the top, then put a \( \frac{1}{6} \) in. parallel reamer through the two of them at once. These holes may be drilled larger and bronze-bushed if desired. (I don't consider this necessary as the brakes are for ornament only and the tender is too light to render it of any use for service stops.) Drill two No 30 screw-holes on the centre line between the sides.

The brake shaft is a piece of \( \frac{1}{16} \) in. round steel a full \( \frac{1}{16} \) in. long. One end carries two horizontal arms which are brazed to the shaft with the brake nut between them. The arms are filed up from 16-gauge steel, the large end being drilled No 14 and the reamer being inserted only just far enough to make the hole a press fit on the shaft. For the nut chuck a piece of \( \frac{1}{4} \) in. square bronze rod truly in the four-jaw, face the end and turn down a bare \( \frac{3}{8} \) in. length to 3/32 in. dia. Part off at \( \frac{1}{8} \) in. from the shoulder, reverse in the chuck and turn a similar pip on the other end. Drill the block No 40 and tap to suit the brake spindle. Squeeze one arm on the shaft to \( \frac{1}{8} \) in. from the end, then, the other on the extreme end with the nut between, the pins working in the slotted holes as shown in the general arrangement drawing. Then braze or silver solder the arms to the shaft, and be sure that they are in alignment.

The other end of the shaft carries a lever to which the pull-rods are connected; this is made exactly similar to those on the rocking-shafts of the valve gear and all the dimensions are given in the drawing. The boss should be reamed a tight fit for the shaft. Push the shaft with the horizontal arms attached through the bracket and the bracket put on the bossed arm at right angles and pin it with a bit of \( \frac{1}{16} \) in. silver-steel or 16-gauge spoke wire.

The easiest way to locate the assembly for erection is to hold the nut against the bottom of the brake spindle and turn the handle until the long arms are lying horizontally while the top of the bracket is tight against the soleplate. Then set it so that the brake shaft is at right angles to the centre line of the tender (see underside view) and the pins or trunnions on the nut are at the end of the slot nearest the shaft.

With a bent scriber mark off two circles on the underside of the soleplate, through the holes in the bracket; swinging the latter out of the way, drill two No 30 holes in the soleplate at the marked places, scrape off any scale, as the brass drilled holes in the forks is obtained from the actual job. Screw up the brake nut until it is about \( \frac{1}{4} \) in. from the collar and push the top of the actuating lever on the leading truck in a forward direction until the brakes are hard on.

THE PULL-RODS

The front pull-rod is merely a piece of \( \frac{1}{4} \) in. silver-steel or drill rod (better than mild steel for this purpose) approximately 4\( \frac{1}{2} \) in. long, screwed at each end and furnished with a couple of forks or clevises. The exact length of the finished pull-rod between the centres of the holes in the forks is obtained from the actual job. Screw up the brake nut until it is about \( \frac{1}{4} \) in. from the collar and push the top of the acting lever on the leading truck in a forward direction until the brakes are hard on.

(Continued on page 349)
The information I have collected from MODEL ENGINEER articles gives little or no information to help one design the most efficient engine without the "trial and error" system being necessary. The article by Mr. H. Nicholls of February is very interesting, but I fail to understand the 260 p.s.i. on one side of the piston and 150 p.s.i. on the other side when using compressed air. Why the back pressure?

In November 1952 Mr. Corbett gave us a drawing of an engine with the working cylinder of lesser bore than the displacer cylinder, and during November 1954 Mr. Manley supplied particulars of a large fan engine quite the reverse.

My best information comes from an article by a reader a few weeks ago (I have mislaid the number) who has emphasised the necessity of "trial and error" by instructing one to have an experimental adjustable crank in order to arrive at the correct stroke and not rely on an adjustable con-rod to adjust the clearance when alteration is made to the stroke.

It is evident that this reader was careful not to over expand the air contained in the system as, with a piston open at one face to the atmosphere, the gauge pressure would exist before the crank turned the bottom centre.

To pass the air at pressure through the cooling end of a displacer cylinder before it acts on the working piston appears to be wrong, but we should be able to alter that cycle, although it appears to be accepted as standard design.

Fleetwood.

S. McGregor.

PUT THEM IN CHAINS!

Sir,—The correspondence concerning static electricity reminds me of a very peculiar case of disturbance to television through this cause.

The disturbance took the form of flashes on the screen at about five-second intervals and only occurred between the hours of 7.30 and 9 p.m. during cold weather.

Every conceivable source of interference was explored. Experts (amateur and Post Office) were called in but still the trouble persisted.

The family were wont to settle down to watch the programme about 7.30 p.m. and usually stayed viewing until the station closed down. It was while spending a weekend with them that I observed that the trouble ceased at the time that Granny retired to bed.

Granny was an old lady of 75 and like many old people she suffered from the cold and also did not hold with new-fangled televisions; so she used to sit in front of the fire nursing her old cat, Nonax.

I eventually discovered that the interference was due to the static discharges caused by her stroking the cat.

We obtained 18 ft. 9½ in. of brass chain, took a couple of turns round the necks of Granny and the cat, soldered the free end to the nearest rising water main and efficiently earthed them!

No further trouble of a static nature was encountered.

Sheffield. J. Gordon Hall.

PAINTING "PETROLEA"

Sir,—With reference to the query by C.G.R., Carlton, Victoria, Australia, on painting Petrolea [Readers' Queries, March 21], I would point out that the inside of the cab was painted brown.

The inside of the main frames, motion plate and crank axle were light straw. The coupling rods were bright red, the wheels were blue with black tyers and a red line and the axle ends were black, outlined with a red circle.

In the instructions for building this engine no mention was made of the fact that no edging or running-board was provided along the sides of the tender—it was not possible to walk or clamber round it; unless at a platform the only way to get from the cab to the back of the tender was over the coal or down into the ballast, and this applied to all Holden's tenders.

Brantree, Essex.

W. B. Hart.

Sir,—Your reply to C.G.R. omitted to mention that the driving-wheel splasher had a wide brass beading which, with the copper pipe of the boiler feed, was always brilliantly polished.

The coupling rods were painted vermillion with bright steel eyes, and the guard irons, also in vermillion, made the engines of this class a lovely sight in sunshine. The name was painted in large white letters in an arc on the leading splasher.

I have done a good deal of research into the details of Petrolea and I have painted several portraits of her.

More than 100,000 of these were in circulation about 25 years ago in the form of a cigarette card! C.G.R. would like an accurate layout, he might care to get into touch with me through MODEL ENGINEER.

Welwyn Garden City.

R. Barnard Way.

BEGINNER'S PLEA


I am a beginner at steam locomotive building, with no lathe, but a kitchen table and much enthusiasm.

I started reading MODEL ENGINEER about 18 months ago hoping to find articles on the building of fairly simple gauge O locomotives. Except for one, which L.B.S.C. admitted was only a toy, there has been nothing but references to diminutive engines.

So I had to design my own first attempt, named Sir Thos. Thumb. It is a 2-2-0 of (believe it or not) quite good, Britannia-ish appearance. It has outside oscillating cylinders, reversing gear and lead pistons (which were cast in the cylinders). The boiler has a firebox, two water-tubes, one internal flue. It is spirit-fired from a tank in the tender.

After every conceivable blunder the engine was finished—and it worked! It can haul 12 on the Forsby shaft and coaches at ever-increasing speed for about 25 min. non-stop. Lack of adhesion is the worst fault.

Although most of your readers are experienced chuck-in-the-three-jaw-face-off men, I can't help thinking that it would probably be a good idea to give the beginners a chance to be active, if only for a short time. But I can only wish the Perkins P.15 and the others well. It is a pleasure to me to have shared in this happy life. The chap, to me, who has missed the bus but would be overjoyed if some of the now-unobtainable "words and music" on beginners' engines could be reprinted.

Didcot, Berks. Roger R. Anscombe.

VIRGINIA . . .

The distance between the centres of the holes in the actuating lever and the vertical arm on the brake shaft in these positions is the length of the pull-rod between the centres of holes in forks.

The rear pull-rod is similar to the front one except that the front end carries a fork, the jaws of which are wide enough to grip the back end of the front pull-rod as shown in the underside view. Details of this fork are shown in one of the small sketches. If both sets of brake gear have been made exactly alike the length of the pull-rod between pin holes in the fork should be the same as the distance between truck centres, viz. 8 in. But check this off by holding both the actuating levers in the "brake on" position and checking the distance between the pinholes in their upper ends.

The front end of the leading pull-rod and the rear end of the back one may be pinned to their respective arms or levers by pieces of 3/32 in. silver-steel or drill rod—the same as those in the compensating gear. But a bolt made from the same material, screwed on the end and held in place by a nut should be used for the wide-jawed fork as illustrated.

To be continued
This article concludes L.B.S.C.'s instructions for building the interesting old-time 3½ in. American engine very thin split-pins (see illustration). They were squeezed up very tightly in the bench vice, so that the heads were as near circular as possible.

As they had several serrations, I cut them with a small milling-cutter; but those for Virginia are of the tongue-and-slot pattern, so all that is necessary is to file away the dotted parts to form the tongue and slot. The longer piece is filed to the shape shown and can be either riveted to the lid or spot-welded; the same applies to the shorter piece. The hinge-pin is a piece of wire of the same thickness as was used for forming the hinges.

Drill a couple of holes in the bottom of the box with a No 41 drill, place in position at the back of the tender, run the drill through the holes and make countersinks on the soleplate, follow with No 48 drill right through, tap 3/32 in. or 3/48 and put a couple of screws in, which will hold the box securely. Keep a couple of 5/32 in. split-pins in it; then if you drop one in the grass when coupling engine and tender on the club track it will save a time-wasting search!

**TENDER STEPS**

Some of the old full-size engines had wooden steps—they seemed to be mighty fond of wood construction in days of old—but they wouldn't be much use in 3½ in. gauge.

The treads are made from 13-gauge steel, the upper steps being ⅜ in. wide and the lower ¼ in. wide; all are ⅛ in. long. The outer ends are rounded off. The supports are made from strips of 3/32 in. steel a full ⅜ in. wide.

The easiest way to assemble steps and supports is to brace them; and I expect beginners will wonder how on earth they are going to get the steps to stay in place while the brazing job is under way. Well, there are tricks in every trade.

All that is required is a simple jig for holding the steps. A short bit of ⅛ in. x ⅛ in. steel would do fine. File or mill two 3/32 in. slots in it at 1 in. centres, one a little deeper than the other. Jam the step-treads into the slots with the squared edges outwards and level with each other, and lay them in place on the supports. These can be taught good manners by laying them parallel at the right distance apart on a piece of asbestos, and putting pins at each end to prevent side movement.

**Little more remains to be done to complete the job.**

I mentioned last week that the brake gear described for the smaller tender could be applied to the larger more modern one, and the only variation needed would be in the position of the brake column. This is fitted in the same way, through a hole drilled in the soleplate at ¾ in. off the centre-line, but it will have to be set nearer to the front of the tender as there is no coal recess and the tank extends almost the full length of the tender body.

Drill the hole about ½ in. ahead of the front plate, which will allow for the easy operation of the brake handle. Don't forget that the handle only has one end turned up.

The brake-shaft assembly is fitted in the same way, being located at the bottom of the brake spindle, and the same method of getting the length of the leading pull-rod is used; but turn the shaft a complete half-turn so that the arm to which the pull-rod is attached hangs down and the actuating arms point forward. This will allow the assembly to be fitted behind the centre line of the brake spindle, and will give more room for the job.

If the feed pipes get in the way, bend them to clear; the pull-rod can also be set up a little if it runs foul of the bottom of the leading bolster. Anyone wishing to set the brake column nearer to the side of the tender can easily do so by lengthening the brake shaft and bracket to suit; put it any place you fancy, provided the pull-rod arm is kept on the centre line of the tender. If it isn't, there will be trouble on curves. In the central position, the flexibility of the rods allows for truck movement.

**TOOLBOX**

The front, bottom and back of the toolbox can be made from a single piece of thin brass, about 22-gauge, measuring 4½ in. x 2½ in. Mark this out as shown, and bend on the dotted lines. The sides are cut from the same kind of material, soldered in flush with the ends. The top is another strip, ¾ in. wide, which should overlap the box at each end by 1/32 in. This can be soldered in place.

The lid is the same length, but ½ in. wide, and it is attached by two little hinges, which should be small and neat. The way I made those on my L.B. and S.C.R. Grosvenor was to cut two pieces of very thin brass to the width desired and bend them around a blanket pin, so that when viewed endwise they looked like

**Left:** Details of the toolbox

**Below:** How the hinges are made

**MODEL ENGINEER**
Apply some wet flux, heat the lot to bright red and touch the joints with a bit of soft brass wire about 16-gauge, or a ½ in. Sifbronze rod. Let it form a little fillet between thread and support. Quench in cold water when the redness has gone and trim with a file if necessary, after pulling off the jig.

The supports are attached to the frame sill, close to the front end, as shown in the general arrangement drawing of the tender. The rear one can be screwed direct, but the front one will come just where the curved part begins and the support will have to be twisted a little to make it bed nicely against the sill.

In a drawing of a full-size tender of this type, which I have here at the present moment, the front support not only has a twist in it but also two offsets as well. I should say that the craftsman who forged up that merchant was certainly some blacksmith—and I’d dearly love to know what he said about the draughtsman responsible while he was doing the job!

The modern type of tender can be furnished with the ordinary type of steps made from 16-gauge steel sheet, the bottom tread being bent at right angles in one piece with the back support. The upper step can be riveted to the back, or brazed, as desired. The dimensions are the same as the old-fashioned pattern shown, so no separate drawing should be necessary. Alternatively, the step-ladder pattern can be used, both rungs and sides being made from 16-gauge steel with brazed joints.

The sides should be the same length as the old ones shown, and a full ½ in. wide. The holes for the rungs should be drilled No 52 at ½ in. centres, starting at ½ in. from the bottom, and the rungs (of 16-gauge spoke wire) cut to about ½ in. and pushed through, the sides being set at ½ in. apart. Braze the rungs where they project through on the outsides of the supports and file the projections flush with the sides. This process makes neat little ladders.

COUPLING OR DRAWBAR

The drawbar between engine and tender can be filed up from a piece of ½ in. x ½ in. mild steel to the size and shape shown. The engine end is drilled ½ in. clearing, and attached to the bracket screwed to the drag beam by a turned bolt made from ½ in. hexagon steel rod. The turned part of this is ½ in. long and is threaded 5/32 in. x 40, a nut to suit being made from the same material. I have shown it inserted from the underside as it can easily be inserted that way without disturbing anything, and as long as the threads are fairly tight it stands no chance of coming adrift.

The nut takes no strain but merely prevents the pin from coming out; the pin itself takes the pull. However, anybody who wants to put it in from the top can do so by drilling a hole in the cab deck just big enough to let the bolt-head go through; it can be located by putting a ½ in. drill through the hole in the bracket from underneath and drilling up through the deck, afterwards enlarging to the correct size from above.

The tender end of the drawbar fits in the slot in the bracket which is attached to the front end of the tender frame and is secured by a commercial 5/32 in. split-pin for reasons mentioned earlier; but there is no objection to the use of a turned pin by those who like to take the trouble to turn it! The turned pin won’t do the job any better, though.

Current for the electric headlight

I promised to show how the electric headlight specified for the modernised *Virginia* could be supplied with “juice,” and here is a diagram showing a simple arrangement utilising an ordinary torch battery of the flat pattern. These have three cells and are rated at 44 v. The bulb in the “pencil” torch will probably be only 2½ v., so it will have to be changed to suit the battery unless a large battery of the two-cell type, such as a cycle-lamp battery, is utilised. This would be rather awkward to fit under the tender without being unsightly.

The battery is attached to the underside of the soleplate, behind the rear bolster, by two clips made of thin springy brass screwed to the soleplate. Two brackets made from 16-gauge brass strip are also screwed to the soleplate in such a position that they make contact with the strips on top of the battery. The bracket contacting the short battery strip (the negative pole) is left plain, but the other one carries an insulating bush made from fibre or ebonite, with a 3/32 in. brass screw through the middle and a nut and washer on the back, to which an insulated wire is attached. This goes to a switch in the engine cab.

Uncoupling connector

To enable the engine and tender to be uncoupled, a connector, which merely consists of a plug and socket, is inserted in the wire at the drag beam. The plug is a little brass split-pin, and the socket a short piece of brass or copper tube. As they are not insulated they should hang clear of the engine frame; but for perfect protection a short length of rubber tube could be slipped over them.

Unless a very small switch of the usual pattern can be obtained, one can be made as shown in the detail sketch. The disc is a piece of ½ in. fibre or ebonite, the contact stud being an ordinary cheesehead screw with the head turned thin. It goes through the insulating material and has a nut and washer on the back. The lever is made like a tiny throttle lever and is pivoted on a similar screw; ½ in. screws are fitted, one each side, to act as stop pins for limiting the travel of the lever.

*Left: Wiring diagram for the electric light*

*Below: Details of engine and tender drawbar*
The tender steps

The complete switch can be attached to the side of the cab by a brass bracket screwed to the back of the insulating disc, but file a clearance in the bracket for the pivot screw of the lever, otherwise you'll get a "dead short" on to the engine frame as this is connected to the negative of the battery. "Milly Amp" is the quickest thing on earth, but also the laziest—she always takes the shortest way home! By the same token, as Pat would remark, set the switch far enough away from the cab side to avoid the contacts on it touching the metal.

The wire from the stud on the switch to the headlight can go along under the running-board out of sight. A neat way of doing the job would be to use a 3/32 in. tube for the handrail, instead of solid rod, and run the wire through that. The best kind of wire to use would be the enamelled kind used for winding the field magnets and armatures of very small motors. I used this on my 2-6-6-4 Annabel for connecting the wee turbo-generator to the headlight, after I found that ordinary insulated wire soon developed bare places.

The insulated wire would be awkward to thread through a hollow handrail, whereas the enamelled wire slips through easily. The working headlight, whether oil on the old-time engine or electric in the modernised version, is well worth fitting as it gives a realistic effect when the engine is running in the dusk of evening or at night.


due to the heat, but cabs and tenders were decorated like gipsy caravans, often with elaborate lining, or striping as it is called in U.S.A. The wheels were usually red or yellow and the bosses were lined out. I am not offering any specific suggestions as to how _Virginia_ should be painted; I am content to leave that part of the business to suit the tastes of individual builders.

The modernised version should be all black. Why this funereal and sombre finish superseded the original colourful appearance was probably an anticipation of what happened in the later years of the first grouping of the railways of Great Britain when certain folk, whose souls did not rise above statistics levels, decided that as long as locomotives could pull trains and earn dividends it didn't matter what they looked like, or even if they were clean.

Another factor was that, in the early days, both in U.S.A. and G.B. each engine had its own regular driver and naturally he took a pride in its appearance. All enthusiasm was killed by the "what the hell" stunt, which incidentally sent maintenance costs soaring. It is interesting to note that the "new toys," the diesels, are usually decked out in pretty colours!

Heat resisting

Whatever colour is adopted for the little engine, the method of application is the same. What I do is to give the whole bag of tricks a good wash-down with some petrol to remove all the grease and oil; then when dry I paint it with a good brand of either heat-resisting enamel or a synthetic hard-gloss paint, such as Valspar, Sol or any similar well-known brand. I don't use undercoating nor bother about rubbing down; my locomotives are intended to do hard work and not to be showpieces, and as long as the paint is thick and reasonably smart I am satisfied.

A trick I usually work to make sure that the paint on the boilers doesn't go soft the first time steam is raised is to fill the boiler before applying the colour and then heat the water almost to boiling-point by the aid of a small gas-burner in the firebox.

If the heat is kept up for several hours, and a "tunnel" of stiff brown paper placed over the engine to keep off dust as much as possible, the paint will "set hard" and no small splashes of hot oil will affect it. After a run, a rub with a soft rag restores its pristine beauty and, to quote a well-known advertisement, "the more you rub it, the better it looks."

**EPilogue**

Well, I guess that is about all there is to say about little _Virginia_. It has been rather a task in some ways to give fully-detailed drawings and instructions for building a small edition of a type of locomotive that I have never seen, and at the same time to guarantee that it will do the job given average workmanship.

I have Forney's _Catechism of the Locomotive_ and McShane's _The Locomotive Up-to-Date_ (which it was when published in 1899) and both these books give the information about the full-size 4-4-0 engines of the period; but a slavish copy of a 4 ft 8 1/2 in. gauge job would be absolutely useless as a really efficient working proposition in 3 1/2 in. gauge.

I have found by practical experience that to get the best results the engine must be designed to suit the gauge; and it may interest those critics whose letters appear from time to time in Postbag that this has been endorsed by the several eminent chief mechanical engineers who have honoured Little Swindon or Little Crewe, as they call it, with a visit and have tried out my locomotives for themselves on my own small railway. They found no fault with my original drawings.

No complaints

I have had a considerable amount of correspondence from various good folk who are building the engine and up to the present there have been no complaints; the job seems to be progressing smoothly and judging by the sales of casting and material the job will be quite a success as far as it can be from the old-timers taking the road in due course.

I rather think that some of them will be capable of showing their more modern sisters how to perform the pull-and-go act!

When the valve gear is O.K. and set carefully, and the boiler can supply the steam, the only limit to tractive effort is the bite—not the weight—of the coupled wheels on the railheads; and speed is only governed by the ability of the engine to stay on the rails. Just as a miniature racing automobile can travel as fast as a full-size one, so could a little locomotive if it would stay on the line.

It is more than likely that some critics will scoff at this assertion, just as they did when I first asserted that a 2 1/2 in. gauge coal-fired locomotive

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POSTBAG . . .

each buoy and its correct position in relation to passing other competing craft. Mechanical ability would also enter into the scoring and the skill of the "captain" bringing his craft home.

2. A reliability and distance trial. If judged on length of running time and distance travelled such might well have a tendency to interest the internal combustion brethren. It could tempt them to build larger and more seaworthy models and perhaps slow-running marine engines similar to the Bolinders and Palmers. These I believe are built in two-cylinder models and run on the two-stroke principle. Is it too much to anticipate a model marine engine designed to run on paraffin?

3. A manoeuvrability trial for power boats equipped with radio control.

Such a contest might require a boat to come alongside a dock, to reverse out of its position and steam again. Perhaps, it could pick up some small floating object in a scoop net attached first to the port then to the starboard side and execute turns within a given radius. Natural weather conditions would have a tendency to stiffen competitive conditions. A really tough test would be to require certain of the manoeuvres to be executed when in reverse.

I always enjoy reading your journal whenever it arrives Stateside. Now that you are including articles on boats it is doubly interesting.

Buffalo, U.S.A. JOHN U. COCKIN.

EARTHING DANGER

Sir,—I have a drilling machine from Cowell’s castings, fixed and travelling steady from scrap, and recently an adjustable grinding rest with my own improvement of wing-nuts to avoid searching for the spanner. Moreover, when the wing

...nut is tightened the rest does not tilt from the angle set by the gauge.

With regard to the subject of earthing electrical apparatus, a neighbour was nearly killed recently when carrying a properly earthed hand-drill in one hand and the cable (in a bundle) in the other. The cable was attached by a three-pin plug to the mains, and I presume there was a leak in the plug.

The point is that if the drill had not been earthed he would not have received the shock, as he was indoors and standing on lino and there would not have been a path to earth for the current.

Is it not a fact that an earthed tool is sometimes as dangerous to touch as a water-pipe, if there is any chance of touching the other hand on a live wire?

Bournemouth, Hants. E. DAVIES.

MAKING A PANTOGRAPH

Sir,—After reading Duplex’s article “Mechanical Drawing Aids” [MODEL ENGINEER, February 14] which shows a pantograph, I decided to try and simplify matters a little as I have no means of metal turning apart from carbide tools on a wood lathe.

After trying normal screws and finding the joint too free I sorted through my junk box for ready-made bearings. I finally settled for a 3½ in. gauge model of a narrow-gauge would be too large for those who normally prefer 5 in. gauge, on a smaller scale, in 2½ in. or 1½ in. gauge it would suit the average model engineer and help to revive the smaller gauges.

I prefer Taliesin to Prince on the Festiniog Railway, which would be quite a size. But there are other locomotives which are suitable.

The Talyllyn, Vale of Rheidol, Ravenglass and Eskdale, and the Romney, Hythe and Dymchurch would provide suitable prototypes.

Let's have a change from 4 ft 8½ in. Ashford, Kent. C. E. CARTER.

L.B.S.C.’S NEXT

Sir,—Apropos L.B.S.C.’s next locomotive serial—what about one of the Lima Locomotive Company’s famous Shay engines? They will “turn on a dime” and pull like nobody’s business, and it would be a popular serial with the American and Canadian readers.

I feel that Virginia was a welcome break from the usual run of British locomotives, for with all that is now “on file” almost any of the modern British locomotives could be built from L.B.S.C.’s previous gen.

Alternatively, why not—if we must revert to a British prototype—give us the Knowhow. Beyer-Peacock Garrett articulated?

Either of the above suggestions have the merit that the resulting product would be a great puller and yet smile at sharp curves.

Edinburgh, 3. W. LOCH KIDSTON.

Sir,—I am with John Bennet in that it is time for a narrow-gauge locomotive.

A 5 in. gauge is too large; I agree with J.N.M. I don’t think a 3½ in. gauge model of a narrow-gauge would be too large for those who normally prefer 5 in. gauge, on a smaller scale, in 2½ in. or 1½ in. gauge it would suit the average model engineer and help to revive the smaller gauges.

I prefer Taliesin to Prince on the Festiniog Railway, which would be quite a size. But there are other locomotives which are suitable.

The Talyllyn, Vale of Rheidol, Ravenglass and Eskdale, and the Romney, Hythe and Dymchurch would provide suitable prototypes.

Let’s have a change from 4 ft 8½ in. Ashford, Kent. C. E. CARTER.

VIRGINIA . . .

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could haul a living load and keep on doing it; but it has been proved.

Some years ago when the miniature motor-racing fraternity were clocking “full-size” speeds a correspondent told me that for the sake of curiosity he had tried a 3½ in. gauge locomotive on a test stand with the flywheel removed from the axle of the friction wheel. This put the engine on the same footing as the little racing cars, which of course always run “light”; they never haul a load. With 80 lb. boiler pressure, full regulator and 25 per cent. cut-off, the driving wheels spun at a rate that would have knocked up 86 m.p.h. had the engine been on the rails.

I don’t know what the maximum speed of a 3½ in. gauge locomotive would be on a straight line, as I don’t build them for the purpose of testing to destruction, but an engine built to my design, running on a continuous track and hauling its owner, attained a speed of just over 100 m.p.h. over the road at the entrance to a curve and crushed clean through a featherboard fence. All the damage it sustained was a distorted smokebox front and a bent corner of the buffer-beam. The owner was not so fortunate, as he got a lacerated arm and a dislocated shoulder.

So, for the present, “Goodbye, Virginia,” as the song said; I’ll bear in mind the request for a few hints on a larger version but I would remind those interested that blueprints can be obtained for Walt Disney’s Lilly Belle, a 7½ in. gauge locomotive of the same type, which was illustrated and described in this journal some time ago.

However, she differs in many respects from your humble servant’s practice, though she could easily be modified to conform with it.