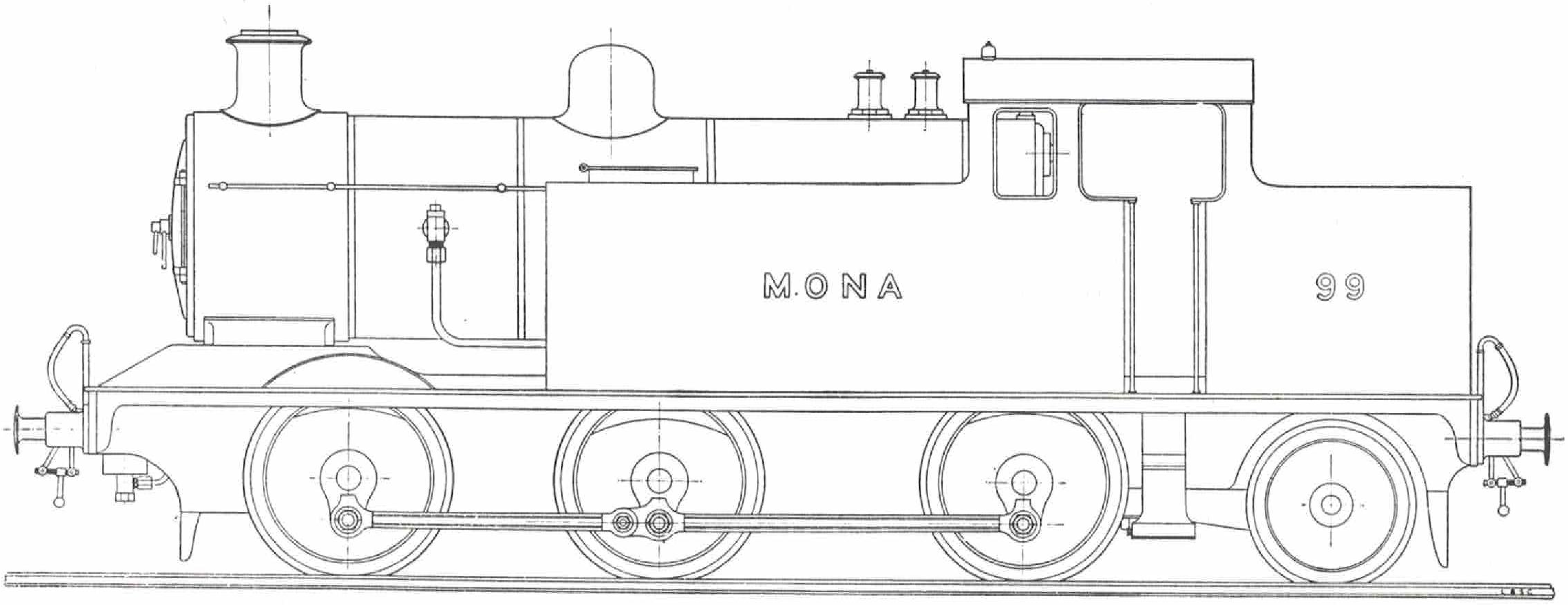
MONA
A SIMPLE 0-6-2 TANK ENGINE

by L.B.S.C.

A Simple 0-6-2 inside cylinder tank engine based on a London, Chatham & Dover Rly locomotive in 3½ in & 1¾ in gauges from a series which appeared in Model Maker



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HAIL, readers — the gang's all here — L.B.S.C. otherwise Curly; Inspector Meticulous, Milly Amp, Bert Smiff, and the rest. At the invitation of our worthy Knight of the Blue Pencil, I'm going to try and tell you how locomotives can be built the *easy* way; not as an animated textbook, but as an ordinary human being. Anybody should be able to understand the drawings at a glance; and even if a prospective builder doesn't know how the piston is pushed up and down the cylinder—or doesn't even know what a cylinder is—he has only to follow the "words and music" faithfully, to produce an engine that will steam, pull, and go. Thousands have already done it—thousands more can do it—including yourselves!

Our friend mentioned above suggested a simple job as a kick-off, so I thought an inside-cylinder tank engine would fill the bill. The 3½-in. job will be a very powerful coal-fired passenger-hauler; the 1¾-in. edition would do fine for "scenic" railways, able to make a long, non-stop run with a ten-coach suburban train. On an outdoor line, it would pull a kiddy easily. The frames are practically all straight lines, easy to cut out. There is only one cylinder casting to machine up in the larger engine, and only one cylinder in the smaller. There will be a choice of valve gears, both exceedingly simple, but fully efficient. The larger boiler will be coal-fired; the smaller, spirit or oil, as desired. As half my ancestry hailed from north o' the borderrrr, ye ken, it is only natural that I shall make every effort to keep down the cost. Anyway, a tank engine is the cheaper job.

As there are 0-6-2 tank engines running on all regions of British Railways, builders may, if they fancy, fit whatever kind of boiler mountings, cab, tanks, and so on, to suit their pet idea; the working parts remaining the same. When I was a small child I frequently travelled on the long-defunct Nunhead-Greenwich branch of what was the London, Chatham and Dover railway; and the train of five little four-wheelers was usually hauled by a little 0-4-2 radial tank engine, 99 *Mona*. The train was nicknamed the "Greenwich Galloper," and I just loved the engine, so I'm keeping her memory green with a very much modernised version. Well, so much for that; now let's get cracking.

Frame Assembly, 3½-in. gauge

Two pieces of soft mild steel will be needed, 25 in. long, 3 in. wide, and ⅛ in thick. If bright steel is supplied, coat one piece with marking-out fluid made by dissolving some shellac in methylated spirit, and adding some blue or violet aniline dye to colour it. This dries in a minute or so, and scriber scratches stand out on it like the lines at Watford Junction in sunshine. If blue steel is used, it can be marked with a "Hardwhite" pencil. These pencils (Cumberland Pencil Co.) can be obtained at most stationery shops, and are the cat's whiskers for marking on iron and steel—the tip may be useful. On the one piece mark out very carefully the outline of frames as shown in drawing. Builders who would like to braze the frames to the buffer-beams, need not mark out the four holes shown at each end. Now be mighty careful to mark out the cylinder screwholes correctly. You'll see that I have dimensioned the position of the end holes in the top row. Dot these with a centre-punch, draw a line between them, and dot the other two on that, ½ in. apart. Next, set out the centre-line of motion; this rises at 5½ deg. from the centre of driving axle, but you don't have to bother about a protractor. In the middle of the opening for the driving hornblock, at ⅝ in. from the bottom, make a dot. At 13/16 in. below any of the four screwholes already dotted, make another. Draw a line right through the two, and there is your centre-line of motion. The other four cylinder screwholes are set out at right angles to this line,

$\frac{1}{2}$ in. below the first four.

The three screwholes for the motion plate are set out from this line, as shown, at right angles to it. Locate the U-shaped gap above the driving hornblock opening, by making a dot 3/16 in. behind centre-line of it, and $\frac{1}{4}$ in. below top of frame line. The three holes behind the opening are for frame-stay screws, and the three ahead of the semi-circular opening at rear end of frames, are for pony-bolster screws.

Drill one of the marked holes at each end of frame with No. 30 or $\frac{1}{8}$-in. drill; put the unmarked plate under it, drill through this, using the holes in the marked one as guide, and temporarily rivet the plates together, using $\frac{1}{8}$-in. rivets. Then saw and file them to outline. I use a hacksaw blade with 18 or 22 teeth per inch for this, wetting it with cutting oil diluted with paraffin and applied with a brush. Soapy water can also be used. To get straight lines, use the vice top as a guide, holding the steel in the bench vice with marked line just showing above jaws; put the hack-saw blade sideways in frame, and keep it pressed down on the jaws while cutting. Saw along the sides of each hornblock opening; drill a row of 3/32-in. or No. 40 holes along the top, almost touching, break out the piece with pliers, like a molar engineer pulling a tooth out, and file the ragged edges smooth. Cut the big opening at the back, by sawing as close to the marked line as the hacksaw blade will allow, and finishing with a half-round file. All the holes are drilled with a No. 30 drill, and the ringed ones countersunk with a 7/32-in. drill. The U-shaped opening is formed by drilling out the dot with a $\frac{3}{8}$-in. drill, and then sawing down to it at each side from the top of frame, finishing with file. Part the frames by knocking out the temporary rivets, and smooth off any burring left by the drill. The countersinks tell you which is the outside.

Buffer Beams

The buffer beams may be cast, in which case they will have the lugs for attaching the frame, cast on. Angle steel, or brass, may be used, either bright or black; two pieces long enough to finish to $6\frac{1}{2}$-in. length will be needed. The top will be 1 in. wide, and the face $1\frac{1}{8}$ in. deep; if not available, get the nearest size larger, and saw or mill away the surplus. Saw away $\frac{1}{2}$ in. of the top at each end. The frame slots can be milled in the lathe, by mounting a $\frac{1}{8}$-in. saw-type cutter on an old bolt, or between two nuts on a bit of round steel screwed to suit them. Hold this in the three-jaw chuck, or mount it between centres. Grip the beam under the slide-rest tool-holder, with the position of slot level with the cutter, and feed straight in with the cross-slide, applying some cutting oil with a brush, if the material is steel. Cast beams can be slotted in similar manner, the cutter trueing up the attachment side of the lug at the same operation. Slots may be hand-cut by up-ending the beam in the bench vice with the marked slot level with jaws, sawing along with a hacksaw, using vice top as guide, and finishing with a key-cutter's thin warding file. Frames should be a tight fit in the slots.

For angle fixing, drill holes in face of beam as shown, and rivet a $\frac{7}{8}$-in. length of $\frac{3}{4}$-in. x $\frac{1}{8}$-in. angle flush with the inner side of each slot. What I do myself is to jam a bit of $\frac{1}{8}$-in. frame steel in the slot, butt the piece of angle tight up against it, hold it there with a toolmaker's cramp, then drill the rivet holes through the angle, using those in the beam as guide. Put iron rivets in, hammer the shanks into the countersinks, file flush, and Bob's your uncle. No angles are needed for brazed frames.

Hornblocks

Use the hotpressed type of hornblock—they need no machining. Drill seven holes in the web of each. as shown, using No. 41 drill. Fit them to the openings in the frame, on the inside, which is the side without any countersinks. Clamp in place with toolmaker's cramp, drill frame, using holes in hornblocks as guide, countersink, on outside of frame, put in 3/32-in. iron rivets, hammer into countersinks, and file flush outside frame. Iron rivets don't come loose as easily as copper or brass. Now temporarily bolt the frames back to back, or inside out, as the kids would say, through any of the vacant screwholes. With a big, flat, smooth file, ease out the hornblock jaws until a piece of $\frac{7}{8}$-in. square bar will slide between them nicely, without any shake.

Frame Erection

Jam the ends of the frames into the slots in the beams. Set the assembly on the lathe bed, and adjust until the bottom edges of both frames touch the bed full length. Then set the beams dead level, same height from the lathe bed at each end, and set them square with the frames by applying a try-square to the ends. When O.K. put a tool-maker's cramp over one of the angles and the frame. Run the No. 30 drill through holes in frame, making countersinks on the angle. Follow through with No. 40, tap $\frac{1}{8}$ in. or 5 B.A., and put screws in. Ditto repeato on the other three angles, and your frame assembly should be about perfect.

To erect by brazing, jam frames into slots in beams as before, and set level on lathe bed. Now, steel takes an unholy delight in distorting under heat. To teach it good manners, I get two pieces of iron steam- or gas-barrel, $1\frac{1}{2}$ in. or 2 in. diameter, about 3 in. long, and face the ends off in the lathe, holding in three-jaw chuck, until they are exactly $2\frac{7}{8}$ in. long. One of these is placed at each end of frame, opposite a hornblock, or any other place where you can get a bolt through. Then a $\frac{3}{8}$-in bolt is put through, with a big washer outside frame each side, between frame and bolt head or nut. The frames are thus clamped tightly to the bits of barrel, which act as spacers. Stand the frame, end up, in a pan of coke or blacksmith's breeze (small coke), propping it up against a fire-brick, or anything else available. Anoint the joints between frame and beam with some Boron compo (sold in tins at ironmongers, or from our advertisers) or powdered borax, mixed to a paste with water. Heat evenly to bright red, with a blowpipe or blowlamp; then touch each joint with a bit of soft brass wire, about 16-gauge. If the heat is right, this will melt and flow into the joint. If it doesn't, then you need a few more therms: practice soon makes perfect. Let cool to black, then repeat process at other end. Quench in water, knock off any burnt flux, and clean up. Try again for truth on lathe bed. If the spacers were properly clamped, the frame should still be true; but if any slight distortion has taken place, judicious use of a hammer should put it right.

I use an oxyacetylene blowpipe, and Sifbronze, for frame assembly, and the job is easier than mending a leak in a kettle. The whole beam doesn't need heating: the little, intensely hot flame just heats the joint, there is no distortion, and precious little cleaning up is needed.

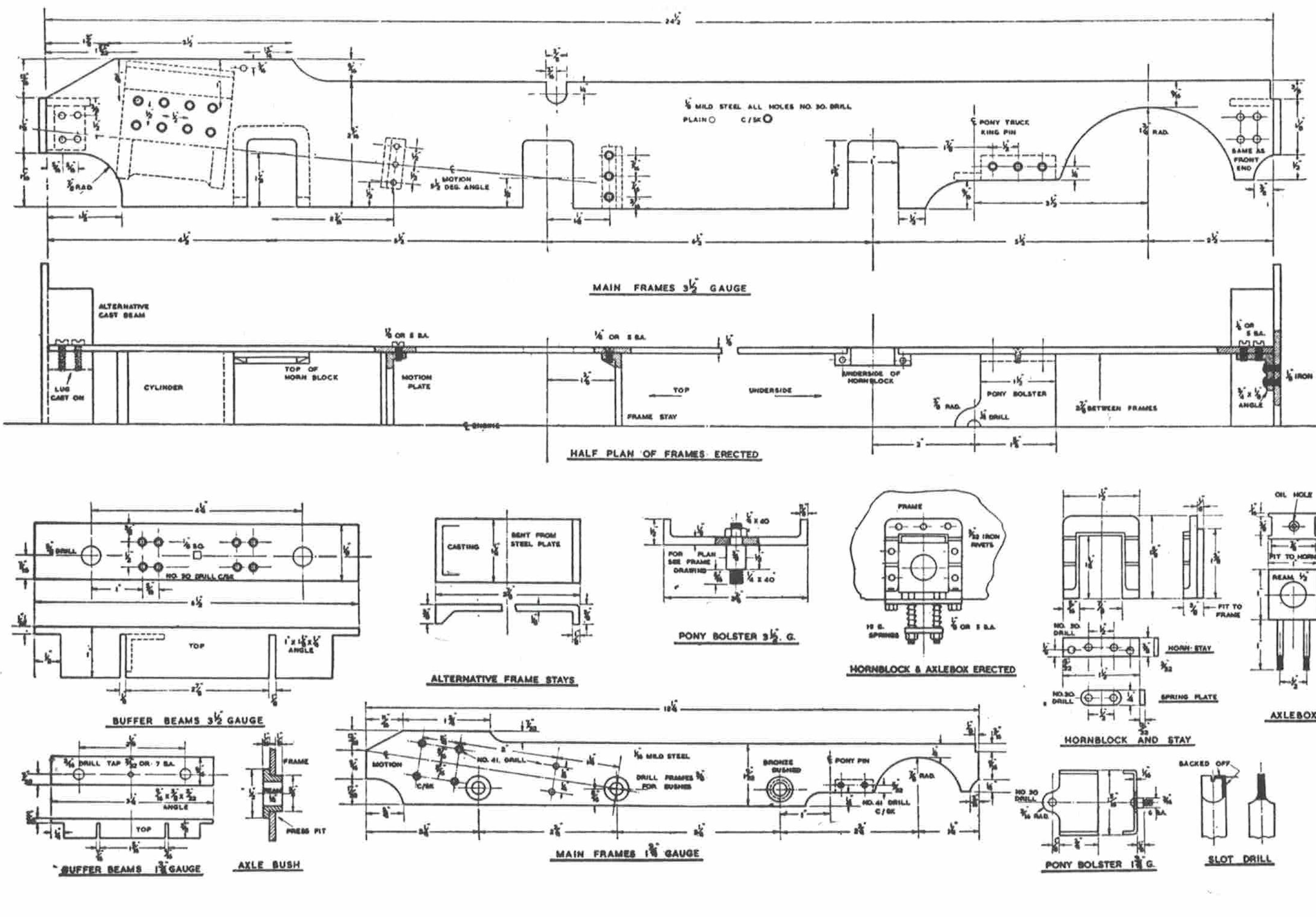
Assembly for $1\frac{3}{4}$ in. gauge engine

The frame assembly for the little engine is done in exactly the same way, as far as cutting-out and erecting is concerned, but there are no hornblocks to fit, as the axles run in bushes. Use 16-gauge soft mild steel, mark off and cut to outline shown, and drill a $\frac{3}{8}$-in. hole at the location of each axle. Cast beams can be used, slotted 1/16-in. for frame ends, which are secured by two 3/32-in. screws in each. If steel or brass angle beams are preferred, silversolder the frames into the slots, using the brazing technique described above, but using a coarse-grade silversolder in place of the brass wire.

The bushes for axles are fitted after assembly. Chuck a bit of $\frac{1}{2}$-in. bronze or gunmetal rod in three-jaw; face the end, centre with a size E centre-drill held in tailstock chuck, and drill to $\frac{1}{4}$ in. depth with 15/64-in. drill. Turn $\frac{1}{8}$ in. of the outside to $\frac{3}{8}$-in. diameter, a very tight fit in the hole in frame. Part off a full 3/16 in. from the end. Reverse in chuck, and take a skim off the flange, to true it up. Squeeze the bushes into holes in frame with flanges outside, then poke a $\frac{1}{4}$-in. parallel reamer through each pair, which will ensure that the axles will work freely. Warning to beginners—don't use the material sold as brass rod by most metal merchants for bushes, as this is a special alloy used for making screws, and known in the trade as "screw-rod." It takes a lovely thread, but its wearing properties are poor, and bearings from it wouldn't last the proverbial five minutes.

Frame Stay and Pony Bolster.

On the $3\frac{1}{2}$ in. gauge engine, a frame stay is fitted behind the driving axle. This can be a casting, or it may be bent up from $\frac{1}{8}$ in. steel plate. The casting can be machined in the lathe, by clamping it under the slide - rest tool - holder, with the side to be machined, set at right angles to the lathe bed. This can be done, without measurement, by putting on the faceplate, running the rest up to it with the casting on it, holding a try-square with its stock against the face-plate, and adjusting the casting until the longer edge of it touches the blade of the square full length. Tighten the tool clamp, put a $\frac{1}{2}$ in. endmill or slot drill (easily home-made—I make all mine) in the three-jaw, and traverse the casting across it by turning the cross-slide handle, feeding into cut with the top-slide handle. Reverse casting end-for-end, to machine the other side.



To make a slot-drill, file or grind the faced-off end of a short piece of ½ in. silver-steel, to a screwdriver-edge about 3/32 in. wide. File a 1/16 in. nick in the middle, back off the edges in opposite directions at each side of the nick, and back off each side for about ½ in. below the edge. Harden and temper to dark yellow; first make the end redhot and plunge into water. Then rub the cutting part on an oilstone or a piece of fine emerycloth. Put it on a piece of iron, or sheet steel, and hold over a gas flame, such as the small burner of the domestic gas cooker. As soon as the bright part turns to dark yellow, tip the lot into cold water.

The sides of a casting could also be carefully filed to fit between the frames, but test with a try-square, as both sides must be parallel, and square with the top and bottom; the vice top forms an excellent filing guide.

To erect, place the stay in position shown in frame drawings, and hold it there with a big cramp over the outside of frames. Run a No. 30 drill through the holes in frame, making countersinks on the side flange of stay; follow through with No. 40, tap ⅛ in. or 5 B.A., and put countersunk screws in.

A steel frame-stay can be made by hammering over each end of a 3¾ in. length of 1¼ in. x ⅛ in. mild steel gripped in the bench vice with sufficient to form the flange, standing above the jaws. File off any hammer marks, and fit to frames as above. The 1¾ in. gauge engine doesn't need a frame stay.

The sides of a cast pony bolster can be machined in the same way as the frame stay. Drill a ¼-in. hole through the tongue, as shown in the plan. For the pin, chuck a piece of ⅜ in. round mild steel, face the end, and turn down ¾-in. length to ¼-in. diameter, screwing ¼ in. x 40 nearly to the shoulder, with a die in tailstock holder. Part off at 13/16 in. from shoulder, reverse in chuck, turn down 5/16 in. of the other end to ¼ in. diameter, and screw ¼ in. x 40. Put the longer end through hole in bolster, and fix with a nut. To make this, chuck a piece of ⅜ in. hexagon rod in three-jaw; face off, centre, drill 7/32 in. for ¼ in. depth, chamfer off the corners of the hexagon, and part off about 3/16 in. from the end. Rechuck to run truly, and put a ¼ in. x 40 tap through. It's far easier to tap a thoroughfare hole than a blind alley! The complete bolster can then be erected in the position shown in drawings, in the same way as the frame stay, with three ⅛ in. or 5 B.A. countersunk screws each side.

The pony bolster for the little engine is bent up from 1/16 in. sheet steel, to dimensions given in the drawing. The pin is turned from 3/16 in. steel, and is riveted in place in the bolster. Tip — when hammering over the stem to form the rivet-head, put a nut on the threads, to prevent damage or burring. Fix with two 3/32 in. or 7 B.A. screws at each side.

Axleboxes.

The axleboxes can be made from cast stick bronze, or drawn bronze or gunmetal bar of ½ in. x 1 in. section. If a milling-machine is available, a piece of 7 in. long can be gripped in a machine-vice on the table, and the groove formed with a ⅜ in. side-and-face cutter on the arbor. To do it in the lathe, saw the bar in two. Clamp each piece, either under the slide-rest tool-holder, or in a machine-vice attached to a vertical slide, at right-angles to lathe bed, and at centre-height; then traverse across a ⅜ in. end-mill or slot-drill held in three-jaw. The grooves should just be deep enough to allow the box to slide freely in the hornblock jaws without shake, and I use a spare hornblock for a gauge. After the grooves are milled out, saw off the boxes to full length, then face off to dead length by holding them in the four-jaw chuck, and using a roundnose tool set crosswise in the rest.

Fit each box to a hornblock, and number them both, so that they can always be replaced correctly after being taken out. Mark one side 1, 3 and 5, and the other, 2, 4 and 6. Now it is very important indeed, that the boxes are drilled about right for the axles, as these MUST go dead square across the frame. Make a heavy centre-pop dead in the middle of boxes 1, 3 and 5, and put a No. 30 drill through them, either on a drilling machine, or in the lathe; hold the drill in the chuck, and hold the boxes against a drilling-pad in the tailstock. File off any burring, then clamp box 1 to box 2, and put the drill through box 2, using the hole in box 1 as guide. Repeat process with boxes 3 and 4, and 5 and 6. Now put all the boxes in the frame, with bits of ⅛ in. silver - steel (which is usually quite straight) through the holes; and you'll soon see if they go across the frames dead square. If O.K. clamp each pair of boxes together again, and open the holes with 31/64 in. drill. If not, correct the offending hole with a rat-tail file before opening out.

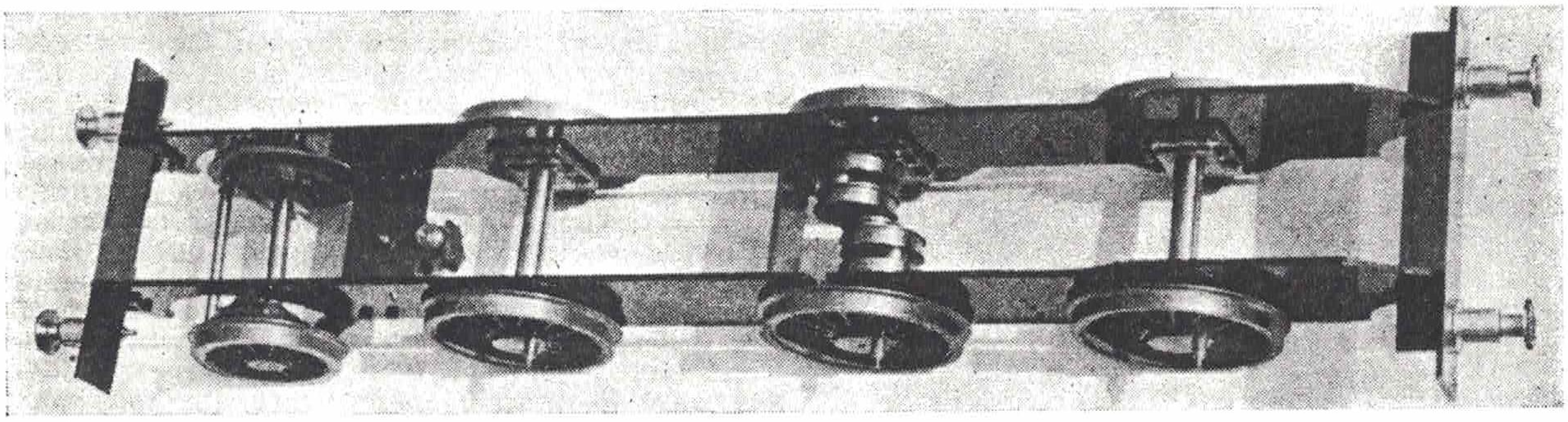
Hornstays and Spring Pins.

The hornstays are merely 1½ in. lengths of ⅜ in. x 3/32 in. mild steel, drilled as shown. Smooth off the hornblock feet, flush with bottom of frame; put a hornstay in place, hold with a cramp, and make countersinks on the feet, through the holes in stay, with No. 30 drill, following through with No. 40 drill and tapping ⅛ in. or 5 B.A. Cheesehead or roundthead screws can be used, if desired, in place of those shown. The spring plates are made similarly, from ¼ in. x 3/32 in. steel. The spring pins are 1¼ in. lengths of ⅛ in. silver-steel, with a few ⅛ in. or 5 B.A. threads on each end; hold in chuck, and screw with die in tailstock holder.

Jam each axlebox tight up against the hornstay with a wood wedge at the other end. Poke the point of a No. 30 drill through the centre holes, and make countersinks on the axlebox. Follow with No. 40 drill, and tap to suit thread on spring pins; then screw in the pins. This makes absolutely certain that the boxes have free up-and-down movement. The springs are wound up from 19-gauge tinned steel wire. Put a piece of ⅛ in. silver-steel in three-jaw. Bend the end of a length of spring wire at right-angles, and put it between the chuck jaws. Hold wire tightly with right hand, pull lathe belt with left, and carefully wind on about three even coils. Then, if you press your thumb tightly on the coils, and pull the belt slowly, the rest of the wire will wind on easily, and evenly, your thumb acting like a guide nut. It doesn't hurt! Wind enough for a dozen ¾ in. lengths. After cutting off, touch each end of each spring on a fast-running emery wheel, to square off. Assemble as shown, using ordinary commercial nuts below each spring plate; drill the oil holes before assembling.

The axleboxes must be temporarily fixed in running position before fitting wheels and axles, so put a short bit of ⅛ in. square brass or steel between the axlebox and hornstay, and tighten up the spring-plate nuts sufficiently to hold it there. This will locate the boxes correctly; then finally put a ½ in. parallel reamer through each pair of boxes, by hand, using a tapwrench clamped on the reamer shank to turn it.

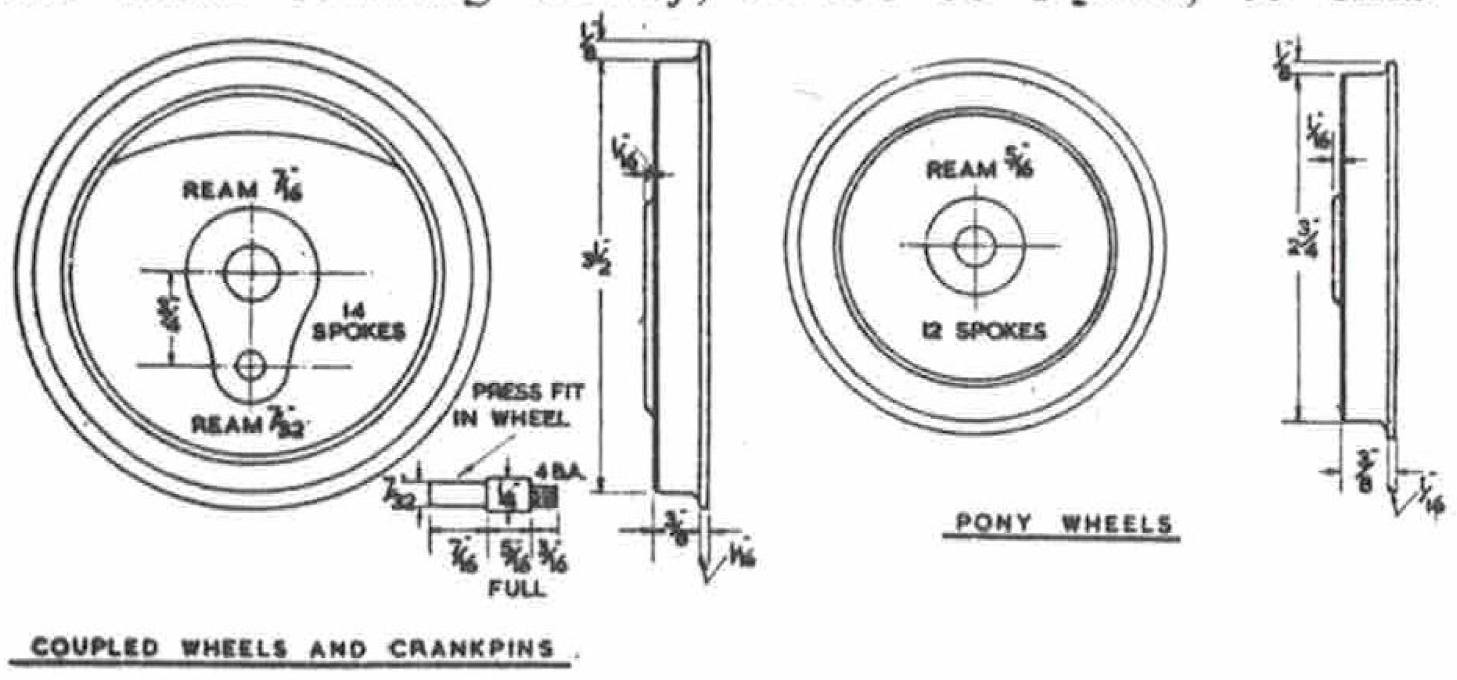
Heading picture **A looking down shot of progress to date on Curly's own version of "Mona"**



THE next job is to turn the wheels. Now, some good folk make a lot of unnecessary fuss about this, insisting that as the coupled wheels must all be the same size, and same contour, the use of profile tools, gauges, and so on are called for. Nothing of the sort; just follow the simple instructions given here, and you can't go wrong. Although the general arrangement drawing shows different-sized balance-weights in the driving and coupled wheels, this isn't essential; in fact, on my own engine, I have used up some castings that I've had in stock since goodness-knows-when, and the balance-weights are all same size. Take a quiz at the photos for confirmation! No spoke-cleaning should be needed; I've never had to file a spoke on a Reevesco wheel yet, and hope I never shall.

Chuck a casting in the three-jaw, back outwards, and set it to run as truly as possible, with the flange just clear of the chuck jaws. Use either a tool with a rather pointed round nose set over to an angle of 45 deg., or a straight tool with a similar snout set over to that angle under the slide-rest tool-holder. Take a cut over the wheel boss, just enough to true it up. With a centre drill, size E or a little larger, held in tailstock chuck, make a deep centre in the boss, then drill it right through with 27/64-in. drill. If your lathe is small, or in bad shape, it would help if you put a smaller drill through first, say about 3/16 in. Next, grip the shank of a 7/16-in. parallel reamer in a tailstock chuck, and put it through the hole in the boss by sliding the tailstock bodily along the lathe bed, only stopping to reverse and pull it out.

Now take a cut right across back and boss, with the lathe running slowly, about 60 r.p.m., to shift all the skin off the casting; after which, take a light finishing cut. Turn just enough off the flange to true it up, and note the position of the cross-slide handle, or reading of "mike" collar. Ditto-repeato operations on the rest of the wheel castings, turning the flanges to same setting. Next, chuck the wheels the other way about, gripping by the trued-up flange. Face off the bosses to $\frac{1}{2}$-in. thickness, as measured by a depth gauge; my first depth gauge was one of mum's hatpins, stuck through a tram ticket. This can be done at a fair speed. Then face the rims until they are 1/16-in. below the bosses, still using the same tool, and running slowly. If you note position of topslide handle when doing the first one, and do the rest with the handle in same position on finishing cut, no further measurements will be needed. Then put a parting-tool crosswise in the rest, and turn a rebate (like a little ledge) in each wheel at the point where the spokes join the rim. This represents the joint between wheel-centre and tyre in full-size. The parting-tool will cut a complete groove in the balance-weight: this is quite O.K.

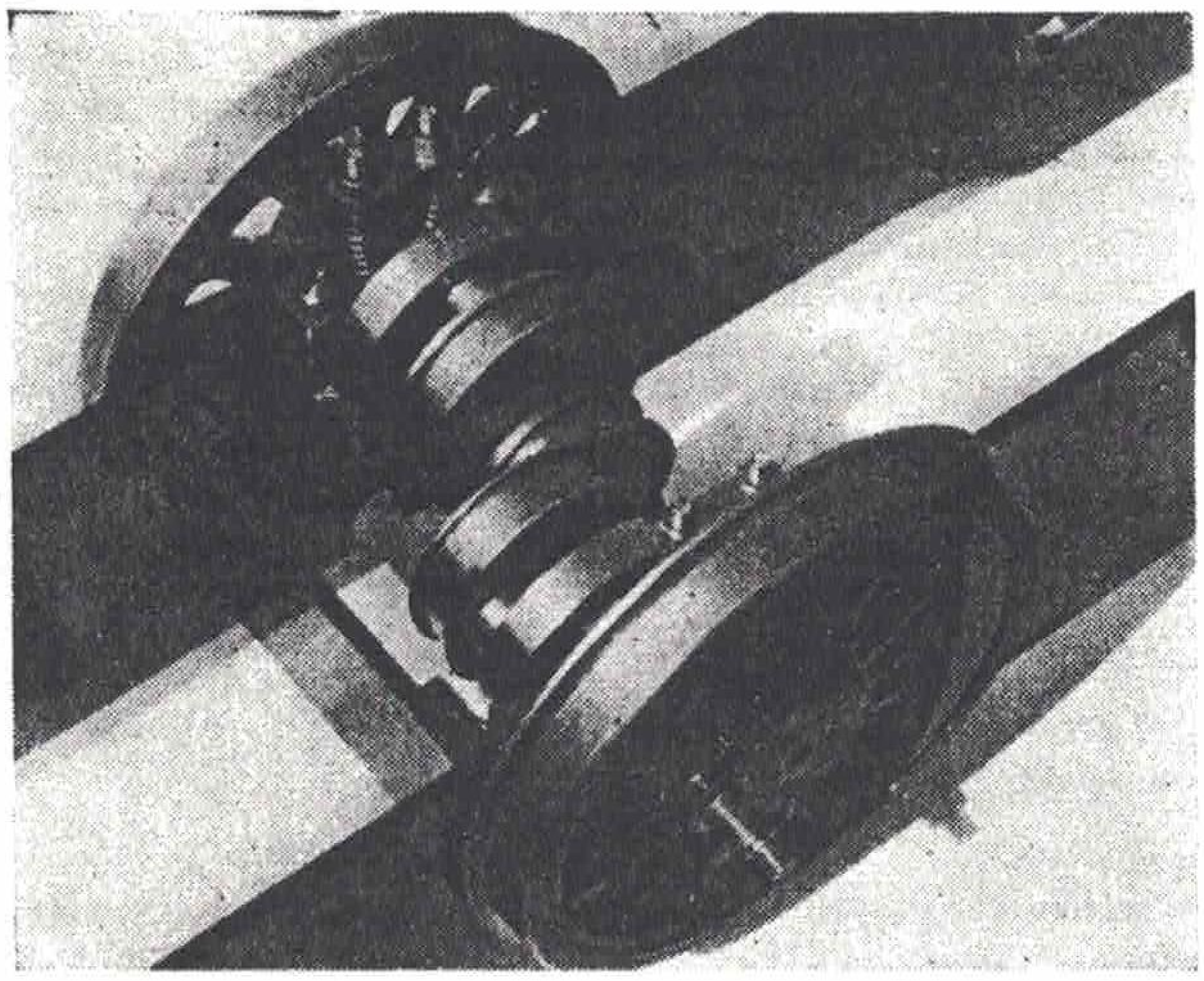


COUPLED WHEELS AND CRANKPINS

PONY WHEELS

Now chuck a spare casting, disc of metal, or anything else handy and a little less than $3\frac{1}{4}$ in. diameter, in the three-jaw. Face it truly, and turn a recess about 1/32 in. deep, about an inch across, in the middle. Centre it, drill 15/32 in. and tap it $\frac{1}{2}$ in. any fine thread. Screw in a stub of $\frac{1}{2}$-in. steel rod, leaving 1 in. standing out. Turn this to a nice sliding fit in the 7/16-in. holes in the wheel bosses. Turn down $\frac{1}{2}$ in. of the end to $\frac{3}{8}$-in. diameter, screw it $\frac{3}{8}$ in. x 26 or 32, and make a nut to suit. Put a wheel on the stub, face outwards, and fix with the nut, putting a steel washer between nut and wheel boss. Don't tighten up the nut too much, just enough to prevent the wheel slipping.

With an ordinary roundnose tool in the slide-rest, turn the tread of the wheel to within 1/64 in. of finished size, also the flange, which should be well rounded at the root; use the slow speed. Note the position of the handles again, then turn the rest of the castings to the same dimensions. When the last one has been done, don't remove it from the stub, but give the tool a touch-up with an oil-stone slip while it is still in the rest. Then



Again, Curly's own "Mona" poses for a close up. Note clean wheel spokes as advised!

turn the wheel tread to the finished size, leaving it parallel. I have found, by experiment, that a parallel tread runs far easier on sharp curves than a coned tread, on any engine with more than four wheels. The flange can be rounded off by applying a fine file to it as it spins around at a good speed, and the sharp edge of the tread can be slightly bevelled with a dose of the same medicine. Note the position of the cross-slide handle, or the reading of the "mike" collar, before removing the wheel; then go ahead and serve the other five in the same way, and they will all be exactly the same diameter, if the finishing cut is taken with the cross-slide handle at same setting.

The wheels for the pony truck are turned in exactly the same way, using a smaller plate to mount them on for finishing treads; ditto the wheels for **Mona's** wee $1\frac{3}{4}$-in. gauge sister.

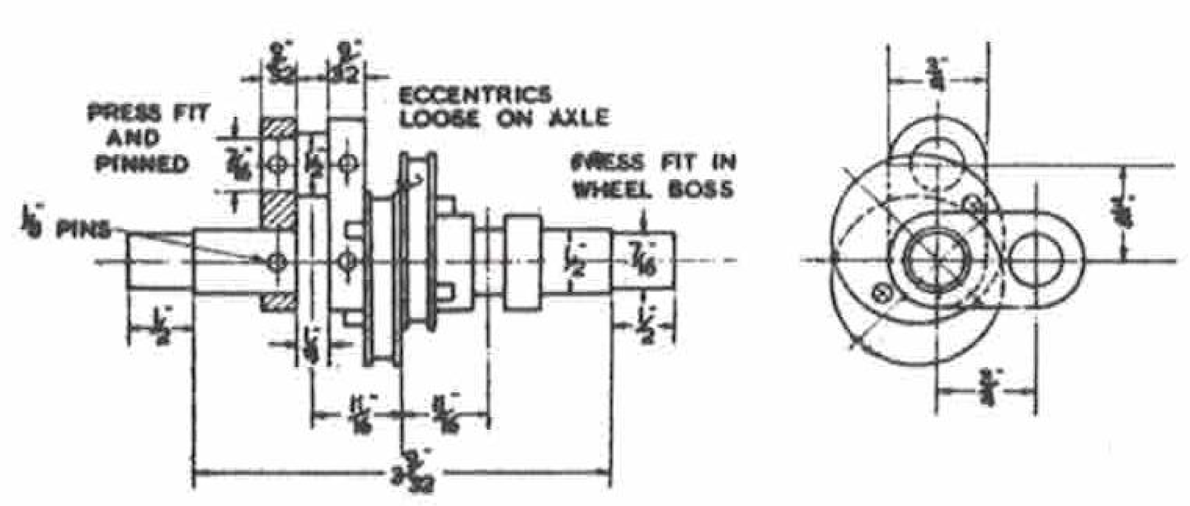
Crankpins

The holes for the crankpins must all be exactly the same distance from the axle holes, otherwise the coupling-rods will bind. Another easy job, and no jig needed. Note: although the distance is shown as $\frac{3}{4}$-in. on the drawing, it may be less, **as long as all six are exactly the same.** They are less on my own engine, owing to the fact that I used old stock castings with smaller bosses than shown. They are often less in full-size practice, on engines with inside cylinders, as the less distance the big coupling-rods are flung around when running fast, the steadier the engine will run.

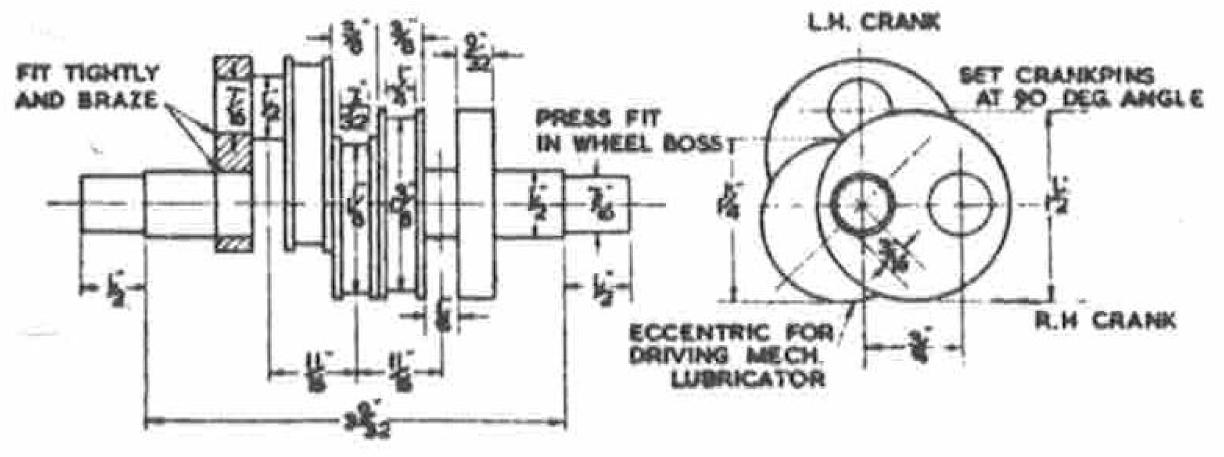
Mark off the position of the crankpin hole on one of the wheels, centrepop heavily, and drill with No. 6 or 13/64-in. drill, using either a drilling-machine or lathe; **not** by hand, as the drill **must** go through dead square with the boss. If the lathe is used, put the drill in the three-jaw, and use a drilling-pad on the tailstock-barrel, with a hole in the middle, so that the drill can run clean through the wheel boss when same is held tightly against the pad. To drill all the rest exactly the same, put the drilled wheel on top of an undrilled one, with a bit of 7/16-in. rod through the axle-holes, to line them up. Set both the bosses in line, then poke the drill down the hole in the upper boss, and drill through the one underneath it. The holes can't help being exactly the same, if the rest are treated in the same way.

The crankpins are turned from $\frac{1}{4}$-in. silver-steel. Now, this material has a lovely surface which resists wear to a wonderful extent, so we must keep it intact. If you have a dead-true chuck, or collets. the rod can be gripped direct, and one end turned down to 7/32-in. diameter for 7/16-in. length. This must be a press fit in the hole in the wheel boss, but not tight enough to split the boss when it is squeezed home. Beginners are often scared stiff of turning press fits: well, it's just a piece of cake when done thus. First put a 7/32-in parallel reamer through all the holes in the wheel bosses, using drilling-machine or lathe, as when drilling. Then take a tiny scrape out of the end, for about $\frac{1}{8}$ in. down, with a taper broach: I keep one stuck in a file handle, specially for this purpose. If the end of the silver-steel is turned so that it will just start in the broached part of the hole very tightly, it will be the exact size for a press fit in the reamed part of the hole. Simple enough, surely!

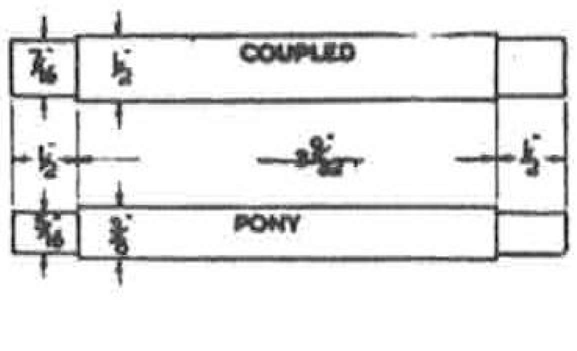
After turning the spigot, part off at $\frac{1}{2}$ in. from shoulder; reverse in chuck, gripping by spigot, turn down a bare 3/16 in. of the other end to 9/64-in. diameter, and screw 4 B.A. If your chuck isn't related to Mrs. Caesar of old, the rod can be held in a split bush, to get the necessary concentricity (good word that!) between spigot and rod. Chuck a short bit of $\frac{1}{2}$-in. brass rod in the Ananias, face the end, centre, drill through with 15/64-in. or letter C drill, and put a $\frac{1}{4}$-in. parallel reamer through. Make a mark opposite No. 1 jaw, on the reamed bush, remove from chuck, slit it down one side with a hack-saw, and replace with the mark against No. 1 jaw. Grip it fairly tightly and then poke the reamer through again. When the chuck jaws are released, the silver-steel will slide into the bush, and when the chuck is tightened again, the steel will be held dead true.



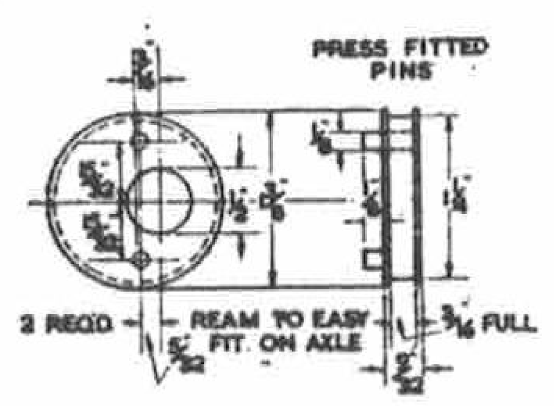
CRANK AXLE FOR LOOSE ECCENTRIC VALVE GEAR



CRANK AXLE FOR RADIAL VALVE GEAR



CARRYING AXLES



LOOSE ECCENTRIC

Put a brass nut on the threads of each crankpin before pressing into the wheel boss, to protect the threads from damage. The bench vice makes a nobby squeezer, but if the steel insets in the jaws are rough, put a piece of sheet copper or brass between the inset and the wheel before pressing, to prevent the wheel being defaced. Same instructions apply to the baby, working to dimensions given.

Crank Axle

As there is a choice of two valve gears, there is a variation in the crank axles, the one for radial gear having circular webs, two of which also act as eccentric sheaves, and the other, for loose eccentric gear, having ordinary webs and carrying separate eccentrics. Nothing to be scared of in either! I'm using the first-mentioned, as you'll see from the photos. To make it, a piece of 1½-in. round mild steel is needed: an offcut of shafting does fine, and should be about 2 in. long. Chuck in three-jaw, face the end, and with a parting-tool set dead square with it, turn a groove ¼ in. wide and 1/16 in. deep, at 1/16 in. from the end. Part off at a good 1/16 in. from the groove. Repeat operation, then part off two plain slices a full 9/32 in. wide. If a slow speed is used, and plenty of cutting oil (I use a 50/50 mixture of "Cutmax" and paraffin), the cuttings come off in a tight coil like a watch-spring, with a sound just like bacon frying, though the smell isn't as appetising. Most inexperienced lathe users part off at too high a speed, and get chatter-marks, but practice makes perfect. Rechuck each piece with the parted-off side outwards, and face off smooth, to dead length.

On one of the pieces, scribe a line right across the toolmark indicating the true centre: you'll see it plainly enough! At each side of the centre, and ⅜ in. away from it, make a deep centrepop, and drill through each with No. 30 drill, using drilling-machine or lathe, as the holes must go through dead square. Use this as a jig to drill the other three, making quite sure that the pieces are clamped together truly before putting the drill through. Then open out one hole in each, with 27/64-in. drill, and ream 7/16 in. The other hole is drilled 31/64 in., but don't ream it yet.

An eccentric for driving the mechanical lubricator goes between the cranks. Chuck a piece of 1¼-in. round steel, and face the end. At a bare 3/32 in. from the end, form a groove 1/16 in. deep and 7/32 in. wide, with a parting-tool as before. Part off at 3/32 in. from the groove, then rechuck and face off until the piece is ⅜ in. wide, with the groove in the middle. At 3/16 in. from the toolmark indicating the true centre, drill a No. 30 hole, open out to 31/64 in. and ream ½ in.

If the three-jaw chuck is reasonably true, the crankpins and axles can be turned from ½-in. round mild steel held direct in it. If not, make a split bush as described above, from a bit of ¾ in. round rod. Chuck the ½-in. rod, face the end, and turn down ⅜-in. length to a press fit in the 7/16.-in. hole in the crank web. Part off at 17/32 in. from the shoulder, reverse in chuck, and turn down 9/32 in, of the other end to a press fit likewise. Repeat operation, then squeeze the ⅜-in. end into the reamed hole in the grooved web. The shorter end is squeezed into a plain web. To make certain they line up truly, turn a stub of steel rod to a tight push fit in the larger holes in the webs, and push it through the two webs while the pin is being squeezed home. The holes in the webs may be slightly countersunk. Remove the guide stub. then put a ½-in. parallel reamer through both larger holes in the webs; and if they aren't dead in line after all that, it won't be any fault of mine!

Now turn the axles. All three can be made while on the job, as the leading and trailing axles are same size and diameter. Each requires a piece of ½-in. round mild steel 4-5/16-in. long. Chuck in three-jaw, or split bush, face off and turn ½-in. length to a press fit in the wheel boss. Builders ought to be dab hands at press-fit turning after doing the small crankpin spigots and the ends of the main pins: the process is the same whatever the size. Reverse in chuck and serve the other end likewise, taking care that the distance between shoulders is exactly 3-9/32 in. as shown, and the wheel seats ½ in. long. The pony axle can be turned at the same time if you like, from ⅜-in. round steel, wheel seats and distance between shoulders being exactly the same as the coupled axles.

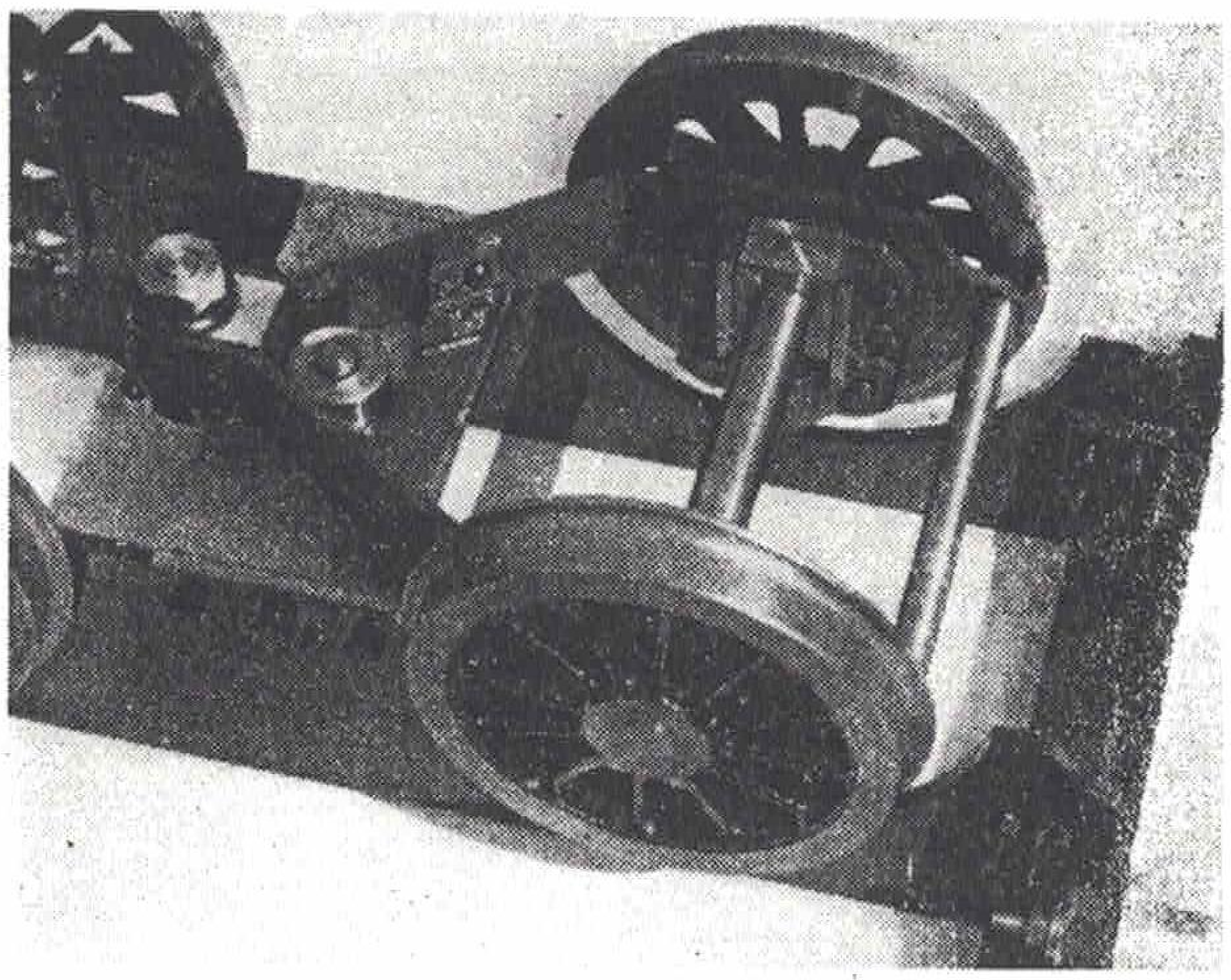
Now comes the bit where you must watch your step if a beginner. Push the pump eccentric on to one of the axles and set it exactly in the middle. Push on a crank assembly each side of it, with the grooved webs next to the pump eccentric, and set the cranks at right angles, or 90 deg. That's easy, too. I have a little pair of V-blocks which I stand on a surface-plate, resting the ends of the axle in the vees. I set my try-square to the axle, close to the crank, and turn the crank around until the end of the crankpin, showing through the web, is 1/32 in. away from the try-square blade when same is touching the axle. Then I set the needle of my scribing-block (surface gauge) to the centre of the axle on the other side, and adjust the crank until the centre of the crankpin is spot-on to the scriber needle. The cranks are then exactly at right angles.

To prevent anything shifting, the whole bag of tricks should be brazed or silver-soldered. Anoint all the joints with some wet flux. For brazing, use Boron compo mixed to a paste with water. For silver-solder, either powdered borax mixed as above, or if Easyflo is used—good stuff that!—the special flux sold for use with it. Lay the assembly in a pan of small coke or breeze, heat the whole lot to bright red for brazing, and touch the joints with a piece of soft brass wire. If the heat is right, this will melt instantly and flow into the joints. For silver-soldering, a dull red is all that is necessary, the process being the same; but be verra frugal wi' the stuff, for not only does it cost muckle bawbees the noo, ye ken, but spreads like nobody's business and will run all over the pins and axle-ends if given half a chance. Then it's not only a thankless job to clean off, but is pure vaste, vot you tink, eh?

The final job is to cut away the unwanted bits of axle between the webs. I usually do this on my milling machine, with the axle in the machine-vice on the table, and a ¼-in. side-and-face cutter on the arbor, which wipes out the lot at one cut; but the bits can be cut out with a hacksaw, and the stub smoothed off with a file, the inside faces of the webs being left quite smooth. Any discoloration and scaling left by the brazing can be removed with emery-cloth, leaving the axle as clean as that shown in the picture.

Alternative Crank Axle

The webs for the crank axle used with loose-



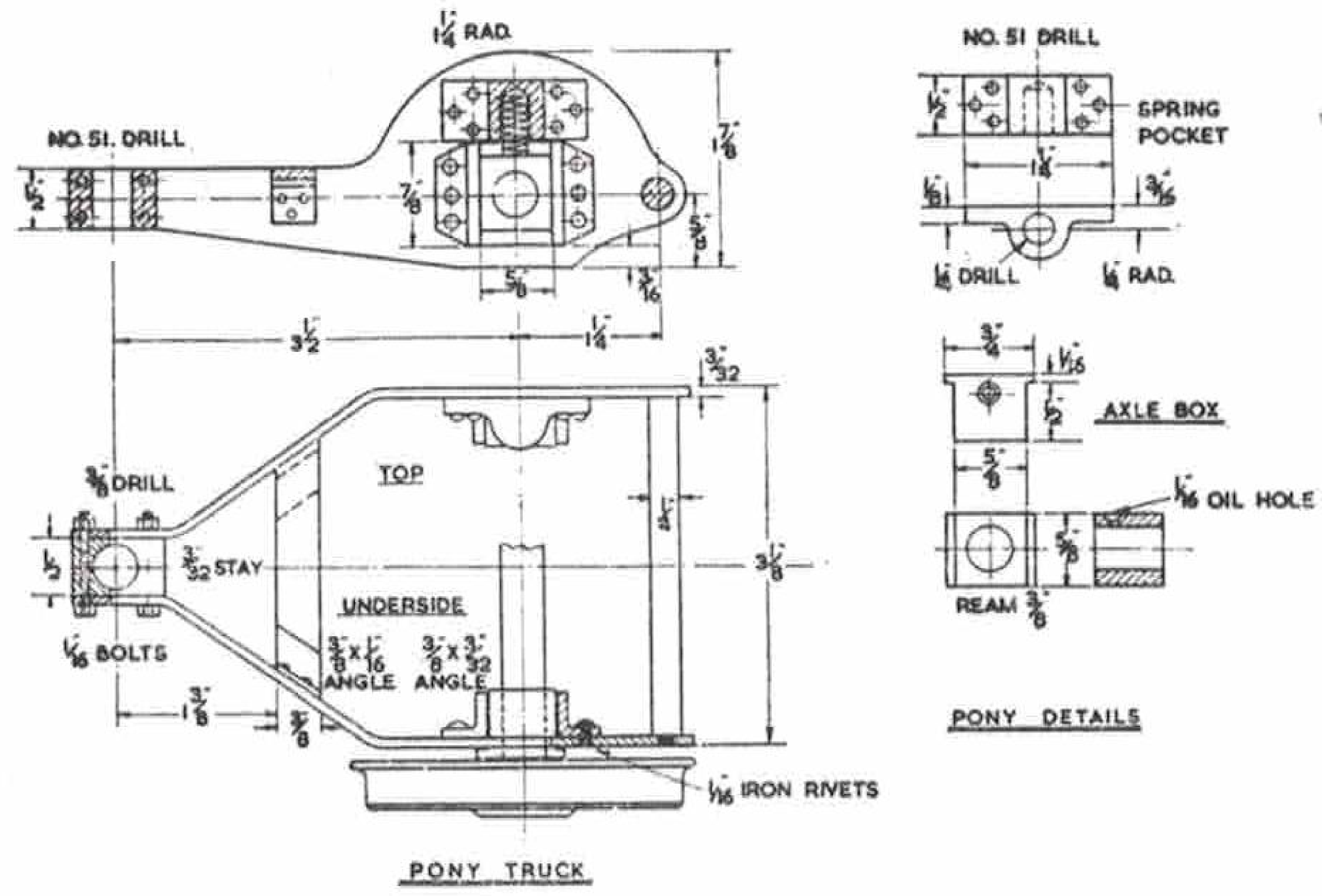
eccentric valve gear are made from four pieces of 9/32-in. x $\frac{1}{4}$-in. mild steel bar, each a full $1\frac{1}{2}$ in. long. The holes are set out and drilled, and the crank-pins fitted, just as described above, the axle holes being reamed and the ends rounded off after the crankpin-pressing process. The eccentrics are made exactly as described for the lubricator eccentric, but to the dimensions shown in the drawing, round steel of $1\frac{3}{8}$-in. diameter being used. Mark off, very carefully indeed, the location of the pins, as these determine the valve setting, and if they are not absolutely O.K. the engine won't perform to expectations. Drill the holes with No. 32 drill, and squeeze in bits of $\frac{1}{8}$-in. silver-steel, leaving a full $\frac{1}{8}$ in. projecting.

To assemble, put the two eccentrics on the axle, pins outward. The eccentrics must be perfectly free to run. Then press the cranks on at each side of them, but still leaving the eccentrics free. Set the cranks at right angles as previously described. The job can't be brazed or silver-soldered, or it would be good-bye to the freedom of the eccentrics; they would probably be brazed up solid! To prevent the webs from shifting, drill two No. 32 holes through the thickness of each web, cutting through axle and crankpin ends. Bits of $\frac{1}{8}$-in. round steel are squeezed into these, and the ends filed off flush. Cut out the bits of unwanted axle between the webs, and Bob's your uncle once more. I'll give details of the single crank for the baby, along with the instructions for the single cylinder.

How to Quarter the Wheels

The wheel seats at the ends of the axles should be slightly eased for about a third of their length, so that they can be just started in the wheel bosses by hand. This is easily done by chucking them in the three-jaw and applying a flat file, taking off just enough to allow the wheels to go on very tightly for about $\frac{1}{8}$ in. by hand. Then press one wheel on each axle. In the case of the crank axle, put on the axlebox first; and to prevent any distortion of the crank webs, jam a piece of $\frac{1}{4}$-in. flat rod between them. The crank-pin in the wheel is set in line with the one in the axle: this was Stroudley's practice on the L.B. and S.C.R., and gives a direct pull on the coupling-rod, instead of the stress being taken by the axlebox, as it is when inside and outside cranks are opposed.

With the other axleboxes still in the frame, poke the axles through them and put on the other wheels



Pony truck in close-up. Study springing here and in previous picture

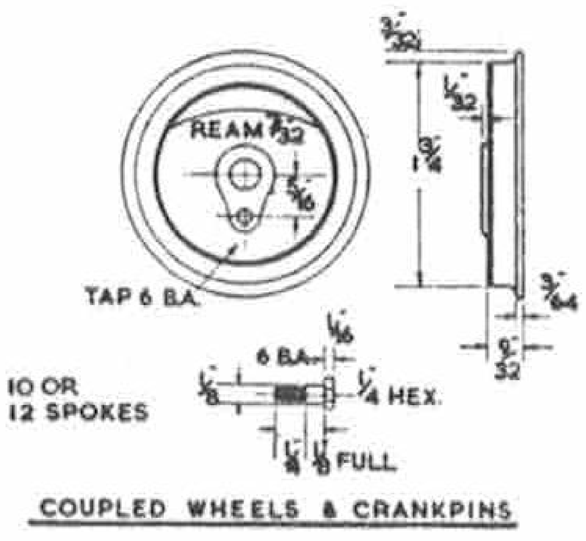
by hand as far as they will go, setting the crank-pins at right angles as near as you can by eye. This makes certain that the boxes don't accidentally get mixed up, which would mean taking off the wheels again to correct. Then remove the lot by taking out the hornstay screws.

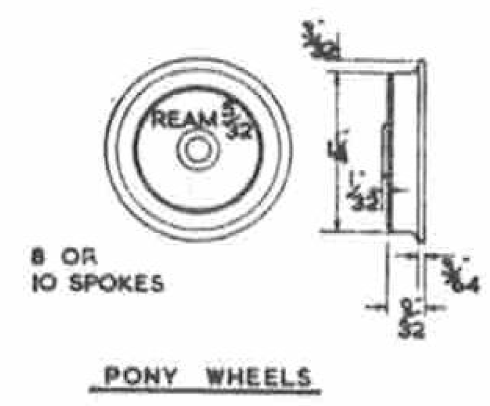
Put the remaining driving axlebox on the crank-axle, and put the wheel on as far as possible by hand, with the crank-pin lining up with its inside relation. To set the crankpins exactly at 90 deg. is only a few minutes' job. Stand the assembly on something flat, with the wheels either resting in a big pair of V-blocks, or with a small block of metal at each side to prevent them running away. I use my big surface plate, but the drilling-machine table or the lathe bed will do. Set your try-square beside the pressed-on wheel, the stock resting on the flat surface, and adjust the wheel so that the edge of the blade just comes level with the centre of axle and centre of crank-pin. Now set your scribing-block with the needle point to the centre of the axle on the other side, and adjust the wheel on the axle until the centre of crank-pin is at the same height when the scriber needle is applied to it. If the other side wheel hasn't moved (take a look at it to make sure), the crank-pins are set O.K., and the wheel can be pressed right home. Serve the other wheels with a dose of the same medicine, and when the whole lot are replaced in the frame, they should spin freely and be perfectly true.

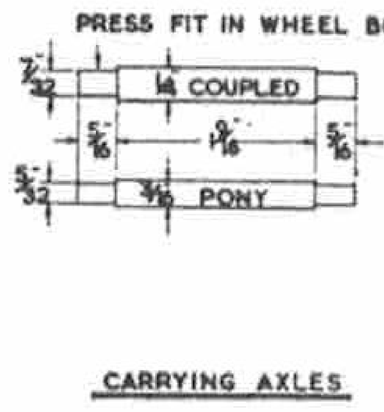
Pony Truck

Two pieces of soft mild steel 3/32 in. thick, $1\frac{7}{8}$ in. wide, and approximately 6 in. long, will be needed for the pony frames. Mark one off, and then proceed exactly as described for main frames. Don't forget, when marking, to allow for the bend, the position of which should be marked on both frames. The bending can easily be done in the bench vice, with the marked line of the bend just showing above the jaws. The slots for the axleboxes should be cut while the two frames are still temporarily riveted together, using a bit of $\frac{5}{8}$-in. square bar as a gauge. After parting the frames, rivet a $\frac{7}{8}$-in. length of $\frac{3}{8}$-in. x 3/32-in. angle at each side of each slot, to serve as horn-cheeks; bevel them off at top and bottom as shown.

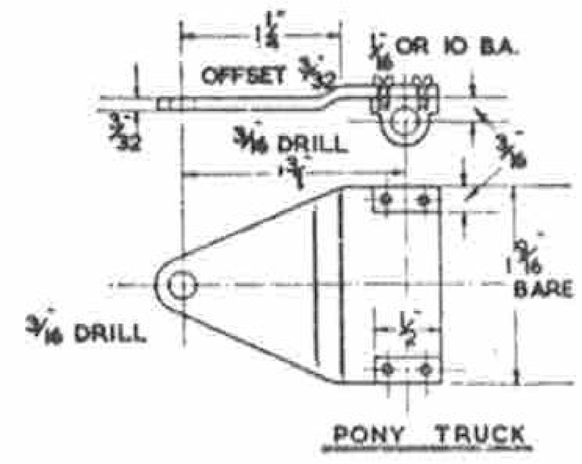
The back staybar is a piece of $\frac{1}{4}$-in. round mild steel $3\frac{1}{4}$ in. long. Drill the holes for this in the pony frame with No. 30 drill, and countersink on







Drawings for the $1\frac{3}{4}$ in. gauge version of "Mona".
Below: **Curly's own "Grosvenor" which graces the cover, seen this time with a cab interior view**

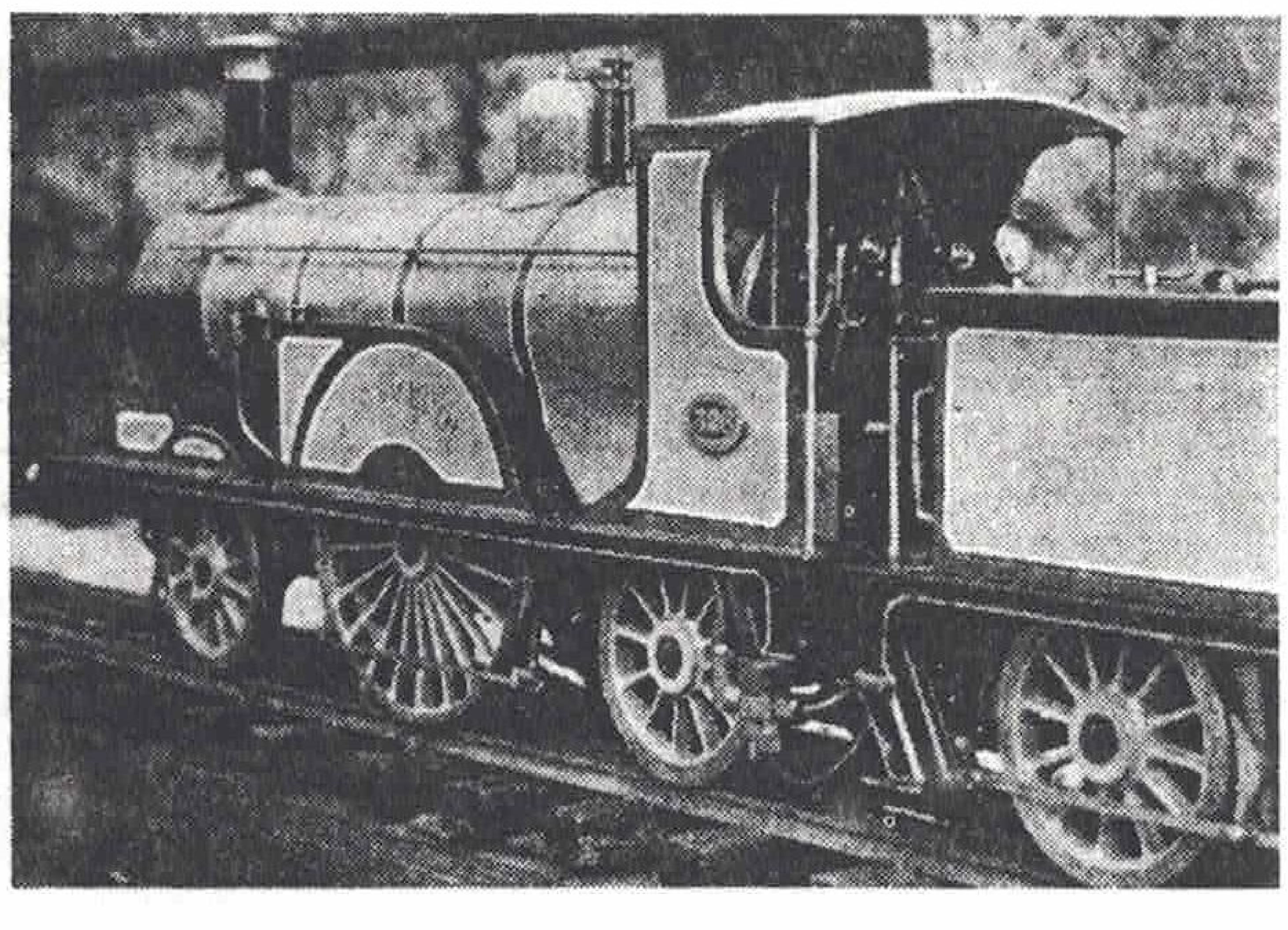


the outside. Turn the ends of the staybar to fit, the distance between shoulders being 2-15/16 in. Fit the bar as shown, riveting the ends into the countersinks, and file flush.

The pivot block is a piece of $\frac{1}{2}$-in. square bronze or gunmetal $\frac{3}{4}$ in. long. Drill a $\frac{1}{8}$ in. hole through the middle of it, then clamp it in the position shown in the plan drawing, between the ends of the frame. Drill four No. 51 holes clean through the lot, and secure with 1/16-in. or 10 B.A. bolts. I never bother to turn up little bolts—life's too short. I made mine by cutting off four bits of 1/16 silver-steel, 1 in. long, putting a few threads on each end, poking them through the holes, and putting commercial nuts on. Reeves sells nuts! After screwing the nuts up tight enough to stay put without stripping the weeny threads, the bits sticking out were filed off, leaving the job as neat as you see in the picture. The cross stay, also shown clearly, is just a bit of $\frac{1}{8}$-in x 3/32-in. steel strip, cut to fit between the sides of the frame, and attached by pieces of $\frac{3}{8}$-in. x 1/16-in. angle, and rivets. It should be flush with top of frame.

Friend Reeves may supply castings for the spring pockets, in which case they will only need smoothing with a file, $\frac{1}{4}$-in. holes drilled in the bosses for the springs, and the rivet holes drilled. The latter should be set out and drilled in the frames first; then all you have to do is to put the spring pocket in position shown above the axlebox, hold it there with a toolmaker's cramp, put the 51 drill through the lot, and rivet up. Tip: use iron rivets if possible. Copper rivets are daddies at working slack, in the smallest sizes; brass are better, but iron and steel are the best of the lot. If castings aren't available, the pockets are easily filed up from $1\frac{1}{4}$-in. lengths of $\frac{1}{2}$-in. square bar; brass will do, as there is nothing to wear.

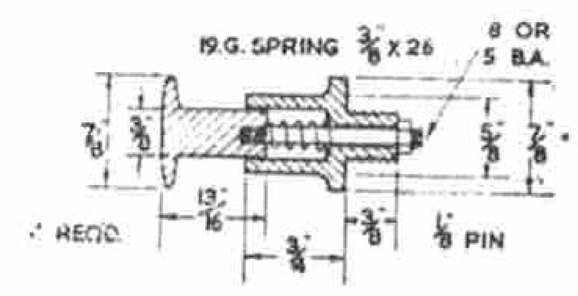
The axleboxes are machined up from cast or drawn bronze or gunmetal, in exactly the same way as the coupled axleboxes, so we needn't go through all that rigmarole again. They should fit fairly



easily in the horns, but not slack. Wind up the springs from 22-gauge tinned steel wire around a $\frac{1}{8}$-in. mandrel, same as the main axlebox springs, and put one in each pocket (they should be $\frac{5}{8}$-in. long uncompressed) with the pony upside down on the bench. Put the axleboxes in with flanges outside, press one of the wheels on the pony axle, put it through the boxes, and press on the other wheel. Pressing tip: if your bench vice doesn't open wide enough, a little extra width can be sneaked by taking out the hardened insets. The complete pony truck is erected by slipping it over the pin in the bolster and securing with a nut and washer; it should swing perfectly free. To prevent mine swinging too far out when the engine is lifted off the rails, I fixed a stop between the sides; just a slice of $\frac{5}{8}$-in. round rod $\frac{1}{4}$-in. thick, attached to the bolster by a $\frac{1}{8}$-in. bolt. You can see it in the picture. The pony truck for the wee engine is about the rock-bottom of simplicity, being cut from a single piece of 3/32-in. sheet steel, $2\frac{1}{4}$ in. long and 1-9/16 in. wide. It has a 3/32-in. offset in it, as shown, which can easily be made in the bench vice. The wheel bearings are two blocks of brass, filed to shape and size shown, and attached to the truck plate by two screws in each. There is no need to ream the axle holes: just drill them, as the pony wheels carry little weight and should run very easily.

Buffers

My chassis somehow looked forlorn without any buffers, so I fitted them before carrying on with the "works". For the sockets chuck a piece of $\frac{7}{8}$-in. round rod in the three-jaw, face the end, turn down $\frac{3}{8}$-in. length to $\frac{3}{8}$-in. diameter, and screw $\frac{3}{8}$-in. x 26. Part off $\frac{3}{4}$-in. from shoulder. Rechuck in a tapped bush, held in three-jaw, turn $\frac{5}{8}$-in. of the outside to $\frac{5}{8}$-in. diameter, centre the end, drill right through with No. 30 drill, and open out to $\frac{5}{8}$-in. depth with $\frac{3}{8}$-in. drill. For the heads chuck a piece of $\frac{7}{8}$-in. mild steel rod, face off, centre, drill No. 40 for $\frac{1}{4}$-in. depth, and tap $\frac{1}{8}$ in. or 5 B.A. Turn $\frac{5}{8}$-in. length to a sliding fit in the sockets, part off at 13/16 in. from the end, reverse in chuck, and turn the head to the outline shown. The finishing touches can be given with a fine file before removing from chuck.



The pins are $1\frac{3}{8}$-in. lengths of $\frac{1}{8}$-in. round rod, with a few threads on each end, screwed tightly into the shanks. The springs are made from 19-gauge tinned steel wire, like the carrying springs. The assembly is shown in the drawing, commercial nuts being used on the pins; but you'll have to make special nuts from $\frac{1}{2}$-in. hexagon brass (just a kiddy's practice job, that) to secure the screwed sockets to the buffer beams, as shown in the photos. The buffers for **Mona's** baby are made just half size, so no special drawing is needed.

Coupling Rods

If you take a quiz at the drawing of the coupling-rods shown here, and compare it with those on the general arrangement, you'll spot a little difference, viz.: that the knuckle joints are behind the middle boss instead of ahead of it. They are practically always ahead in full-size practice, but I lengthened *Mona's* wheelbase so as to have plenty of room for a decent firebox, and on my own engine decided to shift the knuckle, and break up the long expanse of rod between driving and trailing coupled wheels. It looks so good that I'm passing it on. Inspector Meticulous won't mind! Our old nighthorse knows that the late Mr. Pettigrew of the old Furness Ry., did the very same thing, for nearly the same reason.

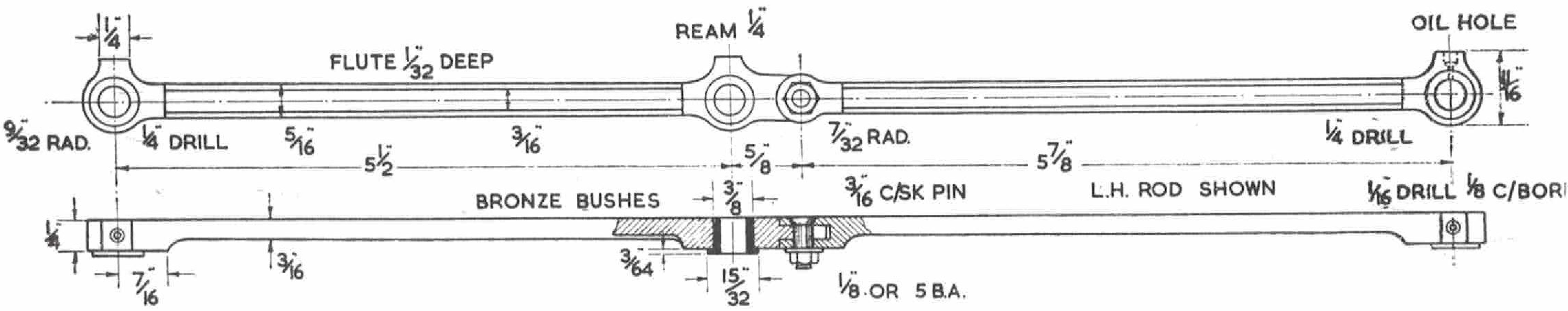
Four pieces of ¾ in. x ¼ in. mild steel are needed, two 6½ in. long, and two 6¾ in. Coat with marking-out fluid and mark out one longer and one shorter rod, making deep centrepops at the bosses. Drill No. 32, use the drilled blanks as jigs to drill the other two, and temporarily fix each pair together with bits of ⅛ in. rod driven through the holes. How I machined mine was to grip each pair in the big machine-vice on the table of my milling-machine, and run them under a 1½ in. slabbing cutter on the arbor. I guess that old machine doesn't belong to any union, otherwise it would soon be kicked out for working too hard—it just took out the deeper side in two cuts, and the other side in one cut. In fact, it was so energetic that it nearly cut the boss off one end, I just caught it in time!

The rods were then parted, and each one clamped down to a length of 1 in. square bar held in the machine-vice, by aid of improvised cleats at each end. The bar provided the necessary backing to prevent the rods springing, whilst the same cutter took out 1/16 in. of the face; the cutter was changed for a saw-type one 3/16 in. wide, and that merchant put the flutes in—or should I say, cut them out? Then all I had to do was to open out the holes to ¼ in. and round off the bosses. A short bit of ½ in. square bar with a ¼ in. pip on the end, was gripped, pip upwards, in the vice on the table of my vertical mill. The end of the rod was slipped over the pip, the rod ran up to a ⅝ in. side-and-end-mill in the chuck, and as I slowly swung the free end of the rod around in a semi-circle, the cutter rounded off the boss as easy as cutting cheese. The tiny ridges where the cutter started and finished were trimmed off with a fine file.

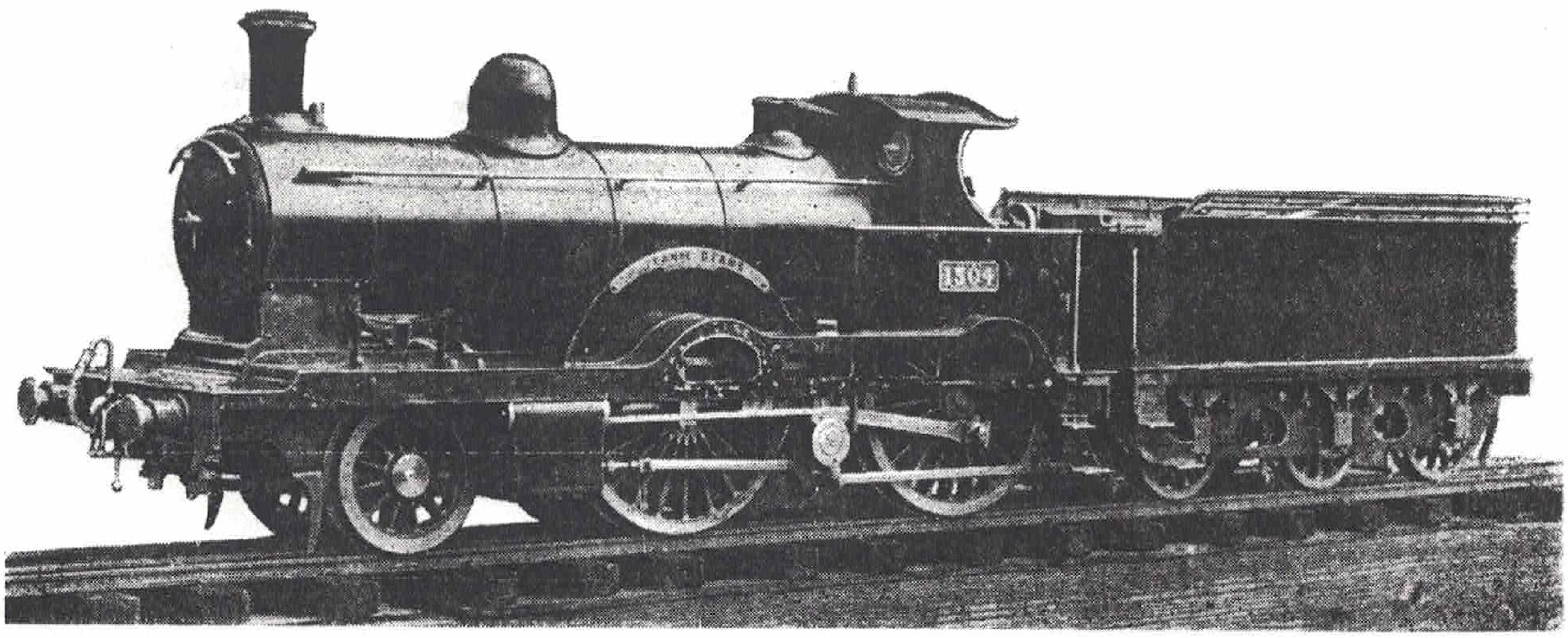
The surplus metal can be removed by a similar process in the lathe, if you have no milling-machine, by gripping the rods in a machine-vice (regular, or improvised with short pieces of angle-iron held by bolts) and running under a cutter on an arbor between centres. The lack of vertical adjustment can be got over by filing a small recess at the starting end, and starting with the cutter in the recess, the work being adjusted high enough to do this. It means ditto-repeatoing for each cut, but it saves a dickens of a lot of file-pushing. The rods can also be turned—sounds curious, but it's quite easy. Cut the rod blanks well over length, mark out all four, leaving the extra length all at one end, then on each end, exactly in line with the centre of the bosses, make centre pops. Open these out with a small centre-drill (say size E) and put the rod between lathe centres, with a carrier on the extra bit beyond the boss. The surplus metal between the bosses can then easily be turned away. This leaves the rod rounded at top and bottom, but judicious use of a flat file soon puts that to rights. I've made two or three sets of fish-bellied rods that way, finding it quicker than setting up for profile milling. Flutes can be formed by clamping each rod to a piece of square bar, gripping the bar under the slide-rest tool-holder at right angles to the lathe bed and at centre-height, and traversing it across a 3/16 in. endmill or slot-drill held in the three-jaw.

Bosses can be rounded in the lathe by using a bit of square bar with a ¼ in. pip turned on the end, gripped under the tool-holder, at centre-height and parallel with the bed, the pip facing the chuck, in which is held a small side-and-end-mill. Slip the hole in the boss over the pip, grip the free end of the rod tightly (wind a bit of rag around it—safety first!) run the boss up to the cutter by turning the cross-slide handle, and when cutting starts, slowly swing the free end of the rod around. The cutter will round off the boss, same as it does on my vertical miller, and a drop of cutting oil helps to a nice finish; but be mighty careful to avoid swinging the end far enough around to cut off the oil box! If you are unlucky, don't fret; file a flat where the oil box should be, silver-solder a little block of steel on the flat, and file to the shape of the oil box. Nobody would dream that there had been a mishap.

The knuckle joints are simple to make. Slot the round bosses on the shorter rods, by gripping them under the slide-rest tool-holder at centre-height and at right angles to the bed, and running them up to a



COUPLING - RODS



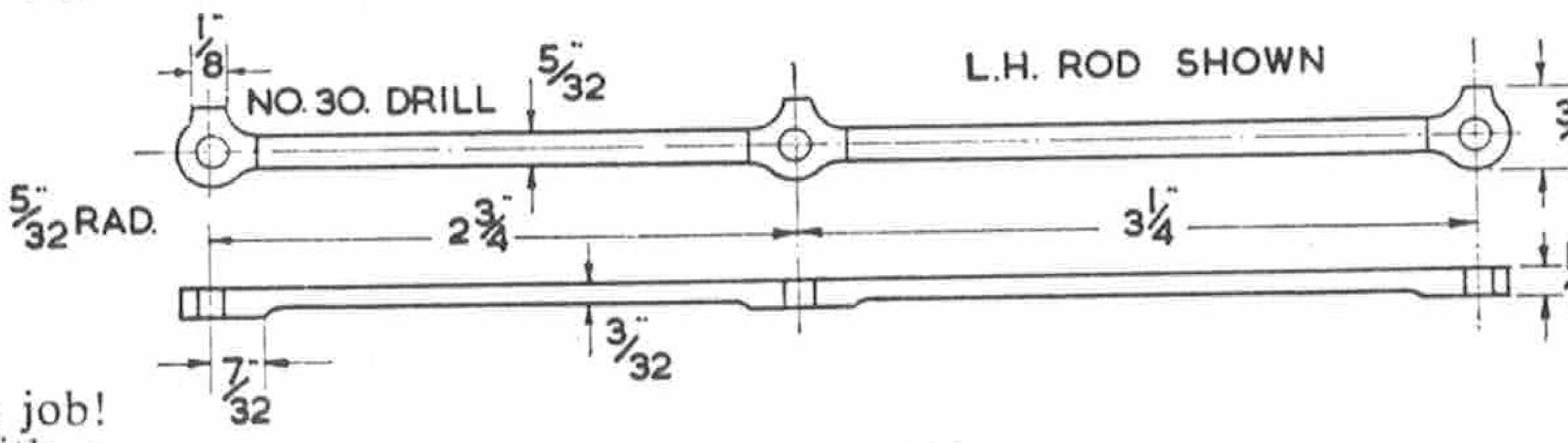
⅛ in. saw-type cutter on a stub arbor held in three-jaw. A bit of round steel, screwed at one end and furnished with two nuts, does fine for an improvised arbor, the cutter being gripped between the nuts. The tongue to fit is made by pin-drilling 1/16 in. off each side of the end hole in the longer section of rod. I make all my own pin-drills, from silver-steel of size required. The steel is chucked in three-jaw, end faced, centred, and drilled for size of pin needed, for about ½ in. depth. The steel is then filed and backed off, exactly the same as the slot drill illustrated in first instalment, then hardened and tempered, and a silver-steel pin (which is **not** hardened) fitted in the hole. Use plenty of cutting oil when slotting and pin-drilling.

The tongue should fit the slot easily, but without shake. The hole in the fork should be countersunk on the side that goes next to the wheel boss. The pins are turned from ¼ in. round steel held in three-jaw; they should fit the holes in fork and tongue easily, without being slack. The end of the pin which projects through is turned down to ⅛ in. and screwed ⅛ in. or 5 B.A., and furnished with a commercial nut and washer. The end of the pin next to the wheel boss is filed flush.

Rods can be formed by hand, but it's a tiring job! Mark out as above, and grip in bench vice with a marked line showing. File a recess wide enough to take a hacksaw blade on its side, close to one of the bosses; put the blade in the hacksaw frame sideways, and saw along to the boss at the opposite end, keeping the sawblade pressed down on the vice jaws, and applying enough cutting oil with a brush, to keep the blade wet. If smoke comes off, you'll know that the blade is cutting all right, and the tops of the vice jaws will keep the blade from wandering. The resulting cut should be quite clean, and only need the saw marks removing with a file. To round the ends nicely, use a button filing-jig, made in a few minutes. Chuck a bit of 9/16 in. round silver-steel in the three-jaw and turn a pip on the end ¼ in. long and ¼ in. diameter. Part off at ¼ in. from shoulder, then harden the piece right out by heating to medium red and dropping into cold water. Drill a ¼ in. hole in the middle of the marked-out coupling rod boss, put the pip in it and grip together in the bench vice; then file away the surplus steel until the file touches the jig—but don't file away the bit on top that forms the oil box.

The engine shown above is a 3½ in. gauge Webb three-cylinder compound, and when building her, L B S C. eliminated various faults of the full sized engines. She has run 53 laps of Curly's railway (nearly 2½ miles) on one firing, equal to running from Euston to Bletchley, hauling 320 tons, at 90 m p h.

Before fitting the bushes, put the knuckle-pins in and try the rods on the wheels; the ¼ in. holes in the bosses should fit easily on the pins. If your measurements and workmanship are O.K. the rods should slip on easily, and the wheels should turn freely with no sign of tightness at any part of the revolution. If there is a tight place, take a close look at the pins, and you'll be able to see which side the trouble lies, and which pin is bearing to one side of the hole in the boss. Ease it with a round file until the wheels turn freely. The rods can then be bushed. Open out the holes in the bosses with a ⅜ in. drill, and be sure it goes through dead square; use drilling machine or lathe, and take the sharp edge off each hole with a bigger drill. Chuck a piece of ½ in. rod in three-jaw—drawn bronze or good quality gun-metal—turn down about 1 in. length to 15/32 in. diameter, then further reduce a full ¼ in. length to a press fit in the hole in the boss. Centre, and drill down to a bare ⅜ in. depth with letter C or 15/64 in. drill. Part off at 1/16 in. from the shoulder, make five more in same way, then chuck each with flange outwards; and take a skim off the face, bringing down the thickness of flange to 3/64 in. Squeeze them into the holes in the bosses; drill the oil holes in the boxes, running the drill right down through the bushes, then put a ¼ in. parallel reamer through the middle bush, and drill the others at each end, with



COUPLING ROD

$\frac{1}{4}$ in. drill, as they should fit easily to allow the wheels to follow any unevenness in the line, without causing the rods to bind. The end bushes in the coupling-rods of a full-size engine are usually bored 1/16 in. bigger than the pins, for the same purpose, and this is what causes the well-known ringing clank when running with steam shut off. The rods can then be erected, and fixed with 4 B.A. nuts and washers, and should be quite free when the nuts are right home.

The coupling-rods for *Mona's* baby are made by the same process, but to dimensions shown; each rod is in one piece, knuckle-joints not being required, and the rods don't need bushing in this size.

Cylinders for 3½ in. Gauge Engine

The efficiency of a locomotive depends on the workmanship put into the cylinders and valve gear—provided, naturally, that the design is O.K. — so take great pains with the next job. I made up the cylinders for my own engine from castings that I've had in stock for years, and had to adapt them to this particular job, but they planned out very well. Those I am specifying incorporate the experience gained by first doing the job myself; nuff sed!

The first job is to check the position of the core-holes in the cylinder casting; if reasonably true, and at 1⅜ in. centres, no marking-off will be needed. If they are out, plug the ends with discs of wood. On these, set out the true centres, and with a pair of dividers, scribe circles 1⅛ in. diameter on the end of the casting, which should be smoothed off with a file and coated with marking-out fluid. If the portface is at all rough, that can be smoothed also, but I've never had to smooth off one of the Reevesco brand yet! Next, bolt an angleplate to the lathe faceplate, and set the castings on it, portface down, securing with a bar across its back, held with a bolt at each end. The end of the casting should overhang the angleplate by at least 3/16 in., and the line of the bores must parallel to the lathe bed. Set this by applying a try-square to the job, stock against face-plate, and blade to the side of the casting; or else do what I did, viz. held a bit of 1 in. square bar against the faceplate, and backed the casting up against it. That lazy Curly invariably takes the easiest way! Now shift the angleplate on the faceplate until one of the coreholes, or marked circles, as the case may be, runs truly. Check with a scribing-block standing on the bed of the lathe, the needle being set to the edge of the hole, or marked circle. When O.K. tighten all bolts, but not tight enough to cause distortion, otherwise there will be trouble later on.

The weight being toward the side of the faceplate, means that a counterbalance will be needed, otherwise there will be an earthquake in the workshop as soon as the lathe is started. Just recently I cast a few round weights in tin lids of various sizes, using bits of scrap lead pipe which had been kicking around in the junk box, and drilled $\frac{1}{4}$ in. holes through the middle. One or two of these, attached to the face-plate by $\frac{1}{4}$ in. bolts opposite the work, do the trick in fine style, a nearly perfect balance being easily got by setting them towards or away from the edge of faceplate, the exact distance being found by trial and error. The lathe will then run at normal speed without the least vibration.

With a roundnose tool, set crosswise in the rest, face off the flange, right across the casting, the amount taken off being slightly less than half the difference between length of casting and length of finished cylinder block. Then set an ordinary boring tool in the rest, with the tip slightly above centre, and take a good hefty cut right through, to shift the hard skin and true up the hole. I did the job on my Myford "supersonic" with the gearbox set to 0.005 in. feed. On an ordinary screwcutting lathe, set the changewheels for the finest feed available. If the lathe has no self-act, the top slide must be set to turn parallel before starting the cylinder-boring. It's quite easy. Chuck a piece of round rod about ¾ in. diameter in the three-jaw, and take a fine cut along the projecting part, which should not be less than 2 in. Measure diameter at both ends of cut, with "mike" or calipers. If there isn't any variation, it will be a miracle. Anyway, adjust the slide to cut off a shade more at the larger end, and measure again. About three shots usually does the trick; when the "mike" reading at both ends only varies by half-a-thousandth of an inch or less, or you can't detect any difference in the "feel" of the calipers applied at either end, the slide is set all right for the cylinder boring, and if the handle is turned very slowly and evenly, the resulting bore should be equal to what you would get on a good screwcutting lathe.

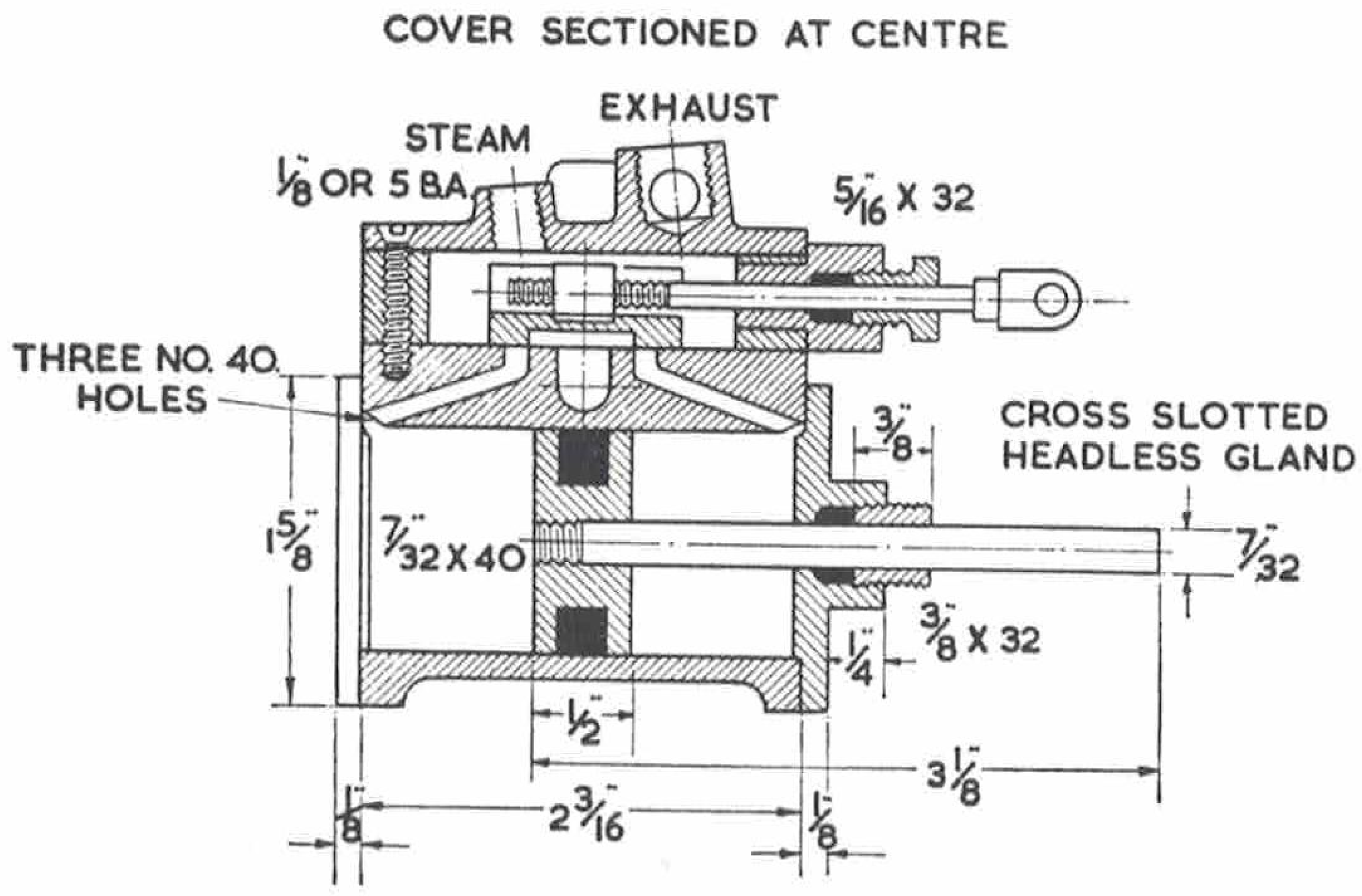
Very few average workshop owners possess a 1⅛ in. parallel reamer, so we'll do without it. Set the "prong" side of your slide-gauge, or a pair of inside calipers, to 1⅛ in. and continue boring until the prongs or legs just *won't* go in (says Pat). Then, with an oilstone stick, or gouge slip, touch up the cutting edge of the boring-tool without taking it out of the rest; after which, take another fine cut through the cylinder bore. This time the prongs or legs *should* go in rather tightly. Then, if the tool is run through the bore twice more *without shifting the cross-slide handle*, the hole should be perfectly circular and parallel from end to end, and the finish almost like glass.

Don't on any account slack the clamp bar, but ease the bolts holding the angleplate to faceplate, shift the whole issue until the second corehole or circle runs truly, tighten bolts again, and repeat the whole operation, finally taking a tiny skim over the end, to give it the finishing touch. Incidentally, as this will be the end to which the back covers will be attached, make a mark on the casting so that you'll know which end is which.

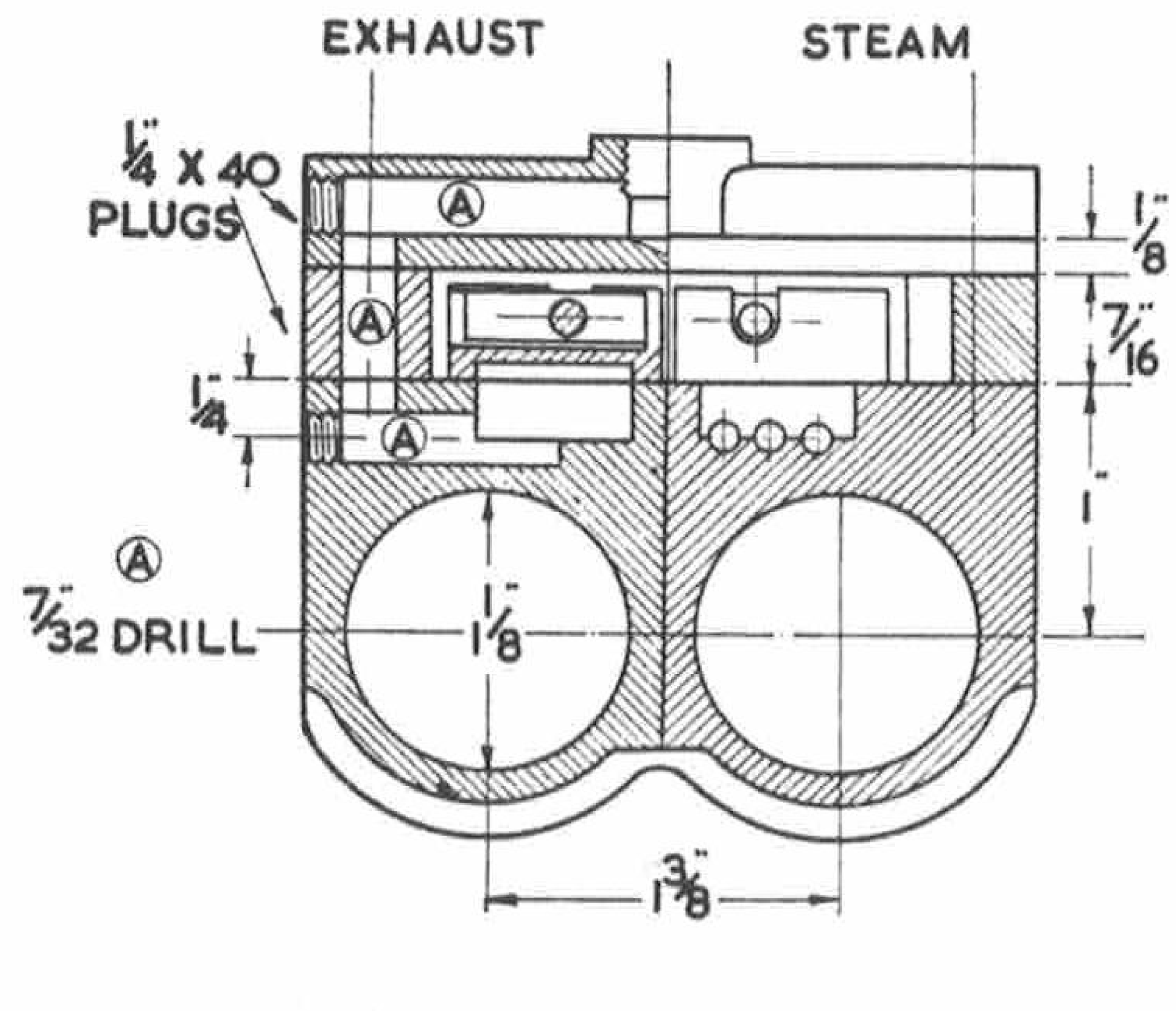
I faced off the other end of my cylinder block by holding the before-mentioned piece of square bar against the faceplate, and butting up the faced end of the block against it, holding it there while I tightened the clamp bar; a roundnose tool set cross-wise in the rest, quickly machined off the rough end, and reduced the overall length of the block to 2-3/16 in.

How to machine portface and sides

Set the casting end-up on the angleplate, with a thin bit of copper or brass sheet between the machined end and the angleplate, to prevent the surface being marked. Fix it with two $\frac{1}{4}$ in. bolts through the bores, with big washers under the heads, plus another bit of thin metal, for purpose mentioned, drilling holes in the bits of metal to let the bolts pass through. Set the angleplate so that the casting is as near the middle of faceplate as possible. The port-face should overhang the edge of angleplate by about $\frac{1}{4}$ in. or more, and be at right angles to lathe centres; set it thus by applying a try-square to it, stock against faceplate, and blade to the side of casting. The port-face can then be machined off truly, with a roundnose



SECTION OF CYLINDER



SECTION THRO' PORTS

tool set crosswise as before, until the distance from edge of bore to portface is exactly 7/16 in.

Slew the casting around a quarter-turn, to machine off one side. Set with try-square, stock to faceplate, and blade to portface. Face off until within 3/16 in. of the bore. Then shift the casting around half-a-turn, setting as above, and repeat process. The block should then be the exact $2\frac{7}{8}$ in. wide, and portface and sides at the correct right angle, distance from portface to centre of bore being exactly 1 inch.

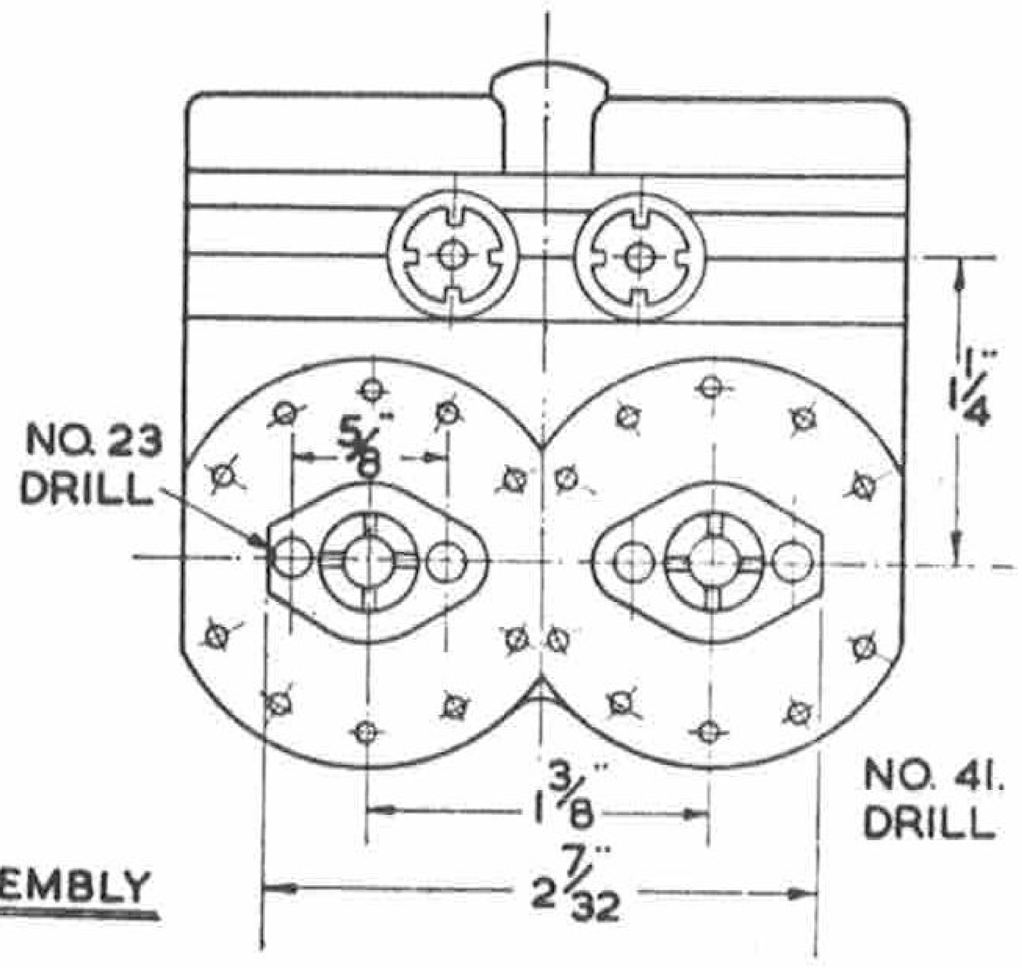
Port cutting

Coat the portface with marking-out fluid, and mark ports as shown. If a vertical slide is available (every lathe should have one as standard equipment) cutting ports is a piece of cake. Set up the cylinder block on an angleplate attached to the slide, just as it was set up for machining portface, only this time facing the lathe headstock. Either put a $\frac{1}{8}$ in. endmill in the three-jaw, or a $\frac{1}{8}$ in. home-made slot-drill. Adjust the upper steam port level with it, start up lathe, running at high speed, feed the casting on to the cutter for about 1/16 in. by turning the topslide handle, and very carefully traverse the work across the cutter by turning the cross-slide handle. The great thing to watch is to avoid what engine-drivers call "overshooting the platform"; that is, to traverse the cross-slide too far, and so cause the cutter to run past the end of the marked space. Note the starting and finishing positions of cross-slide handle on first cut, and keep to them on subsequent cuts. Two more traverses, with the cutter set in another 1/16 in. for each bite, should cut the port to depth required, which is 3/16 in.

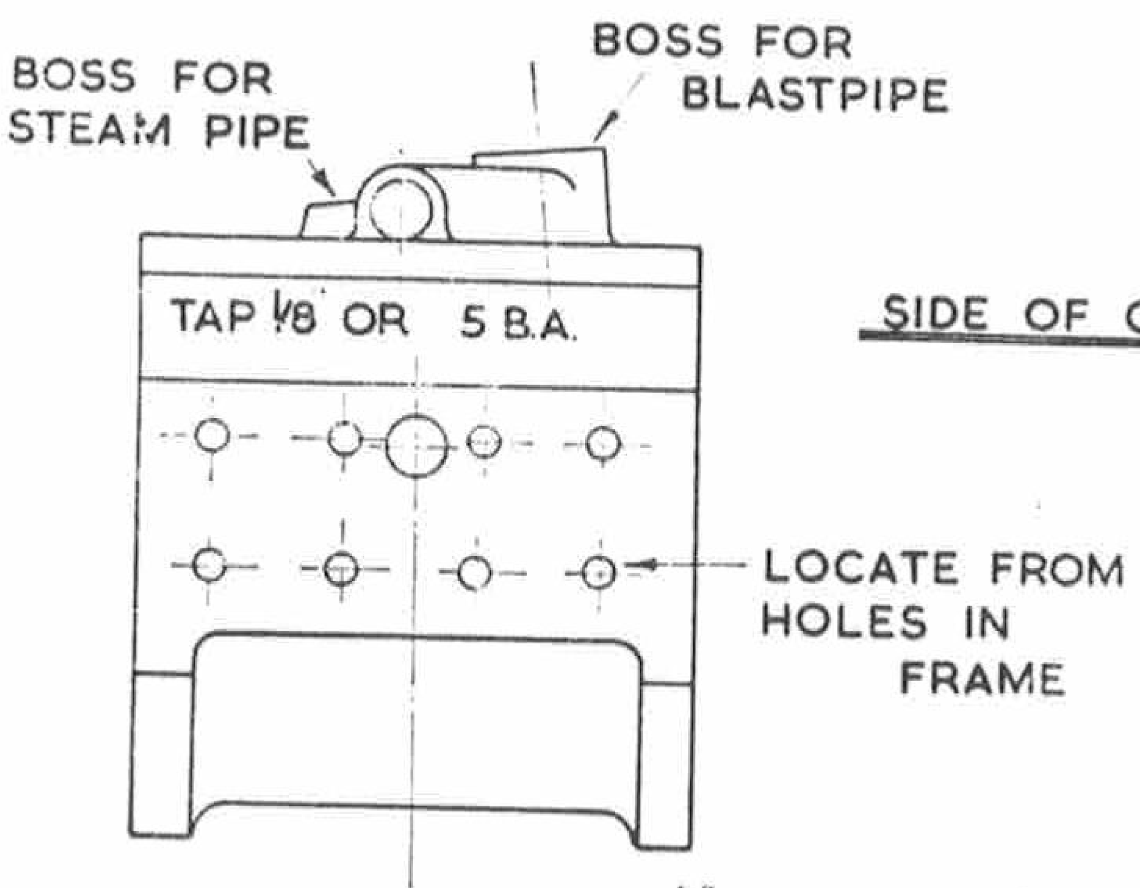
The vertical slide allows each port to be brought level with the cutter, merely by turning the handles. The exhaust ports can be formed with the same cutter by doing half the width at the time. It doesn't matter a bean about the ends of the ports being rounded. If a vertical slide isn't available, the casting can be mounted on the slide-rest tool-holder, but it will have to be packed up to bring the port location level with the cutter, for each port cut.

Some folk advocate forming ports by "gang-milling", three small saw-type cutters being mounted on a spindle at correct distance to suit ports and the casting fed on to them. I don't advocate this at all because the ports thus formed are just like the seating of a Woodruff key, curved at the bottom and very shallow, so that they have to be deepened. Ports can be cut by hand, by drilling a few holes 3/16 in. deep

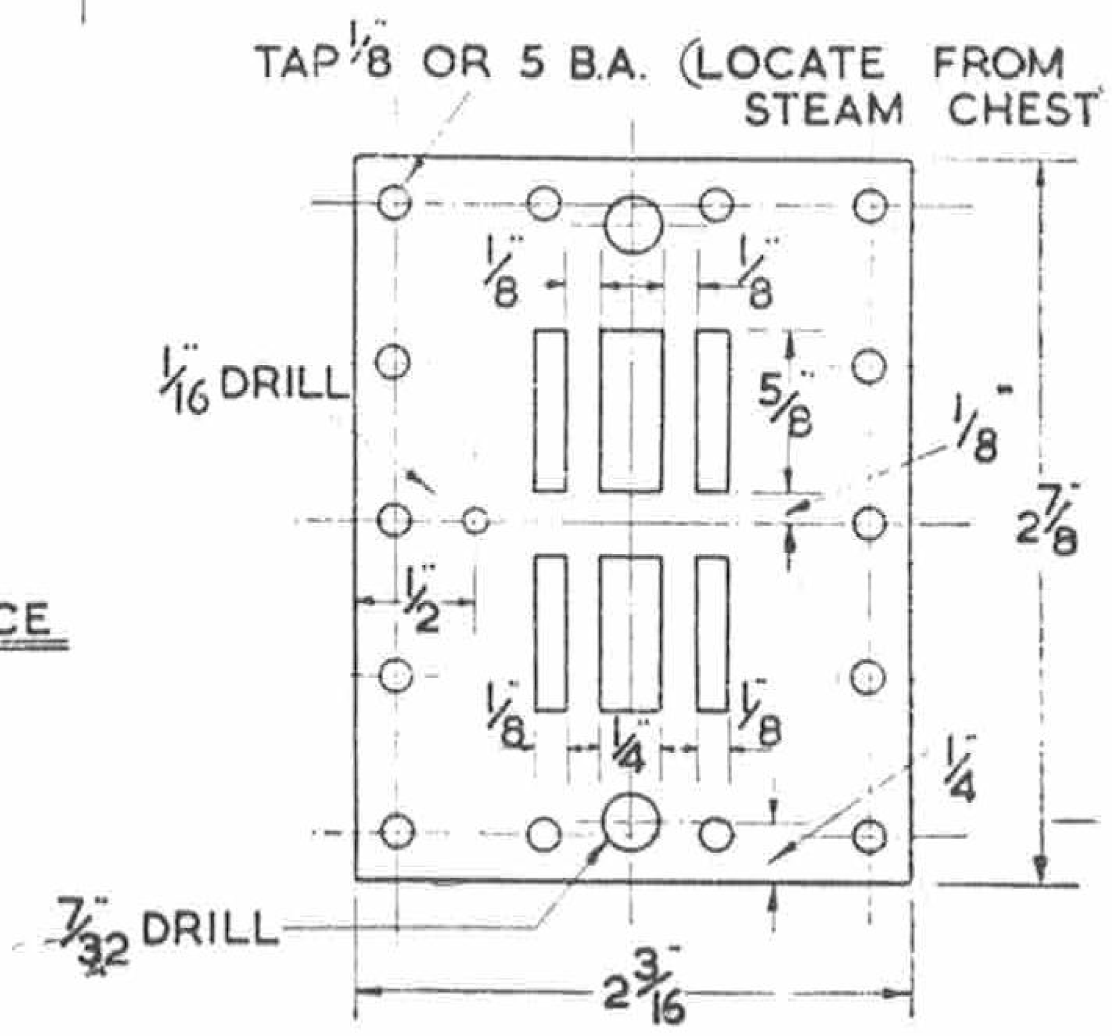
BACK OF CYLINDER ASSEMBLY



SIDE OF CYLINDER



PORT FACE



in the marked out spaces, and chipping them into slots with a little chisel made from silver-steel. Two would be handiest; one 1/8 in. wide for the ends, and another about 3/8 in. wide for the sides. I cut many ports that way in the days before I got my present equipment. I do them on the vertical miller now, with the cutter in the spindle collet, and the cylinder block in the machine-vice on the table, which can be moved up-and-down, side-and-endwise, so there is no difficulty in setting the port under the cutter. I use dental burs for cutters; and the way those little instruments of torture chew out ports in cast-iron explains why they give you gyp when the molar engineer starts in to clean out a hollow tooth when you are in the operating chair!

Steam and exhaust ways

THE steam passages must be drilled to miss the screws which hold on the covers, so take a look at the illustration showing them. Make three centrepops in the position shown by the black marks, close to the cylinder bores, and from these, drill into the port with a No. 40 drill. This can be done on a drilling machine, if the casting is first set on the slope in a machine-vice on the table, and the drill pulled down outside the casting, the angle at which same is held in the vice being set so that the drill will break into the side of the port. As the ports aren't over the centre of cylinders, this needs a different angle of tilt for each hole; but as it is only the work of seconds to sight the drill, the job is neither long nor difficult. Tip: grind the drill a wee bit off-centre, so that it drills a hole a little bigger than itself. Then, if it breaks, which small drills take a delight in doing in inexperienced hands, the bits can be shaken out and the casting won't be spoilt.

If the casting is held in the bench vice, with bits of soft metal at each side to prevent damaging the machined surfaces, the holes can easily be drilled with a hand-brace, holding same at such an angle that the drill makes a bee-line for the port. The danger point is just as the drill breaks through into the port, so be very careful to avoid a break of another kind. Wee drills cost muckle bawbees the noo, ye ken, as some of my ancestry would remark. When all six are drilled, file a bevel at the end, as shown in the section, so that steam has a free entrance into the cylinder bore when the covers are on; a watchmaker's square file will do this very well.

On the vertical centre-line at each side, and 1/4 in. below portface, drill a 7/32 in. hole cutting right into the exhaust port for half its length. This forms what Pat calls the entrance to the way out. On the portface itself, at 1/4 in. from the edge, and in line with the exhaust ports, drill a 7/32 in. hole straight down into the one previously drilled. Tap the ends of the horizontal holes 1/4 in. x 40 and screw in two little plugs 1/8 in. long, made from 1/4 in. brass rod. These plugs mustn't reach farther than the edge of the vertical holes, or they will tend to choke the exhaust, and that is fatal.

Last drillling job is the oil duct. At 1/2 in. from the front edge and on the centreline of portface, centrepop and drill a 1/16 in. hole right through the casting, between the bores. This must be done on a drilling-machine or lathe, to avoid any chance of getting too close to the bores. Warning to beginners—don't attempt to make a nonstop run, or you've had it. Withdraw the drill every one-sixteenth or so, to clear the chips from the flutes, otherwise the drill will choke, seize, and break. When through, turn the casting over, open the hole for 3/16 in. depth with 5/32 in. drill, and tap 3/16 in. x 40 for the oil union.

Cylinder Covers

Each front cover is chucked by the chucking-piece provided on the casting, and faced off with a knife tool, the spigot or register being turned to fit the bore, but only a full 1/32 in. deep. Face the contact flange, and turn the cover to 1 5/8 in. diameter. The chucking-piece can be sawn or parted off. To turn the face, either grip the cover truly in three-jaw by the edges, or better still, in a stepped ring. This is a ring of brass about 2 in. diameter, 1/2 in. wide and about 3/8 in. thick The outside has a 1/8 in. step 3/8 in. long turned on it, to hold in three-jaw. The face has a recess cut in it with a parting-tool, about 3/32 in. deep, just big enough to take the cover. It is cut through on one side with a hacksaw. If the cover is placed in the recess, and the step held in the three-jaw, tightening the chuck closes in the ring on the cover, and it is gripped tightly enough to allow it to be faced off without hurting the edge in any way. I make them with several recesses to take different-size covers.

The contact side of the back covers is turned the same way (be sure to turn the spigots or registers an exact fit in the bores) but before removing the chuck, centre and drill right through, with 7/32 in. or No. 2 drill. Reverse, and hold by edge or in stepped ring. Saw or part off the chucking-piece, face the gland boss to size shown, open out the hole to a full 1/4 in. depth with a pindrill a bare 11/32 in. diameter, and tap 3/8 in. x 32. If an ordinary drill is used for opening out, it is a 1,000-to-1 chance that the two holes won't be dead in line, and the gland will bind on the piston-rod. Face off as much of the outside as you can without cutting into the gland boss; the parts not turned, can be finished with a file.

A piece has to be cut off each side of each cover, to allow them to fit on the cylinders. Put a back cover (the one with boss) in place with the boss horizontal, as shown in the drawing. Scribe a line down the centre of the cylinder block, using a try-square with the stock resting on edge of portface. The line should cut across the edge of the cover. Repeat operation with the other cover, removing the first for this purpose. Now carefully file or mill the edges of the covers to the marked lines. Replace with the two filed edges touching, as shown in the back view. Then file the outer edges flush with the sides of the cylinder block. The front covers are fitted in the same way.

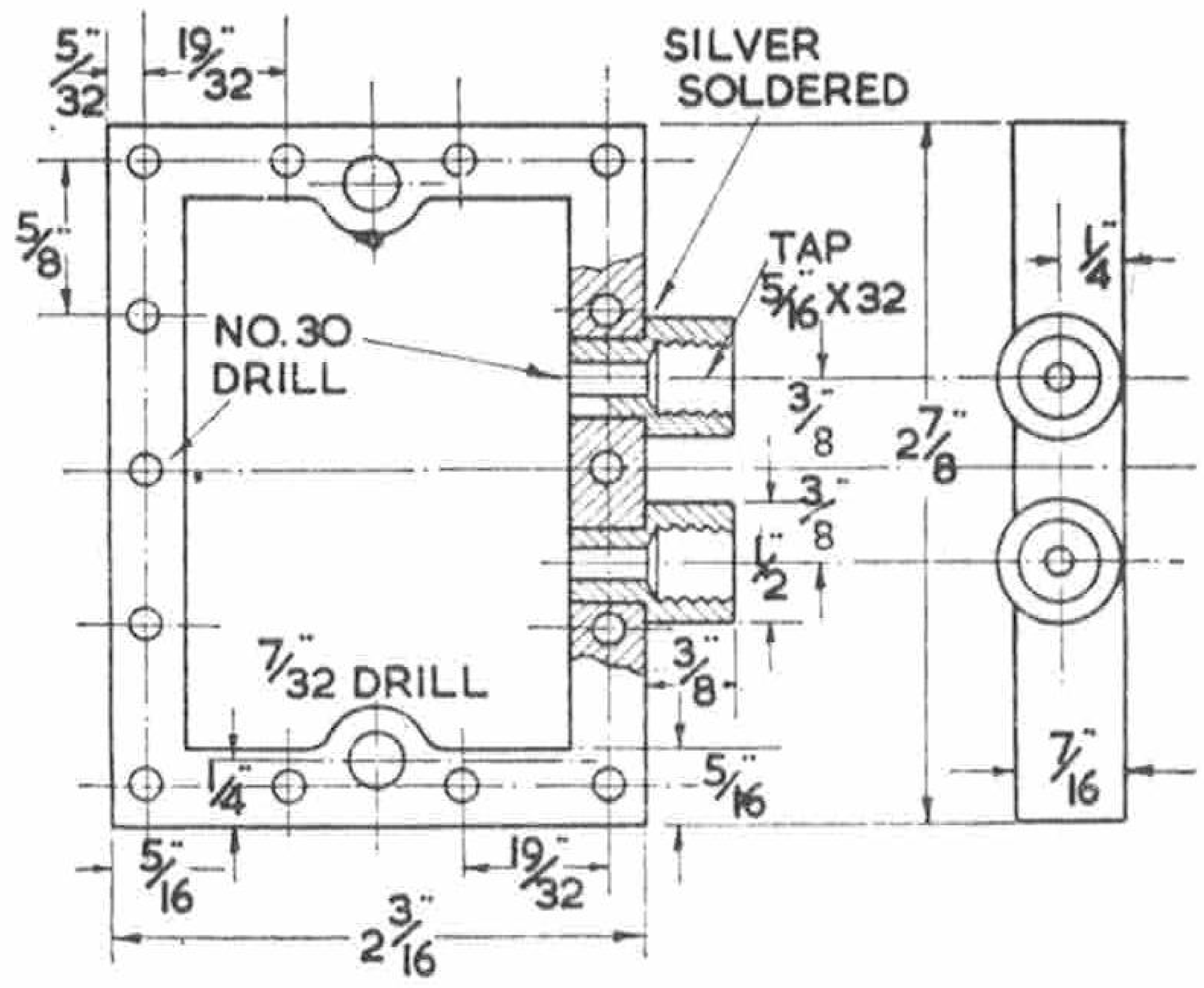
Drill the screwholes by aid of a jig. This is simply a steel washer 1 5/8 in. diameter, with the hole in it bored out to fit over the spigots or registers on the inside of the covers. File a straight piece on each side, exactly matching the covers. On this, carefully set out the location of the screw-holes as shown, centrepopping and drilling them with No. 41 drill. Smooth off any burring, then clamp the jig to the inside of each cover in turn, with the flats at each side lining up, and put the No. 41 drill through the lot. Each cover will then have the screwholes exactly alike and in the right places.

Next, put both front covers on; stand the block, covers upward, on the drilling-machine table, and with a No. 41 drill in the chuck, make countersinks on the flange of the block, through the holes in the covers. Ditto-repeato with the back covers—and then you have a nice little repetition job! Drill through all the countersinks with No. 48 drill, to about ¼ in. depth, and tap the holes 3/32 in. or 7 B.A. This job requires care and patience. It is one of the easiest things in the world to break off a tap in a blind hole, like those in the solid part of the cylinder block. The best way is to start with a taper tap, and finish with a plug tap, turning the latter back and forth until it goes "hard", indicating that it has reached the end of the hole.

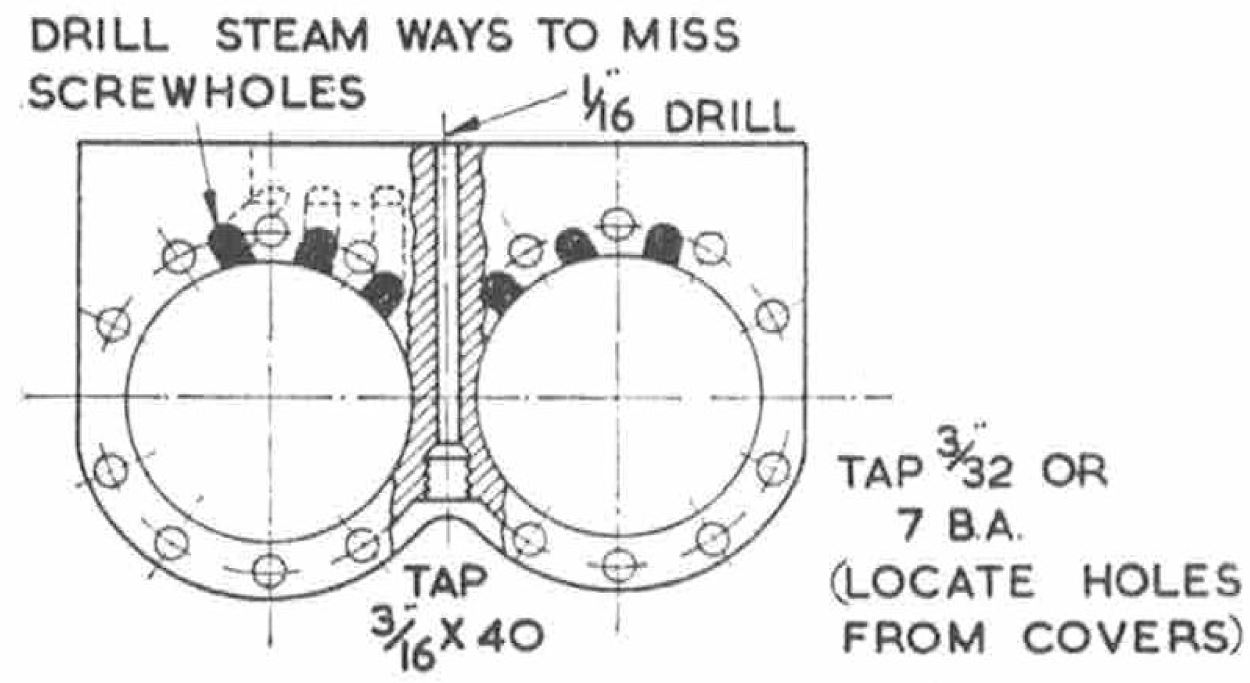
Another warning to beginners; don't attempt to drill these screwholes by hand. If you haven't a drilling-machine, use the lathe. Put the No. 48 drill in the three-jaw, and hold the casting against a drilling-pad in the tailstock. I made my first drill-pad from a broken drill with a taper shank, and a wheel casting. The casting was chucked in three-jaw, faced, and a hole drilled through it, into which the broken stub of drill was tightly driven, leaving the taper shank sticking out. This shank was then put in the taper hole in the mandrel, and the wheel casting turned on the rim and faced off truly. When I eventually sold the lathe, to get a better one, the improvised pad went with it; and for all I know, it may still be in use! It certainly did the trick all the time I had it.

Pistons and Rods

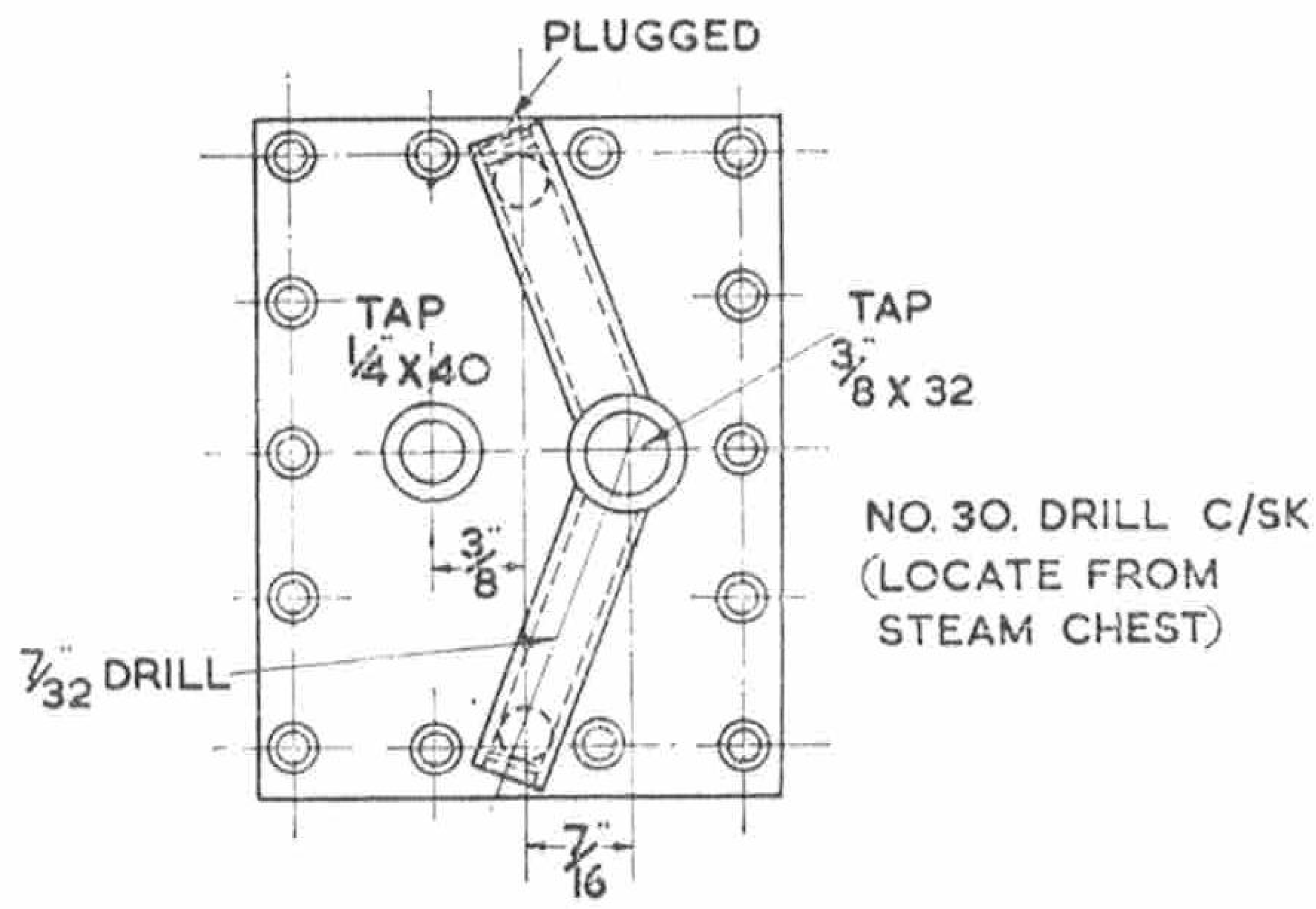
Before describing piston-fitting, just a word of warning to those good folk who are building their first locomotive. You want your engine to deliver its power at the drawhook, not waste it in overcoming internal friction; and to do just that, one of the essentials is that the pistons should be fitted so that they are steamtight, but not mechanically tight. They should be turned to an exact sliding fit in the cylinder bores, and be dead true on the piston-rods; the packing should merely act as a seal, and not be relied on to make up for bad workmanship. I once had a friend—now, alas! long since passed to the Great Beyond—who was a director of the Great Western Railway, and was keenly interested in little engines. He had ten of 2½ in. gauge built by a Sheffield firm now defunct. They were spirit-fired, with water-tube boilers. Not one of them would pull a light train continuously, and lost steam even when running light. I rebuilt the lot, and turned them into live passenger-haulers. One of the troubles was badly-fitted pistons, with rods out of centre, and packing jammed so tightly in the grooves, that it required considerable effort to move them by hand. Easing the packing promptly allowed steam to blow past. I rebored the cylinders, fitted new pistons and rods in the manner described below, and reduced friction to the minimum. One of them pulled my weight for over half-an-hour non-stop on one charge of spirit and water. Comment is needless.



STEAM CHEST



HOW TO DRILL STEAM PASSAGES AND OIL DUCT



PLAN OF STEAM CHEST COVER

For *Mona's* piston-rods, two pieces of 7/32 in. rustless steel or hard-drawn phosphor-bronze rod will be needed, squared off at each end in the lathe, to 3¼ in. length. Chuck each in three-jaw, and with a die in the tailstock holder, put ¼ in. of 7/32 in. × 40 thread on the end.

The pistons can be turned from 1¼ in. hard-drawn bronze rod, or from cast gunmetal stick, or if an old alloy car-engine piston is available, melt it down and cast it into a stick 1¼ in. diameter. A short piece of thick cardboard tube does for a mould, but it must be dry. Chuck any of above in three-jaw, and turn down about 1¼ in. length to 1-9/64 in. diameter. Face the end, centre, and drill to 9/16 in. depth with 3/16 in. drill. With a parting-tool, cut a groove ¼ in. wide and ¼ in. deep, at ⅛ in. from the end, then part off at ⅛ in. from the groove. Repeat process for second piston-blank. Chuck one in three-jaw, open out the hole for ¼ in. depth with No. 3 drill, and tap the remains of the hole 7/32 in. × 40. Put a piston-rod, thread outwards, in the tailstock chuck, gripping it very tightly; run it up to the piston and enter it in the hole, pulling the belt by hand. The thread will drag the plain part of the rod into the enlarged end of the hole, so that the piston fits on the rod in exactly the same manner as a chuck on a precision lathe; I never fit pistons in any other way.

If the lathe has collets, grip the piston-rod in one of suitable size, and carefully turn the piston to an exact sliding fit in the cylinder bore, using the cylinder itself for a gauge. There should be no shake whatever. If collets are not available, use a split bush. Chuck a bit of ⅜ in. round rod in the three-jaw; ½ in. length will be plenty. Face, centre, and drill through with No. 4 drill, following with 7/32 in. reamer. Make a mark on the bush opposite No. 1 chuck-jaw. Remove from chuck, and saw the bush through with a thin backsaw, along one side only. Replace in chuck with the mark opposite No. 1 jaw, grip just tight enough to prevent slipping, and run reamer through again. If the chuck is now slacked, the piston-rod can be inserted in the bush, and tightening the chuck grips the rod perfectly true. Finish-turn the piston as above, and take a slight skim off the end to true it up.

Piston-glands

Owing to the restricted space between the guide bars, we can't fit the usual type of gland with a big slotted flange, but that doesn't matter. The easiest thing to do is to dispense with the heads altogether. Just chuck a piece of 7/16 in. or ½ in. round bronze or gunmetal rod in the three-jaw; face, centre, and drill to 7/16 in. depth with No. 3 drill. Turn down about ½ in. of the outside to ⅜ in. dia. and screw ⅜ in. x 32. Tip to beginners: Adjust the die to "cut large" by setting the screw on the die-holder into the slot in the die; and after screwing try the cover on. The gland should fit the tapped hole fairly tightly, so that it can't slack back of its own free will and accord, when the engine is running. If that little—ah, um!—so-and-so came adrift when *Mona* was doing the knots in the approved style, and got caught between the crosshead and the stuffing-box, something would happen, and mighty quick at that! I've seen the effects on a big engine.

Part off at ⅜ in. from the end, ditto repeato operations, then cross-slot one end of each with a hacksaw. To hold them, drill and tap a ⅜ in. x 32 hole in a bit of ½ in. square brass about ¼ in. long which makes a square nut of it; slot one side with a hacksaw, run the tap through again to clean out the burring, and screw in the gland. Put the lot in the bench vice, tightening it just enough to prevent the gland turning in the nut, and you can saw the slots across the end without hurting the threads. Finally poke a 7/32 in. reamer through the hole, which should then fit the piston-rods exactly. If your lathe has collets, you could make the glands from ⅜ in. round rod and there would be no need to turn the outside; but with the average chuck, the safest way is as described above.

Steam Chest

A steam chest with separate gland bosses is shown, because this enables the contact faces to be machined in the lathe. First clean up the outside with a file, then chuck in four-jaw—see that the casting sets right back against the flat part of the jaws—and face right across with a roundnose tool set crosswise in the rest. Reverse in chuck, and face off the other side until casting is 7/16 in .thick. On one of the long sides, scribe a line 3/16 in. from the edge; mark the centre of it, and at ⅝ in. each side of this make a heavy centrepop. Drill through the wall with a 9/32 in. drill; both holes must be parallel with the turned faces, and with each other, so use drilling-machine or lathe, holding the steam chest in a machine-vice by its machined faces. The holes for the screws can then be set out and drilled No. 30, and the two for the exhaust outlets with 7/32 in. drill. These should line up with the corresponding holes in the portface. All the holes must go through dead square with the contact faces, or there will be trouble when assembling.

To make the bosses, chuck a piece of ½ in. round bronze or gunmetal rod in three-jaw, face the end, turn down 5/16 in. length to 9/32 in. dia. a tight fit in the holes in the wall of the steam chest, and part off at ⅜ in. from the shoulder. Reverse in chuck, gripping by the 9/32 in .spigot; centre, drill right through with No. 30 drill. open out to 5/16 in. depth with a pin-drill a bare 9/32 in. and tap 5/16 in. x 32. Press the bosses into the holes in the steam chest wall, and silver solder them, using either best grade silver solder, or Easyflo. Just smear a little wet flux (powdered borax, or Easyflo flux, mixed to a paste with water) around the bosses, heat to dull red and touch the joints with the strip of silver solder. It should melt immediatey and run around the boss in a neat fillet. Quench in acid pickle, wash off and clean up. For these small jobs a handy pickle-bath is an earthenware jar containing some stale accumulator acid mixed with three times its bulk of water.

To make the glands, chuck a piece of ⅜ in. bronze or gunmetal rod in three-jaw, face, centre, and drill down to about ½ in. depth with No. 30 drill. Turn down ¼ in. of the outside to 5/16 in. dia. and screw 5/16 in. x 32. Part off at ⅛ in. from shoulder, reverse in chuck and skim over the end, and cut the slots in the flange with a fine hacksaw; as with the piston glands, these spindle glands should be a good fit, to prevent slacking off when running.

Steam Chest Cover

The steam chest cover called for a little judicious wangling, as I aimed at avoiding both external pipe connections, and having a central exhaust pipe through the steam chest . On my own engine I just used a piece of ⅛ in. brass plate for the cover, and drilled two holes in it, for the exhaust steam to come through. These, of course, correspond to those at the sides of the steam chest. Then I made up the fancy pipe assembly shown in the photos. A piece of ⅜ in. x 20-gauge pipe forms the blastpipe, and is screwed to take the nozzle, not yet made. Two holes were drilled close to the bottom of this, and two pieces of ¼ in. x 22-gauge pipe fitted in. On the other ends of these were fitted two brass bosses, in such a position that they lined up with the exhaust holes. The whole assembly was then set on top of the brass plate, and silver soldered at one heat. It panned out O.K. as you can see The blastpipe was set on the cover at such an angle that it stood vertically when the cylinders were set in the frame at their proper inclination. The steam pipe was also fitted vertically, and silver soldered at the same heating. Anybody who fancies their skill at small plumbing and silver soldering, could perform the "follow-my-leader" act with advantage. It certainly makes a neat strong job.

For those who prefer to work up a casting, steam chest covers will be available with ribs and bosses cast on as shown. Centrepop the blastpipe boss, set the casting in a machine-vice at approximately the same angle that it will be in the frames, and drill to 5/16 in. depth with 11/32 in. drill. Don't go too deep and break right through! At the same setting, drill the steampipe boss 7/32 in. and this time go right through. Tap ⅜ in. x 32, and ¼ in. x 40 respectively. Next centrpop the ends of the ribs at the sides of the cover, and drill with 7/32 in. drill, right into the blastpipe boss. Tap the ends ¼ in. x 40 and fit plugs made of brass rod. At each side, drill a 7/32 in. hole from the underside of the cover, into the hole in the rib; these must correspond to the exhaust ways in the sides of the steam chests.

Now chuck the cover, plain side out, in the four-jaw, setting to run as truly as possible, and take a cut right across it, so that it will make true contact with the steam chest. If the four-jaw isn't deep enough to take it, and the bosses foul the jaws, rub it on a piece of coarse emerycloth or similar abrasive, laid on something perfectly flat, such as the drilling-machine table; the resulting matt surface will be perfectly steamtight with a bit of jointing material between it and the steam chest.

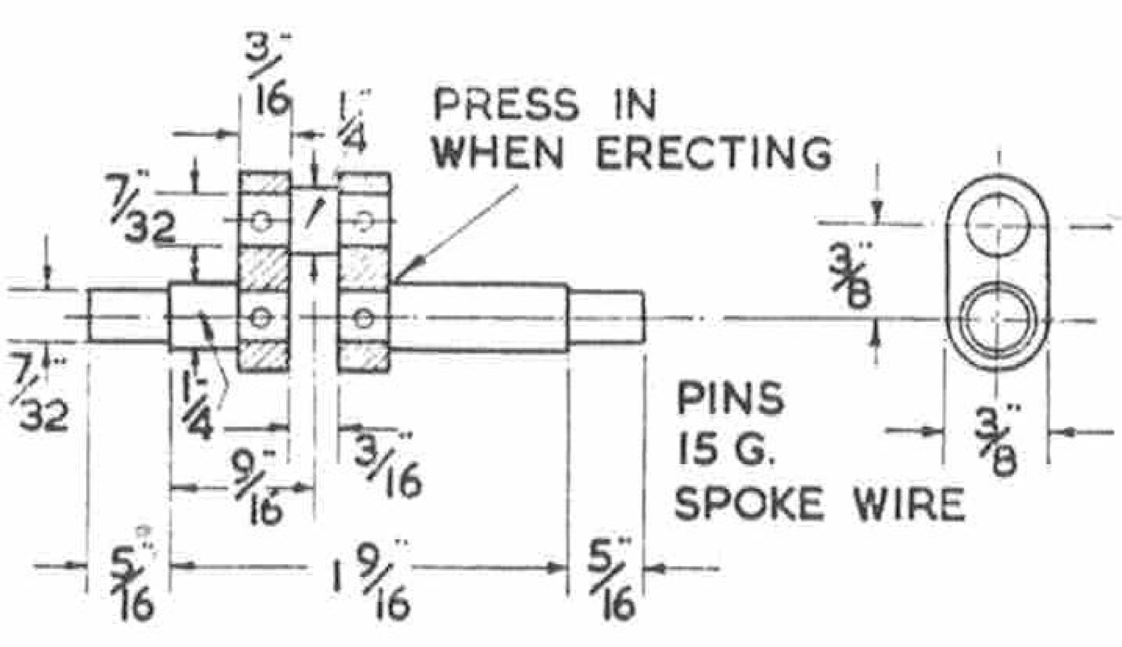
Finally, clamp the cover to the chest with a toolmaker's cramp and run the No. 30 drill through all the screwholes in the chest, and right through the cover; that makes absolutely certain that they line up. Then set the steam chest on the portface, lining it up carefully with the cylinder casting, and clamp it there. Run the No.30 drill through the screwholes and make countersinks on the portface. Remove steam chest, drill the countersinks No. 40 and tap them ⅛ in. or 5 B.A. Don't go too deep, about 5/16 in. is plenty. Tip to beginners—when tapping, hold the cylinder block in the bench vice with the portface vertical, and parallel to the side of the jaws; use a small tap-wrench, hold the tap horizontal and dead square with the portface, and support it with your left-hand fingers as close to the portface as you can, while tapping. About 50 per cent. of broken small taps, is caused by inadvertant side pressure, and much of the rest by bottoming in blind holes. Keep turning the tap back and forth, and at the slightest sign of "sticking," withdraw it and clear the chips. My munition girls in the Kaiser's war tapped thousands of little blind holes, and casualties were very few indeed.

Slide valve and spindle

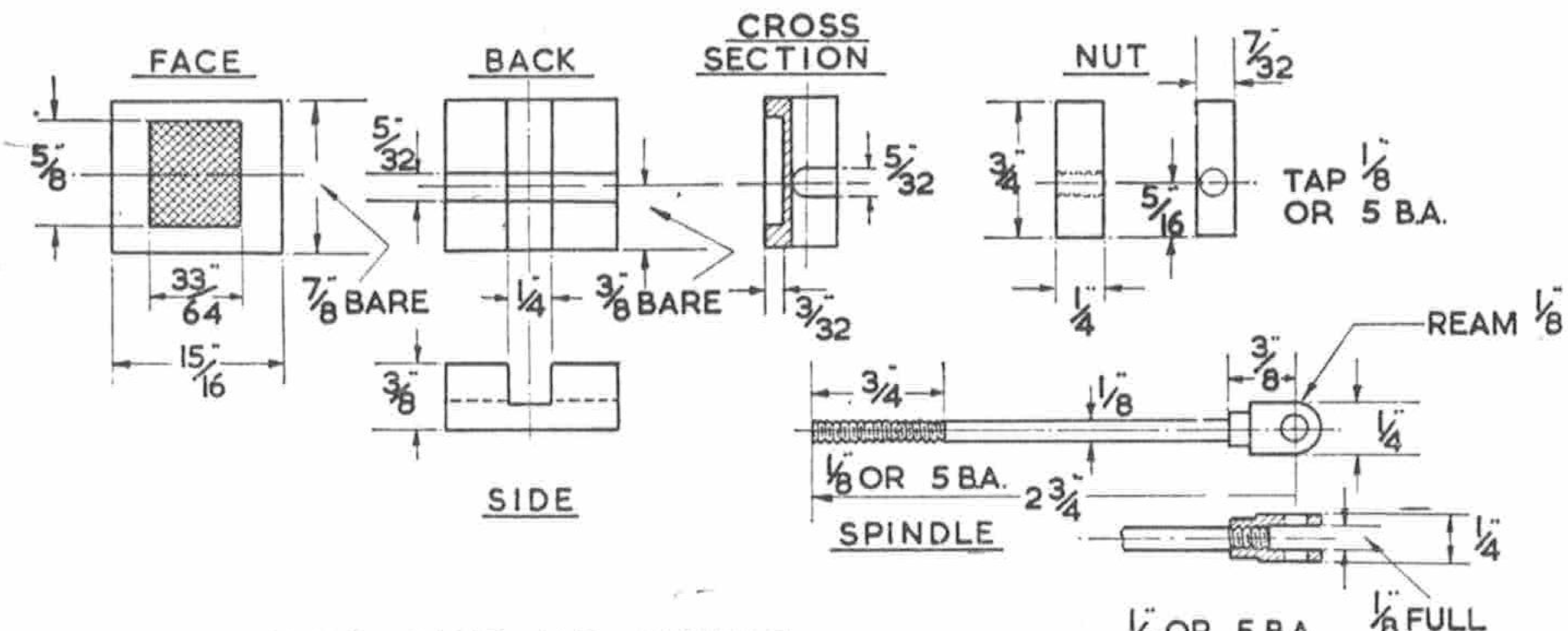
It is quite likely that castings will be available with the exhaust cavities cast in; if so, it will only be necessary to check up on dimensions, and finish the edges with a small chisel. Otherwise the valves can be made from 1 in. x ⅛ in. bronze or gunmetal bar. Saw off 1 in. lengths, and clamp them together in the four-jaw chuck with the sawn end projecting. Face this off, then reverse in chuck, and face off the other sawn end until the blocks are a bare ⅞ in. wide. Now turn them halfway around in the chuck, and face off the projecting side until the blocks are 15/16 in. across, and there are your valve blanks. As simple as that!

Coat one side of each with marking-out fluid, and mark out the exhaust cavities. If the lathe has a vertical slide, hold each valve blank in a machine-vice attached to it, with the marked side facing the headstock, and parallel with the faceplate. Then, with the cutter used for milling ports, held in three-jaw, the cavity can be milled out by the same process as port-cutting. Rounded corners don't matter, but dont go deeper than 3/32 in.

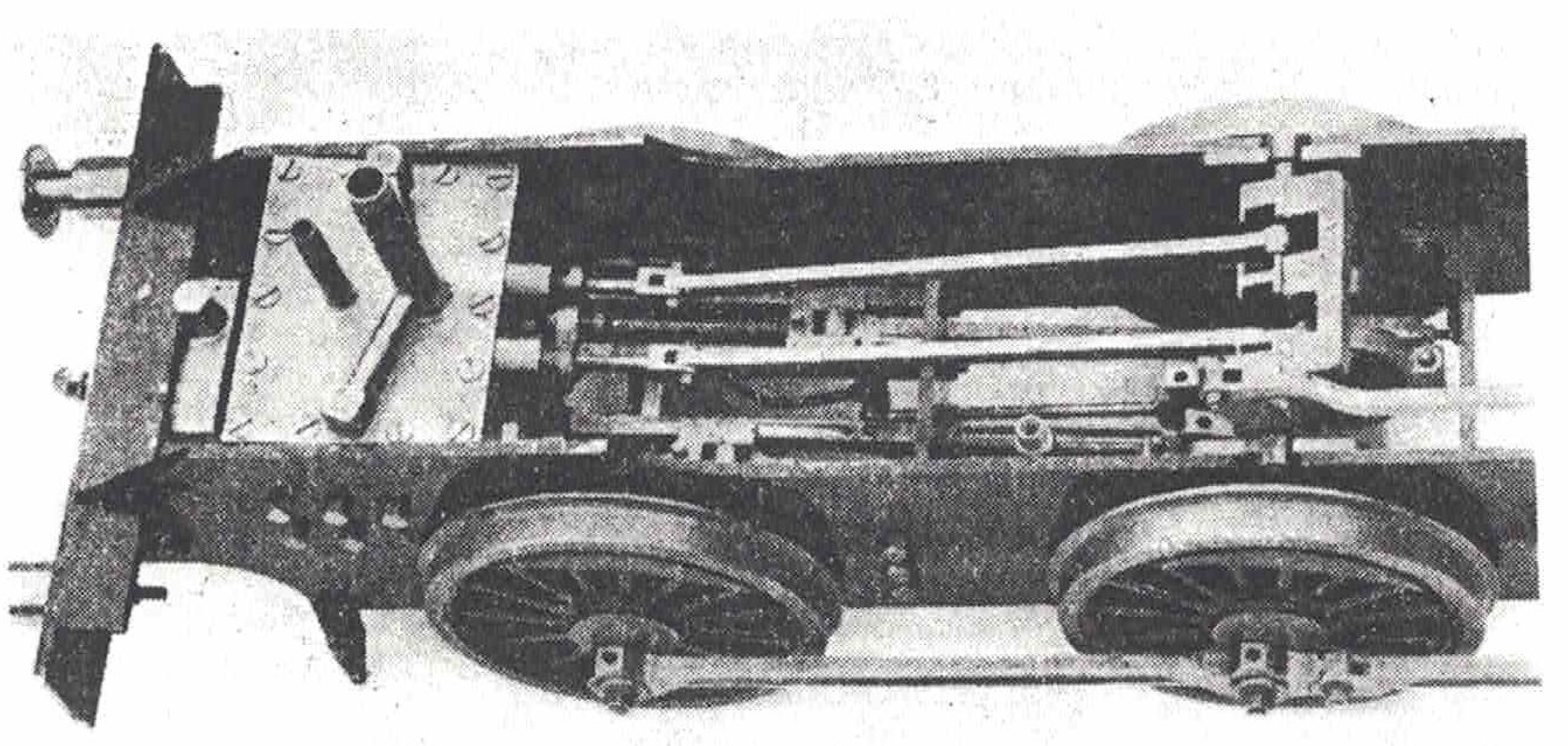
There is another well-known dodge which I used in days gone by, viz. cutting the cavity in a piece of sheet metal by drilling a hole slightly smaller than the cavity, filing it to dimensions required, and silver soldering a block to it, to make up the thickness of the valve. This can be used in the present case if a piece of good hard bronze 3/32 in. thick is available, but don't use ordinary soft sheet brass, or the valves won't last the proverbial five minutes. The piece of



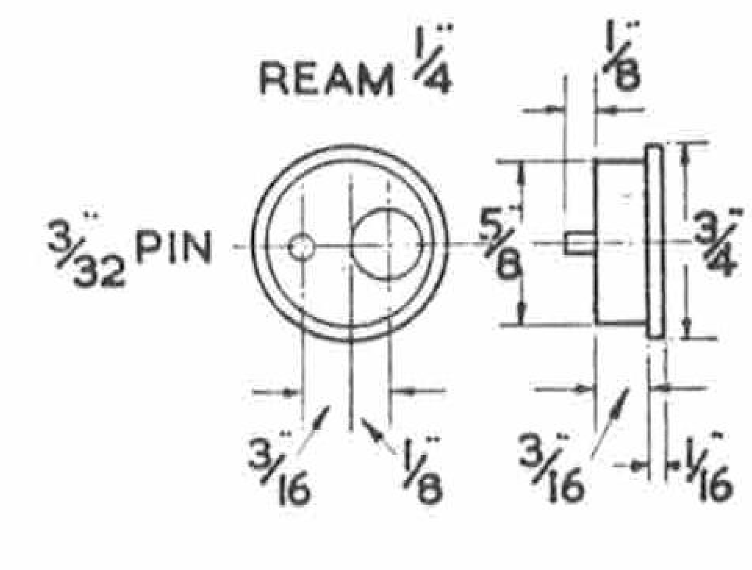
CRANK AXLE



SLIDE VALVE AND SPINDLE



Progress of Curly's Mona goes on apace! Here we have cylinders, valve gear and punp erected



ECCENTRIC

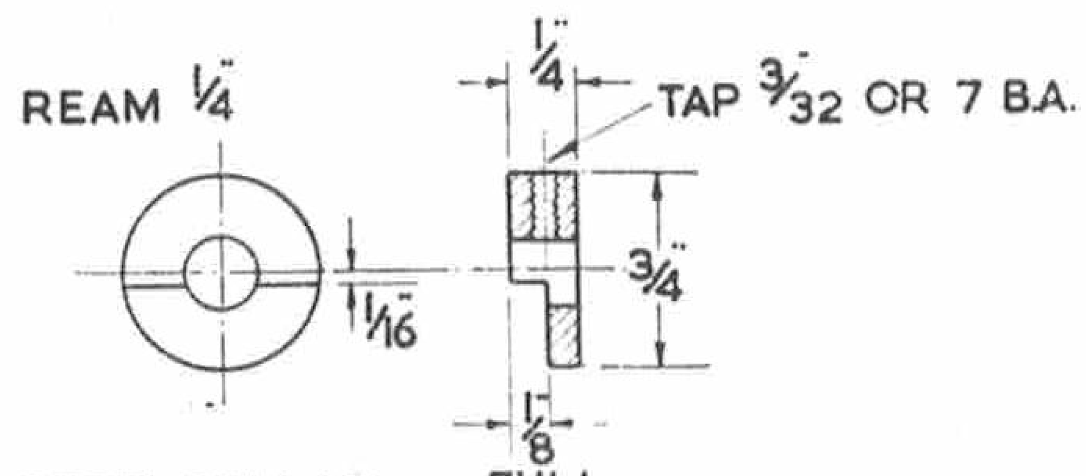
sheet metal should be cut a little larger than the finished valve face. The make-up block can be of brass, 1/4 in. thick, and length and width as given. When silver soldering, lay the block in the brazing tray and set the valve face on it, putting some wet flux between. Put a weeny bit of silver solder in the cavity, and with a piece of stiff wire in the hand that isn't holding the blowlamp or blowpipe, press on the face to prevent it moving. When the silver solder melts and disappears between face and block, wait until the redness has gone before you let go. Pickle, wash and clean up, and then file or mill the valve to size.

The cross slots for nut and spindle can be endmilled with the valve either held in a machine-vice on a vertical slide as mentioned previously, or clamped under the slide-rest tool-holder at height required, as when milling axle boxes. They can also be cut with a saw-type cutter on an arbor between lathe centres, if the valve is held in a machine-vice, regular or improvised, bolted to the saddle, the valve being set in the vice at the proper height. Don't attempt to cut them by hand. They can also be cut in a planer or shaper, holding them in a machine-vice on the table, and operating with a parting-tool in the clapper-box. I have a dinky planer, and although I do most of my flat-and-grooved work on my milling machine, there are times when a lathe tool in the planer saves a lot of setting-up.

The valve spindle is a piece of 1/8 in. round rustless steel or hard-drawn bronze rod, 2 5/8 in. long. Put 3/4 in. length of 1/8 in. or 5 B.A. thread on one end, and 3/16 in. same pitch on the other, holding the rod in chuck, and die in tailstock-holder, to ensure truth. The fork, or valve crosshead, is made from 1/4 in. square mild steel. Take a piece about 2 in. long and drill a No. 32 crosshole about 3/16 in. from each end, then slot down 1/8 in. wide and about 5/32 in. deeper than the crosshole, by the method described for slotting the coupling-rods. Round off the ends, then saw off the pieces about 7/16 in. behind the crosshole. Chuck truly in four-jaw with sawn ends outwards; face off, centre, drill No. 40 and tap 1/8 in. or 5 B.A. to match valve spindles. The nuts are just 1/4 in. lengths of 1/4 in. square brass rod, with a crosshole drilled No. 40 at 5/16 in. from one end, and 1/32 in. off centre, and tapped to match valve spindle. True up portface and valves by rubbing them on a piece of fine emery cloth, laid business side up, on the lathe bed, or something equally flat and true.

Assembly

Pack the pistons with 1/4 in. braided graphited yarn;



STOP COLLAR

this, as sold, is a little bigger than 1/4 in. but is soft, so that it can be pressed into the grooves. Cut each length long enough to form a ring, and cut off the ends on the slant, so that when put together they form a scarfed joint like that in a motor piston-ring. The packing-rings will stand a shade above the grooves, but as you insert the piston into the bore, prod down the packing with a narrow screwdriver or similar implement, and the piston will then enter. When once in it should move fairly easily from end to end.

The joints between cylinder flanges and covers can be made of brown paper smeared with cylinder oil, 1/64 in. Hallite, or any similar jointing of good make. If desired, hexagon-head screws may be used to hold on the covers, excepting those in the back covers nearest the frames; these must have countersunk heads, to clear the axlebox flanges.

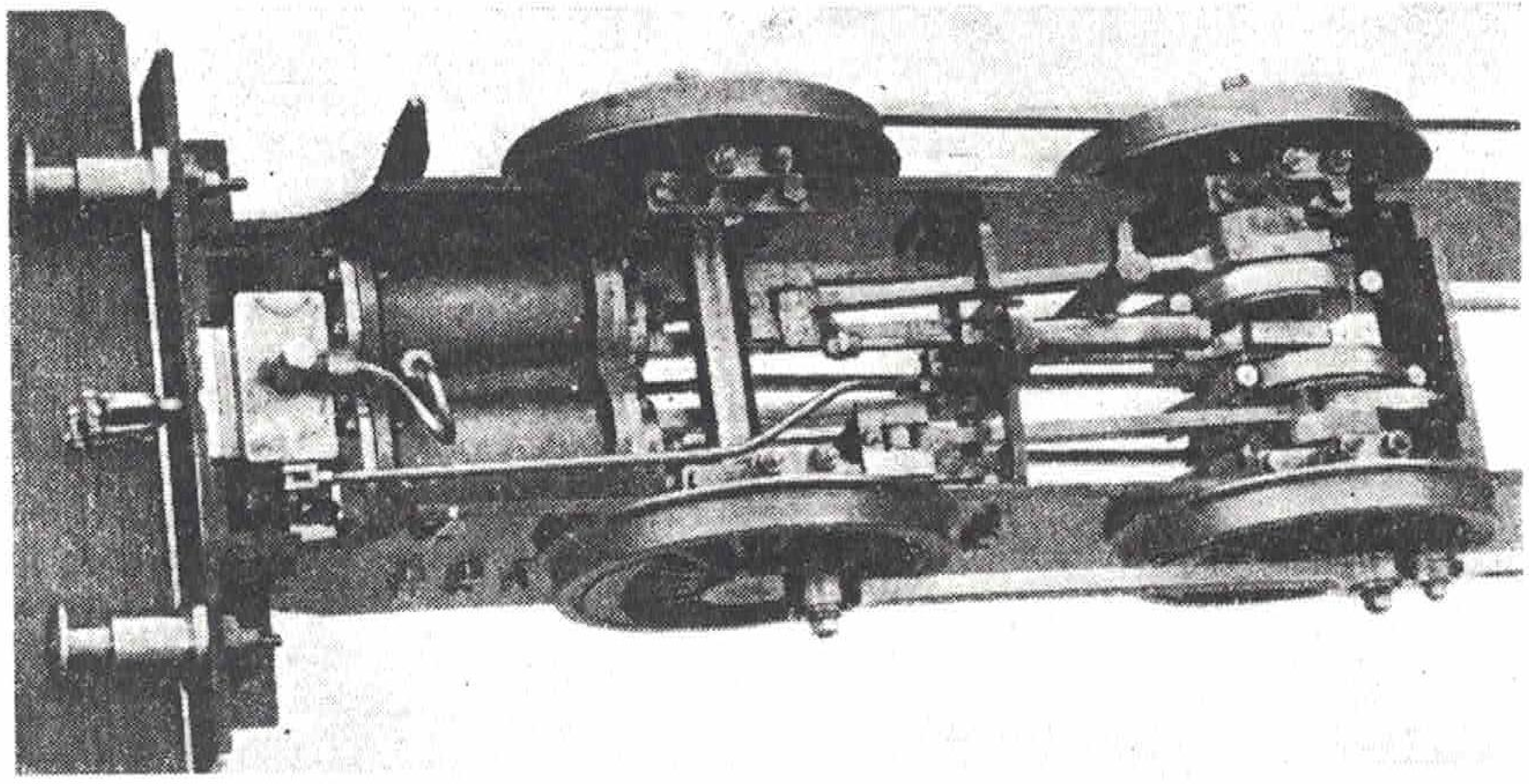
The steam chest joints are made from similar material. Cut them to the shape of the steam chest, lay one on the portface, put the chest over it, then put the slide-valves on the portface, with a nut in the groove. Insert the valve spindles through the glands, and screw through the hole in nut, about halfway down the thread Then put on the cover, with the blastpipe boss nearest the spindles, and secure with countersunk-head screws, 3/4 in. long. Poke your scriber down each hole before inserting screw, to pierce the packing. The glands are packed with a few strands of ordinary graphited yarn, such as Palmetto. Don't screw them up tight.

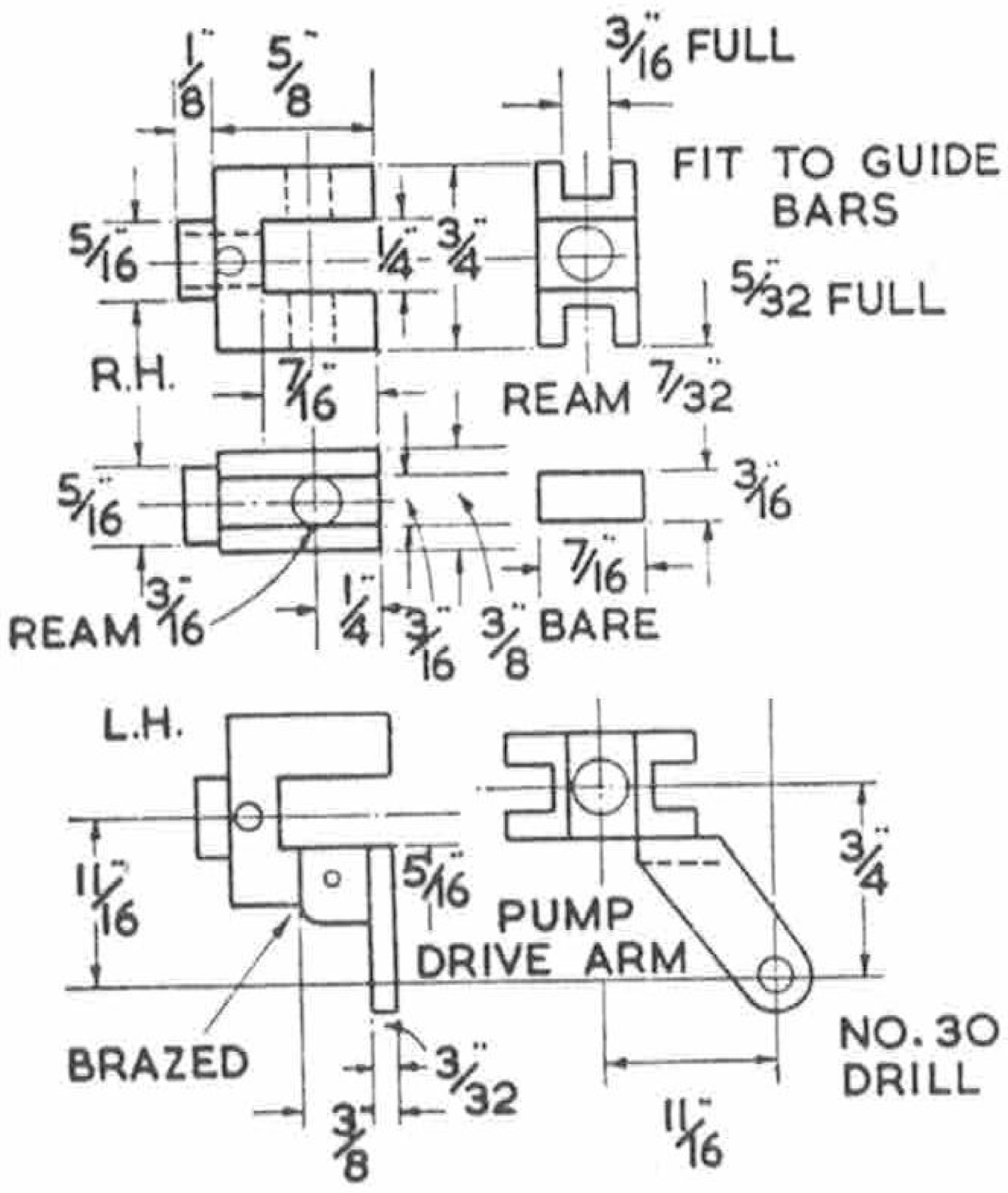
Components for 1 3/4 in. gauge engine.

The little kiddy only needs a single crank, as she only has one cylinder—but what that one can do, will surprise the uninitiated! It is made in much the same manner as the double one for "mum," using 1/4 in. round steel for shaft and pin. Note, however, that as the axle runs in one-piece bush bearings, it must be finally assembled in place, so leave out the longer end of the axle for the time being.

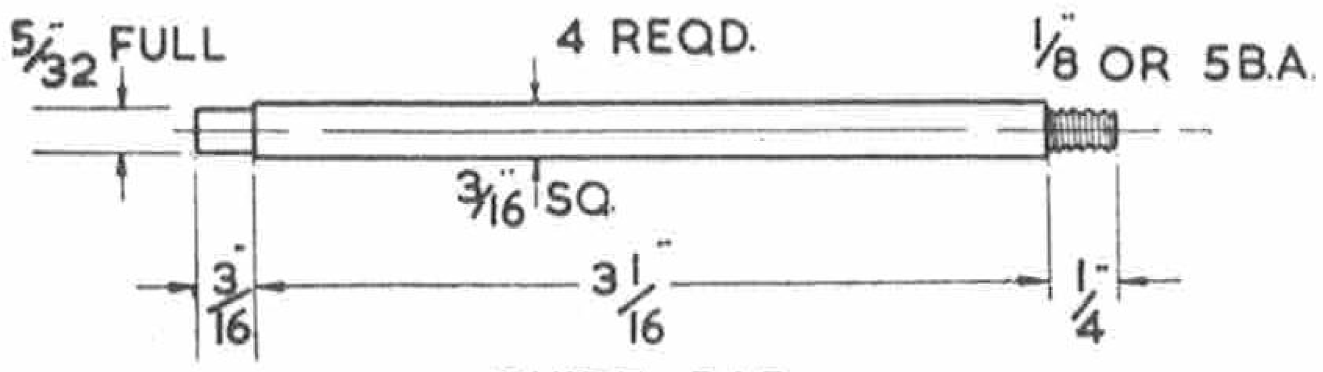
The little eccentric—only one is required—is turned from 3/4 in. round mild steel, by exactly the same

Another view, this time from beneath showing cylinders, radial valve gear and crosshead driven feed pump





CROSSHEADS



GUIDE BAR

process described for the 3½ in. gauge size. The stop pin is a piece of 3/32 in. silver-steel pressed into a hole drilled No. 43. If the end of the pin is slightly eased with a fine file while running in the lathe, it will start easily in the hole.

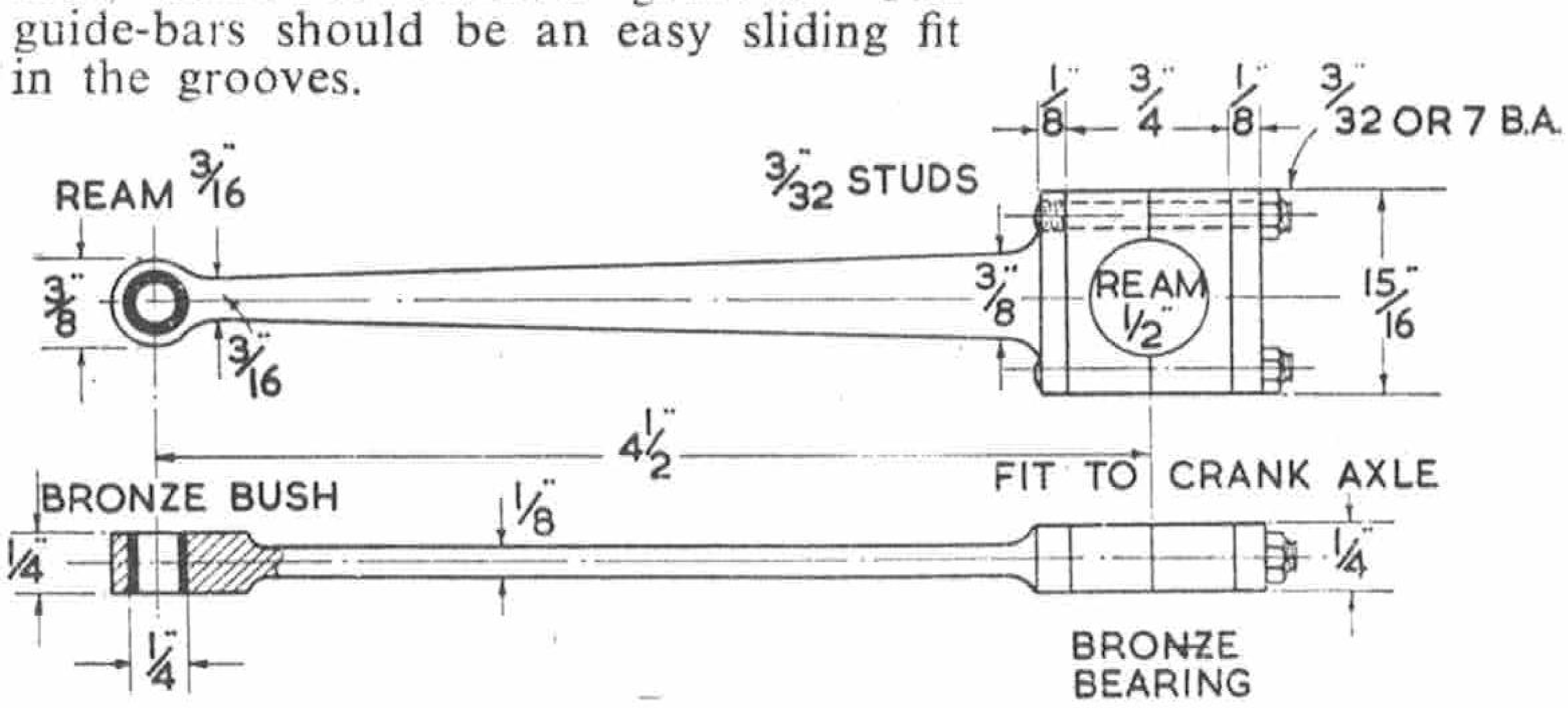
The stop collar is also turned from ¾ in. round steel, or brass would do. Chuck, face the end, centre, and drill to 5/16 in. depth with 15/64 in. drill. Part off at a full ¼ in. from the end. Saw or mill out a ⅛ in. segment as shown, coming to within 1/16 in. of the middle of the centre hole. If sawing, finish with a file to exact size shown. Right opposite, in the thickness of the collar, drill a No. 48 hole and tap it 3/32 in. or 7 B.A. for a setscrew. Finally put a ¼ in. reamer through.

To erect, insert the end of shaft with crank attached, through the bush in right-hand frame, from the inside. Then put the longer half of the axle through the other bush from the outside, and as it goes through, thread on the stop-collar inside the frame, with cut-away segment facing crank; then the eccentric with flange side next crank. Enter the turned-down end of axle into hole in crank, put a bit of 3/16 in. steel between the jaws to prevent them being crushed in, and press the axle into the crank web, pinning it as shown. Leave the packing between webs while the wheels are pressed on, with the cranks set at right angles as described for the larger engine. The coupling-rods can then be fitted, and the next job will be to make the little cylinder.

Guide Bars and Crossheads

The guide bars are made from 3/16 in. square steel; silver-steel for preference, but bright mild steel will do quite well. Cut four pieces a full 3¼ in. length; chuck truly in four-jaw, face the end, and turn down ¼ in. length to ⅛ in. diameter screwing ⅛ in. or 5 BA. Reverse in chuck and turn 3/16 in. of the other end to a tight fit in the holes in the gland bosses on the back cylinder covers. When reversing square stuff in the usual four-jaw chuck with independent jaws, slack jaws 1 and 2, and tighten same two again to same amount, after reversing the work, which will then run true without further adjustment. Incidentally, I have a four-jaw chuck with self-centring jaws, which is mighty handy for this sort of job. Make quite sure that all four bars are exactly 3-1/16 in. between shoulders, or you'll have a spot of bother when erecting them, as uneven lengths will pull the motion-plate lopsided.

The crossheads can be made from ⅜ in. × ¾ in. mild steel or hard bronze bar, cast or drawn. Kick off with a piece about 2 in. long. If you have a milling-machine, grip the piece in a machine-vice on the table, and run it under a 3/16 in. end-and-face cutter, cutting a groove a full 5/32 in. deep in each narrow side. This job can be done in similar fashion in the lathe, putting the cutter on an arbor between centres, and gripping the bar in a machine-vice, regular or improvised, bolted to the saddle. Set the bar at such a height that the full depth is taken at one cut; a Myford ML7 will do this easily on the slow speed, with the aid of a drop of cutting oil. Failing that, clamp the bar on its side under the slide-rest tool-holder, at centre-height, and form the groove with a 3/16 in. endmill or slot-drill, same as axlebox grooves. The guide-bars should be an easy sliding fit in the grooves.



CONNECTING RODS