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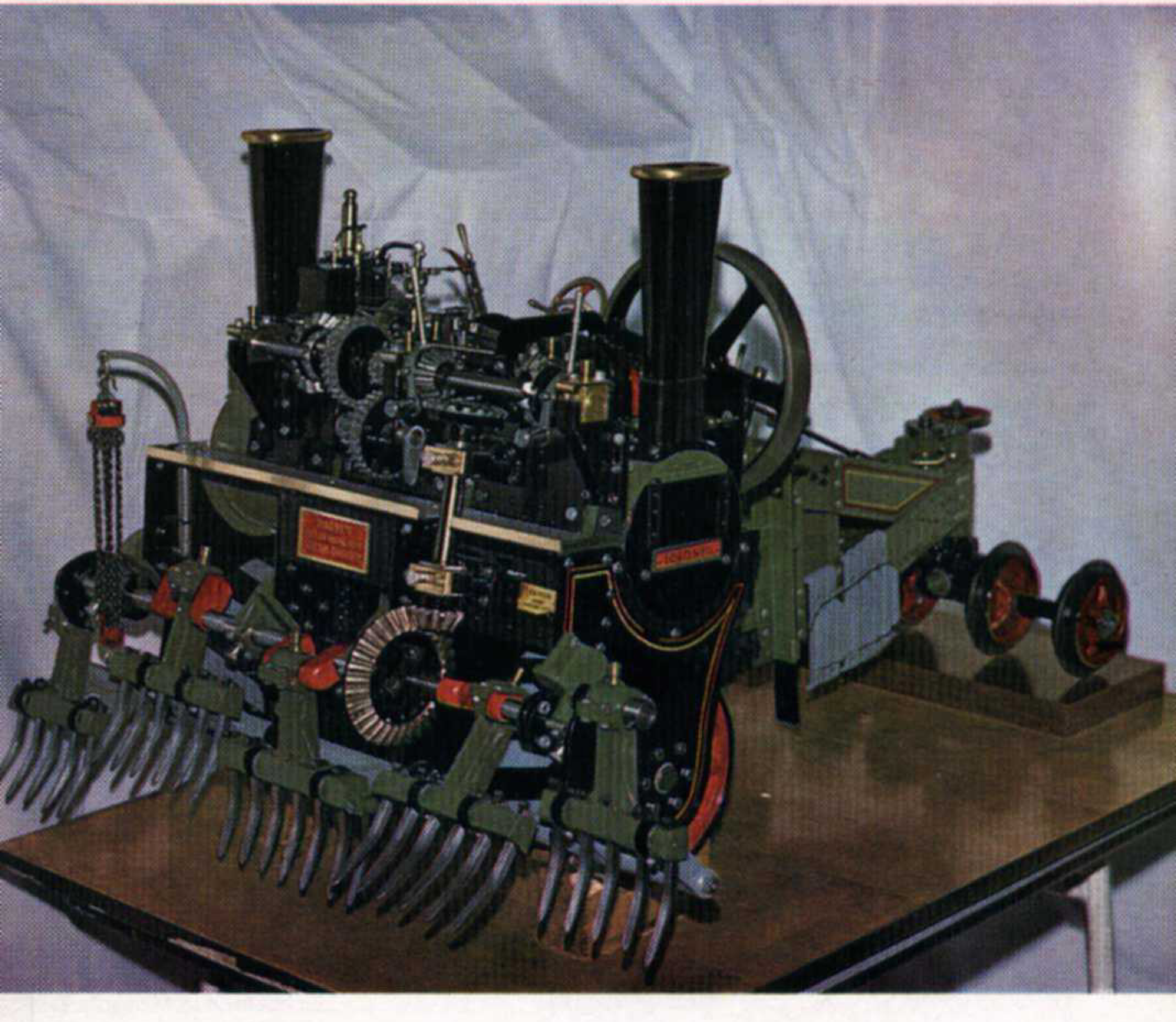

BUILDING A MODEL DARBY DIGGER

Model Engineer

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Volume 143 Number 3561
20 May 1977

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COVER PICTURE

The Darby-Savage digging engine described by Colin Tyler in this issue.

NEXT ISSUE

George Thomas on boring tools. Further details of the new locomotive "Greene King".

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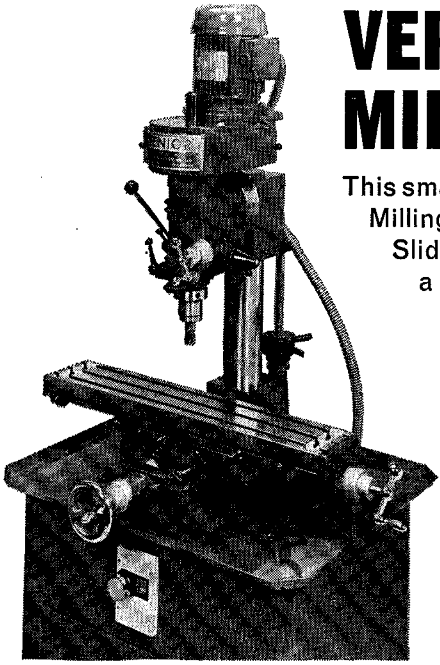

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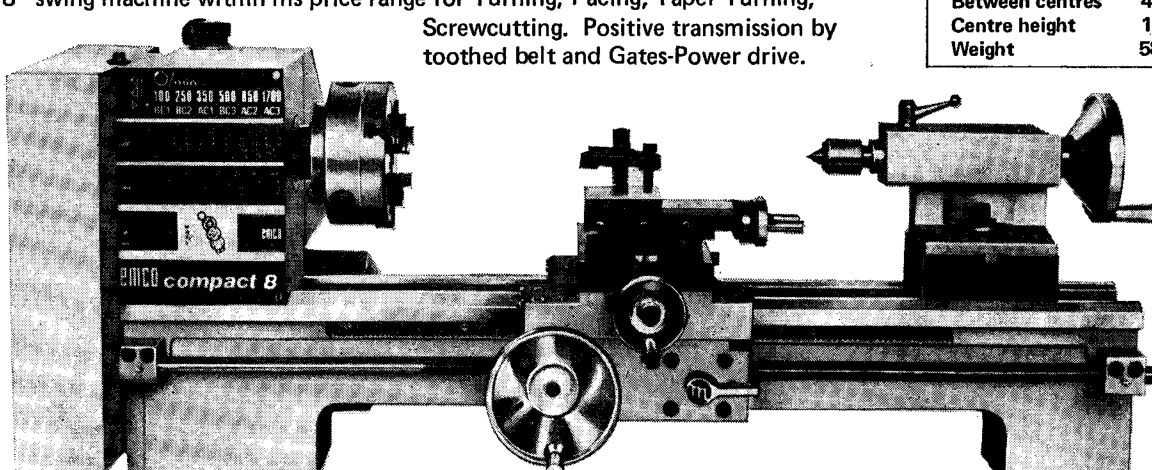

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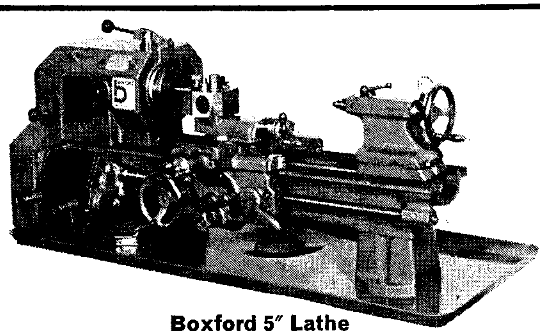

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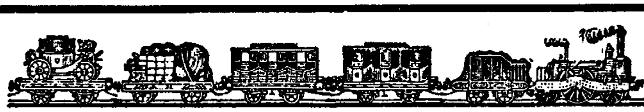

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SMOKE RINGS

A Commentary by the Editor

"Dickie" enjoying a run on "Curly's" old track.

Mr. D. J. Laidlaw-Dickson

Mr. Laidlaw (Dickie) Dickson, our Managing Director and Editorial Director, retired from the Company at the end of last month. We all much regret his leaving us and wish him every happiness in his retirement. He sends the following farewell message to our readers:

"Exit: pursued by a bear. No sadness of farewell . . . It has been a grand life with MAP— nearly half man's allotted span — doing for the most part, just the sort of things I would most like to have been doing anyway! Flipping the pages of memory one recalls early Dorland Hall Exhibitions, Eaton Bray Model Sportsdrome with its binding works, full-size Russon Cars, International Weeks, Grasstrack Racing, Air Shows, Showjumping and the excitements of a shoestring economy!

"Then, under Argus Press, the original trio of Stan Rushbrooke, Harry Hundleby and I when we moved to Watford; launching of *Radio Control Models* with Tommy Ives and launching electric model car racing with Geoffrey Deason.

"Harry went into engine manufacture, Stan, alas, died suddenly, which marked the beginning of another trio with Ron Moulton—only survivor of the Eaton Bray days!—and Vic Smeed, a happy partnership which has survived now for some twenty-five years.

"Together we have seen the acquisition of *Model Engineer, Model Railway News,* and the Percival Marshall model book range, the re-start of Model Engineer Exhibitions, *Woodworker* coming into our grasp, followed soon after by Fountain Press with its photographic magazines and books. Special highlights include the first *Aeromodeller Annual* in 1948, the "three-day week" M.E. Exhibition in 1973/4 held "against all expectations" in a period of economic gloom, driving steam locomotives on LBSC's Purley Oaks track and more recently on the footplate of Lord Gretton's mighty *Berkshire* locomotive at Stapleford Park.

"Above all, I must treasure the loyal friendship of Ron and Vic, the pleasure of seeing the young entry grow up and burgeon into responsible editors, Tony Dowdeswell, Alec Gee, Peter Richardson and now Ray Rimell; the splendid support of readymade editors such as Martin Evans and Tony Rose who have adapted so well to our way of things.

"Right across the board I have been blessed with my staff. Only three secretaries in over twenty years—Julie Baron, Sheila Ashby and Vena Pearman — plus countless young ladies in accounts, advertising, subscriptions, who have brought back their babies for us to praise. Then there is the hardworking plans department—again noted for longstaying staff—and the clever sales department under Sheila Hodgkins which has kept them hardworking with their orders (often interpreted from chaos) . . . I could go on . . .

"What was little more than a cottage industry in the immediate post-war years has grown into a worldwide leisure magazine group demanding an ever more specialist approach. The management cloak will, in future, be spread more widely with Gospatric Home, who has been understudying the part these last two years, assuming overall control as Managing Director, Ron Moulton, always the best known of us, takes on the complete Editorial Directorship (regretfully Vic Smeed is leaving to do his own thing, though retaining some ties with us) with group managing editors under him, a new exhibitions and promotions division, and Jim Connell holding tight to the financial reins . . . and I should add that we now have a computer!

"Yes, it is indeed a long haul from Eaton Bray, with one magazine, a single book-keeper, and a safe which would not always lock. In saying goodbye, thank you everyone for just being you, wherever you are. I have made innumerable acquaintances, some very good friends and I think

Continued on page 568

DARBY-SAVAGE DIGGING ENGINE

A most unusual model, built and described

Part II

by Colin R. Tyler

From page 432

OUT OF THE COMPLETE SET of thirty works drawings, twenty-eight survive. They are nearly all drawn on heavy cartridge paper which after nearly a century of being rolled up, will persist in staying rolled up when being used. A special tray with a heavy lid constructed for the purpose has had little effect on flattening them after three years, even with clamps to increase the pressure on them!

The drawings are neatly executed, the general arrangement sheets being inked in and colour washed, typical of the period. They seem to have been drawn as the engine was being constructed in Savages' works and indeed their system was to work to rough sketches issued by the foreman and the sketch used to work to in making the part. If the part was satisfactory then it was included in the main set of drawings by the drawing office, which when finalised were inked in and colour washed. The trouble with this system was that any subsequent modifications were rarely incorporated in the "finalised" drawings, or alternatively, the assembly was redrawn without reference to the parts which were altered, leaving this poor latter-day model engineer in an extremely confused state as to which of several differing parts were actually used in the full-size engine!

In February 1952 a photograph was published in this magazine showing the 6 h.p. digger at work. It is the survival of this photograph (reproduced p. 549) which finally confirmed many of the details which were actually used on the engine and it is doubtful whether the model could have been made with much guarantee of accuracy without it, due to the conflicting nature of the drawings.

Using the model digger is a somewhat unusual experience. At the time of writing the engine's performance has not been fully assessed. However, it is quite clear that ample power is available from the 1½ in. bore cylinder to dig a fairly soft soil, which must be without entangled grass roots or too large stones. Trials were carried out during the hot dry summer of 1976. The fascinating sight of the forks rhythmically plunging in and out of the soil was well worth the effort of building the model. Soil conditions were not ideal as the dusty texture did not provide enough grip to the straked wheels which tended to slip. Further trials on firmer ground were much more successful and a quite nice tilth 1½ in. deep was obtained.

In 2 in. scale (Fig. 1) the digger is a convenient engine to construct as all parts—including the cast wheels—can be turned on a 3½ in. gap bed lathe. The largest requirement is the 7¼ in. dia. flywheel which makes the Myford ML7 or a similar lathe ideal for the job. Perhaps those model engineers who have tackled up to 1½ in. scale previously may be persuaded that a 2 in. engine is within their workshop's scope.

The model is very heavy for its size—approximately 180 lb.—and as it stands on the ground, is not the most convenient model to transport, although detachment of the outrigger and the two outer sets of forks does assist considerably in reducing its overall size. To enable the engine to be lifted without the risk of bending shafts and damaging plates and paintwork, I have constructed a wheeled frame upon which the engine and outrigger sits, making the task of lifting the whole engine comparatively easy. Construction of the carrying frame will be included in a later article.

When building the model engine, being a prototype it was inevitable that the making of drawings and patterns together with the actual construction ran more or less concurrently and I intend to describe the sequence of events roughly in the order of occurrence. I am often asked which is the most suitable part of an engine to construct first. There are no fixed rules about this and I think it is for the constructor to decide which is the most convenient item to start on from the point of view of materials and machinery to hand. The boiler is as good an item as any to commence with and I will now deal with this.

Construction of the somewhat unorthodox boiler for the digger is not a job to cause too much concern. The overall size is somewhat shorter in length and no larger in other dimensions than the Fowler 2 in. scale Class BB ploughing engine boiler. It is made from similar gauges and diameters of copper as the well tried and popular design by John Haining. For the record, John and I are working together on our common interest as keenly as ever, although at present on our individual projects as extensions to our collections of model engines and artefacts of steam powered agriculture.

Returning to the digger boiler, the central firebox is of quite usual design, except that its situation determines that it has two sets of tubes attached instead of the usual single set.

Design of the model boiler follows the original

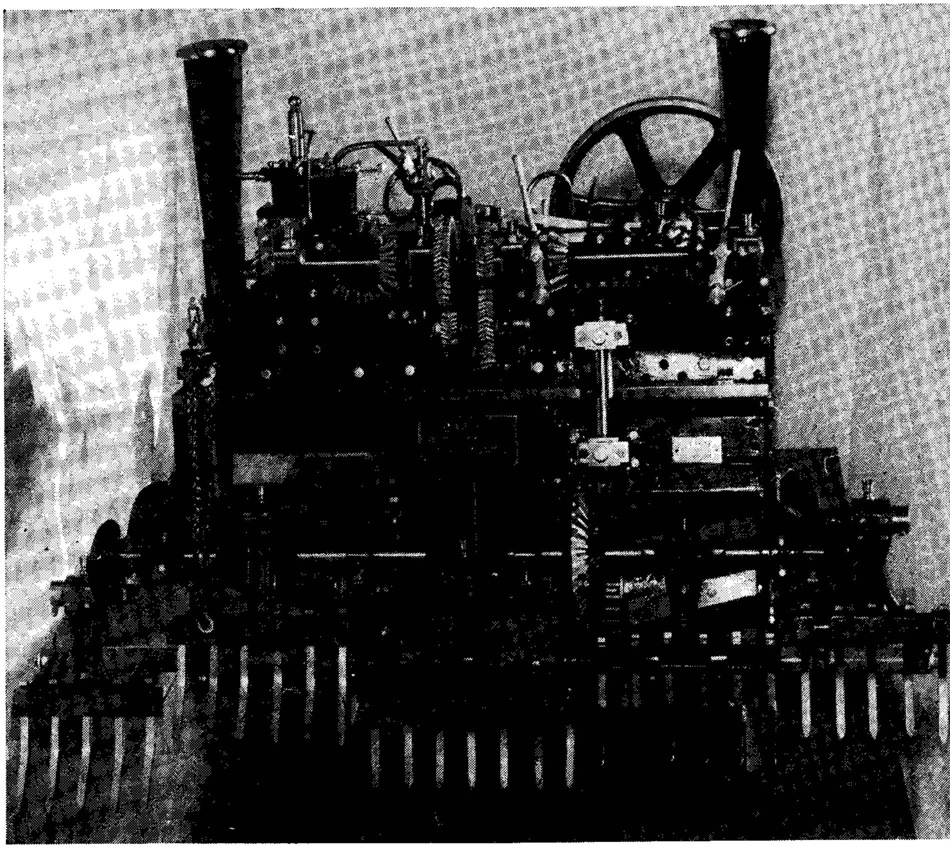


Fig. 1: Front view of the model Darby-Savage digging engine.

closely. It is unique in agricultural and road engines, although boilers of similar external but different internal arrangement were made by Howards of Bedford and the Yorkshire Steam Wagon Co., while the Fairlie locomotive employs an identical type of boiler to that used by Darby. Savages' drawing of the boiler is the only one of the set of originals which shows a complete assembly on one sheet. An inked drawing, on the typical heavy cartridge paper of the time and quite unreproducible except by photographic means, it is neatly executed and has a table of details incorporated, some details of which are:

No. of tubes	80
Dia. of tubes	$2\frac{1}{4}$ in.
Barrels, arch and throat plate	$\frac{3}{8}$ in. thick
All other plates	$\frac{1}{2}$ in. thick
All up weight	2 tons 10 cwt.

As mentioned, the 2 in. scale boiler follows the original as closely as is practicable, the main alterations being a 5 in. dia. boiler barrel thus utilising standard copper tube and 28 tubes. With these two exceptions it is an accurate copy and in performance is a rapid steamer, supplying adequate amounts of steam to the cylinder (Fig. 2).

Fundamentally, the design is two boilers placed firebox to firebox, these items combining into one common firebox in the centre of the two barrels. The two smokeboxes are incorporated within the length of the boiler as extensions of the barrels, thus obviating the need for making them as separate items. Each smokebox has an oval section chimney and an upward hinged split door.

Each of the two barrels is made from 10 s.w.g. tube $6\frac{1}{2}$ in. long. If preferred they can be made from sheet copper, rolled with a scarfed silver soldered joint. It is convenient at this stage to cut the oval chimney holes and do not forget the internal stiffener in one barrel for the cylinder, made from 10 s.w.g. copper and riveted in position inside the boiler barrel. Also required are two tube plates $4\frac{3}{4}$ in. finished diameter, with flanges $\frac{1}{2}$ in. wide. These are made from 10 s.w.g. copper and should be a sliding fit within the boiler barrel.

The inner firebox shell is of standard pattern, made from 10 s.w.g. copper; the $\frac{3}{8}$ in. wide flanges should be formed over suitably shaped hardwood formers. Next make the inner wrapper and cut the firehole in. Ensure that the angle of the firebars is correct. It may be as well to leave some surplus

Fig. 2

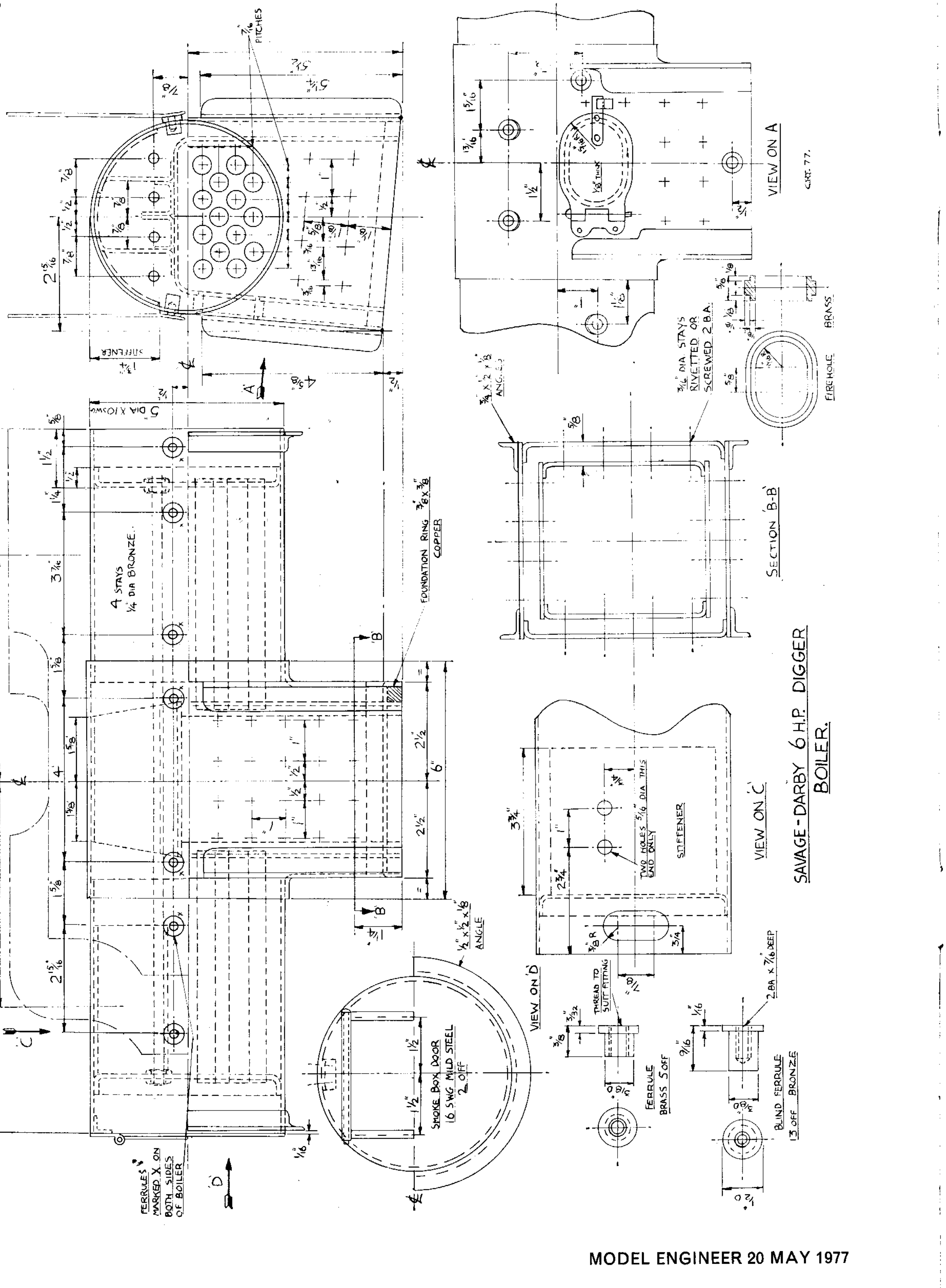
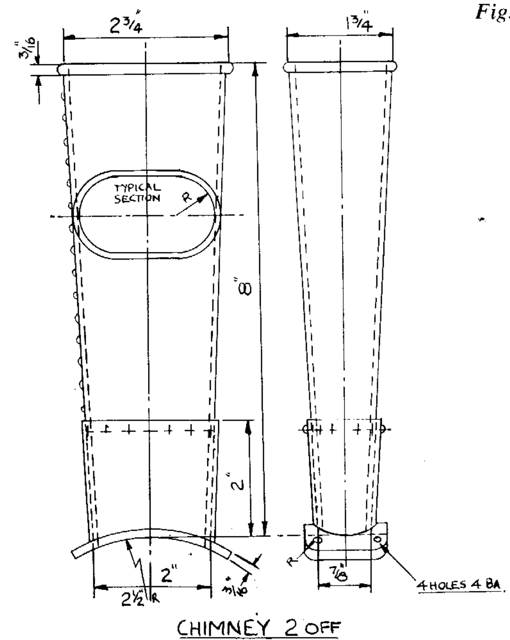

SAVAGE-DARBY 6 H.P. DIGGER
BOILER.
VIEW ON A
SECTION 'B-B'
VIEW ON 'C'
VIEW ON 'D'
FIREHOLE
BRASS
3/16 DIA STAYS RIVETTED OR SCREWED 2 B.A.
4 STAYS 1/4" DIA BRONZE.
FOUNDATION RING 3/8" x 3/8" COPPER
STIFFENER
TWO HOLES 5/16" DIA THIS END ONLY
SMOKE BOX DOOR
16 SWG MILD STEEL
2 OFF
FERRULES MARKED X ON BOTH SIDES OF BOILER
THREAD TO SUIT FITTING
FERRULE
BRASS 5 OFF
BLIND FERRULE
13 OFF BRONZE
2 BA x 7/16 DEEP
CRANK
CYLINDER
PITCHES

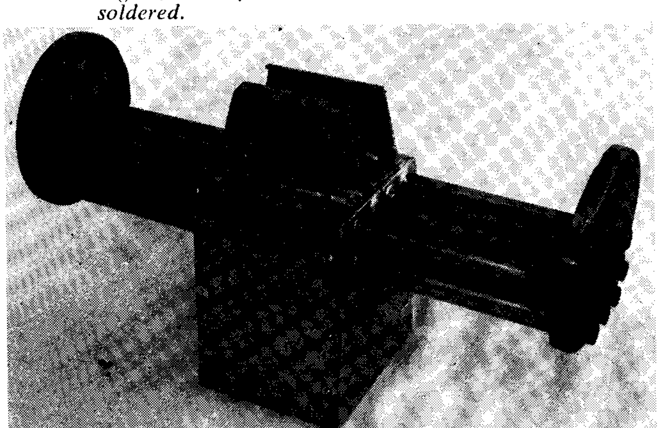
Fig. 3



material here to trim off after final assembly. Four crown stiffeners are required and riveted to the inner firebox as shown on the drawing.

Rivet the inner firebox sides and wrapper together, then marking out and drilling the 28 tube holes $\frac{1}{2}$ in. dia., $5\frac{7}{8}$ in. long, fourteen each side. Ensure that the assembly is accurately made as it is important that the two barrels are in line when the boiler is finally silver soldered. Insert the $\frac{1}{2}$ in. dia. tube ends into the previously tack riveted firebox. To ensure alignment of the two sets of tubes, use the tube plates as jigs sliding them along the tubes until they are as close as possible to the firebox, in this way giving a degree of rigidity to the assembly while silver soldering. A somewhat risky aid to accuracy may be achieved by inserting two rods right through two of the tubes in each set, but beware soldering these immovably into the tubes! Some may consider it desirable to construct a jig for the purpose of holding the tubes in line with the firebox. If the time is available, this is without doubt the best method. Now silver solder the assembly with a high temperature silver solder with a melting point of about 800°C (Fig. 4).

Fig. 4: Inner firebox and tubes assembled and silver-soldered.



Cut and form the outer wrapper, ensuring that the 5 in. dia. of the boiler barrel fits snugly into it. Form the two throat plates and tack rivet them to the wrapper (Fig. 5). It is very important that the wrapper is accurately made as the two boiler barrels must be precisely in line with the previously soldered inner firebox and tubes when finally soldered. Make four $\frac{1}{4}$ in. dia. phosphor bronze stays threaded each end. A trial assembly of the boiler will ensure that all parts fit as closely as possible, bearing in mind that silver solder is definitely not a gap filler! (Fig. 7).

All the firebox stays are of the same size—a convenient feature which saves some time. They are made from 2 BA threaded bronze rod (3/16 in. dia.) screwed into holes tapped as shown on the drawing through the inner and outer firebox walls.

Next tack rivet the tube plates into the barrels and finally assemble them to the firebox. It is convenient at this stage to make and tack rivet the semi-circular mounting angles to the smokeboxes and the four straight mounting brackets to the firebox by means of two 6 BA screws tapped blind into the firebox wall. Assemble the outer firebox wrapper around the barrels, not omitting the fire-hole ring, together with the two throatplates securing the complete firebox with the previously threaded and tapped stays. The stays should be lightly riveted over on each end. Insert the pre-formed foundation ring, again fixing into position with eight 6 BA screws, drilled and tapped through the outer wrapper and throatplates.

For attachment of the hornplates, thirteen blind ferrules, turned from brass rod, and five boiler fitting ferrules are positioned as shown on the drawing. The blind ferrules are tapped 2 BA while the boiler fitting ferrules are tapped according to the particular fittings being used. I have incorporated Stuart Turner items on my boiler.

The completely assembled boiler should now be silver soldered with a low melting point solder of about 650°C. Take great care not to overheat the copper locally and disturb the previously soldered inner firebox and tubes. Finally test the boiler hydraulically to 200 p.s.i. after pickling.

The two smokebox doors are made from 16 s.w.g. mild steel trepanned to 5 in. dia. Two strap hinges riveted to each door are pivoted at the top on a pin which is located in a tubular fitting riveted to the smokebox, thus securing the doors.

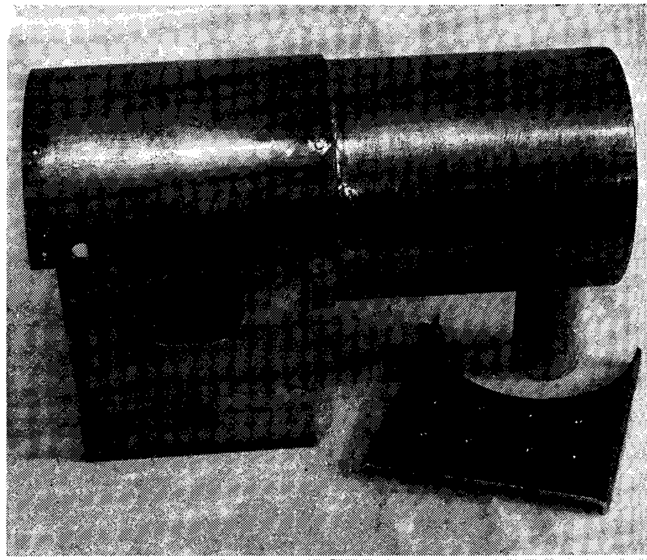
Ensure that both ends of the smokeboxes and the doors themselves are flat so that an airtight seal is made when closed.

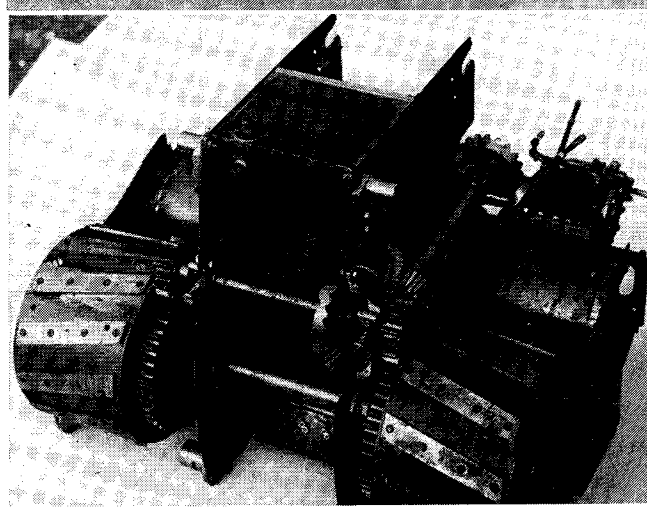
My own engine possesses chimneys which are cast in aluminium and fitted with copper capping, but they can of course be fabricated from 18 s.w.g. mild steel of riveted construction (Fig. 3). Design of the chimneys is notable in that their section is oval, enabling the overall length of the boiler to be kept to a minimum, and resulting in an engine only 9 ft. wide, affording easy progress of the engine through farm gates from one field to another. This was a major design feature of the 6 h.p. Savage digger as it simplified and cheapened the cost of the engine due to it being unnecessary to change the direction of travel from lengthways to sideways (broadside) and the complicated—not to say expensive—equipment required to achieve this was eliminated.

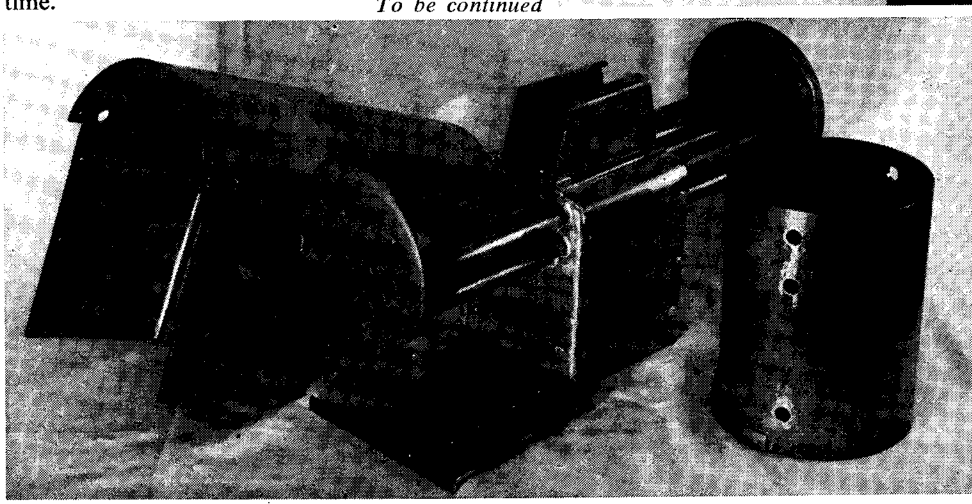
The water tank is of rectangular shape and is of box construction made from 18 s.w.g. copper flanged, tack riveted and silver soldered. Three ferrules are required for the connections. To clear the final drive bevel gear, it is necessary to cut out one of the corners as shown in the accompanying photograph. This is best done after the tank is assembled. With care the corner should be sawn out and turned "inside out", requiring only to be soldered back into position, thus giving the necessary clearance to the gear. A drawing of this item will appear in a later article.

I must acknowledge the work of Mr. R. R. Chambers of Weymouth in making the boiler illustrated here and I am most grateful to him for a fine product. In my situation with limited time available for model engineering (more's the pity!) Mr. Chambers provides a service which although more expensive than if one does the job oneself, enables an engine to be completed in a reasonable time.

To be continued







Top, Fig. 5: The outer wrapper and throatplate.

Centre, Fig. 6: Water tank, note reversed corner, to clear final drive bevel gear.

Left, Fig. 7: Barrels and throatplates ready for assembly.

A FOUR-COLUMN BEAM ENGINE

Part II **by "Tubal Cain"** *From page 492*

APPLY A NON-ACID FLUX—I use powdered resin—and a trace of solder paint just around the port ways in the cylinder. Attach with the screws fairly tight. Heat till the solder runs, and wipe the outside. Allow to cool naturally—don't quench it—and then remove the screws. Finally, countersink the two screwholes each end, insert clean brass screws, and solder over them. Finally, trim with a file till it looks as if it is one piece. You may have to tickle the valve face a bit on a flat surface when you come to fit the valve.

Steam Chest and Cover, Parts D and E

There is very little work to do on either bar filing or milling the surfaces—or you can turn them in the 4-jaw; the boring of the gland is the same procedure as that for the cylinder cover apart from the size. The only point that is a bit important is to bring the inside of the chest to dimension first, and get a good finish on the bottom end, so that the drill doesn't wander when making the No. 30 tail guide hole. So, file up the inside, then machine or file the exterior and set up (with soft packing) in the 4-jaw with the gland facing out. Face the end of the gland-boss and centre. Drill No. 30, and then take the drill right down and give a little jab to the point to make a centre for the bottom hole. Drill this, and then open out and bore as previously described for the "O" ring cavity. In this case a letter "G" is about the right size for a gauge, but check it. Drill for the steam passage, but don't mark out for the flange or gland studs till you have the mating parts. The cover, part E, only needs facing, filing to match the chest, and the holes drilling—leave the 10 BA till you have the throttle valve made.

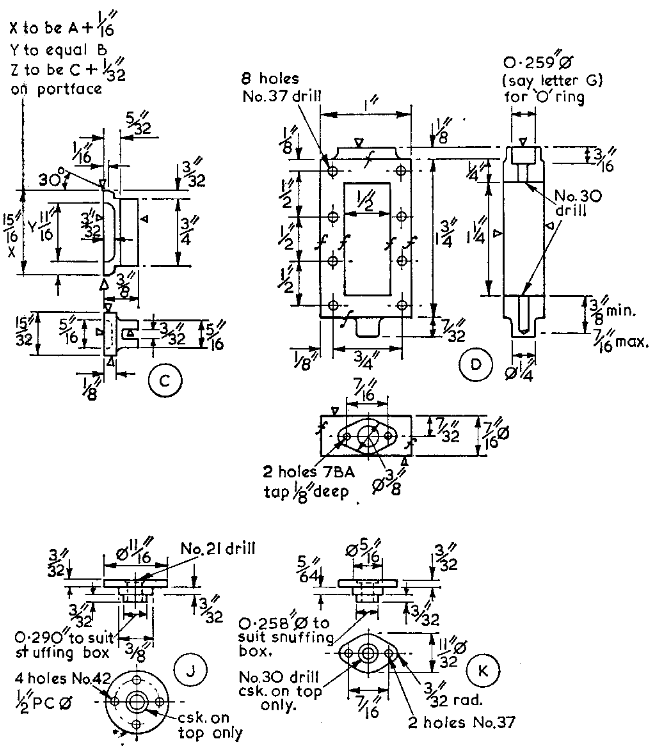


Fig. 5

Valve, Part C

File the face flat and then file the back to the correct overall thickness. File the sides to dimension, keeping the cavity central, and clean up the outside of the valve-rod boss—but leave a bit on the ends at this stage. The only part I recommend you to mill is the valve-rod slot, and this I did by holding in the machine vice on the vertical-slide and running a little 3/32 in. endmill down. Take care to align this with one side of the valve—mark it to indicate it as a reference face. Now for the "business ends". Check the length of the cavity "Y"; it should be the same as the length "B" on the portface. Correct this with care and a fine file, at the same time keeping it square with the marked reference face. A few thou. undersize won't matter but try to avoid making it over. That is, Y less than B; the 11/16 in. is not important. Now decide which will be the "top" of the valve and mark it. File the length about 1/64 in. above the length shown on the drawing, keeping the cavity central. Check the top port width—3/32 in. on the drawing—and file the top lip of the valve till this is between 30 and 34 thou. larger; repeat for the bottom edge—in both cases keeping the edges square to the reference side of the valve. Finally, carefully polish the timing edges till the overall length X and the bar widths Z are as indicated—.062 greater than A and .031 greater than C give or take a thou. or so. The valve will now give the correct steam distribution even if the ports are a mile out. Wrap up the valve to save it from damage; in the final fitting remember to bed it to the port-face.

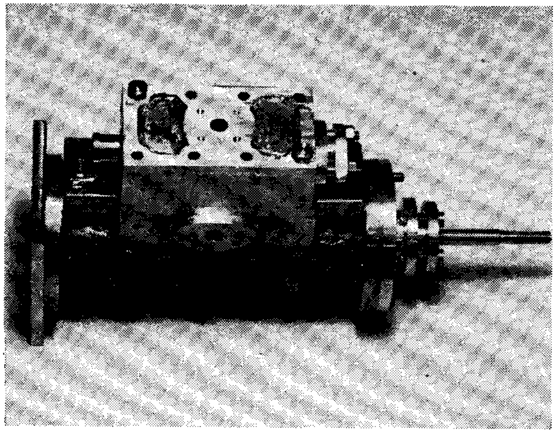


Fig. 6. Temporary erection of the cylinder.

Bottom Cover, Part H

Nothing to this part, except to remind you to hold it gently and take light cuts, or it may distort. Make sure that the thickness of the flange ($\frac{1}{8}$ in.) is uniform—within a couple of thou.—or the cylinder will sit up out of line and that will cause trouble later. Mark out for the holes and drill them; you can now spot through and drill the cylinder from both covers, but take care that you get the port-face truly aligned to one of the faces of the bottom cover and mark which way round it goes. Similarly for the top, as otherwise the bolt will look askew. Tap the cylinder for the studs but don't fit them yet.

Glands, Parts J and K

These are straightforward chucking jobs. The reason for the two different diameters on the plugs is to make them look as if they were packed glands despite the presence of the "O" ring. Note that "O" rings are supposed to work up and down in their cavities, but be nipped at the sides. I recommend you mark out for the holes in the chuck, and for the oval of the gland flange before you drill them. Note the little countersink at the top of the rod hole. Once finished, spot through, drill, and tap the cylinder cover and steam chest.

Pedestal, Part AA

To reduce cost the oval holes are not cored out, but it is an easy job to mark out and drill, then file to shape. Note that the $1\frac{1}{4}$ in. length is important—if you get it too small the valve gear won't go in! The same applies to the $\frac{1}{4}$ in. x $\frac{1}{2}$ in. holes in the one other side. Now, an important point. The $\frac{3}{4}$ in. height should be held to micrometer size, and should be uniform all round, otherwise alignment of the engine may be difficult. But the part is quite fragile and if gripped too tightly, either when facing in the lathe or filing in the vice, may go out of shape. So, once all other work is done, measure up with your micrometer and correct the thickness; 5 thou. up or down won't hurt much, but even a couple of thou. inequality of height can throw the motion over so far sideways as to make for stiff running. The four No. 29 holes are marked out from the cylinder bottom cover, the port-face of the cylinder to lie over the two rectangular holes.

Piston, Parts F and BA

Make the rod, BA, first. This is a normal turning job, but use the old trick of paper under the chuck jaws if it doesn't run true. Use a sharp die for the threads. Note, the upper shoulder between the 5/32 in. and $\frac{1}{8}$ in. diameters may need adjustment on assembly, but you should have no difficulty in doing this even with the piston assembled, as there is ample space within most 3-jaw chucks to accept it. Having made the rod, take the piston casting and hammer it all over, both faces and the edges, with a light cross-pein hammer. Lots of light, smart blows, like a woodpecker, going over it two or three times. This "closes the metal" as they used to call it and improves the wearing quality. Grip in the chuck and trim the chucking-piece,

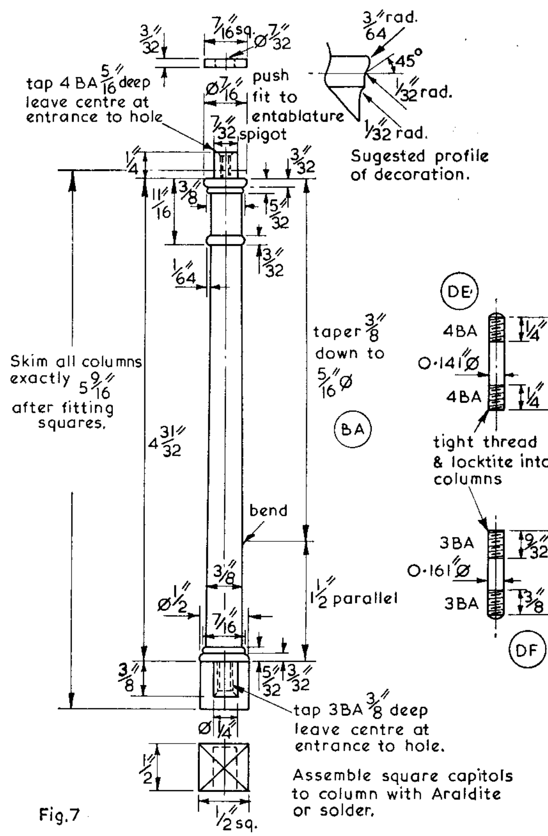


Fig.7

facing that side at the same time. Get a good finish. Reverse, and bring to diameter plus say 6 thou. and face this side to thickness. Machine out the groove, again leaving in a couple of thou. on the width and say 6 thou. on the diameter at the bottom. (You can finish it if you are going to use soft packing, in which case make it $\frac{1}{8}$ in. wide and deep). Centre, drill, and tap 5 BA, taking great care to get the tap aligned truly, and then open out about $\frac{1}{8}$ in. deep and .125 in. dia. (What's the difference between $\frac{1}{8}$ in. and .125 in? Well, $\frac{1}{8}$ in. can be anything from 0.115 in. to 0.135 in., but .125 in. is what it says!) Saw off the chucking piece and carefully re-chuck to face off the roughness.

Chuck the piston rod, again using packing to set true, and screw on the piston, really tight. Use Loctite if you like, but I prefer to rivet the end, very lightly. Now true up the O.D. to size; a little wag on the faces won't matter, but if they are more than say .003 in. out, give them a skim, too. Now machine the groove to dimension—deep enough to take a No. 39 drill is about right, and wide enough to accept a No. 35. The finish must be really good. Once the groove is finished, take a $2\frac{1}{2}$ thou. cut off the O.D. to give the necessary working clearance (rather less if with soft packing, but even here not less than $1\frac{1}{2}$ thou.—3 thou. on the diameter). Remove the sharp edges from the corners—just ease them, don't make a radius — and finally machine off any projecting part of the rod.

This completes the machining of the cylinder set, and I suggest you make a temporary assembly, if only to keep all the parts together—Fig. 6. (Note that this, and several other photographs, will show slight differences from your castings, nearly all of them improvements made after machining the first set; so your engine should be better than mine!)

Columns, Part BA

The drawing shows the columns made in three pieces, the circular part and two square ends spigoted on. However, I suggest you make the top and bottom (circular) mouldings also as little

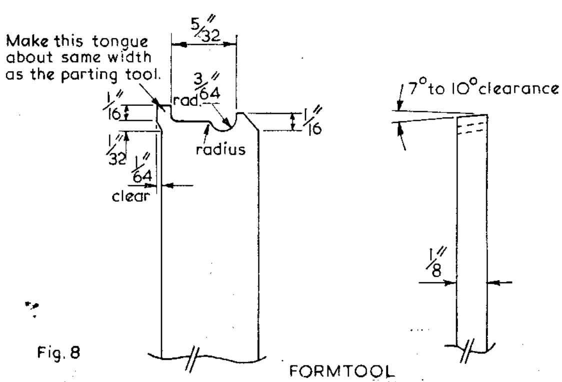


Fig. 8

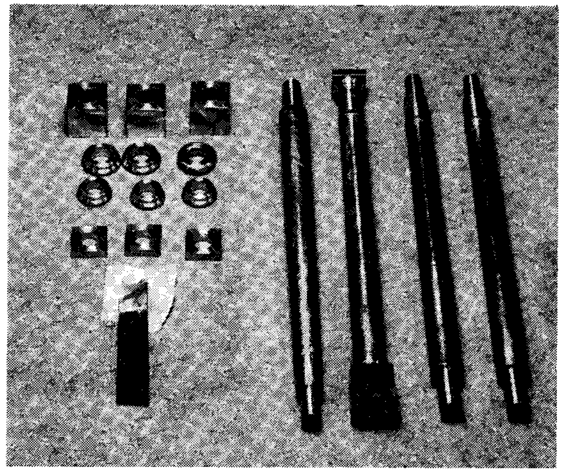


Fig. 9. Column parts (one assembled) and form tool.

washers, thus enabling the column to be turned from smaller stock. Make a new sketch, showing the 4 31/32 in. as 4 25/32 in., and the two spigots 3/32 in. (each) longer. Check carefully with the main drawing and then carry on. Clean up a length of $\frac{3}{8}$ in. brass and part-off four pieces exactly 5 19/32 in. long. Set truly in the 3- or 4-jaw and turn down the spigots at each end on all four. Centre deeply and drill for the tapped holes—a bit of the centre should remain after drilling. Now form the top end to 11/32 in. dia. for a length of about $\frac{5}{8}$ in., giving the diameter of the top band. Mark the position of this, and another point at 1 13/32 in. from the bottom shoulder, with a felt pen.

Set over the tailstock by trial—towards you—to give a change in diameter of 1/16 in. between the two pen marks, the stock being carried between centres. Turn the taper (use power feed) between the two pen marks, taking care to terminate the cut just at the lower edge of the upper decorative band. As soon as you have taken enough off just to brush the lower pen mark, note the cross-slide index reading and then machine the part above the upper band to the same taper and to this index setting, leaving the band the required 3/32 in. wide. The next step would be to machine the eccentric rod, as this also needs the tailstock set over, but assume you have done that and restored the machine to turn parallel! With the column again between centres, blend the parallel and the taper sections using, I suggest, a No. 4 cut precision Swiss file. (Don't forget that a file is only carbon steel, so keep the cutting speed down!) Very lightly radius the edges of the decorative band. Finally, frost or abrade the surface with fine emery, to give a key for the paint. (Yes, I know it's a pity, but can you imagine what brass columns would look like after having been shipped across

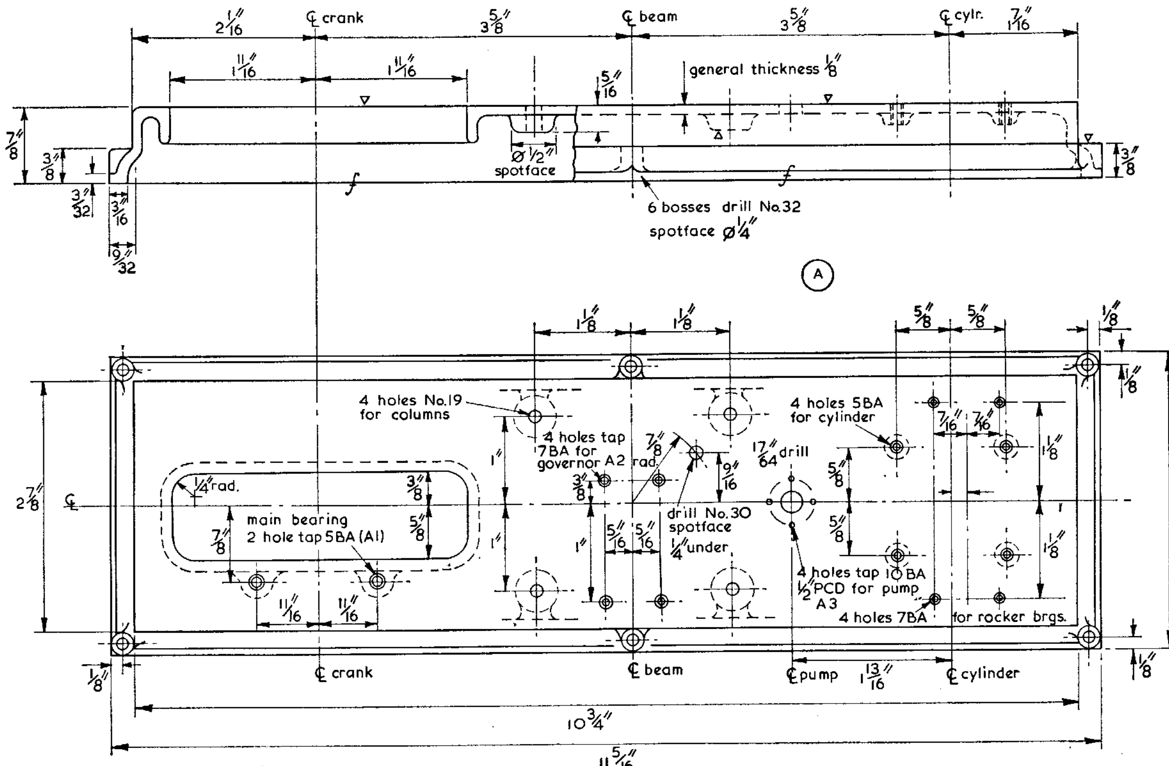


Fig. 10

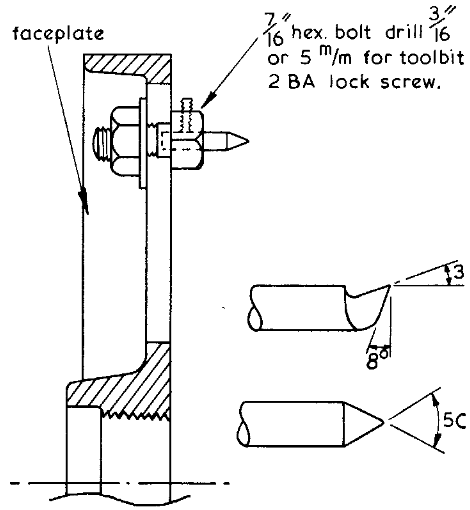
the Atlantic, and erected in a tropical island in the West Indies?)

The collars may be turned using hand tools—far the best and most interesting way—or you can make a little form tool as shown in Fig. 8. Drill a No. 43 hole and open out to 3/32 in. to form the 3/64 in. radius first; you will have to start the drill upright and then cock the silver-steel over at an angle on a taper block of wood to drill at the correct angle. Mark out the rest of the profile from this hole, and file it to shape. Take care to get a first-class finish but don't use emery or you will round off the cutting edge. The trick is to file to size and then polish with a tiny oilstone—a small gouge slip will serve. Harden and temper to straw, and lightly clean up the top of the tool on the side of the grindstone. Finally, polish the cutting edges with the gouge slip and, if you have one, a small Arkansas stone. Note that thereafter the tool must be sharpened on the top only, and must always be used at true centre height. The collars are made from ½ in. brass stock; work close to the chuck, centre and drill the correct diameter deep enough for four collars. Nick with your parting tool 5/32 in. wide and then feed in the form tool till the 3/64 in. radius just cleans up the surface. Complete parting-off, and there you are!

For the square ends I simply chucked square section in my self-centring 4-jaw; these are still available, but not publicised very much, and well worth getting one if you can afford it. Otherwise use the ordinary 4-jaw. But in either case, dress up the stock first, and take care not to mark it in the chuck jaws. After parting off each bit, face the exposed surface slightly concave, and let this face downwards on assembly. Having tapped the columns and made the studs (I needn't tell you how to do that, need I?), degrease all parts with carbon tetrachloride or strong soap and hot water solution, dry thoroughly, and assemble with Araldite; use temporary screws to hold all together, and make sure that the squares at each end are aligned. Allow the Araldite to cure and then check the overall lengths. The 5 9/16 in. is important, but even more so that all four columns be identical. Correct by putting the long ones between centres and facing-off a little from the bottom. Fig. 9 shows the completed parts and an assembled column.

Bedplate, Part A

There are several ways in which this part can be handled; it is, I'm afraid, too long to swing on the faceplate of a 3½ in. lathe. The first step is to remove all flashes and file up the underside till it sits on a flat surface without rock, and at the same

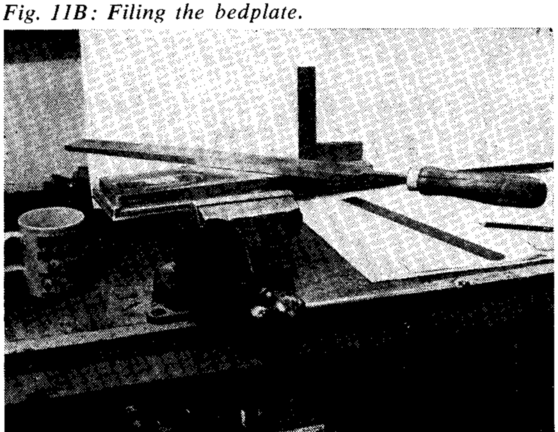


FLYCUTTER FOR MACHINING BED

Fig. 11A

time bringing the 3/32 in. lip even all round. Now, you can mill the top on the vertical-slide a bit at a time; flycut it mounted on an angle plate; or file it. If you have a hand shaper, then this is ideal—just the thing! I prefer the filing method, but will deal with the others first. For either you need some holes to hold the casting; I wouldn't care to rely on the six No. 32 holes in the bosses. Fortunately you can put in a few ¼ in. clear holes which won't show. One on the cylinder centreline (this one could be quite large), one on the pump centreline, which should be positioned fairly carefully even if it is enlarged later, and one can be sited on the bed centre, between the four columns, where it will be hidden by the governor in due course. These holes, together with that for the crankpit and those in the six bosses, will give quite adequate clamping. But if you have doubts, drill some more

Fig. 11B: Filing the bedplate.



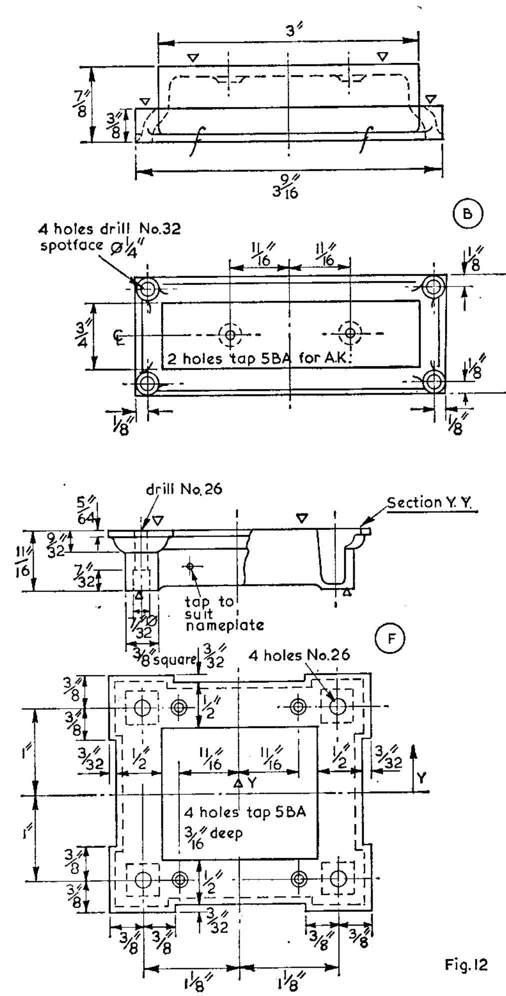


Fig. 12

to a tapping size and plug them afterwards.

Put the casting on a flat surface and traverse over it with the surface gauge to find the "low spots", which mark with a felt pen. Set up your vertical-slide, taking more than usual care to get it square both ways. Set up the casting on the slide with the lowest of the low spots central to start with. Clamp up well with the available holes, and with dogs on the side flanges. Engage the clasp nut and use the leadscrew handwheel to put on cut, traversing under a really sharp endmill, running fast and using lashings of paraffin (T.V.O. is better) mixed with about 20% by volume of engine-oil. If you can't get a good flood to wash the chippings away, it may be better to run quite dry—no oil at all is better than too little. Traverse over as much as you can and note the handwheel index at the final cut. Reset the castings in a new place and repeat; with any luck you may be able to cut away the boss left under the clamping nuts at the first setting.

To be continued

THE HOT AIR ENGINE COMPETITION

at the Wembley Model Engineer Exhibition

by Professor D. H. Chaddock

AN INNOVATION this year, entirely due to the generosity of Mr. A. N. Clark who not only suggested it but donated the prizes, was a special competition for Hot Air Engines. This in its turn had been triggered off by the account of Mr. Slack, *Model Engineer* 2 November 1973, of his very successful development of a hot air engine suitable for powering a small boat and reinforced by the work of others, notably Dr. Senft of North Dakota, Mr. Urwick of Malta, Mr. Thomas of Hereford and Mr. Ross of Ohio. Quite a galaxy of international talent and clearly the time was ripe to bring it all together in friendly competition.

The terms of the competition were arrived at after some considerable thought and discussion. It was the Sponsor's intention, inspired by Mr. Slack's original engine and warmly supported by the writer, who by that time had undertaken to organise and run the competition, and the Editor, that the engines should be kept small so that they should be easy and cheap to build and within the capabilities of model engineers with even the most limited resources. So the limit of capacity was fixed at 5 cc., about $\frac{3}{4}$ in. bore and stroke, a size which Mr. Slack had already demonstrated could provide enough power to drive a small boat without excessive weight or bulk. Otherwise the rules were almost non-existent, deliberately so because the competition was intended to encourage original ideas, new design and experimental development work generally.

In this it can only be described as being brilliantly successful. There were 17 entries, two from U.S.A. and one from Malta, whose owners we were very glad to see at the exhibition, all apparently specially built for the competition and as will be described later incorporating some novel and highly successful features. One snag only appeared in the proceedings. Although it had been intended to run the engines on test in public on the stand of the S.M.E.E. Workshop, this was banned by the Authorities who would not allow any gaseous or liquid fuels to be brought into the Exhibition Hall. Consequently all the tests had to be carried out in a part of the building to which the public did not have access, the results only being chalked up on a score board. To those who were disappointed our apologies and although one or two of the spirit fired engines were demonstrated on improvised "Meta" solid fuel firing, they were not of course running under their designed conditions.

The winner, by a long way, turned out to be a surprise beyond our wildest expectations. A concentric piston engine by Mr. E. F. Clapham of Bristol turned out the incredible output of 39.4 watts mechanical at 900 r.p.m. Fortunately I had prior knowledge of this and as it was so far beyond the capacity of the simple friction brake which I had designed and made for use in the competition, I readily agreed that Mr. Clapham should use his own electric dynamometer and tachometer on which the engine had been developed. I did however check all the essential constants to make sure that the readings were accurate. Although Mr. Clapham is under an obligation, by the terms of the competition, to give a full account of his engine and I am sure he will, it is perhaps not inappropriate to give a brief description of it or at least of those features which contributed to its outstanding success.

A general view of the engine on its test bench is shown in Fig. 1 and as will be seen from the close-up in Fig. 2 the engine has an enclosed crankcase and is completely sealed so that it can be pressurised. Before starting, the internal pressure is raised to 400 p.s.i. from an air bottle, but as the compression is then too high for the engine to be turned over by hand it is motored up to speed using the electric dynamometer as a motor. When heat is applied to the coils at the "hot end" the engine becomes self sustaining and the dynamometer is switched from motor to dynamo. By admitting more air from the bottle the internal pressure is raised progressively, the dynamometer being adjusted at each stage to absorb the increased power and keep the speed constant at 900 r.p.m. Finally when the internal pressure reached 1000 p.s.i. a car headlamp bulb, which was the electrical load on the dynamometer, was glowing at full brilliance. The actual mechanical power was of course measured by the load on the torque arm, an incredible 59.14 oz./in., which multiplied by the measured speed of 900 r.p.m. gave a mechanical power of 39.4 watts. Apart from the high pressurisation, higher than that attempted by any other competitor, the engine also had extended heating and cooling surfaces in the form of very fine capillary tubes of stainless steel, the heating tubes being visible in the photograph but the cool-

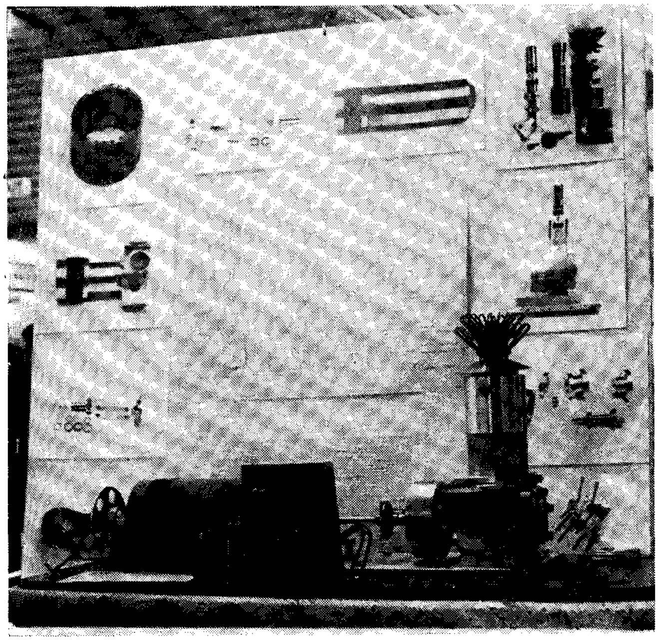


Fig. 1: Mr. Clapham's engine on its test bench and coupled to the dynamometer.

ing tubes being enclosed in a water jacket. This undoubtedly contributed much to the success of the engine because although it is one thing to increase the mass of air in the engine by raising the pressure, unless the increased mass can be heated and cooled effectively the nett result may be a loss and not a gain in power output. Apart from the test conducted at the Exhibition, Mr. Clapham has done a lot of research on his engine, of which I have details, and which I hope he will publish because he has done more to bring the model hot air engine up to the standard of its full-size counterpart than any other worker and upon which he is to be heartily congratulated as a very worthy winner of the first award in this competition.

The runner-up and winner of the Second Prize was Dr. Senft of North Dakota who will be known to readers of this journal by his previous articles and by readers in U.S.A. of *Live Steam Magazine.* As Dr. Senft had crossed the Atlantic specially to attend the Exhibition and had brought his engine with him it was understandable that owing to pressure of work it was not quite complete, notably lacking a burner. As however it was very closely similar to Mr. Thomas's, both being based upon a design by Mr. Ross, Mr. Thomas very sportingly agreed to allow his burner to be used and, the resources of the workshop being called into play, it was very soon fitted. This engine, without its borrowed burner, is shown in Fig. 3 and is also a concentric piston engine with a sealed crankcase so that it can be pressurised and a rhombic drive. A belt-driven pump circulates water around the "cold" end of the cylinder. This engine was beautifully made with a wonderful bouncy compression and gave no trouble whatsoever in the quite extentive series of tests to which it was subjected. Because it was not designed to run at such a high pressure as Mr. Clapham's engine and could therefore be pressurised by means of a foot pump it was decided to run a series of power curves at atmospheric and then increasing pressures until the maximum power of the engine was reached.

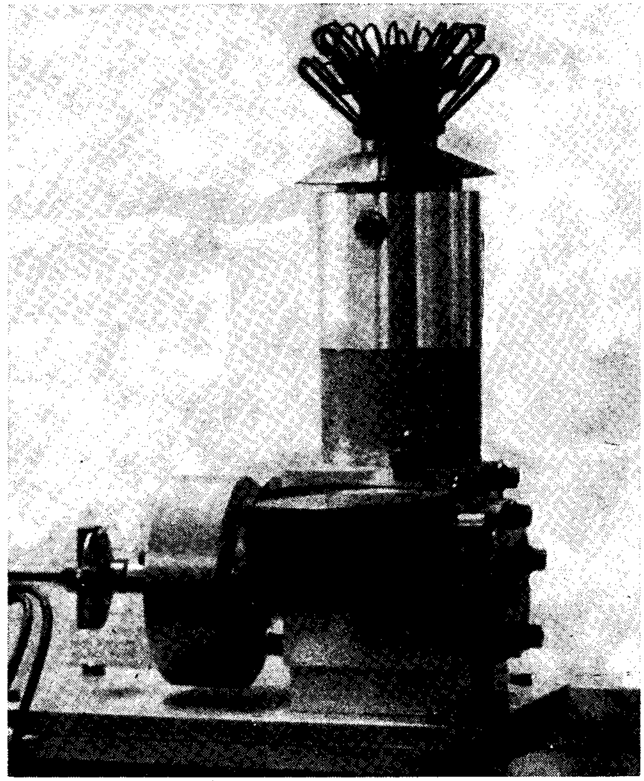


Fig. 2: A close-up of Mr. Clapham's winning engine.

The results are shown in Fig. 4. In the first run the engine was unpressurised and produced a maximum power of 3.38 watts at 2285 r.p.m. but the power fell off rather rapidly above this speed, the engine reaching a free speed without load at about 3300 r.p.m. The maximum torque of 3.8 oz./in. was developed at about 960 r.p.m. The pressure inside the engine was then raised to 15 p.s.i., and the test repeated. The maximum power now rose to 4.1 watts but at the much lower speed of 1390 r.p.m. The maximum torque also rose to 5.85 oz./in. but at much the same speed as before. Finally the internal pressure was raised to 30 p.s.i. In the first run, not plotted here, the results were inferior to those obtained at 15 p.s.i. so the run

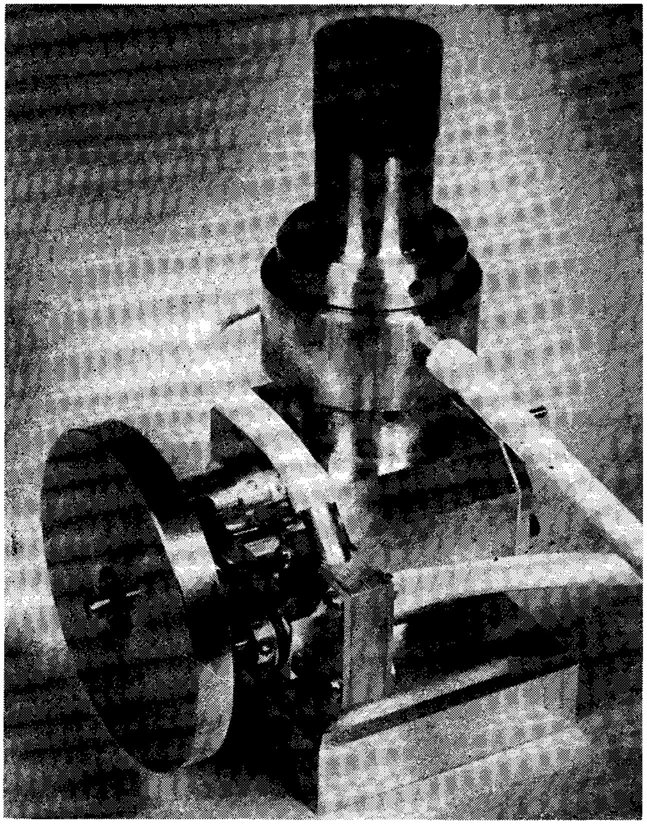
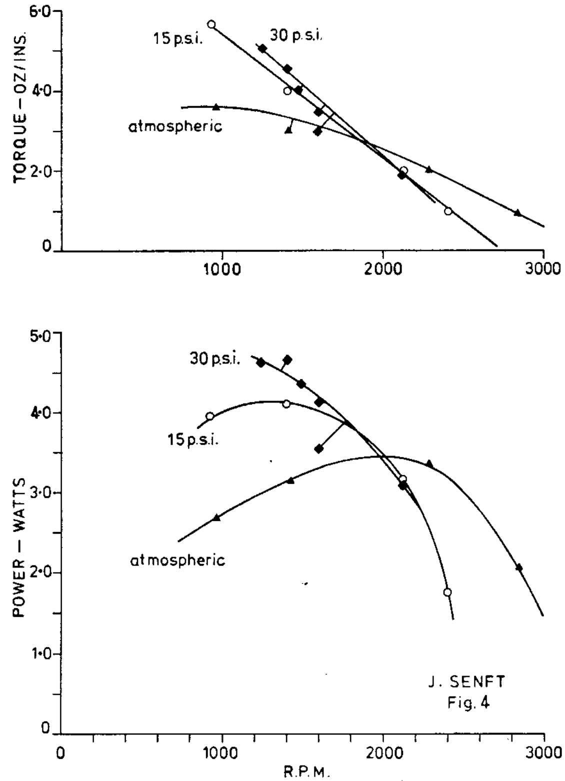


Fig. 3: A very neat rhombic drive engine by Dr. Senft —runner-up.
Below right, Fig. 5: Mr. Collins' engine was awarded the prize for the best workmanship.

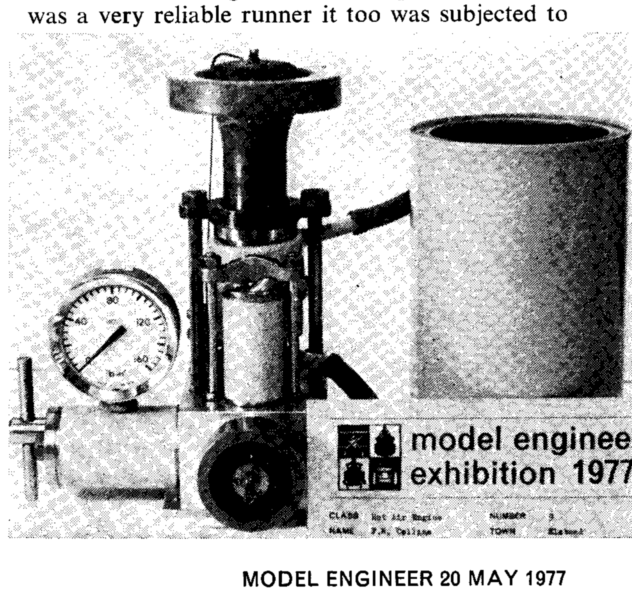
was repeated. Above about 1750 r.p.m. there was no perceptible difference in the results, but at the lowest speed at which the engine could be run, namely about 1260 r.p.m., it gave both maximum power and torque, 4.69 watts and 5.0 oz./in. respectively. This came as something of a surprise and a close examination of the curves, allowing for some experimental error, shows that the engine ought to have been developing even more power if it could have been persuaded to run at even lower speeds. As was to be discovered later, other pressurised engines also showed this characteristic and is one of the unexpected results which these tests have revealed.

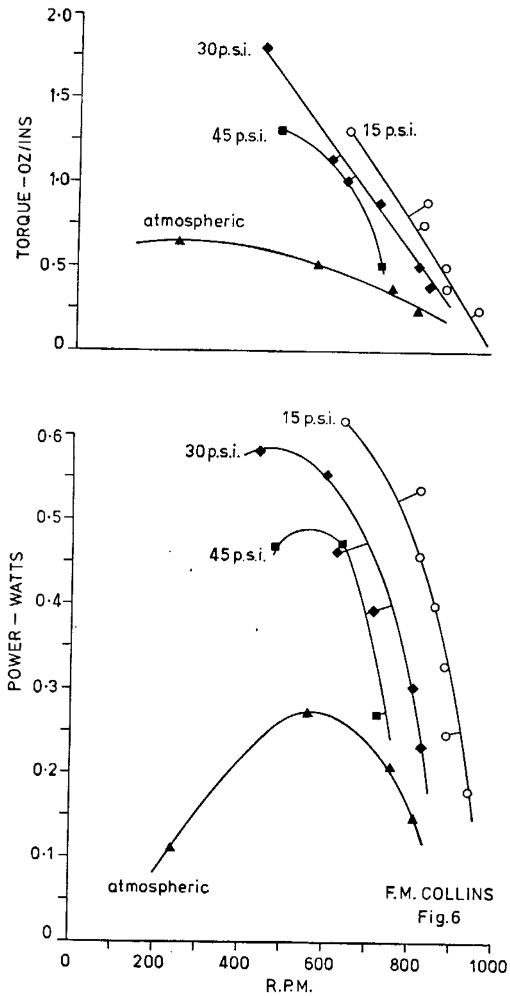
A Special Prize for the highest standard of workmanship, apart from those already receiving an award, went to Mr. F. M. Collins of Elstead for a vertical Stirling engine shown in Fig. 5. This engine too had an enclosed crankcase and could be pressurised, a vertical cylinder with an "Andy Ross" ring type burner, but unlike the previous engine a separate power cylinder, both power cylinder and displacer being driven from separate



cranks on a crankshaft running on ball bearings. Very great attention had been given to perfect sealing in this engine—it would in fact hold its pressure overnight when once pumped up—and to eliminate the need for lubrication of the working parts since oil vapour and hot compressed air can be dangerous—more will be said of this later.

Because this engine could be pressurised and was a very reliable runner it too was subjected to





F.M. COLLINS Fig.6

an extensive series of tests to determine the effects of pressurisation. The results are shown in Fig. 6 and although much less powerful than Dr. Senft's engine, showed exactly the same trends. Unpressurised a modest 0.28 watts at 650 r.p.m. which improves as the pressure is raised to 15 p.s.i. is not so good at 30 p.s.i. and shows a considerable fall off at 45 p.s.i. Here again the curves at 15 and 30 p.s.i. are definitely not complete, but the engine could not be persuaded to run below the critical speed when it was developing both its maximum power and torque. The reason for this is by no means clear but I am of the opinion that it may be due to the flywheels being insufficiently heavy to carry the engine through compression as the internal pressure is raised. It would be instructive therefore to try the engine with a heavier flywheel and to see if the points of both maximum power and torque could in fact be reached. The marked drop in power at 45 p.s.i. is I think simply and solely due to lack of heat transfer. With four times the mass of air in the engine, but no increase in the heat flow, the working temperatures of the fluid must be reduced and the increased density give rise to increased aerodynamic losses. Here I must pay a special tribute to Mr. Collins not only for his help throughout the competition in testing his and

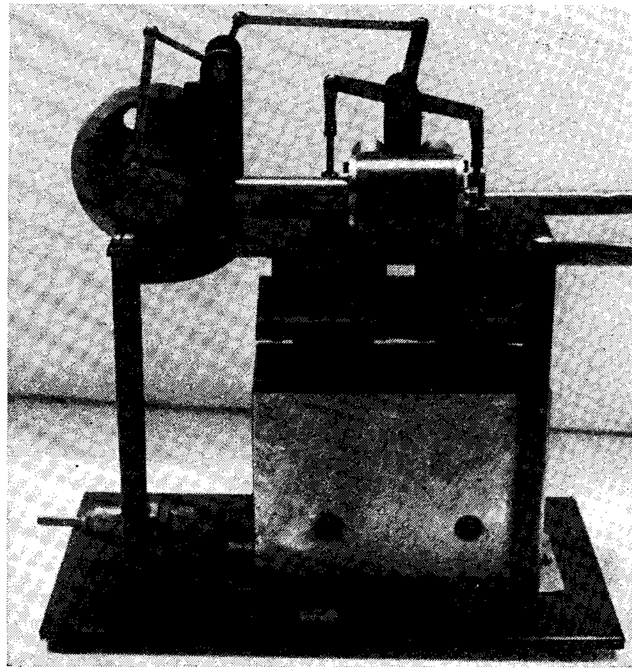
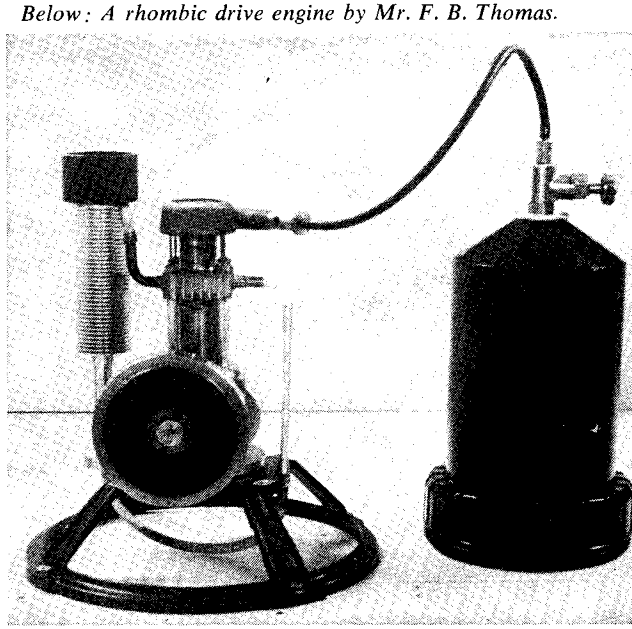
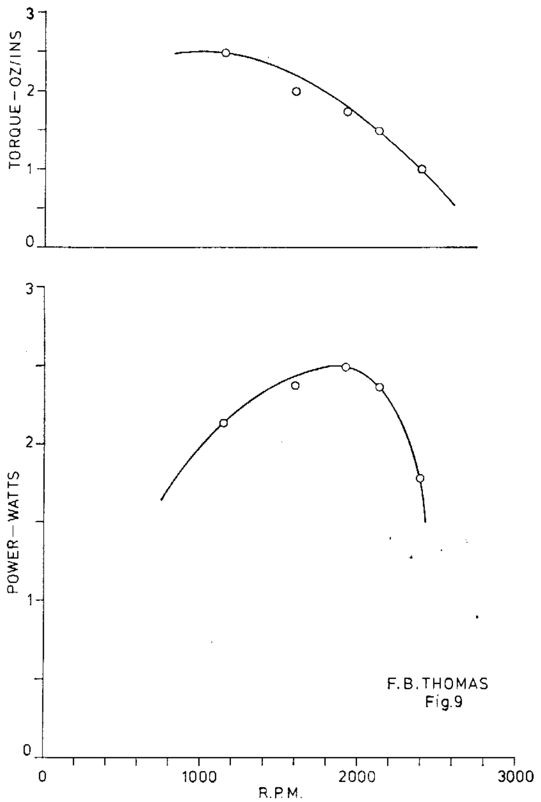
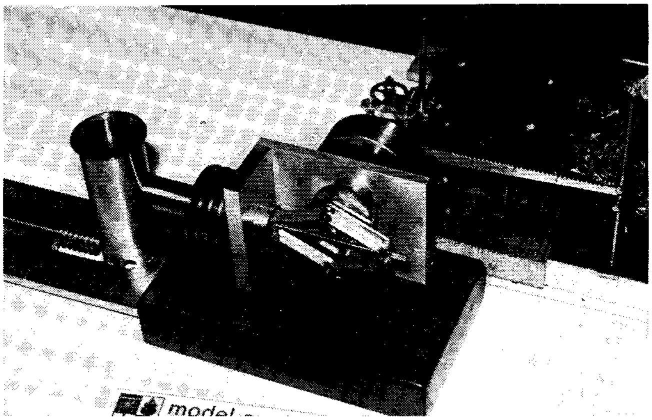


Fig. 7: A double-acting engine with twin displacers by Mr. Wilkinson, awarded the prize for originality.

Below: A rhombic drive engine by Mr. F. B. Thomas.





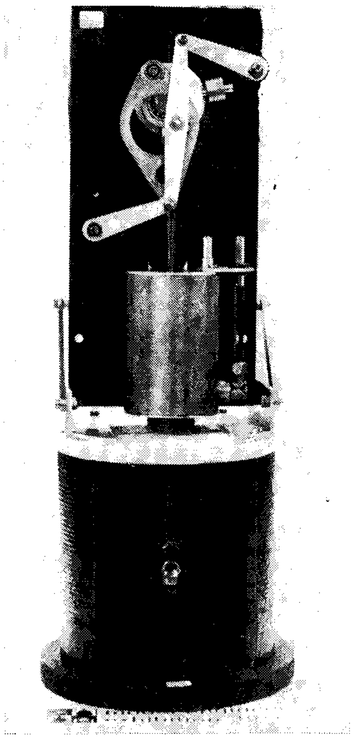


Stirling himself in his famous and very successful "Dundee" beam engine and which incidentally was pressurised to 100 p.s.i.—in 1845!

The only improvement to the layout which I would suggest in the light of experience with other engines is that the displacers should be mounted above and not below the cylinder. Although it may appear logical to place an object to be heated above the flame it does mean that all the waste heat rises and the cooler spends most of its time getting rid of it instead of its legitimate business. This is a relic of the old "Heinrici" designs whereas experience has shown that an upright displacer with a ring burner around it is a very efficient way

other engines, but for producing an engine which has shown so clearly the directions for further development.

Another Special Prize for the engine showing the most original design work was awarded to Mr. F. R. Wilkinson of Bexley Heath. This engine, shown in Fig. 7, was the only double acting engine in the competition and acquitted itself very well, returning 1.12 watts at 1010 r.p.m. without pressurisation. This layout of a double acting cylinder with dual displacers serving each end is particularly attractive for further development as it has many advantages. Firstly as Mr. Wilkinson himself pointed out it is really equivalent to two 2.5 cc. engines and since the ratio of heating surface to internal volume increases as the size is reduced this automatically gives an improvement —the cube/square law in fact. Secondly, although this engine was not pressurised, it lends itself very readily to it. The piston rods of the double acting cylinder and of the displacers can be readily sealed by ordinary glands and the whole of the working space sealed off without the complication and lubrication problems of a sealed crankcase. The linkage adopted by Mr. Wilkinson for driving the dual displacers in anti-phase is very neat and introduces a minimum of friction and backlash. It is in fact almost identical to that adopted by James



Top picture, Fig. 10: An interesting engine with external rhombic drive by Mr. Chellis of Concord, Mass.

Right, Fig. 11: A novel engine by Mr. Rainer with a parallel motion drive for the displacer.

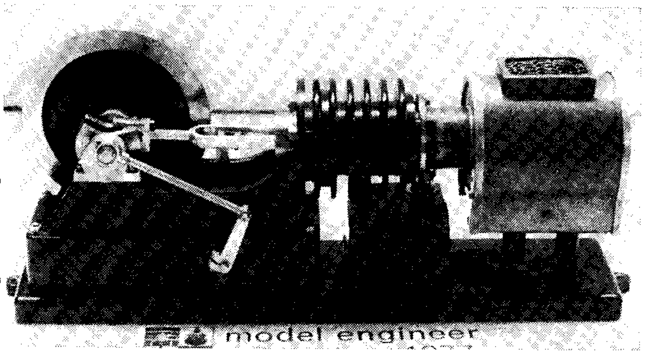
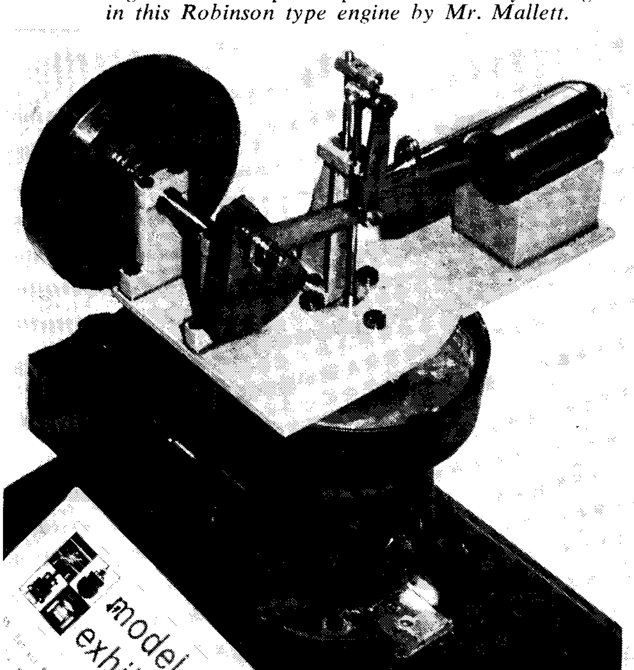


Fig. 12: An elegant horizontal engine by Mr. Broughton.

of heating and one in which the waste heat naturally clears itself. The "Andy Ross" burner is ideal for use with gas but it should not be too difficult to devise a ring burner for liquid fuels along the lines of similar burners employed in paraffin heating stoves. With chimney draught they give very clean and intense "blue flame" combustion although none of the spirit fired engines in the competition had more than simple wick type burners, not always very well guarded at that, so there is room for improvement here.

Second runner-up in the matter of power production was Mr. F. B. Thomas's rhombic drive engine shown in Fig. 8. This engine is a smaller version, specially built for the competition, of an engine already described in these pages and is unique in having an external working piston. This engine is also very well made and a consistent performer so that its power curve is of special interest. This is shown in Fig. 9 and it is significant that it reaches its maximum of 2.5 watts at 2000 r.p.m., the highest speed recorded of any engine in the competition.* It is this ability to produce power at speed that puts Mr. Thomas's engine in a class by itself and if only that power curve would keep on going up instead of dropping catastrophically above 2000 r.p.m. great things might be achieved. But why this engine runs faster than any other and why the power drops so suddenly is just not known and only serves to indicate how much there is yet unknown in model hot air engines.

Fig. 13: The displacer piston rod is very well guided in this Robinson type engine by Mr. Mallett.



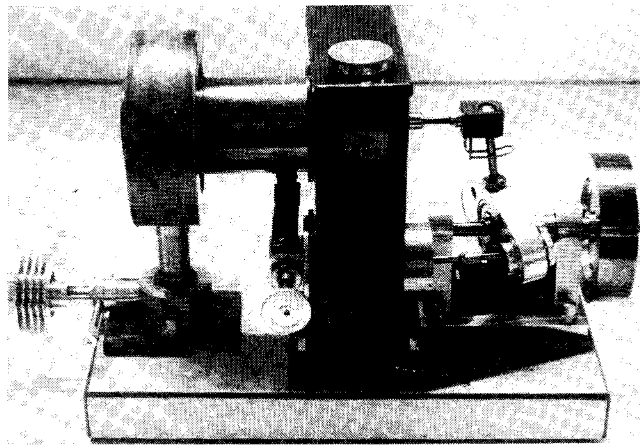


Fig. 14: A moving regenerator and wobble-plate drive engine by Mr. Urwick.

Another very welcome engine with its builder from across the Atlantic was an open rhombic drive engine by Mr. F. F. Chellis of Concord, Massachusetts. This engine, shown in Fig. 10, had the conventional "Philips" layout but set horizontally instead of vertically and being unpressurised did not need a sealed crankcase. This enabled a simple single wick spirit burner to be used to heat the hot end of the displacer cylinder. The engine performed very well indeed, 1.25 watts at 1129 r.p.m., and had there been a test of thermal efficiency would probably have won it because with its single wick spirit lamp burning in a chimney which gave just the right amount of draught while concentrating the heat on the displacer cylinder it was obviously burning much less fuel and using it much more effectively than many of the other engines. Although fuel economy is not yet an element in the competition it is not good engineering to use a steam hammer to crack a nut so congratulations to this competitor whose engine was a

* This is not strictly true since Dr. Senft's engine, unpressurised, produced 3.38 watts at 2285 r.p.h. and would therefore have been the runner-up whether pressurised or not. See Figs. 4 and 20.

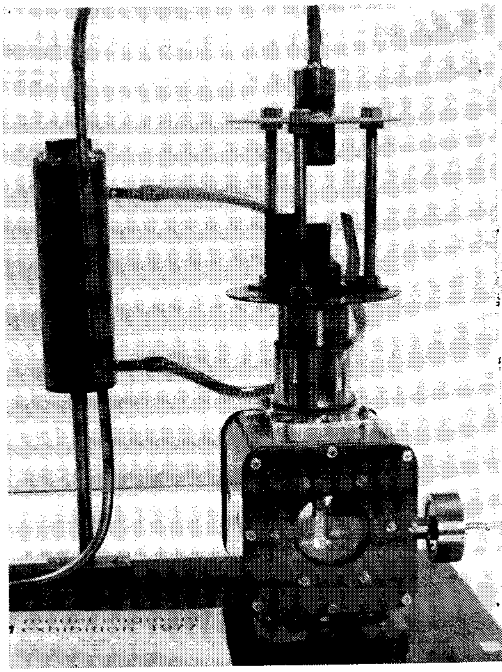


Fig. 15: A vertical Stirling engine with overhead firing by Mr. Pattinson.

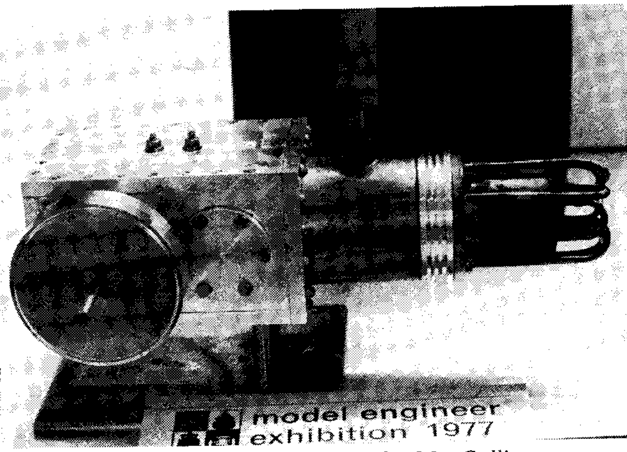


Fig. 17: A promising engine by Mr. Collin.

pleasure to run and with its open rhombic drive of special interest to spectators.

Heading the "less than one watt" competitors was a rather unusual engine by Mr. P. Rainer of Pinner. This engine, shown in Fig. 11, although of the classical concentric piston "Heinrici" type drove the displacer through a return crank, a connecting rod with a large hole in it and a Watt parallel motion. It was a fascinating mechanism to watch and being counterbalanced by a large bob weight ran very smoothly. Having the output shaft some 12 in. above the table level and with no means of securing the engine at the base presented something of a problem to the test team, but eventually with the aid of a liberal supply of weights and a wooden box it was managed and the engine turned in 0.899 watts at 811 r.p.m. Reasonable precautions had been taken to prevent heat from the furnace reaching other parts of the engine, but albeit at the cost of some considerable increase in size and bulk for the power developed.

A very neat and well finished horizontal concentric piston engine was entered by Mr. D. W. Broughton of Barnetby. In this engine, shown in Fig. 12, the power piston was driven by a forked connecting rod and the displacer by a separate crank, connecting rod and rocking arms outside the engine frame. It ran very smoothly and the engine recorded 0.774 watts at 1.047 r.p.m., much in line with others in its class.

Mr. T. H. Mallett of Harrow was the only competitor to enter an engine of the "Robinson" type shown in Fig. 13. Particular attention had been

Fig. 16: An engine made entirely on a Unimat lathe by Mr. Churchill.

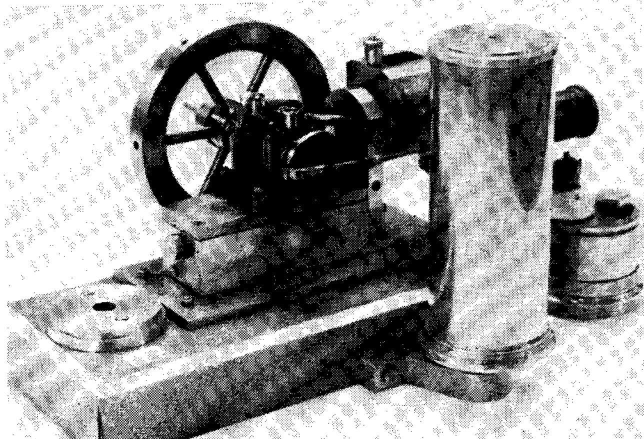
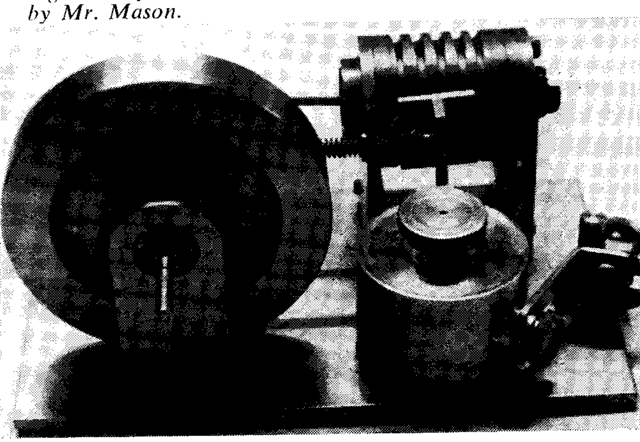


Fig. 18: Alpha and Omega—a flame or vacuum engine by Mr. Mason.



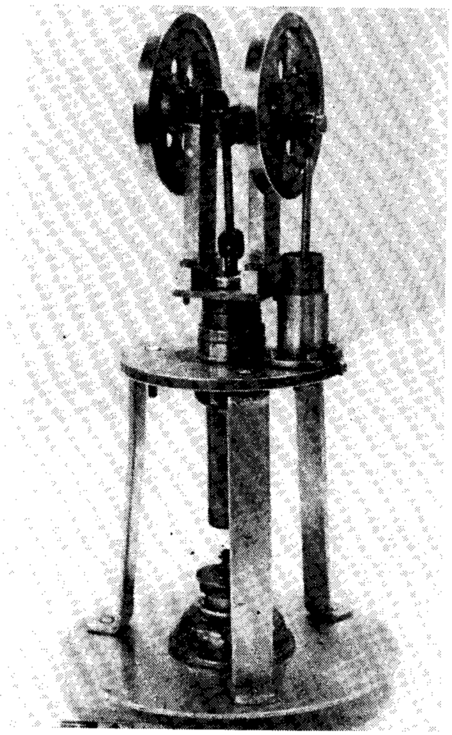


Fig. 19: This engine by Mr. Piyasena could not be tested as the output shaft did not comply with the rules.

paid to guiding and sealing the displacer piston rod by means of a long guide and with its relatively simple motion work this engine ran very smoothly with a minimum of friction. However the "Robinson" layout is probably not the best for power output. For one thing, like all engines with the heat below, the cooling system has more than its fair share of work to do and when the water in the cooling trough boiled there were cries of "tea up" although this did not seem to affect the running of the engine! For another, the rather long passage between the displacer and the power cylinder adds to the dead volume and the aerodynamic losses, although the exact significance of these factors may be open to dispute. However with 0.53 watts at 480 r.p.m. the engine did quite well although if the speed could have been doubled without loss of torque it would have been in the one watt class.

As was only to be expected, an engine with a moving regenerator was entered by Mr. D. Urwick of Malta and we were very glad to see him and his engine in the competition. In addition to its moving regenerator, of which a separate example was on display but not included in the photograph (Fig. 14), and ring burner the separate power piston and regenerator were driven by an ingenious "wobble-plate" mechanism. This was fascinating to watch in action and ran very smoothly although its mechanical efficiency may be in some doubt. It lends itself very well to multi-cylinder arrange-

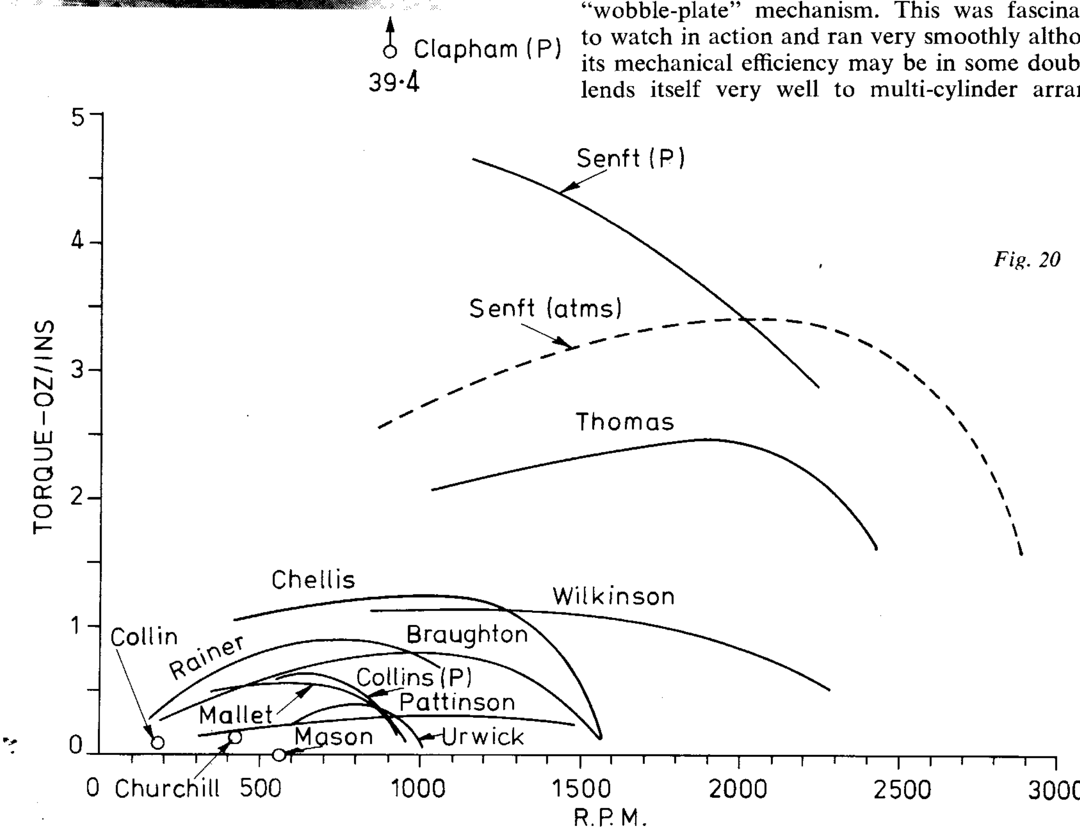


Fig. 20

ments, particularly a four-cylinder engine of the "Rinia" type in which each cylinder serves as the displacer for the next. The engine was also fitted with a stop valve between the power cylinder and the regenerator to regulate the power of the engine. In the tests of course this was left wide open. The performance of the engine with a moving regenerator was of course looked forward to with interest, but in fact it proved somewhat disappointing, 0.40 watts at 729 r.p.m. Although I personally believe that Mr. Urwick has got something with his moving regenerator I do not think he has got the proportions of his engines quite right and there is a difference of opinion between us as to the importance of dead volume. We also had on display and ran from time to time his double acting engine but it was not of course in the competition, being very much larger than 5 cc.

Mr. A. Pattinson of Reading also entered a very promising-looking vertical Stirling engine (Fig. 15). Gas fired by quite a powerful torch and with deflectors to concentrate it there was no lack of heat but in spite of this the engine failed to give more than 0.266 watts at the very modest speed of 720 r.p.m. Clearly this could be very much improved by further experiment and development. This indeed has been the whole message of the competition, it is not enough just to build an engine and then to hope for the best. The best will only come after careful trial and experiment, checking each feature in turn until an optimum is reached.

What may be regarded as a classical twin cylinder side by side horizontal engine was entered by Mr. J. G. Churchill of Fareham. Made entirely on a "Unimat" lathe, Mr. Churchill appeared to have paid more attention to the mechanical design of the engine, which was very well carried out in detail, than to its thermodynamics. As a result it did not perform very well, 0.146 watts at 417 r.p.m. This may have been due to the very small size of the displacer cylinder which, as may be seen in Fig. 16, was very much smaller than in most of the other engines.

Nothing but sympathy can be extended to Mr. D. M. Collin of Bristol for the misfortune which overtook his entry. Designed to run at up to 30 p.s.i. internal pressure it was a concentric piston type with sealed crankcase and as will be seen from Fig. 17 was the only engine apart from Mr. Clapham's to be fitted with external heat exchangers. As such it could well have been in the multi-watt class but alas owing to some internal derangement it would barely run unpressurised and not at all when pressure was applied. So the 0.09 watts recorded at 179 r.p.m. is no more than a gallant attempt by a crippled runner and it is to be hoped that Mr. Collin will have much better luck with his engine next year.

The real "tail end Charlie" however came from our old friend Len Mason of *Mastiff* fame who entered an engine of a totally different sort shown in Fig. 18. This is a flame or vacuum engine in which a flame is sucked into the working cylinder during the outstroke at the end of which a valve is closed and the highly heated air now trapped in the cylinder rapidly cools and contracts, so producing a partial vacuum which provides the power stroke of the piston. I was very glad to see this engine in the competition because I once was lent one myself which went like the clappers when the flame was in the right place, although I never had an opportunity to test its power and speed. Mr. Mason's engine proved to be no exception to the flame adjustment rule and despite the micrometer adjustments provided for the burner it took the judges quite a time to find the place where the engine would run at all. Not unnaturally this was exactly where Mr. Mason had set it himself so we ought to have left well alone! Although the engine chuntered away happily enough at 548 r.p.m. it would not really pull any load so it was entered on the Results Board as N.L.—no load. This was a bit of a disappointment really, but Mr. Mason's engine has a different valve to the other engine which had a plate valve very lightly loaded across the end of the cylinder. Consequently it could be and was blown off its seat with a loud raspberry noise as soon as the pressure inside it reached atmospheric. In Mr. Mason's engine the release appears to be timed mechanically and I suspect that his engine is suffering from excessive end of stroke compression. These flame engines are not to be ignored however since a flame will raise air to a far higher temperature and more quickly than ever can be achieved through metal walls. At high temperature, air cools very rapidly in contact with cold metal walls so there is very little limit to the speed at which the engine could run and a partial vacuum of 5 p.s.i. is just as good as an over pressure of the same amount which is all that a non-pressurised engine is likely to give. So thanks Len for reminding us of this and carry on with the good work.

An engine of the classical "Heinrici" fan engine type was entered by Mr. T. Piyasena of Cheshunt. Fig. 19 shows it to be simple and straightforward in construction but it could not be tested because the output shaft did not comply with the specified dimensions and the brake could not be fitted.

So what have we learned from the competition and its results? Firstly that it was a tremendous success and the thanks of everybody are due to Mr. A. N. Clark for thinking of it in the first place and generously donating the prizes. Secondly that the results covered a very wide range, tabulated

Entry No.	*Entrant*	*Type of engine*	*Power Watts*	*Speed r.p.m.*	*Position*
1	L. C. Mason	Flame engine	N.L	548	14
2	J. Senft	Philips Pressurised	4.69	1411	2nd Prize
4	T. H. Mallett	Modified Robinson	0.532	480	9
6	P. Rainer	Concentric Piston Inverted	0.899	811	6
7	E. F. Clapham	Concentric Piston Pressurised	39.4	900	1st Prize
8	D. H. Collin	Horizontal, Conc. Piston	0.09	179	13
9	F. M. Collins	Vert. 2 Cyl. Pressurised	0.615	640	8 Consolation Prize
10	A. Pattinson	Vertical Stirling	0.266	720	11
11	F. R. Wilkinson	D.A. Twin Displacers	1.121	1010	5 Consolat on Prize
12	D. W. Broughton	Horizontal Stirling	0.774	1047	7
13	W. D. Urwick	Wobble Plate. Moving Regen.	0.40	729	10
14	J. G. Churchill	Twin Cyl. Horizontal	0.146	417	12
15	F. B. Thomas	Rhombic Drive. Ext. Piston	2.49	1920	3
16	T. Piyasena	Vertical Heinrici	Not Tested		—
17	F. F. Chellis	Open Rhombic	1.25	1129	4

above and plotted to a common scale in Fig. 20.

Can we draw any general conclusions from these results? Apart from Mr. Clapham's engine, which was in a class of its own, four engines turned in more than 1 watt. Of these three had rhombic drives but the one that did not was double acting with twin displacers. Four engines were pressurised. Of these, two won the 1st and 2nd Prizes but the other two gave less power than the best unpressurised engines. The eight engines which did not reach the 1 watt level were all well made and ran well, but lacked that extra something which characterised the leaders.

And what of the future since Mr. Clark has already promised his support for another competition in 1978? Some reconsideration of the Rules is I think desirable.

Several correspondents have suggested that the 5 cc. limit is too small, particularly if multi-cylinder engines are to be developed. On the other hand it has worked well for single-cylinder engines so I propose that multi-cylinder engines be allowed provided that the individual cylinder capacity does not exceed 5 cc. In assessing the results the extra number of cylinders will be taken into account so that they will compete on equal terms with the single-cylinder engines which will of course remain within the 5 cc. limit. It will be interesting to see if multi-cylinder engines have any real advantage in view of the increased friction, weight of moving parts etc. Some readers have suggested that the competition should include a test of thermal efficiency, but at the moment I do not recommend this. Not only would it be very difficult to measure with sufficient accuracy for a competition but until the engines are developing a reasonable amount of power, say tens of watts, the thermal efficiency will I fear be found to be so low as to be meaningless. Prompted by the exchange of burners between Dr. Senft's and Mr. Thomas's engine it might be possible to organise a trial in which all engines had to use a standard burner in the case of gas fired engines or a standard wick in the case of spirit firing. But at this stage what shall the standard be and will it not restrict the very development which the competition is designed to encourage?

Another matter is pressurisation. Few model engineers would have the skill or technical knowledge to take their engines up to 1000 p.s.i. as Mr. Clapham did, nor to face the risks, of which he was well aware, in doing so. This arises from the fact that if any lubricating oil gets into the working space it may become vaporised and, mixing with the heated and highly compressed air, form a dangerously explosive mixture which could be readily ignited in contact with the hot metal parts. Unless therefore the working space can be designed to be at all times absolutely free of mineral oil lubricants, helium or other inert gas is the only safe fluid to use at very high pressures. On the other hand I am convinced that the future of the Hot Air Engine lies in its pressurisation, just as the future of the steam engine lay in high pressure and not atmospheric engines. I propose therefore that for next year's competition at least the pressurisation shall be limited to 100 p.s.i. This is no more than we use in our steam locomotives and presents no special problems in glands or sealing. Even so the engines must be built sufficiently robustly, like an i.c. engine, to withstand an internal explosion and will have to be tested to twice working pressure before being run in public. It has been suggested that the competition should be divided into three classes, one for atmospheric engines, one for pressurisation up to a maximum of 100 p.s.i., and an unlimited class. This would need a redistribution of the prizes and the use of an inert gas in the unlimited class.

As to how the engine shall be pressurised, the view has been expressed that any self-respecting engine should pressurise itself. This is fair enough but steam engine builders are not prohibited from using hand pumps to feed their boilers and in experimental work it is very convenient to supply a variable pressure from an external source. I suggest that the question can be resolved by offering alternatives. If the engine is externally pressurised then it must be disconnected from the source of pressure before the test begins. If during the test it loses pressure, and power, then it will only be credited with the *lowest* power recorded during the test. This will present builders with a nice dilemma. Either they will have to make their engines leakproof, say for a period of an hour or more, or if they cannot do this will have to fit an air pump and face the consequent loss of power in the engine.

So far we have only spoken of hot air engines but there is no reason why other gases should not be used. Helium is ideal and can be obtained in small quantities (do not ask me where just yet) but because of its expense would only be used in a sealed and not a pumped engine. Hydrogen must be barred because although it is an excellent fluid, better than helium, it forms dangerously explosive mixtures with air or oxygen which could be all too easily ignited by hot metal parts. The refrigerant gases, carbon dioxide and ammonia would be permissible but not the liquids, Freon and the like, because if they condensed at any part of the cycle the engine would be operating on a Rankine and not a Stirling cycle.

Finally if engines are to be run in public we shall have to introduce some simple safety rules. Fuel tanks must be brass or copper with silver soldered or brazed seams and screwed filling caps. They must be removable from the engine so that they can be refilled in an area to which the public has not access and must not contain more than 100 cc. ($3\frac{1}{2}$ fl. oz.). Gas burners must be connected to containers by metal pipes and screwed unions or approved flexibles of the type used with blow torches—push-on rubber or plastic tubes will definitely not be allowed. Adequate stop valves to be provided and makers' fittings on cylinders etc. not to be altered or modified.

These after all are only reasonable precautions which we should take but on them and any other matters connected with the competition I should be glad to have the views of intending competitors, either as letters to the Editor or addressed to me c/o *Model Engineer.*

SMOKE RINGS

From page 547

only a minimal share of enemies. I hope to be around for a good time yet, a perennial Peter Pan, fulfilling some remaining ambitions, to complete my own live steam locomotive, sail a r/c yacht, take some films and print my own colour photos . . . so be seeing you . . . " "Dickie" Dickson (D. J. Laidlaw-Dickson)

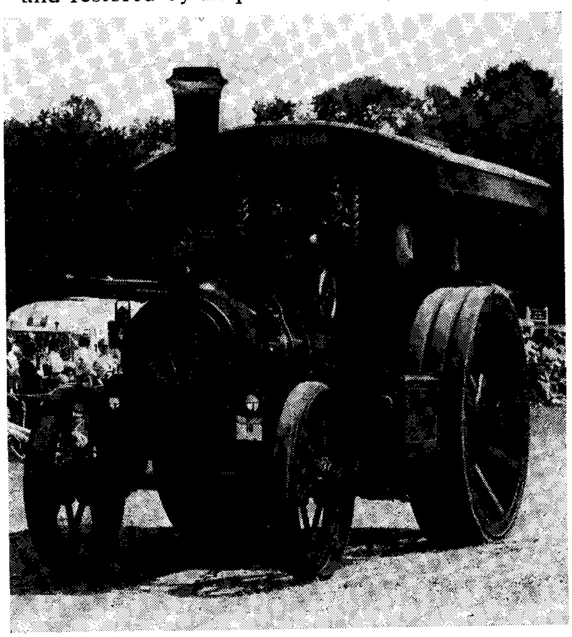
The late Cecil Moore

I was very sorry to hear of the death of Cecil Moore, founder of Myford Ltd., on 8 April. He was 88. Cecil started the firm of Myford with his late wife Adelaide in 1934, for the manufacture of small lathes for the model engineer and amateur craftsman. By dedication and hard work, they built up the business to gain a worldwide reputation in the manufacture of precision machines and tools.

Cecil was throughout his life an enthusiastic model engineer and I doubt if anyone contributed more to the success of our hobby. He was made an Honorary member of the S.M.E.E. and was a Vice-President of the Nottingham Society of Model Engineers. Cecil was always great company and had many friends throughout the world. He will be much missed.

Clapham Rally

The Clapham Common Jubilee Rally is being held on 28 and 29 May. The picture below shows one of the many engines which will be there — a McLaren road locomotive "Boadicea", built 1919 and restored by its present owner, Anthony Heal.



"HOLMSIDE"

A new locomotive for $7\frac{1}{4}$ in. and $7\frac{1}{2}$ in. gauges based on a National Coal Board saddle tank

Part II

by Martin Evans

From page 393

THE NEXT COMPONENTS to be tackled for our $1\frac{1}{2}$ in. scale National Coal Board engine are the hornblocks. These are quite simple castings, which would be equally suitable for most other types of locomotives in this scale, and in view of the very high price of gunmetal, will be available from one (possibly two) of our advertisers in iron. Note that the hornblocks are arranged with their bottom edges $\frac{1}{8}$ in. below the frames, so that the hornstays can be fitted to totally enclose the horns, making a very strong assembly.

The axleboxes can also be made as iron castings, although it might be safer to use gunmetal just for the keeps, as there is rather a tricky job involved here, in milling out a small recess to take an oiling pad, an operation which is likely to be much easier in gunmetal than in iron.

The axleboxes have been given the generous width of $1\frac{1}{4}$ in. and with adequate lubrication, should last a very long time before overhaul is necessary, especially if dust, grit and ashes from the fire can be kept out of them!

The two 5/32 in. dia. silver pins which hold the keep in place may be a light press fit with advantage, but their ends should be slightly rounded and polished so that if they should work loose, they will not score the working faces of the hornblocks. The spring pins are held in place by a single 5/16 in. dia. silver steel pin, and they should be a fairly easy fit on this pin, but without any shake.

Two methods of lubrication for the axleboxes are shown. One uses holes drilled from the ends of the axles, communicating with cross-holes drilled at 90 deg., approximately in the middle of the axlebox; the other uses the more conventional scheme; $\frac{1}{8}$ in. dia. tube running down from oilboxes with "trimmings" which can be mounted on the running boards, or at any convenient point at that or higher level, the tubes ending with a little cap of about $\frac{1}{4}$ in. dia. with a thin flange to prevent the tube entering the axlebox too far. A light spring bearing between this flange and the hornblock takes care of the vertical movement of the axlebox.

The hornstays are cut from 1 in. x 3/16 in. b.m.s. and are machined to a close fit over the lower ends of the horns. The holes for the spring pins may be a little larger than the diameter of the spring pins, and lightly countersunk on both sides, to allow greater freedom to the axleboxes in traversing a rough road.

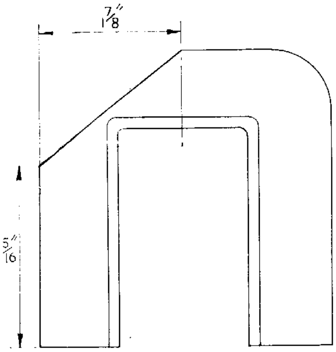
The wheels are shown drawn to the new agreed standards for flange and profile. The greater width of tread, although probably not welcomed by those who like to work to scale, will I expect be well received by builders who may want to run their locomotives on temporary or portable tracks.

As regards the balance weights, I should point out that the given size of these is only based on an approximation, but as some simple attempt at balancing may be worth while in $1\frac{1}{2}$ in scale, here are a few notes on this interesting subject.

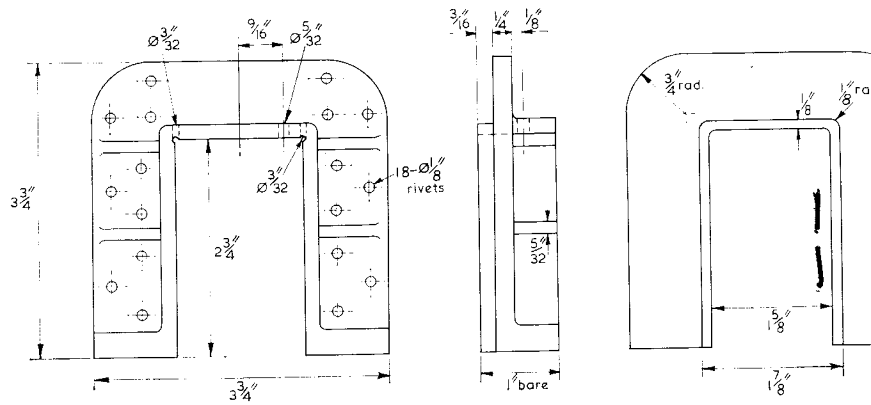
It will be appreciated that the balancing of locomotives is very much a compromise, one of the difficulties being that it is impossible to arrange the counterbalancing masses in the same plane as the parts being balanced. If the reciprocating parts, such as the piston, piston rod, crosshead and a part of the connecting rod are not even partly balanced, there will be a reaction on the frames of the locomotive, tending to jerk it backwards and forwards. If all the weights of these parts were added together and balanced by extra weight in the driving and coupled wheels, there would be a similar disturbance up and down.

The tendency of this extra counterbalancing is to lift the wheels from the rails one moment, and to increase the load at the opposite point the next. Thus is set up the so-called "hammer blow".

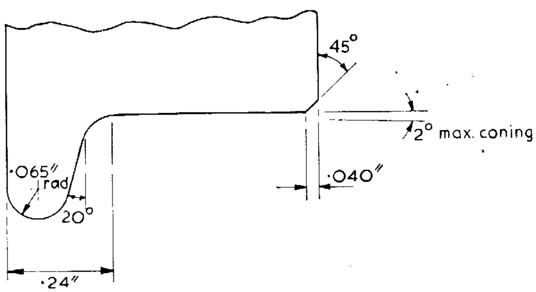
In full-size locomotive work, the most common method of balancing is to balance the whole of the revolving parts, and a proportion of the reciprocating parts—usually between 40 and 60%. If the reciprocating parts were fully balanced, the variation in pressure on the rail throughout each revolution of the wheels would be great, certainly to an amount that would be unacceptable in full-size practice, though we might "get away" with it in $1\frac{1}{2}$ in. scale. If, on the other hand, the revolving weights were completely balanced, but the recipro-



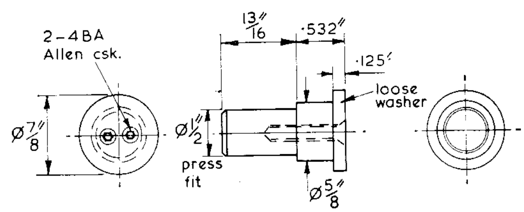
TRAILING HORNBLOCKS: 2 off
All other dimensions as for L & D hornblocks



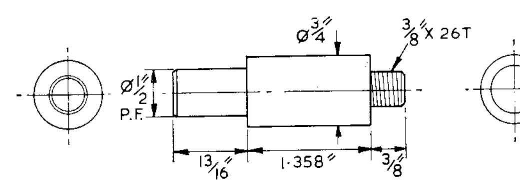
LEADING & DRIVING HORNBLOCKS: 4 off cast iron
N.B. Horns project 1/8″ below frames



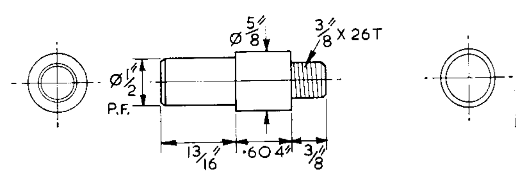
WHEEL CONTOUR



LEADING CRANKPINS



DRIVING CRANKPINS



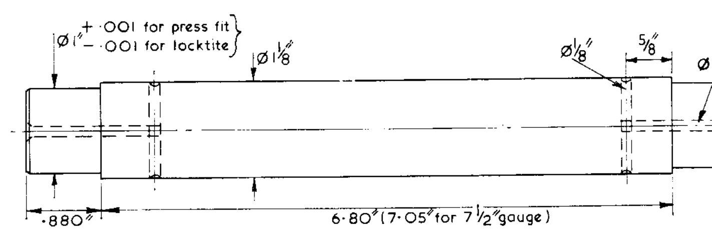
TRAILING CRANKPINS: silver steel or mild steel case hardened

cating parts not at all, the horizontal forces and the swaying couple produced might be dangerous at high speeds.

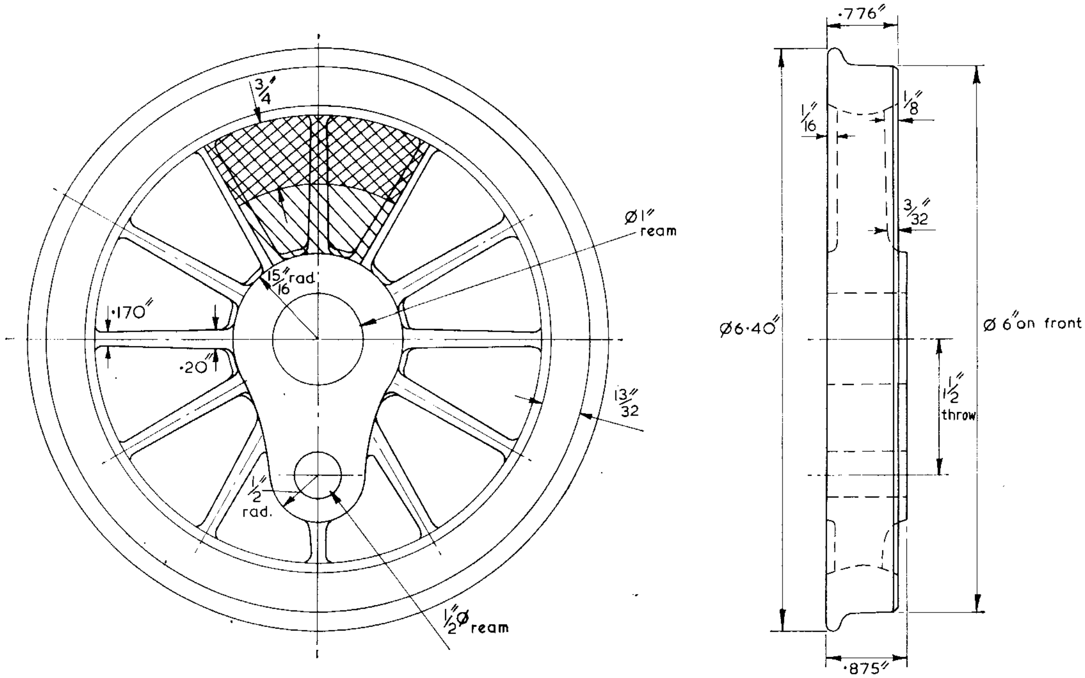
As far as our tank locomotive is concerned, the operation should not be attempted until all the parts have been made and weighed. The wheels will be finished and the balance weights fitted but not filled with lead. The valve gear eccentrics will also need to be made and weighed, though not yet fitted to the axle. Other parts to be weighed will include the piston and piston rod, crosshead, connecting rod, coupling rod.

A further complication arises with this engine, owing to the disposition of the eccentrics in relation to their respective crankpins and connecting rods, not to mention the valve gear eccentric rods and links, though these will be comparatively light in comparison with the outside parts of the motion. I will return to this subject in a later article when we have dealt with the valve gear.

In the meantime, the wheels can be turned, and one wheel only fitted to its axle at this stage, although all the crankpins can be turned and fitted to their wheels. The crankpins can be turned from silver-steel, the bearing surfaces left in their "natural" state, or ground mild steel can be used, and the working surfaces case hardened, in which



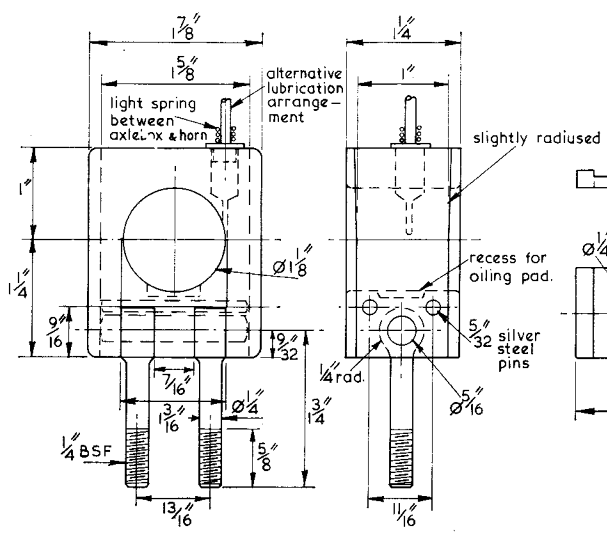
DRIVING & COUPLED AXLES: 3 off b.m.s.



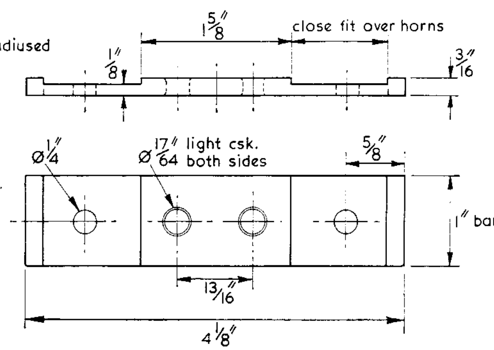
DRIVING & COUPLED WHEELS C.I. (Single hatching shows driving balance weight, double " " coupled " ")

case, builders should remember to protect the threads from the heat of the flame during the case hardening operation.

Although I prefer to use Loctite to secure the wheels to their axles, using a simple jig, as has been described many times in *M.E.*, to get the wheels "quartered", I still prefer a press fit for the crankpins. The wheels should of course be pinned, a 5/32 in. dia. silver-steel pin put in, half in the wheel and half in the axle, but there should be no need to pin the crankpins, as there is no outside valve gear to worry about.



AXLEBOXES: 6 off cast iron or gunmetal
(Keep to be gunmetal)



HORNSTAYS: 6 off b.m.s.

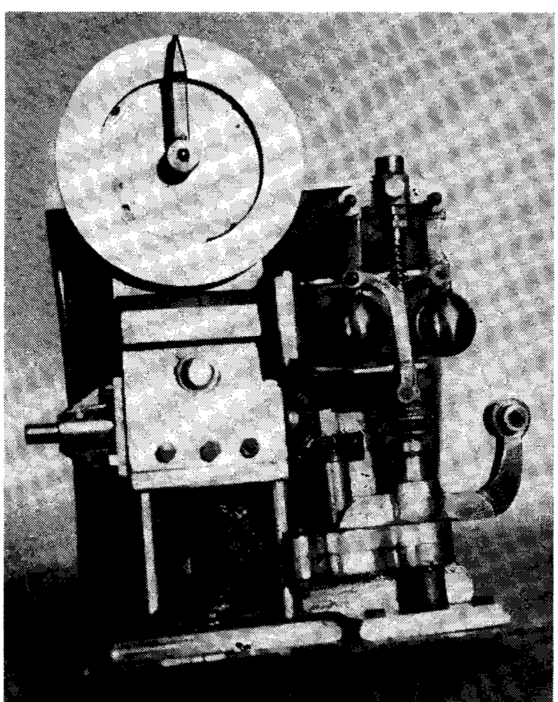
HOLMSIDE and SOUTH MOOR COLLIERY

by E. Cheeseman

I WAS VERY AGREEABLY SURPRISED on opening my copy of *Model Engineer*, No. 3558, to find Martin Evans' new project for an industrial locomotive 0-6-0 for 7¼ in. gauge was *Holmside*; it was like meeting an old friend, as I knew this locomotive very well as a youth, when I worked at the Morrison "Busty" Colliery, at which time its livery was green. The name Holmside comes from Holmside Hall which was approached by a road several miles long; and the proprietors of Morrison Busty Colliery were the Holmside and South Moor Coal Co. Ltd., who operated two groups of pits in the Stanley area.

The name Busty is applied to a seam of coal which was first worked near Busty Bank farm, and was very good coking coal; it was mined at Marley Hill, and further West a band of stone appeared in the seam, which grew in thickness, until it became impossible to work it as one seam, therefore further West it was worked as two seams, "Top Busty" and "Bottom Busty"; this seam outcrops along the banks of the rivers Derwent and Pont.

The cage in shaft indicator and overspeed steam cut-off. No castings used. This part of the model contains 107 pieces.

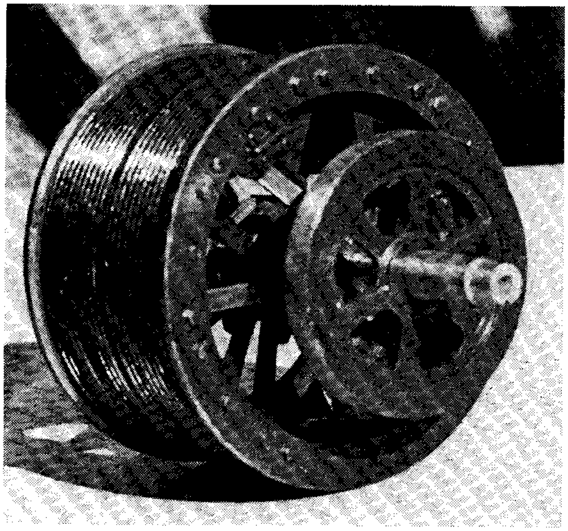


Most of the Holmside and Southmoor company's locomotives were based in a shed beside the Morrison pit, and served the two shafts at the Morrison pit, two shafts at the Morrison Busty, the brickworks at the "Charlie" pit, the domestic coal hoppers at both South Moor and Stanley, the company's farm where pit pony feed was produced, the pit prop yard, and the two shafts at the Louisa pit. The output from the William pit and the Hedley pit together with the output of "The Drift" were also handled, and the locomotives worked over a stretch of L.N.E.R. line which had formed part of the Stanhope and Tyne Railroad. I think the statement that the Holmside worked between Morrison Busty and Craghead means it may have worked at both these places, as there is some ten miles of L.N.E.R. intervening, now of course British Rail.

A smaller locomotive establishment was sited at Craghead where not only the output from the company's group of pits was handled, but also the traffic from the Burnhope group of pits, from the bottom of the Burnhope waggonway to the head of the Craghead/Grange Villa incline. The Burnhope waggonway haulage engine was mentioned by Ted Jeynes in one of his "Corners", and later the letter from the last man alive to have driven this hybrid monster, which appeared in "Postbag", was full of interest to industrial archaeologists.

Coal has been mined in this area for centuries, and the original Morrison colliery was the southern extremity of the Tanfield line, before the advent of the Stanhope and Tyne Railroad. It is interesting to note that the roadbed of the original

The model winding engine house showing position of winding drum. Note the window frames.



View of the winding drum, which is built up like a traction engine wheel. Note rope end grip. Photographs by E. H. Jeynes.

route of the Stanhope and Tyne was laid over some of the old Morrison waggonway, and that when the line was diverted to allow of locomotive haulage all the way, some of the old Tanfield road-bed was used.

It will be seen that my roots are in this area, and it has always been an idea of mine to model a complete colliery, especially one I was very well acquainted with as a boy. It is of course gone, and the site bears the foundations of a new school, and the N.C.B. were unable to offer me any help. However, County Archives, the local Council, and a letter in the local paper, brought me a welter of general information; so much so that I was encouraged to get out the old drawing board, and make a start on my project. I am still collecting information and piecing together these scraps from history, and I now have no doubt that given the time, I will be able to preserve in miniature a North West Durham coal mine sunk in 1888, and laid in a few years after the 1939/45 war ended.

I chose the Hedley pit, and intend to carry out my project in say six phases; each will be a model complete in itself, but later to form part of the grand whole. I have taken the airshaft engine and engine house as the first phase, and have made good progress with both the engine house and the engine and ancillary gear, having completed the cage position in the shaft indicator, and overspeed gear which cuts off the steam over a certain speed. The winding drum with R and L hand grooves is also completed; the drum is constructed like a traction engine wheel with staggered spokes.

JEYNES' CORNER

E. H. Jeynes writes about Magnetic Recording

In conversation with a University student, the subject of Tape Recorders came up, he claiming it was an invention of his generation, and he was very surprised to learn that the principle was well over 100 years old. Some of the early experiments using iron wire were made in 1868, and a book was published in 1888 on the subject; this was by Oberlin Smith, in which he proposed to use flat impregnated ribbon.

The first practical magnetic recorder was produced in 1898 by Vladimar Poulsen, who formed a company in 1900 to manufacture magnetic wire recorders, for dictation, or recording telephone conversations; thus it is some 77 years since the magnetic recorder came into commercial use. Its progress was rather slow for some years, although many scientists were interested in perfecting the invention.

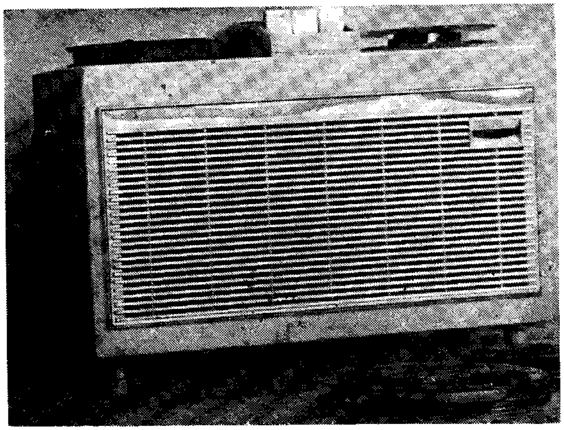
In 1928 a German engineer took out a patent for using plastic or paper ribbon or tape coated with a magnetic material. This patent was taken up by a large German electrical firm, named the A.E.G., who later developed the coated tape. The first commercial tape recorder to use this system was the "Magnetophone" recorder, using a high-speed tape.

The Marconi Company developed a machine in England which used a steel tape, a system which suffered the disadvantage of self de-magnetisation of the steel, as the B.B.C. found out.

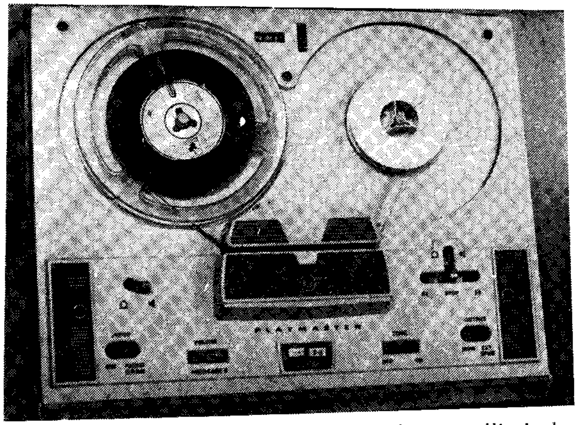
The early magnetic wire recorders used carbon steel wire as the only available material, and there were several difficulties in its use; the wire itself was difficult to handle in spooling, and was also subject to atmospheric corrosion. Later tungsten steel, and other alloys containing cobalt, nickel and vanadium were tried out with varying success. It is of some interest to note that later recorders used stainless steel, which had generally been regarded as a non-magnetic material, and which had to be treated specially before it could be used for recording, when it was run at two feet per second; this wire was very difficult to rejoin after a breakage.

After tapes generally superseded wire, they were at first subject to becoming affected by the atmospheric conditions they were exposed to; however, in 1955 a new type of tape was developed, the base of which was polyester plastic which was much stronger, enabling a much thinner base to be used, which in turn allowed greater lengths to be wound on the same size reels. Of course the spooling of tape is far easier than when wire was in use, as one trouble with round wire was to prevent it twisting, a problem absent with tape.

Perhaps a few words on the principle of magnetic tape recording may be of interest to some; I have always found it a fascinating subject. Current is generated by sound waves in the microphone, and is passed through an amplifier, after which the amplified current is passed through the coil of an electromagnet, termed the recording head, the recording tape is drawn over the pole pieces at a constant set speed by the capstan head, and the fluctuations of magnetic flux, corresponding to the variations of the sound, produce a variation in the magnetic state of the recording tape.



This is the machine Mr. Jeynes uses for reel-to-reel recording. It has a 6 in. circular speaker.



This machine takes larger reels and has an elliptical speaker.

This is of a permanent nature, and if the tape is passed over a similar type of head, at the same speed, a reversal of the proceeding takes place, and a varying voltage is induced in the reproducing head which can be amplified, and reproduced as a faithful copy of the original sound.

It is possible to completely erase a recording from a tape by running it through as though recording, but with microphone off. The same effect can be carried out by placing the complete tape in a powerful magnetic field fed by A.C. and slowly withdrawing it, or by running the tape through the gap of a powerful permanent magnet. Many tapes have had the recording accidentally erased by proximity of a magnet.

The coating of the tape with magnetic material completes the magnetic circuit, so any inequality of the thickness of the coating would set up a magnetic field capable of producing a noise voltage during reproduction. Another cause of noise in recording arises from slight irregularities passing between the head and the tape, forcing the tape further away from the head, which has the same effect as widening the gap in the pole pieces. The gap is closed with a non-magnetic metal; this makes the lines of force spread slightly outward into the space above the gap, enabling them to penetrate better into the magnetic medium of the tape, which is in contact with the head about 1/16 in. on each side of the gap.

The early tape recorders were all single track, then the two track appeared, followed by the four track and stereo, now eight track machines are available. The reel-to-reel machines for two and four track use tape ¼ in. wide; the cassette type of recorder, which has become very popular, uses tape ⅛ in. wide for two tracks. The valve has steadily given way to the transistor; this removes the heat from filament source, and ends valve failure.

The small cassette recorders have only very small diameter loudspeakers, whereas the general run of reel-to-reel machine has a fair-sized speaker, allowing reproduction of lower notes in the bass section. There are now some "Cassette Care Kits", which include a cassette-head cleaner, an empty cassette to which the tape from a damaged cassette can be transferred; there are also some plastic tabs for insertion in the holes in the backs of music cassettes, thus allowing them to be erased and re-recorded; the ordinary cassette has built-in tabs in these holes, and to render the tape proof against any accidental erasure, these tabs can be snapped off. A tape splicer is also included.

Finally, I would again stress that all magnets are kept well away from recorded tapes, otherwise quite a lot of noise will be introduced, or the recording partly or wholly spoilt.

SPHERE LATHE

Sir,—I wonder if I may ask you and your readers for any information regarding a 5 in. by 24 in. lathe that I have just acquired.

The name on the casting is "Sphere" and also says "Made in England".

It has four-step vee-belt pulleys and two countershaft speeds, giving sixteen speeds with the backgearing. The speed changes are made by moving the countershaft down by means of a lever operated cam.

One feature which I think is quite unusual is a dividing facility which comprises sixty radial holes drilled in the face of the first gear on the mandrel and a detent inserted in the casting of the headstock. A leadscrew dog clutch is also provided, together with power facing.

I would be grateful for any information at all, especially some on the source of some new screw-cutting gears.

72 Ivor Road, Sparkhill, Birmingham. S. P. Sparrow

GAS ENGINES

Sir,—I am a student studying an H.N.D. Course in Mechanical Engineering at Bournemouth College of Technology. As a project in my Final Year I will be attempting to restore to running order a 1910 Gas Engine; in doing so it will be necessary to convert the engine to run on either natural gas or a bottled gas.

The engine itself was manufactured by "Gardner Engines" of Manchester, of single-cylinder design, and the ignition is of the hot tube type with a porcelain tube heated by a bunsen burner with the speed controlled by a hit-or-miss governor.

I would therefore like to appeal through the correspondence columns to any readers who may have any information regarding gas engines in general, this particular type of engine, or any advice or information regarding the conversion.

All information, photographs etc. will be returned after photostat copying.

76 Hunt Road, Christchurch, Dorset. S. Masterman

Two Model Fire Engines

by G. D. McLeman

Part II *From page 527*

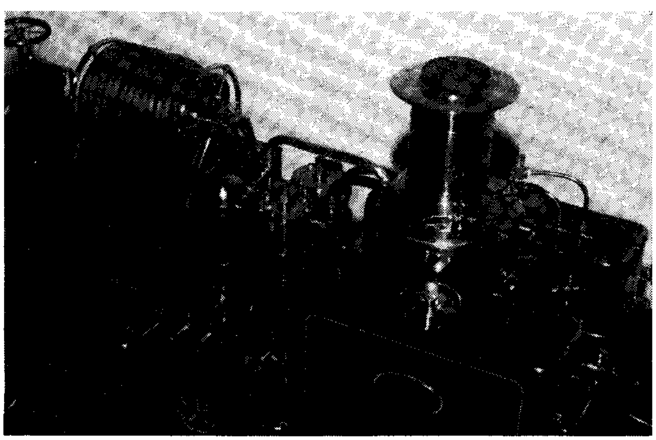
ATTACHED TO THE bottom of the boiler is a steel extension to take the oil burner, the oil tanks being housed in the front trough either side of the "Kemic" cylinder. Baffles are fitted inside the firebox to protect the copper from direct heat from the burner. On test outside the boiler and on air, a flame from a small pencil to a full 12 in. long was possible, but one has to be rather careful of the boiler as the burner was found to be rather erratic and I had to continually make adjustments.

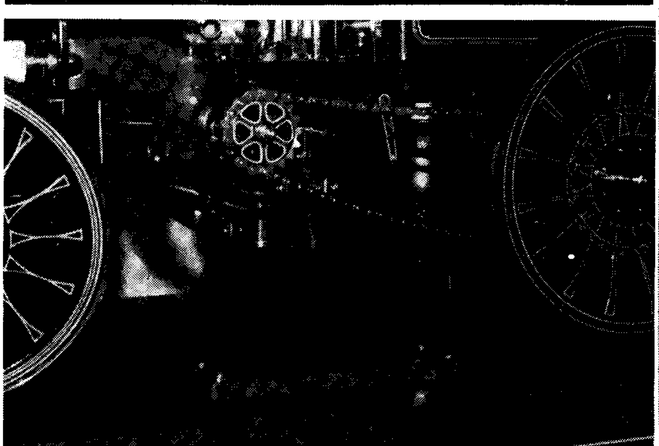
The boiler fittings are of the usual range, water gauges, pressure gauges, whistle, feed valve from boiler feed pump, safety valves and steam feed to oil burner. The boiler cleading and chimney are of brass and formed, from deep drawing brass, into tubes, then spun and formed on the lathe. An inner chimney is fitted to allow smooth passage of exhaust from the firebox and pump. On the boiler skirt there are four cleaning plugs, drain tap, and the firehole, facing the rear.

The main steam pipe is of 7/32 in. copper taken from the top of the boiler, and the exhaust pipes, again of 7/32 in. copper, run either side into the inner chimney. The main steam pipe is fitted onto a unit on the valve chest, between the steam cylinders. A main steam valve is controlled by a handwheel operated from the nearside of the engine, and after that comes the driver's control which is of a plunger type. A displacement lubricator here looks after the valve chest, and there are two more on the cylinder covers.

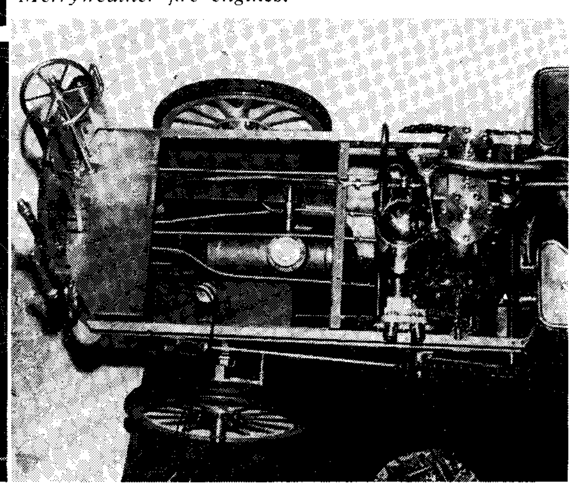
The steam pump block is built up from preshaped pieces of brass, 12 in all, the complete assembly being silver-soldered and then machined. The cylinders are $\frac{3}{4}$ in. dia. and the stroke is $\frac{5}{8}$ in. Slide valves are fitted, operated by eccentrics fitted in the middle of the crankshaft. The cranks being at 90 deg. enable the engine to start at any position. Stephenson's valve gear is used, and I had to be very careful here, as space is rather restricted. The crankshaft and eccentrics are lubricated from oilboxes fitted to the cylinder sides. Brass cleading is fitted with 14 BA R.H. screws.

The steam block is connected to the water pump by four turned steel columns. The two rear columns have bearing surfaces to control the movement of the piston rods. The connecting rods are shaped from steel having split bearings at the crankshaft, and forked ends, fitted onto a sliding block on the piston rods. The water pump rods are attached to this block. Very careful lining-up is essential here, as the clearance between rods and crankshaft is virtually zero. The whole pump unit is bolted to a $\frac{1}{8}$ in. steel plate fixed to channel





Three further views of Mr. McLeman's model Merryweather fire engines.



members which are in turn bolted onto the main chassis.

The water pump cylinders are $\frac{5}{8}$ in. dia. with an inlet chamber between and the inlet valves are fitted at the bottom of the cylinders. Outlet valves are fitted to the pump pistons. By controlling a valve fitted between the outlet and inlet, it is possible to increase or decrease the delivery pressure independent of pump speed. The boiler feed pump is driven from an eccentric on the offside of the crankshaft, and there is also a small flywheel fitted at this side. On the other side of the crankshaft is fitted a gear, sliding on splines and fitted with a dog clutch to enable the steam pump to either propel the vehicle, or deliver water.

From the gearwheel on the crankshaft, the drive is taken by another gear integral with the differential, and through a cross shaft to the driving sprockets. The roller chain is of $\frac{1}{4}$ in. pitch, and the sprockets of 18T on the driver and 36T on the rear wheels. Gears, sprockets and chain I had to make myself as no commercial sizes were exactly correct.

Both the inlet and delivery sides of the water pump have copper air cylinders fitted to smooth out the pulses of the pump; the larger vessel being on the delivery side. A valve box is fitted here to enable either one or two hoses to be used.

On test the engine proved to work satisfactorily, apart from the burner proving rather erratic, although on the second model I was able to make some improvements. I suspect however that trying to keep the burner to scale was the main reason. As I wanted to keep the engine as close to scale as possible whilst still making it a working model, one is always battling against Mother Nature!

After the tests the model was stripped and prepared for painting. One of the more difficult jobs on fire engines is the elaborate lining, as it seems to have lining wherever it could be painted! On the "Fire King" the lining is wide gold and narrow white. Most of the lining I did with a draughtsman's pen, using paint thinned down about two-thirds paint and one-third thinners.

Whilst the paint was hardening I completed the various hoses, tools and nameplates. The model was finally mounted on brass pillars with the wheels just clearing the base board to allow the engine to run under air if needed. A kit of tools and nameplate completed the model.

If I may, I would like to take the opportunity of thanking Mr. Barclay and Mr. Scott for their invaluable help; without their knowledge and interest I would never have started a "Fire King". To any reader seeking inspiration to build a model, try reading *Model Engineer,* 13 May 1954, and 1 December 1967.

A Norwegian's Views

SIR,—Living in a country in which the term "model engineering" is completely unknown (Norway), it was a very pleasant day when in 1973 I got my first copy of *M.E.* Since then I have bought many of the M.A.P. range of technical books, and gradually I have got some theoretical background for starting to set up a little workshop of my own.

This has however offered some difficulties. The first is of course your Imperial measurements which are almost entirely out of use in this country during the last few years. Even our largest supplier of taps has never heard of the M.E. range, and today even B.S.F. and B.S.W. taps are hard to obtain.

As we in Norway always have had to buy a great part of our machinery from other countries, and therefore are rather neutral in the question of measurements, I think Mr. C. Maude ("Postbag" 21.1.77) is mistaken if he believes that it is going to take over 100 years before British firms realise that they must change to metric if they still intend to sell their products to other European countries.

My second difficulty in obtaining suitable equipment for my workshop is the very long delivery time from British firms.

I ordered a vertical-slide from one of your regular advertisers on 6 November 1976, but the slide did not arrive in Norway until 9 February 1977. It is also hard to understand why it should take almost two months (by air mail) to supply a drawing to Norway from another of your very regular advertisers.

Finally, I would be very grateful if *M.E.* could help me to contact other model engineers in Norway.

Oslo 8, Norway. Kiell Klinkenberg

Making D-bits

SIR,—I was puzzled by one aspect of Mr. Harman's article on page 217 of the 18 February edition of *Model Engineer*. My comments are only applicable to those aspects of the article which deal with D-bits for making parallel holes.

I have always made and used D-bits with the greatest of success in the manner outlined in the MAP publication *Sharpening Small Tools.* Summarising from this publication:

> "The tool is formed to a D section to form a front cutting edge. Although, in theory, the upper face of the D section should lie on the diameter of the tool, in practice the depth of the tip is made greater than half the diameter (customarily 0.5d plus 0.001 in. per 0.1 in. of diameter) to prevent the bit from cutting oversize."

Similar comments are made in the M.E. lathe manual by Edgar Westbury. Why therefore does Mr. Harman go to some length to produce a cutting edge and clearance on the side of the bit when a parallel drill is only required to cut on the end? The ability to cut on the side appears to be detrimental to accuracy if there is any tendency of the drill shank to spring especially when long holes are being cut. I am indeed puzzled as to how one of Mr. Harman's bits for producing parallel holes proceeds forwards at all since no cutting clearance in addition to relief is mentioned.

Perhaps the author or any other person with working experience of D bits would care to comment on my observations?

Milton Keynes. R. Castle-Smith

ANOTHER LATHE TOOL POST

by L. Philips

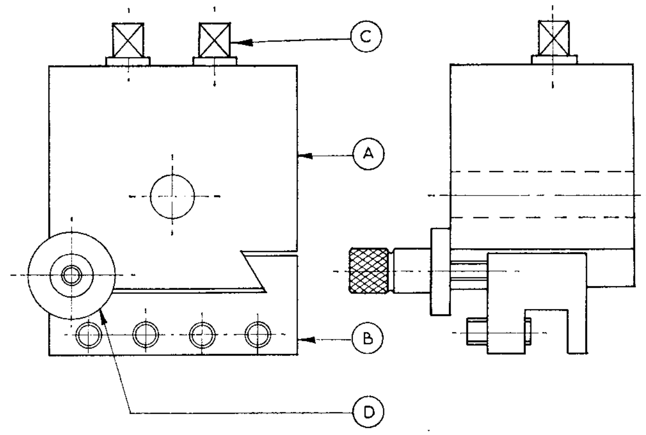
THOSE INFURIATING packing strips under lathe tools are the worst time-consuming inventions one can come across. The very first thing I made when I bought my Myford ML7 24 years ago, was the tool-post I like to describe here. It has saved me time and temper and it is accurate.

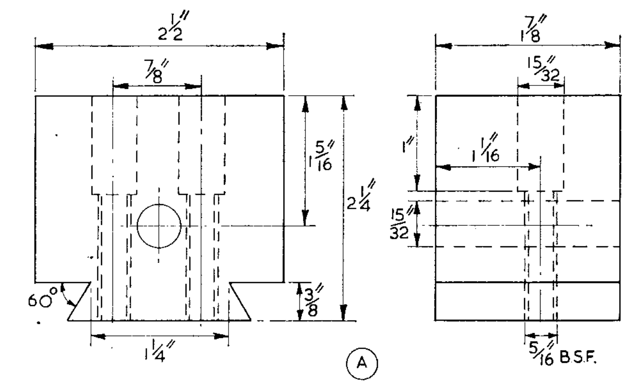
The body of the tool-post is a steel block (A). The tool slide (B) slides up or down the body by turning the thumb nut (D) clockwise or anti-clockwise. The tool is held in the slide by means of four set screws (hexagonal socket). When the tool has reached centre height, the two bolts (C) are screwed up to the slide, and that is all.

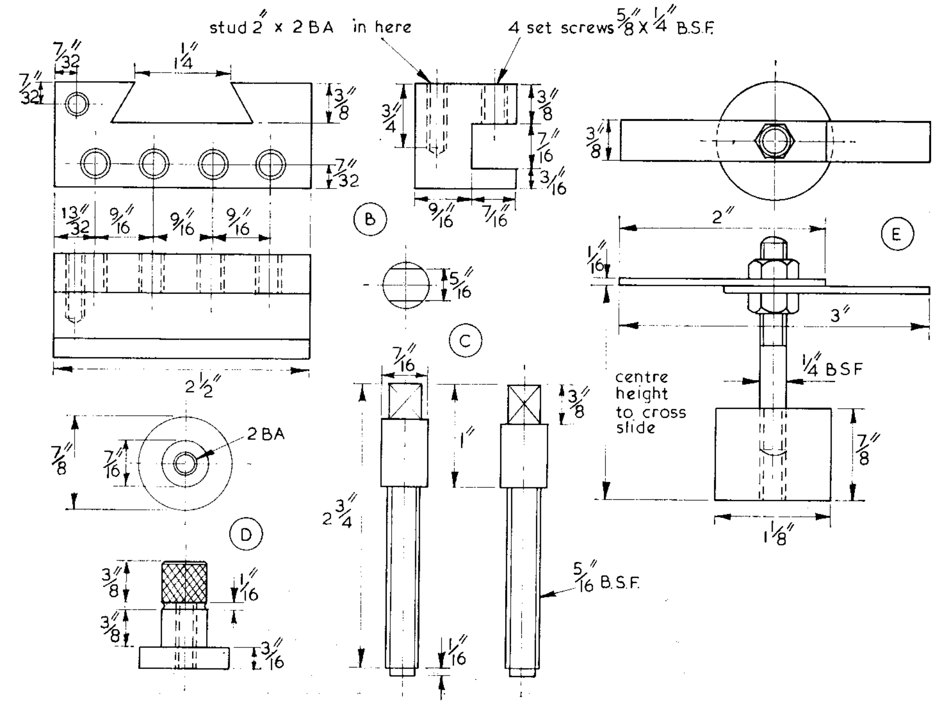
A little refinement is pillar (E). The photograph (page 579) shows how it works.

Turn the thumb nut clockwise till the point of the tool comes up to the under side of the brass strip. Or, if the tool has to be used with the tool point downward, turn the thumb nut anti-clockwise and the slide will go down by its own weight till the cutting edge touches the other brass strip. The dovetail need not be an accurate fit. In fact, it should have a good deal of clearance or it won't slide easily because of swarf and dust that will jam it. With slight modifications this tool-post will probably fit any lathe.

The tool slide takes square shanks as well as round ones. As I like things to last, the tool-post body and the slide were both casehardened. The two bolts are made of silver-steel and to prevent damage to the screw thread the last two windings near the tips have been turned away.







A FIRST ATTEMPT

A. D. Church builds a $3\frac{1}{2}$ in. gauge "Firefly"

FOR MANY YEARS I had been toying with the idea of building a model of a steam locomotive. The problems were immense; I had no workshop, where could I obtain drawings, what sort of machinery was required? If I started it, could I finish it? After all, starting from scratch was going to call for a large investment in machinery and tools.

Suddenly it all began to fall into place. I bought a house with a garage, and with the approval of the domestic authorities I set up a workshop in the garage—the car has never been inside it! I had by then joined the Bristol Society of Model Engineers, whose various members supplied me with all the information I required, and I purchased a Myford M.L.10 lathe, quite adequate for building in $3\frac{1}{2}$ in. gauge, and *Firefly,* based on the Great Western 45xx 2-6-2T class, was chosen—not an easy locomotive to build as a first attempt with inside valve gear and tapered boiler barrel, but interesting and a challenge.

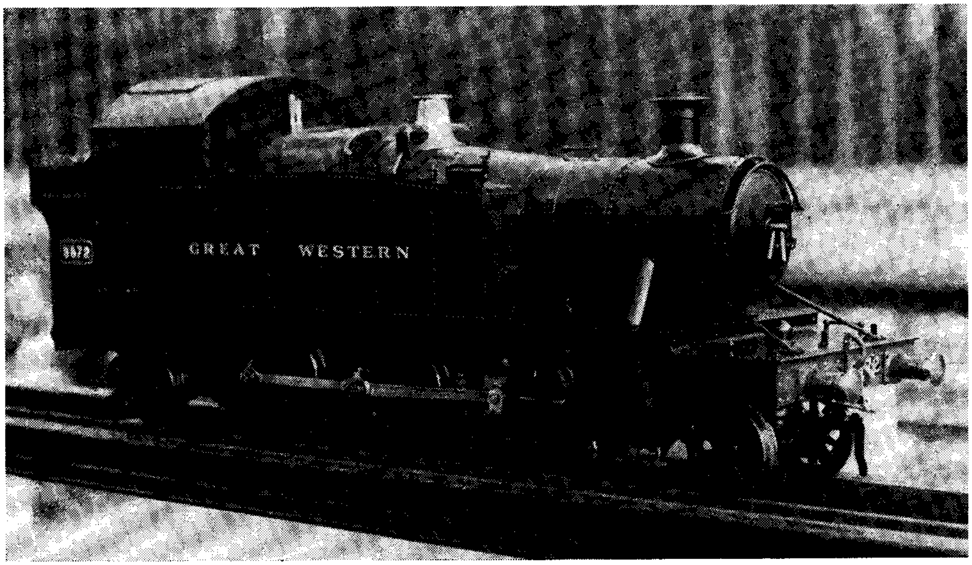
Frame material was duly purchased, marked out, cut and filed to shape. Building was straightforward, and by this time I had enrolled at night school (in my own way I was getting quite a dabhand at turning). All went well, wheels were turned to size and fitted, coupling rods, valve gear etc. were made—the satisfaction I had as individual pieces were hewn and shaped to size was enormous.

Then came the first snag—the cylinders. Money was short and I could not afford to purchase a set of castings so I decided to make a pattern of the cylinders and had them cast by a friend who worked in an iron foundry, for the price of a packet of cigarettes. By the time the cylinders were machined and fitted, my enthusiasm was beginning to lag. Was I ever going to finish? Had I taken on too much? But I persevered, and it was not long before the chassis was ready for testing by air to see if my two and a half years' work was successful. A fellow Club member had an air compressor and one Friday evening air was let into the cylinders and in full forward gear the wheels turned over, with no help from myself, and ran quite evenly. It was a great thrill to watch the valve gear operate, and the whirling of the coupling and piston rods gave me renewed vigour to carry on.

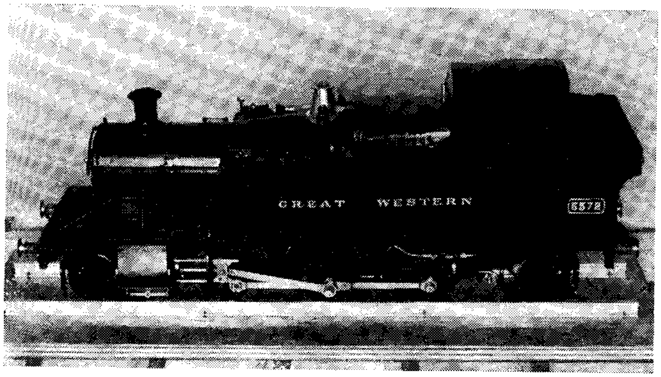
The boiler and smokebox were next on the agenda. I purchased a short length of brass tube for the smokebox from the scrap-box of a local non-ferrous stockist—the smokebox door and ring were purchased as castings from Reeves. I turned the chimney from a length of 2 in. dia. dural to get the correct shape and detail as the full-size prototype.

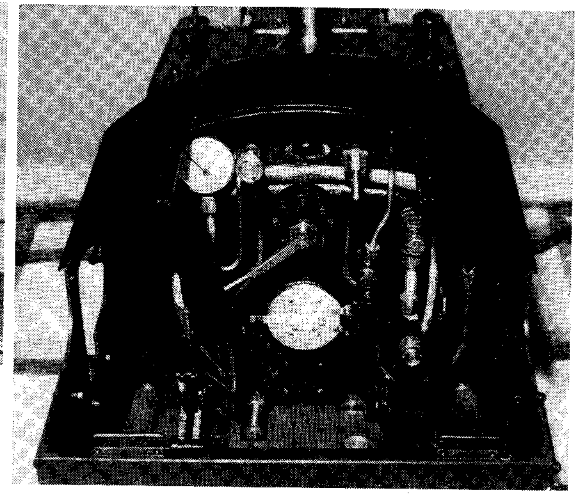
Now the moment I had been putting off arrived—boiler making. Harrowing tales had been told of various members' experiences in making boilers. I sent off to Reeves for a list of boiler parts and in due course acquired a set of flanged plates and taper barrel from them. The outer and inner fireboxes were bent to shape by using a length of round iron bar in the vice, and constant annealing of the copper.

All the boiler parts had now been fabricated and it was just a matter of brazing it all together, so I decided to seek help from fellow Club member and



A real bit of old Swindon!





Right: What the driver sees.

friend Derek Pring, builder of a very fine *Pansy* (see *Model Engineer* Vol. 140 No. 3501). Derek's help was enormous and boiler brazing sessions were held every Saturday afternoon. After five sessions the boiler was finished—a hydraulic test to twice the working pressure showed no leaks.

After the boiler it was all downhill work; the tanks, boiler fittings etc. were all finished, and the great day arrived for its first steaming. Again Derek came to the rescue as he happens to have a straight section of track in his back garden. The fire was lit, and after a few minutes the gauge was showing 30 lb. Off came the electric blower and on went the locomotive's own blower. With 90 lb. on the clock and safety valve feathering, the regulator was cracked open, and the locomotive pulled away in true Great Western fashion . . . only to seize up and refuse to go any further. After careful examination it was found that steam condensing in the cold cylinders had caused the pistons to lock. I had not fitted drain cocks because of a long delivery period due to the after effects of the "three-day week", intending to fit them at a later stage during painting. The fire was dropped and I returned home, very disappointed.

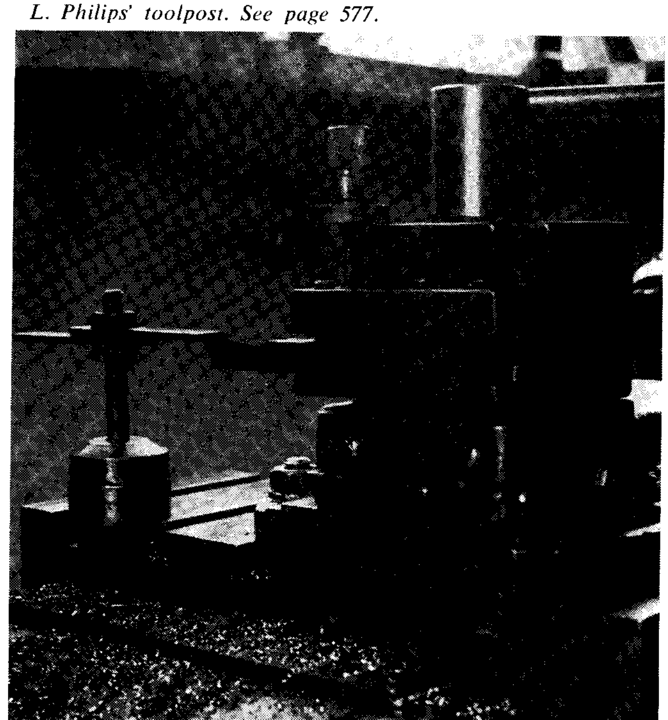
A set of drain cocks was purchased from a local supplier and in the following weeks the cylinders were removed and the drain cocks fitted, the operating gear still to be made and fitted as I originally planned during the painting of the model.

On a bright Sunday morning at the Society's track, the fire was lit and steam raised. The passenger car was coupled up, and with fingers crossed the regulator cracked open. After a few yards the drain cocks were closed and the locomotive pulled away with no trouble. The water level was checked and the by-pass valve set to keep the boiler full—a couple of shovelfuls of coal to keep the fire going and a nice even beat to the exhaust, when notched up, was produced. Success at last! I stayed on the track for about an hour getting the feel of driving, and noting some items that needed modifications.

During the winter the locomotive was stripped down and painted in Great Western livery and numbered 5572—the Great Western Society at Didcot have preserved the full-size one. The operating gear for the drain cocks was finally fitted and the whole works reassembled.

Finally I should like to thank Derek Pring for all his help in the building of *Firefly*, and our worthy editor for the numerous books he has written, which I frequently consulted, on this most rewarding and satisfactory hobby of ours.

L. Philips' toolpost. See page 577.



A VALVE-LESS STEAM ENGINE

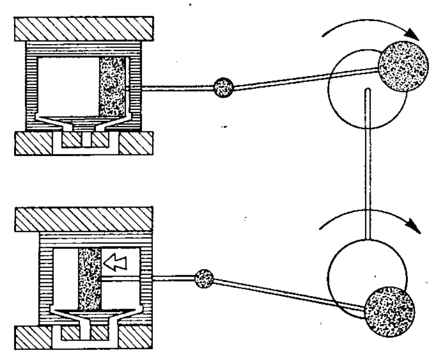
by R. L. Tingey

WITH THE GENERAL AVAILABILITY of "O" rings, I decided that it would be a good idea to construct a steam engine with valves simplified or eliminated by the use of these rings. I toyed around with the idea of using the rings on pistons passing over ports but found I could not avoid slicing up the rings. I abandoned the scheme and thought out this idea instead. This engine started out as a complex double-chamber change-over piston, but when I started to make it, simplification became obvious, and I ended up with this protoype which runs well.

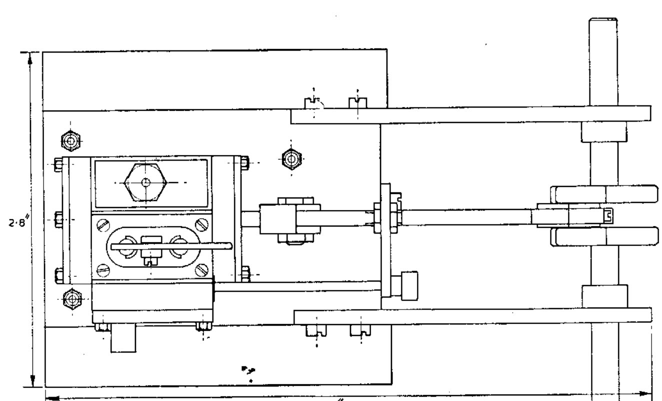
This system employs no valves, as such, and could be loosely described as a valveless, double-acting engine, but in fact the cylinder moves to make the change-over from steam to exhaust and back. This means that there has to be a cylinder and piston, and a cylinder block. The cylinder is a sleeve with two bores and not complex, yet it eliminates all the need for valve gear and eccentrics which all too often lead to over scaling and complications in the smaller gauges.

The "O" rings carry out more functions than usual. They act as packing seals for the moving parts, the larger cylinder rings are hermetic seals to keep a general pressure within the cylinder system, and in the third place they are used as buffers both for the piston to move the cylinder and for the cylinder to stop in the block. The "O" rings pass over no ports so that damage and wear are minimised.

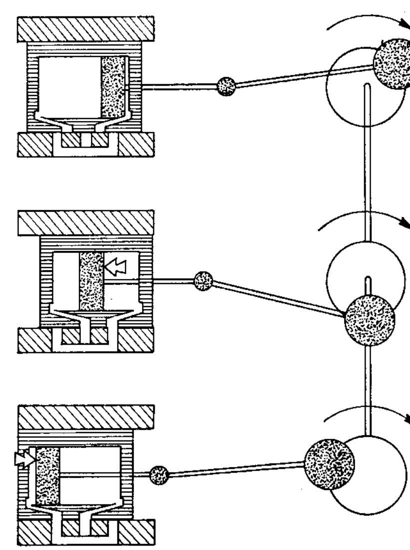
This steam engine was envisaged as a simple engine capable of being machined on the Unimat without difficulty, as indeed this prototype was. Small inaccuracies can be tolerated; for example any leakage between the cylinder block and cylinder is kept within the system by the "O" rings and goes finally to exhaust. The optimistic way to view this is that it does away with the need for a blower. The single-cylinder version needs a flywheel but this is less necessary with multiple-cylinder versions. In fact the multiple-cylinder versions are self-starting in all positions and the direction of rotation is determined by giving the crankshaft a half-turn in the required direction which sets up the cylinders correctly, before running.



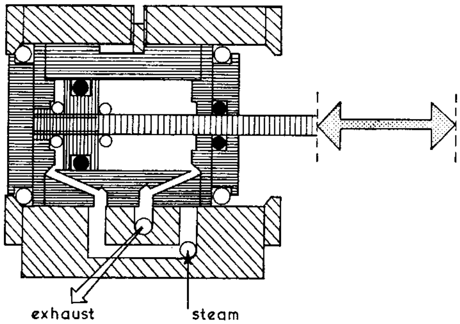
TWO CYLINDERS — ONE NULL



A PROTOTYPE VALVELESS STEAM ENGINE



THREE CYLINDERS — ONE NULL



BASIC ENGINE UNIT

The Moving Cylinder Principle

The single-cylinder prototype consists of a piston with an "O" ring as a piston ring, moving a piston rod and having an "O" ring back and front to buffer it from contact with the cylinder covers; the rod is sealed, in the front plate, with another "O" ring. The piston moves within the cylinder for only two-thirds of its travel. For the other third the piston moves the cylinder, changing over ports in the cylinder from steam to exhaust and vice versa, relative to the cylinder block. The cylinder has plates over its covers holding "O" rings which seal the cylinder-to-block space from atmosphere. It has a milled slot in which a grub screw locates to keep the cylinder from turning. The cylinder block has flanges at each end, tapered to take the cylinder "O" rings and buffer the travel. Steam and exhaust ports are drilled and milled in the block, and a simple piston type regulator is fitted, complete with an "O" ring seal. Provision is made for fitting a safety valve and a lubricator.

The Steam Cycle

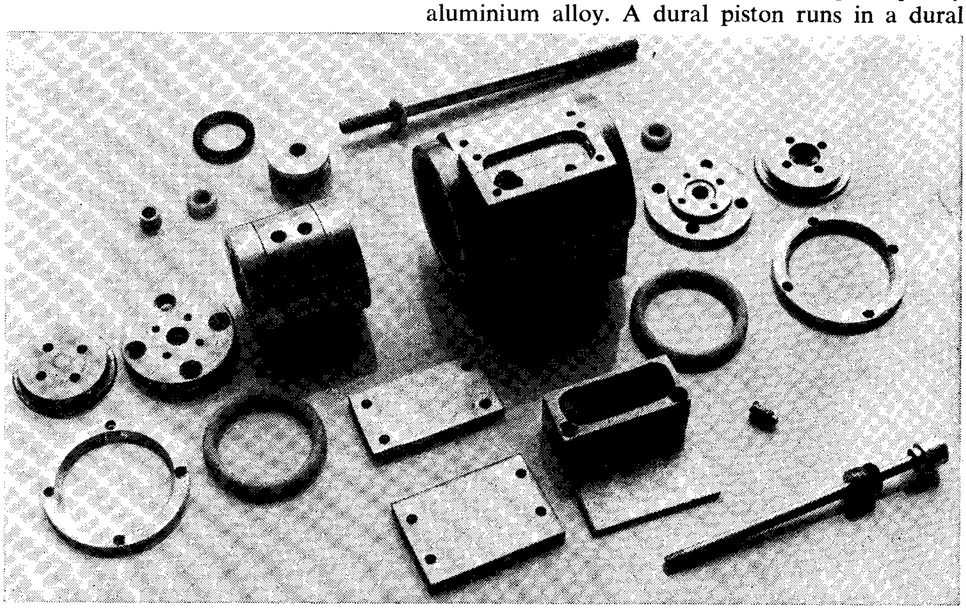
The steam cycle starts with the piston and cylinder at one end of the block when steam will be passed through the passages into the cylinder, driving the piston for two-thirds of its travel when its forward "O" ring will butt against the cylinder cover pushing the cylinder for the final third, changing the port from steam to exhaust and the other port to steam, driving the other side of the piston for the double action.

There is some lead, in fact the steam port is fully open by top dead centre, but the change-over is sudden; there is also exhaust clearance by the same token. However, cut-off occurs after the end of the power stroke so there is no expansion after admission, but this could be rectified by bringing the piston rod through the back cover and fitting springs and stop collars back and front to initiate the cylinder change-over whilst the power stroke is still under way. This is something for future experimentation.

The Prototype Engine

The prototype engine was constructed very economically, the most expensive items being the "O" rings. All parts were machined on the Unimat or worked by hand and adaptability was taken into consideration as each part was made. The version I ended up with is intended for use on a small traction engine, using it as a test bed, hence the provision for the regulation, lubrication, and the safety valve. Before final fitting the steam inlet has to be blocked off, a saddle fitted and the steam dome milled out.

The engine was constructed from the solid, the engine moving parts being made from good quality aluminium alloy. A dural piston runs in a dural



The components of the basic engine unit.

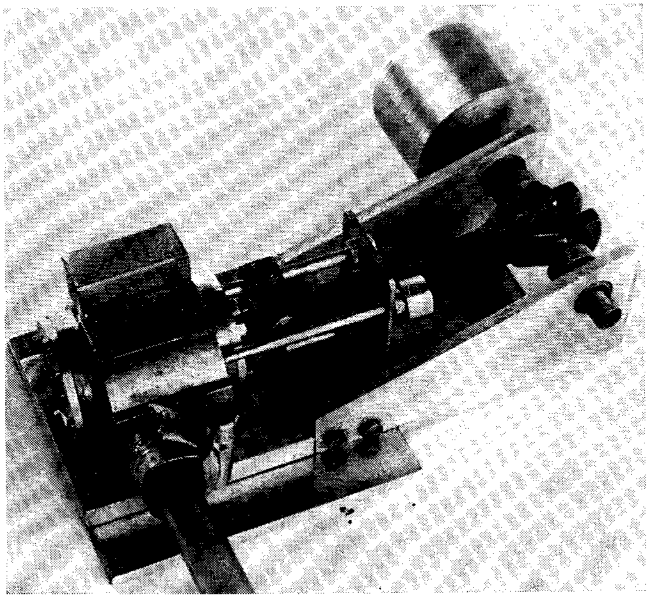
cylinder; these parts change direction rather a lot and need to be light in weight. The cylinder block is machined from solid brass, a hard brass should be used; gunmetal or bronze would also be suitable but more difficult to machine with the Unimat. Phosphor bronze is used as a bearing surface for all fast-moving parts of the motion, but in the most economical and easily-made way. Stainless steel is used for the piston and regulator rod as they are in contact with the steam. The connecting rod and crosshead are of mild steel and the crankshaft is of silver steel. The crosshead is a little taller than is usual, but it runs on two phosphor bronze rods for cheapness plus smooth running. The bed is constructed of aluminium, but duralumin is to be recommended due to the difficulties encountered in tapping the soft aluminium with small BA sizes, even with over-sized holes.

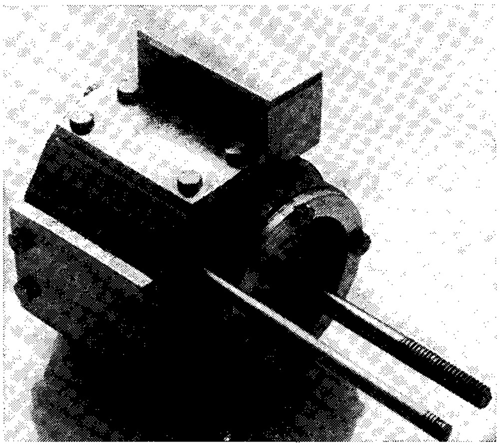
The "O" rings used are of two types. For use in hot oily steam with fast-moving parts the black Viton rubber "O" rings are to be recommended, as they retain their size and hardness and wear well under these conditions; they are also obtainable in very small sizes. On the other hand silicone rubber "O" rings are used for seals where they may get less lubrication and heat, and as buffers. The silicone "O" rings swell and soften very easily, when they are easily damaged, but they are excellent as buffers and where oil may not immediately reach as they are slippery in their own right.

Testing the Prototype

After construction, the engine was given a pneumatic test and ran readily with an air pressure of

Prototype engine ready for air test.



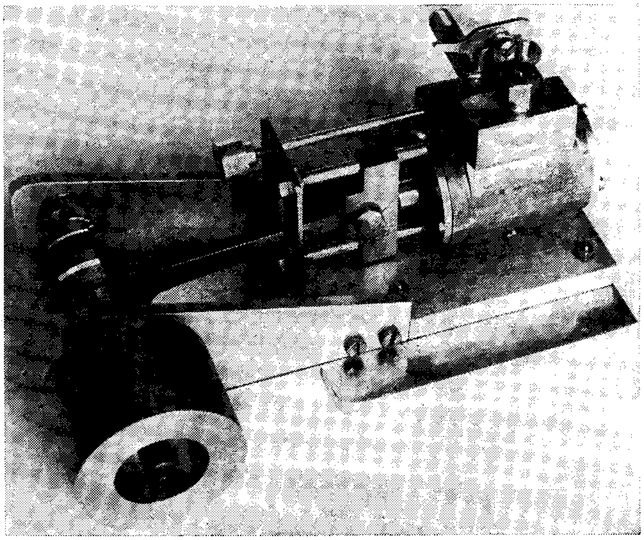


The basic engine unit, with regulator.

30 p.s.i., stopping work when the pressure fell below 15 p.s.i. The regulator worked well providing from full-speed running to total cut-off. The most promising part of this test run was that no parts were finally tightened up or sealed and yet the engine ran with only a little leakage to exhaust. At this stage neither the safety valve nor the lubricator were fitted, so the next task was to complete and fit these. The safety valve is the Ramsbottom type, but fitted with balls, and the lubricator is to my own design working by gravity, steam pressure, and displacement.

Before running the engine in steam, I tightened down all the nuts and bolts, sealing them with Loctite, and gaskets were fitted where needed. Then I gave the engine another test on the air compressor, fitting the larger flywheel. The compressor was run up to a pressure of 40 p.s.i. and

Prototype engine with small flywheel.



The prototype engine on steam test.

the little engine opened up, when it ran easily and very fast. I checked the speed with a stroboscope and found that it was running in excess of 1000 r.p.m. The large flywheel twisted itself off when the regulator was closed to slow up the engine, but the engine continued to run. It was vibrating badly and would not speed up. I was pleased with this test and was covered with a film of light oil as I had used 3 in 1 in the lubricator as a running-in oil.

To run on steam I used the small boiler for the traction engine, to which the engine is to be fitted later. A steam pressure gauge and water gauge were fitted and the various unions and pipework made steamtight. As the boiler had no steam dome the "backhead" top fitting was used for this purpose so that the boiler had to be run in a nose-down position to obtain something like dry steam. This is not an ideal position to get a good draught for steam pressure, but with the smokebox and chimney removed, two spirit burners heating the firebox end, and a spirit blowlamp heating the front end, a pressure of just over 25 p.s.i. was recorded on the pressure gauge, and the engine run on steam. A few leaks became apparent and the pressure soon dropped, but it had proved my point. With the leaks secured I ran the engine again on steam and it ran easily in either direction, but not very fast as there was insufficient pressure.

Surprisingly the engine runs very smoothly without any knocking, considering the movements involved. For the next test I intend to mount the engine on the boiler, with its proper steam dome, smokebox and exhaust tube in place.

Future Developments

Being a self-contained engine these units are envisaged as being capable of running in any position, with just the cylinder block changed or modified to suit the design requirements and number of journals on the crankshaft. With a short motion the unit has only to be pointed in the right direction and secured, the length of connecting rod being determined by the configuration desired. For example it is easy to imagine a pair of units as a horizontally opposed twin-cylinder engine, and three units, in line, as a vertical marine engine; I hope to make these versions in the near future.

When I chose one-third as the period for the change-over, it was for design convenience, and it happened to work, but the position of the ports and their size was given considerable thought. The cycle could possibly be improved by altering the timing; this is something for experiment.

The size of construction of this prototype was determined firstly by the scale requirements of the crankshaft stroke, and also by the volume of the steam chambers, but another consideration in the smaller gauges is the cross section dimension of the "O" ring which is quite massive if scale is considered. Larger gauges can have the advantage of only needing a cylinder sleeve no thicker than that of the small gauge. Cylinder blocks need not be bulky if the steam chest, regulator and safety valve are placed elsewhere, such as with a locomotive with outside cylinders, so that something like scale appearance may be achieved.

Conclusion

I designed this engine as something between the full valve gear type and the oscillating cylinder engine, and hope that the simplicity of construction and operation with no elaborate valve gear will encourage others to built this engine, and to design models around it.

I believe this design to be original, but who knows what is hidden in Patent Office files. Perhaps my reward will be for this to be remembered as the "Tingey Cycle Engine" in future. I have nearly completed the drawings and construction details of this prototype, which may be followed, in due course, by any future developments.

Footnote

I must mention that this engine is a good in-line, high-speed energy converter, running well on steam, air or gas pressure and may well be of use in pneumatic tools, or for use where a sparking electric motor would be hazardous.

A MILLING MACHINE STORY

by D. J. Unwin

NOWADAYS more model engineers seem to be including a milling machine of some sort in their equipment. For the benefit of readers I am recounting some of my experiences with such a machine and describing the accessories I have made to extend its range of usefulness.

I started my model engineering using my father's "Relmac" lathe, drilling machine and grinder, all treadle operated. Undoubtedly the best way of teaching you to keep tools sharp!

All milling work was carried out on the lathe. One method was to hold the cutter either in the 3-jaw chuck or on an arbor between centres, the work being held on the slide rest or on a "jury rig" vertical-slide made of an old lathe slide and an angle plate clamped to the top-slide.

Another way was to hold the cutter in a milling spindle—we had two of these, both home-made, one large one for normal work and the other adapted from a bicycle hub for small cutters which needed to be run at high speed. They were usually supported on the vertical-slide, the work being supported on the faceplate, in the chuck or on centres as was most convenient. The milling spindles were driven by a belt passed round a drum mounted above and parallel to the lathe axis. This drum was driven from the treadle by belts on stepped pulleys. The drum was carried on a swinging frame which was sprung upwards to keep the belt tight as the spindle moved up and down, whilst the belt ran along the drum when the spindle was traversed sideways. When the lathe was eventually motorised this overhead gear also served as a countershaft to drive the lathe.

Whilst these arrangements produced adequate results when used with care, setting up was often time consuming. I still hankered for something better so decided to save up for a hand shaping machine. Eventually enough cash was accumulated to buy a small "Adept" shaper but my father, with considerable wisdom, wouldn't let me get it, but made me save another six months until I could afford to buy the larger model. This was a wise move, for many years the machine performed valuable service, during which time it was improved and fitted with many gadgets. One particularly useful rig was to fit one of the milling spindles onto the clapper box, which was locked during the operation. The spindle was driven by means of a long belt from a motor clamped onto the bench to one side, thus enabling the shaper to be used as a vertical milling machine. Cutting steam ports in cylinder blocks was a snip by this method! This machine augmented the lathe con-

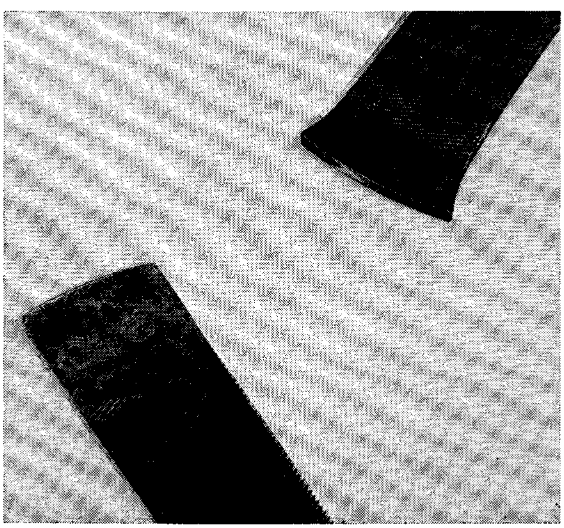


FIG. 1

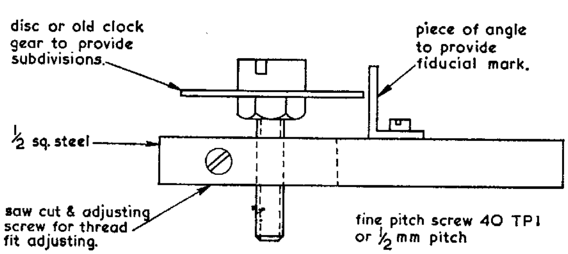


FIG. 2

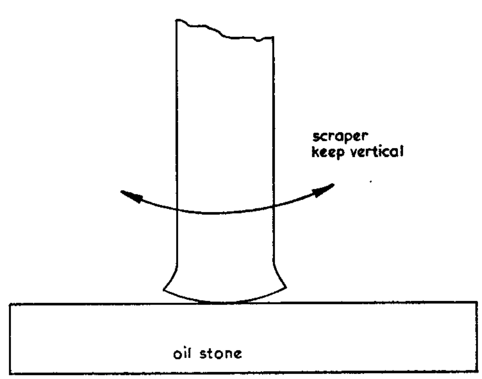


FIG. 3

siderably but I still hoped for, but didn't expect to get, something better.

My chance came some years later, after I had married, changed my job and set up my own workshop. In one of the instrument shops of my new employers was an elderly small horizontal milling machine. It was in poor condition and was avoided like the plague by all the craftsmen. However, I made a few enquiries to find out why they disliked using it as it had obviously been a good machine originally. I found the objections were mainly against the installation of the machine—the original belt and cone pulley drive had been removed and had been replaced by badly fitted drive incorporating an Austin 7 car gearbox which had the habit of jumping out of gear at crucial moments! A secondary objection was the rather weird method of holding the cutter arbor into the mandrel. This allowed the arbor to come undone and unscrew out during a cut—an irritating habit often ruining the work and/or the cutter in the process. None of these problems caused me any concern. Firstly I knew from past experience that a machine which had once been good could be reconditioned to be good again given sufficient time and effort. Secondly the horrid gearbox drive could be replaced by a better arrangement and the arbor problem could be easily corrected. Why this had never been done before I can't imagine.

Armed with this knowledge I approached the plant manager and asked that if ever this machine was to be thrown out could I have first offer, which he agreed to do. About 12 months later the works manager sent for me and told me they were disposing of the machine and I could have it for the same figure they had been offered by the machine tool trade—£25! After some argument he agreed on a reduction of £2 and I went away to look for £23. On reflection I felt that the hand shaper was likely to become redundant so I decided it would have to go. In any case there would not be room in my workshop for a miller, a shaper and me! I eventually found a buyer who gave me £14 for the little shaper and I managed to find the rest, paid for the miller, dismantled it and got it home in a borrowed trailer. The gearbox contraption was left behind but a search in the millwright's store shed revealed the cone pulley which had originally belonged to the machine.

Now the fun could start. The machine was completely stripped down and every part thoroughly cleaned, not forgetting all oil channels, and note taken of any broken or missing parts which might need repair or remaking. Machine tool reconditioning is a very interesting job, but needs care and cannot be hurried.

The first job was to true up the slides and slideways. For this job a set of flat scrapers was made by forging the ends of some worn out flat files (Fig. 1). The cutting edges need to be left dead hard as continual use will have polished a hard skin on the slide surfaces. The other items needed were a depth micrometer (home-made), some circular straight rods of $\frac{5}{8}$ in. dia. silver steel, a surface plate, 12 in. steel straight edge (I used the hardened one out of a Moore and Wright combination set) and some smooth or second cut files, flat and half round. As the depth micrometer is used only as a comparator, it can be improvised from any fine pitch screw in a good fitting tapped hole, with an old clock gear wheel or similar to indicate the amount of movement (Fig. 2).

When truing slides the first thing to do is to examine them closely to see where the most badly worn places are located and to notice if there are any unworn areas which can be used as witness surfaces. These often occur under gib strips or in places where the slide widths do not quite match. Witness surfaces allow the degree of wear to be measured with a micrometer so that the amount of metal to be removed is known. Then as filing proceeds it can be checked systematically by measurement. After the surfaces are as near correct as possible by measurement, final truing is undertaken by scraping using the surface plate, a piece of plate glass or an already trued mating surface and marking blue to show the high areas. Scraping should not be in one direction but as random as possible. Sharpening the scraper is im-

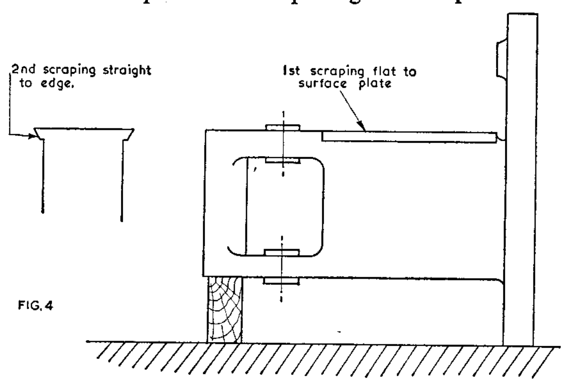


FIG. 4

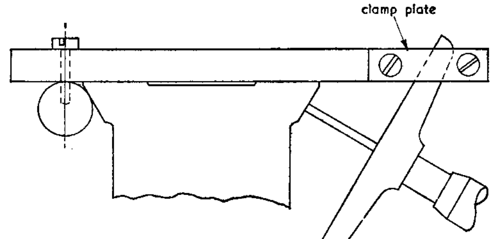


FIG. 5

portant and it is essential to have an oil stone by your side as you are working so that the edge can be repeatedly touched up (Fig. 3).

The front face of the column was the first to be attacked, the job being made easier by laying the casting on its back. Using the surface plate and blue the front face was flattened by filing the high areas down then scraping until true all over (Fig. 4). Next, one dovetail angle was straightened. Care was needed here to avoid altering the angle whilst the unworn portion was filed down. The straight edge with feeler gauges was used first, followed by blue, and a surface plate formed by a narrow piece of plate glass about 2 in. wide by 6 in. long.

To get the opposite angle of the dovetail parallel, a simple fixture was rigged up out of a piece of 1 in. x ½ in. mild steel bar, with a short length of ⅝ in. dia. silver steel screwed rigidly onto one end and the depth micrometer clamped on the other (Fig. 5).

Although slow and laborious, using this rig made it quite easy to get the two dovetails parallel. With this completed the corresponding surfaces of the knee were mated up to it. The top of the dovetail had worn most whilst the flat face had worn slightly curved due to the weight of the table and knee (Fig. 6). The depth micrometer, working from the machined but unworn surface, was used to restore the squareness (Fig. 7). The angle faces of the gib strip must also be flattened using the surface plate as a reference. A fair amount was taken off all the surfaces including the gib strip and this was accommodated by slightly elongating the bolt holes in the strip. After fitting together, a small amount of final local touching up was necessary to get the knee to slide sweetly throughout its travel. To compensate for wear it is a good plan to scrape all these surfaces very slightly concave. The next surface was the cross-slide guides on the top of the knee. First the top face was trued to the surface plate then the dovetails were treated exactly as the guides on the front of the main column. Once again after the mating cross-slide had been trued up, again slightly concave, a little local scraping got them working nicely.

The worst job of all was truing up the slideways of the main table. This is about 2 ft. long and this and its mating surfaces in the cross-slide casting had worn slightly curved. It took a great deal of filing and scraping to restore these. The table was inverted and the two flat surfaces of the slideways straightened by measuring down from the unworn surface with the depth micrometer (Fig. 8). The locating vee face (that opposite to the gib strip) was then straightened using a straight length of round silver steel and blue (Fig. 9). The two vees were then made parallel by a slight adaptation to the depth micrometer (Fig. 10). The gib strip in this case is a long tapered strip located endways by a large-headed screw. Unfortunately the amount of metal removed allowed it to go in about an inch too far and I had no way of machining a new one. This problem was got over by hard soldering a short piece of steel on the large end, filing and scraping it to form a continuation of the taper and re-forming the recess for the head of the adjusting screw. The thin end was shortened by the same amount (Fig. 11). The top working surface of the table, apart from a number of bruises, was reasonably good and only needed the "bumps" taking off.

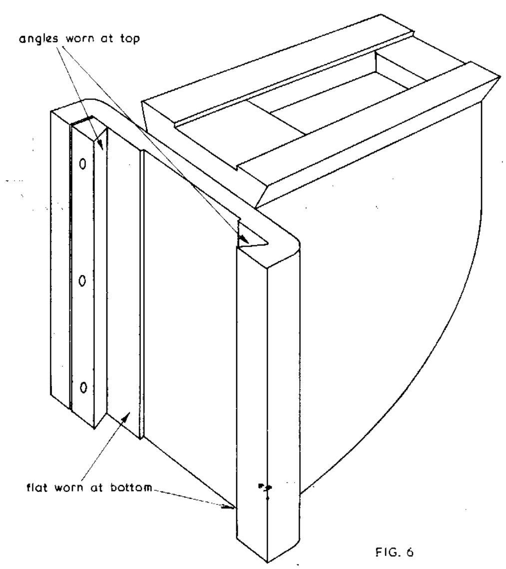


FIG. 6

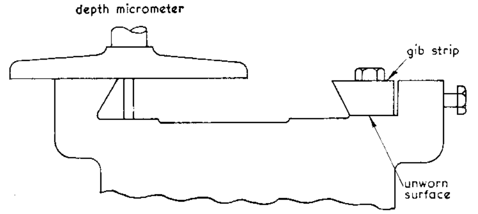


FIG. 7

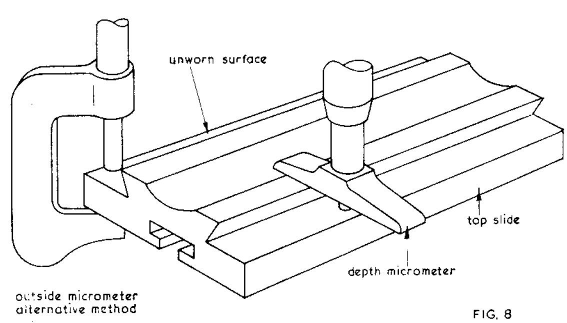


FIG. 8

All this work took about six months and by the time I had finished I had collected a pile of worn out files and developed some excellent biceps! If the surfaces of a machine are very badly worn indeed the best resort is to have the slideways ground by a firm specialising in this type of work. In my case it would have been a great saving in time and manual work but was ruled out for economic reasons.

As the rebedding of the slides had caused some displacement of the relative components, the nuts and lead screws no longer lined up. Fortunately it was possible to accommodate this by elongating the fixing bolt holes of the nuts and then repinning by enlarging the pin holes and fitting new pins.

The next item on the reconditioning exercise was the lead screws. Although I was lucky on this occasion and they were reasonably good, these can be badly worn locally sufficient to need recutting which can be a problem if no screwcutting lathe is available. On square or Acme form threads the usual method is to true up the flanks and then make a new nut to fit. This can be screw cut from bronze or of white metal cast round the screw. This latter method is easy to do, gives very good results and wears well. If, as is often the case, the screw is not too badly worn but the nut is, possibly even stripped, then the cast nut provides an excellent solution.

The nut body is bored out about ⅛ in. larger than the outside diameter of the screw to within 3/32 in. of each end and cross holes drilled right through one side and into the other (Fig. 12). A good unworn section of the screw is coated with lamp black, shoe polish or something to stop the white metal sticking. The nut is then slid on and sealed with fire clay.

To be continued

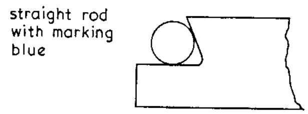


FIG. 9

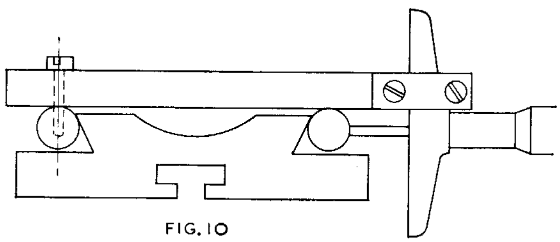


FIG. 10

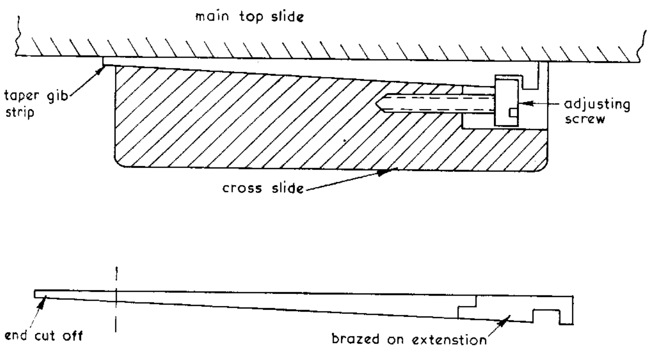


FIG. 11

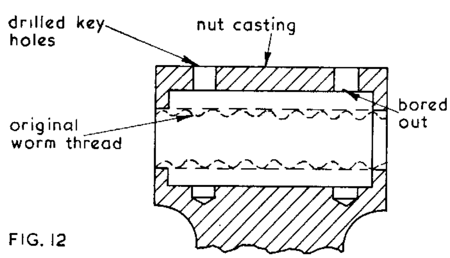


FIG. 12

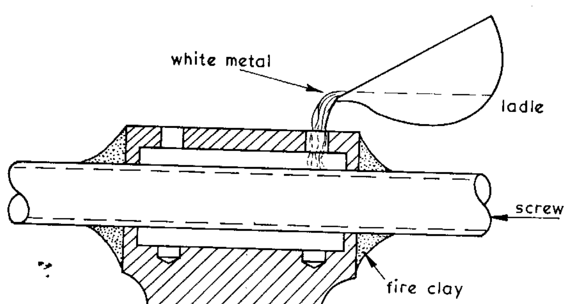
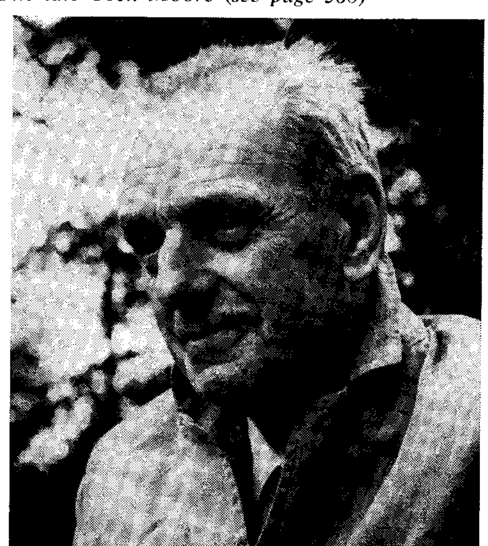


FIG. 13

The late Cecil Moore (see page 568)



NINTH INTERNATIONAL MODEL LOCOMOTIVE EFFICIENCY COMPETITION

FOR STEAM LOCOMOTIVES OF 3½ in. AND 5 in. GAUGES

THE COMPETITION WILL BE HELD ON THE CHINGFORD TRACK OF THE CHINGFORD & DISTRICT MODEL ENGINEERING CLUB

(By kind permission of the Committee of the Society)

ON SATURDAY JUNE 25th

Commencing at 9 a.m.

The Prizes will be as follows:

The Winner — Martin Evans Challenge Trophy and Cheque for £35
Second — Cheque for £12
Third — Cheque for £8
Fourth — One year's subscription to "Model Engineer"

The winner will also receive an engraved "replica" trophy for permanent retention

ADMISSION FOR SPECTATORS WILL BE BY TICKET ONLY OBTAINABLE FROM "MODEL ENGINEER"

ADMISSION 20p per person. Car parking free

Please make cheques and postal orders payable to "Evans Locomotive Fund"

COMPETITION RULES AND ORGANISATION

1. The Competition will be open to 3½ in. and 5 in. gauge coal-fired steam locomotives.
2. Entry will be restricted to owners who have basically built the engine they enter. (Parts bought "outside" such as pressure gauges, boiler fittings, lubricators etc. will not disqualify). Overseas competitors however may enter any suitable locomotive.
3. No competitor may enter more than one locomotive.
4. Competitors who have entered a locomotive in TWO previous I.M.L.E.C.s will not be permitted to enter the same locomotive, but they may enter another locomotive.*
5. There will be 15 entries, accepted on a "first-come first-served" basis. Closing date for entries 15 May.
6. The owner may nominate a driver if unable to drive the locomotive himself, any prizes won would go to the owner, not the driver.
7. Locomotives entered must carry a current boiler test certificate. This (or a Xerox copy) should be sent to the Secretary of the Chingford Society before the event.
8. Coal to be used will be provided by the Host Society in weighed 2 lb. bags, in two grades (of size).

9. As much charcoal, paraffin, meths, or wood as requested by the competitor will be provided and this will be used to raise steam to a working pressure of approximately 60 p.s.i. After exceeding this pressure, and while waiting to go on to the track, the coal supplied may, at the discretion of the driver, be fed to the fire.
10. The train with Dynamometer car will be prepared for the competitor who may choose the size of his load. The duration of the run will be not less than 30 minutes, starting at the station. The timekeepers will keep competitors informed of their progress and will indicate when they are on their last lap.
    The run must finish at the station to unload the passengers. Should drivers stop due to shortage of steam, water or coal before reaching the station, even though they have been running for the full 30 minutes, they must "blow up" and complete their run to the station.
11. No time allowance will be made for stops except in case of derailments.
12. At the end of the run, engines will be taken back to the steaming bays, all unused coal will be collected and weighed in the presence of the driver. No allowance will be made for unburnt coal left in the firebox.
13. The results will be calculated by the Society's officials and displayed on the notice board as soon as possible after the run.
14. The Society's speed limits must be observed. The official observer will warn drivers if speed limits are exceeded. Two warnings will be given, but if a third warning is necessary, this will result in disqualification.
15. Drivers must not lean on their locomotives so as to gain adhesion; they must not apply the brakes in order to increase drawbar pull, although they may of course do so to reduce *excessive* speed or in emergencies. Disqualification may follow disregard of this rule as outlined in 14.
16. Sanding the rails will be permitted at the start only, at the discretion of the Officials. Drivers who have locomotives fitted with working sanding gear are at liberty to use it at any time.
17. The Society will appoint a Panel of Judges, whose decision on all matters appertaining to the Competition will be final.

* *Last year's winner excepted.*

CLUB NEWS

Scunthorpe S.M.E.

The Scunthorpe Society of Model Engineers will be attending the British Steel Corporation's Children's Gala at Brumby Hall on 4 June. Members will be operating their passenger-carrying railway and also displaying examples of their work. The Gala starts at 2 p.m.

Secretary: R. D. Needler, 113 Warwick Road, Scunthorpe, South Humberside, DN16 1ES.

Steam Gala at King's Lynn

The King's Lynn and District Society of Model Engineers is holding a Steam Gala at their track in the "Walks", a public recreation area in King's Lynn. Their track, built entirely by the efforts of the members, gives a continuous run of about 700 ft., for locomotives of 3½ in. and 5 in. gauges. There will also be model traction engines and stationary engines in steam.

The Society, which now boasts some 100 members, also operates a sectional portable track.

The Steam Gala is on Sunday, 12 June.

Secretary: M. B. Mallett, 28 Pilot Street, King's Lynn, Norfolk, PE30 1QL.

Jubilee Traction Engine Rally

One of the most important traction engine events of the year is the Jubilee Rally on Clapham Common over the week-end 28-29 May. It is being organised by the National Traction Engine Club and sponsored by Courage (Eastern) Ltd. The London Borough of Lambeth have generously provided the site and other facilities.

For steam, engineering and vintage vehicle enthusiasts of all kinds this will be a unique occasion. More than 50 steam traction engines and steam wagons, some nearly 100 years old, will provide a contribution to Her Majesty's Silver Jubilee Year. Two-thirds of the proceeds from the Rally will go to the Silver Jubilee Appeal Fund; the remainder will go to help the National Traction Engine Club.

In fact not one but four Jubilees will be celebrated at Clapham. The Jubilees of 1887, 1897 and 1935 will be commemorated by groups of contemporary steam engines and machinery.

On display will be five large Showman's engines including examples of Burrell, Foster and Foden. Showman tractors by Burrell and Tasker and ten different makes of agricultural engines. There are five different makes of roller including a rare Wallis Simplicity and an Aveling conversion. Steam wagons include the unique Leyland and Atkinson and there are eleven different makes of tractor.

Other sections will consist of road locomotives, a portable engine by Brown and May, a fine pair of Fowler AA ploughing engines which illustrate the rope system of ploughing, a Garrett Agrimotor and Mann direct traction ploughing tractors.

In the ring a full programme has been arranged of competitive steam events, with parades by the supporting attractions. Outside the ring there will be demonstrations of steam-driven saw-milling and threshing machines.

A selection of vintage internal combustion-engined tractors and some stationary barn engines will be included, plus some rare, restored commercial vehicles. It is hoped to stage a road run with these and the steam wagons during the rally. Fred Watson of Balham will be in charge of the model tent containing traction engines and fairground models, some of them in steam.

A narrow gauge steam railway will be giving passenger rides throughout the rally and possibly a launch will ply on the lake within the rally site. Bars and buffets will be open for refreshments.

Further information from: Peter Barber, Chairman, Rally Sub-Committee. Tel. 01-891 2303.

Club Diary is on next page

CLUB DIARY

Dates should be sent at least five weeks before the event to ensure publication. Please state venue and time. While every care is taken, we cannot accept responsibility for errors.

MAY

20 Stockport & District S.M.E. Mr. Kay—7¼" Gauge Locomotives. The Parish Hall, Church Road, Cheadle, Cheshire. 8 p.m.

20 Rochdale S.M.E.E. General Meeting. Springfield Park, Rochdale. 8 p.m.

20 Romford M.E.C. Track Night. Ardleigh House Community Centre, Ardleigh Green Road, Hornchurch, Essex. 8 p.m.

20 Brighton & Hove S.M.L.E. Workshop. Elm Grove School, Elm Grove, Brighton. 8 p.m.

21 King's Lynn & District S.M.E. Dereham School Fete—Portable track in operation.

21 North London S.M.E.E. Southern Federation Rally—Blenheim.

21 Ilford & West Essex M.R.C. welcomes members and prospective members of Model Railway Clubs, Model Engineering Clubs and Preservation Societies, to their open day. Clubhouse adjacent to Chadwell Heath B.R. Station. 10 a.m.–6 p.m.

21 Chesterfield and District M.E.S. "Efficiency Trials". Hady Track. From 1.30 p.m.

21 Wigan & District M.E.S. Meeting at Co-operative Guild Room, Thompson Street, Whelley, at 7.15 p.m.

21 Southern Federation Rally. Blenheim.

21 Polegate M.E.C. Open Day. Martello Beach Caravan Park, Pevensey Bay, Sussex. (Boiler certificates must be shown).

21 The White Horse M.R.C. Model Railway Exhibition. Memorial Hall, off Station Road, Wootton Bassett, Swindon, Wilts. 11 working model railway layouts in all popular gauges. Light refreshments available. 10.30 a.m.–8.30 p.m. Details from Reg and Audrey Palk, 5 Bradene Close, Wootton Bassett, Swindon, Wilts. SN4 8DG.

21/22 Southend Round Table. Steam Engine Rally. Hullbridge, Essex. Free car parking. Proceeds donated to Charity.

21/22 Cambridge Museum of Technology. Special event—"Craft and Steam". Cheddar Lane, Cambridge. 11 a.m.–6 p.m.

22 Bristol S.M.E.E. Public running. Track at Ashton Court, Bristol. 11 a.m.–6 p.m.

22 Ardeer Recreation Club. Monthly meeting—Ardeer Track. 2½", 3½" and 5" gauge. 12 noon–6 p.m.

23 Bedford M.E.S. Informal Meeting. Clubhouse, Wilstead.

23 Stafford & District M.E.S. Track Night. County Showground, Weston Road, Stafford. 7.30 p.m.

25 Cleveland Assoc. of M.E. Monthly Meeting. 2 Strait Lane, Stainton. 7.30 p.m.

25 Harrow & Wembley S.M.E. Extraordinary General Meeting. B.R. Sports Pavilion. 7.45 p.m.

25 Sutton Coldfield Railway Society. Zaire Railways by Peter Johnson (slides). Wylde Green Library, Emscote Drive, Little Green Lanes, off Birmingham Road, Sutton Coldfield. 7.30 for 8.15 p.m.

26 Leyland, Preston and District S.M.E. Meeting. Roebuck Hotel, Leyland.

27 Hereford Live Steamers. Monthly meeting. White Swan, Aylestone Hill, Hereford.

28 Sussex Miniature L.S. Visit to the Maidstone M.E.S. at Mote Park.

28 Cambridge & District M.E.S. Public Track Day. Fulbrooke Road, Cambridge. 3 p.m.

28 Milton Keynes M.S. Portable Live Steam Track. Lakes County Middle School, Bletchley, Milton Keynes. 2 p.m.

28 Keighley & District M.E.S. International Harvesters Gala. Apperley Bridge, Track site, Marley, Keighley.

28 S.M.E.E. Headquarters Clean-Up.

28/29 North Cornwall M.S. Exhibition. The Meeting Room, Camelford Conservative Club, Camelford, Cornwall.

29 Rugby M.E.S. W.M.F. Efficiency Trials and Cup Competition at Illshaw Heath.

29 Harrow & Wembley S.M.E. Public Running. Roxbourne Park. 2 p.m.

29 North London S.M.E. 2½ in. Gauge Rally. Colney Heath.

29 National 2½ in. Gauge Assoc. Rally in conjunction with the North London M.E.S. at the Colney Heath track. 10.30 a.m.

29 Birmingham S.M.E.E. W.M.F. Efficiency Trials at Illshaw Heath.

29/30 Papplewick Pumping Station, Notts. 1884 Watt beam engines in steam. Details from G. P. Barnes, 184 Burford Road, Forest Fields, Nottingham.

30 Willesden & West London S.M.E. Talking Book Service. Talk by Mr. E. L. Wade. Kings Hall Community Centre, Harlesden Road, London NW10. 8 p.m.

30 Guildford M.E.S. Track Event at Surrey County Show.

JUNE

1 Harrow & Wembley S.M.E. Committee Meeting. B.R. Sports Pavilion, Headstone Lane. 7.45 p.m.

1 Cannock Chase M.E.S. Meeting Cannock. Park. 7.30 p.m.

1 Bristol S.M.E.E. "Cochrans of Birkenhead", Steve Witham. B.R. Staff Association Club, Temple Meads, Bristol. 7.30 p.m.

1 Sutton Coldfield Railway Society. Layouts, Test Track and Chit Chat. Wylde Green Library, Emscote Drive, Little Green Lanes, off Birmingham Road, Sutton Coldfield. 7.30 for 8.15 p.m.

3 Stockport & District S.M.E. Bits and Pieces. The Parish Hall, Church Road, Cheadle, Cheshire. 8 p.m.

3 Rochdale S.M.E.E. General Meeting. Springfield Park, Rochdale, at 8 p.m.

3 Romford Model Engineering Club. Competition Night. Ardleigh House Community Centre, Ardleigh Green Road, Hornchurch Essex. 8 p.m.

4 Maidstone Area Model Railway Club. Model Railway Exhibition. Kent Hall, Corn Exchange, Maidstone. Between 10 a.m. and 6.30 p.m.

4 The Northern Mill Engine Society. Open Day at Courtaulds Dee Mill, Shaw, Oldham. Engine in steam 9 a.m.–3.30 p.m. Engine houses at the Diamond and Fern Mills also open.

4 Rochdale S.M.E.E. Syke Pond Boat Regatta at 2.30 p.m.

4 M.E.S. of N. Ireland. Monthly Meeting. Transport Museum, Cultra, Co. Down. 3 p.m.

4 Scunthorpe S.M.E. The S.S.M.E. will be attending the British Steel Corporation's Children's Gala at Brumby Hall. They will be operating a passenger hauling railway as well as displaying an exhibition of work. Start 2 p.m.

4 S.M.E.E. Films by James Neill (Tools) Group.

4/5 The West Riding S.L.S. 25th Annual Rally. Everyone welcome. Blackgates, Tingley, nr. Wakefield.

4/5 City of Leeds S.M.E.E. West Riding Rally, Blackgates.

4/5/6/7 Whitchurch & District M.E.S. Open Day and Exhibition. Highfield Road, Heath, Cardiff

5 Guildford M.E.S. Running Day for members. H.Q. Stoke Park.

5 Harrow & Wembley S.M.E. Pondside meeting. West Harrow Recreation Ground. 10.45 p.m.

5 Guildford M.E.S. Running Day for members.

5 Cambridge Museum of Technology. Open Day. Cheddars Lane, Cambridge. 2 p.m.–6 p.m.

5 Rugby M.E.S. Members' Running Day.

5/6 Papplewick Pumping Station, Notts. 1884 Watt beam engines in steam. Details from G. P. Barnes, 184 Burford Road, Forest Fields, Nottingham.

5/6/7 Bristol S.M.E.E. Miniature Steam Fair. Track at Ashton Court, Bristol. 11 a.m.–6 p.m.

6 North London S.M.E. Marine Section Regatta.

6 Milton Keynes M.S. Portable Live Steam Track. The Linx, Bletchley, Milton Keynes. 2 p.m.

6 City of Leeds S.M.E.E. "Slide Show" by Mr. D. Ricketts. Salem Congregational Church, Hunslet, Leeds 10. 7.30 p.m.

6 Birmingham S.M.E. Jubilee Party Day. A party for the children in the afternoon followed in the evening by a disco and evening run with fry-ups.

6 North London M.E.S. Marine Section Regatta.

6/7 Guildford M.E.S. Track event at Surrey County Show.

6/7 Bracknell R.S. Public Operation of Jocks Lane track, Bracknell, Berks. 3 p.m. to 6 p.m.

7 North Cornwall M.S. Meeting. The Meeting Room, Camelford Conservative Club, Camelford, Cornwall. 8 p.m.

7 Sussex M.L.S. Special train service, Silver Jubilee Day.

7 Keighley & District M.E.S. Carlton—Skipton Jubilee Gala. Track site, Marley, Keighley.

7 South Cheshire M.E.S. Ajax No. 2—F. Clarke. Victoria Hotel, Crewe. 7.45 p.m.

8 Southampton & District S.M.E. Traction engine evening. Slides, engines or parts welcome. Atherley Bowling Club, Hill Lane, Southampton. 8 p.m.

8 Harrow & Wembley S.M.E. Track. Headstone Lane. 6.30 p.m.

8 Sutton Coldfield Railway Society. Modellers' Problem Night. Wylde Green Library, Emscote Drive, Little Green Lanes, off Birmingham Road, Sutton Coldfield. 7.30 for 8.15 p.m.

9 Leyland, Preston and District S.M.E. Meeting. Roebuck Hotel, Leyland.

10 Polegate M.E.C. "Locomotives of the L.B.S.C.R." by Mr. A. C. Perryman.

10 Melbourne S.M.E.E. (Australia). "Metal spinning" S. Gaal. 92 Wills Street, Glen Iris. 8 p.m.

11 Birmingham S.M.E. Visit from the Shirley Good Companions.

11 Keighley & District M.E.S. Airedale Hospital—Gala. Track site, Marley, Keighley.

11 Gauge "1" Model Railway Assoc. Get Together. P. Howland, 35 Horsell Park Close, Woking, Surrey.

11/12 Hungerford Steam Engine Rally and Country Show. Steam engines, commercial vehicles, v/cars, motor-cycles, tractors and stationary engines. Sheepdog demonstrations, sheepshearing demonstrations and Arts and Crafts exhibition.

12 Guildford M.E.S. A visit by Portsmouth M.E.S. to H.Q. Stoke Park.

12 Harrow & Wembley S.M.E. Public running. Roxbourne Park Track. 2 p.m.

12 Boston S.M.E.E. Steam Gala Day. All members invited. Notify Secretary if you are going. Bring it if it can be steamed. King's Lynn Track. 9.30 p.m.

12 Bedford M.E.S. Invitation Day. Clubhouse, Wilstead.

12 Cannock Chase M.E.S. "Steam-Up" Cannock Park. 2 p.m.

12 King's Lynn & District S.M.E. Steam Modellers Meet. Walks Track, London Road, King's Lynn. 9.30 a.m. onwards.

13 Fareham & District S.M.E. Society meeting at the "Royal Oak", West Street, Fareham. 7.30 p.m. for 8 p.m. start.

13 Bedford M.E.S. Small Gauge Steam by Mr. R. Everitt. Clubhouse, Wilstead.

13 King's Lynn & District S.M.E. Monthly Meeting. St. James School, London Road, King's Lynn. 7.45 p.m.

15 Cannock Chase M.E.S. "The Elevator" lift hoisting machine—Mr. D. Sansom. Lea Hall Club, Sandy Lane, Rugeley. 7.30 p.m.

15 Birmingham S.M.E. Visit from the Wheelers Lane Railway Enthusiasts Course.

15 Sutton Coldfield Railway Society. America 1948-76 by Mike Watts (Cine). Wylde Green Library, Emscote Drive, Little Green Lanes, off Birmingham Road, Sutton Coldfield. 7.30 for 8.15 p.m.

16 Nottingham S.M.E.E. The Papplewick Trust—Courtesy of the Curator. The Friends' Meeting House, Clarendon Street, Nottingham. 7.30 p.m.

17 Stockport & District S.M.E. Barbecue at the Track.

17 Rochdale S.M.E.E. General Meeting. Springfield Park, Rochdale. 8 p.m.

The Editor welcomes letters for these columns. He will give a Book Voucher for £3.00 for the letter which, in his opinion, is the most interesting published each month. Pictures, especially of models, are also welcomed. Letters may be condensed or edited.

Screwcutting Odd-Pitch Threads

SIR,—I read with interest Martin Cleeve's contribution on goof-proof screwcutting of odd threads (*M.E.* 18 March 1977, p. 334), and would like to comment on his suggestions for cutting metric screws.

As he says, the regular 127-T translating wheel is so large that certain gear trains are awkward to set up on a normal quadrant or swing-frame. His idea for using some special gears of reduced D.P. is excellent and involves no loss of accuracy. Even with quite massive lathes there is the same problem. My own machine has 12 D.P. changewheels so that a 127-T gear has a pitch diameter of 10.583 in. and I have found it more convenient to use 14 D.P. wheels for metric trains.

However, my main point in writing is to show that highly accurate metric screws can be cut by trains using small gears in the standard D.P. range with errors which are probably less than those of the leadscrew itself or in the associated gears.

The basic formula to be used when cutting metric threads on an English lathe is that the gear ratio:

$$\frac{\text{Drivers}}{\text{Driven}} = \frac{5}{127} \times \text{leadscrew t.p.i.} \times \text{millimetre pitch.}$$

Now a little doodling with a good pocket calculator will give a highly accurate equivalent of the ratio 5/127 using compound fractions with numbers much smaller than 127. For example, 5/127 is close to the fraction $\frac{30 \times 55}{13 \times 52 \times 62}$ (The error is 1 part in 20956, much less than the figures tabulated by Mr. Cleeve).

Considering the Myford leadscrew of 8 t.p.i. and supposing that we wish to cut a thread of 1 mm. pitch, the requisite gear train is:

$$\frac{\text{Drivers}}{\text{Driven}} = \frac{20}{31} \times \frac{30}{52} \times \frac{55}{65}$$

The gears are fairly small and only two "specials" are required.

For 2 mm. pitch, replace the 20-T or 30-T gears by 40-T or 60-T respectively and so in proportion for other pitches.

A still more accurate train (1 mm. pitch; 8 t.p.i. leadscrew) is: $\frac{\text{Drivers}}{\text{Driven}} = \frac{31}{56} \times \frac{33}{58}$

In this case the error is only 1 part in 129920 or just under 0.001 in. in 10 ft. Again, all the gears are small but four specials are required. Fairly obvious modifications will cope with different metric and leadscrew pitches.

A point which Martin Cleeve did not mention concerns the use of lathes with quick-change screwcutting gearboxes. There is no problem. Assuming a leadscrew with 8 t.p.i., suppose we set the box for this same pitch. There is then a 1:1 drive through the system and the translating gears are the same as for the leadscrew alone. If we set the box for any other pitch, the machine behaves as if the leadscrew were of the same pitch. In the metric conversion formula we merely use the *selected* t.p.i. instead of the actual t.p.i. of the leadscrew.

Anyone with even the most primitive gearcutting equipment can produce the special wheels with acceptable accuracy using as a division plate a strip of squared paper wrapped round and cemented to the rim of a hardwood disc of suitable diameter. Considering the 33-T wheel and using squared paper marked off in tenths of an inch, cut off a strip including 33 squares. Prepare a wooden disc with a diameter 3.3 in. divided by π, or d = 1.504 in. Better still, use a much larger disc, say four times this size, with a correspondingly longer squared strip, counting off four squares for each division instead of one.

Failing a regular involute cutter, a fly cutter, off-hand ground to fit the tooth space of a standard gear with 30 or 35-T, will serve to do the job.

As regards the opposite conversion, when using a metric lathe for cutting English threads we merely reverse the procedure just described. In principle, all that is required is to invert the gear trains used in the English-metric translation. In practice, matters are not so simple because, for accurate conversion, the 127-T wheel becomes a driver. This is an absurd situation, particularly when we remember that reduction gearing is usually required between spindle and leadscrew so that the driven gear is even larger than 127-T or a compound train must be used. We are thus driven to use approximations of the sort tabulated by Mr. Cleeve.

As an example he quotes the problem of cutting 16 t.p.i. with a leadscrew of 3.5 mm. pitch using a gear train, accurate to 1 part in 5460, but which uses non-standard wheels of 39-T and 43-T. A better train, accurate to 1 part in 8001, using gears in a standard set is given by: $\frac{\text{Drivers}}{\text{Driven}} = \frac{40 \times 80}{7 \times 63 \times \text{t.p.i.}}$

A full set of English changewheels should extend from 20-T to 100-T with increments of 5-T and also include 38-T, 63-T and an extra 40-T gear. Using selections from these and again assuming a 3.5 mm. pitch leadscrew, metric to English conversions can be made with an accuracy within 1 part in 8000 as tabulated below:

t.p.i.	*Gear train*	*t.p.i.*	*Gear train*
4	$\frac{50}{35} \times \frac{80}{63}$	11	$\frac{20}{35} \times \frac{50}{55} \times \frac{80}{63}$
5	$\frac{40}{35} \times \frac{80}{63}$	12	$\frac{20}{30} \times \frac{25}{35} \times \frac{80}{63}$
6	$\frac{25}{30} \times \frac{40}{35} \times \frac{80}{63}$	14	$\frac{20}{35} \times \frac{50}{70} \times \frac{80}{63}$
7	$\frac{40}{35} \times \frac{50}{70} \times \frac{80}{63}$	16	$\frac{25}{35} \times \frac{40}{63}$

8	$\frac{25}{35} \times \frac{80}{63}$	18	$\frac{25}{35} \times \frac{40}{45} \times \frac{40}{63}$
9	$\frac{25}{35} \times \frac{40}{45} \times \frac{80}{63}$	19	$\frac{20}{35} \times \frac{40}{38} \times \frac{40}{63}$
10	$\frac{20}{35} \times \frac{80}{63}$	20	$\frac{20}{35} \times \frac{40}{63}$

Minor modifications of the gear train will allow the last pair of wheels to remain fixed at 80/63 and if desired they could be of reduced D.P.

Reverting to the problem of cutting metric screws on an English lathe, there is much to be said for Martin Cleeve's use of reduced D.P. for the 127-T gear but even so there are difficulties in cutting coarse pitch threads. For example, the gear ratio to cut 5 mm. pitch with an 8 t.p.i. leadscrew is 200/127. As a compound train, 50 × 80 / 20 × 127 could be used or a still more complex train using smaller gears, such as 40 × 40 × 50 / 20 × 20 × 127.

If an error of 1 part in 129920 is acceptable the second table shows how a number of metric pitches can be obtained by using only four special gears of 20 D.P. with the 8 t.p.i. Myford leadscrew. All the gears are small and could be set up in a fixed compact cluster used only for millimetre pitches.

Pitch (mm.)	*Gear train* All × 31/28 × 33/29
5.0	25/20
4.5	45/40
4.0	Direct (×1)
3.5	35/40
3.0	30/40
2.5	25/40
2.0	20/40
1.0	20/80 or 20/40 × 25/50

To conclude, it might be mentioned that the relationship 1 in. = 25.4 mm. is *exact.* Older text books, conversion tables and mechanics' pocket books quote a slightly different ratio (the variation is around 9 parts in 1 million). International conferences on metrology resulted in this rationalisation. It is a great pity they did not settle for 1 in. = 25.6 mm. (a nice binary number which would have made life easier!).

Cheltenham. F. Butler

Strength of Copper Boilers

SIR,—In your issue of 18 March, Mr. K. E. Wilson and Dr. M. J. Phillips wrote about the elastic properties of copper in relation to boilers. Unfortunately, Dr. Phillips implies that the elastic limit is the same thing as the yield point and also seems to have confused it with the 0.1% proof stress. This is likely to puzzle anyone who then reads Mr. Wilson's letter.

Common engineering terminology is not always used as precisely as it might be and perhaps it will help if I outline what happens when a piece of mild steel or wrought iron is stressed in a tensile testing machine and the extension is measured.

At low stresses the elongation will appear to be proportional to the stress in accord with Hooke's law, but if the load is removed and sufficiently accurate measurements are made, it may be found that it does not return to its original length but has taken a permanent set. The stress which is just sufficient to cause this is called the "limit of perfect elasticity". At about the same stress or a very little higher it becomes possible to detect that extension is no longer proportional to the load; this is the "limit of proportionality" or "the limit of linear elasticity" or very commonly the "elastic limit". It will be obvious that both the limit of perfect elasticity and the limit of proportionality are very indefinite and that the measured values will depend on the sensitivity of the extensometers used.

If the load on a mild steel test piece is increased appreciably above the elastic limit there is a sudden and quite definite yield usually at about two-thirds of the ultimate breaking load. Higher grade steels show less marked yield points and very high tensile steels no yield point at all.

For materials without a definite yield point, which includes practically all metals except mild steel and wrought iron, it is necessary to have a commercially practicable way of defining the elastic property; this is the 0.1% (or 0.2%) proof stress and is defined as the stress at which the extension is 0.1% (or 0.2%) greater than it would have been if the extension had been proportional to the stress.

I give below the properties of copper taken from one of the Copper Development Association's books:

Condition	Limit of Proportionality (or Elastic Limit)	.1% Proof Stress	Ultimate Tensile Stress
Annealed	1 ton/sq. in.	4 tons/sq. in.	14 tons/sq. in.
Cold Worked			
10% Reduction	7 tons/sq. in.	12 tons/sq. in.	17 tons/sq. in.
30% Reduction	10 tons/sq. in.	17 tons/sq. in.	20 tons/sq. in.
60% Reduction	12 tons/sq. in.	21 tons/sq. in.	25 tons/sq. in.

In giving the elastic limit for annealed copper as 9000 lb./sq. in. (4 tons/sq. in.), Dr. Phillips is obviously confusing elastic limit with proof stress.

It will be seen that only a small amount of cold work is necessary to increase the limit of proportionality enormously and I would not go along with Mr. Wilson in saying that the increase in the ultimate stress is very slight. For example, Mike Smart is justified in thinking that his stays screwed in and caulked with Loctite after the boiler is brazed are 75% stronger than if they had been silver soldered in. On the other hand, I think that it is inconceivable that a hydraulic pressure test could cause any measurable work hardening. Anyone who has made a boiler or bent a copper pipe knows that copper will stand a lot of bending without hardening. It is hammering or a reduction in thickness by rolling which hardens it.

The first hydraulic pressure test of a boiler I always regard as part of the manufacturing process, not just an inspection function. It serves to iron out the creases and any permanent set caused will in general be in the direction of producing a shape better able to resist pressure. Slight local yielding at points of high stress concentration will cause a beneficial redistribution of stress. From these points of view the greater the difference between the proof stress and the ultimate the better. It is quite normal and proper for the elastic limit to be exceeded during the testing of a soft copper boiler.

A classic, if tragic, example of the effect of a high-pressure test on a pressure vessel occurred on the early Comet airliners. Several aircraft were lost due, it was found, to failure of the pressure cabins from cracks starting at the cut-outs for the square cabin windows. This weakness had not been shown up on fatigue tests on a sample cabin and the reason was found to be that the test sample had first been subjected to a high static pressure test which had relieved the stress concentration at the windows.

A stress concentration may arise from large or small discontinuities including inclusions or other material defects and a pressure test on an annealed copper vessel will make such defects far less damaging.

It should be pointed out that all the ironing out of creases and redistribution of stress occur the first time the pressure is raised to any maximum value. Repeat tests will not increase the strength of a boiler, rather the reverse is the case. On the other hand, a hidden defect which does not show up on the first test may develop and come to light after several repeats. Repeat tests can therefore increase one's confidence that a boiler is free from serious manufacturing defects. If such repeat tests are done the pressure should be, say, 10% below the initial test pressure.

During the last war, cyclic pressure testing of Arco engine oil coolers and radiators was introduced and was carried out on every unit before delivery, and it resulted in a substantial improvement in reliability. As far as I know, this is still done. I cannot remember how many cycles of pressure were made but I think it was several hundred. If a model boiler is known to be well made I doubt whether testing on such a scale would be justified and very little would be achieved by a dozen or so cycles.

My remarks on the effects of pressure testing have been directed at those parts under internal pressure, the failure of which could lead to an explosion. Parts under external pressure which would fail by collapse, such as fire tubes, flues and unstayed cylindrical fireboxes are in a different category.

The theory of the collapse of thin tubes under pressure is very difficult although for long tubes when the end support can be neglected it boils down to arithmetic which is easy enough. According to the theory the collapsing pressure is independent of the strength of the material, but only on Young's modulus and Poisson's ratio. But the model engineer doesn't have to bother with these things and if he makes the thickness of his copper tubes or cylindrical firebox equal to not less than 1/27 of the diameter they will be O.K. for a working pressure of 100 p.s.i. providing they are truly circular in cross-section to start with.

I think "Tubal Cain" was wise to stay his 18 s.w.g. firebox, but how much simpler it would have been to use 2 mm. material and to cut out the stays.

Bitton, Nr. Bristol. B. G. Markham

Boley Lathe

SIR,—My lathe, which I have had for two years now, is a Boley Leinen of approximately 5 in. centre height and 18 in. between centres. Unfortunately I know nothing of its history and have no manual for it.

The manufacturer's principals in this country suggest it was made in 1929 from the number stamped on the side of the ways, 4734. The 3 mm. pitch Acme leadscrew is metric. The tailstock barrel appears to be reamed No. 2 Morse taper, but the spindle nose (about 1 in. bored through) has strange machinings just inside. The spindle nose thread is 44 mm. x 3.5 mm., although it tapers to 43 mm. at the end of the spindle—I don't know if this is deliberate or due to wear.

The headstock is mounted on the same vee on the bed as the tailstock (the bed has no gap), which presumably makes alignment of the centres certain. The backgearing is below the spindle, not unlike Myford's, and is helical cut. The spindle is driven via a flat belt and three-step cone pulleys from a rather large and solid clutch-countershaft which seems to be of German manufacture.

It is still possible to buy suitable changewheels, but they are imported and far too expensive for me to afford. I have only four and would like to buy any secondhand ones. I would be grateful if anyone could supply me with any information on this machine or similar. I will, of course, reimburse all costs.

77 Nuttall Street, Accrington, Lancs. J. Dalton

Old Lathe

SIR,—A friend of mine has recently purchased an old 3 in. treadle lathe of unknown make. As it is a nicely made tool with some unusual features, I offered to try to find the make of the machine and something about it. I therefore began looking through old copies of *Model Engineer*, and, much to my surprise, found two photographs of the machine on pages 567 and 568 of 31 May 1923 under the heading "Workshop Topics", which show the lathe employed in the cutting of changewheels.

One of the nice points of the machine is that the headstock can be swivelled 5 deg. either side of the centre-line on the bed, and has a small index at its base beneath the front bearing. There is also a locating pin for re-aligning to zero. Protruding towards the operator from the rear headstock casting is a small cast fork, machined on the side facing the changewheels. This I find rather puzzling and would be pleased if someone could explain it.

If any reader can identify this lathe and tell me a little about it, I should be most pleased.

35 Sherwood House, R. S. Holder
Woodberry Down East, London N.4.

Garratt Drawings

SIR,—In reply to Mr. Lockyer (*M.E.* No. 3553), if he wants official drawings of the S.A.R. Class GL Garratt locomotive, he should write to the Chief Mechanical Engineer, S.A. Railways, Z.A.S.M. Building, Paul Kruger Street, Pretoria, S. Africa, 0002.

The prints cost 40 cents each, and the drawings are to 1 in. scale, so the GL is too big a locomotive to get onto one sheet. He will probably need two prints of the general arrangement and I advise him to ask for a print of the index sheet. That is R1.20c. In addition the postage will probably cost another R1.00, so I suggest he sends a bank draft for R2.50c.

Johannesburg, S. Africa. D. F. Holland

SIR,—The recent correspondence in *M.E.* reminded me that Mr. B. A. Lockyer had requested information on the S.A.R. class G. L. Garratt locomotives. Drawings for this engine can be obtained from The Manchester Museum of Science and Industry, 97 Grosvenor Street, Manchester.

A few years ago I obtained drawings for S.A.R. class G.E.A. and also for the War Standard Light 4-8-2-2-8-4, having selected these from over 70 G.A. drawings made available for perusal. I spent a most interesting day at the museum and obtained much help from Mr. H. Milligan and Mr. Makepeace. I suggest, therefore, that Mr. Lockyer should contact the museum and arrange with them to meet his requirements.

I happened to be one of the "enlightened" eight model engineers who were in discussion with Mr. P. Wardle at Bristol, and as far as I can judge of all of the Beyer-Garratt projects being undertaken at the present, all are based on different prototypes. Models are being constructed to my knowledge in $2\frac{1}{2}$ in. gauge, $3\frac{1}{2}$ in. gauge, 5 in. gauge and of course there is the huge $7\frac{1}{4}$ in. gauge E.A.R. class 59 which attended one of the $7\frac{1}{4}$ in. Gauge Society meetings.

Cheltenham. R. W. Jones

The Limited Society

SIR,—Many clubs are at this moment holding what often turn out to be very lengthy and heated discussions about whether or not their Society should become limited by the Companies' Act or the Industrial and Provident Societies' Act.

I feel that these discussions are often so because the topic under consideration is very complex and I doubt if the majority of societies have the necessary talents amongst their members fully to understand the relevant Acts, their interpretation and application. Let's face it, industry employs many highly skilled and eminent legal persons to sort out just such matters.

Let us first of all examine the reason why registration is being considered: this being that at present the society's and members' assets may be at risk in the event of any injured parties' successful claim for negligence not being covered by the normal third party insurance policy.

While on this topic, I seem to hear people discussing the "one or two" model engineers who have been taken to court for such negligence but I have never seen published legal proceedings, the circumstances of the incident leading up to the proceedings or any lessons to be learnt from the incident.

If then we register our Society and thereby limit the assets available in the event of any such claim, what of the injured party who is now faced with the prospect of suing a "man of straw" and possibly suffering some disability for life? Surely a more satisfactory approach would be to define the worst credible incident and the possibility of such an incident—perhaps the underwriters for the M.A.P. insurance scheme may be able to furnish suitable statistics—and then to approach our insurers with a view to securing *adequate* cover.

The phraseology that poses doubt in members' minds seems to be the clauses that include "practical" and "reasonably practical" especially when associated with clauses that imply the obligation to take all practical steps to avoid accidents; the statutory instruments covering safety in industry use just such phrases and in fact these are interpreted and defined in Redgrave's *Health & Safety in Factories 1976*.

By now you are probably thinking that I am strongly opposed to the idea of registration—not so. I am one of many who feel that they have insufficient information to enable a logical decision to be reached and would not like to see societies' business lumbered with statutory paperwork in order to comply with some Act that was not really intended for model engineering societies. This would only detract from our real aim of pursuing a hobby in a convivial atmosphere.

I therefore hope to stimulate someone who has intimate knowledge of the Acts under consideration and also who understands how a model engineering society functions and what makes it tick, to publish advice and comment so that I may realistically compare the merits of the various possibilities.

Selby. D. Beale

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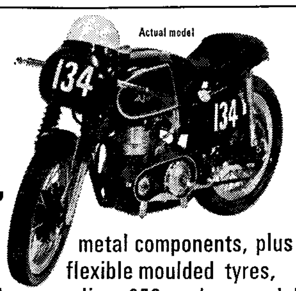

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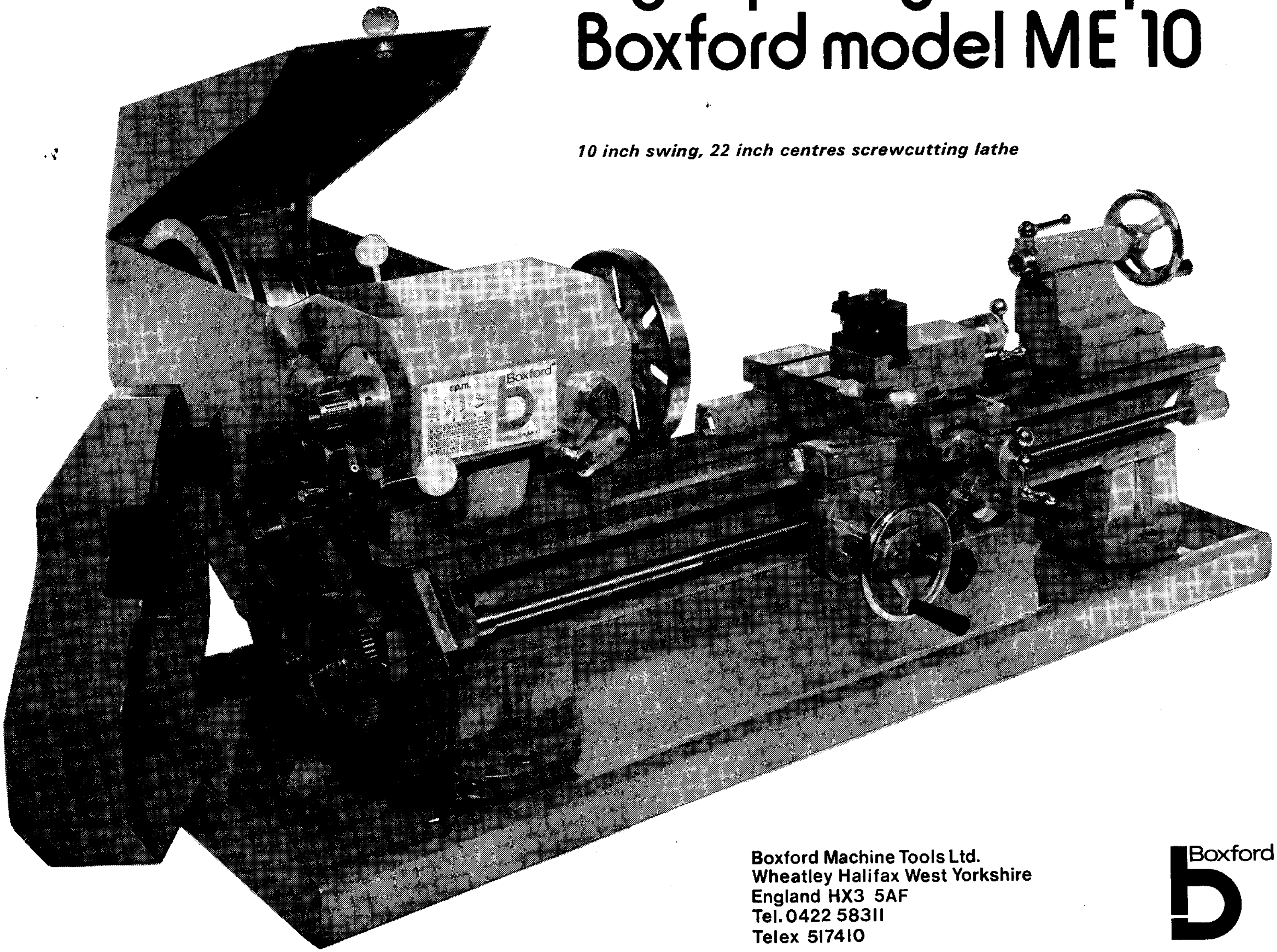

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