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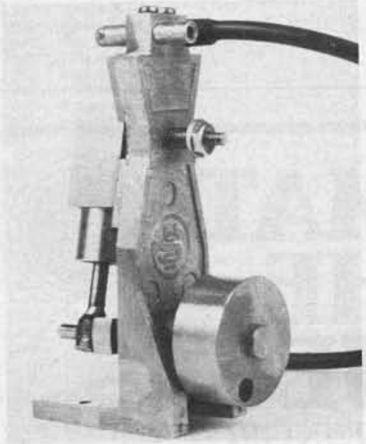
Model Mechanics

VOLUME 1 Number 5 JUNE 1979

John Bridge and his R/c Scooter.
Photograph by Alec Gee.



Special offer in this issue!
An oscillating steam unit engine kit.

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M.M QUERY COUPON
JUNE
1979

Editor's Chat

Aeromodeller all scale day at Old Warden aerodrome.

Perhaps the best place to start this month is as a result of certain correspondence we have received. Firstly, my apologies must go to Stan and Ella Roberts of the Gauge '1' Model Railway Association whose address we printed as 12 Clarendon Road, Broadstone. The number is, of course, 112, so our apologies must also go to the residents at 12. However, at least two readers letters found the right destination so all is not lost and I hope the Association ranks are swollen by many more before long.

Another address I can print is that for the Little Torch Portable Welding Unit which appeared in Les Bryant's article on Soldering. This equipment is made by The British Rototherm Co. Ltd., Port Talbot, W. Glamorgan, S. Wales.

We have had many enquiries about the model of 'Rocket' which appeared on the April front cover. It is strange what fascination vintage machines hold and this beautiful example by Mr. Procter really shows what the original loco must have looked like. Mr. Procter actually obtained drawings from the Science Museum in South Kensington, London, which were prepared in detail for a one-eighth scale model, the original of which is believed to be in the National Railway Museum in York. However, Mr. Procter did not want a loco that large, so he halved the dimensions, making his one-sixteenth full-size. Several of you have asked if Mr. Procter could describe his model in Model Mechanics, to which he is giving "some thought".

Another request we have received is for articles on the mechanisms of guns, but whether this is to restore actual weapons or just to copy I cannot say. What I must emphasise is that for a working gun, whether it be a replica in full-size, an antique, or even a model of, say, a piece of artillery, you must have a gun licence and we feel that if any reader is keen on firearms to study them in great detail, he would obtain more information by subscribing to one of the specialist magazines on this subject. There are, of course, marvellous kits of pistols etc., to be obtained from companies such as the Mid Suffolk Gun Store and when these are constructed, it would be difficult to tell the difference against a genuine article. Mind you, although the mechanisms are faithfully reproduced, it is not possible to fire the weapons.

So much for this issue. In July we hope to have Ian Jensen writing for us about Stock-Car Racing and if copy is forthcoming we should include a description of building a model cannon from Barrie Voisie's Kits. That should go some way to pleasing the gun fanciers.

Let's look at some of the events taking place. For aeroplane enthusiasts, the Aeromodeller All-scale model flying day will be held at Old Warden aerodrome, Bedford, on 10th June. For those of you not in the know, this airfield houses the famous Shuttleworth collection of aircraft so you can see model and full-size at the same time. For those who think that flying is not strictly for the birds, the Lions Club of Bognor Regis is once more organising the International Birdman Rally for 12th August.

A superb model of a Spitfire being tuned up. This radio controlled model will perform all the aerobatics in the book plus a few more!

For the steam and mechanically interested readers, the Sudbury Mammoth Olde Tyme Rallye 1979 will be held at Melford Hall, Long Melford, Sudbury, Suffolk on 30th June and 1st July. Apart from the model engineering and the display of that I am sure will be breathtaking, the full-size vehicles and equipment of a bygone age will be there in force—and working. The latter includes agricultural machinery so if you have never seen a traction engine driving a thresher this should be your chance. Other attractions should include the aircraft used to film 'Wings' and TV celebrities.

Mr. Ratcliffe's compound road locomotive "Sir John Fowler" seen at the Knowle Hill rally.

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Electronics

Roger Barrett

IN MY article last month I talked about the operation of diodes and transistors. This month I will try to show how these simple elements can be combined into something more complex and, I hope, more useful. The subject that I have chosen for the design is a speed controller for a permanent magnet d.c. motor such as those used in model railways. I hope that by showing the step by step development of this circuit I can demonstrate the underlying simplicity of what appears to the uninitiated to be rather complicated.

Before any circuit design can be started it is essential to know just what the circuit is expected to do and how it is to do it. I am assuming here that the circuit is to control the speed of a motor that requires 12 volts maximum at not more than 1 amp. To be able to say how the circuit will control the speed we need to know at least some of the characteristics of this type of motor.

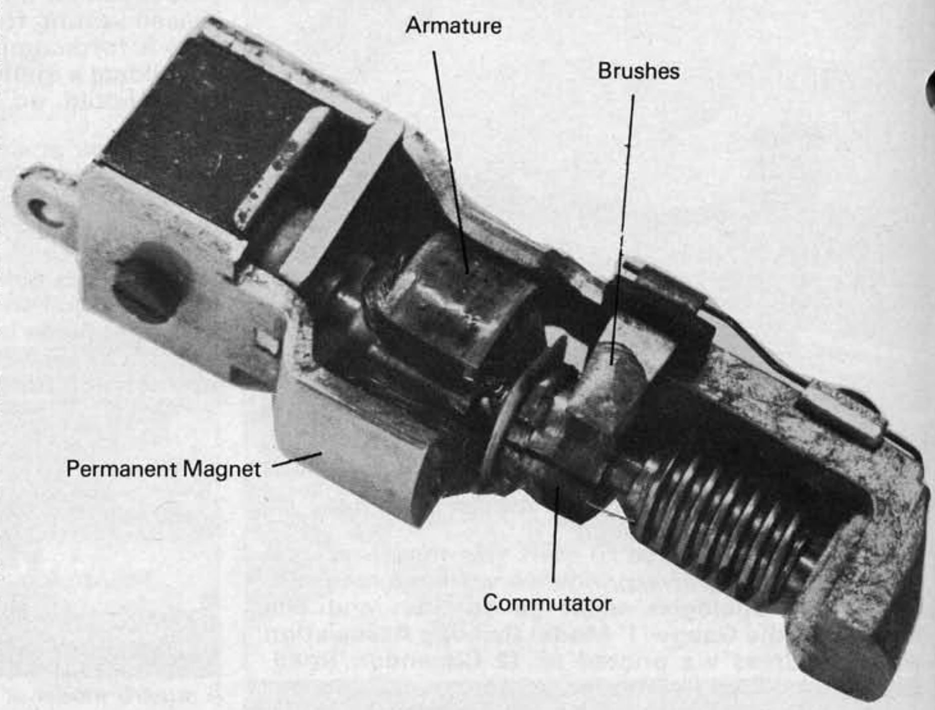


Fig 1 Above photograph of a model railway electric motor, showing main components.

The Permanent Magnet DC Motor

The model railway electric motor shown in Fig 1, is probably familiar to most readers. One of the interesting things about this type of motor is that it is essentially the same as the d.c. dynamo which is usually drawn in exactly the same way. This means that if a current is passed through the coil, or armature, the armature will rotate; if on the other hand the armature is rotated by some external drive, it will generate a voltage which will cause a current to flow in an external circuit. This equivalence of motor and generator is generally known and very easily demonstrated but some of the more subtle points are probably not so well appreciated, or so easily demonstrated.

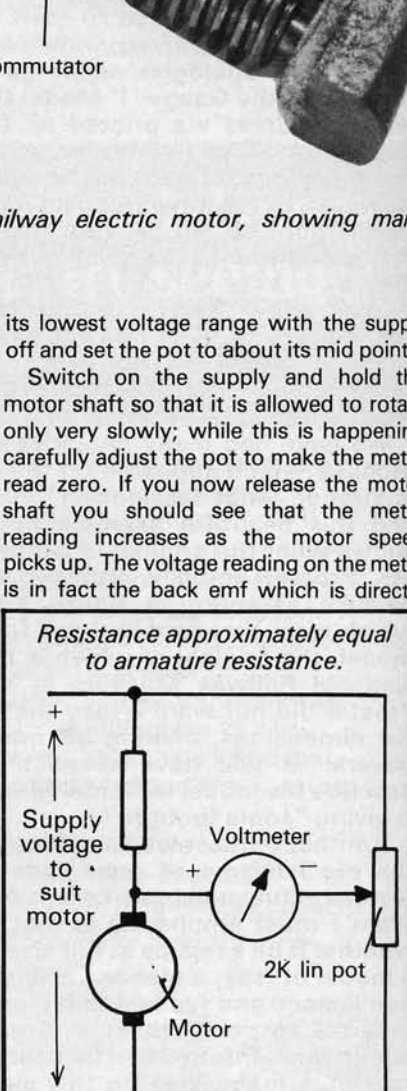
Imagine a motor connected to a power source and running at high speed. If the power source is now disconnected it is pretty obvious that the armature will still rotate until the bearing friction brings it to a stop. During this free-wheeling period it is also pretty obvious that the motor will be acting as a generator and producing its own voltage. Now, does it only begin to produce this voltage when the power source is disconnected, or is it producing a voltage all the time? The answer is of course that it is being produced all the time that the motor is rotating, so the next question is, what happens to the current that it generates? The answer to this is that the current is fed back into the power source. It may seem pretty pointless to say that the motor puts current back into the supply when a meter in the circuit would quite clearly show that the motor was taking current from the supply.

The reason for thinking about this generated voltaged (known as the "back emf") and the current that it produces becomes clear when the motor is loaded. The speed naturally drops and since the generator of the back emf is slowed down, the magnitude of the back emf must drop in proportion to the speed. This means that less current is fed back into the supply, or to put it another way, the supply must provide more current. This extra current helps to compensate for the drop in speed caused by the increase in load. As the load increases, the speed drops and the current increases until eventually the motor stops, or "stalls". In the stalled condition the current taken is given by Ohm's Law and is the supply voltage divided by the armature resistance. When the motor is running, the current is less than this and can only be calculated if the back emf is taken into account.

If you are still not convinced about the existence of the back emf then perhaps the following little experiment will help convince you. Take a small d.c. motor and measure its armature resistance as accurately as you can using a multimeter. Then take a resistor of about this value and wire it in series with the motor. This resistor will be taking the full motor current so make sure that it can stand the power. Connect this combination across a suitable d.c. supply and check that the motor runs reasonably well. Now connect a 5K linear potentiometer across the same supply and connect a multimeter (set to read volts) between the wiper and the motor as shown in Fig 2. Set the meter to its lowest voltage range with the supply off and set the pot to about its mid point.

Switch on the supply and hold the motor shaft so that it is allowed to rotate only very slowly; while this is happening carefully adjust the pot to make the meter read zero. If you now release the motor shaft you should see that the meter reading increases as the motor speed picks up. The voltage reading on the meter is in fact the back emf which is directly

Resistance approximately equal to armature resistance.



When the circuit is balanced using the pot, the meter reading is proportional to the motor speed.

Fig. 2. Measurement of back e.m.f.

proportional to the motor speed. It will give a reading which depends only on the speed and not on the supply voltage because the circuit 'balances out' the resistance of the armature. This type of circuit can be used to make a very good speed controller because it is possible to measure the speed, using the back emf, and use this signal to keep the speed constant. Unfortunately this type of circuit is rather complicated and better than can be justified for this application.

Motor control

One method of controlling the speed of the motor is just to vary the voltage supplied to it, or the current in the armature. The simplest method of doing this is using a variable resistance, or rheostat, in series with the motor as shown in Fig 3. When the rheostat is set to zero resistance the full supply is given to the motor which runs at its maximum speed. As the resistance is increased, more of the voltage is lost across the resistance and less and less is available to the motor. This naturally has the desired effect of slowing the motor down. Unfortunately there is a snag, which shows up when the motor is put under load.

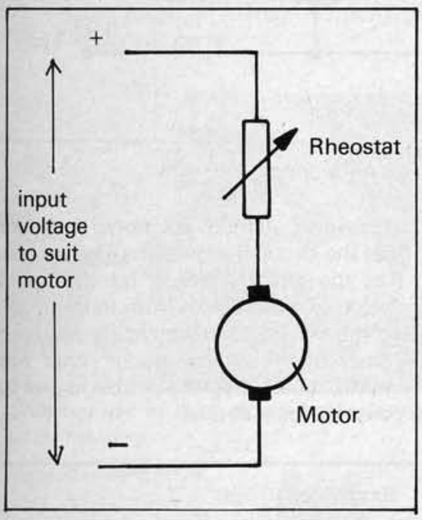


Fig. 3. Rheostat speed controller.

As the load is increased, the motor slows down and the motor demands more current. When the current tries to increase, the voltage drop across the rheostat must increase and the voltage across the motor therefore decreases. This makes the motor slow down, which makes it demand more current, which makes the voltage across the rheostat increase, which makes the voltage across the motor decrease which makes the motor slow down . . . The net result of this vicious circle can easily be that the motor will slow down so much that it will actually stall, mainly because the rheostat limits the current that the motor can take rather than just limiting the voltage. A better control would be achieved if the voltage could be varied without limiting the current. This then is the objective of the circuit design.

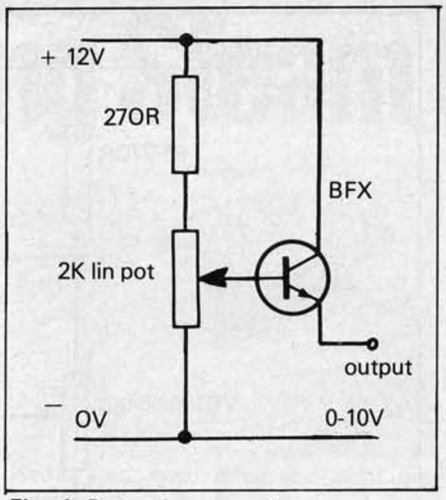


Fig. 4. Potentiometer with emitter follower.

Variable voltage supply

The idea of a variable voltage source was introduced last month in the form of the potentiometer, which enables us to 'tap off' a fraction of the voltage applied to it. This very simple arrangement suffers from the same problem as the rheostat of Fig 3 in that it limits the current available to the motor. The solution to this lack of current was also introduced last month and is of course the transistor amplifier. The arrangement used is exactly the same as that used for the amplifier applied to the zener regulator; the only difference is that the zener is replaced by the potentiometer as shown in Fig 4. This type of amplifier is known as an 'emitter follower' because the voltage at the emitter, which is the output, follows the voltage on the base, which is the input. Remember that the output does not follow exactly because there is always a voltage difference of about 0.6V between the base and emitter of a silicon transistor.

This amplifier increases the current available by a factor equal to the transistor gain. Unfortunately, with the values shown, this is still not enough for the 1 amp that we are aiming for. One of the nice things about emitter followers however, is that they can be cascaded as shown in Fig 5. The principle is that the emitter current of the first transistor, Tr1, is fed into the base of the second transistor, Tr2. The current available from the emitter of Tr2 is now given by its base current times its gain; but its base current is the emitter current of Tr1 which is its base current times its gain. The overall effect is therefore to multiply together the gain values of the two transistors to make what looks like a single transistor of very high gain. Taking typical values for the gain of the BFX85 and of the 2N3055, the combined gain is about $100 \times 30 = 3000$. To provide 1 amp, this combination only requires 1/3000 amps or 0.333 mA, and should be adequate for the purpose.

I have briefly mentioned the power rating of devices before, and this is something that deserves a bit more

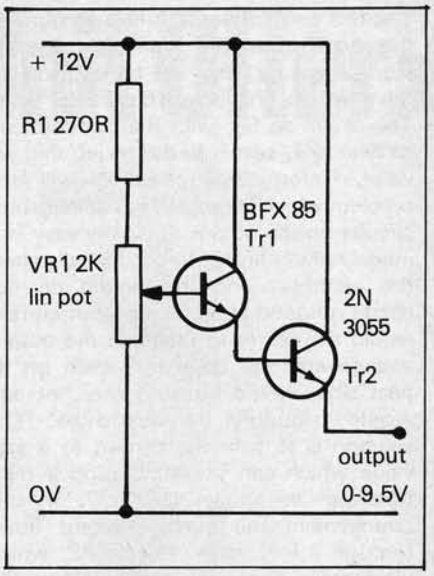


Fig. 5. Potentiometer with compound emitter follower.

explanation. The power dissipated in a device is given by the voltage across it times the current through it. If the units are volts and amps the power is given in watts. For the 2N3055 in Fig 6 the maximum power is dissipated when the output is set near 0V and the output current is at its maximum value of 1 amp. The power is of course $12 \times 1 = 12$ watts. Now, this amount of power is enough to run a miniature soldering iron at a temperature of about 300°C. The transistor cannot be allowed to get anywhere near that temperature so a method must be found to remove the heat. This is done by bolting the transistor, which is a pretty meaty device, to a finned heat sink as shown in Fig 6.

Fig. 6.
A 2N3055 power transistor fitted to a finned heat sink.

The fins on the heat sink help to transfer the heat from the transistor to the surrounding air, and the temperature of the transistor chip is kept below 150°C.

The circuit so far, with the transistor on its heat sink, seems to do the job that we want. Unfortunately, there is still one problem which is protection against short circuits on the output. It is very easy in a model railway layout to accidentally short the controller and this would do our circuit no good at all. The output current would rise to try to maintain the output voltage and the transistor, even on its heat sink, would become very hot and would probably be destroyed. The solution is to limit the current to a safe value which can be done using a third transistor as shown in Fig 7. In this arrangement the output current flows through a low value resistor R2, which incidentally does not greatly affect the output voltage or current; the extra transistor, Tr3, has its base-emitter junction connected across this resistor. As the output current from Tr2 increases, the voltage across the resistor increases in proportion. The value of this resistor is chosen so that as the current approaches the maximum allowed value, the voltage approaches 0.6V. At this point Tr3 will begin to conduct because its base-emitter voltage will be 0.6V. The result is that Tr3 will draw current through its collector, through the LED, and through R1. This current can no longer flow into the base of Tr1 and so the current in Tr1 emitter cannot increase. This in turn means that Tr2 emitter current cannot increase and the current is limited to a safe value. You will notice that this limiting action does not begin to come into effect until the output current is high enough to cause a voltage drop of 0.6V across R2. With R2 = 0.47 ohms this occurs at a current of about 1.2 amps. An indication of the overload condition is given by the LED which lights when Tr3 switches on.

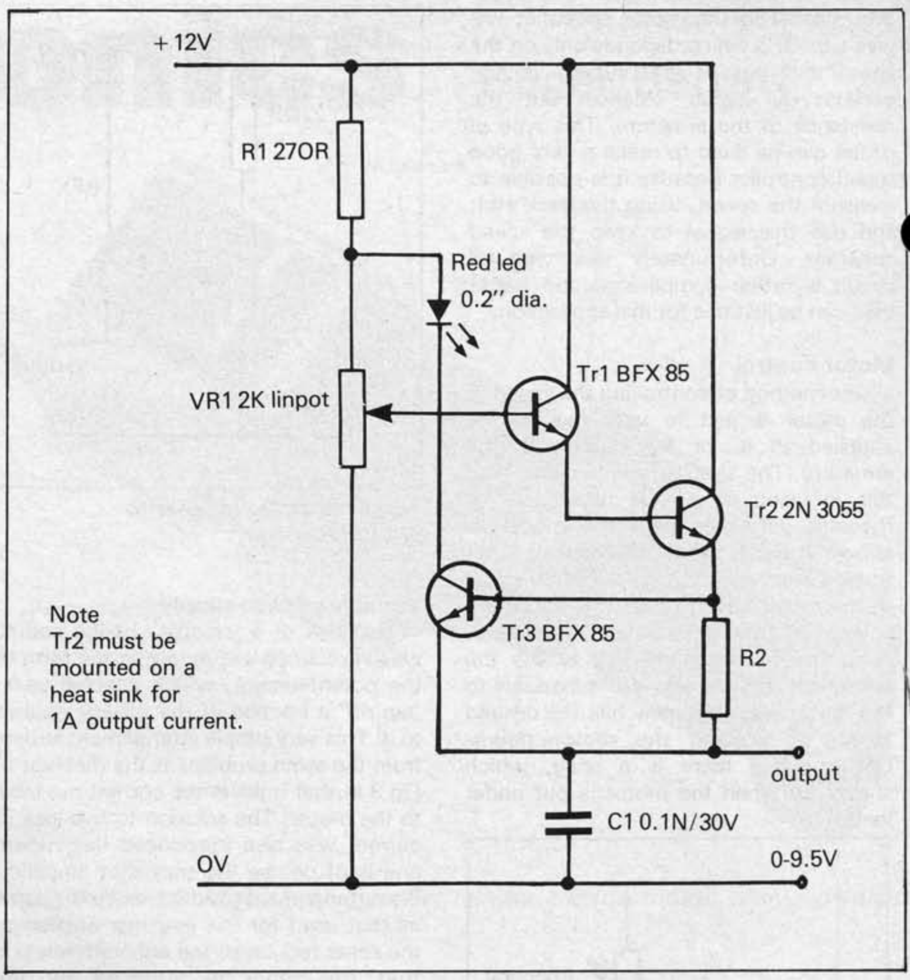


Fig. 7. Variable voltage supply with short-circuit protection.

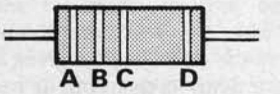
The only other component in the circuit is a small capacitor across the output. The purpose of this is to ensure that the circuit remains stable, but the way in which it does this is not of any real importance to us at the moment.

The design is now complete, and if you have followed my explanation its operation should be clear to you. It is often said among electronic engineers that the circuit design is the easy part and that the difficult part is the mechanical design and assembly. With this in mind I do not intend to say anything about the construction of this design until next month, when I hope to be able to give full constructional details.

This is a revised colour code chart, as the previous one did not take account of the very low resistances now to be found in modern circuitry. Such as: 4.7 ohms where Gold is the multiplier or .47 ohms where Silver is the multiplier. Modern practice in marking some resistors is to replace the decimal point with a letter indicating the multiplication factor. For example:

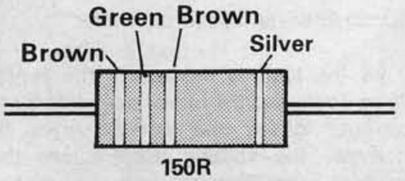
R = Ohms; K = Kilo ohms; M = Meg ohms; e.g. 0.47 ohms would read R47, 1 ohm would read 1RO, 4.7K would read 4K7.

After this is added a letter to indicate the tolerance:— F = 1%; G = 2%; J = 5%; K = 10%.

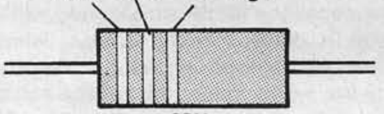


	A and B	C = Multiply	D = Tolerance
Black	0	1 ohm	
Brown	1	10	1%
Red	2	100	2%
Orange	3	1000	
Yellow	4	10000	
Green	5	100000	
Blue	6	1000000	
Violet	7	10000000	
Grey	8	100000000	
White	9	1000000000	
Gold		·1	5%
Silver		·01	10%
No band of colour at D			20%

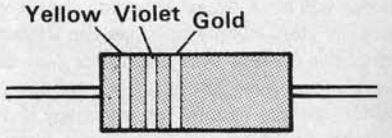
Examples



150R



68K



4R7

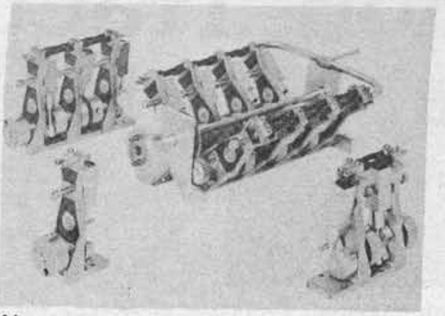
★Oscillating Steam Unit Offer★

The kit we are offering contains all the necessary parts to build a one unit steam engine capable of powering a boat up to one metre long.

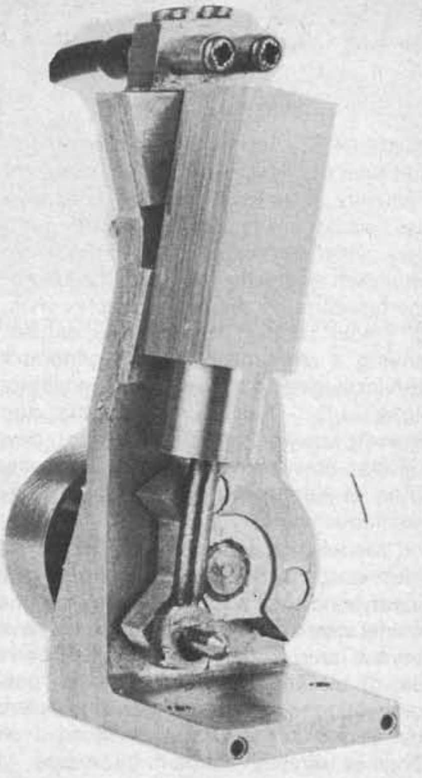
One great advantage of this design is that you can join units together to make a more powerful multi-cylinder engine.

Its construction is a good exercise in both hand and machine work, and would be ideal for someone who is new to lathe work.

The kit is supplied with a comprehensive set of plans and written instructions.

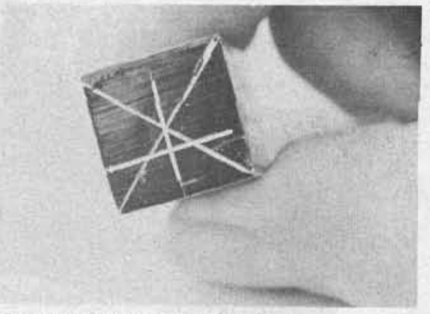


Above one, two, three and eight unit engine.

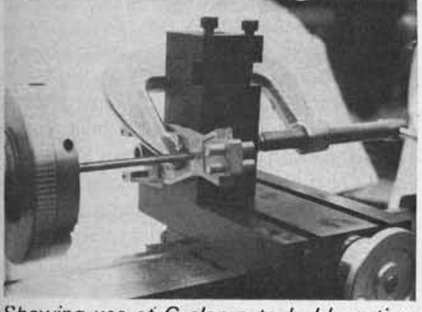


The finished kit, this of course will require a source of steam or compressed air up to 40lb psi.

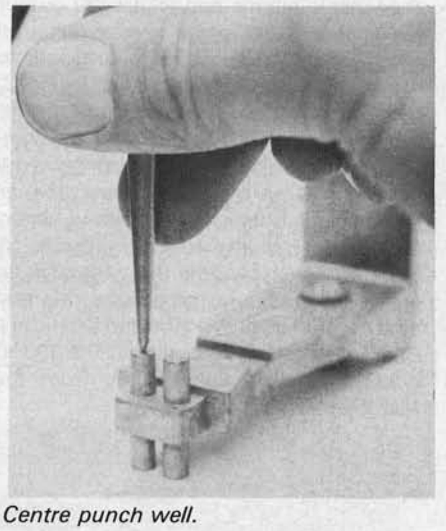
The component parts.



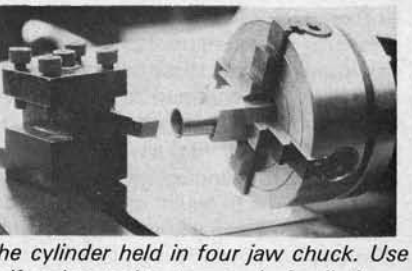
Marking out for cylinder bore.



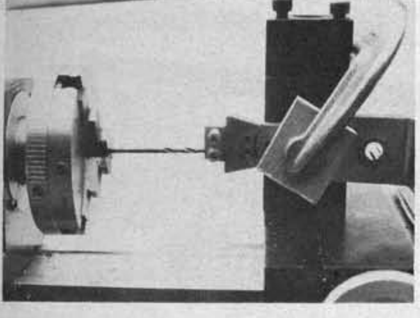
Showing use of G clamp to hold casting while reaming.



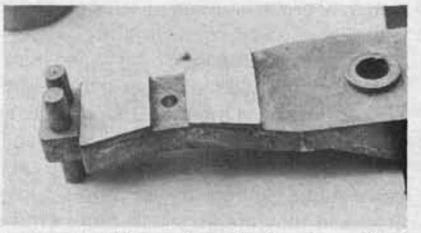
Centre punch well.



The cylinder held in four jaw chuck. Use knife edge tool to turn end of cylinder.



Left: use a piece of wood under G clamp to protect casting. Use a straight edge to line up drill with inlet and exhaust holes. Drill is shown extended for lining up only. To prevent wander ensure drill protrudes from chuck the minimum amount.



Ensure that the surface facing the cylinder is flat.

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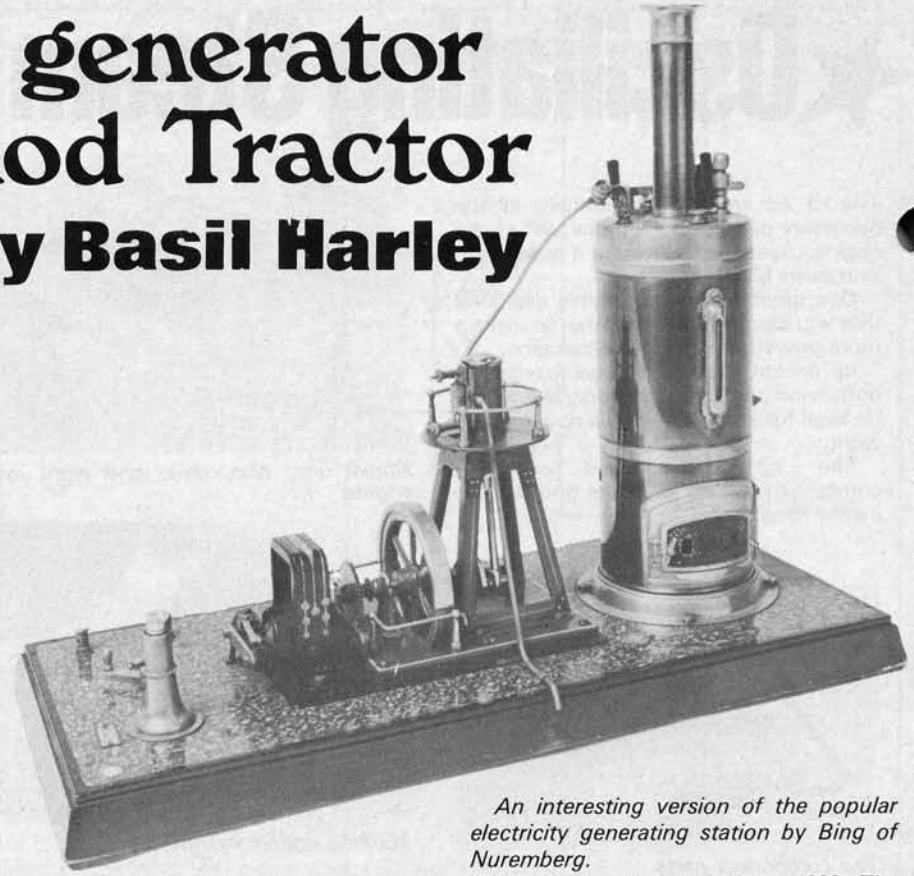


An interesting version of the popular electricity generating station by Bing of Nuremberg.

This was introduced about 1908. The engine is geared 4-1 to the Siemens type dynamo.

SOME OF the exciting things that model, and even toy, steam engines can drive are miniature generators or dynamos as they used almost universally to be called. It is a very satisfying experience to generate your own electricity right from the heat of the fuel through the quite complex chain of steam raising, running the engine, driving a permanent magnet generator and lastly getting a glow from a miniature light bulb. Over seventy years ago Bassett-Lowke imported a (then) new German steam plant, made by Gebruder Bing of Nuremberg (Fig 1) and in their catalogue wrote:

"Model engineers have long demanded Electric Light from the pent-up energy methylated spirit through the medium of a model steam engine. This season we have several new, complete plants. The Boilers are of the vertical type, fitted with gas-generating spirit lamps, and are connected to vertical high-speed type Engines directly coupled by means of gearing to permanent magnet Siemens' Armature Dynamos. The plant is mounted on one base and provided with screw cap Lamps, H.E. and Switch."

The power of these toy engines, and in particular the generators, remained low for many years. Permanent magnet materials were confined to cobalt steel at best and to save the expense of commutators almost all were made to produce a rough alternating current via slip-rings which could only be used to light one or possibly two flash lamp bulbs. The Bassett-Lowke/Bing plant is rated at 4 volts (with "2500 turnings a minute") and 0.10 amps and has to struggle hard to make its one lamp glow brightly.

The past decade or so has seen a complete transformation in the design of small permanent magnet D.C. motors and these, as everybody knows, can also be used as generators, if driven at a reasonable speed by a prime mover. Because they are so much more efficient than the earlier ones the output of one motor used as a generator can be fed to other motors to run them. In the past losses were so high that no such working was feasible with commercial toys. But now all sorts of interesting possibilities are opened up for combining even the simplest oscillating cylinder engines with some of the many, often very inexpensive, motors which are widely available.

For my example this month I have taken the Mamod Steam Tractor (Fig 2) and designed a simple bracket to carry a generator in front of the smokebox. The result is a very fair representation of a showman's engine and whilst the output is not enough to light a row of coloured lamps round the canopy it is sufficient to run at least two other motors. In Fig 3, which shows the outfit running in steam, just one is driving a circular saw with one of those charming German workmen who slaved away on many a nursery table all unconscious that, half a century later, they would become collectors' pieces. A rather more appropriate thing for such an engine to drive is a fair ground ride and next month I shall describe and illustrate a Chair-o-plane (very popular in the 1930s) which runs very successfully from the Mamod tractor.

Stationary engines such as those sold commercially by Wilesco, Mamod or Unit Steam Engines or the home built ones to designs such as that of John Wheeler in the February and March issues can all be adapted to generate enough power to drive two or more motors. This makes possible a modern approach to miniature workshops with individually powered machine tools with an appropriate switchboard — after all, there may not be enough power to run them all at once.

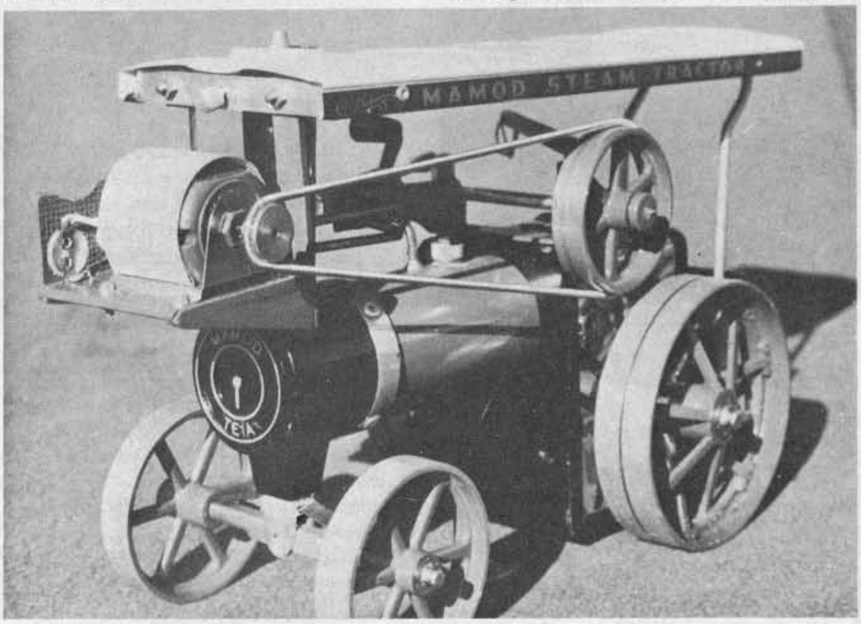


Fig. 2. Mamod tractor with Orbit SO5 motor used as a generator.

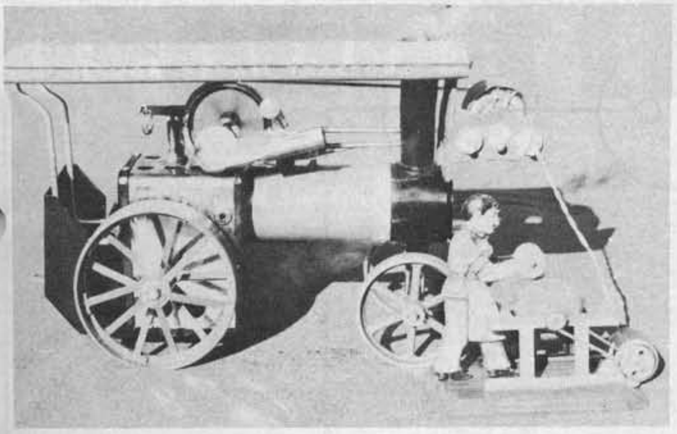


Fig 3. In steam driving a circular saw from a 1-5v motor.

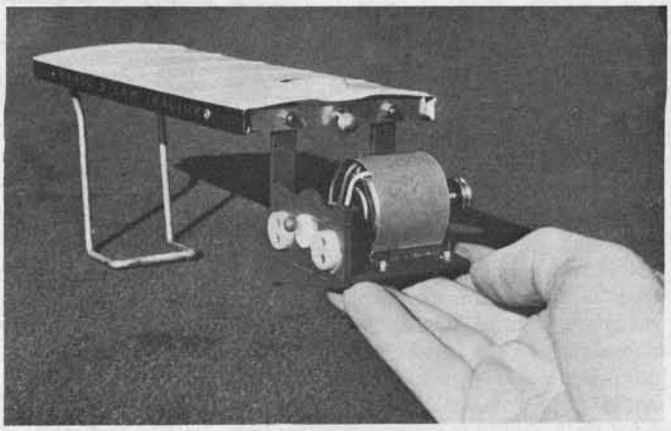


Fig 5. Generator and switchboard can be removed with the canopy as a unit.

The vintage belt-driven workshop described in the April issue could then have a more up-to-date counterpart alongside.

A Mamod tractor is not at all difficult to adapt and Fig 4 shows the generator bracket, made from $\frac{1}{8}$ in. thick hardboard. This material is perfectly satisfactory since it is mounted well away from the heat in the firebox. The sketch is, I hope, self explanatory and after cutting the hardboard pieces to size they can be glued together with any one of the good woodworking adhesives like Evostik. The canopy of the tractor has two $\frac{1}{8}$ in. holes in 1¾ in centres at the front on either side of the knurled headed screw which clamps it to the chimney. These offer a convenient place to bolt the bracket, the bottom of which has a cut-out section to fit the smokebox. It will be found that when the chimney screw is tightened the whole bracket is firmly held between the canopy and the smokebox and the belt tension also helps to keep it in position. On the other hand, as Fig 5 shows, the whole assembly can be removed with the canopy for filling the boiler, oiling etc. At this stage and before fixing the generator give it a good rub down with glasspaper and a couple of coats of green paint. The floor of the bracket can be made a suitable size for the motor/generator to be used. Almost any 1.5 volt to 6.0 volt motor will be satisfactory but remember the engine power is very limited and so only small machines can be driven. The one fitted to the tractor illustrated is the Orbit 505 by Ripmax which as a motor runs on a nominal voltage of 3 and a range from 1.5v to 6.0v. I have added a 'cosmetic' band of aluminium to cover the terminals on top and make it look rather more realistic. As a generator it produces about 2 volts on open circuit at about 1200 rpm which drops to 1.5 volts when driving a similar Orbit motor or the like. So if a belt drive is taken from the 2 in. diameter Mamod flywheel to a ½ in. diameter pulley on the generator shaft an engine speed of something like 300 rpm will be about right — in other words the engine doesn't have to race away at an unrealistic speed in order to get results. My own engine is now well run-in and will achieve this with a steam pressure of about 15 psi — before the safety valve lifts.

Among other motors which will be found to be suitable for both generating and motoring are those sold by Proops Bros. Ltd, for under £2.00 for a pack of 10. The quality of individual motors is a bit variable (understandably) and it is as well to try out one or two from the pack to find the best. The sawyer in Fig 3 is being driven by one of these via a rubber band straight from the motor shaft.

A spring belt drive from the engine is perfectly satisfactory (not too tight to give too much friction) and provided the generator and its pulley is properly lined up it is not necessary to turn a groove in the engine flywheel for the belt to keep on. When the bracket has been bolted on put the generator on it and line it up carefully. Drill on $\frac{3}{32}$ in. fixing hole for a 7BA bolt and fix the generator temporarily

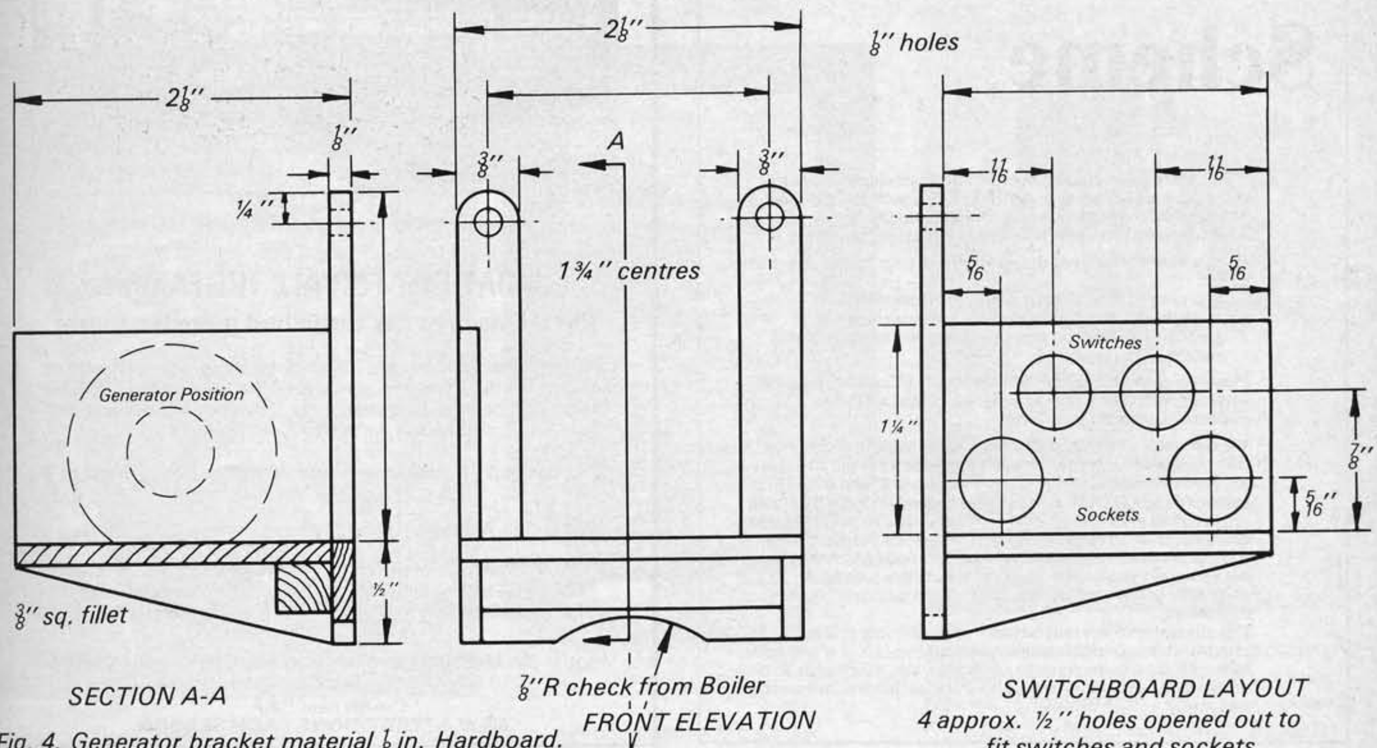


Fig. 4. Generator bracket material $\frac{1}{8}$ in. Hardboard.

with it. Check that the belt runs satisfactorily on the centre of the flywheel by moving the generator or the pulley on its shaft before marking and drilling the other three holes. A good way of checking is to couple the generator to a 4v battery and let it drive the engine — with the filler plug on the boiler removed otherwise, since it acts as a pump, it will soon stall.

It is very convenient to take the output from the generator from a proper miniature control board and there are appropriate single pole switches and tiny plugs and sockets made for dolls' houses which fit in very well. They are available from Hobby's Ltd together with very fine twin core cable. The switches are 12mm in diameter and the sockets 13mm, but both have soldering tags on the back so you will have to increase these dimensions for clearances. Holes can be drilled and filed carefully with a round file in the hardboard panel and the switches and sockets pushed in from the back and held in with a dab of glue. It will be found easier to do this, and solder the connections before finally bolting the generator down.

In my version shown in the photographs I used one switch to control both sockets but it is obviously better to have a separate switch for each and this I have shown in the drawing and in the very simple wiring diagram in Fig 6.

Whether fitted to a stationary engine or a tractor as described the addition of a generator makes a lot of difference to the pleasure to be got out of running a miniature steam engine. Perhaps the first surprise you will get will be the very considerable variation in engine speed that occurs as the electric load is switched on or off — a very real demonstration of the governing problems affecting full sized power station equipment operating under varying load conditions. The direction of rotation of the driven motors can be varied by reversing the engine (if, as is the case of the tractor, it is fitted with a reverse lever) or by changing the polarity by reversing the plugs in their sockets. And lastly, by applying a battery to the generator it will motor effectively and drive the steam engine, so demonstrating very prettily the interchangeability of various forms of energy.

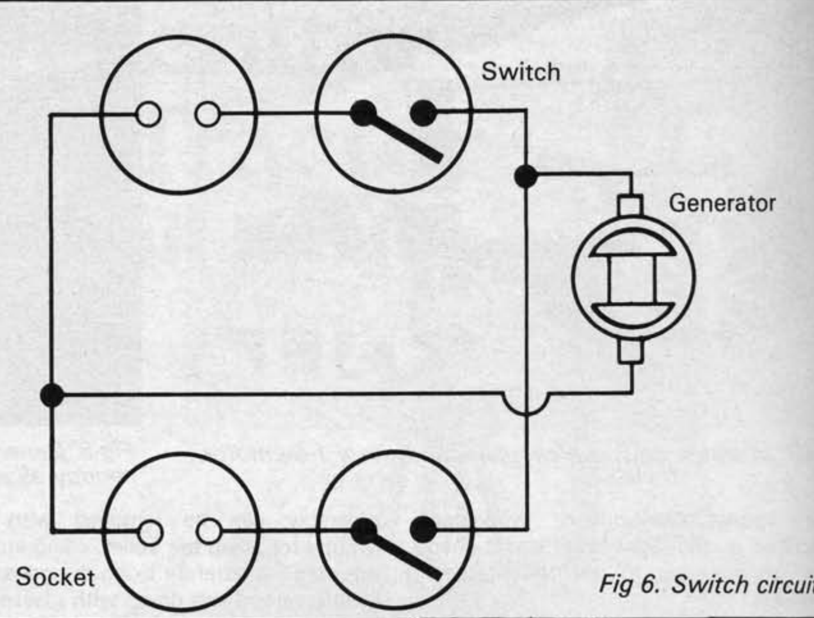
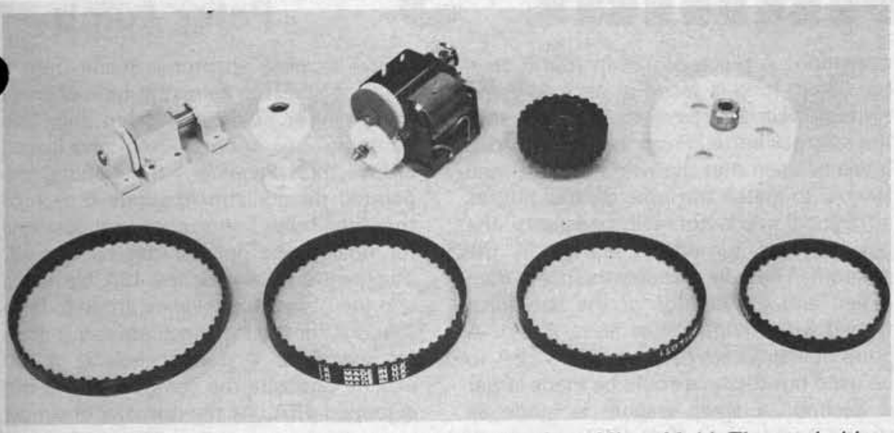


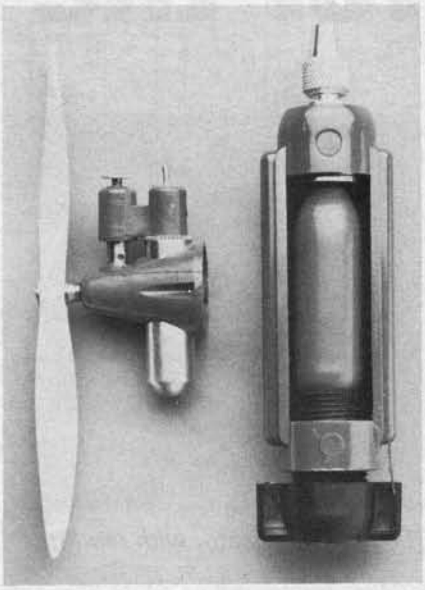
Fig 6. Switch circuit

Around the TRADE

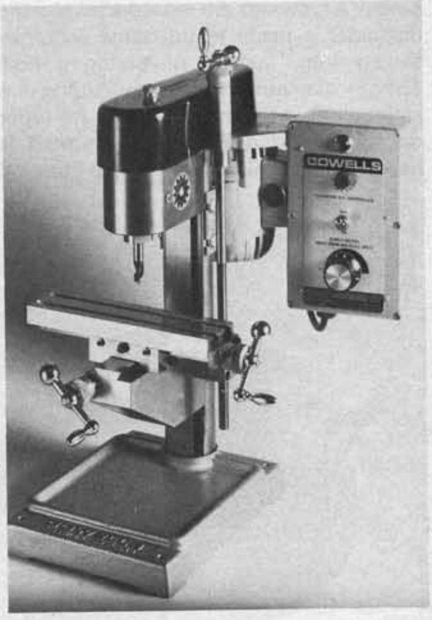


Photographed here are some interesting components from Micro-Mold. The tooth drive belts come in four sizes, 70, 90, 100 and 110 tooth, ranging from £0.93 to £1.05. The tooth drive pulleys also come in four sizes, 8, 12, 25 and 40 tooth, priced from £0.66 to £1.37. The drive shaft mounts (£1.35 a pair) would be most suitable for the axle bearings. For heavier duty use, there is an intermediate drive shaft mount made of Dural with a phospherous bronze bearing, this is priced at £1.97. Finally, for experimenters, a motor that has its own gear box, this is priced at £3.99. All these components are products of Micro-Mold Ltd., Station Road, East Preston, Littlehampton, W. Sussex, BN163AG. Tel: Rustington 73170& 73180.

Selection of very useful adhesives for the modeller from Loctite, Araldite and Bostik.



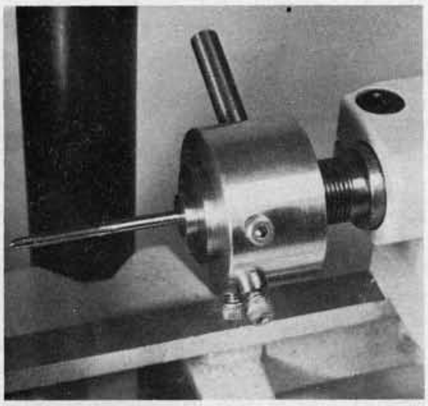
This 'new look' C02 engine will be available fro Humbrol from the middle of this year. As you can see, gone are the copper tubes, which were rather fragile. The Humbrol C02 MkII comes complete with mounting screws, propeller, charger and operating instructions. Details of kits, designed for the C02 motor will be announced shortly. For further details, contact: The Product Manager, Toy and Model Dept., Humbrol Consumer Products Division of Borden, Marfleet, Hull HU9 5NE.



An excellent Vertical Milling machine by Cowells. For further information, contact: Cowell Engineering Ltd., Oak Street, Norwich, Norfolk. Tel: Norwich 614521.

A tapping adaptor for the Unimat 3

by
Peter Lumb



The tapping adaptor with tap fitted.

Many readers will no doubt have seen the excellent article by Rex Tingey in the issue of Model Engineer for the 5th January 1979. The article is perhaps a little ambitious for someone who has just acquired the Unimat together with, perhaps, three jaw and drill chucks. Included in the article is a tailstock dieholder which must be one of the first items usually constructed for the lathe by beginners. However, this again assumes that the screwcutting attachment together with a hob and follower have been bought.

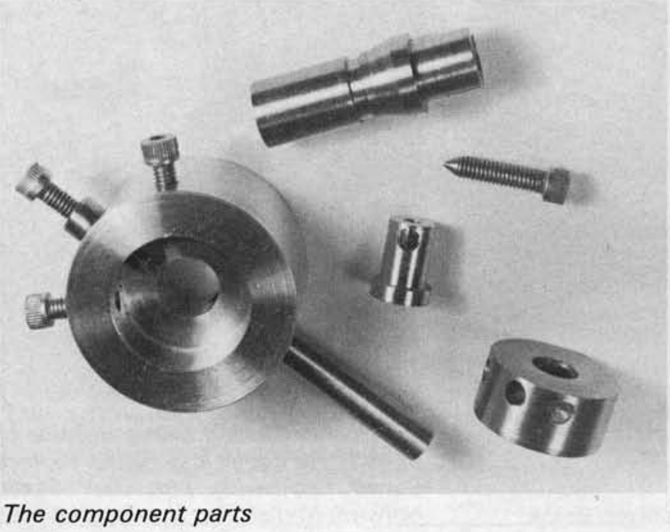
There is an alternative way of making the dieholder without screwcutting and, before the tap adaptor is described, this alternative method will be presented. Mr. Tingey's drawings are reproduced and the dieholder is made to the same drawings except that, instead of boring a hole 13mm diameter for screwcutting, a smaller hole of 10mm is bored. An arbor on which the dieholder is mounted is needed and this is a simple turning operation. A piece of 12mm round steel bar 35mm long is faced at each end and turned down for 15mm to fit closely into the tailstock barrel. From the photographs it will be seen that the writer taper turned the bar to match the lathe centres but, as a frictional grip is not really necessary, the bar may be turned as shown in the diagram. The hole through the bar is then drilled and the outside of the bar finish turned for a length of at least 10mm. A 6mm hole will allow all taps up to 2BA to be used but the hole could be made larger if desired. A small washer is made as shown and tapped 4BA. With the chuck removed the arbor can be pushed into the headstock and held tightly in place by a piece of 4BA studding screwed into the washer with a further washer and nut at the other end of the mandrel. The arbor can now be reduced to 10mm for a length of 10mm to fit inside the dieholder.

Using Mr. Tingey's dieholder, the lathe chuck must be revolved and the tailstock allowed to slide along the bed as the thread is cut. The present dieholder (and tapping adaptor) is used the other way round and the mandrel must be locked and the holder turned on its arbor. A simple headstock lock can be made by threading a piece of steel bar 25mm long for a length of 10mm with a 6mm die. A piece of 4mm silver steel 45mm long is pointed at one end. Remove the front motor bracket screw and replace this with the piece of screwed bar. If the pointed rod is now pushed through the hole in the headstock mandrel it can be used as a scriber to mark the cross drilled hole in the bar. The point can be turned off and the hole in the bar drilled 4mm. If a top slide is not available the pointed bar can be made with a little juggling with the feed wheels or a file. A 4BA tapped hole with set screw holds the silver steel in place.

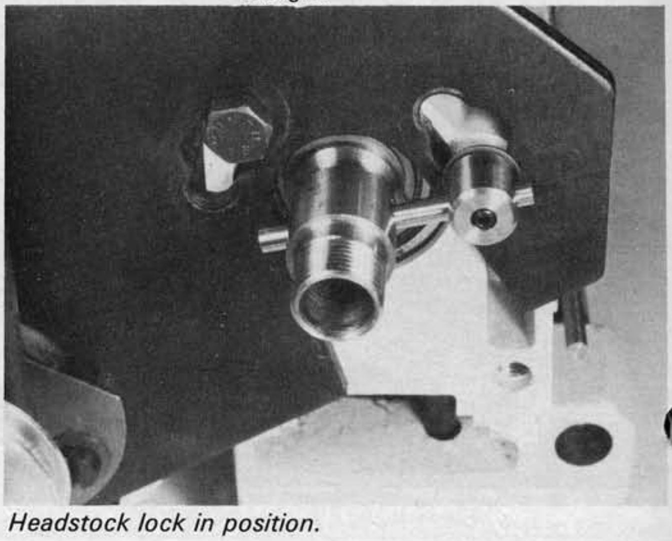
The tapping adaptor is made from a piece of steel bar turned to fit in place of the die in the holder and 10mm long. This "dummy" die is bored 7mm and placed inside the dieholder. By putting the pointed die adjustment screw in each of the three holes in turn the exact positions for drilling the dummy can be marked. The centre hole is drilled 4BA clearance and the other holes slightly drilled to form seatings for the locking screws as is done for the dies. A further hole is drilled exactly opposite the centre hole and this is tapped 4BA. As the diameter of almost every tap seems to be different from all others, bushes must be made for each size. These are turned from brass. Each one is inserted in the dummy and held in place with a 4BA allen screw in the hole provided. The dummy is then inserted in the dieholder and the centre screw (not pointed this time) tightened. Finally tighten the two locking screws. If the whole assembly is now mounted on the tailstock the hole for the tap can be drilled accurately. Remove the dummy from the holder and, using the 4BA clearance hole as a guide, drill half-way through the brass bush.

To assemble the tap holder the correct bush is inserted in the dummy and one of the 4BA screws put through the centre hole and the hole in the bush. The 4BA screw opposite can then be tightened to hold the bush in place. Remove the guide screw and put the tap in place with one of its flats opposite the centre hole. Insert the dummy in the dieholder and tighten the centre screw to lock the tap in place, finally tightening the two locking screws.

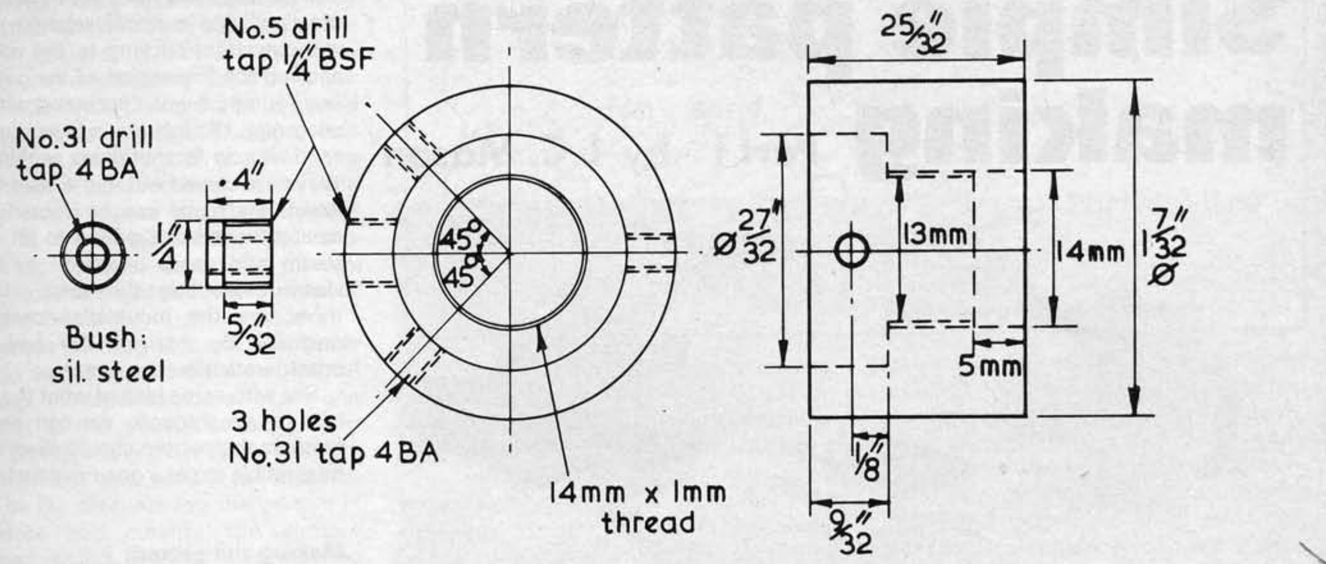
When cutting a fairly long thread the die/tap holder will work along its arbor and come off the end. It is necessary to move the tailstock along the bed at intervals to keep the thread running straight.



The component parts

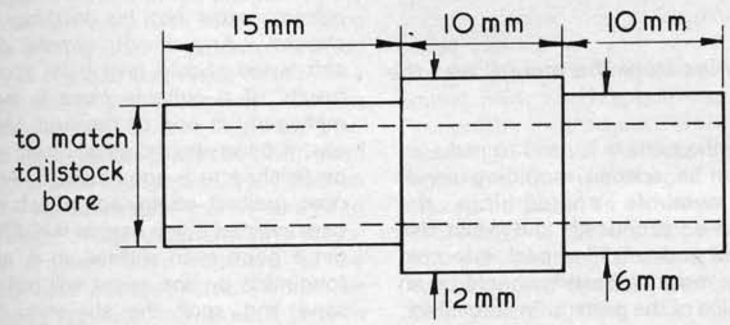


Headstock lock in position.

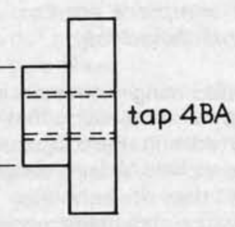


TAILSTOCK DIEHOLDER (Mr. Tingey's)

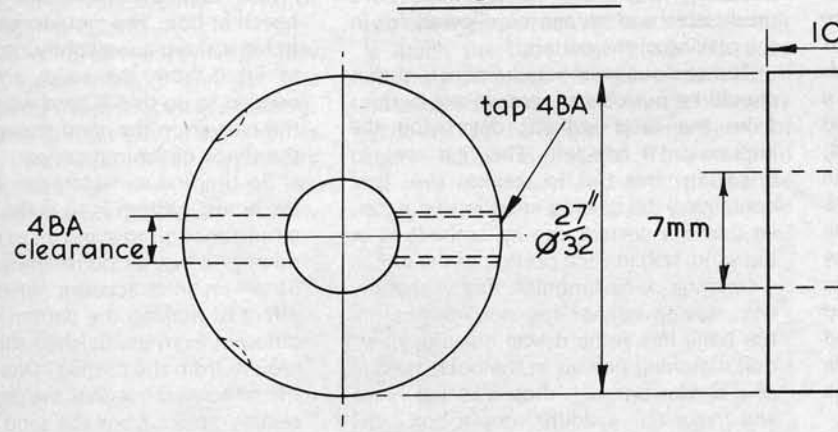
The 13mm tapped hole is replaced with a 10mm hole to avoid screwcutting.



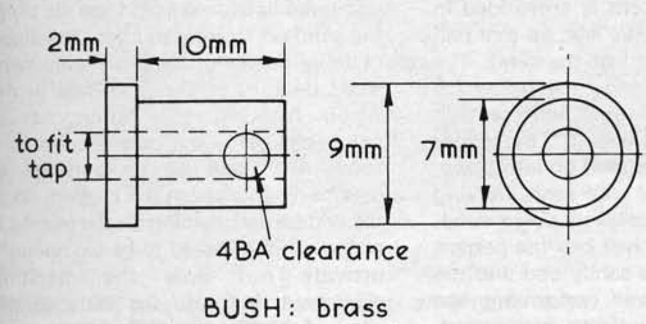
ARBOR: steel



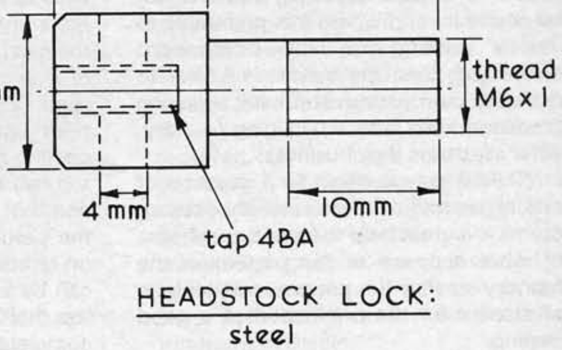
Temporary washer



"DUMMY" DIE: steel



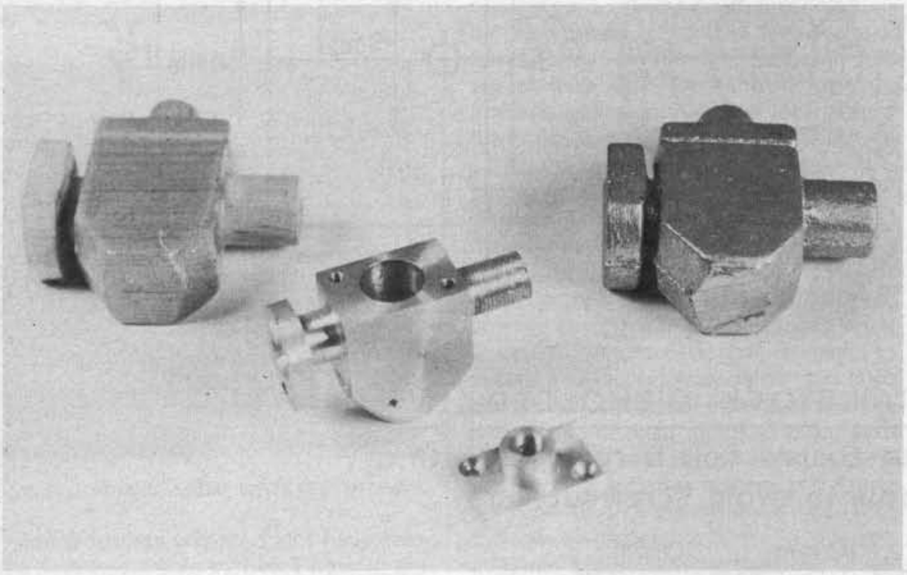
BUSH: brass



HEADSTOCK LOCK: steel

Simple pattern making

Part 1 by L.C. Mason



A simple one-piece pattern, the casting as it comes from the mould, and the finished machined job.

ANYONE becoming interested in model engineering will soon realise that castings play a big part in the construction of engineering models. A fairly simple model may make use of only one or two castings, while something considerably more complex like a loco or traction engine may have as many as a couple of dozen or more.

The use of a casting for some component gives the builder a flying start towards the shape of the item required. Machining up a casting not only saves a great deal of time and work as compared with shaping the article out of the solid, but it represents a great saving in the quantity of metal involved. In many cases the waste of metal involved in carving the piece out of the solid can be offset by fabricating it from suitable pieces of bar or rod, but there is still the assembly and fixing together to be coped with, and generally the final machining shows little saving over the same operations necessary on the casting.

In the case of an original model—i.e., a model to an original design of the builder's—a suitable casting may well not be available, and where it is preferable to use a casting for the component concerned, then the builder will have to make his own pattern and have a casting produced from it by an obliging foundry. After all, that is their business!

When it comes down to a question of making a pattern for an essential casting, then it is a great help to have a rough idea of what happens to the pattern in the foundry so that the pattern is suitable in all respect for the production of a good casting.

Briefly, the pattern is used to make an impression in special moulding sand, molten metal is poured into the impression so produced, and when this has cooled and solidified back into cold metal, the resulting casting should be an exact replica of the pattern. In actual fact, the casting never is truly exactly like the pattern, but the differences are predictable and so can be allowed for in the making of the pattern.

The obvious main requirement is that it should be possible to remove the pattern from the sand without destroying the impression it has left. The first step in ensuring this is to make the box containing the casting sand in two parts, so that the pattern can be embedded in the sand, half in each portion of the box.

Imagine a rectangular, fairly shallow box, having neither top nor bottom. Its top edge has some dowel holes in it, so that matching dowels in the bottom edge of a similar box can drop into the holes and make up a double depth box—still without top or bottom. The bottom half box is placed on a flat bench top and filled with sand, the sand being rammed down quite solid. The pattern is embedded in the sand up to its centre line, so that half of it is standing proud of the sand. The sand surface surrounding the pattern is then lightly dusted over with a thin coating of fine "parting sand", the empty top half of the box pegged on into place, and that in turn filled with sand, burying the pattern. After ramming down solid, on removing the top half box the pattern can be lifted from its sandy bed and the top half box replaced, reforming the complete pattern impression in the sand. The parting sand has the effect of letting the two sand surfaces separate cleanly, without either sticking to the other and spoiling the impression of the pattern. In one foundry I was concerned with some years ago, the moulder's favourite parting sand was, in fact, ordinary cooking flour! Ways are carved out in the sand through which the metal can be poured in, and smaller vent holes added to let out the steam and gases produced by the hot metal contacting the sand. However, those are the moulder's concern and normally do not call for any special consideration on the pattern.

So, with some idea of what the pattern has to go through, we can see what features the pattern should show for it to be possible to get a good casting from it.

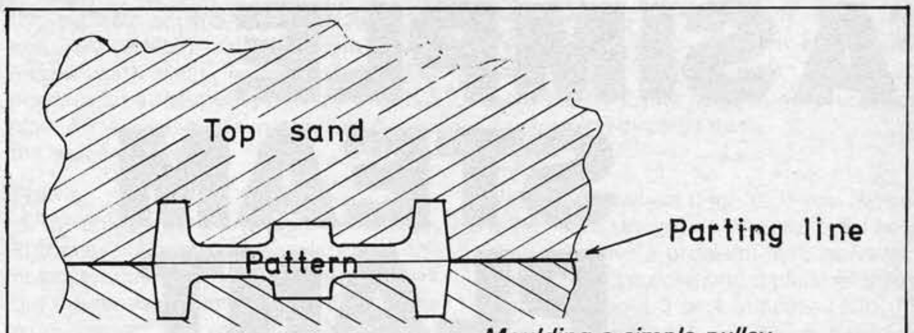
Making the pattern

Patterns are almost invariably made of wood—at least, just for a small number of castings. Professional pattern makers are quite particular about what sort of wood they use, but the model engineer, rarely needing more than one casting from his pattern, need not be anything like so choosey. Any straight-grained medium soft wood should give quite acceptable results. If a suitable piece is available, mahogany is one of the best woods to use; it takes shaped detail nicely and can be finished to a good surface. Any very open-grained, stringy sort of soft wood is best avoided if you can, as it is difficult to get a good even surface on it, and any roughness on the edges will pull up the sand and spoil the sharpness of the impression. It may be liable to warp, too. Avoid too, the very hard woods, like beech or box. The moulder very often has to tap a sharp spike lightly into the pattern to lift it from the sand, and the force needed to do this in hard wood will move the pattern in the sand enough to distort the shape of the impression.

So the first consideration in producing the actual pattern is to make it physically strong enough to stand up to moulding. A number of other considerations need to be taken into account which have the effect of making the pattern very slightly different from the finished shape that you require from the casting. One of the main things to watch is that the pattern can be cleanly drawn from the sand impression. This means that where any depth at all is embedded in the sand, the sides of the pattern must be tapered inwards, so that it is immediately released from the cling of the sand on starting to lift it. The amount of taper need not be very much; two or three degrees is enough. Bear in mind when forming the taper that the narrowest part—the part deepest in the sand—may well be on surfaces that require machining on the casting, so that the widest part coming on the parting line of the sand will need to be big enough to provide not only the machining allowance, but also the extra width to allow of the slight tapering down.

This slight taper applies to all parts of the pattern which have to slide out of the sand on removal. If, for instance, the pattern consisted of a plain cylinder intended to be cast lying down, the ends should be made very slightly conical. This would have the effect of providing the slight taper in all directions, so that the pattern would release cleanly from both halves of the casting box. This also applies to flanges—especially of any depth—such as might occur on the end of an engine cylinder.

A pattern often features one completely flat side. In this case, if the pattern is not too deep, the taper can be all in the one direction, so that the flat surface comes on the parting line in the mould. A pattern for a cylinder end cover, for instance could be like that, turning the pattern in the lathe and making the various diameters slightly conical and tapering gently away from the biggest face. A rather similar shape, that for a three-step cone pulley, could be cast in either of two ways. Where it was intended to machine in the belt grooves from the solid, it could be moulded entirely in the one half of the box, leaving the big back surface to come on the parting line. A pattern moulded wholly in one half box tends to minimise the moulding work required, as no moulding at all is required in the top box. In that case, the top box is filled with sand and both sides made completely flat, so that the top half is used merely as a lid to the bottom half. Alternatively, if the pulley grooves were required to be roughly cast in, the pattern could be moulded edgewise, half in each box. In that case the two end faces of the pattern would need to be very slightly coned, or made very slightly convex.

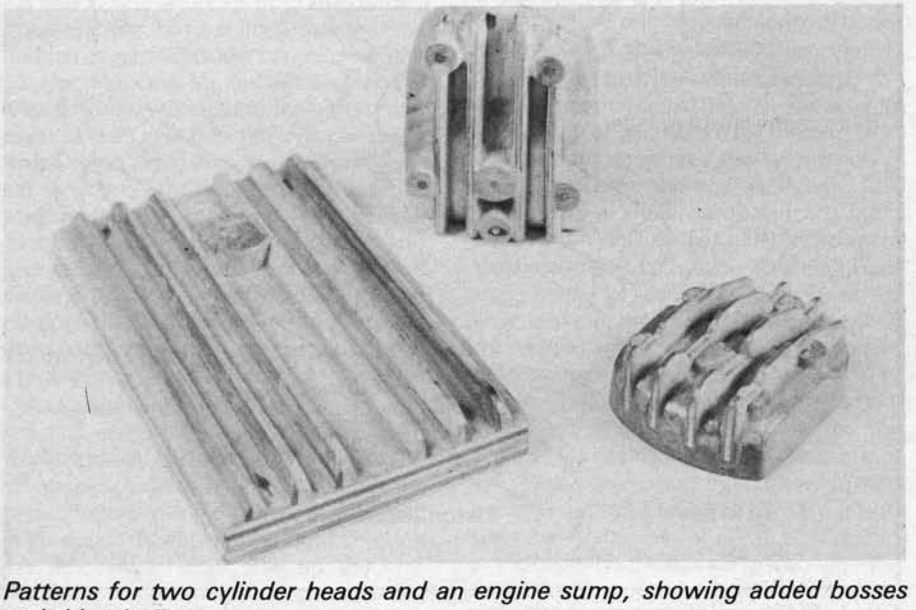


Moulding a simple pulley

While it is often surprising how faithfully a good moulder can get fine detail in a pattern reproduced in a casting, there is a limit to what can be done in that direction. Surface detail generally reproduces well, so that features like lettering or decorative patterns in shallow relief come out well. However, deep and narrow spaces in the pattern should be avoided wherever possible; remember that a deep groove in the pattern will be a thin fin standing up in the sand impression, and this will have very little strength in itself to retain its shape against the movement of the pattern in drawing it from the sand, nor against the swirl of the metal against it when it comes to pouring the casting. A case of this sort might be the cooling fins on an air-cooled I.C. engine cylinder. You cannot reasonably expect to get a set of thin closely pitched fins as cleanly cast in a sand casting as you would get from machining in the fins afterwards in solid metal. Fairly widely spaced sturdy fins will generally reproduce well enough, especially if the depth is kept to the minimum. One useful point in a case of this sort that can be a lifesaver is that any breakdown of the sand impression will be at the thinner tip of the sand fins, and this will be at the bottom of the cast fins, so a little judicious filing will often correct things on the casting.

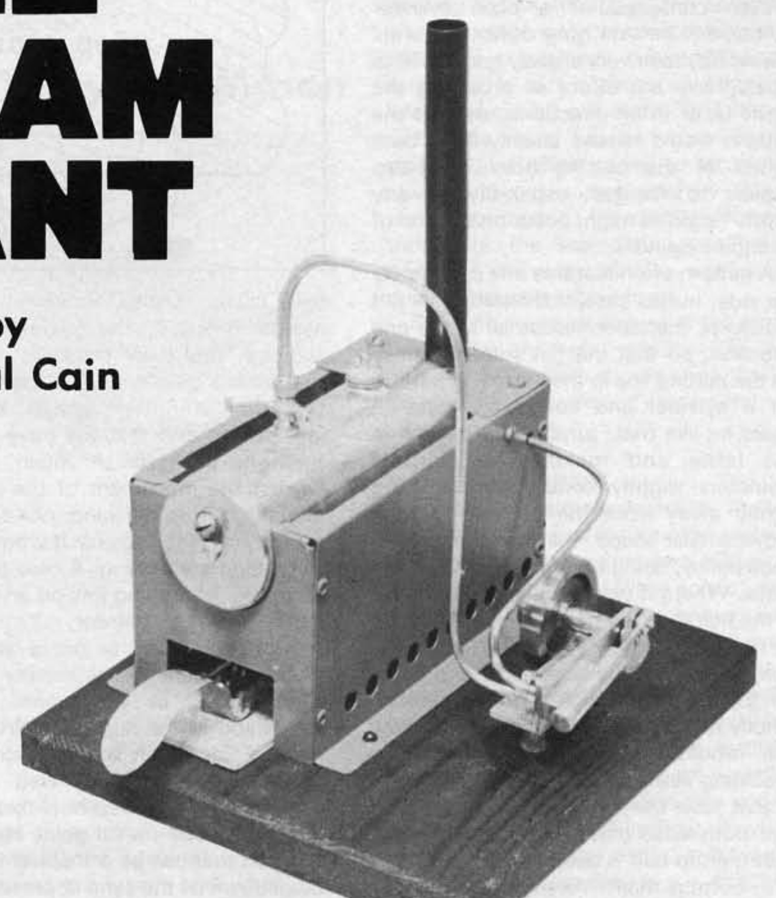
Where features like fins or bosses for nut seatings are required on the pattern, it is much the best way to add these as separate pieces to the basic pattern. Stud bosses can be shaped from short lengths of dowel rod, turning or sanding the slight taper on them in the lathe. They can then be securely pinned and glued on to the body of the pattern, or glued into holes in it. Straight fins can be treated similarly, sanding them to a taper section and glueing them into slots cut in the pattern. Small additions of this sort can generally be of harder wood than the main pattern, making for strength, as the moulder is unlikely to spike some small protruding part to lift the pattern. Added fins or small stand-up ridges can very well be from strips of plywood; three-ply is available down to 1mm. thick. Remember that you can play with plywood to make the thickness needed on the pattern, removing one layer from say 5-ply for a slightly thinner section, or sandwiching a couple of thin pieces to make a very strong multi-ply thickness. One of the waterproof powder glues is very suitable for this purpose.

Extra stand-up pieces of this sort, when added to the main pattern, naturally make a sharp angle at the joint where they are fixed. Such an angle will become a sharp corner in the sand, and so should be avoided because of the possibility of the sand shape breaking down there. The thing to do, therefore, is to arrange a rounded fillet in all corners. With small additions to a small pattern—like the cooling fins mentioned—it is generally sufficient to apply a liberal amount of glue in the joint, and where this squeezes out on assembly, leave it untouched until set quite hard. It can then be shaped into a reasonable fillet with a small round file. If one of the powder glues is used, a wetted ball bearing rolled round the ridge of squeezed out glue in the corner shapes a nicely rounded fillet, which can be touched up when set. Plastic wood can also be used to fill out any sharp angles, although it cannot always be depended on to bond firmly enough to the wood of the pattern to stand up to the moulding treatment. The use of plastic wood in pattern making is generally looked on as a sign of the unskilled worker, as possibly covering up a poor joint! Firms supplying foundry and pattern making materials used to have available triangular section leather fillet in longish strips, which can be cut to length and glued on where required on a large pattern. This, especially if soaked in water first, can be coaxed very neatly round quite sharp bends. If it is attached by a non-waterproof glue, it can be soaked off again afterwards and used again on some other pattern. However, I am not sure if this is still available.


Patterns for two cylinder heads and an engine sump, showing added bosses and thin ply fins.

A SIMPLE STEAM PLANT

by Tubal Cain



HERE IS A present for a child of any age between five and 65 years, and of either sex; the steam set in the photo was made for my daughter, to drive her Meccano models. It is made almost entirely from material from the junk-box, and though a lathe will ease matters it can be made without. The essential safety valve and the desirable steam-cock can be bought ready made from a number of suppliers, like Messrs. Stuart Turner of Henley-on-Thames, Kennions of Hertford, or Reeves of Birmingham. If you have no lathe, order the necessary bushes with the fittings. You can get the tube for the boiler, and other materials as well, from the same people.

The boiler is silver soldered—a low-temperature brazing process, and makes a very much safer job than soft soldering, which I don't recommend at all. If you have never done this before, don't be alarmed. It is, in fact, much easier than soft soldering—you just have to get the joint hotter, that's all. But you *will* need a blow-lamp. A ¾-pint paraffin lamp is ample, and, with care to conserve heat you can manage with the little Soudogaz* cartridge blowlamp fitted with the (normal) bush-flame burner. The very small lighter-gas blowlamps won't do

The size of the engine grew from the materials available, and within reason can be adjusted at will. The *only* dimensions that matter are the stroke, the distance apart and diameter of the ports, and the centre distances of these ports from the cylinder pivot, and of the crank from the same pivot. These govern the steam distribution, and should not be altered unless you know what you are about. In my case, I found a piece of 1¾in. dia. tube which I thought would do for the boiler, and looking at this decided that about ¼ in. bore would do for the cylinder. I would have preferred 2in. for the boiler, but the only piece was a trifle thick, and a couple of feet long—hardly 'junk'! The piece actually used was about 1/32 in. thick, probably 21 gauge. I would have preferred thinner—down to 26 gauge will be quite safe—but this piece works fine. The end-plates of the boiler are bits of scrap 20 gauge copper.

For the cylinder I found a piece of ¼ in. bore brass tube of almost exactly 5/16in. O.D. and after removing the burrs from the end discovered that a short end of

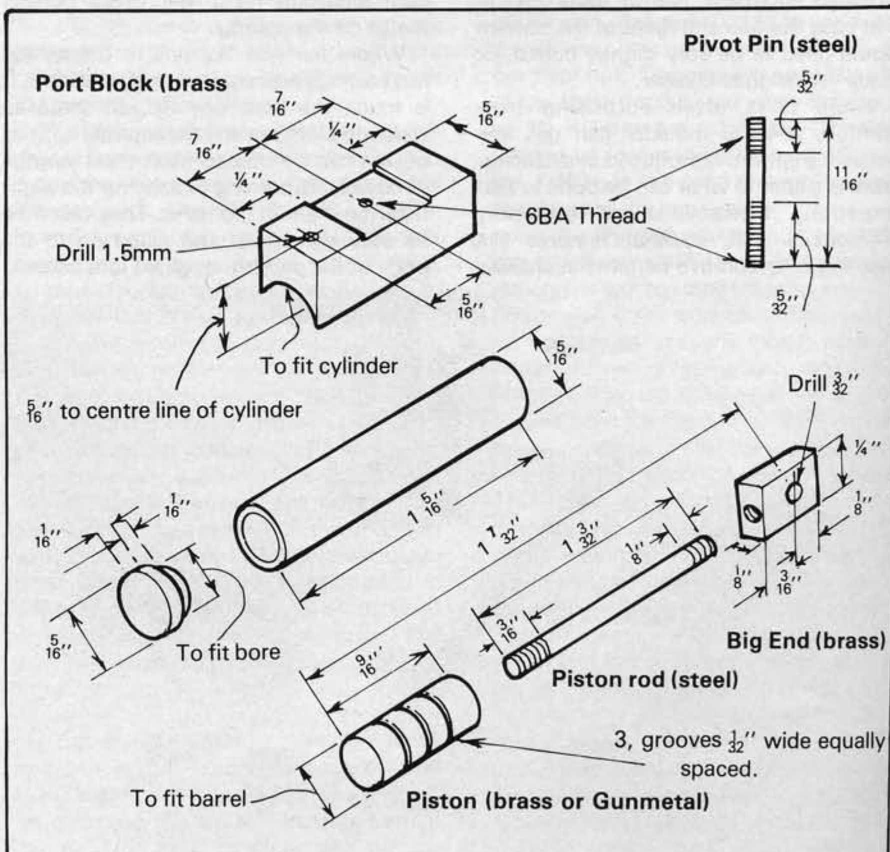


Fig. 1. Block and piston components

brass rod slid down the inside pretty smoothly. With a drop of oil on it, it could be blown back and forth by mouth pressure, and this seemed good enough, so that I didn't bother turning a piston to fit.

Engine

Make the 'engine' first; then you can check this on a tyre-pump before making the boiler. Saw off the correct length of $\frac{1}{4}$ in. bore tube and either file or turn the ends square to the body, removing the burrs (Fig. 1). If you are doubtful about the bore, poke a reamer through, or a drill just a shade larger than the bore. You may find as I did that a piece of $\frac{1}{4}$ in. brass rod will slide through, but if it is tight, so much the better. Reduce it either by turning in the lathe, or by polishing with emery in your electric drill till it just slides through and when oiled can be blown out with a bit of lung-power. Cut the grooves, with a screw-cutting tool, or a 3-square file if you are doing the job by hand. Remove the burrs with *very* fine emery.

It is better, but not essential, to drill and tap the hole for the piston rod in the lathe. If you haven't one, take as much care as you can to get the hole true—'upright' that is. It isn't so important to hav it quite in the middle. The piston rod should be steel rather than brass, but brass will do at a pinch; screw both ends and take care not to get a drunken thread. The 'big end' should be drilled and tapped, and screwed on to the piston rod before drilling the cross-hole; this gives you a better chance of getting it square to the rod. Now you must make a trial assembly of the piston rod and big end to get the overall length correct. This means you may have to adjust the length of the screwed part. Once you have it right (within $\frac{1}{64}$ in.) put a drop of Loctite on the threads and assemble for good.

Port Block

It needn't be an exact fit to the outside of the cylinder, but it *is* important that the flat face be parallel to the centreline of the cylinder. Mark out for and drill and tap the holes before sweating it to the barrel. You might as well sweat in the cylinder cover at the same time; this is merely a plug, and all you need to do is to find a bit of brass that fits the end and file it to look pretty after you have soldered it in. (If you have a lathe, of course, you can turn a proper end with a shoulder to fit). Clamp the port block to the barrel, with solder-paste between, and insert the plug; have a stick of extra solder handy.

Heat all up with a small blowlamp, and when the solderpaste runs, add a bit more of the stick stuff to get a nice fillet. You will almost certainly have to clean out the tapped hole and the port afterwards, and when doing the latter, drill right through into the cylinder-bore. File up the little recess shown on the drawing, make the pivot-pin—brass will do—and check that this projects square to the portface. (If not, very carefully bend it straight, if you follow me!), first having rubbed the portface on a sheet of fine emery on a flat plate, till you get a nice matt finish all over the bearing faces.

Frame

The only part of the engine 'frame' (Fig. 2) that needs care is the setting out of the holes, and their subsequent drilling. Mark out the centreline, and very lightly pop the pivot centre. Set your dividers to $1\frac{9}{16}$in. and mark out for the crank centre; pop that. Reset to $\frac{5}{16}$in. and draw a little arc on which the ports will fall. Very lightly pop where this arc crosses the centre-line, and then set your dividers as close as you can—use an eyeglass—to $\frac{1}{16}$in. From this last popmark, mark out the position of the ports. Drill these first, as if you make a mistake here you will have to plug the holes and try again. I recommend you use the sharpest drill you have below No. 53 (1-5mm) (higher number, that is) and enlarge by stages to the size shown. If all is in order, drill the pivot next. Use the same technique. Finally, drill the $\frac{1}{4}$ in. hole for the crank bush. If you have a lathe, drill and ream this in the lathe first, before soldering in place; if not, solder in the piece of $\frac{1}{4}$ in. dia. stock and then very carefully drill it as square to the rest as you can. If you haven't a $\frac{1}{8}$ in. reamer, drill No. 31 and follow with a $\frac{1}{8}$ in. drill.

Now for the crank (fig. 3): the spindle or shaft must be a very easy running fit in the bearing, so reduce this with emery if need be. Screw the end as shown. The crank disc is shown as balanced, but I doubt if it makes all that much difference; a plain disc $\frac{7}{8}$in. dia. will do. The important thing here is to see that the two holes, for shaft and pin, are parallel. So, drill both in the drilling machine, or using your drill-stand, with the disc held flat preferably in a vice. Take care over tapping the hole and keep it square. The hole for the crankpin is best drilled 43, and a piece of $\frac{3}{32}$in. steel tapered and then driven in. You can drill and tap 7BA if you like, but it isn't necessary.

Incidentally, there is no reason why the crankshaft proper shouldn't be made $\frac{5}{32}$in.; then you can fit Meccano pulleys or gears without bushing them. If you do this, then the hole in the crank-disc can be screwed $\frac{5}{32}$in. Whit. or 3BA, but in the latter case you will need some Loctite on it to lock the thread, I think.

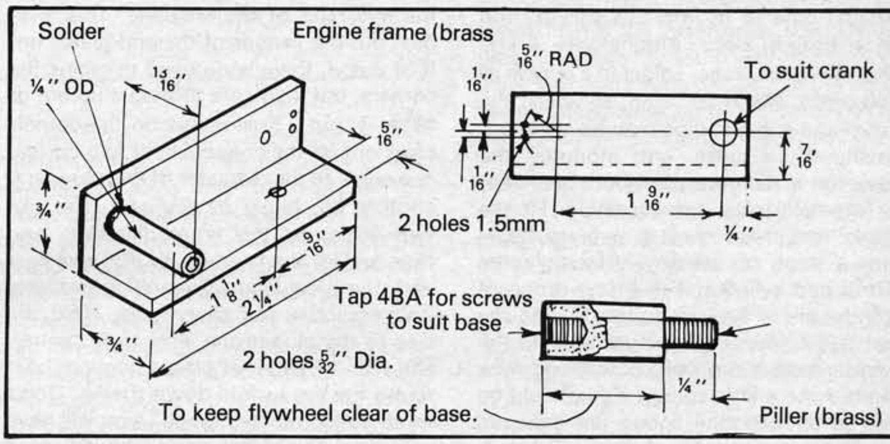


Fig. 2. Frame.

Flywheel

Next, the flywheel (Fig. 3); if you have a lathe, it is a straight turning job, but if not, then you have a problem! Not, however, insoluble. If you can find a piece of brass weighing about 3 or 4 ounces, $1\frac{3}{4}$in. to 2 in. dia., this will do. File it flat, and carefully mark out the centre. Drill a shade under $\frac{1}{8}$ in. and set it on the drill shank, held in the vice, so that you can spin it and observe any eccentricity. If this is more than about $\frac{1}{64}$in., file a bit off the diameter on the high side and keep on testing it till it is as near true as you can get it. If there is any sideways wobble, you can file one side and the other to put it right. This gives you the Flywheel part, and you will have no difficulty making a second little bobbin with a groove filed round it (hold it in your hand drill and use a three-square file) to attach alongside it. Both can be retained with Loctite, Araldite, or Seccotine. But there *is* an easier way; this is to use a Meccano pulley or even the No. 19A flywheel, though this is rather on the large side (3in. dia.). Perhaps the best to use would be the Bush Wheel No. 24, to which additional weight in the form of discs cut from brass sheet can be added. You would have to use either a $\frac{5}{32}$in. shaft, of course, or bush the wheel by winding thin shimbrass round the shaft till the wheel fitted without shake.

The final details of the engine are the two pillars (Fig. 2)—in my case these came from some obsolete piece of radio gear, and *were* pillars; cadmium plated, and polished up something to shout about! But you can use long bolts and a piece of tube, (or even a stack of washers!) or, for that matter, a block of wood.

I haven't mentioned the steam connection, as I didn't face this problem till I had made the boiler, but had better deal with it now. ½in. O.D. steam pipe is quite adequate, but even this is too large to attach direct to the steam chest. I drilled about $\frac{1}{16}$ in. deep from the *back* of

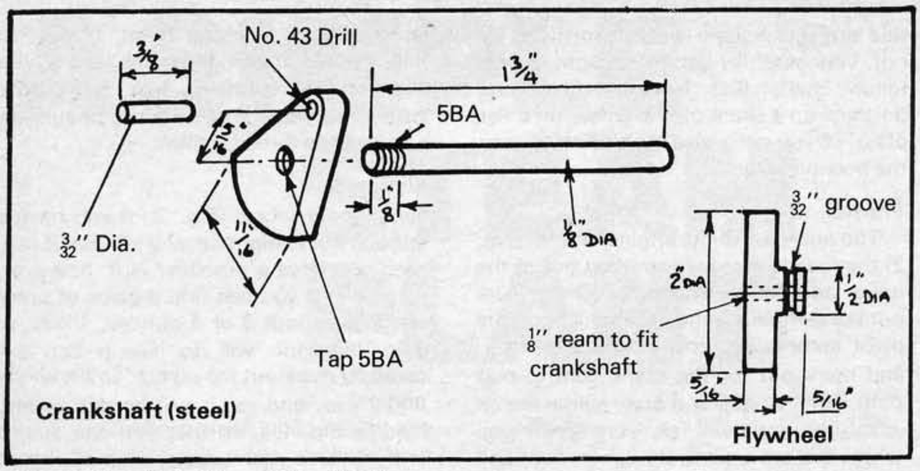


Fig. 3. Crankshaft and Flywheel.

the angle-piece, $\frac{3}{32}$in. dia. You must then file down the end of the steam and exhaust pipe to fit into this socket, and solder both in place. Alternatively, if you have any $\frac{3}{32}$-dia. tube, solder in a couple of stub pipes, about $\frac{3}{8}$in. long, to which the steam and exhaust pipe may be soldered. Having fitted these, and mounted the frame on a temporary support (the vice, for example!) you can assemble. Fit the crank, and make sure it revolves freely with a trace of sideplay. Assemble the piston and cylinder with a few drops of cylinder oil, or SAE 30 motor oil, and see that this is free. Fit the pivot stud to the cylinder with a drop of Loctite, and look for or make a little spring. You should be able to squeeze the spring flat between the finger and thumb of your left hand. Attach the cylinder (con-rod over the crankpin, of course), slip on the spring with a washer each end, then two lock-nuts. The assembly should rotate freely. If it doesn't, look for the fault and cure it. (Pivot pin not square is the usual trouble). Rig up some form of adaptor to fit the steam pipe stub (the lower one) and attach a rubber tube to some source of air—tyre pump, etc. The engine will need assistance to start, but should turn on about 5 lb. sq.in. and run like blazes on 10 lb. Keep her running for some time and you should find that she will run much faster when she is bedded in.

Boiler (Fig. 4): This is quite safe for up to 60 lb. sq.in. or more, but pressed only to about 15. Nevertheless, I have included a stay for the flat ends in the design, to make doubly sure; it also helps in the assembly. Find your piece of tube and a piece of copper, which should be 20's gauge or thicker, not thinner, for the ends. You will need some silver solder and flux. Esiflo No. 2 is best—and this can be had from Messrs. Reeves of Birmingham or Stuart Turners, Henley-on-Thames. A little boiler like this can, with care, be 'brazed' up with the small blowlamp. File the ends of the tube square; it doesn't matter if it comes out ¼ in. longer, by the way—just takes a bit longer to get up steam, but stays longer in steam! Make a plug of hard wood (or metal) that is smaller than the bore of the tube by twice the thickness of the endplate. This is to beat out the flanges of the end-plates on. If of wood, there is no need to radius the corners, but if you are turning it up out of steel, put a little radius on the corner. Mark out on the copper sheet two circles, one equal to the diameter of this plug, and another $\frac{3}{8}$in. larger in diameter. Cut out two circles to this latter diameter, and then anneal them—raise to dull red heat with the blow-lamp. Quenching in water isn't essential, but saves time. Hold the disc to the plug in the vice, truly central, and with a copper or plastic hammer beat round the rim to fold down the lip. Don't try to do too much at once—you will have to anneal the metal again about 3 or 4 times—but take each 'beating' several times *all round*; don't try to beat right down on one half and then the other, or you will get cockles. When you get nearly down, try the piece in the tube; it should be a push fit. At this stage you should beat out any cockle in the flat part, clean all up, trim the edges, and go all over with medium-fine emery. Drill the holes for the stay and for the water-level plug.

Now drill or punch the holes for the bushes in the tube. If you have no lathe, you will have to buy these with the steam cock and safety valve; wait till they come to get the right size. The valve used on the Stuart 'S.T.' boiler will do very well, and their No. 200/1 ($\frac{1}{8}$ in.) cock is the same as the one I used. The stay should be made of copper or drawn gunmetal, not steel or brass. The size is not critical—4, 3, or 2 BA will do. Don't be tempted to use screwed rod—it will be strong enough, but is liable to corrosion in the threads. Note that the thread is a bit longer one end than the other—this is to support the boiler in its casing. Run on a brass nut each end till the two are the same distance apart as the tube is long. Fit the end-plates and put brass nuts outside. Insert in the tube, and make sure all fits closely; if there are any gaps, beat out the flanges a little. Silver solder won't fill gaps more than about .01in. wide.

Take all apart, and clean everything thoroughly. Make a thinnish paste of flux and water and smear this over the flanges of the ends; about ¼ in. deep inside the tube ends; on the screw threads of the stay; on the shoulder of the bushes; and round the bush holes. Assemble whilst this is wet, making sure that the water-level plug bush is vertical in relation to the holes in the tube. (If you have no lathe, don't drill a hole for this bush in the end-plate. When you come to braze up the boiler, set a 2BA brass nut (well fluxed) in position and braze this to the boiler end-plate. When all is finished, drill through the nut with a 2BA tapping drill (4mm) and then tap through the nut and the plate as well. This will be quite secure enough.) Allow to dry and then wipe off any surplus flux that has run where it shouldn't; the alloy will follow the flux and you will get wasteful and unsightly smears of silver solder if you don't take care over this.

Boiler case

The boiler case (Fig. 5) is folded up out of tinplate. You can join the parts enough; it stiffens up remarkably when folded and jointed. You can join the parts with nuts and bolts if you like, but I used pop-rivets, apart from the plate that carries the chimney where I used self-tapping screws, and the cross-bar that carries the boiler end, which are 6BA nuts and bolts. Take care that you get the folds

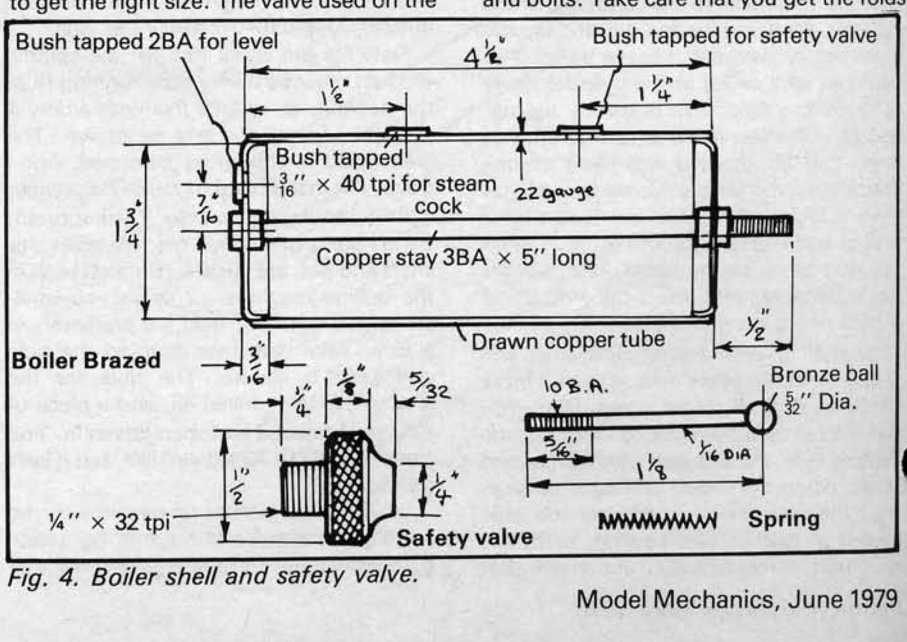


Fig. 4. Boiler shell and safety valve.

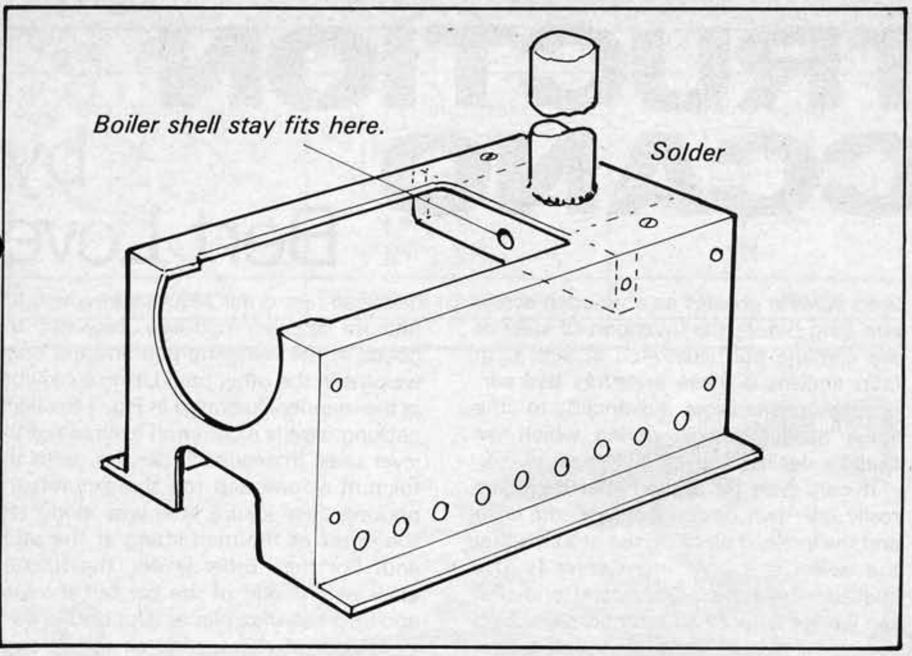


Fig. 5. Assembly of Boiler casing.

square. They can all be done in the usual way with smooth pieces of steel angle or even hard wood in the vice; no problem. Don't fit the boiler shell till you have tested it.

To make the safety valve (Fig. 4), chuck a piece of ½ in. round stock, turn the end down to ¼ in. about ¼ in. long, and screw to ¼ in. × 32 tpi. Turn the curved profile—I used the back of a curved facing tool for this—and then drill 3m. Knurl the $\frac{1}{8}$ in. wide shoulder, and then part off. Ream the hole $\frac{1}{8}$ in., and lightly countersink the lower end of the hole—leave the top a sharp corner. Grip a $\frac{5}{32}$ in. ball (bronze, not steel) in the chuck, just touch with a centre-drill, and then drill and tap 10 BA. It doesn't matter if you go right through, but I went in $\frac{1}{8}$ in. only. Make the stem of the valve from a piece of $\frac{1}{16}$ in. brass rod, and screw one end into the ball. You need a washer with a *square* hole in it, (a) to stop the spring from going through the $\frac{1}{8}$ in. hole and (b) to let the steam through. I filed a square in a 10 BA washer. To set the valve, make a spring from say 26 gauge bronze wire wound round a $\frac{3}{32}$ in. rod, about 10 coils or so. Assemble the valve, and adjust the spring till, using the kitchen scales, it takes between 2 and 3 ounces to lift the ball from its seat. This will give between 10 and 15 lb. sq. in. Then, lightly tap the ball with a hammer to form the seat.

To *test the boiler* you really need a little pump and a gauge, but you may not have these available. There are several ways of doing this. If you live in a town with a good water pressure (a phone call to the Water Authority will tell you this) you can manage well enough. The boiler will stand 60 lb. sq.in. by design, but works at only 15 lb, so that a test at 30 lb. sq.in. will "satisfy regulations"; few water supplies are as low as this but if you are on the top floor of a high-rise block, best to find a friend down below who will lend you his sink for a few minutes. Fit plugs to the level gauge hole and the hole for the steam cock—just screw a piece of steel or brass and fit this with a bit of paint on the thread. Get a short length of tube the same size as the safety valve, put 5 or 6 threads on it and screw this in, again with a bit of paint on the threads. Fill the boiler with water, making sure all air is out, and then attach to the tap with a bit of rubber tube; you may have to contrive a bit to get it to fit. Turn the tap on gently and make sure all is secure—you don't want to flood the place! Dry the outside of the boiler and turn the tap on full. Leave for 10 minutes and look carefully for leaks. If none, good enough; but if you DO find a pinhole mark the spot with a pencil or felt pen.

In the event of such a leak, if it is just a very tiny "squirt-hole" it is usually satisfactory to put a dab of soft solder on, but I always prefer to re-braze. Flux ALL the joint at the affected end, get the job hot again, but concentrate the heat just at the flaw, and apply the rod of alloy; it will run a little either side of the flaw, and you will then know you have a sound joint. Clean off as before, and then repeat the test. You may think this is a big fuss, but "model steam" is just as hot as "real steam" and when one is making something that will be handled by children there is no such thing as "too much care".

You can now assemble the boiler shell to its casing. The chimney is "optional", but it adds to the interest of the plant, especially if you lead the exhaust "up the spout" as shown in the photo. Mine is made of a bit of ½ in. copper pipe left by the plumber, and since the photo was taken I have bell-mouthed the top a little, at the request of my customer! It is soldered to the cover-plate, quite adequate as it doesn't get very hot. The exhaust steam pipe sticks up inside the chimney no more than ½ in. above the level of this plate.

Burner

The burner (Fig. 7) can be fuelled by meths or META solid fuel bricks.

I haven't said anything about piping up, as this is a matter for experiment on the assembly.

The best thing to do is to set up the engine and boiler on its base, and then first bend up a bit of soft wire to get an idea of the run first of the steam and then of the exhaust pipe. With these as templates you can bend some $\frac{1}{8}$ in. copper tube leaving it just a shade long and offer this up till you get a smooth run. The tube will probably need annealing by heating to red, but in this case I recommend quenching, as this removes the scale. Once you have the run of pipe right, clean it up; first solder on the union nipple for the steam cock, then solder the other end to the port block, remembering that the steam inlet is the lower hole. The exhaust pipe is done in the same way, except that it just pokes through the side of the boiler casing and points up the chimney. You can leave it off altogether if you like.

Running the engine

You may find the engine a bit stiff to start with, and its best to use an excess of oil at this stage. However, don't put so much down the cylinder that it gets full, or you WILL have trouble! It pays to use water out of the kettle, as most tap water contains some degree of hardness, which in time will fur up inside. Hot water also saves a certain amount of fuel. If you find there is a persistent leakage of steam at the port-face you should check (a) that the pivot screw is square to the cylinder face, for if it is on the cock it will hold the rubbing face clear of the port; and then (b) that the crankpin is square to the line of the connecting rod. If it isn't, you may see the "big end" wobbling from side to side, and this, in turn, will be pulling the cylinder away from the port-face. In each case a *careful* bending of the offending part should effect a cure. If there is a lot of steam passing the piston the best thing is to make another, a bit better fit. The snag here is that if you are using commercially finished tube the roughness wears off rapidly, and the clearance increases. You

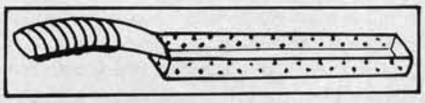


Fig. 6. Burner

shouldn't have this trouble if you have made the cylinder and piston in the lathe, but if you haven't one, then the only thing to do (apart from finding a piece of material for the piston just a shade oversize and fining it down) is carefully to file a groove about $\frac{1}{16}$in. wide and a bit less than this deep right round about $\frac{1}{8}$ in. from the head of the piston, and winding some well-oiled soft cotton thread round till the groove is filled. However, don't do this till the engine has had a few runs and the cylinder bore is well polished.

CONSTRUCTION IN MECCANO by Bert Love

BERT LOVE continues his articles on the MECCANO system with a brief review of basic mechanics and how they may be reproduced in Meccano parts.

How many different kinds of machine can you name? Hundreds?, thousands? It may come as a surprise to some readers to learn that, basically, only half-a-dozen different kinds of true machines exist and these are all shown in Fig. 1 below. Take, for instance, two common pieces of mechanism which dominate the lives of advanced nations, namely, the clock and the motor car. A wind-up clock and a simple motor car are comprised almost exclusively of the six simple machines illustrated. Basic of all, the lever is fundamental to the human body, for our skeletons are a mass of simple levers in various forms. Equipped with a branch broken from a tree, early man had a ready-made lever with which he could break up soil, shift boulders and roll heavy logs or tree trunks.

Every time he changed his position from a lower to a higher level by climbing a hill a man made use of another natural machine, the inclined plane. When he learned to chip flint into a crude axe-head with which he could split logs and even other stone like slate, he had invented the wedge. In his early attempts to move logs by rolling, man evolved the wheel by means of which (even a short log used as a roller) he could move impossible loads of giant stones. Carts came much later with built-up wooden wheels and a combination of a wheel with a roller in one piece produced machine No. 3, the Wheel and Axle. It must be realised of course, that all pulleys, winding barrels, gears and pinions are simple developments of the basic wheel. Most sophisticated of all the basic machines is the Screw, known to the Chinese thousands of years B.C. and used in wine presses as a wooden screw ram long before the invention of steel or the carriage bolt illustrated in Fig. 1. In fact, ancient Chinese inventors had surprising mechanisms advanced to the stage of differential gearing which we shall be dealing with at a later stage.

It can even be argued that there are really only two basic machines, the lever and the inclined plane on the grounds that the wheel is a continuous lever (e.g. a spoked wheel exemplifies this) and that the wedge is really an inclined plane with the screw simply being a case of a continuous (rotary) inclined plane. This becomes obvious when one considers a spiral staircase! Simple though the concept of the lever is, it is necessary to understand its application under different circumstances which are commonly called the three "orders" of levers as illustrated in Fig. 2. In each case, considering a lever as a simple bar of steel or wood, it must have a point at which it may turn, known as the fulcrum, a second point to which the load is attached or at which the load reacts and a third point to which the effort is applied in order to move or to balance the load.

Most common of these is the first order of levers in which the load is placed at one end of the lever, the effort is applied at the other and the fulcrum is placed somewhere between the two. A simple pair of weighing scales is an example of a balanced first order of levers in which the fulcrum appears half-way between the goods in the weighing pan and the brass weights in the other pan. Using a crowbar in the manner illustrated in Fig. 1 to raise a packing case is a common example of the lever used in second order, i.e. with the fulcrum at one end (on the ground) the packing case load a little way along and the effort of the man lifting at the other end. For third order levers, the fulcrum stays at one end of the bar but the load and effort change places. Our bodies have a number of these such as the forearm bones which have their fulcrum at the elbow joint, the load in the human hand and an effort applied by upper arm muscles attached to the forearm bones between the elbow and the wrist. In a purely mechanical sense, the use of the oars in a rowing boat embraces all cases of the three orders of levers as shown in Fig. 3 and we may consider these one by one.

Fig 1 THE SIX BASIC MACHINES

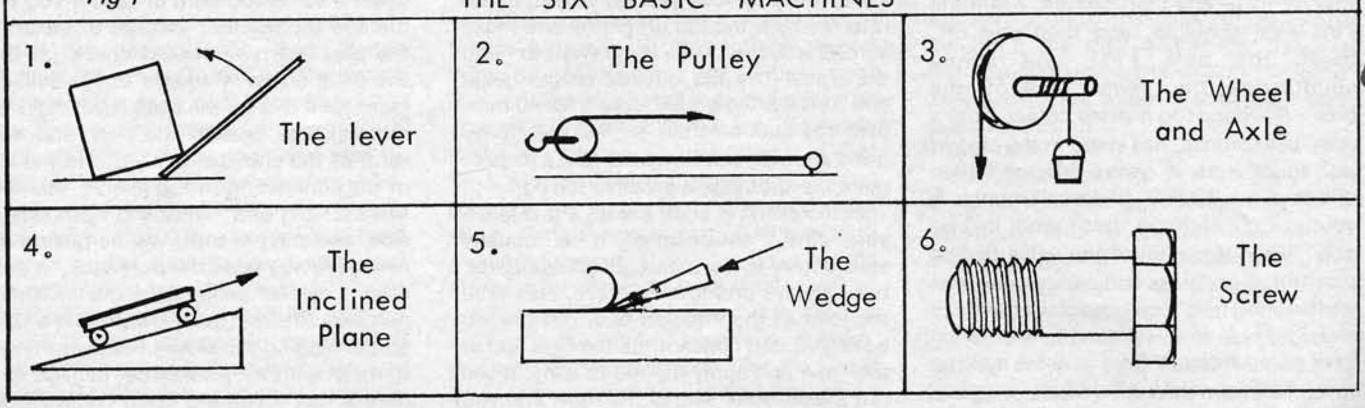
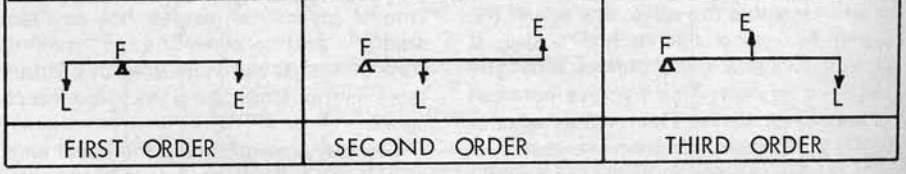
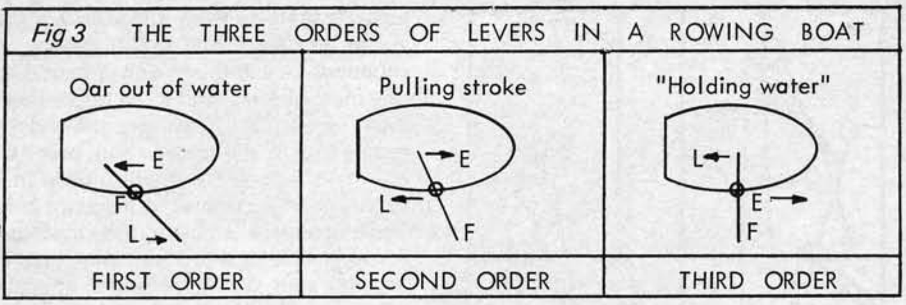


Fig 2 ORDER of LEVERS E = Effort F = Fulcrum L = Load



When the oar is out of the water, it is doing no useful work but in making the recovery stroke, the oarsman is using the oar as a first order lever with the boat's rowlock acting as the fulcrum of the lever. His only load in this case is the weight of the loom (shaft) and blade which is carried outboard of the rowlock. On the pulling stroke the fulcrum shifts to the water and while the effort is still being applied by the oarsman, this time the load is the boat



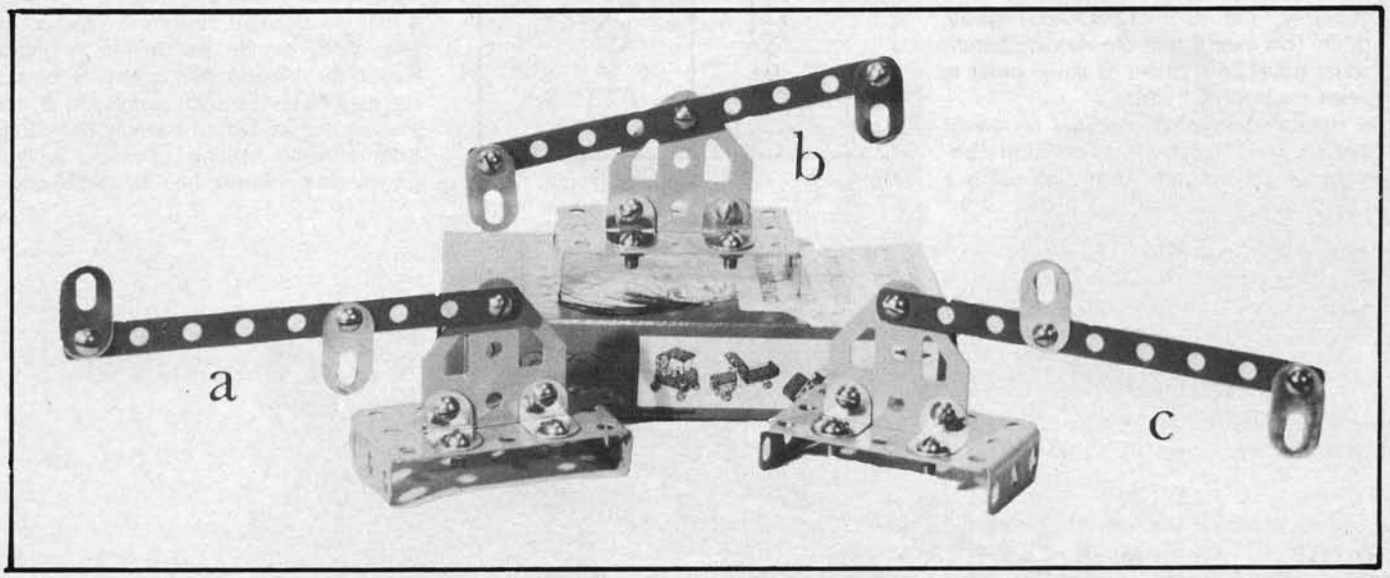


Fig 4. Basic Levers for Meccano parts. Can you name the order of Levers (a), (b) and (c)?

itself effectively at the rowlock swivel. When the oarsman wishes to stop the boat by "holding water", he braces himself against the oar loom to prevent it moving and he then becomes the load on the lever. In this case the effort comes from the boat as it continues forward and is applied at the rowlock and assuming that the blade of the oar is in still water, then that end of the oar is the fulcrum. Hence we can have situations in rowing a boat where one lever has its order changed through all three cases! It is a simple matter to construct all three levers from Meccano parts using the Pocket Meccano Set (probably the cheapest construction kit available in metal) as seen in Fig. 4. Although this is a simple exercise it does help somebody not very familiar with levers to get a 'feel' of the three arrangements of order and, in particular, the directions in which load and effort react to each other according to the lever order chosen. Perforations in Meccano strips make it a simple matter to set the fulcrum position so that the levers can be arranged to have a "mechanical advantage". This means that the load moved by a lever can be greater than the effort applied. However, to achieve this apparent advantage, the effort must always move through a greater distance than the load. If these two distances are calculated or measured they form what is known as the "velocity ratio" of the lever.

Because of the wide range of pulley wheels available in the Meccano system it is a very easy matter to construct some interesting arrangements of pulleys and Fig. 5a shows the simplest of 'cranes' built from a handful of parts and very well known to engineers as 'sheerlegs'. Although this set of sheerlegs is fitted with two 'single sheave' pulleys, only one of them is useful in the 'machine' sense and that is the lower one which actually moves. Fig. 5b is a model of a fixed foundry crane and its single pulley at its jibhead gives no mechanical advantage whatsoever. On the contrary, every pulley in a system adds two forms of friction, (a) spindle friction in the centre of the pulley and (b) fibre friction in the actual bending of the hauling or hoisting rope. This arises as rubbing friction among the internal fibres or wires of the ropes. Nevertheless, the foundry crane does have two stages of 'machines' which give it the mechanical advantage necessary to raise a heavy bucket by hand power. First of all we have a wheel and axle combination using the cranking handle at the side of the crane, followed by a pair of gears with their own mechanical advantage. Strictly speaking, we can only measure the mechanical advantage of a system by comparing the size of the load with the amount of effort required to move it by the system but we can calculate the velocity ratio of the foundry crane model

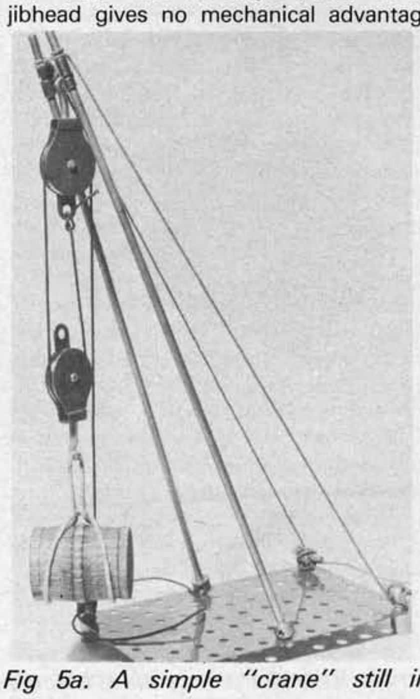


Fig 5a. A simple "crane" still in common use

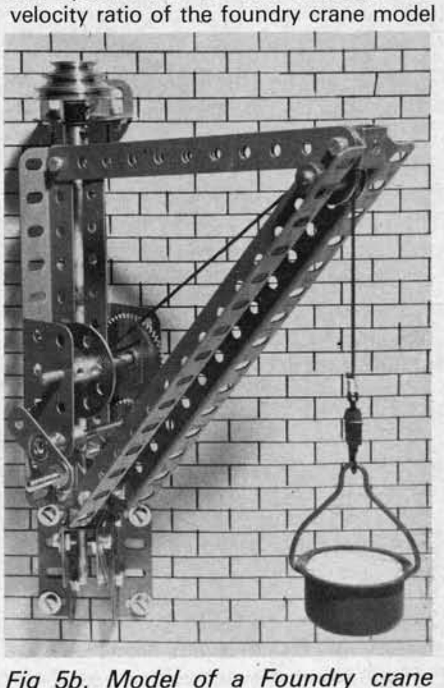


Fig 5b. Model of a Foundry crane exploiting the wheel and axle as a basic "machine"

as follows. Its winding drum and first gear comprise a Wheel & Axle combination with an effective diameter on the gear of 32 mm and 4 mm on the axle rod (round figures). That gives a first velocity ratio of 32:4 or 8:1. A meshing pinion below has 25 teeth engaging 50 teeth on the gear wheel so its ratio is 50:25 or 2:1. Finally the winding handle has a turning circle twice the diameter of the 25 tooth pinion so the ratio there is 2:1. To find the overall velocity ratio we multiply all three together, i.e. (8:1) × (2:1) × (2:1) giving 32:1. This means that the winding handle must travel (in a circle) 32 cm in order to raise the bucket 1 cm.

Before concluding our brief review of the six basic machines it is worth considering the situation of a man using a pulley system to raise a load in a mill or warehouse by hand. Fig. 6 shows two situations, A and B in which system A has one more pulley (fixed to an upper beam) than system B. However, the velocity ratio is exactly the same in both cases and is 2:1. In fact, A has more friction in its system than B because of the extra pulley and is thus less 'efficient' than system B. A mechanical power-driven winch replacing the man would be better employed (with less effort) at B than at A. However, a man would find system A "easier" to use. Many people are unable to give a reason for this apparent contradiction but the explanation is quite simple. At B, the man must raise about half his own body weight while hauling upwards against gravity. In system A, he may use all of his

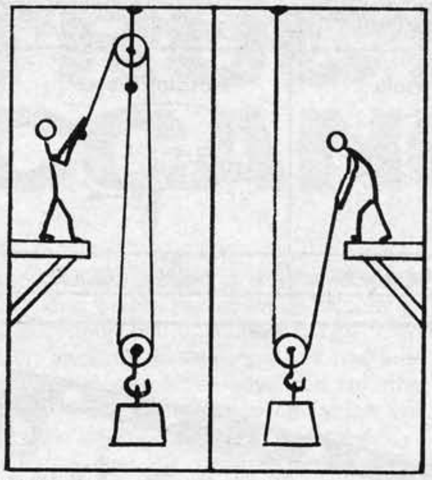


Fig 6 A B

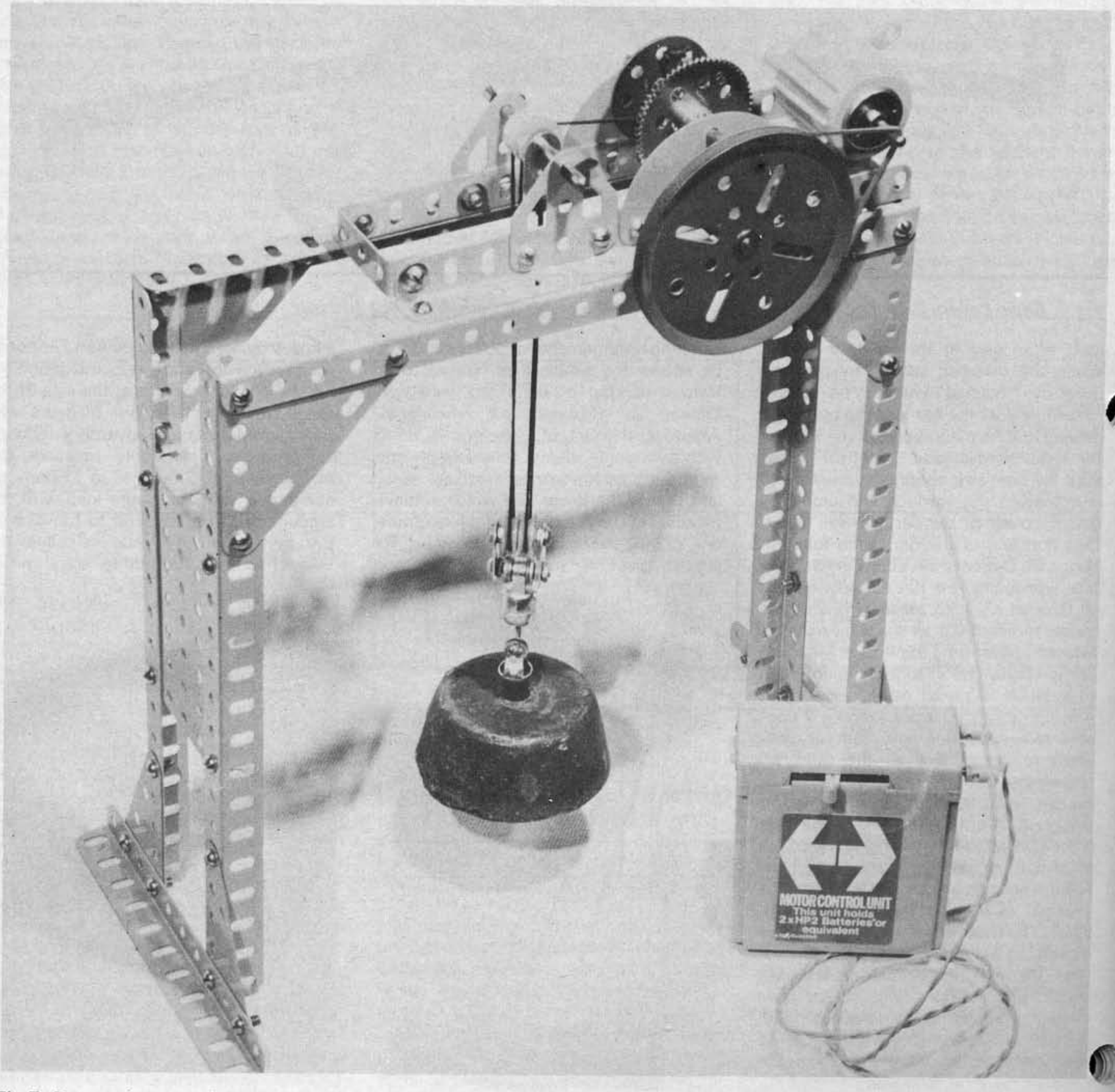


Fig 7. Remotely controlled heavy-duty gantry hoist built from standard Meccano parts and driven by the smaller (3 volt) Meccano Electric motor. A heavy load is raised easily by taking advantage of high velocity ratio throughout the hoist system

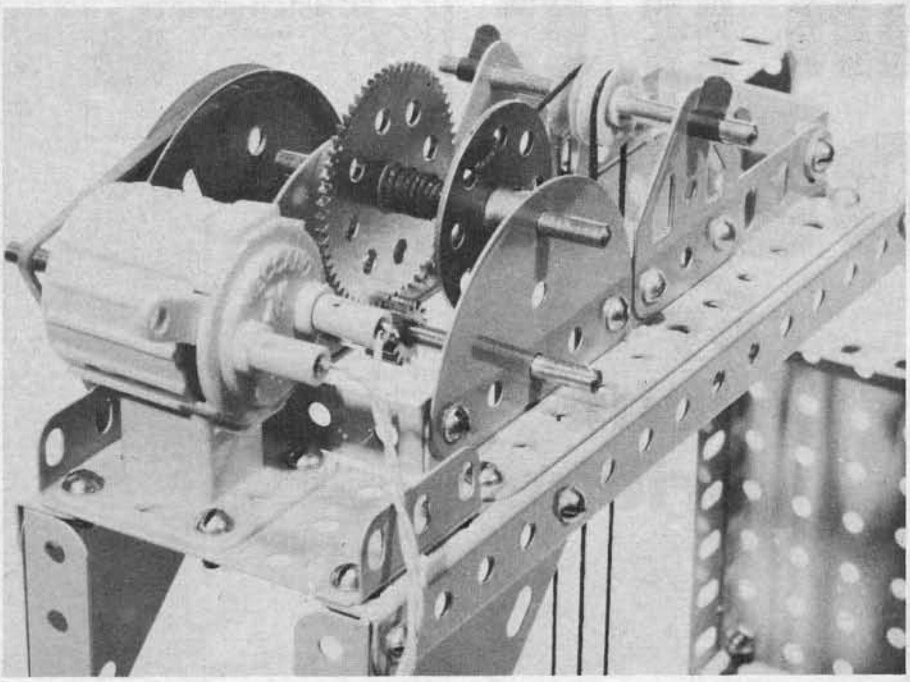


Fig. 7a. Mounting of a 3 volt motor and first stage of reduction drive for gantry hoist. Note the rubber band drive from motor spindle.

Fig. 7c. Close up details of lower pulley block using ¾ in. bolts with lock-nuts.

bodyweight to assist his effort in a downwards direction and is thus assisted by gravity rather than being hampered by it.

If the reader is new to these basic mechanics or wishes to brush up the memory try these two exercises. First of all identify the order of levers shown in Fig. 4. Then, assume that you own a treadle-operated model maker's lathe. Now make a list of at least one case of each basic 'machine' which you might expect to find in your lathe. You will find the answers to both exercises at the end of this article. However, on a more practical project, full building instructions are given here for a high-powered remotely-controlled electric gantry hoist built in current standard Meccano parts. General outlines are shown in Fig. 7 where the fixed gantry is made from 9½ in. Meccano Angle Girders. These girders and all the mechanisms, including the 3 volt D.C. Meccano Electric Motor and Battery Box are included in the standard Meccano Crane Kit but readers with older Meccano sets may use what they have at their disposal, in which case the more frequently found 12½ in. Girders may be used for the gantry outlines. Steadying feet for the ganty are 5½ in. Girders bolted on at the bottom of each gantry leg and reinforced by triangular corner plates or bracing strips at 45°. The general construction is clear from Fig. 7 and it will be noted that additional 5½ in. Girders are bolted to the top of the gantry to give adequate vertical support to the journal plates for the motor reduction gearing and the upper pulleys of the hoist system. Fig. 7a shows the arrangement for mounting the small Meccano 3-volt battery-driven motor on a 2½ in. × 1½ in. Flanged Plate at one end of the Gantry top. Semi-circular plates are bolted to the upper 5½ in. Girders immediately next to the motor plate and a 3 in. Axle Rod is passed through as shown in Fig. 7a. Before tightening the Nuts and Bolts at this stage, the Axle Rod must be tested for free running without binding. It can then be fitted with a 15t Pinion and a Collar between the semi-circular plates to keep the Axle Rod in place. The outer end of this Rod is fitted with a 3 in. Pulley and then again, this is tested for free spinning before connecting the Pulley to the motor shaft with a soft rubber band. Meccano Rubber Driving Bands are available but could be a tight fit in the model described here, causing excessive side thrust on the motor shaft and making its job too difficult. Take a 2½ in. Axle Rod and slide it through the top holes of the semi-circular plates, slipping on a 60 tooth Gear Wheel and a Bush Wheel as shown. Standard Meccano Cord is used for the hoisting rope, one end being looped round the winding shaft and tied to the Bush Wheel while the other end, after passing right through the pulley system, is tied through the slotted hole of a Fishplate on the upper Rod carrying the top pulleys. Details of the lower pulley block are shown in Fig. 7c where it can be seen that two Fishplates are joined by a pair of ¾ in. Bolts holding the Fishplates apart by lock-nuts. Packing washers on the lower bolt centralise the hook and allow it some free movement. Note that the reeving of the hoist cord is as shown in Fig. 7b to allow the lower block to run at right-angles to the upper pulleys (½ in. Plastic Pulleys or brass). This arrangement reduces the tendency of the hoisting block to twist up the cords. Despite the modest motor used, the solid lump of lead (cast in an earthenware flower-pot) is hoisted with ease and this is all due to the very high velocity ratio between the motor spindle and the rising load. This particular four pulley system has a velocity ratio of 4:1 but as the large Pulley and gearing give another 72:1, the total is approximately 288:1.

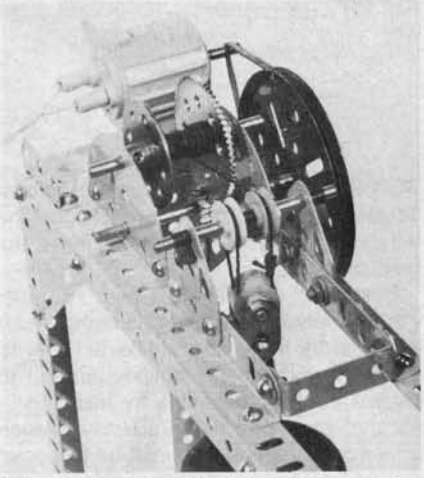


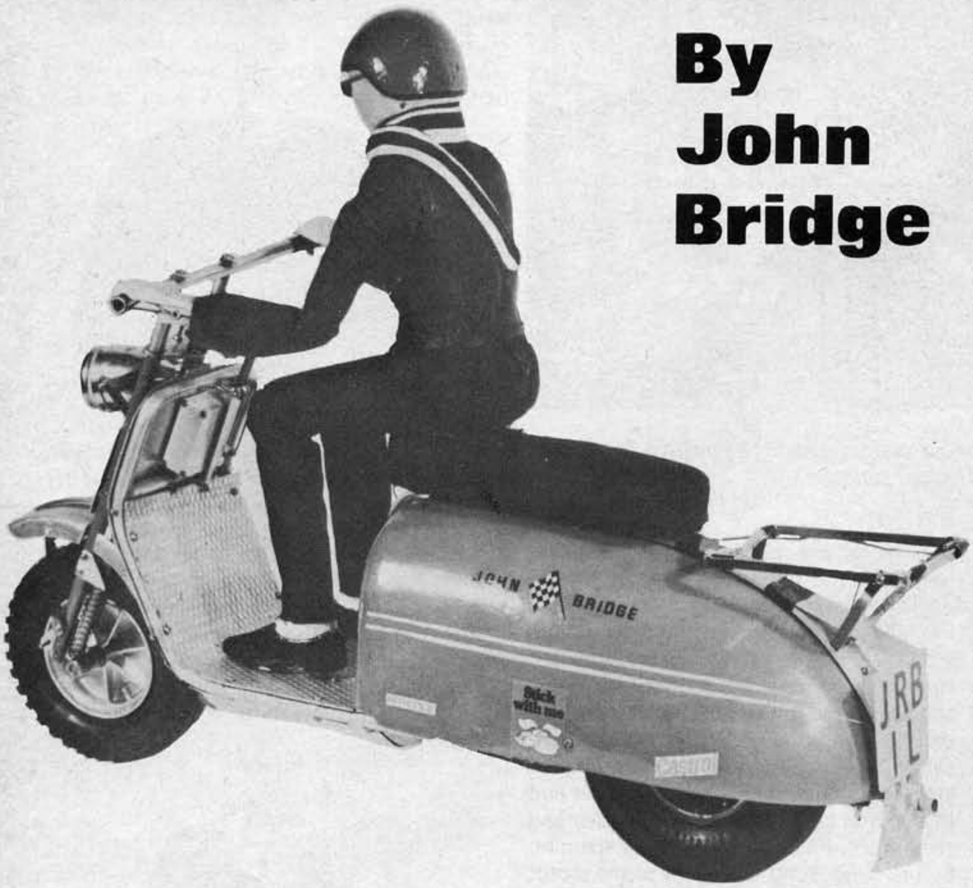
Fig. 7b. Pulley suspension arrangement and cord-reeving for gantry hoist. Note spring-clip separating upper pulleys.

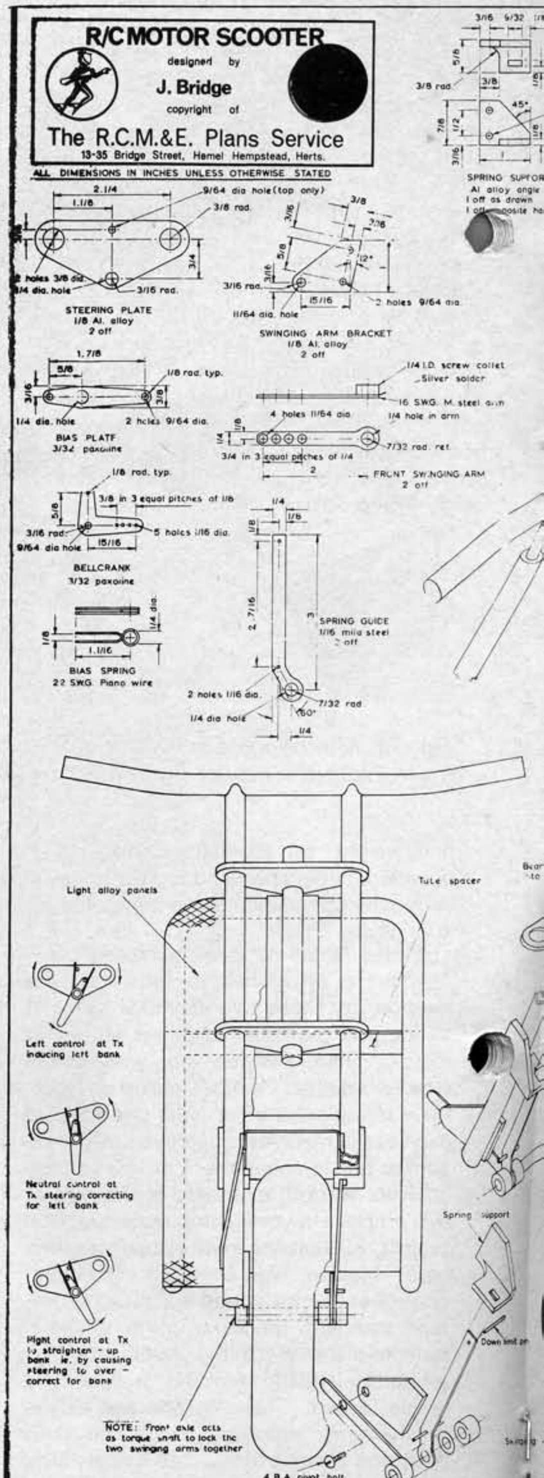
Answers to questions in text:

1. The levers in Fig. 4 are (a) Second Order, (b) First Order and (c) Third Order.
2. Some basic machines found on the lathe; (1) Lever; foot treadle or tailstock lock-lever. (2) Wheel; Mandrel pulleys or change wheels. (3) Wheel and Axle; Back-gear. (4) Inclined Plane; Morse tapers in head and tail stocks. (5) Wedge; Both ends of a lathe centre (6) Screw; Lathe lead-screw or any machine screw attaching parts.

Build an R/C Scooter

By John Bridge





BEFORE describing the constructional details perhaps a few words about the dynamics of cylces will help to make the principles clear.

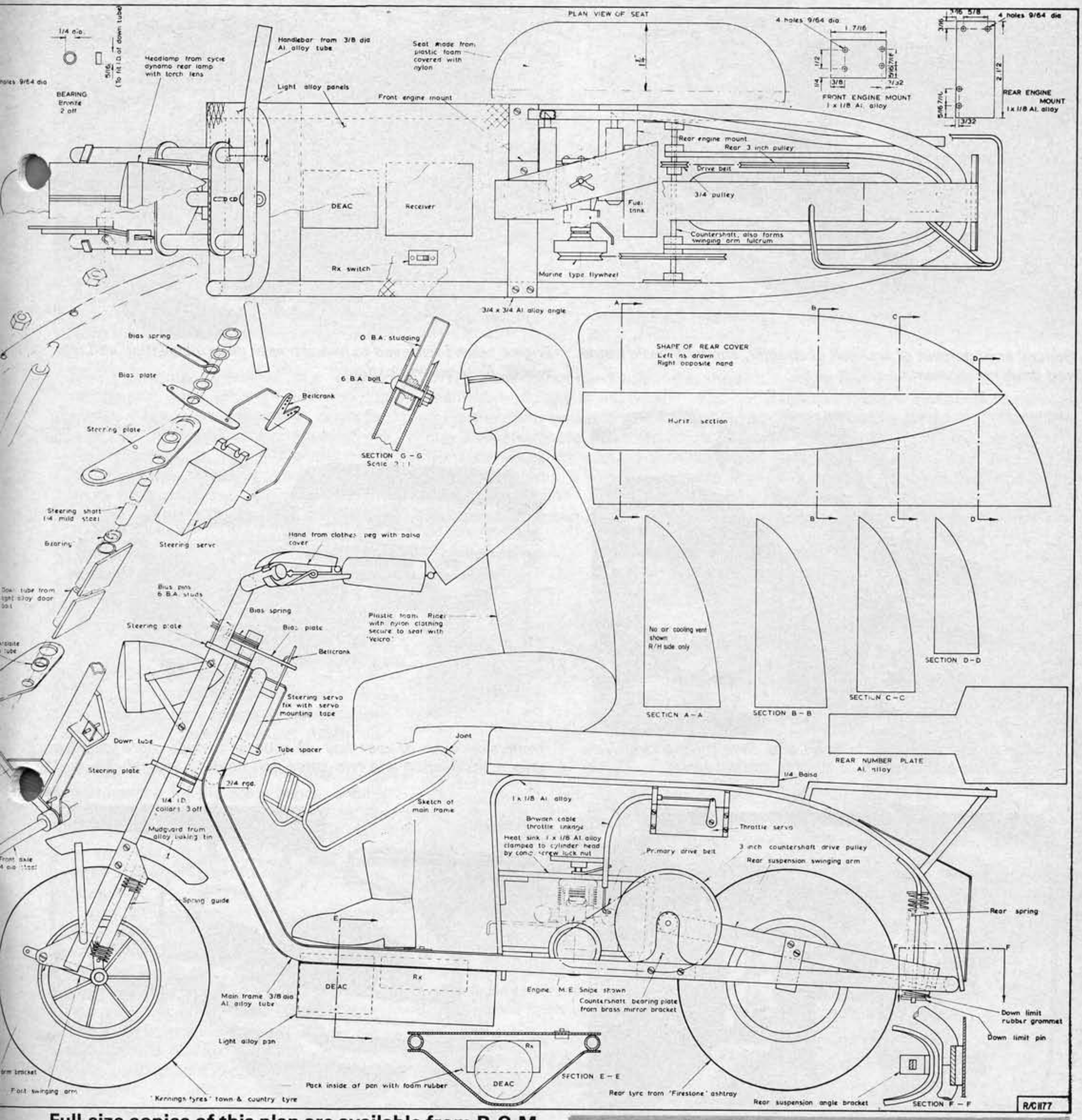
First, to dispel a few popular misconceptions, the first one being that it is necessary to be on the bike in order to sense the movements quickly enough to correct, namely balancing by feel, this in fact has proved to be unfounded as even a moderately stable bike can be balanced by vision from the transmitter, and modern proportional equipment is quite capable of resolving the control movement quickly enough. Secondly, there seem to be misunderstandings about the way turns are initiated. First, it is necessary to understand that any correcting force is made by the centrifugal force of the turn produced by the steering lock. Therefore, if a bike begins to fall to the left it is corrected by left lock, this is well known and understood, what is not so obvious is that an intentional left turn is initiated by applying right lock, this will immediately give a left bank which must then be stabilised by a degree of left lock.

Small stablising corrections can take place automatically, providing that the steering geometry is designed with a high degree of inherent stability. Factors governing this inherent stability will be covered later.

In order to allow these small corrections to take place independently of the steering servo, the link to the steering head is via a spring-bias unit, and the servo link is arranged to bias the steering to the right, if left control is applied at the transmitter. In effect, steering control is reversed.

Now to follow this system through in action, imagine a straight run. Any bank induced by an outside force would be corrected by the steering geometry requiring no movement at the transmitter controls. Then, to produce say a left turn, left is applied at the transmitter, biasing the steering to the right, producing a left bank, which will then be stablised automatically, resulting in a left banking turn. The turn can then be straightened by momentarily applying right.

In order to investigate the inherent stability problems, a simple wire form cycle frame fitted with a pair of wheels was made very early on in the experiments,



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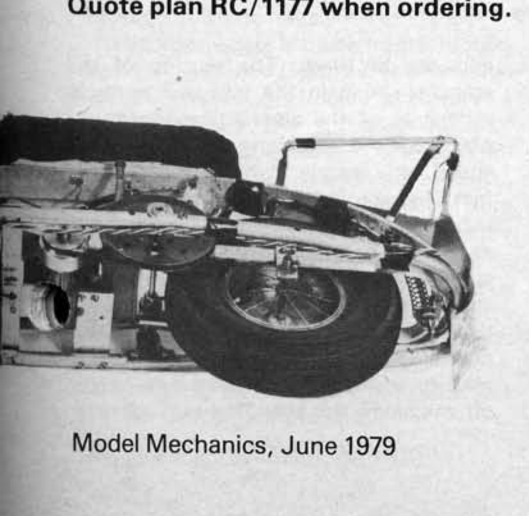
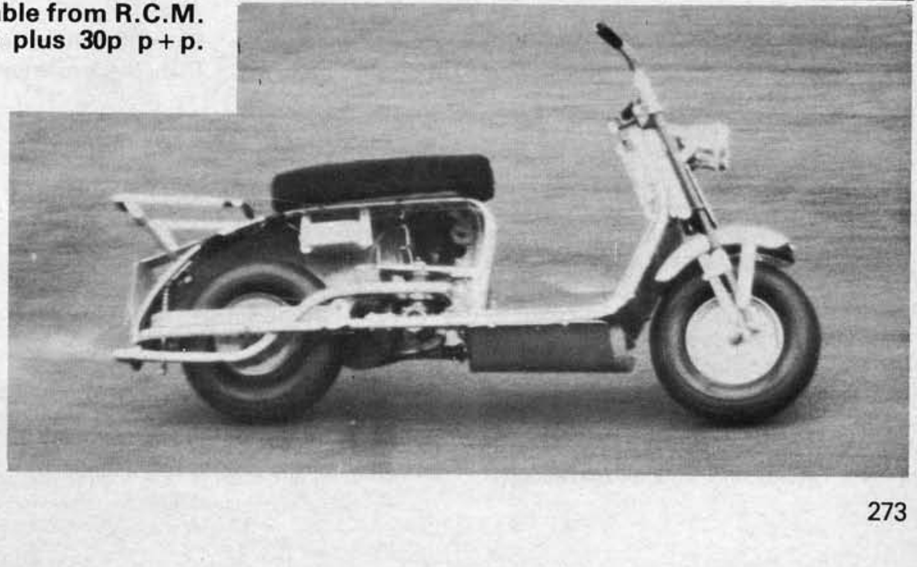
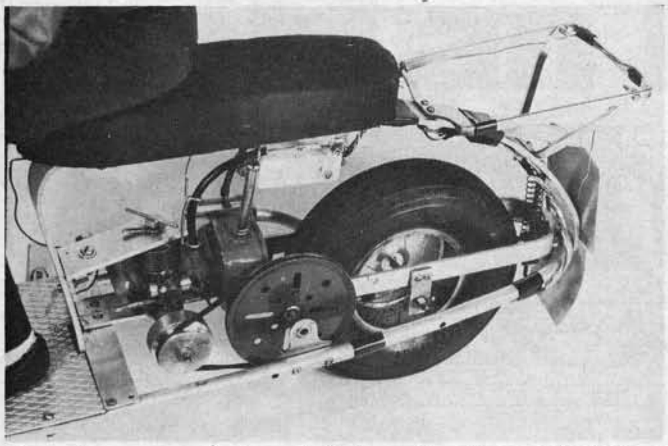
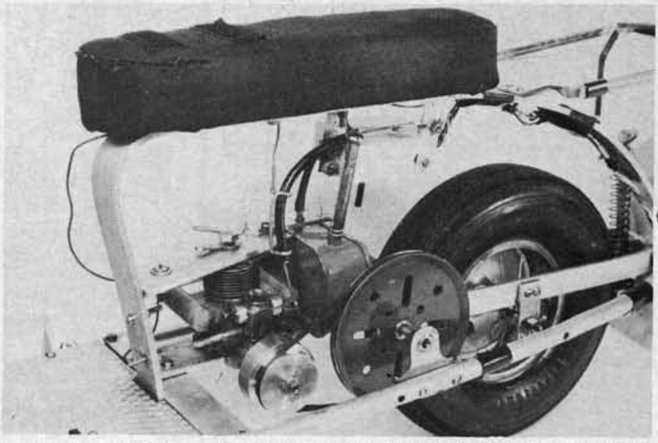


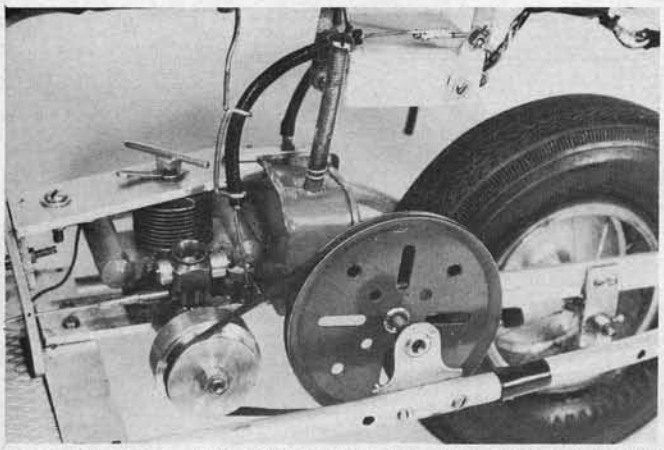




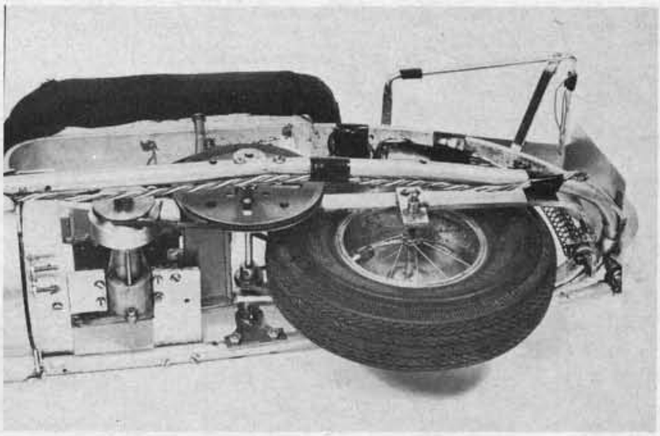
General arrangement of rear half of scooter, showing basic frame and drive mechanism.



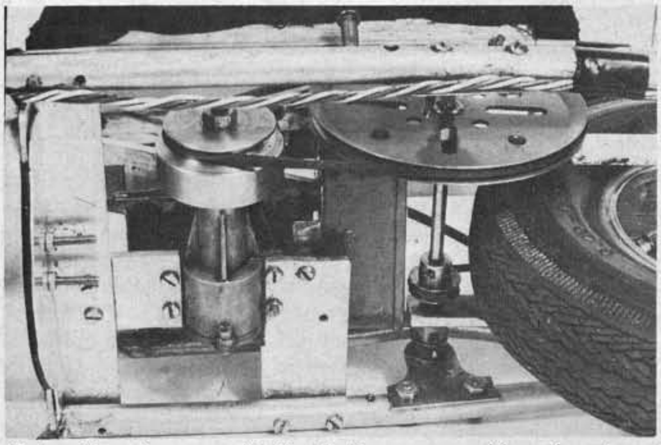
Engine covers removed to reveal power drive installation and rear wheel. Note servo position.



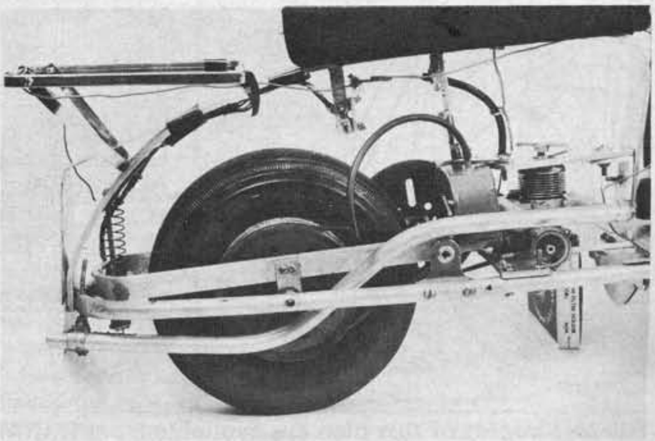
Close-up of the engine installation and drive mechanism. Note engine bearers and position of throttle control servo.



Underside view of rear half of scooter reveals more detail of engine installation and two-stage belt drive to rear wheel.

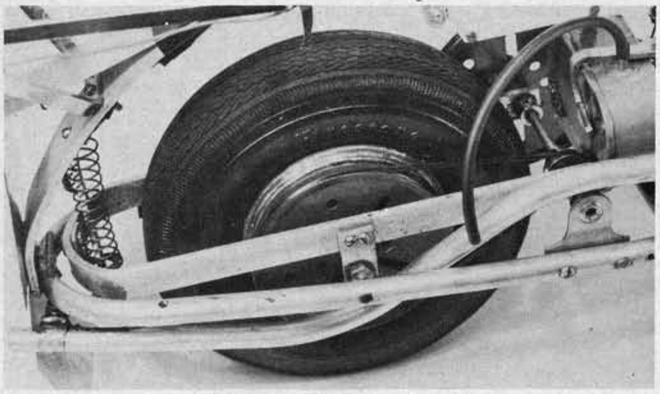


Underside close-up detail of the power drive department, showing the engine installation and the two-stage belt drive.

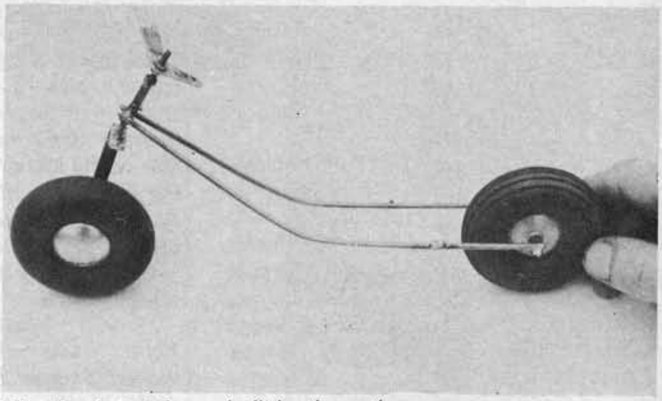


Opposite side of rear end showing rear suspension springing. Side covers to engine bay clip in place.

with plenty of adjustments to try out arrangements. The first thing that became apparent was that for a given down tube angle, corrections were much quicker with the front wheel axis behind the down tube axis (this is not common practice on full-size motor cycles). Next, the best down tube angle appears to be about 30 degrees from vertical. A frame rigged with these two basic requirements will balance free running, and will usually surprise people with its degree of stability. However, on a full radio control model, certain stability problems may arise and it is better to identify these. First, unless there is good suspension, the front wheel will bounce, and if this occurs in a turn, the steering will over-correct on contact and result in a high frequency shimmy. Next, if the centre of gravity of the steering assembly, i.e. front wheel, handle bars, etc., is behind the down tube axis, this will result in a low frequency (about two a second) hunting in a turn. Although the vertical position of the total centre of gravity does not seem critical, it should not be too far back as this will give a tendency for the bike to be snapped into and out of turns. The tension of the scissors spring in the bias unit controls sensitivity of the steering responses. In practice, the stability improves with speed, due mainly to the gyroscopic effect of the front wheel. For this reason it is best to trim the model for best stability in the middle of its speed range. At this speed, the model should maintain a straight run or an induced turn hands off the transmitter, i.e. steering control neutral. Above this speed the model will tend to straighten up from a turn hands off and below this speed the turn will tend



Close-up of rear end showing the simple spring suspension. Note the final drive belt to the rear wheel



The simple test frame built by the author

to tighten up. Therefore, the control techniques are different at varying speeds, but once trimmed correctly, response is very docile requiring no violent action at the transmitter. The model will balance down to a fast walking pace. Launching is achieved simply by holding the back wheel of the model just off the ground using the luggage rack as a hand hold and moving the model forward with a bowling action, the front wheel will immediately straighten up and as the back wheel is lowered on to the ground the model will start a straight run.

Construction

Many unusual components and materials are used in this model but most were bought locally without much difficulty.

First, form the main frame tube, using local heating for the acute bends, ending in a butt joint at the back. Next, fit the light alloy angle cross member and the 1 in. strip top frame. This joins the main frame at the back, and forms the butt joint support.

Next, fit tube spacer to the main frame at the bottom of the down tube bracket.

Make the two steering plates and assemble on to the front forks and bond with Araldite. Heat cure. Fit the two bearings into the down tube bracket (from alloy door bolt) and fit to main frame, drill and tap 6 B.A. Next, make up the bias plate, bias spring and down tube shaft (¼ in. steel).

Assemble steering head using thin washers or shims to take up excessive end float. Fit end collars. Fit swinging arm brackets to front forks.

The front wheel is made from a rubber-tyred plastic wheel, with the tyre removed and the wheel turned down to fit inside a new rim, i.e. a *Tala* egg-poaching ring, and secured with Araldite. These rings are a perfect fit for the tyres sold on ashtrays. These are still readily available from *Firestone* and although these are a little flat-treaded for the front, they are ideal for the back wheel. *Kennings Tyres* turn out a town and country tyre of the same size and this has a sufficiently thick tread to be ground to a round cross section.

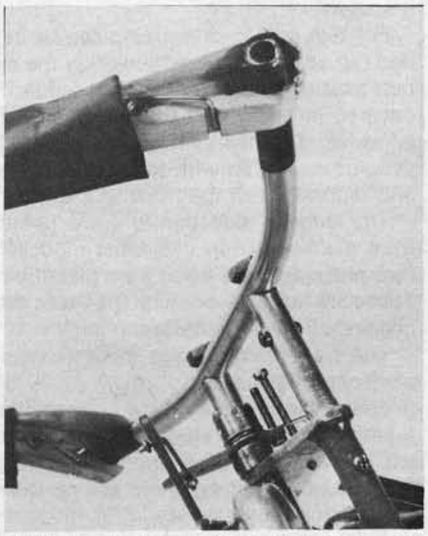
This tread section has a marked effect on the handling of the bike.

The tyres do not need inflating as there is sufficient rigidity in the walls.

Fit the front wheel and the swinging arm assembly (note these are adjustable front and back for trim). Assemble the front suspension. It may be advisable to have a selection of springs (Terry) available during test runs.

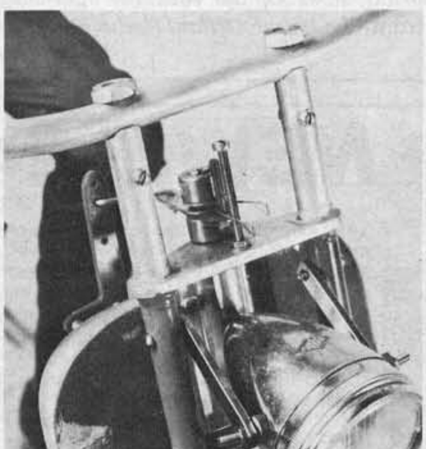
Note that the front axle acts as a torque shaft to prevent independent movement of the swinging arms.

Next, make-up the rear swinging arm and counter shaft assembly and rear suspension. Although the original model had an experimental spoked wheel there is no reason why one similar to the front

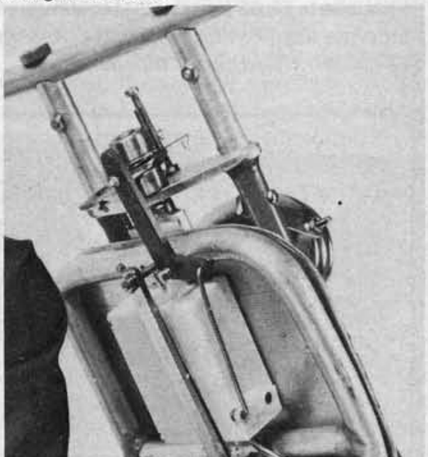


Detail of the handlebars. Note the cut-down clothes peg 'hands' of the 'rider' a glove could improve their looks.

Close-up detail of the front forks showing the spring suspension and 'scale' type mudguard detail



Front close-up showing the scissors springs for the steering and the headlight which is a rear cycle lamp.



Close-up detail showing the steering servo and its linkage to the front forks. Note servo retainer bracket.

John Bridge and his creation, giving a clear indication of size of the model vehicle. How about a new racing class? Radio used in the prototype is Roland Scott Navigator 3, with two functions operative for steering and throttle controls.

Right: the 'launch' technique. Motor is started and the model given a smart shove forward with the rear wheel just off the ground. Action is similar to delivering a 'wood' in game of bowls.

Right: see, it works! Scooter is quite swift and handles easily once the technique is mastered, so our author assures us. The rider makes for realism in action.

should not be fitted providing facilities are made for the 3 in. pulley drive.

Now, at this stage, if you are impatient, you can take your creating out to the nearest car park and give it a good push, just to convince yourself that it is going to work. If there is a tendency to turn in one direction this can be trimmed out at the transmitter later, but providing all bearings are free, the model will balance.

Next, fit the panels (foot rest and front) and make up the radio pan. The radio can now be fitted and the steering servo mounted to the front panel with servo tape and linked to the bias plate via the bellcrank.

The engine can now be fitted with marine-type flywheel. The transmission is a little primitive, but serves the purpose using Meccano drive belts and pulleys.

The technique for starting is cord start, similar to boats, slipping on the drive belt with the engine running (not as difficult as it sounds).

Full test runs and trimming can be carried out at this stage. After which the accessories can be fitted. The saddle is covered in nylon and fitted with impact adhesive. The head lamp is from a cycle dynamo rear lamp with the lens removed and replaced with the front of a torch.

The original side panels were beaten from aluminium but individual modellers may prefer to make a pair from glass fibre. These are held in place with magnetic catches used for fridge doors.

The front mudguard is made from an aluminium baking tin.

The rider is made from polystyrene foam, rough cut to shape with a hot wire and carved to final shape with a razor blade. Unfortunately, there are no dolls' or pilots' heads, etc., commercially available that will do, so you will have to find out if you are any good as a sculptor! Put on two undercoats (not cellulose) and then the foam will take a good gloss for the helmet, shoes, etc., and matt flesh (Humbrol) for the face. The sunglasses are cut from old plastic sunglasses and the frames are made up from model railway track.

The arms are mounted to the body using wire through brass tubes to give free fore and aft movement. The forearms are linked with wire running through and ending in a hook and eye, and must be loose. The hands are carved from bulsa and mounted on to spring pegs to give quick release from handlebars.

The clothing is nylon and the rider is mounted on to the saddle and footrest using Velcro.

Make it Legal . . . get your R/C licence!

Just in case some newcomers to the hobby are not aware, operation of radio control equipment requires a licence. This costs £2.80 but it covers a five-year period, so at 56p per year, the licensing fee can't be described as expensive. Licence application forms are obtainable from *The Home Office, Radio Regulatory Division, Waterloo Bridge House, Waterloo Road, London, SE1 8UA.*

Lathe operations by John Wheeler

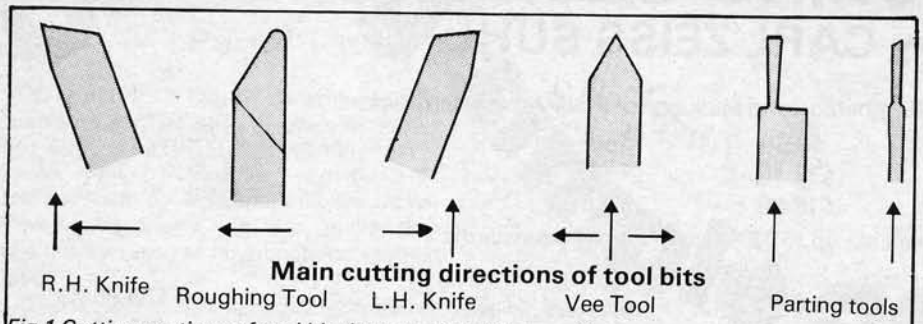


Fig 1 Cutting portions of tool bits in normal working positions

Right Hand Knife Tool Fig. 1

When set up in the plan position shown, you can "face the end" of the work and produce a square to the axis end face, or traverse towards the headstock reducing the diameter of the work and leaving a square shoulder e.g., when turning a screw or bolt.

However, the sharp point on the tool does tend to tear at the work surface, so if you lightly grind or hone this point away to a small radius, a better quality cut surface will be produced. Not too large a radius or you will not be able to obtain a square shoulder, which will prevent the workpiece seating flat on the surface around a hole. The tool is so named because it cuts on the right hand end of the work.

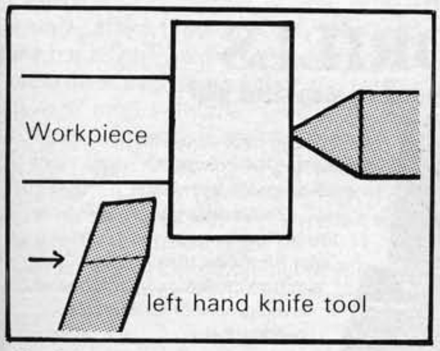


Fig 2 Working position for Left Hand Knife tool

Left Hand Knife Tool Fig. 1 and Fig. 2

This tool cuts on the left hand end of the work or rather on a left-sided face of the work. In all other respects it is similar to the Right Hand Knife Tool.

Roughing Tool Fig. 1 and Fig. 3

Next to the Right Hand Knife tool, I consider this to be the most useful, in fact, I always have a R.H. Knife and a Roughing tool set up in my swivel tool holder block, leaving a third space for a Parting Tool, a Knurling Tool, a Boring Tool or other tools gripped in a commercial holder.

The Roughing tool is designed to remove heavy cuts.

You will notice that the rounded nose leaves a smooth finish to the work. The width of swarf cut off will depend on

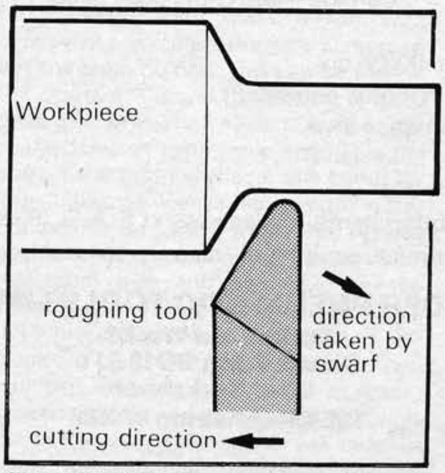


Fig 3 Plan view showing the position of a roughing tool

the rigidity of the lathe. I suggest you try with increasing cuts, possibly decreasing the revolutions slightly until you reach a maximum safe removal of metal for your particular lathe. I often make use of the Roughing Tool, in its correct working position, for some other cutting actions; first to remove the sharp corner off any turned item, leaving a clean small chamfer. Much safer than using a hand file on the revolving work, an action I could not recommend. I also find that with small cuts the tool, if sharp and well honed, will give a light reflecting and therefore very smooth surface on the turned work.

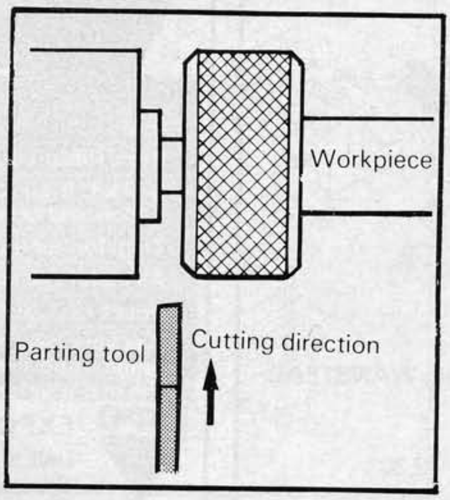


Fig 4 Plan view Parting Tool

Parting Tool Fig. 1 and 4

The Parting Tool seems to be the tool that produces most problems on a lathe, mainly I think because the blade width as supplied is too wide. Therefore, the wide cut at right-angles to the axis of the lathe requires a large force from the cross-slide screw, pushing the work out of alignment. Any slack in the headstock bearings aggravates the problem, as the mandrel and chuck have a chance to jump up and pivot over the cutting edge causing a "dig in".

Try facing off the end of a bar with a R.H. Knife Tool, taking the same width of cut as the Parting Tool and you will certainly make the lathe chatter and want to walk around the floor!

Reduce the *width* of the Parting Tool as much as possible, to below 1.5mm or $\frac{1}{16}$in.

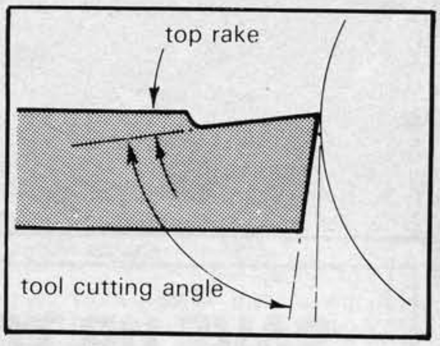


Fig 5 Tool cutting angle viewed from the tailstock

For parting through large diameter material, make several plunge cuts side by side to give clearance room for the swarf to get away. If the swarf jams in a deep cut it will also cause an overload and break the tool. Having locked the saddle, I position these side by side cuts using the topslide set parallel to the lathe axis, and take successive cuts deeper and deeper until the item is cut off. Fig. 4.

A cutting edge ground at a slight angle will cut off the wanted item with virtually no pip. The top rake of a Parting Tool only needs to be about 5°, anything more will give too sharp a cutting angle.

The front clearance can be kept at 5-8°. Note the cutting angle of a tool is the angle between the front and top faces, Fig. 5, and increasing the top rake *decreases* the cutting angle and reduces the strength of the tool.

Vee Tool Fig 1

A useful tool in that it can cut when moving either to the left or to the right so reducing the diameter, or directly into the workpiece to produce a shallow vee groove or chamfered edges.

I would advise newcomers to read more books on the subject. Argus Books Ltd. 14 St. James Road, Watford publish several excellent books on lathe work.

Cutting simple gears

Part II

by Rex Tingey

by Rex Tingey

TOOTHED BELT DRIVE systems provide the same positive drive as gears in mesh, but with the flexibility of positioning that a pulley and belt system provides. A toothed belt drive is more like a chain drive, as it cannot slip, yet, unlike the chain drive requires no lubrication, and is quiet.

The toothed belt is usually from a synthetic rubber, for the belt and teeth, which are reinforced and moulded around non-stretch nylon cords within the continuous part of the belt. The nylon cords become the part about which the belt flexes, and they thus determine the pitch of the belt and teeth around wheels, and the positioning of the teeth. There is little or no information available for the model engineer wishing to make toothed wheels to run with the belts, the manufacturers of the belts supply wheels to run with them, and so I devised my own cutters to make the wheels.

I have been making and using these square-toothed wheels for over two years, to run with just one size of belt. During this time I have been using the drive system for my Unimats and for various workshop machinery I have made, all with far more positive drive than previously.

The size of the toothed belt is 100 × L031, which is a light-weight belt with five teeth to the inch, each tooth being one-tenth of an inch long with the same size space alongside. The teeth are one-twentieth of an inch high, formed approximately as in the diagram. They can be readily obtained from model shops where they are a spare for a radio controlled stock car.

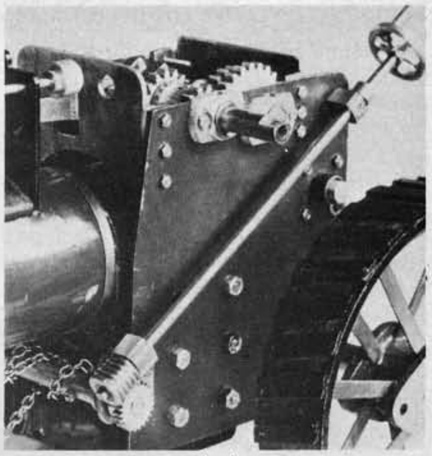
When the belt is manipulated it can be seen that whilst the teeth remain quite stable the size and shape of the space can be made to vary quite a lot; with diminishing diameters the gaps compress, but the teeth do not. This can be seen in the diagram. Cutters for making toothed drive gear wheels are made to cut a single space between teeth, only, as that is the correct and finished shape. The cutter for large diameter wheels has straight sides, but the one for smaller wheels has to have angled sides to cut away rather more of the tooth side and so allow for the compression of the belt spaces.

To make a gear wheel, the size of the blank is calculated to accommodate multiples of one tooth plus a space, around the circumference, and although the non-stretch nylon cords will cause a need for a small reduction of the straightforward diameter, in practice the effect can be ignored unless the belt is to be run without much tension, in which case the after-treatment of a few thou turned off the toothed wheel will do the trick. The formula for the diameter of the blank is:

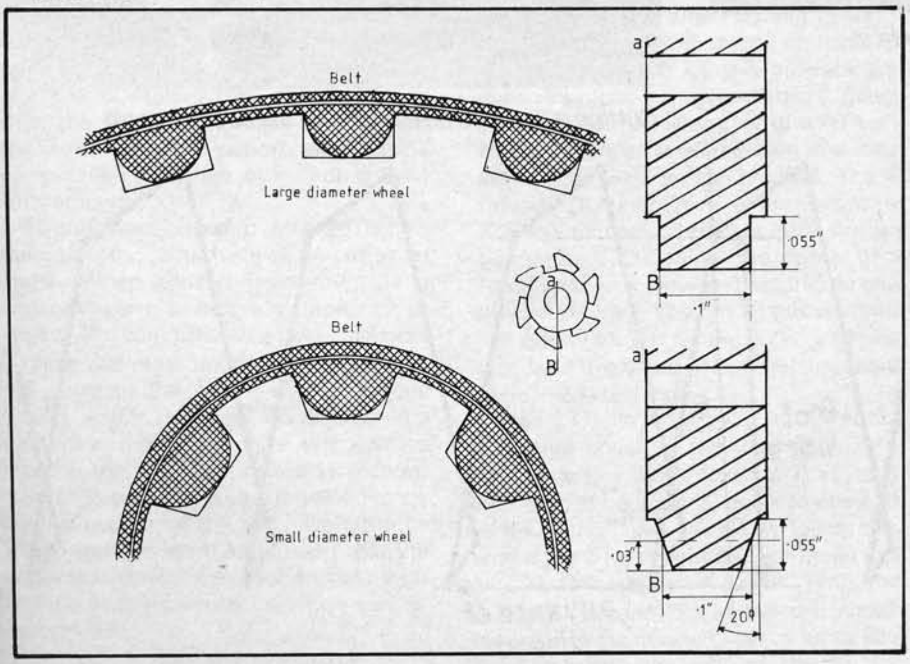
$$\text{Diameter of blank} = \frac{\text{Number of teeth required}}{5 \times \pi}$$

The cutters are made from ¼-in. thick slices of ¾ in. diameter silver steel, with a ¼ in. bore, and they are turned, grooved and ground into cutters on a mandrel made from $\frac{3}{8}$-diameter mild steel, turned down to a ¼-in. diameter collar, $\frac{3}{16}$ in. long to take the cutters. To harden and temper the cutters, use the copper as before, the work is carried out in the same way as for the hobs, and the cutters are then used to cut the blanks with exactly the same methods.

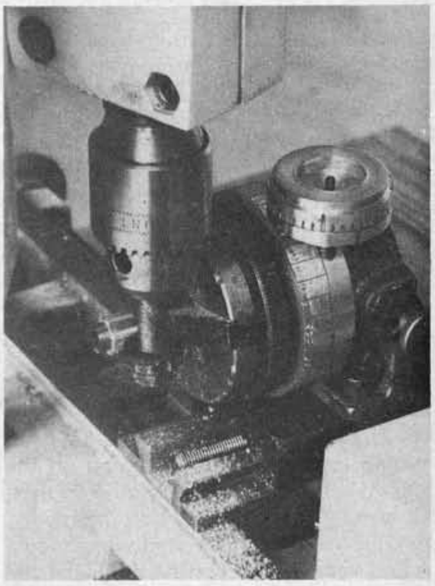
When the gear-wheels have been cut from the blanks check their accuracy with a toothed belt held tightly in place, having removed any burrs beforehand by running emery cloth against the turning gear-wheel. Position the gears and belt so that the tension applied gives no more than a deviation of $\frac{1}{8}$ in. on a 2 in. stretch of belt as a straight. When running a toothed belt system it is usually necessary to contain the belt in some way to stop the belt running off. With a small gear driving a larger gear by means of a toothed belt it is sufficient to rim the smaller gear; this



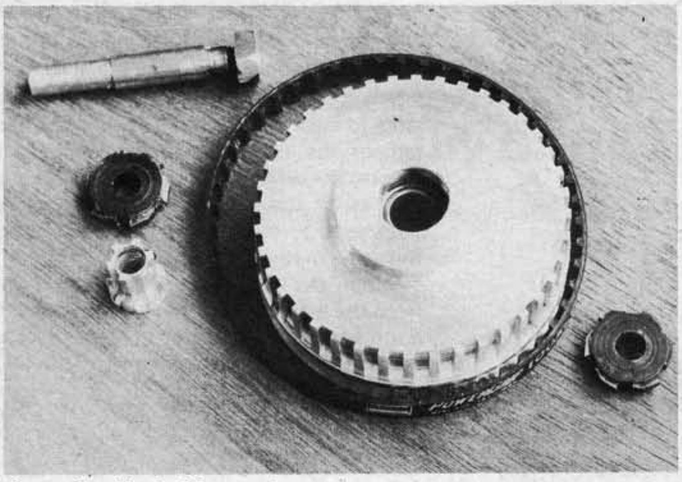
Steering gear and change gears on a traction engine



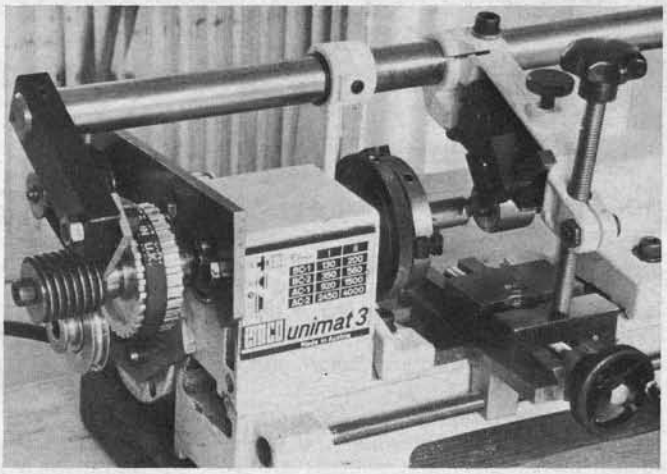
A toothed belt drive, and the necessary cutters



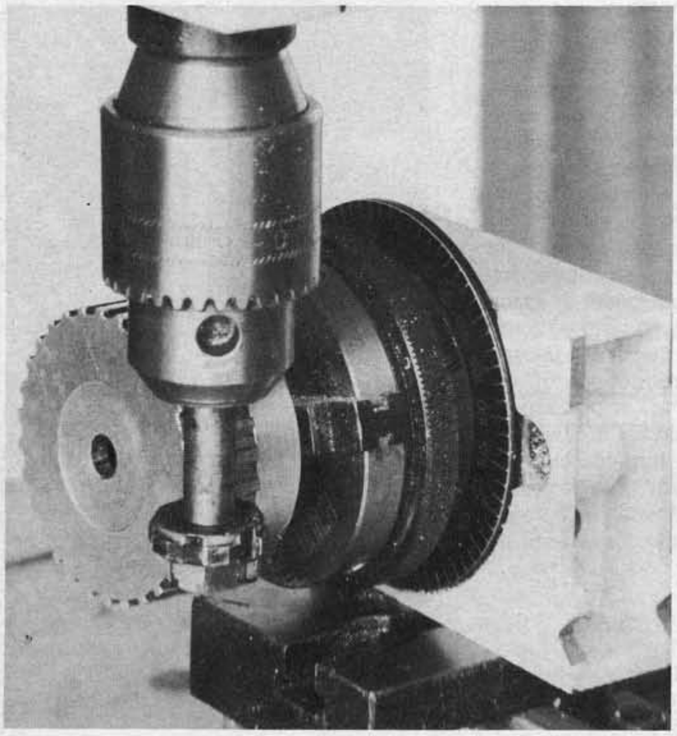
Cutting a small square-toothed belt drive wheel



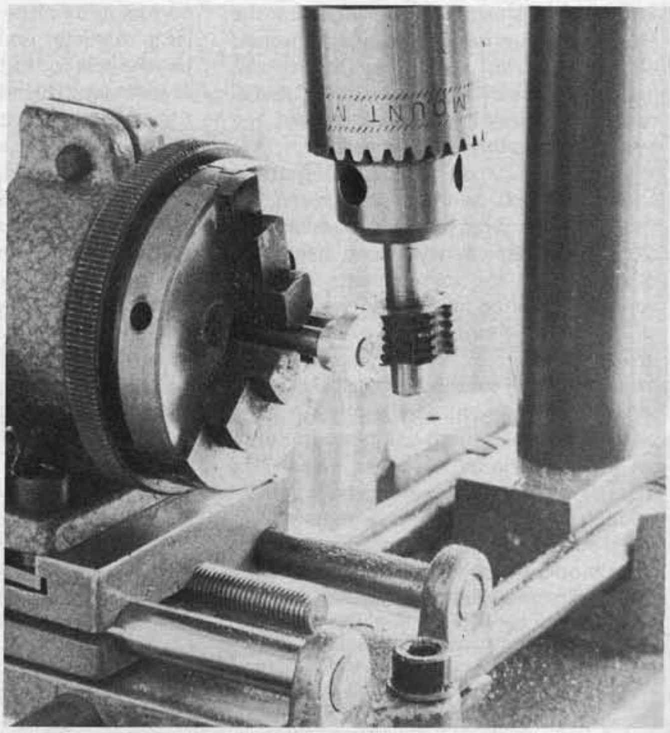
A toothed belt drive and necessary cutters



Cutting a worm-wheel using a home-made leader and follower



Cutting a large diameter square-toothed wheel

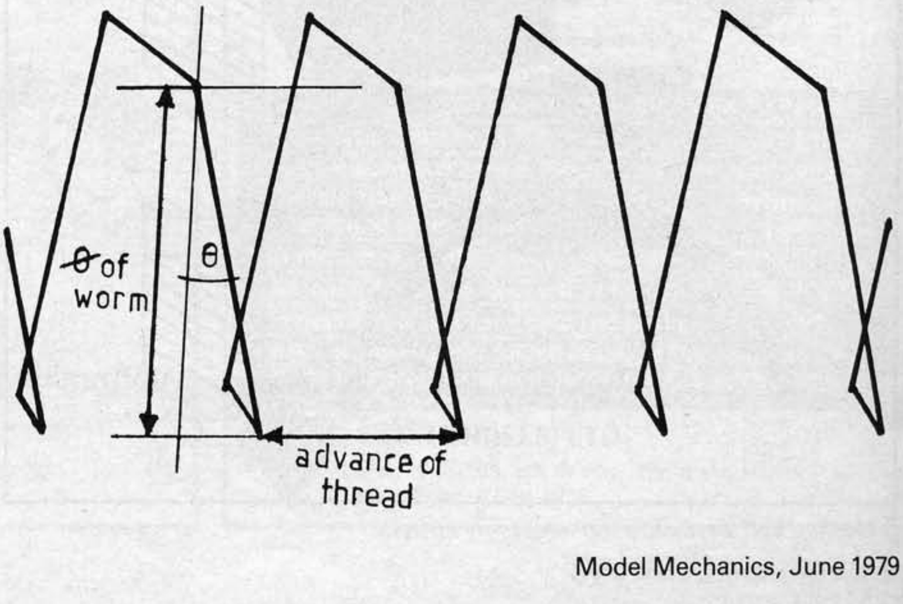


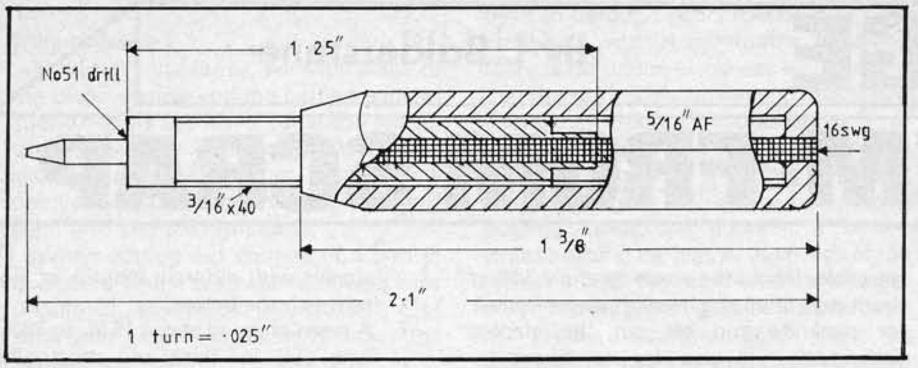
Cutting a worm-wheel pinion at the correct angle

can be by means of two co-axial flanges secured either side of the cut gear.

Wormwheels and Pinions

Whilst I was devising a way to fit non-standard threading leaders to the threading attachment, I found a way to make multiple-start wormwheels on the Unimat SL. I had made the leader from a 1 in. Whitworth bolt by sawing off the head, drilling through ¼ in., fitting an Allen grub screw and securing it co-axially with a length of drilled brass rod on a silver steel rod centred in the lathe. The follower of the bolt's thread was a piece of $\frac{1}{8}$ in. brass plate, filed on one side. After cutting one lot of coarse thread on the brass it became immediately obvious that, by simply turning the bolt relatively, through 180 deg. a two-start worm would result, keeping the bolt hard against the chuck jaws both times. By using the angles of the chuck jaws as a guide a





Depth gauge

A worm-wheel and pinion with leader and follower

three-start worm could also be made. The same methods can be used with the Unimat 3, giving the modified bolt leader a 6mm hole, fitting it in the standard, outside, position on the threading set-up. The pulley, against which it seats, could be calibrated for the various starts.

Since the 1 in. Whitworth bolt has eight threads per inch the two-start worm becomes 16 per inch, and a pinion of 16 teeth per inch is needed to run with it. For this I used the cutter of ¾ in. diameter, which I had made with the other hobs. In theory the cutter should be of similar diameter to the worm-wheel so that the pinion embraces the wheel. However, as the pinion was to be comparatively thin the ¾ in. hob proved satisfactory.

To enable the pinion to run at 90 deg. to the worm the teeth have to be cut at an angle. When viewed from the side a worm-wheel presents a complexity of angles, and with a pinion whose thickness is under half the diameter of the worm it is the angle at the centre of the worm's thread which must be considered. To determine this angle it is siimplest to imagine the worm as square in section, then each side of the square will advance by one quarter of the complete advance of the start. It can then be seen that the angle of the teeth of a pinion to mesh with that particular diameter of worm can be found from:

$$\tan\phi = \frac{.25 \times \text{thread advance}}{\text{diameter of worm}}$$

This calculation gives a compromise angle, close to the lead angle, which runs very well in practice, giving a good tight fit with no backlash. So with a worm of outside diameter $\frac{3}{8}$ in. cut to 8 t.p.i. (the number of starts is not involved) the thread advance is $\frac{1}{8}$ in. and a quarter of this is $\frac{1}{32}$ in. .03125 over .375 equals .083R: this is tan theta. On the calculator this represents an angle of 4.75 deg., the angle to cut the teeth.

To cut the teeth of a pinion, set up the blank as before, but this time bring the centre line of the vertical head to correspond with the lathe centre line. Turn the vertical head the correct deviation from the upright, ensuring the angle is correct using the flat side of a rectangular protractor from the cross-slide. Bring the blank across and check against the wormwheel that the angle is in the right direction, and not cutting incorrectly by a further x degrees. Cut the worm by feeding the blank onto the cutting hob, do not cut across, but make the pinion hollow for the wormwheel. The wormwheel, by the way, should have been cut with the 40 deg. tool that you made for the hobs.

A Simple Depth Gauge

When making hobs and cutters for gear-wheels, and when cutting gears, it helps to have a depth gauge on hand for getting the depth of the grooves just right. A simple, but accurate depth gauge can be made by relying on the 40 t.p.i. Model Engineer series of taps and dies; either $\frac{3}{16}$ in. or ¼ in. can be used. The 40 threads per inch give a movement of .025 in. to each complete turn on the gauge, and by using the faces of a hexagon then 4 thou. is measured as near as you will want. The one I made was with the $\frac{3}{16}$ in. × 40, but for the ¼ in. × 40 one, just use a larger size of hexagon brass and ¼ in. mild steel rod.

Take a 1½ in. length of $\frac{5}{16}$ in. A.F. hex. brass and chuck in the three-jaw. Turn both ends to a finish down to $1\frac{5}{8}$ in., and with a No. 1 centre drill, drill into one end as far as the flutes will allow, follow this with a No. 51 drill right through, then drill No. 21 to a depth of 1¼ in. With the $\frac{3}{16}$ in. × 40 second tap in the drill chuck mounted in the tailstock, tap as far as you can, loosening the quill of the SL for advancement, or adjusting the tailstock position for the 3. Remove the tap and the swarf, to tap again with the plug. Turn a taper on the hexagon until only a thin face of metal remains, to the thread. Reverse and take off the back corners.

Face the ends of a length of $\frac{3}{16}$ in. diameter silver steel or BMS and turn the end $\frac{1}{8}$ in. down to .09in., centre drill the end, then drill in $1\frac{5}{16}$ in. with a No. 51 drill. Get 1¼ in. protruding from the chuck, and with the $\frac{3}{16}$ in. × 40 die in the tailstock dieholder, thread 1 in. past the turned down end, first with the die wide open, and then again with the die not quite relaxed; use plenty of tapping compound to get a nice clean-cut thread. Try the hexagon on, and it should screw quite tightly with the fingers. Put a pointed lathe tool in the tool holder on the cross-slide, bring the point up to the thread and, by turning the bed-slide handwheel, score a fine line through the threads. Remove and mark off the 1¼ in. and wrap a ¾ in. wide strip of alloy around the threads and chuck in the drill chuck. Part off the 1¼ in., and face off the anvil. Push a No. 51 drill through the bore to clean away the burrs, then screw about $\frac{3}{8}$ in. into the hexagon brass. Take a length of 16 s.w.g. steel wire (use the stuff that the model shops sell as piano wire in straight 3ft. lengths; but take a vernier caliper with you to check the gauge) and grind the end to a tapered point and blunt the point straight across.

Push the blunt end into the gauge to protrude at the anvil. If all is well remove the wire and clean off to tin with Comsol at the 2in. to 2.1 in. position, rub the solder down flush. Smear the hole in the hexagon brass with Comsol paste, and push in the wire to the 2.1 in. Solder in the wire with a small flame or large soldering iron, touching the joint with Comsol wire to consolidate. Allow the joint to set and cool naturally, and with a small hacksaw cut off the surplus wire, place in the vice and finish with a fine flat file. Remove the threaded part and clean both parts. Smear the threads with grease and screw right home, unscrew and take off the surplus lubricant.

To zero the gauge rest the anvil on a dead flat surface and hold it upright and still, turn the hexagon slowly, and the needle will lift the anvil from the surface as the zero point is passed, back off the hexagon until the needle coincides, level, with the anvil, and mark the position of the line cut into the threads onto the taper of the brass. To finish off stamp .025 on the brass, on the opposite side to the line, to remind you. To protect the little gauge beg one of the small tubular boxes that hold small twist drills from your tool merchant; it will accommodate the gauge neatly.

Remember that each complete turn of the gauge equals .025in., and in use complete turns need to be counted to get the correct length of needle protruding from the anvil, or can be counted back from where the anvil has lifted on measuring the depth of a tooth cut.

STORAGE SYSTEM FROM SCRAP

By L. Balderstone

How to construct cheap and versatile storage box systems from mostly waste materials.

Model makers have for many years used cardboard of various types as a modelling material for parts of items such as buildings and vehicles, but few people ever stop to consider cardboard as a real life engineering material. However, look at the back panel of your radio set, the trim panels in your car, the packing carton in which your washing machine arrived and some of the other elaborate modern packages: you will soon become aware that cardboard can fulfill an engineered role, often in applications involving considerable mechanical strength.

I was faced with the problem of the compact and accessible storage of an ever-growing collection of nuts, bolts, nails, screws and spare parts of every conceivable nature, which had outstripped the collection of old tobacco tins and odd containers previously used, and reached the point where the search for one particular item could take longer than the rest of the whole job.

The chance availability of some assorted strong fibreboard boxes sparked off some experiment and deep thought, from which emerged the design of a complete and versatile storage system, made at very little cost from mostly scrap materials.

Materials

The type of cardboard required is fibreboard, a dense stiff material looking like very thick grey paper on the edge. Corrugated board and strawboard are no use for our purposes. The most convenient source of the thinner fibreboard (0.016 in. to 0.025 in.) is cereal packets, preferably the largest size cornflakes or shredded wheat. Open the packets carefully without tearing or creasing, remove the contents to a plastic bin, open the box out flat and store flat and dry until required. (On top of the wardrobe is a good place.) The thicker grades are used as outer boxes for packing, and are usually brown on the outside and grey on the inside. The most useful thickness is about $\frac{1}{16}$ in. (1.6mm), which is also the most common. In particular, Croxley Bond paper for printers and office stationery comes in $\frac{1}{16}$ in. fibreboard boxes, so visit your local printer or large stationery store just before dustbin day! The engineering and electronic industry commonly uses boxes of the same material for packing parts and components, so keep an eagle eye open and acquire suitable boxes whenever possible. Dismantle boxes carefully, lifting both legs of all staples with a screwdriver or penknife and lift out the staples individually. If you try to hurry by wrenching boxes open, you will crease the board and spoil it. Open boxes out flat and store the pieces without cutting down the folds, as you may need to incorporate the existing folds in your boxes to economize on material.

Tools

Items 1 to 6 in the following list are essential: the remainder can be managed without, but let us say that results are better and more easily attained if they are available.

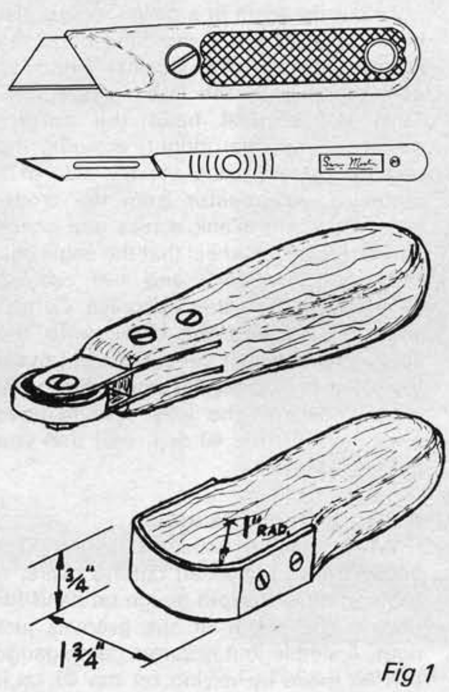


Fig 1

1. A steel ruler, 12 in. minimum, 24 in. more useful.
2. A good quality craft knife, with a pointed, fairly thin blade, tip angle between 30° and 60°. (Fig. 1).
3. A piece of heavy grade cork lino or good hardboard about 15 in. by 20 in., to cut on to.
4. A hard pencil (3H or 4H).
5. A bradawl or similar pointed instrument, with a sharpish but slightly rounded point, for scoring card. (NOT needle sharp!)
6. An ordinary desk stapling machine, of reasonably strong construction, with a reach in from the edge of the paper of at least 3 in. Ensure by a practical test that your machine can staple together two pieces of $\frac{1}{16}$ in. thick fibreboard. If it can insert staples with different lengths of leg, so much the better.
7. A piece of wood about 15 in. to 18 in. long, 1½ in. thick and cut to the same width as the base of the stapling machine, item 6. Straight grained softwood is best.
8. A small piece of mild steel sheet, 18 or 16 s.w.g., 8 in. long by the width of the base of the stapling machine.
9. A small G-clamp, of sufficient size to clamp item 7 to the edge of your workbench, kitchen table or other working surface.
10. A small hammer, say 4 oz., with a reasonably smooth flat face.
    OR: A home made staple clinching tool of either the roller type shown in Figure lc or the direct pressure type as Figure ld. The roller was made using a discarded small ball race and a piece of scrap wood, whilst the other tool is simply a piece of wood with a strip of sheet metal around the end.

Marking out your material

When only one or a small quantity of a particular component will be required, it is sufficient to draw or mark out each one on the board using your pencil and ruler. If a large quantity is needed, or a continuing need for small batches then a template will save much time, material and probably frayed tempers!

Always mark out on the surface of the board which you wish to be the INSIDE surface of the finished box. Bend lines in particular should not be marked even with a pencil on the outside of the bend, or the outer plies of the board will tend to tear when bent.

The required lines may all be drawn with the pencil first if desired, and then those necessary scored after; or you may save time by scoring all lines direct from the dimension marks.

Cutting out parts

The best and most accurate method of cutting fibreboard within our terms of reference is to use a sharp craft knife along a steel straightedge; cutting through one thickness only onto lino or hardboard placed on a firm flat table. The thinner boards (e.g. cereal packets) may be cut with scissors, preferably the heavy, firm jointed type such as dressmakers shears.

Knife blades may be kept sharp by the occasional rub on a fine oilstone, or even a piece of fine wet-or-dry paper on a flat surface. This applies equally to the replacement blade or 'disposable' type of knife available.

Hold the knife firmly, with the plane of the blade vertical and the cutting edge at such an angle to the work that you ensure that the surface layers of the board are sliced cleanly rather than torn. A few practice cuts on scrap pieces of board will soon give you the right idea.

When cutting out corners of a part in thick card which is scored in double lines (Figure 2), always cut along the line of each pair which is furthest from the corner.

Scoring and bending

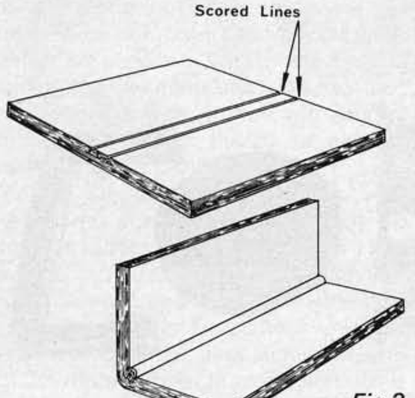


Fig 2

The implement used for scoring, as mentioned in the tool list, should be a pointed steel tool such as a bradawl, with a smooth tapered point, the extreme point being slightly rounded rather than needle sharp. The object is to produce an indentation in the board without cutting or tearing the fibres in the surface layer, and the angle of the point to the board and the pressure applied must be adjusted by practice and experience to achieve this, or your bends will be weakened and liable to tear.

Thin card such as cereal packets will bend well along a single score line, but the neatest effect with the thicker board is achieved by scoring two lines close together, as shown in Figure 2.

After scoring and final cutting to shape of all parts, and before attempting assembly, it is recommended that all bends should be folded up to the final shape, and then allowed to relax.

In the case of the thin card (cereal packets, etc.) a generous overbending to 180° for a final 90° bend; with a firm rub along the fold followed by setting back to the final angle, will produce the neatest results. However, this treatment of $\frac{1}{16}$ in. thick board may cause splitting along the outside of the bend, and so overbending should be confined to 10° to 20° past the desired final angle.

Assembly of boxes

The assembly of the type of fibreboard boxes with which we are mainly concerned in this article is best achieved with ordinary wire staples. It will be found that the average good quality desk stapling machine will insert a staple ½in. by ¼ in. through two thicknesses of $\frac{1}{16}$ in. fibreboard without any trouble, providing there is no undue slackness in joints and that the work is placed flat and held still. If stronger, more sophisticated or specialized machines are available, so much the better; but they are not essential. Figure 3 shows the method of stapling inside the corners of boxes, whilst keeping the legs or open side of the staple inside the box. Adhesive tape, either brown paper, gummed parcel tape or pressure-sensitive tape such as Sellotape or masking tape can be used to assemble all the designs shown; but boxes so assembled will not last so long in the average workshop or garage as staple-assembled boxes, since any fluctuation of humidity or temperature tends to make the bends in the board try to straighten out, which in turn gradually peels off the tape. The adhesive of pressure-sensitive tape also gradually soaks into the board and dries out, until the tape literally falls off.

The staples, as placed by the stapling machine, generally look in side view as in Figure 3, and whilst this is probably secure enough for most uses, the odd end can catch a finger or knuckle) and it is preferable to close them down flat. Figure

Fig 3

4 shows a variety of boxes designed to fit in various combinations in either the steel drawers, or simple home-built trays. Let us call the boxes (e) and (g) one-unit shallow and one-unit deep boxes respectively. Their plan size is about $2\frac{3}{8}$ in. × $2\frac{3}{8}$ in. We then have a four-unit deep box (c); two-unit deep (d) and two-unit shallow (f). These can be put in any convenient combination into the steel drawers or trays as shown at (a), (b) and (h), the last being the shallow boxes in two layers with a dividing tray. Any one division can be easily lifted out and emptied or cleaned out without disturbing the contents of the others.

Box (a) and the dividing tray (h) are made from $\frac{1}{16}$ in. thick card, and the remainder from cereal packets (0.016 in. to 0.025 in. thick).

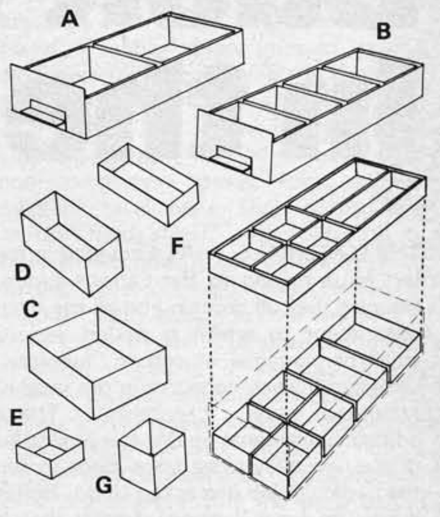


Fig 4

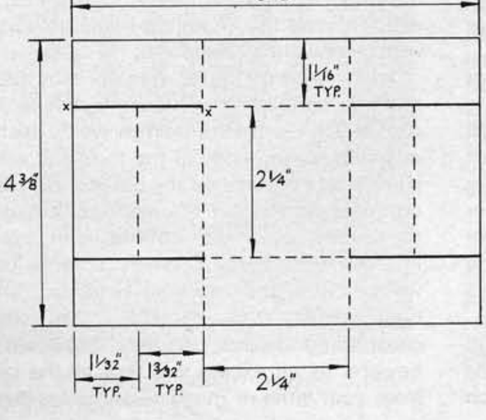
Construction

We will start off with the smallest box, Figure 4g, because it is simple, and you stand the best chance of having available suitable material immediately to hand. You will need for each box a piece of thin fibreboard such as a cereal packet or similar box, 6½ in. by $4\frac{3}{8}$ in. The following instructions apply to all the four sizes made from thin card.

1. Mark out your material in accordance with the drawing (in this case Figure 5).
2. Cut round outside edge, and the four cuts shown as solid lines, as X–X. Score along all dotted lines.
3. Fold all bends to 180° and press flat, then open out.
4. Fold sides and corner flaps up to 90°. Fold ends up and over the flaps, into the box.
5. Staple all corners, as shown on the drawing, and then clinch the staples flat, as described earlier.

You now have one small storage box! In fact, one large cornflakes packet will, with careful cutting and using existing folds, provide eight boxes this size.

In the next article, I will give details of the remaining boxes and some ideas for cabinets and shelves.



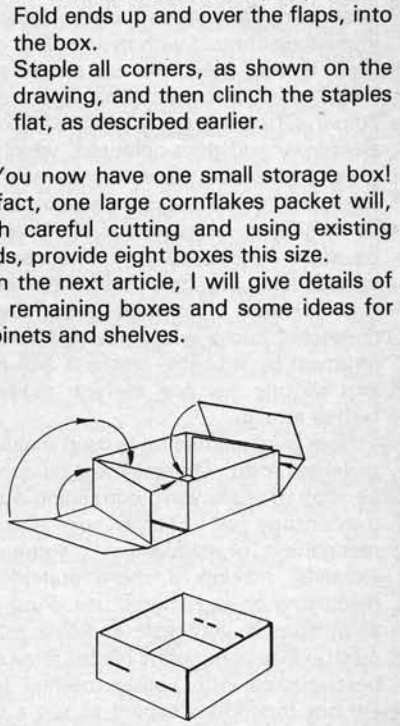
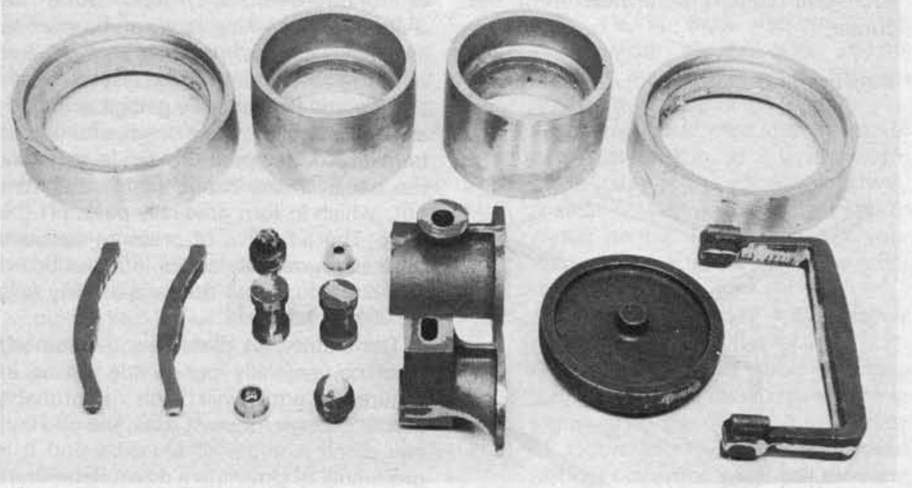


Fig 5

Back to basics in the workshop

By John Wheeler

THE MATERIALS THAT I covered in the last issue belong to the Ferrous group, because they all contain iron as the main constituent to which is added various small percentages of carbon, tungsten, vanadium nickel, cobalt or in the case of stainless steel, chromium. These additional elements enable the properties of the new alloy to be tailor-made to suit the particular job it is asked to do. Hence if you do have a piece of steel that is difficult to file or hacksaw, you could have a piece of special alloy steel, which is best left alone until you can find out more about it. Every steel stockist will gladly supply leaflets describing many of the alloy steels, their working qualities and properties, although actually identifying the particular steel accurately may require a chemical analysis.



A selection of Aluminium and Gunmetal casting.

Aluminium and its alloys

This metal is light in weight and shows a bright silver coloured surface, especially when newly filed or machined, which will polish up extremely well to a mirror like finish. It is non-magnetic, you cannot pick it up or attach a magnet to it; it does conduct electricity very well and is often used in place of copper for electrical connections or bus-bars. Whenever aluminium is machined, filed or scratched, the exposed surface forms a very thin transparent oxide layer on immediate contact with the air. This oxide layer is very inert and so protects the metal which therefore remains as a silver colour. Often this oxide layer is thickened electricaly and then coloured, which will give increased protection and an attractive appearance; a process known as Anodising. However, if aluminium or its alloys is exposed to a very corrosive atmosphere, e.g. near salt water spray, the surface layer will gradually be converted into a white powder, which if removed by rubbing, leaves a dull metal and slightly erroded surface ready for further attack.

Near pure aluminium is used mainly for the sheet form, whereas most bar stock is an alloy of aluminium, containing a small percentage of copper or zinc, or manganese, or magnesium or some other element, making it more suitable for machining or its required use. Pure form aluminium is very soft and will quickly clog up files or hacksaw blades, hence it is best worked with coarse-toothed tools. Do not thnerefore expect to get a good finish when using a dead-smooth file as 'pinning' will wuickly occur and scratch the surface. The 99 per cent pure metal is best suited to beaten metalwork or rivets as it takes longer to work harden.

This brings me to the annealing of aluminium. When the sheet is hammered it gradually becomes harder and harder to stretch or work, offering more resistance to altering its shape, hence to return the sheet to a state ready for further hammering the article must be softened or "annealed".

I find it best to coat the aluminium with a thin layer of liquid soap solution; perhaps a more interesting use for the solution than 'doing the washing up'! Gradually heat up the piece using a gas flame until the soap solution dries and chars first brown then black all over, at this point take away the gas flame, leave the article to cool a little and then quench and wash off the burnt soap layer. The soap solution only acts as an indicator that the correct softening temperature has been reached, because the actual metal does not change colour, even up to the point at which it melts, unlike steel, which shows the changing oxide colours with increasing temperature.

As far as working aluminium alloy bar stock is concerned, you can machine it dry, but the swarf sometimes welds itself onto the cutting edge of the tool, and will leave a torn surface on the bar, so using a cutting fluid will aid the smooth flow of the swarf over the cutting tool and improve the finish. Ordinary soluble oil will be better than nothing at all, but for best results use paraffin from the greenhouse heater or like. However, beware, as an excess will take all the oil from your lathe or machine surfaces, it is best applied in just sufficient quantities with an old paint or swarf brush to the work near to the points of cut.

The biggest disadvantage of using aluminium for modelling purposes is that it can not easily be joined by soldering.* A joint can be made using one of the new epoxy or cyanocrylate adhesives or with rivets or screws. For drilling or threading of aluminium or its alloys I always find it an advantage to use a cutting fluid and to often clear the shavings or chippings from the holes. Letting the drill rub is a sure way to heat weld it in the work leading to a broken drill and spoilt work.

Aluminium alloys are also used for castings when the molten metal is poured into a sand mould or forced under pressure into a die, so producing a complex shape tha will require very little machining to achieve a useful item. Many such castings can be produced from a single master pattern at a reasonable cost, and in fact most modellers eventually make up some patterns and either cast their own or join the local evening class, where they have suitable facilities to make up the mould and pour the molten metal.

In my own local class, we often pour piston blanks, engine base plates, motor mounting brackets, Vee pulley blanks etc., or run a trial on a pattern destined to be poured in bronze or cast iron. We may even just pour a large diameter cylindrical shape that can be turned down in the lathe to make up a stub mandral for supporting a bronze or cast-iron workpiece. Aluminium stub mandrals have a good frictional grip, do not damage a finished machined bore in cast-iron or bronze, and if you do turn down undersize, they are easily returned to the pot and remelted to make other castings. One word or warning, if you are collecting old aluminium scrap for melting down, and you are not sure of its origin, collect a few filings off the piece and sprinkle them into a gas flame, if they flare up brightly, put that metal lump to one side, it is most likely to be a magnesium aluminium alloy which if overheated when molten will become an incandescent ball of burning aluminium and no normal fire extinguishers will be of much use. Many modern lightweight motorcycle castings or small car crankcases contain magnesium, so do take care. If you want to use a quantity of aluminium sheet off-cuts or swarf compress them into as small a lump as possible, which will help in avoiding the thin metal burning away, add to the pot and when molten add about 2 per cent of copper pieces to aid the machining of the casting.

British Standard Specifications 1490 listed pure aluminium and about 20 aluminium alloys for castings when I last saw a copy, it is probably up-dated or revised by now, and may list more alloys. A popular alloy is Duralumin which in sheet form is harder than aluminium and slightly more prone to corrosion. It is possible to obtain sheets of Duralumin coated with a thin layer of aluminium each side which gives protection against this corrosion.

Copper

A freshly-filed or machined surface is a shiny brick red colour, which dulls over a day or so, easily showing finger prints as darker spots. Over longer periods the surface dulls considerably even turning green in places if exposed to the weather or a salt water atmosphere. It is non-magnetic and another test is to heat the copper in a gas flame, which will take on a green tinge long before the copper reaches dull red heat. Pure copper sheet is easily obtained, although expensive and most often used in model work for the construction of locomotive, traction engine or stationary boilers. Copper tube, bar and rod are also freely available.

When drilling, threading or machining copper the swarf will easily weld to the cutting edge and best surfaces are obtained using a general purpose lubricating oil as a cutting fluid. Do not be tempted to drill at high speeds as the heat build up is considerable and will quickly seize the metal on to the drill. Copper is easily joined by soft soldering, hard or silver soldering, brazing or rivetting, but threading copper is often suspect due to the tap or die tearing the material unless it is very sharp, hence threads in copper are best avoided and the use of a threaded bronze bush silver soldered into the copper is preferred.

Copper is annealed by heating to dull red viewed in a subdued light, leaving to cool for a while and then carefully immersing in a dilute sulphuric acid pickle that will remove the black oxide scale or burnt flux and leave a lovely pink and easily bent (soft) metal. The acid must be well washed off and the metal surface scrubbed with pumice powder or one of the abrasive powder household cleaners, to remove the last traces of scale or burnt flux. Some persons are liable to copper poisoning when handling freshly cleaned copper close to cut or abraded skin, so if you think your skin is sensitive, do wear a pair of protective gloves. If you want to silver solder or braze up copper that has already been soft soldered, you must ensure that all traces of the Lead/Tin soft solder are removed, because on heating up to about 600°C or above, for the silver soldering, the area of soft soldering will eat through the copper and leave many holes! Or you will just have to accept that further joints are made with soft soldering techniques. This is the reason why you should not soft solder on the brazing hearth, because just the smallest trace of soft solder will 'jump' to the copper and ruin the work. And it always happens to the most delicate or valuable piece.

Brass

There are many types of brass available, but that most commonly found in the scrapbox is an alloy of copper and zinc about 60/40 sometimes known as 'Yellow metal' or 'Muntz metal'. Additionally there is a British Standard Specification or a high speed machining quality rod that contains a small percentage of Lead.

A fresh filed surface shows as a shiny yellow colour, which retains its lustre for some time, eventually tarnishing to a dull yellow. It files, hacksaws, drills and machines very easily, the swarf occurring as chippings rather than long shavings.

In fact it is due to the curl nature of these chippings that it can be machined, threaded or drilled at high speeds without a cutting fluid. When you do machine brass on a lathe, definitely use that chip guard or wear safety glasses as the chippings will fly everywhere at some fair speed; they certainly spread themselves in all the odd nooks and crevices and make cleaning down the lathe more time consuming than normal. Brass is non-magnetic, available in sheet (either hard or half hard state), strip, bar, rod or extruded section. It can be annealed by heating to a dull red heat, viewed in subdued light, leaving to cool slightly and quenching in water. No scale is formed, although a clean up of the surface with abrasive powder is useful. If dipped in the sulphuric acid pickle, used for copper, to help remove any silver soldering flux, a copper tinge appears on the surface. I think brass is probably the most useful material for the modeller as it can be soft soldered, silver soldered, rivetted, threaded, machined, bent or shaped relatively easily, will take a good finish or polish, is fairly strong for its weight and will not rust away as will mild steel, but it does require sharp cutting tools at all times.

Mr R. H. Dyer's steam wagon boiler. (Made from copper.)

Bronze or Gun Metal

All bronzes have a good resistance to atmospheric corrosion but often the surface becomes so discoloured that it can look very much like dirty brass or oxidised copper, but when you try to file or hacksaw the piece you soon realise that it is much tougher. It is an alloy of copper with 3-12 per cent of tin and about 2 per cent of zinc; the strength of the alloy increasing as the percentage of tin increases, and is available as cast rod or used most often to form cast articles. Bronzes take a good thread and silver solder very well, so it is recommended for the bushes on model steam boilers and as it has a good oil retaining property, especially Phosphor Bronze, coupled with high strength it is very useful for load carrying bearings or the piston and valve glands of steam engines. Machine work demands sharp tools and slower cutting speeds than brass, as a dull tool will rub and form a tough skin that will be difficult to cut through. Cutting fluids are not really necessary although they will help keep the work and tool cool, if it is necessary to use a slightly worn cutting tool. Take care when drilling bronze as it has a nasty habit of producing apparently tapered holes that suddenly, with no warning, take a vice-like grip on the drill twisting the work out of shape or breaking the drill deep in the workpiece—which is just as bad!

*Gerald Wingrove, author of The Complete Car Modeller and other books, recently demonstrated to us a new solder for aluminium. It is made by Multicore Solders—the solder is cored with flux and is marketed under the name of Alu-Sol.

Locomotives by Cyril Freezer

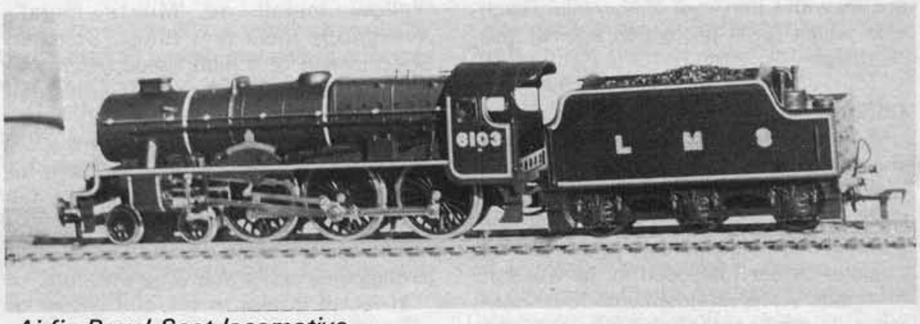
DJH R Class N.E.R. 4-4-0 loco.

I MUST BEGIN this month's article with an apology. I had promised to deal with pointwork but circumstances beyond my control have made it impossible to produce the all-important drawing in time, so I turn to locomotives.

There is a good reason. Once trackwork is laid, it is advisable to test it, and the only practical way to do this is to run a locomotive over it. Gauges and similar devices are all very well in their way, but in the final analysis, unless a loco can run over track freely without de-railing, then it matters little if gauges say it is correct.

Which brings me to the classic chicken-and-egg situation. To test a locomotive you need track, to test track you need a locomotive. If you insist on making everything yourself, then you do have a few problems, deciding which of the two is wrong if results are less than satisfactory.

Those of you who are working in 00 have an easy way out, ready-to-run stock. They are both inexpensive and reliable, and in the main, are excellent reproductions of their prototype. Now, I appreciate that it is, in theory, desirable to do as much as possible oneself, but we have to be practical. A model railway is large and complex and to build the whole from scratch takes a great deal of time. When you consider how much effort is required to build the railway itself, it makes sense to buy in the initial rolling stock.



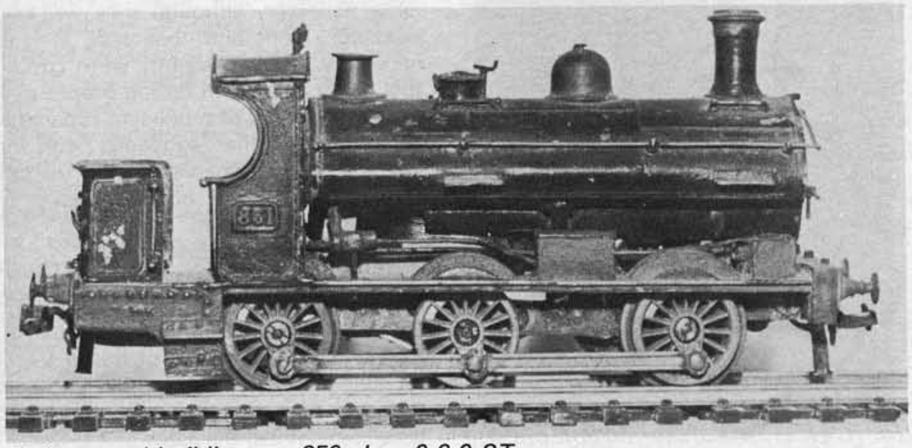
Airfix Royal Scot locomotive.

At this point, we hit the question of prototype. A lot of experts inform you that it is absolutely essential before you begin, to decide which prototype you propose to model, and at what period. In my opinion, unless this question is already decided—for example, because a lifelong interest in say, The Somerset & Dorset Railway has led to your wanting to have a model of some part of that delightful, if defunct line — then the initial move can be made on an ad-hoc basis. Agreed, it is more correct to follow a specific prototype, but at present day levels, this calls for around five years study. The time to make such a decision is before you invest a lot of time and effort in the construction of locos and stock. This is a good reason for beginning with mass produced, expendable r-t-r equipment. I will return to this subject at the end of the article.

As I have suggested, there is so much work involved in the construction of a complete model railway, one can be excused from skipping the actual construction of locos, wagons and coaches, the more so if a good slice of the stock you need is standing proudly on the dealer's shelves. However, there are gaps in a steam stud and so it is helpful to add to the stock, either from kits or by scratchbuilding.

Loco kits now cover most classes one would wish to add to the stud and several, that on the face of it, appear to be so second rate that it seems unlikely anyone would want one. There are three categories, cast whitemetal, etched brass and pre-cut metal. The pre-cut metal kits are the oldest; they are virtually scratchbuilt models on which a little preliminary work has been done. Etched brass kits are a development using modern techniques of chemical milling, combined with a little judicious whitemetal casting and some specialised turnings and can, in expert hands, produce remarkable results. The snag is that in every case I have encountered, the instructions assume a degree of expertise and while I have no doubt that a determined newcomer could get the model together, it is by no means guaranteed.

To a very considerable extent, the popular and ubiquitous cast whitemetal kits has the same fault. I have, over the past year, been dealing in some detail with the construction of cast kits in our sister magazine, Model Railways and refer readers to this series for fuller information. Suffice it to say that a lot of modellers do make a success of putting a kit together, providing they realise that it

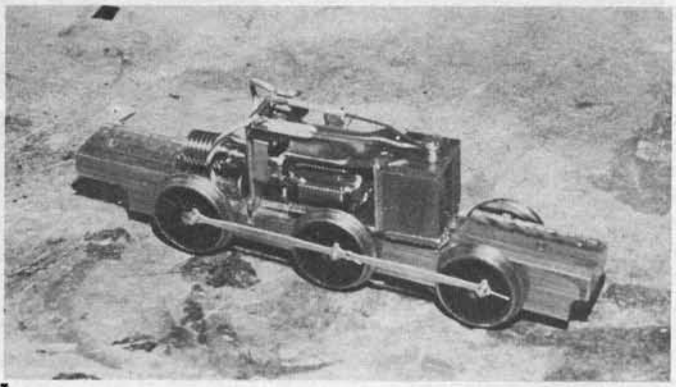


Early scratchbuilding, an 850 class 0-6-0 ST.

Cotswold 4mm scale GWR 16xx 0-6-0 PT

This metal kit has a milled brass chassis, gears, wheels, and only requires the addition of a motor to complete.

1. **The chassis assembled.**
2. **Underside showing pick up, using Veroboard.**
3. **Running in chassis in vice.**
4. **Cab and footplate.**
5. **Cab in position on footplate.**
6. **Boiler in position: part was removed later.**
7. **Body assembled away from footplate.**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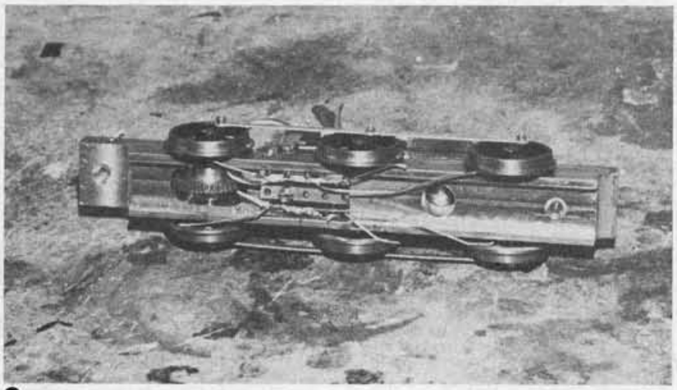
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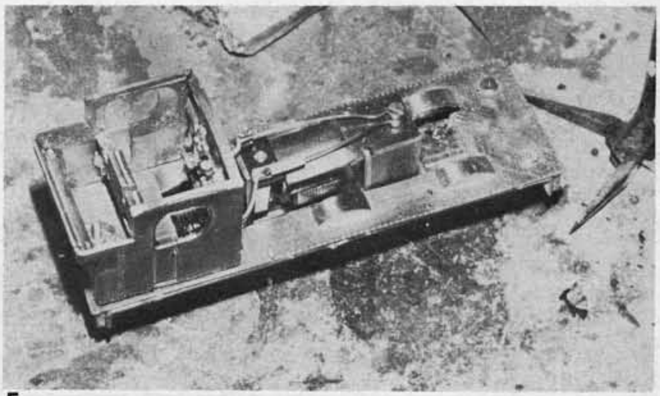
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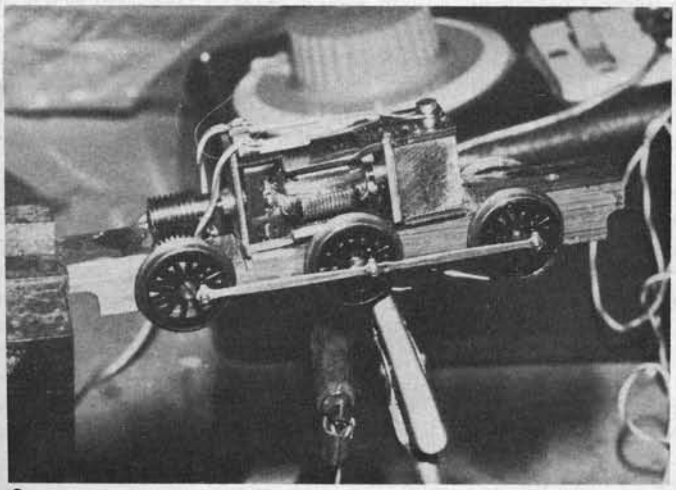
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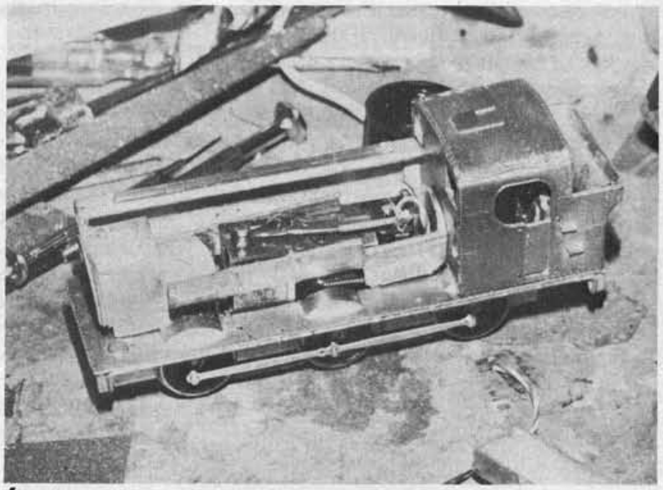
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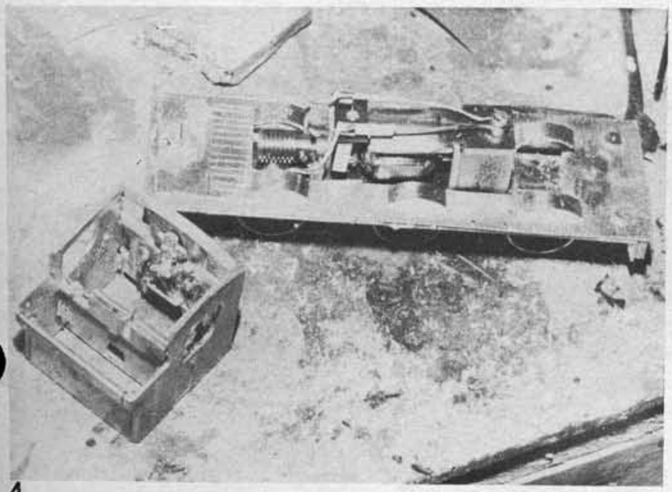
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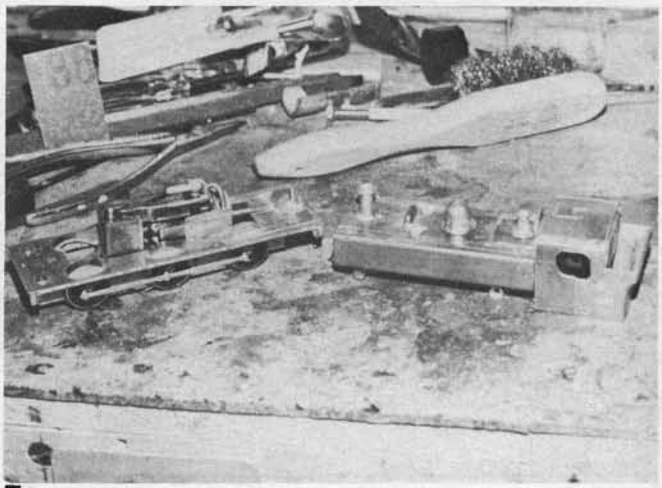
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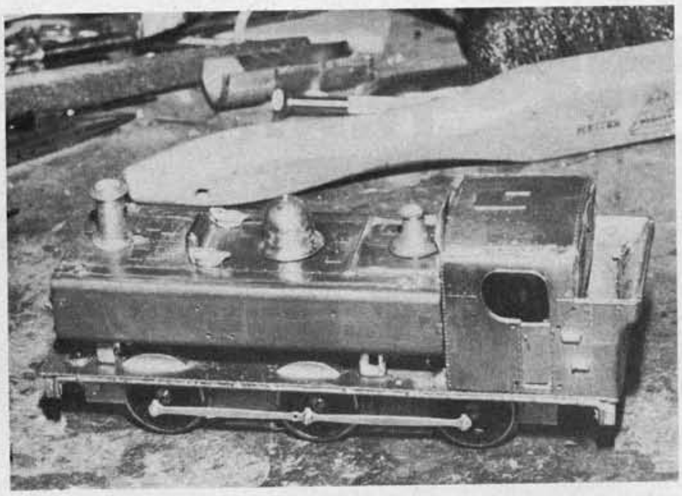
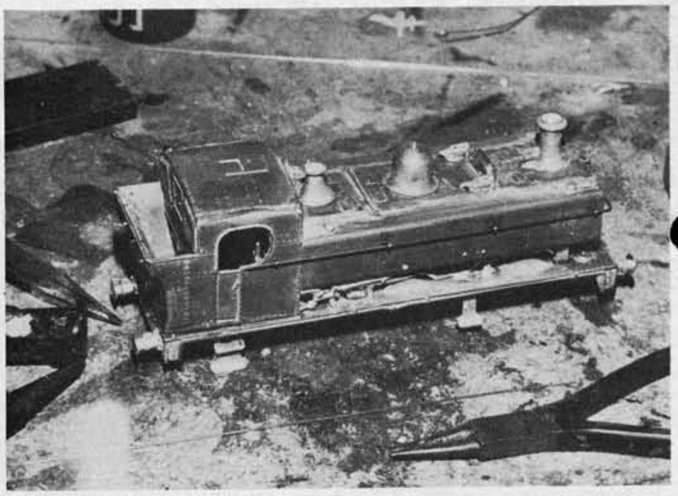
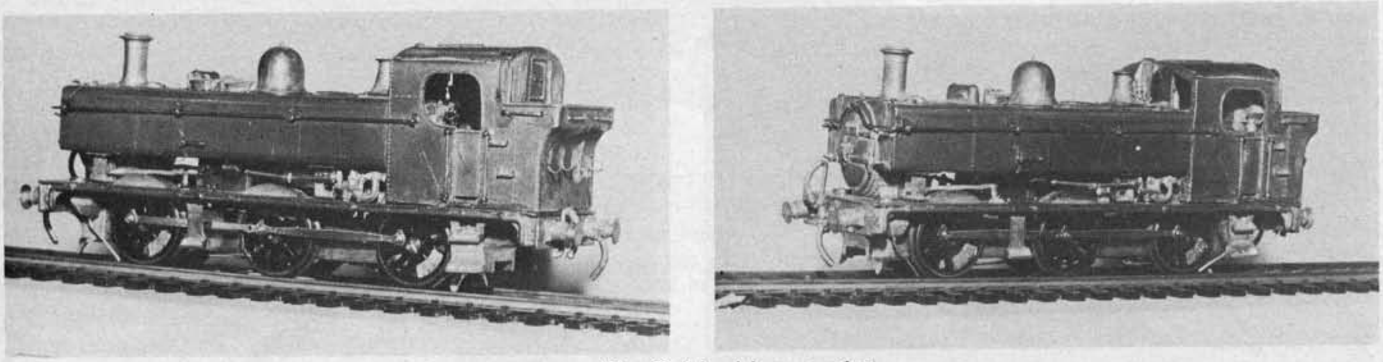


Body awaiting details



Detailing commenced



The finished locomotive

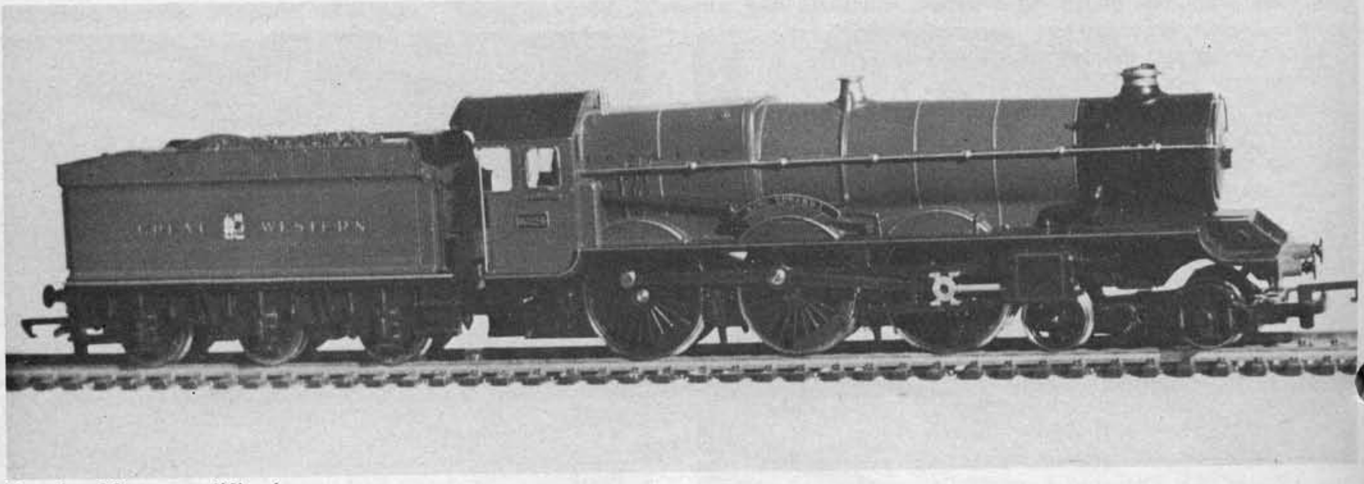
is not necessarily a case of shoving the bits together in a hurry. I think most readers of Model Mechanics are prepared to put effort into their modelling. As I see it, if one is paying around £20.00 for a kit, one ought to get £20.00 worth of fun from putting it together.

One serious fault with most loco kits is that they are incomplete. Few manufacturers provide wheels, only one normally include a motor. One or two do not even include a chassis. The reasons for this state of affairs are many and complex, but it does not exactly help the newcomer, and it certainly puts a very severe strain on the dealer who is expected to know what is needed to finish the job and stock the bits and pieces.

This is a matter on which I hold very strong views: it is very nice for the expert to have a choice, but my sympathies are with the beginner, the less expert and above all, the dealer. As it is, there is a rather tricky minefield to be negotiated, and so it is as well for the newcomer to be warned of its presence.

As indicated, I think it is possible to over-emphasise the importance of prototype choice. What I think is generally forgotten is that locomotives, whilst apparently an integral part of the railway scene, are in fact easily removed accessories. Further more, we must realise that only a large elaborate system needs more than ten locomotives to work the timetable

In actual practice, the railway scene changed little from 1900 to 1950 and then only in small details — road vehicles, posters, the length and style of the lady passenger's skirts for example. The biggest and most obvious differences lay in the locomotives used, and these can be swapped around in about half an hour at the outside. It is feasible on the one layout to arrange complete changes of locos and rolling stock, in the process, altering the character of the model. Furthermore, it is of no great importance if you run a completely foreign locomotive over your metals, providing it does not offend your susceptibilities — which is highly unlikely since you made the choice in the first instance.



Hornby 00 gauge 'King'

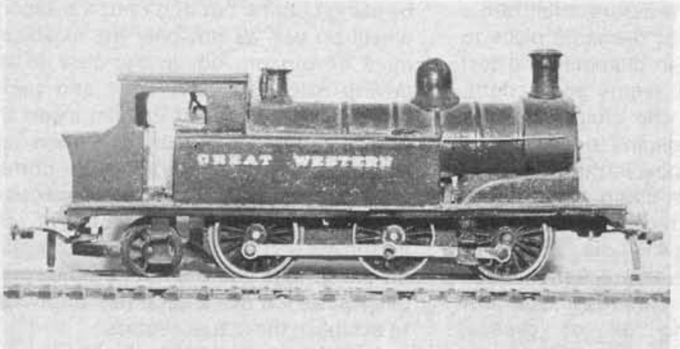
As I see it, there are several ways of dealing with this question, all of which, when properly carried out, produce an effective model. One is to select a specific prototype at a particular period in time and allow only those models that will fit to run on your railway. In theory, this is best. In practice, it is extraordinarily difficult. Indeed, it only seems to work well when the individual concerned has a strong, often sentimental attachment to a specific prototype and period. Certainly, such a limiting choice cannot be made on the basis of a random choice made from insufficient data. All too often the modeller who has, at an early stage, plumped for a GWR branch, discovers a year or so later, that it does not, for him, represent the pinnacle of perfection.

Happily, unless one is scratchbuilding to such a high standard, that one's total output is limited, it is possible to add a few models that do not precisely fit the theme.

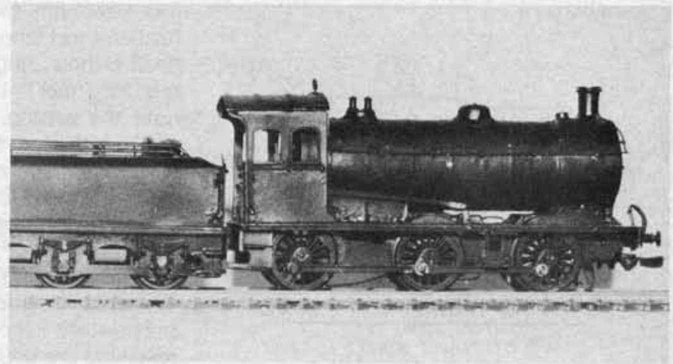
Indeed, one of the finest model railways ever built, Cyril Fry's Irish International, followed a very simple rule, anything that ran on Irish metals was permitted. That, in practice, the juxtapositions seen on the model could never occur was immaterial, the effect was excellent. Indeed one advantage of a model is that one can improve on nature. Some years ago I toyed with the idea of a small suburban layout worked entirely by models of every British 4-6-4 tank locomotives — all five of them! That they never got together was immaterial, it would have been rather pleasant had this been possible.

The best, and in my opinion, only valid reason for adding a loco to your collection, is that you want it, that you are prepared to buy or build it. The snag with too strict an adherence to prototype practice is that it does tend to eliminate a lot of interesting models. To give a simple example, it is difficult to produce a convincing reason why a model of the GWR's only pacific, 'The Great Bear' should appear on any authentic model. It is utterly impossible to justify the appearance of the GER behemoth 0-10-0 well tank 'Decapod' — yet these two prototypes are very popular among modellers.

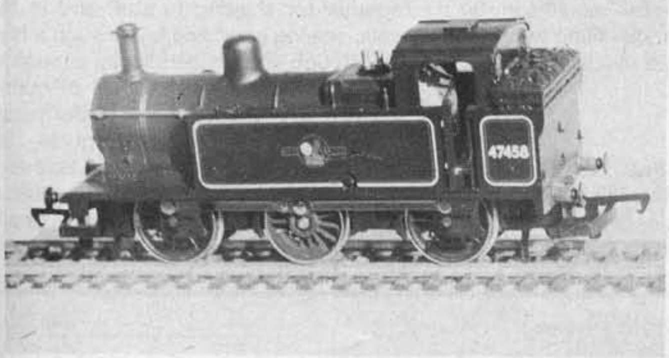
Of course, if you enjoy the research needed to get 100% prototype and period accuracy, all well and good, but if you want Stephenson's 'Rocket' and a Class 87 electric loco on the same layout — well, its your model railway, isn't it?



Wills finecast U1 on Hornby R1 chassis



Nu-cast North Eastern 0-6-0



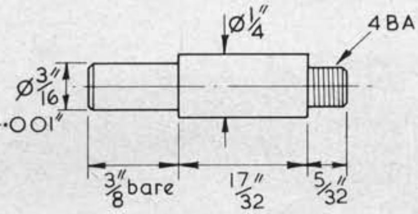
Hornby 00 gauge 'Jinty' 3F 0-6-0T

Hornby 00 gauge GWR 0-4-0T No. 101

The 'Eagle' designed by Martin Evans

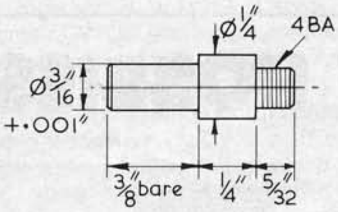
A simple 2½ in gauge 4·4·0 locomotive

HAVING SUCCESSFULLY turned the driving and coupled wheels for our 4-4-0, the next items are the crankpins. These are quite an easy lathe job. Probably the simplest way is to use silver-steel in its "natural" state, which gives us an accurate, ground surface. Some builders may, however, prefer to turn them from ordinary mild steel, then case harden the bearing surfaces. If they do, I would suggest that they put on temporary nuts to protect the threads from the flame while carrying out the case hardening operation.



DRIVING CRANK PIN (X2)

2 off silver steel



COUPLED CRANK PIN (X2)

2 off silver steel

All four crankpins are turned from ¼ in. dia. material, and a collet is desirable to ensure concentricity. However, the 3-jaw chuck could be used, even if it does not hold this diameter truly, by the use of the old dodge of packing out the offending jaw or jaws with strips of paper. Turn the "plain" part first, to a press fit for the holes previously drilled in the wheels. It is sound practice to try out the correct size for a press fit on a scrap piece of the silver steel that is to be used for the crankpins. Turn this to such a diameter that it will just enter with hand pressure, then turn a further short length of the same piece to "half-a-thou" larger in diameter and test this for "feel". If it seems about right, note the setting of the cross-slide dial, and turn the four crankpins to the same.

Reverse the crankpins in the chuck and turn the other ends down to 0.142 in. diameter, for a length of $\frac{5}{32}$ in. chamfering the end ready for the 4 BA dia. The thread may be cut using the tailstock die-holder. To ensure good threads, use any proprietary tapping oil or grease, reversing the die two or three times in the course of cutting the full length.

Ordinary commercial 4 BA nuts *can* be used to hold the coupling rods in place, but builders who would like something a bit nearer to the "full-size" could turn up little collars about $\frac{9}{32}$ in. dia. filing two flats on this. In either case, a thin brass washer enhances appearance.

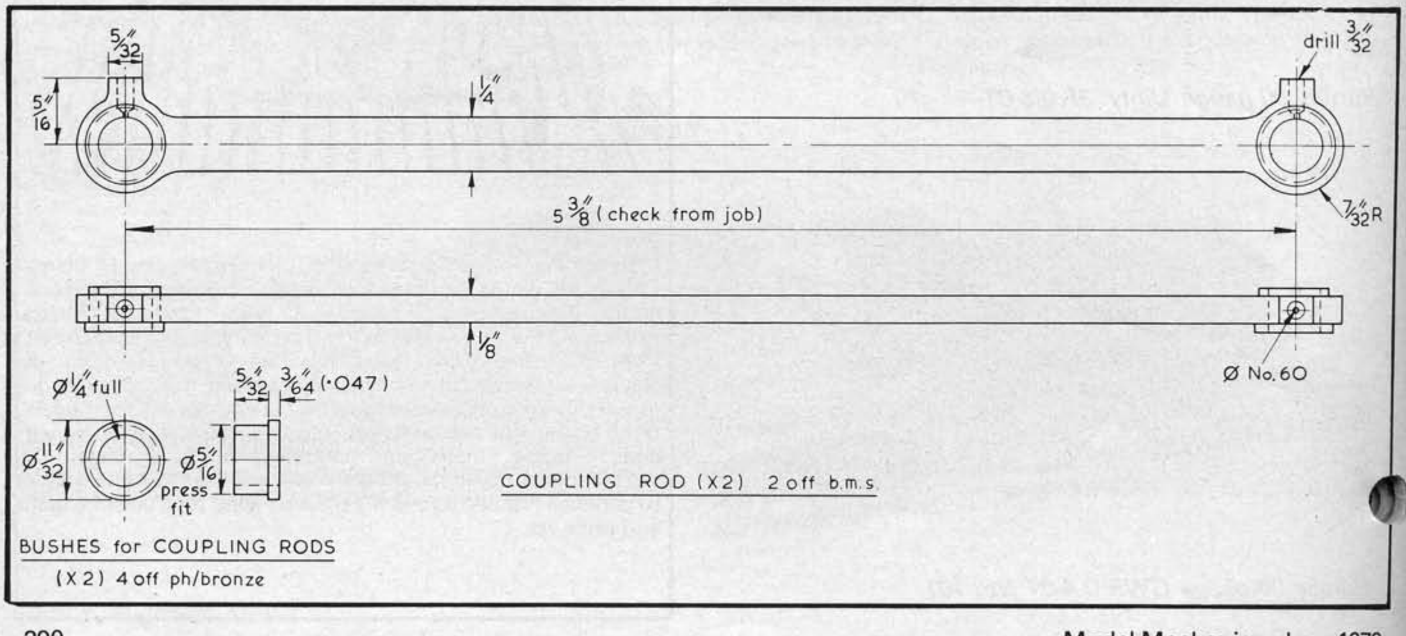
Coupling rods

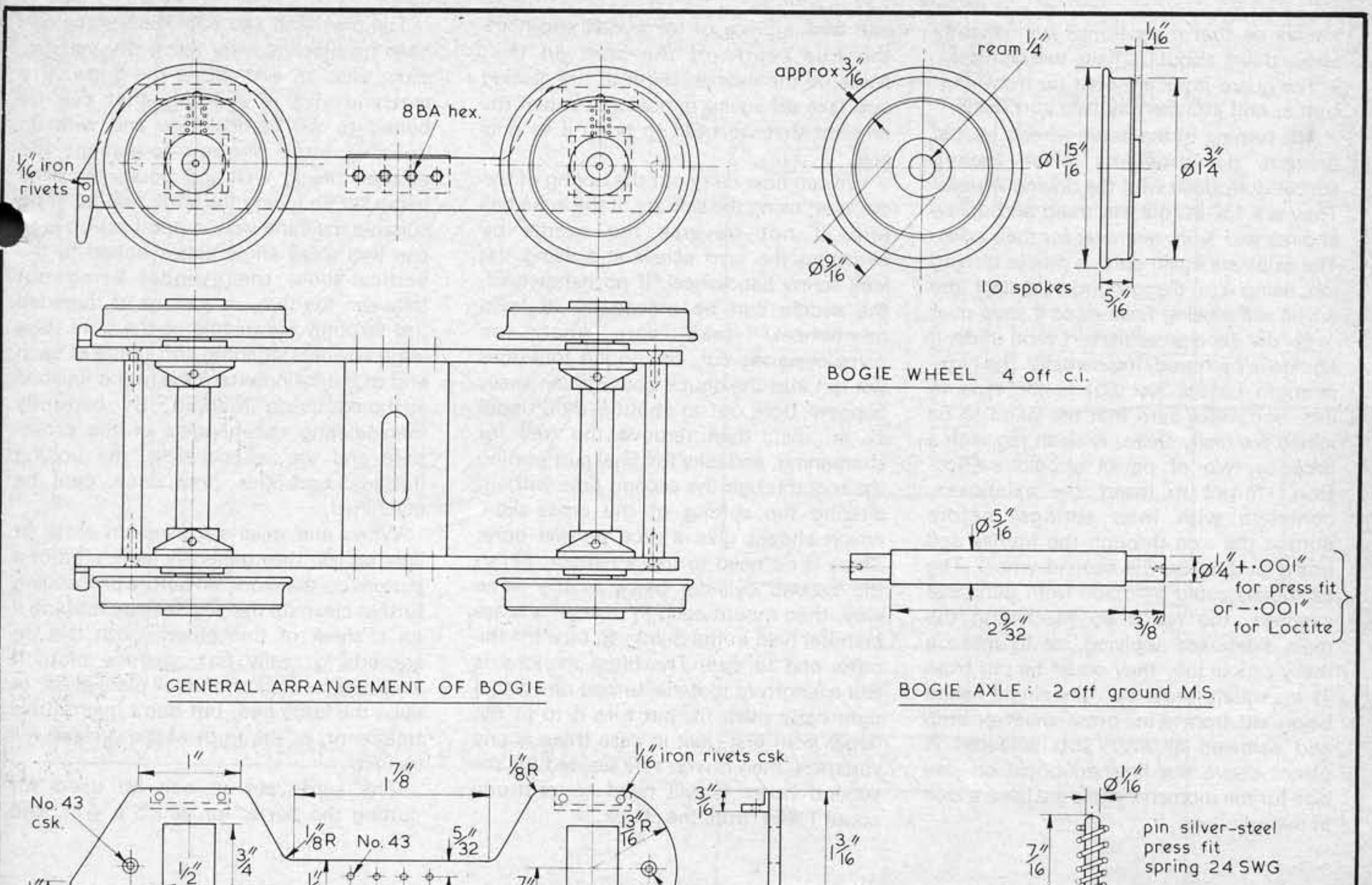
My drawing shows very simple coupling rods, but with a fair resemblance to the prototype article. On the G.N.R.(I) 4-4-0's, the coupling rods were fluted; on many other 4-4-0's the fluting was omitted, but the rods were left "fish-bellied", that is to say they were wider in the middle than at the ends.

Material this time is $\frac{5}{8}$ in. × $\frac{1}{8}$ in. bright mild steel, or if this size is not available, ¾ in. × $\frac{1}{8}$ in. It is of course important to get the centres exactly right. They are nominally $5\frac{3}{8}$ in., but it is a wise precaution to take the dimension from the engine itself. Having pressed the crankpins into all four wheels, one wheel can be put on its axle permanently, either press fitted or by using Loctite, but don't put the second wheel on yet, as not only the axleboxes must be put on, but in the case of the driving axle, the valve gear and pump eccentrics as well. But we can insert the axles temporarily in their axleboxes and set these up in the frames to correct working height, by placing small pieces of metal between the bottom of the axleboxes and the hornstays, and putting on the springs and the nuts on the spring pins, while we use a large pair of dividers to establish the actual centres.

Apply the set dividers to the coupling rod bar, centring and drilling to ¼ in. dia. at this stage, while the shape of the rod is marked out ready for cutting. The two coupling rod blanks can be bolted together for shaping to size, and in this scale, sawing and filing is not such a hard job, though any builders lucky enough to possess milling machines, will of course use them to remove the bulk of the metal.

Although my drawing gives the dimensions of the coupling rod bushes, I would suggest not making the bushes until the wheels have been finally assembled, with eccentrics etc. in place.





The bogie

Eagle's bogie is about as simple as I can make it, short of abandoning springing altogether, and that would hardly be sensible if the engine is to keep the track. Most Club tracks are not *quite* as straight and smooth as British Railways'!

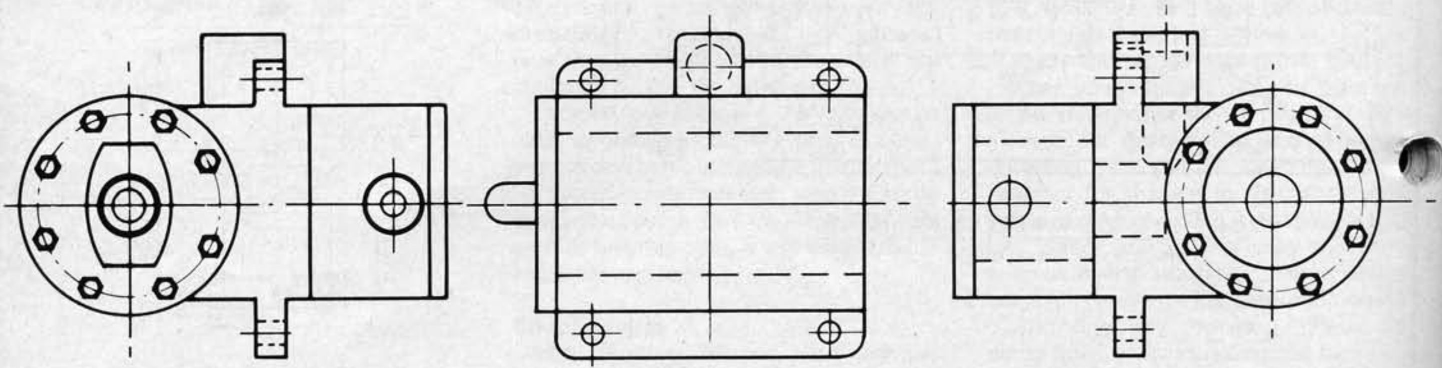
It will probably be asked why the bogie frames are shown as cut from $\frac{1}{8}$ in. material, when the main frames are only $\frac{3}{32}$ in. thick. The reason for this is so as to avoid having to fit horns, the axleboxes being allowed to bear directly against the edges of the frames. If the frames had been only $\frac{3}{32}$ in. thick, this would not have given us quite enough bearing surface.

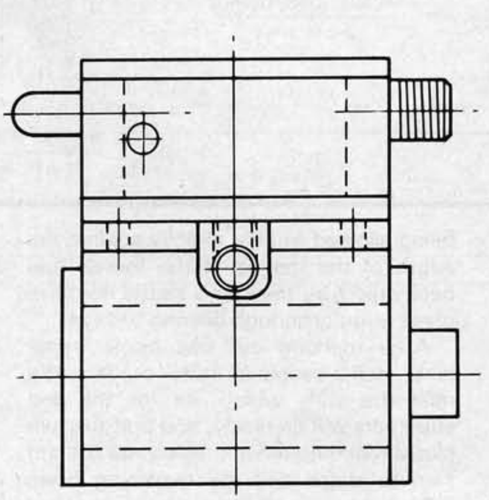
After marking out one bogie frame plate, drill a couple of holes, the No. 43's near the ends which are for the end stretchers will do nicely, and bolt the two plates together, when they can be cut and filed to shape and the remaining holes drilled. After parting the plates, the end holes can be countersunk and the spring pin guides attached. These are made from lengths of ¼ in. brass angle. Thin out the side of these that will be against the frame and fix them with $\frac{1}{16}$ in. iron rivets, which should be countersunk to the outside. No. 50 holes are drilled through the guides as shown.

There are three bogie stretchers, two for the ends are cut from $\frac{3}{16}$ in. round mild steel, drilled and tapped 8 BA each end. The centre stretcher is cut from 1 in. × $\frac{5}{16}$ in. b.m.s. and is slotted for the pin in the engine frame stretcher. Note that this stretcher is located between the bogie frames so that it protrudes very slightly above them, about 0.010 in. will do nicely.

The guard irons are bent up from $\frac{1}{16}$ in. b.m.s. and attached by two iron rivets.

The turning of the bogie wheels should present no problems after having successfully dealt with the driving wheels. They are 1¾ in. dia. on tread and drilled and reamed ¼ in. diameter for their axles. The axles are again quite a simple turning job, using $\frac{5}{16}$ in. dia. ground mild steel, the wheel seats being finished to 1 thou over ¼ in. dia. for a press fit, or 1 thou under if Loctite is preferred. Incidentally, the high-strength Loctite No. 601 is the type to use, and make sure that the parts to be joined are really clean. A clean rag with a drop or two of petrol should suffice. Don't forget to insert the axleboxes, complete with their springs, before putting the axle through the frames and lastly, putting on the second wheel. The axleboxes could be made from gunmetal castings, the notes on machining the main axleboxes applying, or to make a really simple job, they could be cut from ½ in. square brass bar, the single flange being cut from $\frac{1}{16}$ in. brass sheet or strip and screwed or even soft soldered in place. Leave the finished bogie on one side for the moment, while we have a look at the cylinders.





General arrangement of cylinders (L.H. drawn)
Made from gunmetal

The cylinders

The cylinders are of the type that are located through a rectangular slot in the frames, with the steam chest on the inside of the frames, the valve spindle being in line with the piston rod. They will be cast in gunmetal and as with all such castings, it is worth while to spend a few minutes with an old file removing some of the sand and scale that is usually to be found, and so avoid the lathe tool becoming quickly blunted.

On all except the smallest lathes, the cylinder block can be machined using the 4-jaw chuck. First, take a very light cut across both ends, just enough to get under the skin and leave bright metal right across. Now clean up the bore at one end with a round file, just enough so that it can be seen whether the bore is running true, which brings us to the next job, which is to chuck the casting again with the bore running true. Should this cause any difficulty, a good dodge is to plug one end with a piece of hardwood and mark the true centre of the bore on this. Measure the overall length of the casting and face off again, removing just half the amount that we need to bring it to final size.

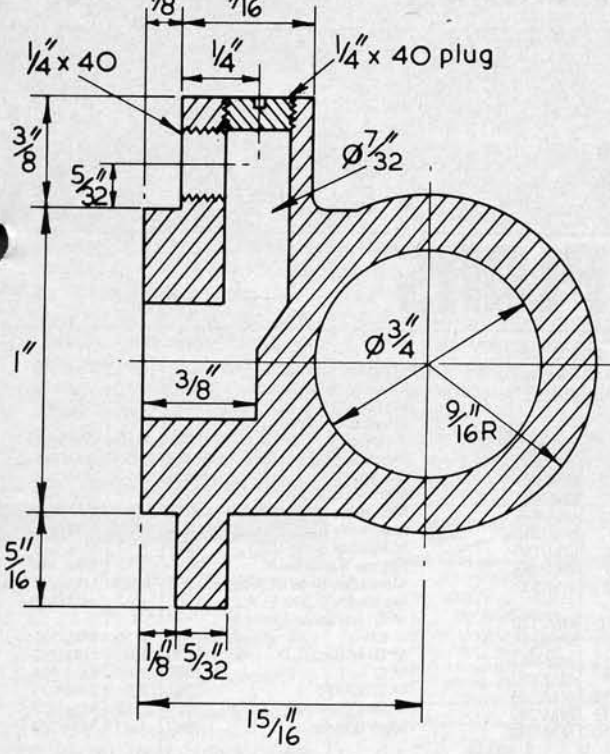
We can now carry out the boring of the cylinder, using the self-act, if the lathe has one, if not traverse the saddle by engaging the lead screw and using the lead screw handwheel. If no handwheel, the saddle can be moved by its own handwheel. Take care that, on completing the cut, the boring tool does not run into the chuck body; it can easily happen! Bore out to about 5 thou under ¾ in. dia., then remove the tool for sharpening, and take the final cut, putting the tool through the second time without altering the setting of the cross-slide, which should give a nice parallel bore. There is no need to use a reamer. Finish the second cylinder block in the same way, then mount each in turn on a brass mandrel held in the 3-jaw, to face off the other end to size. The brass mandrel is just a length of material turned down to a tight hand push fit, but turn it to fit the larger bore first, just in case there is any variation, then it won't be wasted for the second bore. It will need to protrude about 1½ in. from the chuck.

The port face and the bolting face can both be machined by using the vertical-slide, with an end-mill in the 3-jaw. If a machine vice is available that can be bolted to the vertical-slide and with an opening large enough to accept the cylinder block, well and good, the slide being set up facing the lathe spindle. If no suitable machine vice, a good set-up is to use two small angle plates bolted to the vertical-slide, the cylinder being put between the two, or a piece of threaded rod through the middle of the bore. Use large washers of some soft metal at each end of the cylinder to prevent the finished surfaces being marked. By carefully manipulating the handles of the cross-slide and the vertical-slide, the bolting flanges and the port face can be machined.

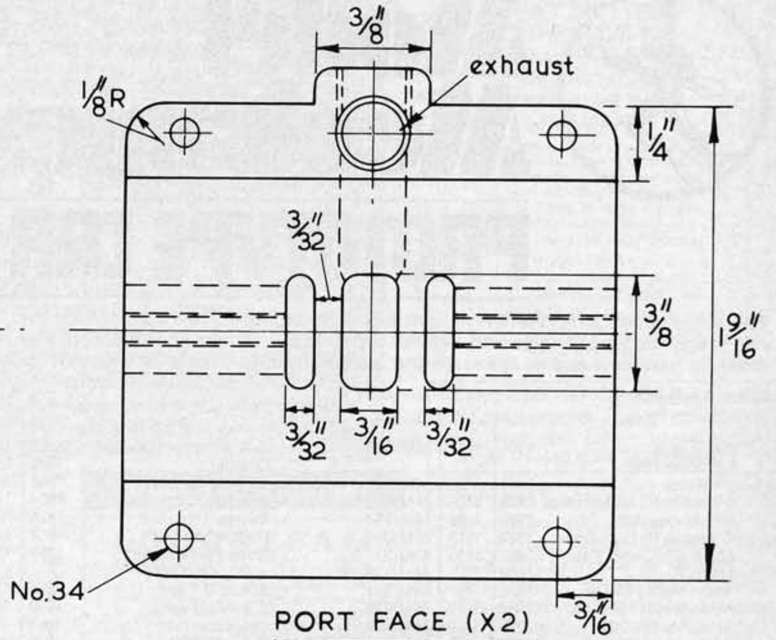
When end mills are used on small or light lathes, they generally leave a bit of a pattern on the work, so before proceeding further clean up the port face by rubbing it on a sheet of fine emery cloth laid on something really flat, surface plate if available, or a piece of thick plate glass, or even the lathe bed, but don't overdo this treatment, or the truth of the surface will be lost.

The same set-up can be used for cutting the ports, for which a $\frac{3}{32}$ in. end mill or slot drill can be used. Mark out the outline of the ports first, although the actual dimensions of the ports can be worked to by careful reading of the vertical-slide and cross-slide dials. The lathe should of course be run at top speed for such a small end mill, and the cuts taken must be strictly modest if the end mill is to survive. The ports are milled $\frac{3}{8}$ in. deep.

The steam passages consist of three No. 43 holes which are drilled as close to one another as possible. First file a chamfer on the edge of the bores, then centre-pop deeply, three countersinks $\frac{3}{32}$ in. apart. Use a drill a little smaller to begin with, say a No. 45, clamping the cylinder block in a machine vice on the drilling machine table or between two small angle plates. Even a large toolmaker's clamp can be pressed into service for this, setting the block at the desired angle to ensure that the drill breaks through in the right place by "sighting" it against the block.



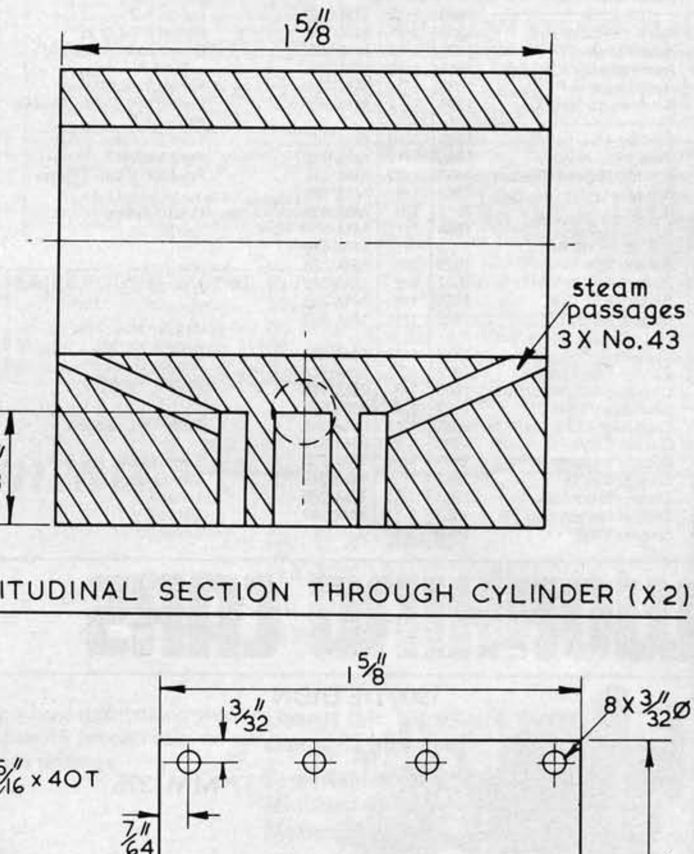
SECTION THROUGH EXHAUST PORT (X2)



PORT FACE (X2)

The exhaust is formed by first drilling $\frac{7}{32}$ in. dia. straight down in the boss provided on the top of the cylinder until it meets the exhaust port (be careful not to go too far and break into the bore!), then tapping this hole ¼ in. × 40t. to a depth of $\frac{3}{16}$ in. and plugging with a short length of brass or gunmetal threaded to match—leave the threads of this a bit on the tight side, then there will be no leakage—finally drill $\frac{7}{32}$ in. dia. again at right angles to the first hole, and just above the port face, tapping this ¼ in. × 40t. for the exhaust pipe.

In the next article, we will deal with the covers, steam chest and pistons.



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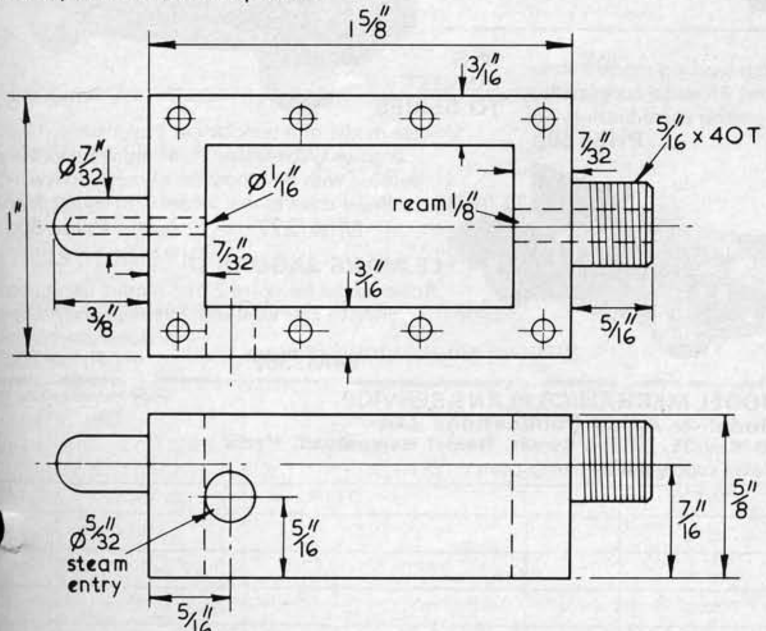

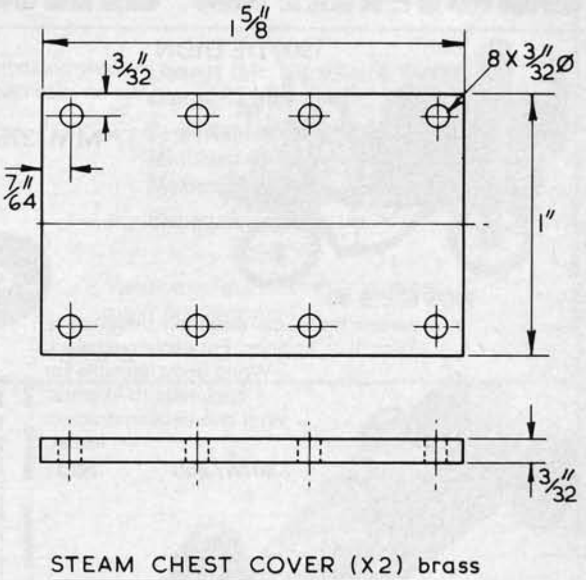

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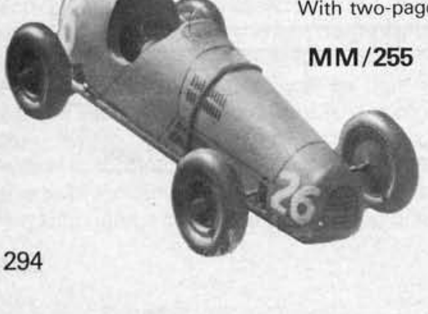

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Tether Car Racing

By Geoff Sheppard

HAVING COMPLETED THE chassis for the 'M.G.' style car, we now turn our attention to the body. As I mentioned previously, this is probably the most simple form of an all metal body, the main structure being formed from one piece of 18 swg aluminium sheet, requiring to be bent in only half a dozen places to get the desired form. The four main bends are made over a piece of $\frac{5}{16}$ in. dia. bar, whilst the others are curves in the body sides to match the shape of the chassis.

The first step is to draw out the flattened or "developed" form of the body on the aluminium. I doubt if it will be possible for the Editor to include a full size drawing for this, so I have tried to give the essential dimensions (Fig. 1). There are probably many readers who do not like the proportions of the car I have drawn (they were quite arbitrary) and some of these may wish to design a body for themselves. I will therefore describe the steps I took to construct the shape so that they may use the same principles if they wish.

The datum lines are the centre lines (AB) and the two transverse lines at the top of the bonnet front (CD) and at the change of chassis section (EF). It is now necessary to determine the widths of CD and EF, each side of the centre line. If the design calls for a body of rectangular cross section with sharp corners to the bonnet (highly unlikely), then it would be a simple matter of making CD and EF the same as the chassis widths at the appropriate points. My choice is for a taper from bottom to top of about ¼ in. from the front to the mid-section, with near enough vertical sides at the rear; so the top of the bonnet must be narrowed by the appropriate amount in relation to the chassis pan. A further small allowance must be made to accommodate the radius, as shown in Fig. 2.

After setting widths CD and EF, join CE and DF to show where the centre of the folds must be located. Now construct lines at right angles to CE and DF at each of the four points.

From the chosen side elevation of your car, measure the height at points corresponding to CD and EF. Mark off the

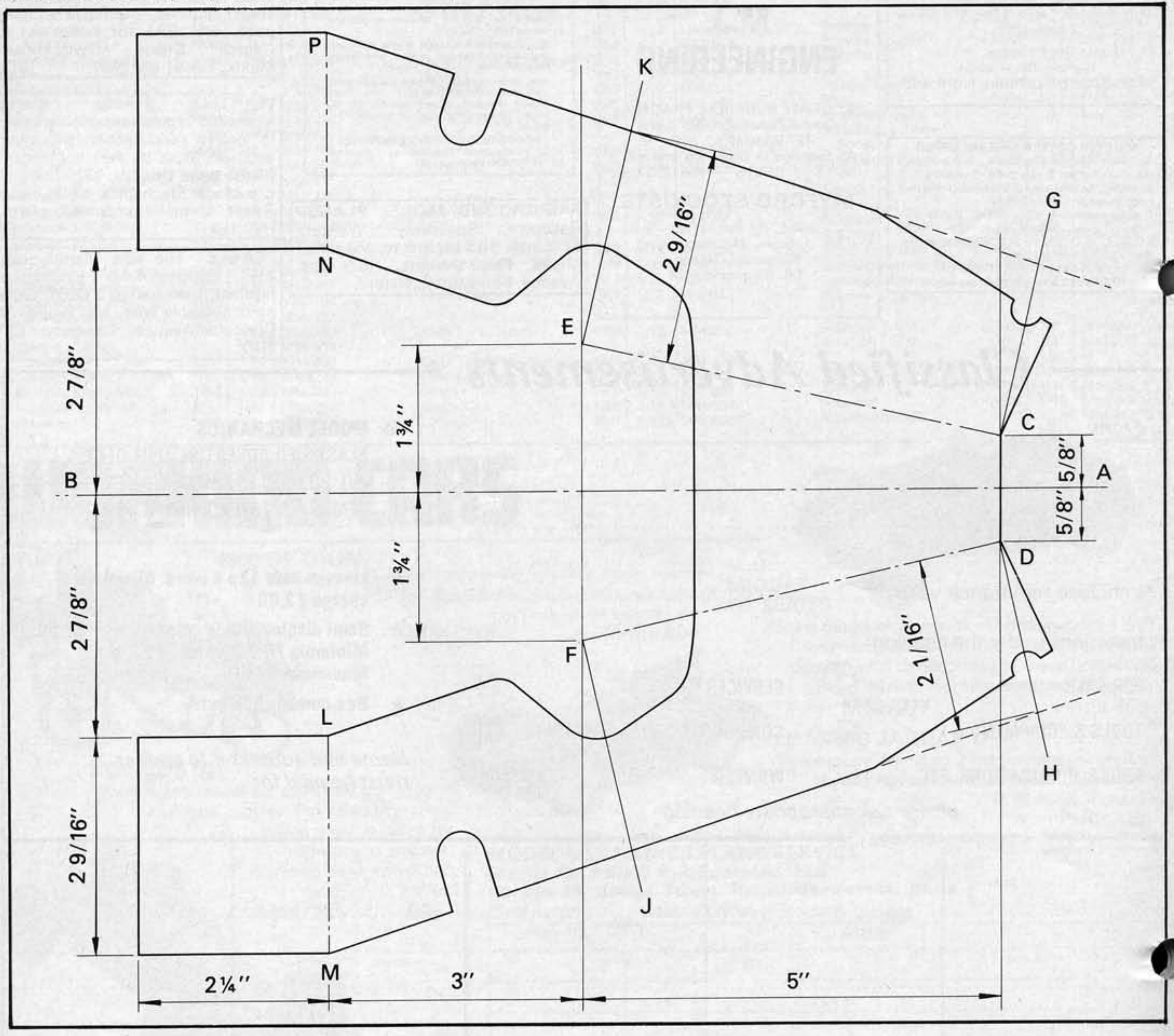


Fig 1 Development of the body shell

former on both CG and DH and the latter on EK and FJ, remembering each time to deduct the allowance for the radius. Lines projected through GK and HJ define the flat base lines of the finished body.

A template of the side elevation of the body will now help to achieve two sides of similar shape. Lay it in turn on each base line GK and HJ, using CG and DH to locate it in a fore and aft direction, and trace round it. Fair in the shape of the cockpits sides to the scuttle, freehand.

The lines for the rear folds LM and NP can now be constructed, each again being moved towards the front of the car by the allowance for the radius.

Lines at right angles at L, M, N, and P show the top and bottom edges of the flat near surfaces. The lengths of each of these rear "flaps" should be made about ¼ in. more than half the width of the car to allow the butt joints to be matched after folding.

Clearance slots for items such as front and rear axles and the cut-aways up to the base of the radiator shell can now be marked in and the sheet should be ready for cutting. When cutting out, leave $\frac{1}{16}$ in. to $\frac{1}{8}$ in. of spare metal around the inside of the curves of the cockpit outline. Should any distortion occur here, the profile can be corrected by filing after bending.

With the edges of the developed body cleaned up, grip a length of $\frac{5}{16}$ in. dia. steel bar firmly in the vice, with about 6 in. overhanging. Position the sheet over the bar with one of the bonnet fold lines, say CE, along the centre line of the bar. Gently press the metal down each side of the bar, being careful to keep the fold line in position, until the desired angle between the top and the side has been reached. Now repeat with the other fold.

Try the job over the body pan to make sure things are shaping up properly. A bit of tweaking here and there may be necessary to make things fit, and to ensure that the bonnet top is horizontal at both radiator and scuttle positions and that the sides have the correct slope. If any adjustment is required remember to make only one move at any one time before checking and to make it a small one. Once you have over-done things with sheet metal it can be very difficult to shift it back without ruining the appearance.

When satisfied with the front end, set the body over the chassis pan to locate the slight bends along the sides where the chassis changes section. It is perhaps better to put these curves in with the fingers, rather than get too hard a bend over a bar.

The rear end bends are made in exactly the same way as those for the bonnet, and when finished, the top and bottom edges of each side should be coincident when the rear side panels are square. Any small errors can be taken out with a file when the back end is finally bolted up. This is achieved using a lap strip about 1 in. wide and a couple of rows of small countersunk screws, with the nuts inside. If the lap strip is cut over-length, then bent into an L shape, you will have a convenient means of attaching the rear end of the body to the chassis.

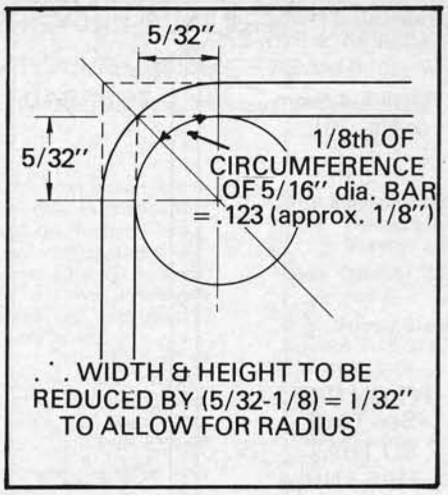


Fig 2 Allowance for effect of radius

Radiator Shell

It is often said in the vintage car world that, when the uninitiated come across an old car at a rally, the first thing they examine closely is the radiator, and the second is the dashboard. The dash, if you wish to fit one, I will leave to your own choice, but I will outline the method I used to make the shell. The principle is exactly the same as used by the steam boys to make boiler end plates, but using brass instead of copper. The first thing required is a former around which to shape the brass. A piece of hardwood is quite acceptable as a former for a one-off job, but for all my flanged plates I now prefer to use ½ in. thick aluminium sheet, so I looked through the scrap box for an off-cut of suitable size. I keep all the off-cuts for an opportunity to use the evening class foundry, when all the odds and ends get remelted and poured into a slab ½ in. thick, ready to make new flanging plates.

Stand the body shell nose down on your chosen piece of material and scribe around the inside onto what will be the rear face of the former. Cut out and clean up to this line, then, maintaining this shape on the rear face, relieve the sides by filing at an angle towards the front face to create a taper on the top and sides which will match the line of the top and sides of the body. Check this by offering the former up to the front of the body when it is sat on the chassis, to see if the body line is continued into the former. Remember that the former must be smaller than the body by a little more than the shell thickness to be used.

Place the former, front face down, on your piece of stock brass and scribe around. Scribe another line all round about $\frac{3}{8}$ in. away from the first and cut out to this second line. Before the brass can be beaten over the former, it must be softened by annealing. Heat the brass with a blowtorch (one of the modern butane fired devices is ideal for this) until it glows dull red in a subdued light. It may then be quenched in cold water. Lay the former with its front face against the brass, within the original scribed line (which should still be visible after annealing) and grip firmly in the vice with one edge protruding. Soft jaws, or some form of packing must be used to stop the jaws marking the brass. I often use a second former, cut from chipboard to provide a backing, because it helps to keep the plate material close to the former during the "bashing" process.

With a soft mallet (hide or plastic faced) knock the protruding flange of the brass over the former. Do not attempt to knock it down completely in one place straight away. Work right round the job moving it in the vice as necessary, taking the flange down bit by bit.

You will not do it in one go. The metal will work harden and you will feel a resistance to the mallet blows. It is then time to reanneal. The corners will be the difficult areas. If you think about the shape of the finished product compared with the original flat plate, you will realise that you are having to "lose" quite a lot of material. This is partly achieved by a thickening (and also a lengthening in a fore and aft direction) of the material. Be careful not to crease the metal near the corners, as once this happens, it can be difficult to restore a smooth finish.

Do not be afraid to re-anneal. This may be necessary six or seven times before the shell comes down close to the former all

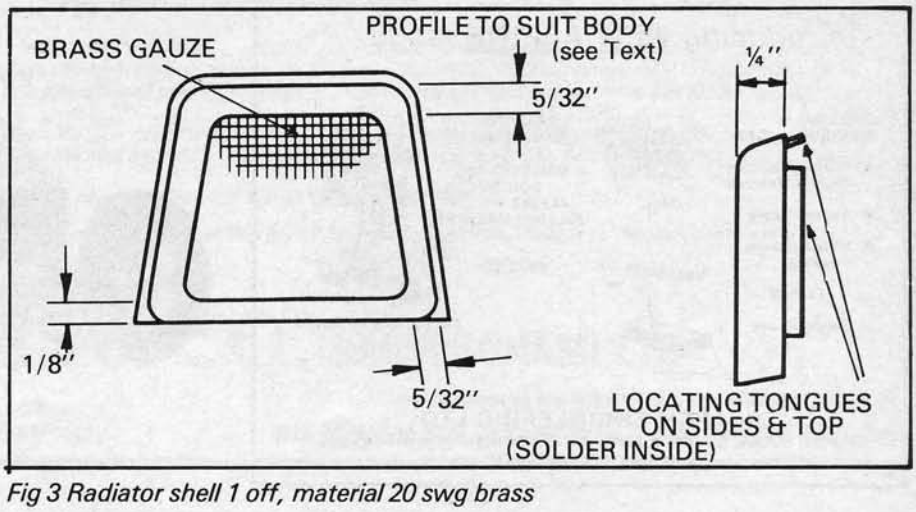


Fig 3 Radiator shell 1 off, material 20 swg brass

round. The one saving grace is that the mass of metal under consideration is very small, so it does not take long to get to red heat. I can assure you that a backhead for a 5-in. gauge loco boiler, in ⅛ in. thick copper is quite a different matter!

When the shell fits snugly to the former all round (including the flat front face), place it face down on a flat surface and with the scribing block set to the appropriate height, scribe all round the flange. Grip the shell carefully in the vice with a piece of packing in its centre, and with saw and files, trim off the excess metal from the flange.

The next task is to create the centre aperture. This is done simply by marking out, chain drilling just inside the scribed lines, chiselling out the bit between the holes and cleaning up by filing.

To complete the shell, solder in a bit of brass gauze and the 3 small strips of brass which form the tongues which locate inside the body shell. I suggest soft solder for the beginners. The first time I tried this I used silver solder. Concentrating very hard on the soldering task, I overheated the gauze and burnt a hole in it — most frustrating! Do try to get the strands of the gauze running vertically, or at 45°. There is nothing worse than a shell with a mis-shapen grill. The completed shell is bolted to the top of the chassis apron.

Dummy Fuel Tank

Many of the cars of this era had the fuel tank mounted across the rear of the body. If you think this will improve the appearance, again make it from thin sheet brass over a hardwood former. Two flanged end plates and a wrap-around sheet will do the trick. This time I suggest that the former is left inside the finished tank. A swift clout if the push-stick slips, will ruin the appearance of your carefully formed hollow tank, and it will be very difficult to restore the shape.

Small woodscrews and epoxy resins will hold the lot together and a couple of woodscrews through the back of the body from the inside will hold it on. A couple of strips of thin brass judiciously placed will represent the attachment straps (loco boiler bending would probably be just right) and a turned aluminium filler cap will complete the appearance.

If your tastes are purely functional, leave the tank off and let the silencer outlet protrude through the rear of the body.

Tonneau Cover

The cover which kept the rain off the rear seats of these open cars will be ideal for hiding the machinery. I shall leave mine off for running, so that plenty of air can circulate round the engine, only putting the cover on for "concours" events.

Anyone who is deft with needle and thread can have a go at a fabric one, but mine is simple flanged aluminium sheet painted matt black. Glueing fabric to the aluminium could well improve the appearance — I must get round to trying it some time.

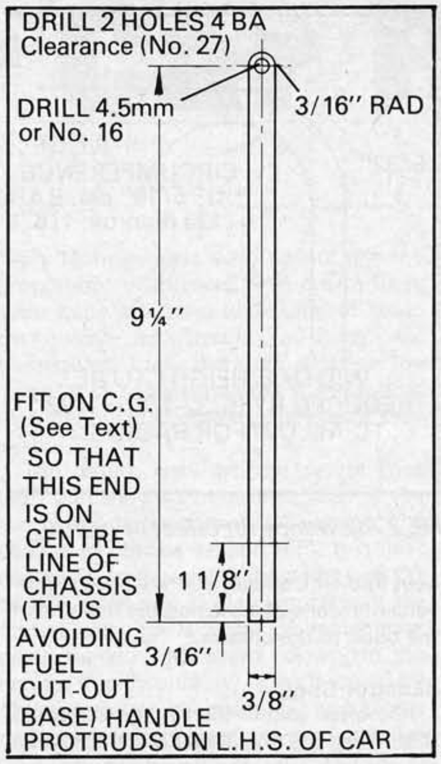
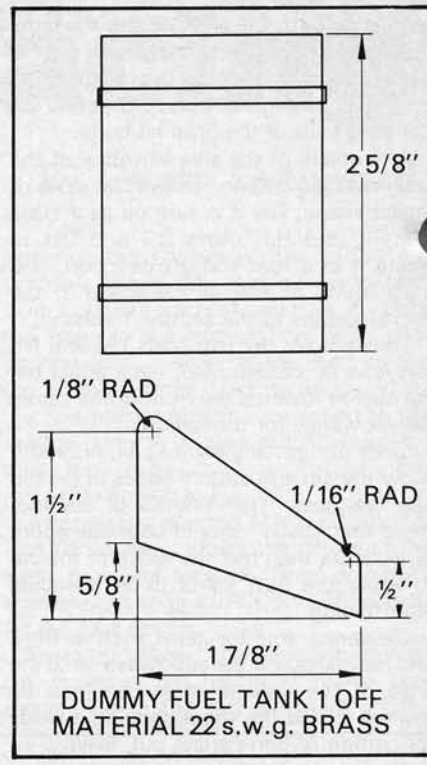


Fig 4 Pan handle 1 off, material ⅛ in. S/S



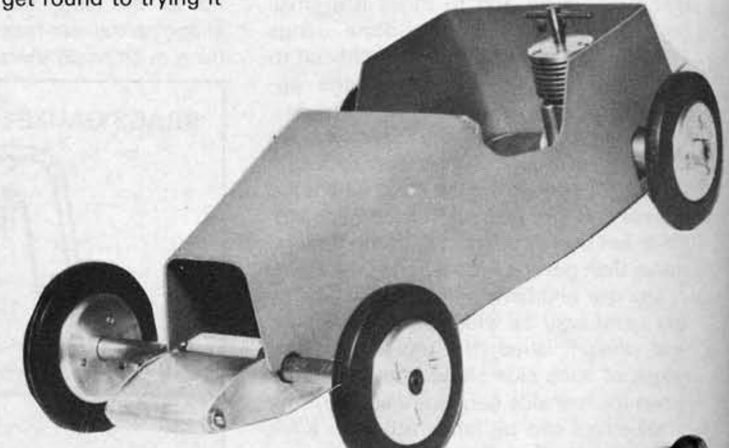
Dummy fuel

Pan Handle

The last, and essential item, is the attachment handle for the tether line. Stainless steel is the preferred material, firmly attached to the chassis with bolts and self locking nuts. It is located on the left hand side of the car for the reasons I outlined last month.

Its fore and aft position is set by finding the C of G of the completed car by balancing it on a knife edge (steel rule held in the vice). When attached, hang the car up by the hole in the handle and bend the latter until a line through the axles sits vertically.

The second tether design should now be ready for a tank full of fuel and its first trial run. I hope all your lap times are low!



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