Model Mechanics

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MAP HOBBY MAGAZINE

MILEAGE MARATHON

Model Mechanics

Volume 1 Number 9
October 1979

BOOK REVIEW

I have just received a list of over 70 instructional manuals published by the E.I.T.B. (Engineering Industry Training Board), plus three of the manuals to review which I feel would be most useful to any mechanically interested person. These books are designed for a one year off-the-job training for apprentices and technicians. The first one **First Year Training No. 2**, covers fitting, forging and hand skills. It is beautifully illustrated throughout with short, but very precise descriptions of how and how not to do a particular operation, from reading engineering symbols, marking out, hand skills, fitting components, to actual forging techniques. The second manual **F.Y.T. Booklet No. 13—Mechanical and Instrument Fitting**, is ideal for anyone considering constructing "Sweet 16" or the "Eagle". The contents include: securing devices i.e. screw nuts, liquid sealants, etc., assembly techniques, bearings, gears, springs, plus pipe work, bending, joining plastic tube etc., etc. The third manual **Module H3 Mechanical Fitting 1**, is designed to develop the skill of engineering craftsmen. Once again, simply illustrated with precise instructions. Areas that are of particular interest to the model mechanic are marking out, clamping techniques, drilling and boring, hand grinding of tools and scraping bearings. These books are tremendous value at £1.10, £1.20 and £2.55 respectively.

A complete list is available from:
The Publications Dept., E.I.T.B., P.O. Box 176, 54 Clarendon Road, Watford, Herts. WD1 1LB.

A First book of Metalwork by Bernard Cuzner. 162pp. Published by Unwin Brothers Ltd., The Gresham Press, Old Woking, Surrey. Price £2.50.

The author was for many years head of the Metalwork Department of Birmingham Technical College, and in this book covers the field of general metalwork in a form suitable for students with limited equipment.

After a short chapter on metals and their uses, Mr. Cuzner deals with the essential tools for metal-working, including such things as the bench, the vice, the anvil, hammers and mallets, files, shears, pliers, stakes, drills and saws. Measuring equipment and screwing tackle is briefly dealt with, also equipment for soldering, silver-soldering and brazing.

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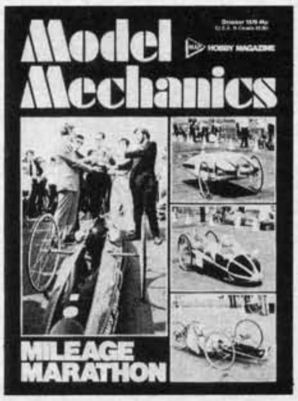

Cover pictures of the Shell-Motor Mileage Marathon. Photographs by courtesy of Shell.

On the right a photograph taken by a beam of light. See Opto Electronics in this issue.

Contents

MM Query Coupon
October 1979

Opto Electronics

By Roger Barrett

OPTOELECTRONICS is one of the more recent branches of electronics, and is one which has grown very rapidly over the past few years. The 'man in the street' may know nothing of the word, but it is pretty certain that he owns or has access to a pocket calculator; this calculator will include a numeric display which is one example of the technology of optoelectronics. In fact it can be argued that without the development of such displays the pocket calculator boom would never have happened, and our arithmetic would be as good (or as bad) as it was twenty years ago.

This type of display is only one of the aspects of optoelectronics which I would like to talk about, and I intend to make my discussion a bit wider than a description of the latest technology.

Light Sources

The most useful source of light in any of our lives is the sun, but we all know that it is not always the most convenient or reliable, especially during our holidays. Primitive man relied entirely on the sun for light until he was able to harness fire for his own use. The great advantage was of course that fire could be turned on when it was needed, unless the wood was damp. Fire, in one form or another, remained the only practical artificial light source until 100 years ago when Swan invented the incandescent filament lamp. In the past 100 years the filament lamp has become the most widely used light source in our civilisation, and it has hardly changed in that time.

The principle of operation is delightfully simple. Inside the glass bulb is a filament of tungsten wire which is heated by the passage of the electric current. We all know from experience that hot bodies give out light and that the colour of the light depends on the temperature. The terms 'red hot' and 'white hot' have meaning for all of us, although it takes a skilled observer such as a blacksmith to gauge the temperature accurately from the colour.

The filament of a lamp is white hot, which means that its temperature is about 2,500°C. If the current in the lamp is increased by increasing the voltage across it, its temperature rises and it becomes brighter. Unfortunately you get 'nowt for nowt' and in this case you pay for the extra light with a shorter life. The effect is quite dramatic; take as an example an ordinary household light bulb which is meant to run at 240 volts and to give a life of 1,000 hours. If this is run at 260 volts it will give almost twice the light but its life will be reduced to about 100 hours!

Filament lamps come in a vast range of shapes and sizes from 1,000 watts or more down to 0.1 watts as used in electronic equipment and of course in models. Fig. 1 shows a selection of miniature and sub-miniature lamps used in these applications.

Light Emitting Diodes

The light emitting diode, or L.E.D. as it is usually called, is the most recent development in artificial light sources. The LED is very different from the incandescent lamp in that it does not give out light because it is hot. The light comes from a semiconductor junction and is generated by the flow of current through the junction. The light from a filament lamp is white, that is it contains all the colours of the spectrum in roughly equal parts. By putting a coloured lens on a filament lamp we can select any colour from blue through to the deepest red. This is not so with the LED which only gives light over a narrow range of colours. The material used for the LED, and the way in which it is processed by the manufacturer, determine the colour of the light. The lens merely improves the appearance of the device but does not have much effect on the colour.

The semiconductors used for LEDs are generally compounds of gallium, arsenic and phosphorous. By varying the mix in the recipe the colour can be changed from green through to deep red. Unfortunately, there is not yet a practical blue emitter, but the international signal colours of red, amber and green are easily made.

The active part of the LED is usually very small, in the region of 0.015 inches square. This is rather small even for a miniature indicator, so the chip, or die as it is often called, is normally mounted on a metal structure and the whole assembly is encapsulated in a transparent epoxy resin. This type of construction is shown in Fig. 2. Other constructions are also fairly common although the finished size and shape does not vary very much as can be seen from the examples in Fig. 3.

LED Numeric Displays

The same kind of chip used in the LED indicators shown above is used in the so-called 'seven segment' displays used so widely in watches, clocks, calculators and so on. These displays are made up of seven bars and each of these is lit by one or more LED chips. By selecting the right combination of bars or segments the unit can be made to display numbers 0 to 9 and also a few letters.

In some of the displays, normally the small ones, each segment is a long thin LED chip. This would be too expensive for

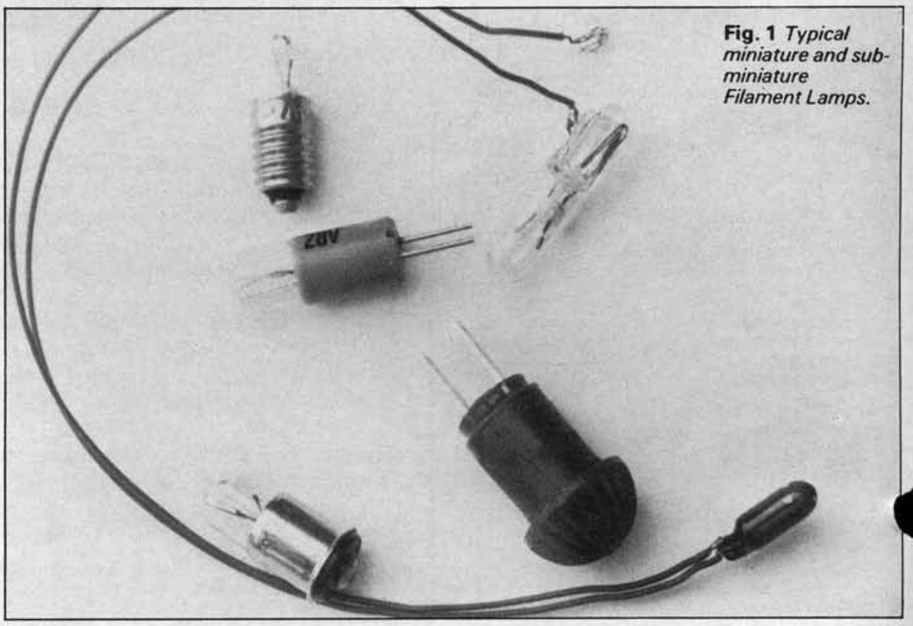

Fig. 1 *Typical miniature and sub-miniature Filament Lamps.*

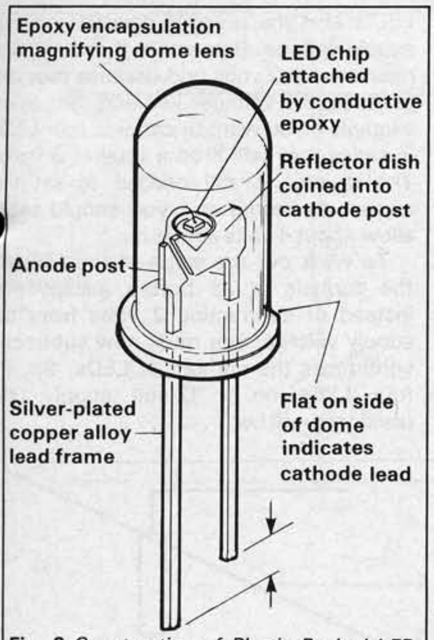

Fig. 2 *Construction of Plastic Packed LED.*

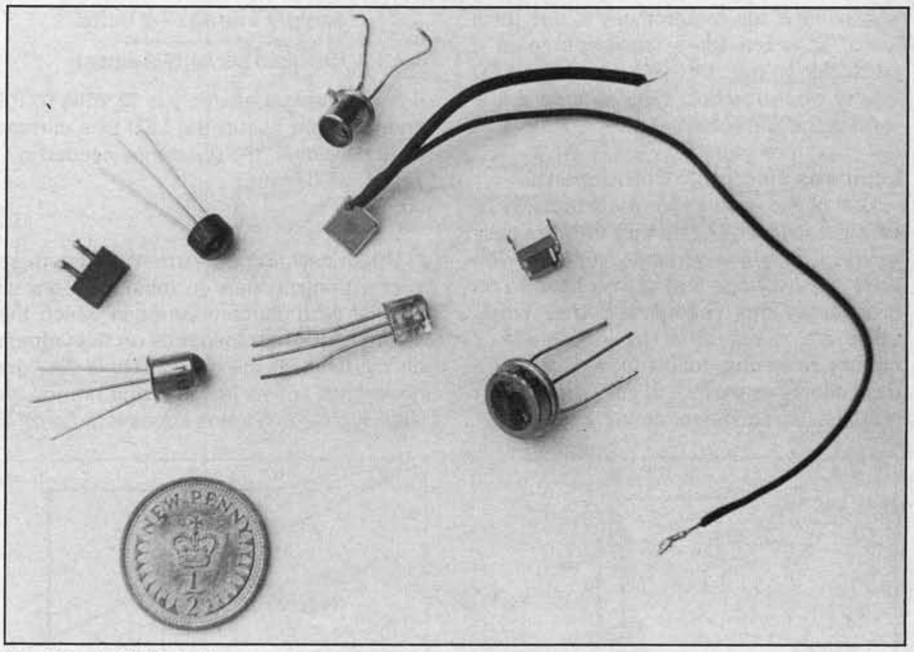

Fig. 3 *Typical LED Indicators.*

the large types which use the technique shown in Fig. 4. The LED chip is mounted at the base of a wedge-shaped tube called a light-pipe. The light from the chip bounces round inside the light pipe and most of it comes out of the wide end which forms the segment. The end is normally covered with a diffusing material which gives a more even illumination.

Fig. 5 shows some typical displays, one of which has been dismantled to show the light-pipe and diffuser.

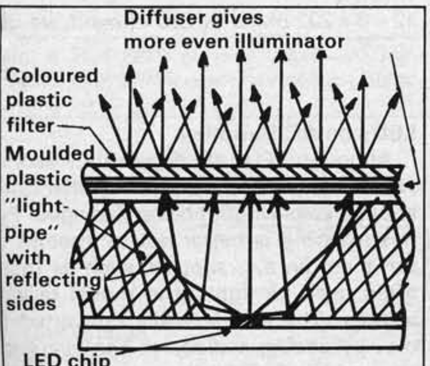

Fig. 4 *Light-Pipe used in large seven-segment displays, showing how light from LED chip is reflected forward to form a "Bar" of light.*

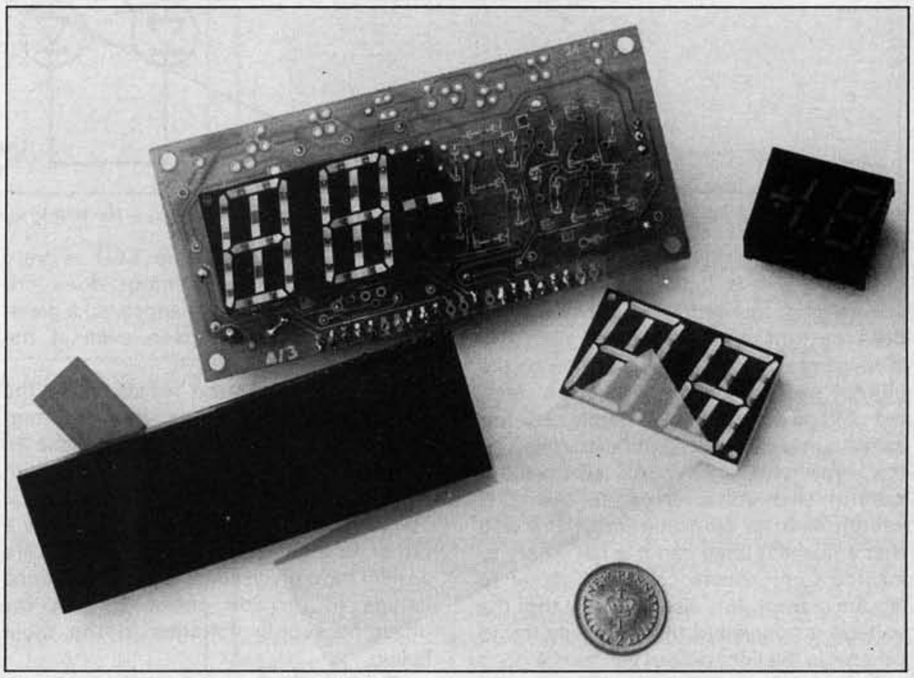

Fig. 5 *Typical Seven-Segment LED displays.*

Infra-red Emitting Diodes

I said that the colour of the light given by a LED is determined by the particular compound from which the diode is made. If the material is gallium arsenide, whose chemical formula is GaAs, the radiation given out is in the infra-red part of the spectrum and is not visible to the human eye. This type of device, often called an IRED, is pretty useless as an indicator but is easily sensed by silicon sensors which I will talk about later. The great advantage that IREDs have over LEDs is that they are more efficient at converting current into radiation. (The term 'radiation' is used to describe any part of the electromagnetic spectrum which is not visible and should not be confused with radioactivity). For this reason they are used in such applications as burglar alarms, computer tape readers, counting objects on conveyor belts etc.

Uses of Light Sources

In the days of primitive man the artificial light source probably served only one purpose and that was to enable him to go about his business after the sun had set. In other words the lamp was used to throw light on some object or scene that our caveman wanted to see. We still use our electric lamps in this way, but there are other ways that we use them too. On a car for instance we have headlights which illuminate the road in front of us; the caveman may have used his oil lamp for the same job. The tail lights on our cars serve a different purpose and that is to warn other people that we are there. The lamp is there to be seen and not to make other things seen. We also have direction indicators on our cars which again are there to be seen, but more than this they are intended to convey a message to others.

These simple examples serve to illustrate the three basic functions of lamps, that is to illuminate, to indicate and to communicate.

If we are looking for a light source to illuminate either a house or the interior of a model railway coach, we will generally choose a filament lamp because it gives 'white' light, a bit like sunlight, and gives plenty of it. So, for sheer brightness the filament lamp is the 'best buy', but what about the other uses?

A lot of lamps are used in models not to illuminate but to indicate and to signal or communicate. For many of these applications the requirement is not for a lot of light but for a small source of a particular colour. In these cases the LED is very often the best type of lamp if it is used in the correct way.

Lamps as Electronic Components

One of the reasons for the popularity of filament lamps must be that they are easy to use. They are generally marked with their rated voltage and all you have to do is to apply this voltage and they work. LEDs are rather different in use but if certain rules are followed they can be used almost as easily and can give a much more realistic appearance to models.

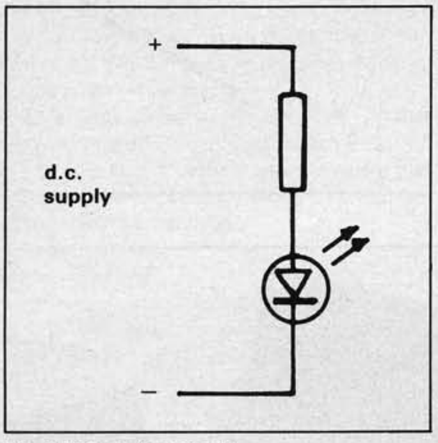

Fig. 6 *LED on d.c. supply.*

The LED is basically a semiconductor diode and if it is forward biased (anode positive with respect to the cathode) it will pass current and give out light. The amount of light given out depends on the current and not on the voltage. In fact, the voltage across an LED hardly changes as the current changes, and depending on the type will always be somewhere around two volts. Because the LED cannot limit its own current in the way that a filament lamp can it is necessary to include some resistance in the circuit to set the current. It is also essential that the voltage is connected the right way round otherwise the light output will be nil!

The circuit arrangement is shown in Fig. 6 and is very simple. If the supply voltage is known, the value of the resistor can be worked out using Ohm's Law as follows.

First decide the current at which the LED is to be run. There is a maximum value above which the life will be reduced and a minimum value below which the light output will be too small to be useful. Generally a current of 10 to 20 milliamps is suitable.

Now, we know that the voltage across the LED is about 2 volts so the rest of the supply must be across the resistor. The current through the resistor, and therefore through the LED, must be equal to

$$\frac{\text{Supply voltage} - 2\text{ volts}}{\text{Resistance (in ohms)}}$$

By a simple bit of algebra we then can say that the resistance we require is given by

$$\frac{\text{Supply voltage} - 2\text{ volts}}{\text{Required current (in amps)}}$$

If for example the supply is 12 volts (d.c.) and we want to run the LED at a current of 20 milliamps, the resistance needed is

$$\frac{12-2}{0.02} = 500 \text{ ohms}$$

When deciding the current to use there is one thing to bear in mind. We are all familiar with filament lamps in which the colour of the light depends on the voltage on the lamp. If the car battery is flat, the headlights appear to be a dull orange. A lamp with a green lens appears to be off if

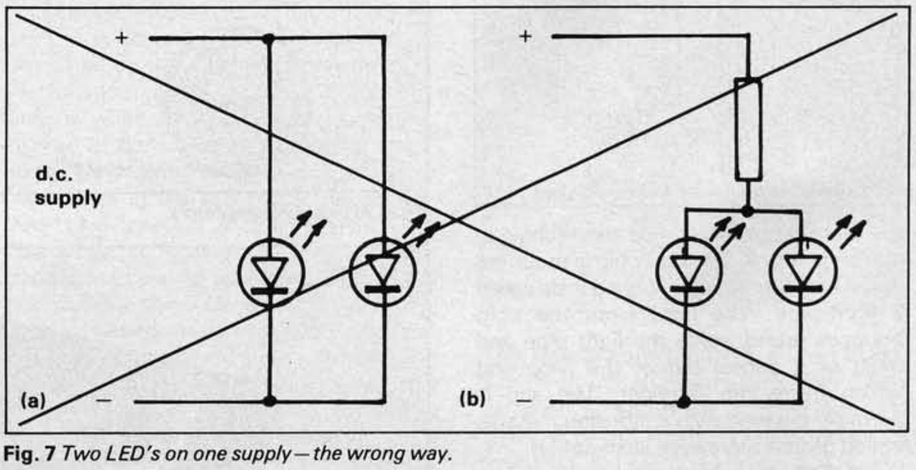

Fig. 7 *Two LED's on one supply—the wrong way.*

the voltage is low. The LED is very different in that the colour does not change as the current changes, so a green LED will always be green even at the lowest current.

If you work out the resistance in the way described above you may find that the value you arrive at is impossible to buy. This is because resistors used in electronic circuits are made in certain "preferred" values. These values follow a rather strange sequence, so to make life easier I have given some typical resistance values to provide about 20 mA for different supply voltages in the table below

Table 1: Preferred Resistance for various supply voltages for Fig. 6 circuit

Supply Voltage (volts)	Preferred Resistance (ohms)
5	150 ¼ watt
6	220 ¼ watt
9	390 ¼ watt
12	560 ½ watt
14	680 ½ watt

LED's in Series

In many cases you may want to run more than one LED from a supply so that they are on or off together. Of course any number of filament lamps can be put across a supply, but the situation with LEDs is a bit different. It is possible to use the LED plus resistor (Fig. 6) like a filament lamp, but the arrangements of Fig. 7 should never be used. The best way to arrange them is in series using a single resistor a shown in Fig. 8b). In this arrangement it is possible to use several LED's and the number depends on the supply voltage. Remember that each one needs about 2 volts and because they are in series, the voltages just add. So, as an example if you want to connect four LEDs in series they will drop a total of 8 volts. The resistor is still needed to set the current as before and you should really allow about 4 volts across it.

To work out the value of the resistor, the formula is as before except that instead of subtracting 2 volts from the supply voltage, you must now subtract 2 volts times the number of LEDs. So, for four LEDs on a 12-volt supply, the resistance will be

$$\frac{\text{Supply voltage} - (4 \times 2)}{\text{current}}$$

which is

$$\frac{12-8}{0.02} = 200 \text{ ohms}$$

or 220 ohms if we use value.

LEDs on AC Supplies

Although LEDs are diodes they cannot withstand reverse voltages greater than about 5 volts without being damaged. For this reason it is better not to attempt to run them on a.c. supplies such as those often used for lighting in model railway layouts, The a.c. is easily converted to d.c. by adding a diode to the circuit as shown i Fig. 9. This allows current to flow in one direction only and for this reason the effective voltage is reduced (for the conservation-minded readers, the power is not wasted because the diode prevents current flow in the reverse direction). If this arrangement is used, the a.c. voltage shnould be halved to give the approximate value of the d.c. obtained. So a 14 volt a.c. supply driving one LED needs a diode and a resistor of 270 ohms.

Advantages of LEDs

The real reason for the development of the LED in the first instance was to provide a small, bright, reliable indicator for military and aerospace use. A modern airliner contains hundreds of indicator lamps and the reliability of filament lamps is such that it may be necessary to replace dozens of lamps after every flight. The LED on the other hand has an average life of about 100,000 hours, which is around

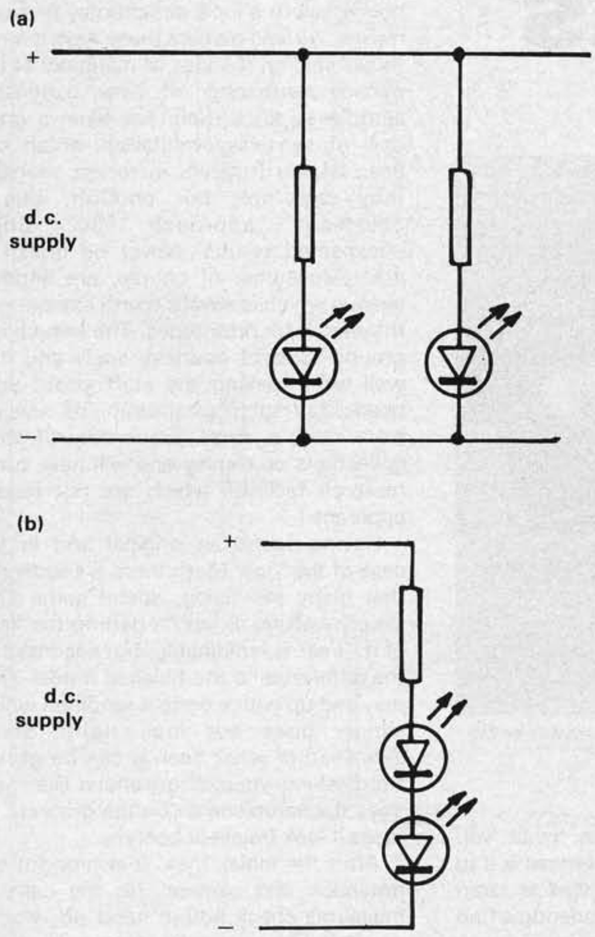

Fig. 8 *Two LEDs on one supply—the right way. (a) With individual resistors; (b) With a common resistor.*

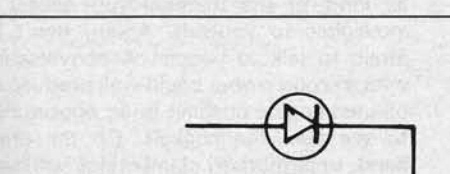

Fig. 9 *LED on a.c. supply.*

twelve years continuous use. They are also very rugged and are not greatly affected by vibration.

This long life may not be of great advantage to model makers, but the small size and low temperature will be. LEDs can be mounted in very confined spaces without any overheating problems and in the knowledge that they will probably never need replacing.

Scale projects

A philosophy of model making by Stephen Kent

Tiger Moth N6848 (G-BALX) taken at the recent Grouse Tiger Moth rally, which started at the Hawker Siddeley airfield, Hatfield, Herts.

A NUMBER of years ago, a friend of mine came out with a statement which has remained with me ever since. We were discussing the drawing of scale elevations of aircraft and he said 'never believe what has been done before, *look* for yourself'.

As a maxim, it has become a corner stone of my particular philosophy towards making models. Today it is all too easy for the newcomer to the hobby to be totally daunted by the high standards attained by the most talented members of the modelling fraternity and the plethora of equipment and aids available.

Perhaps worse is the snobbishness and so-called 'expertise' which has in the last decade infiltrated what used to be a most pleasant pastime. I stress the word 'pastime' for some would now have modelling as a life or death affair, taken to obsessive and irrational lengths. The youngster will be faced with X faction who decry any model which is not made in Y manner out of Z materials and their complete opposites, while Mr. A. will maintain that he knows exactly what a certain piece of machinery looked like even he has never actually seen one!

My first 'rule' is then that there is room for everyone from the builder of plastic kits to the engineer of the wonderful museum standard pieces, which I for one can only stand in open-mouthed awe at. Such awe is, however, nor or should not be destructive; it is respect due to a master craftsman and most certainly not an indictment of one's own lack of skills but rather a challenge to improve them.

Having hopefully established that any project executed at any skill level is worth while, let us go on and look at how the best results can be achieved. The first thing to establish is exactly what you want of your model. By this I mean is it to be a working model, one that is radio controlled or a true scale rendering of an original. This is vitally important, for each category has its own special needs. I must declare myself to be a devotee of static scale aircraft models and as such my rendering of an aerofoil shape will be very different from the fellow who makes a flying model of the same subject. His wing has to lift his creation from the ground and because of the nature of its construction and size, it may well be advantageous to subtly alter it from the original upon which it is based. This may seem a very obvious point to many, but I think it is of vital importance to the youngster who has his work criticised without a real explanation of what that criticism is based upon.

The second 'rule' is therefore to establish in your own mind exactly what it is you are trying to do. A clear direction from the start will save a lot of heartache along the way to the completed model.

The real starting point to the actual model building process is research. Once the original for the replica has been picked there is nothing else for it but to immerse oneself in it. This article contains illustrations of the de Havilland Tiger Moth which, apart from being a delightful little aeroplane, will serve as a focus for the text. Let us suppose that the decision has been made to produce a static scale model of such an aeroplane, how does one go about researching it?

The question of research brings us neatly back to the quote with which the article began, namely 'looking'. There is no substitute for observing the real thing. Of course this is not always possible but a phone call to a local airfield may produce results. Airfield owners these days are not totally sold on the idea of members of the public clambering all over expensive aeroplanes since there has been a great deal of senseless vandalism which has been all too frequent in recent years. If they say 'no', fair enough, but a courteous approach can bring unexpected results. Never be afraid to ask. (Museums, of course, are another avenue which is always worth exploring in the search for prototypes. The same basic ground rules of courtesy apply and it is well worth asking the staff about your needs for such establishments usually have only a small proportion of their collections on display and will have other research facilities which are not readily apparent.)

Having found an original and in the case of the Tiger Moth there are sadly not that many still flying, spend some time simply walking around it getting the 'feel' of it. 'Feel' is indefinable, but will make all the difference to the finished model. One may end up with a perfect rendition which simply does not look right. Some indication of what 'feel' is can be gained from asking yourself questions like 'how does the aeroplane sit on the ground?' or 'does it look fragile or beefy?.

After the initial 'look' it is time for the notebook and camera. (In the case of museums check before hand on what if any restrictions are in force concerning photography.) Make notes and sketches on everything and back these up with photographs if at all possible. You don't have to be an artist or photographer just as long as the material you collect is intelligible to yourself. Again, don't be afraid to talk to people. A conversation with a proud owner could well produce an opened engine cowling or an opportunity to see over the cockpit. On the other hand, unauthorised clamberings will have you marched double quick to the gate with a flea in your ear. At all times use your common sense and always have an eye to the future; better to be welcomed back than to be permanently banned from an invaluable source of information!

Opportunities to see prototypes are often rare so, to make the most of the visit, thoroughly prepare before hand. This brings us to the second side of research; namely books, magazines and photographs. Any model maker worth his salt will have a voracious appetite for the written word. magazines are without doubt the best starting point. A regular subscription to a couple of magazines will not only provide articles on your chosen subject but will provide information on shows and museums where prototypes may be seen, book reviews and a myriad of other useful tit-bits. Cast your net as wide as your pocket will allow and horde everything which comes your way. A reference library may not be too popular with the family, but will stand you in good stead for a lifetime's enjoyment.

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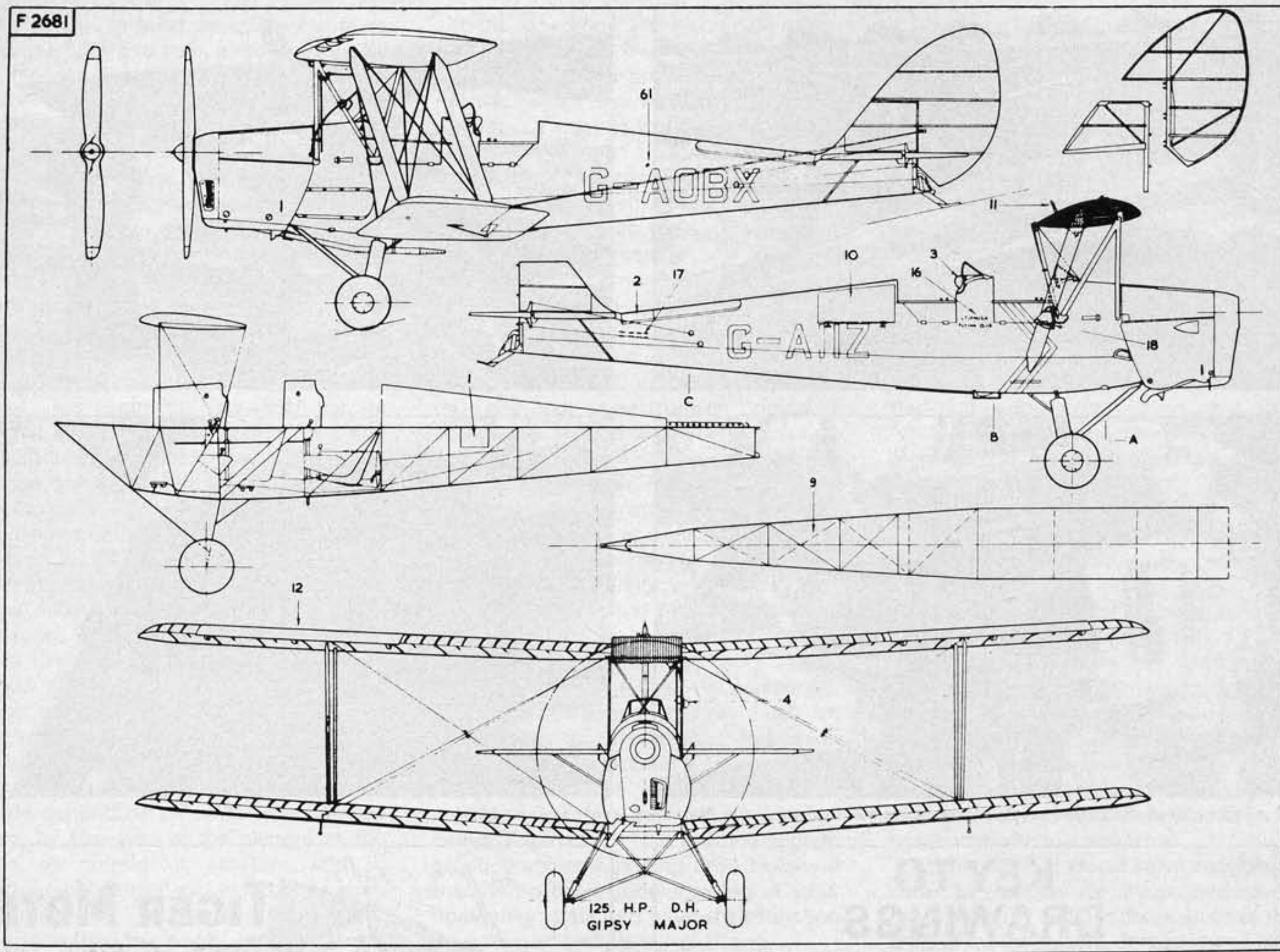
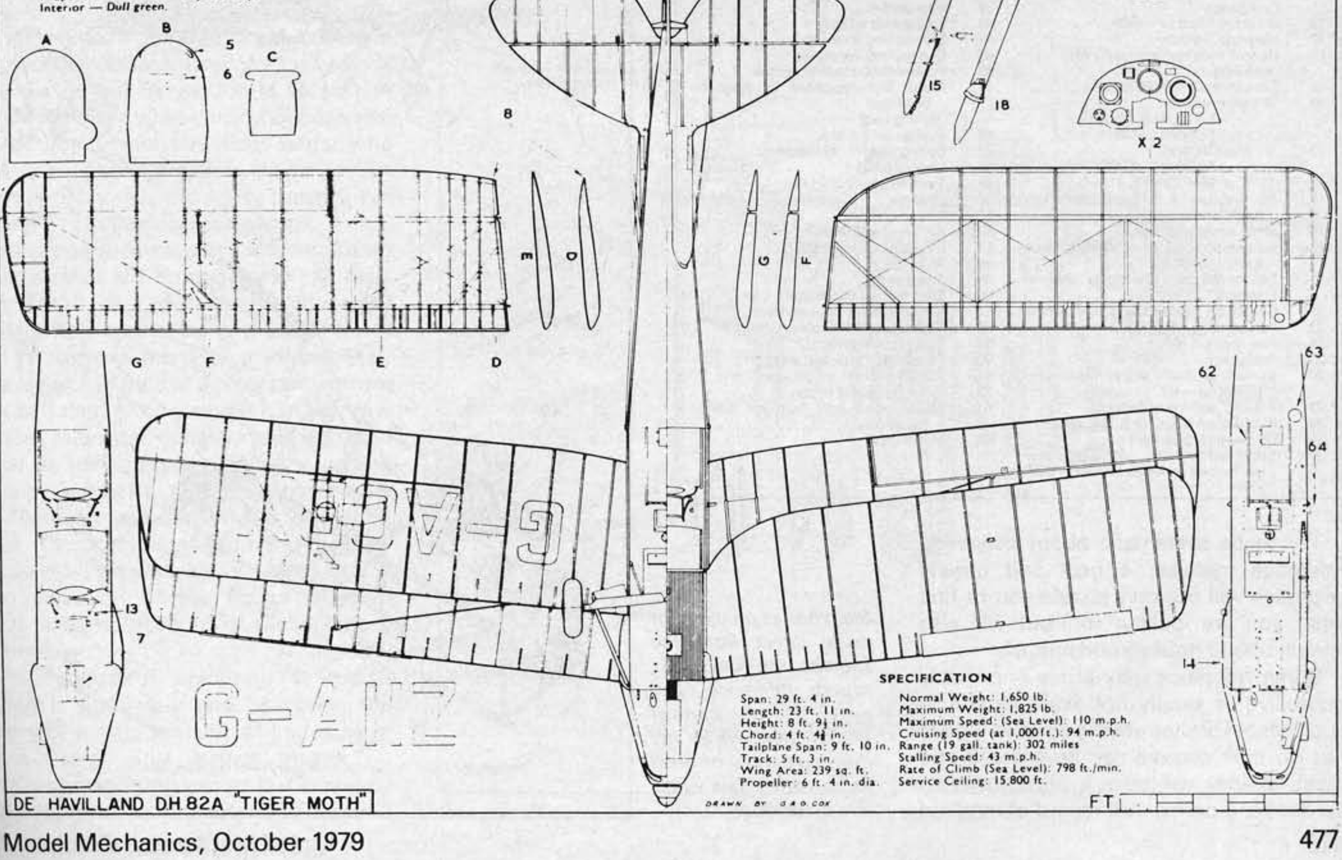


COLOUR DETAILS

G - AOBX
All Silver except :—
Malachite Green—Struts, wires, wheels, registration letters.

G - AIIZ
London Transport Red—Fuselage, Struts, Wires, Wing Registration Letters, Wheels.
Silver — Wings, Tail, Fuselage, Chevrons and Registration Letters.
Black — ¼" outline to Chevrons and Fuselage Lettering.

BOTH MACHINES:
Propeller — *Black with 4" yellow tip.*
Interior — *Dull green.*

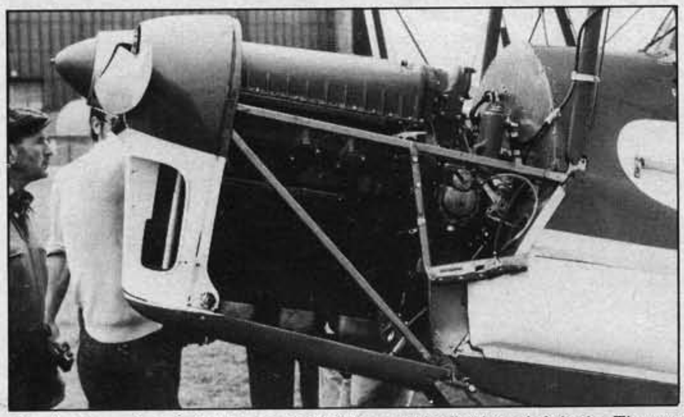


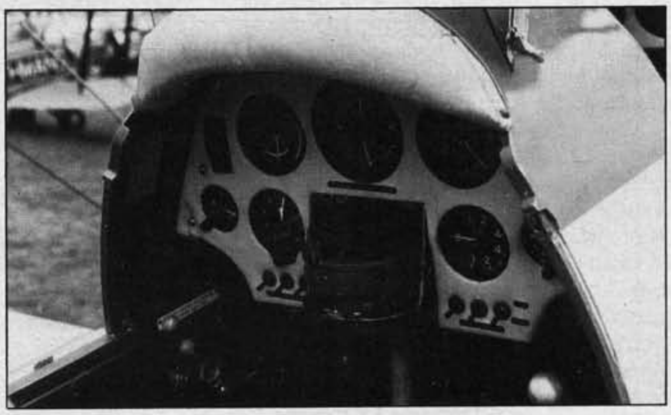
SPECIFICATION

Span: 29 ft. 4 in.	Normal Weight: 1,650 lb.
Length: 23 ft. 11 in.	Maximum Weight: 1,825 lb.
Height: 8 ft. 9¼ in.	Maximum Speed: (Sea Level): 110 m.p.h.
Chord: 4 ft. 4⅜ in.	Cruising Speed (at 1,000 ft.): 94 m.p.h.
Tailplane Span: 9 ft. 10 in.	Range (19 gall. tank): 302 miles
Track: 5 ft. 3 in.	Stalling Speed: 43 m.p.h.
Wing Area: 239 sq. ft.	Rate of Climb (Sea Level): 798 ft./min.
Propeller: 6 ft. 4 in. dia.	Service Ceiling: 15,800 ft.

DE HAVILLAND DH.82A "TIGER MOTH"

DRAWN BY G A G COX

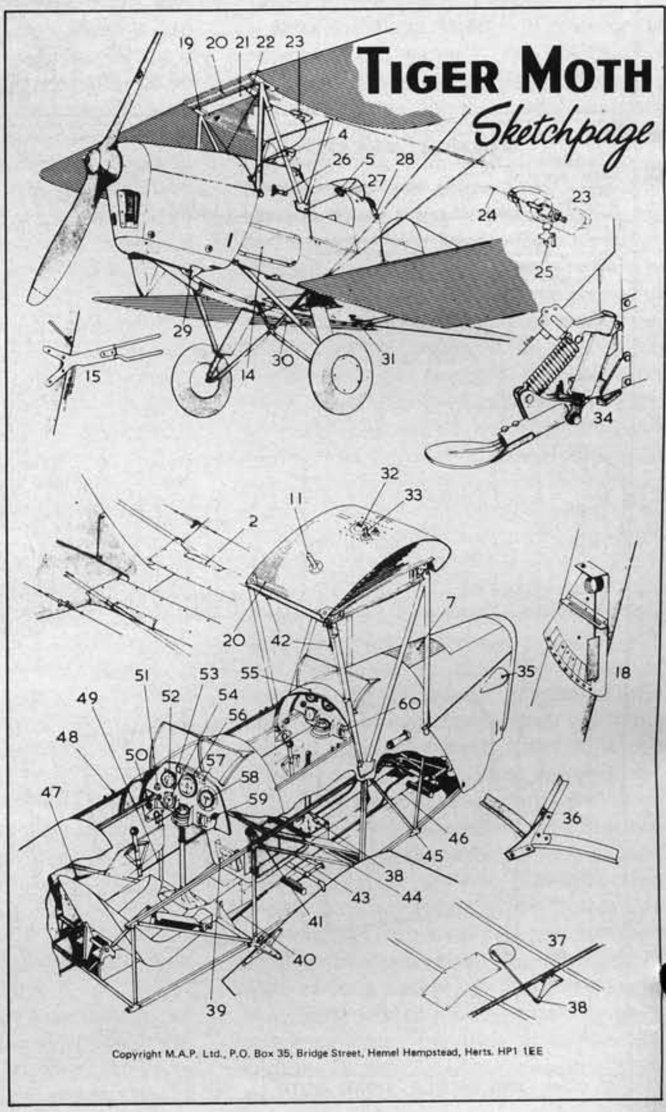




A selection of useful pictures again taken at Hatfield top left is the Thruxton Jackaroo Tiger Moth.

KEY TO DRAWINGS

1. First-aid stowage.
2. Chafing plates on anti-spin strakes.
3. Leather-covered crashpad.
4. Rear view mirror.
5. Handgrips in front cockpit only.
6. Slot for safety harness.
7. Corrugated step plate.
8. T.E. slopes up from aileron to root.
9. Bottom truss members shown dotted
10. Intercom. and baggage stowage.
11. Fuel gauge.
12. Slots not fitted to —OBX.
13. Magneto Switches.
14. Oil tank mounted externally for cooling.
15. Pitot on front starboard strut.
16. ¾" white letters: L.T.(C.R.S.) S.A. FLYING CLUB.
17. ½" black letters: MAX WT. 1825 lb. EMPTY WT. 1185 lb.
18. Air pressure A.S.I. on front port interplane strut of —IIZ.
19. Metal retaining plates.
20. Corrugations flattened locally to give a smooth strip.
21. Flat cover plate over spar shannel in tank.
22. Connector pipe across bridge of tank
23. Fuel sump.
24. Fuel shut-off rod.
25. Drain cock.
26. Venturi on both sides, chromium-plated on —IIZ.
27. Pressed aluminium fairing.
28. Rubber seal strips for B.F. hood.
29. Oil overflow pipe fairing.
30. Short exhaust on —IIZ, long pipe perforated on lower half on —OBX
31. Steadying arm for aileron return cable.
32. Filler cap.
33. Overflow valve.
34. Skid detail.
35. Carburettor air intake.
36. Chromium-plated windshield frames on —IIZ.
37. Aileron cam detail.
38. Leather cuff.
39. Map pocket.
40. Spring bias on rudder.
41. Slot locking lever.
42. Slot locking handgrips.
43. Parallel action rudder pedals.
44. Front seat mounted in diagonal bulkhead.
45. Jacking pad.
46. Rudder linking rod.
47. Spring bias for tail trimming.
48. Door catches.
49. Tail trim connecting rod.
50. Throttle.
51. Watch holder.
52. Air speed indicator.
53. Deviation card holder.
54. Altimeter.
55. Crash pad.
56. Turn and bank indicator.
57. No smoking notice (white).
58. Engine speed indicator.
59. Cockpit light switch.
60. Oil pressure indicator (red).
61. Pull tab for first-aid access.
62. ¾" × ½" wood strips.
63. Identification light here on R.A.F. machines.
64. Pitot tubes.



Try to be systematic about collecting reference material; a neat and orderly approach will not only enable you to find what you are looking for, but will also endear one to houseproud mums!

Some reference may prove impossibly expensive or simply not available and in such cases libraries are the answer. Books not on their shelves can be ordered and most libraries will have a photo-copying service for a permanent record of required

Sketches as on the right made direct from the subject are obviously superb reference. But even if you cannot sketch that well, any drawing can be of great value with a few notes and dimensions.

information. In most cases librarians are only too willing to help, although you will find instances of the attitude 'library first, reader second'. Don't be put off, the institution is there to serve you! Many of the museums have library facilities, but these are sometimes harder to gain access to. In certain instances you will first have to obtain a reader's ticket before you can use the library, details of which should be forthcoming from the inquiry desk.

Photographs are another vital aspect of research. The more illustrations available of an original the better. Again, 'look' at the photographs you have. In many cases, it is surprising how much can be missed even in a poor quality print and one should always be armed with a good magnifying glass when looking at photos. Sadly, the ability to 'see' is not quite as simple as might first appear. A knowledge of how a black and white photographic print is produced can tell you a great deal about what is going on in the image. For instance, a negative made on Ortho or Line film will render such colours as yellow as a very dark tone, whereas the same colour shot on Continuous Tone film will show up as a light grey tone. The same is true of Colour film, a single red, say, appearing as a totally different shade dependent on what type or even make of film was in the camera at the time. A couple of sessions with a photographer friend can help out on such technicalities—incidently, take every opportunity to seek advice from specialists, a friendly chat is on of the best ways I know of increasing knowledge—and constant scanning of photographs will create the ability to observe and thereby increase the value of any photograph which may come your way.

As a last point on research, be critical of what you can amass. Every article or book that has or will be written is subject to human fallibility. One can readily develop an 'ear' for the conscientious writer who does not make overblown claims for his findings. Dogma is especially prevalent in the areas of colour and scale plans.

With regard to colours, it is important to realise that NO human being can have exact recall of a particular colour; our brains simply cannot do it. If you find this hard to believe then try a simple test. Have a quick glance at a neighbour's front door and then mix up a colour match to it an hour later and compare the results. I would be very surprised if they are even remotely similar! If this is the case, how can there be a definite right or wrong about the colour of something seen twenty years previously! Of course, this is a simplification of the colour problem which takes no account of the existence of samples.

The subject of colouring in model making is enormous and has been the subject of a vast amount of literature in recent years. This author makes no pretence of being an expert but is merely trying to put forward a case for discretion and the use of one's own common sense. Learn to trust your own judgement, in the final analysis it is probably as good as anyone else's if based on sound research.

Again, a common sense approach to scale plans is called for. It is very easy to be seduced by super detail applied to a basic shape which is totally wrong. Always check basic dimensions against reputable source material. An electronic calculator will be invaluable here and if something 'looks' wrong when compared with a photograph, go for the photo. Despite its limitations, some of which have been touched on, the photograph is only one step away from an original; a scale plan is several more such steps away. This is not to say that all published plans are worthless, far from it, there being draughtsmen at work to-day whose work is staggering in its fidelity, attention to detail and sheer craft. Again, I am urging a critical outlook which in the long run will, I believe, lead the model maker to a satisfying self-sufficiency and to the production of truer replicas.

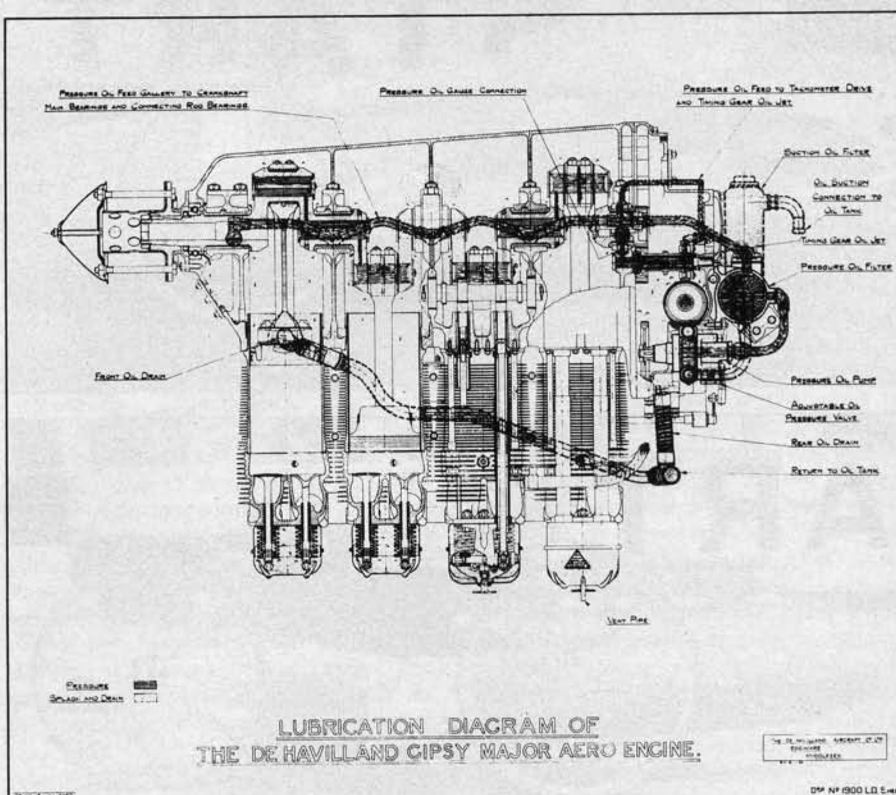
Once the research has been completed, the modeller can start the real task, the construction of the replica. Before so doing, though, a word of warning. All the foregoing will be to no avail if there is no real understanding of how the original works. For instance how can one hope to produce accurate rigging on a biplane if there is no basic understanding of what rigging wires are and what their function is on such an aeroplane.

With regard to construction, one or two basics have stood me in good stead for many years. The first of these is the fairly obvious one of not biting off more than you can chew. If you are not up to producing a detailed engine to be revealed by opening cowlings, don't attempt it. Nothing is more off-putting than producing something which you know in your heart is not very good. How much better to exercise one's skills simply and successfully at first and to build upon success as a basis for more ambitious projects.

Again, start with a simple set of tools, the best you can afford, and learn how to use them. Try and have an open mind as well, that bent piece of tube may have enormous potential as a modelling aid which is not immediately obvious. As with the models themselves, build on a solid foundation; technique cannot be gained overnight, it has to be worked at and perhaps more importantly, earnt by application. As a last point, bear in mind the old adage, 'look after your tools and they will look after you'—it happens to be very true!

With regard to materials, an open mind will be a great help here as well. I firmly believe that you can see anything in the manufacture of a model, the only criteria being that the material should do the job in the best possible way. As with tools, however, there is no substitute for understanding the nature of what you are working with and such understanding will only come with trial and error.

At this point, it would seem sensible to close, as the brief for the article was on the philosophy and not the practice of the craft of model making. It is to hoped that the foregoing will provoke thought and if there was to be one overriding axiom to base one's modelling activities upon then it should be to enjoy one's hobby to the fullest possible extent.



Drawing taken from an original de Havilland maintenance book.

The Shell-Motor Mileage Marathon

by John Stroud T.Eng (C.E.I.)M.I.E.

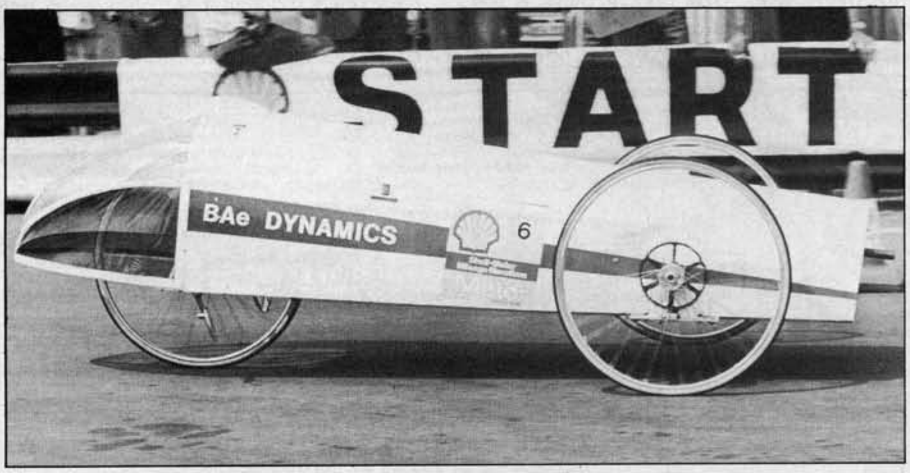
The entry by the winning team from King's College, London, who achieved 1,684 mpg.

THE COMPETITION is promoted and organised by Shell UK Oil, Motor Magazine and the Bugatti Owners Club under the General Competition Rules of the RAC (incorporating the provisions of the International Sporting Code of the FIA).

The contest is over a 10-mile course which has to be covered at minimum average speed of 15 mph and results are based on the measurement of the amount of petrol used in completing the course.

All forward propulsion must be obtained from the combustion of standard Shell 4-star petrol in an engine system, though one ingenious team from a Finnish university did manage to use a moped petrol engine with a further small steam engine running off the exhaust heat! It is therefore forbidden for the driver to push on the ground, erect sails, put rocket fuel in the petrol or to use electrical energy from a battery on board for more than a self-starter (proven to have negligible propulsive effort), instrumentation or fuel metering. Any further electrical energy must be generated by the engine. Most competitors will be using small moped motors like a Honda 50cc.

The driving technique is most important. The engine is started and the vehicle accelerated at full throttle when the heat energy of the petrol is most efficiently converted into forward propulsion. When about 25 or 30 mph is achieved, the engine is cut and the vehicle coasts down to 5 or 10 mph on its momentum. The engine is restarted and the cycle repeated—not quite what could be recommended for use on the road.



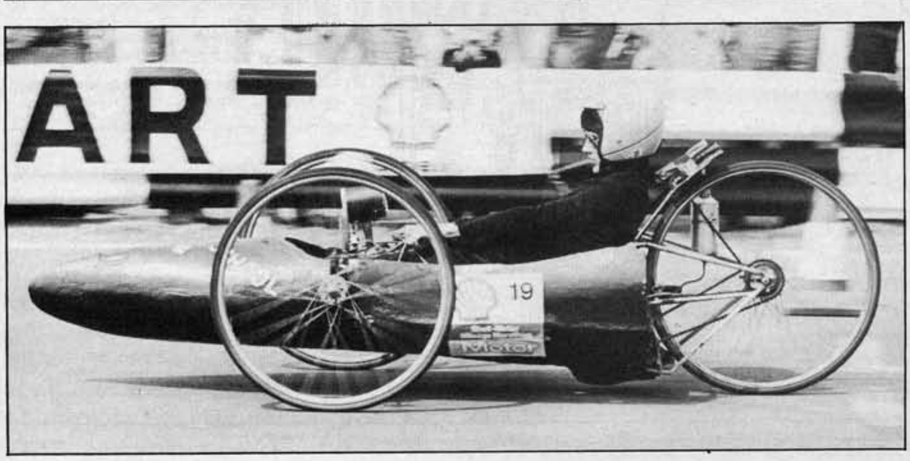
Left Entry No. 6 British Aerospace Dynamics who came second in the Marathon with 1,348 mpg. This achievement also made them the winners of the Shell Super Mileage Project, a special award for student teams.

One of the pleasant aspects of my job with the Engineering Industry Training Board is that it allows me to attend such interesting events as the Shell Motor Mileage Marathon. I am a firm believer in project work to develop and display the talents of the young people joining our industry. Having noticed that many student and apprentice teams were entered for the event, I decided to motor over to Mallory Park on July 4th, to take a look at the results of their labours. On my way to the track, I began thinking over the problems which would need to be tackled to achieve a competitive result.

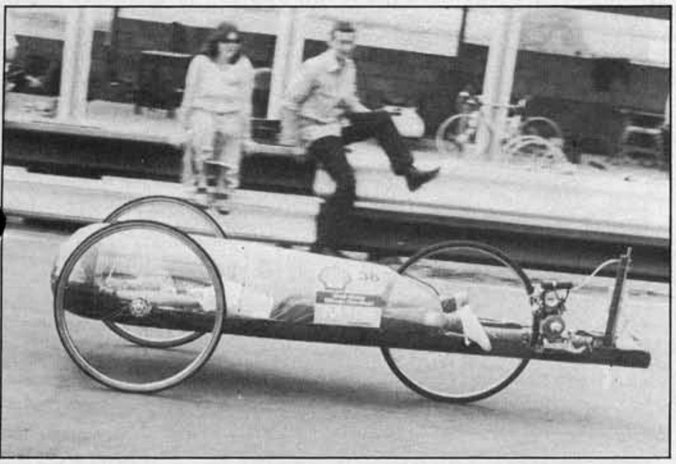
Low rolling resistance—good bearings, wheels and wheel alignment.

Low weight—has some effect on the above and the circuit has gradients which need to be climbed.

Low aerodynamic drag—even at the required average speed of 15 m.p.h., this must be important.



Left the entry from Hatton School, who won the Shell Motor Junior Mileage Marathon with 436.5 mpg. They were joint winners of the Junior Technical Award also.



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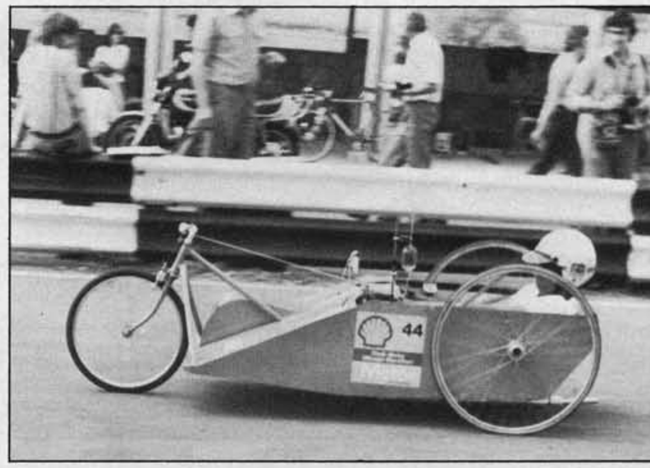

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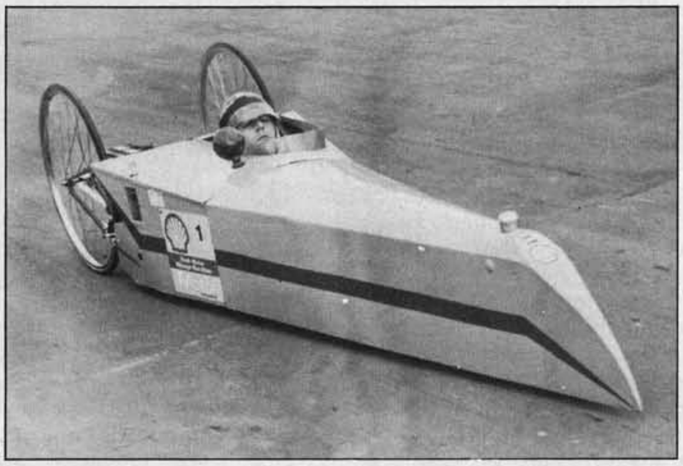

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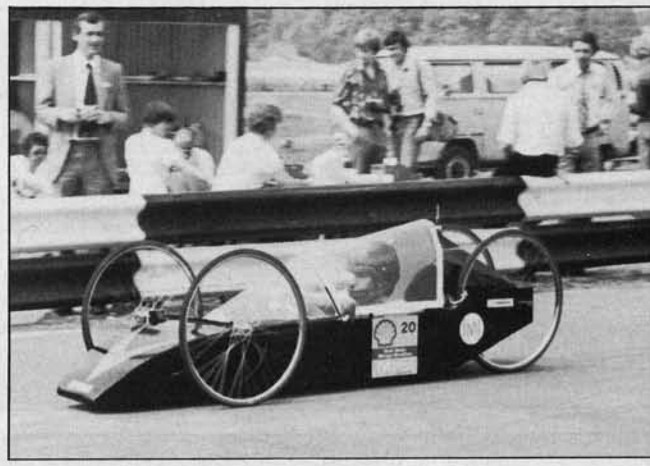

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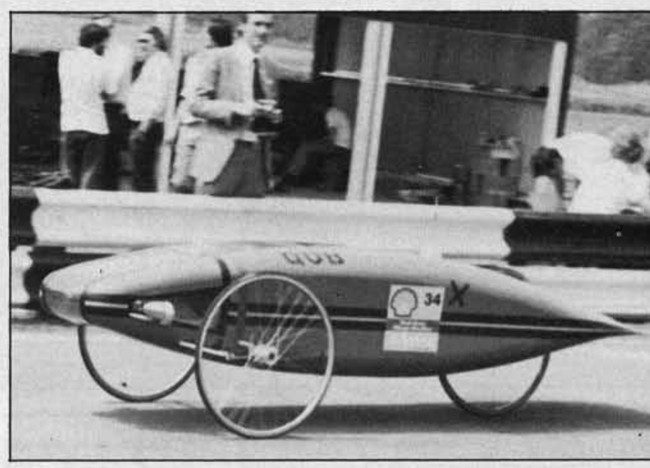

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1 *G. R. Seyfang's entry driven by 11-year-old Stephen Green, winner of the Motor Merit Award.*

2 *University of Wales Institute of Science and Technology.*

3 *Shell Research—Engine Fuels 1.*

4 *Entry from IMI Summerfield.*

5 *Grosvenor School of Motoring Merseyside.*

6 *Queen's University, Belfast.*

Engine efficiency—an average cyclist can produce .25 b.h.p., so that should be enough. There should be room for interesting experiments in this department.

Driving technique—coasting is allowed so there needs to be some trial and error to sort out the best routine.

After drawing up this list in my mind, I realised this competition might have been drawn especially for a model mechanic with an interest in model aircraft. In fact, control line team race men have been tackling almost identical problems for years. Would the young enthusiasts be any match for a keen and experienced modeller?

By the time I got to the track, practice was in full swing. The most incredible devices were rumbling round the track and occasionally making a "phut-phut" noise as they climbed a hill or picked up speed. I hurried to the pits to search out the likely winners who would surely be using miniature engines, etc. There were over 40 entries and almost the first I talked to was Louis Borsi. His car was without doubt the simplest and lightest present. Powered by a water-cooled HB25 and using a Mardane clutch, his entry weighed only about 30 lbs. Lack of preparation time foiled his brave effort and I doubt if anyone else will try running a glow motor on petrol! The only other entry I could find with a "modelling approach" was Mr. George Seyfang. He even had a miniature driver, 11-year-old Stephen Green weighing about 4½ stone. The vehicle was very nicely made and won the Motor Merit Award, although,

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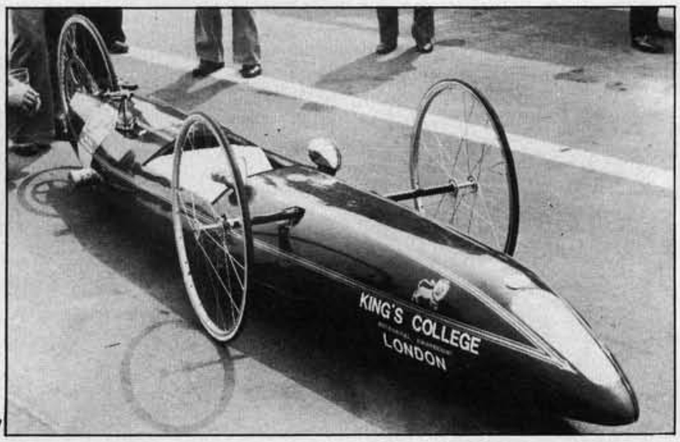

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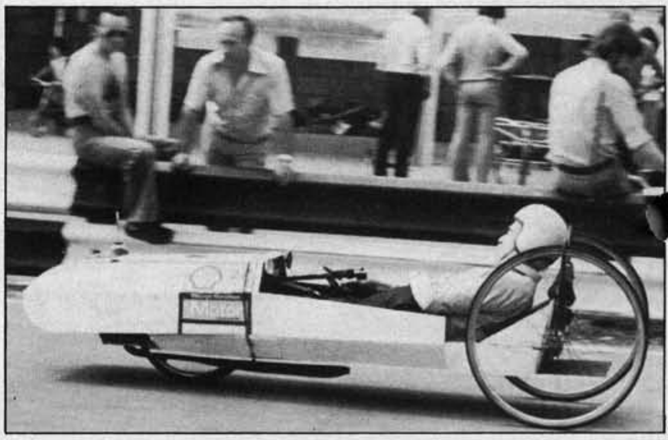

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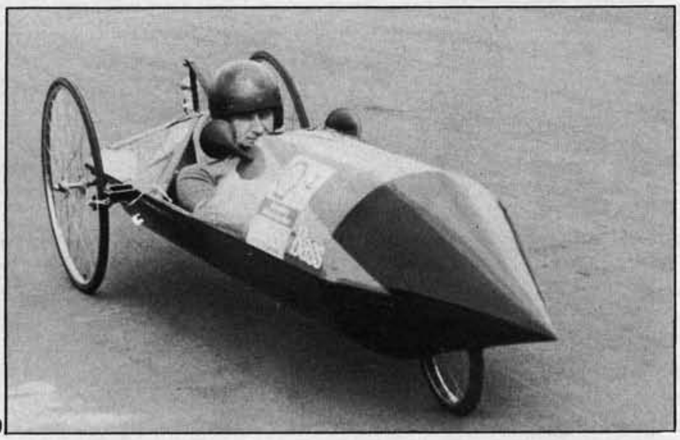

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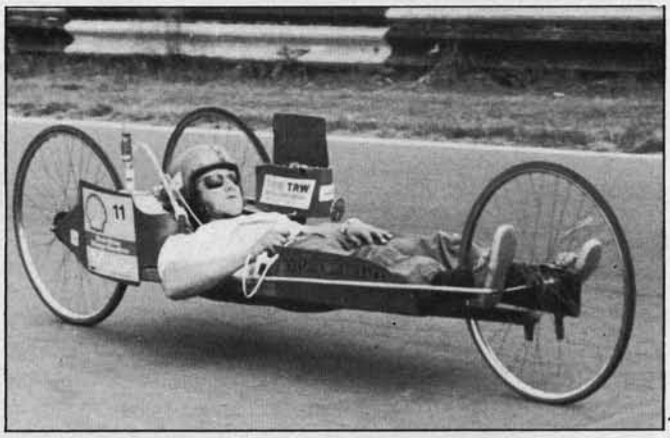

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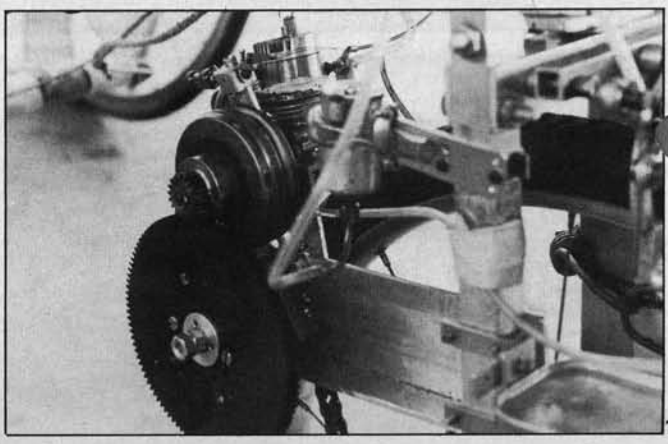

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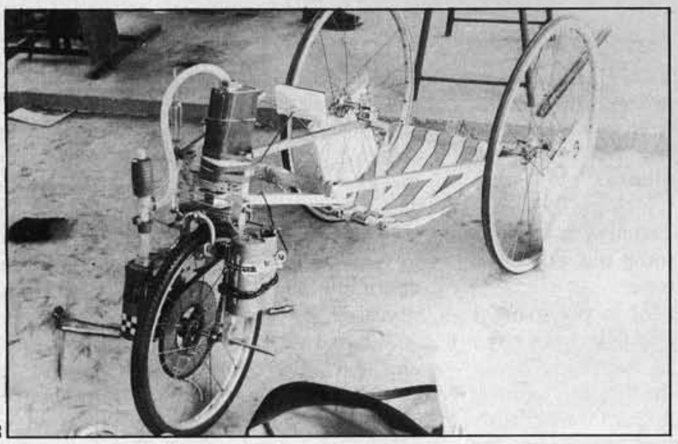

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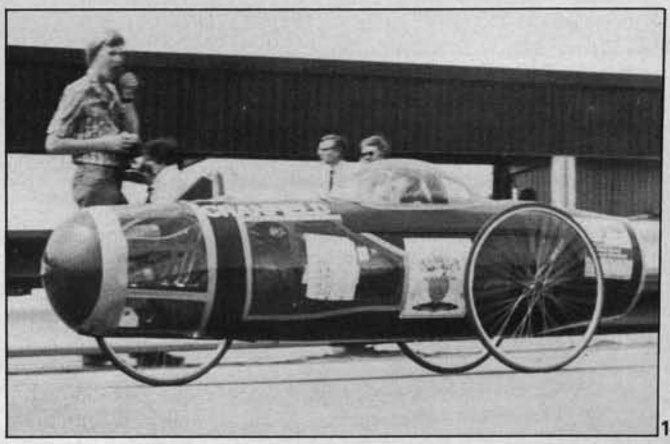
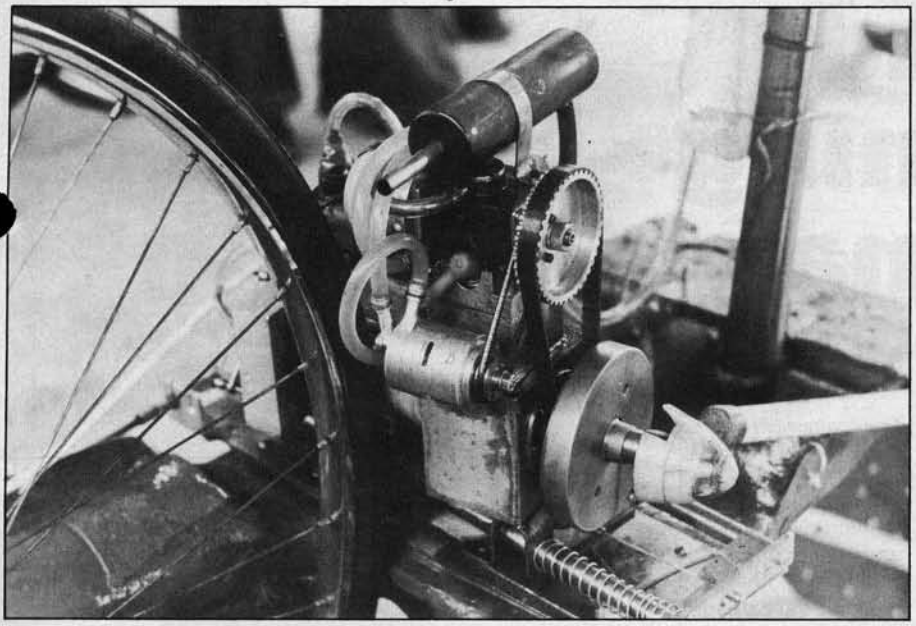


7 Beautifully produced fibre-glass bodywork of the King's College entry.
8 Mr. J. Lowrey's entry covered a distance of 821.7 miles.
9 Bass 941.6 miles.
10 Cyclone Hovercraft 1339.4 miles.
11 Mr. M. L. Buswell 337.2 miles.
12 Close-up of Mr. L. Borsi's entry showing the engine reduction gear to the chain drive.
13 The entry of Mr. L. Borsi.
14 Cranfield Institute of Technology School of Automotive Studies they achieved 1,243.2 miles.



Left the engine powering Mr. Seyfang's entry. This is a 15 cc overhead camshaft, four-stroke engine designed and built by Mr. John Ramsay. It also has a variable speed drive, this works by moving the engine sideways, altering the position of the tapered drive drum which runs on the tyre.

unfortunately, the friction drive ran out of friction after nine laps when ten were required. The ingenious engine was made by Mr. John Ramsey using, I am told, only a lathe and a file. The specifications included 15cc, OHC, water-cooled four-stroke.

The drive seemed to be direct from the crankshaft onto the tyre. The drive roller is tapered and the gearing can be changed by moving the engine to use a different part of the roller. I felt particularly sorry for young Stephen when their effort failed. Will he be too old and large at 12 next year? I hope not.

Having looked at the only two "mini" entries, I then turned to the conventional competitors. With only one exception, a 175 cc Asper, they have chosen to use a small four-stroke Honda engine. Some efforts at streamlining were more serious than others. Queens University Belfast told me they had spent a lot of time in the wind tunnel and it certainly showed. In contrast to other entrants, they decided to mount the body/fuselage high and dispense with skirts and effects. Most entrants had fitted electronic ignition and electric starters to restart the engine after coasting. Trying to kick-start an engine whilst being inside a cigar tube is not easy, although some did try!

The friendly and enthusiastic atmosphere in the pits made the day memorable for everyone. For me, as a lone observer, it made gathering detailed information almost impossible. The only vehicles with their teams in attendance were those obviously very busy and working on their entries. In most other cases, the owners were off somewhere else to examine the oppositions' machinery. For me, the enormous interest and fascination is summed up by the fact I forgot to go for lunch until 4.30 and then it was too late!

As a project for students and trainees, the Shell-Motor Mileage takes some beating as illustrated by the ingenious machines and the motivation of the teams. Last year's winner used a 90 cc Honda engine, weighed about 150 lb. and did 1,644 m.p.g., at an average of 10 m.p.h. This year Kings College had to average 15 m.p.h. yet still managed to increase it to 1,684 m.p.g. using a 50 cc Honda engine.

What about next year? Surely a modeller can produce a more efficient, smaller engine and grab that prize for 2,000 m.p.g. Perhaps you already have one! Anyone wishing to get involved in a team project could write to the Editor for help in contacting others of like mind in their area.

Shell—Motor Mileage Marathon Results 1979

Winner: £1,000, No. 25, Kings College London, 1684.0 m.p.g.; 2nd: £500, No. 6, British Aerospace Dynamics, 1348.6 m.p.g.; 3rd: £250, No. 11, Cycline Hovercraft, 1339.4 m.p.g.; 4th: £125, No. 10, Cranfield Institute of Technology, 1243.2 m.p.g.; 5th: £75, No. 1, Shell Research, Engine Fuels 1, 1230.4 m.p.g.; 6th: £50, No, 39, Shell Industrial Lobs 2, 1065.9 m.p.g.

Shell—Super Mileage Project Special Awards for Student Teams

1st: __250, No. 6, British Aerospace Dynamics, 1348.6 m.p.g.; 2nd: £125, No. 5, British Aerospace Aircraft, 1029.0 m.p.g.; 3rd: £75, No. 29, Newcastle University "A", 1018.4 m.p.g.; 4th: £50, No. 31, Oxford Polytechnic, 966.7 m.p.g.

Shell—Motor Junior Mileage Marathon Special Awards, 11-16-year-olds

1st: £100, No. 19, Hetton School, 436.5 m.p.g.

Motor Merit Award: Best combination of enterprise and ingenuity with due allowance for resources available to the teams (all comers).

Winner: £200, No. 36, G. R. Seyfang.

Shell Technical Award: As above (students).

Winner: £200, No. 34, Queens University, Belfast.

Junior Technical Award

Winners: £25, No. 17, Hayes School and No. 19 Hetton School (jointly).

2000 m.p.g. Award

£1,000: Not achieved.

Technical Details—Special Characteristics: of the Kings College, London entry:

Extensive theoretical and experimental tests were made on an elementary rolling chassis before the vehicle was designed, to decide the best rolling configuration. As mileage marathons are becoming a popular world-wide sport we are not willing to lose our lead by releasing too many technical details, but a short list of the more obvious facilities of our vehicle are included:

1. Light weight throughout
(a) monocoque fibre-glass + resin bodywork;
(b) tubular subframe for engine + transmission.

2. Minimum aerodynamic drag
(a) good aerodynamic drag;
(a) good aerodynamic shape;
(b) minimum frontal area;
(c) low slung to minimise wind velocity.

3. Minimum rolling resistance
(a) high pressure tyre;
(b) minimum tyre pattern;
(c) all wheels mounted on small deep groove ball races.

4. Minimum transmission losses
(a) small link chain transmission;
(b) direct drive from crank shaft to rear sprocket (chain reduction).

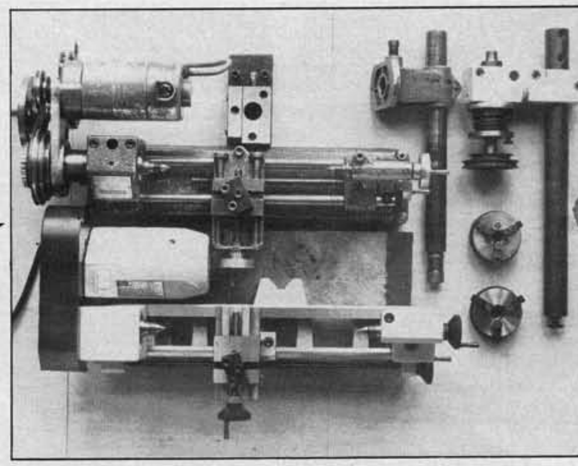
5. INcrease efficiency of engine
(a) Honda C50 moped engine used;
(b) Modified valve cam (form and lift);
(c) very small carburettor operated at full throttle;
(d) lean air-fuel mixture;
(e) optically switched electronic ignition with variable timing;
(f) replaced many plain bearing with ball and roller bearings;
(g) lagged engine for maximum thermo efficiency.
(h) electric starter motor (to increase starting reliability).

6. Electronic digital display speedometer: The engine is operated for approximately 20 seconds every 225 seconds. The speedometer informs the driver when to engage and disengage the engine.

Engineering Drawings: Not for general release.

Using and maintaining the 'Unimat 3'

By Rex Tingey



Size comparison between the SL and Unimat 3.

THE Unimat 3 differs in size from the SL model mainly in the height of centres above the bed and cross-slide, and the greater distance available between centres, as can be readily seen from the photographs. Construction differs mainly by the use of a cast-iron bed, which is far more rigid than the two round bars of the SL. Apart from this extra rigidity a Unimat SL, with all my modifications incorporated, can perform just as well as a 3, within its limitations of size.

The Unimat 3 is not easy to immediately clean and service as it traps swarf in its bed casting and other intricacies, and has no cleaning slots for the lead and cross-slide screws, so that fine swarf and metal dust often finds its way between thread and nut, which then bind and grind; the part must be immediately dismantled and cleaned out to avoid wear. The fitting of metal aprons and felt or rubber traps is never to be recommended on a small precision lathe, as they cause more wear than they prevent with a mixture of lubricant and metal dust entering the soft material within minutes of use, turning them into abrasive strips.

Maintaining

After working with the lathe for about 100 hours, using the recommended lubricants and care, it is a sound idea to strip it right down to its component parts and clean off all surfaces, using one of the cleaning sprays, which replace the toxic C.T.C., and a piece of Terry towelling. You may be surprised to find that the cross-slide carriage travels along the bed held in place with only a plastic strip each side, beneath, with assistance from a big square locking nut.

To remove the lead-screw it is necessary to loosen the screw, underneath at the handwheel end which holds in the bush, and to tap out with a ¼ in. brass drift from the headstock end. Then screw it right out of the fixed nut of the cross-slide carriage, remembering that it is threaded left-hand. Remove the headstock block, two hex cap head screws underneath, and after removing the cross-slide by winding it right off, slide the carriage to a convenient under-hole in the bed and dismantle it from beneath, to clean up all the parts. There is a separate dovetail plate which will fall out from the cross-slide; it replaces quite easily with its slot onto one adjusting screw's end.

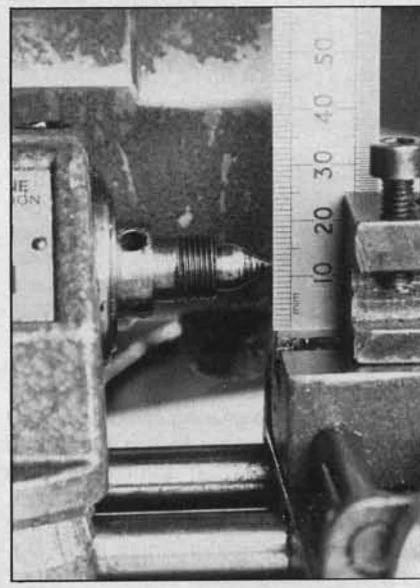
Assemble the carriage onto the bed, nothing else fitted, tighten the screws underneath and slide from one end of the bed to the other and lubricate. You will feel that the carriage is freer in the centre of the bed, where all the work takes place, than at the ends where it will feel quite tight. This is merely a running-in effect where microscopic roughnesses have been smoothed off the cast-iron bearers. Should this eventually become a problem of wear this could be eliminated by making slips of crocus paper to fit under the plastic bearing strips, of the same size, to be pushed up and down the bed to even out the wear up to the ends; then removing the slips and cleaning off. The only other wear points likely are the cross-slide dove-tails, where wear can be adjusted out, and the feed-screw and nut, which will require a new carriage and feed-screw to be fitted.

Oil the feed-screws and the bush and assemble the carriage and cross-slide feeds, with the slide and the dove-tail tension plate in place, making any necessary adjustment. Tighten the carriage locking screw and nut to the correct running tension.

The main spindle ball-races will require no oiling, but feel that they are running smoothly; they should need no attention for at least a year. If they ever need dismantling then use the correct circlip pliers, and it will be found that the back race pops out under tension from spring washers. Clean off the ways underneath before replacing the headstock block with its two screws.

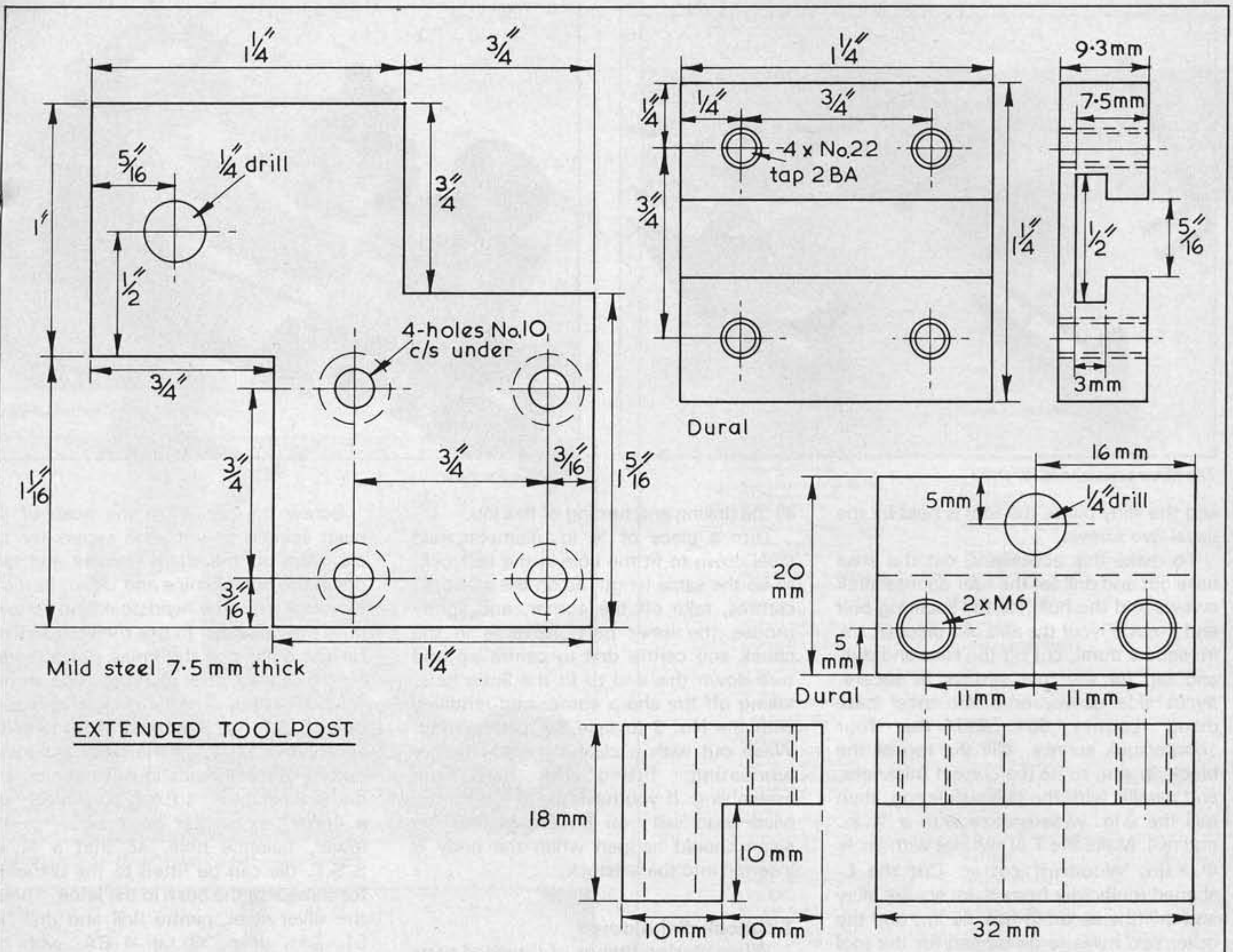
The motor should need no attention, but the intermediate drive on the drive plate should be regreased by first removing the circlip, lifting off the pulley wheel and cleaning up before regreasing with a good motor grease. The tailstock can be oiled by simply removing the two back screws, oiling well in the holes and replacing the screws. Always take care that the ways beneath the tailstock are clean and free from swarf, or work will not run true. Oil all the hand-wheels, run them in and out and clean off surplus oil.

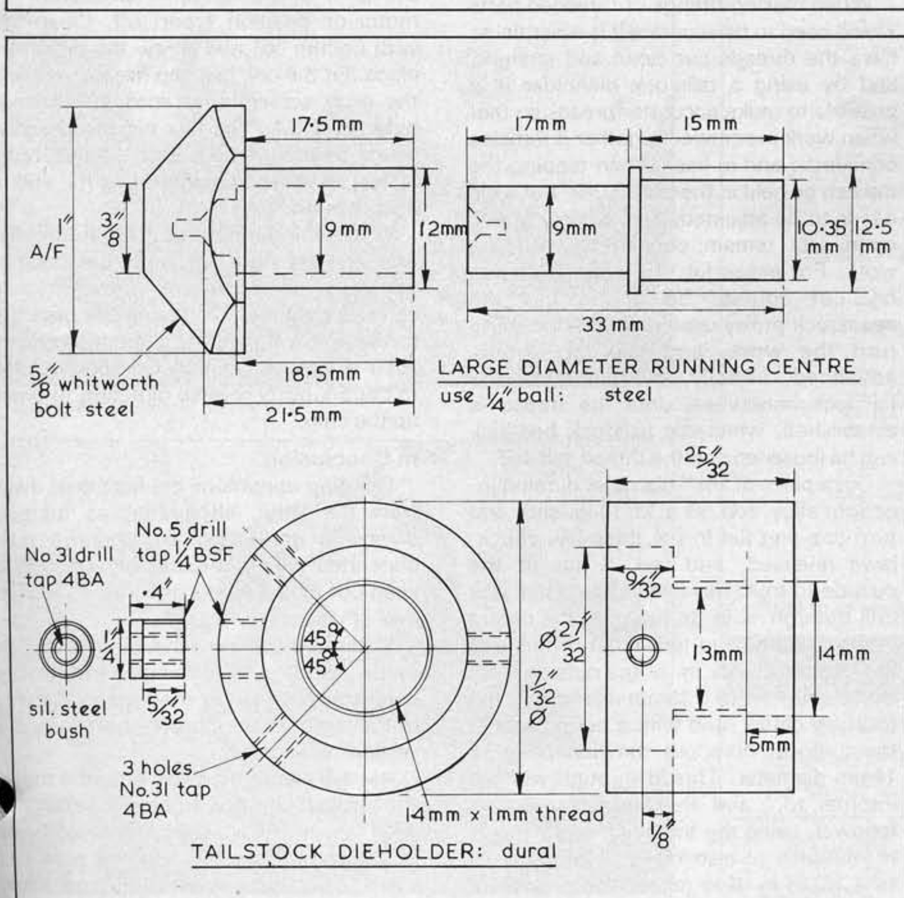
The vertical head should need little attention apart from the oiling of the movement by lubrication in the annular bottom spring cup. The bearings are of the sealed type and should need no attention as swarf should not jump th[is] high! Keep a weather eye on the gru[b] screw at the front of this unit as it does tend to work loose and to give a torque twist to the motor plate when drilling and milling.



Centre height above the cross-slide of the Unimat SL.

Centre height above the cross-slide of the Unimat 3.





It will be noticed that soluble oil and cleaning sprays do not remove all the paintwork, unlike the SL model. For all the cleaning up jobs on the lathe use a ½ in. paintbrush, and lubricate with 3-in-One after every job.

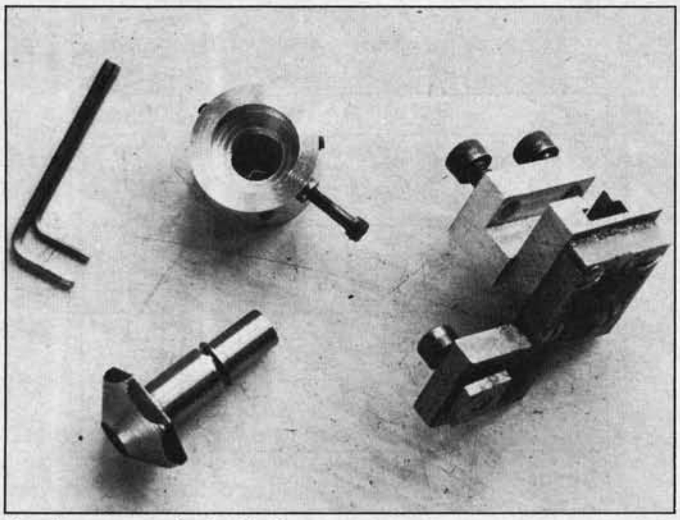
Some accessories

A shortcoming of the lathe is the short reach of the cross-slide in the backward direction, and the better turning circle cannot be exploited because a tool cannot be used from the standard toolpost to turn down the outside of anything much larger than 2 in. diameter.

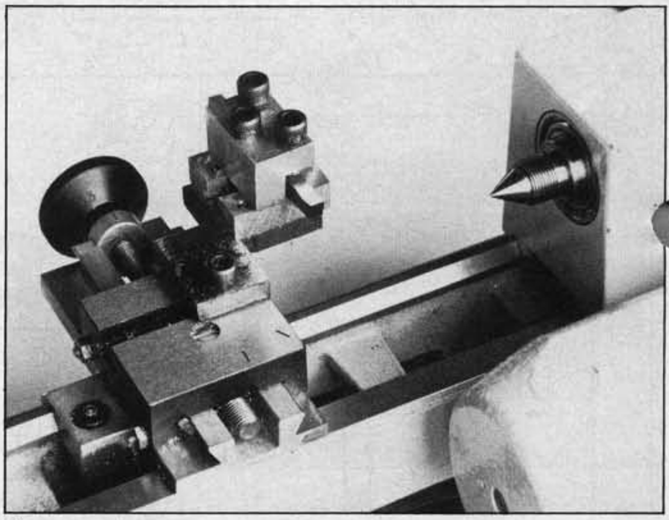
"Round the Corner" Toolpost

The answer to the limitation is to fit my "round the corner" toolpost, which still puts the point of the tool at centre height, and is easily made and fitted. The tool, positioned dead straight in the new post, will cut the maximum diameter along a length of $1\frac{1}{8}$ in., and to about 1½ in. when angled, or when a cranked tool is used.

The round-the-corner toolpost has a base of 7.5mm thick steel, fitting onto the cross-slide of the lathe and held by a T-nut and hex cap head screw. Onto the base an alloy plate, with a T-slot cut, is screwed and firmly adhered, into this T-slot another T-nut and bolt holds a bottomless toolholder in various positions, to hold a tool between itself



The three accessories for the 3



The new toolpost

and the alloy plate: the tool is held by the usual two screws.

To make this accessory, cut the steel base out and drill for the four countersunk screws and the hole for the securing bolt and T-nut. Flycut the end of a piece of 1 ¼ in. square dural, cut off the slice and drill. and tap for the four screws to secure, flycut side down, onto the steel base using Loctite 601 and the four countersunk screws. Mill the top of the block, in situ, to be the correct thickness, and parallel with the cross-slide top, then mill the $\frac{5}{16}$ in. wide groove with a ¼ in. end mill. Make the T of the slot with an ½ in. × $\frac{1}{8}$in. Woodruff cutter. Cut the L-shaped toolholder from ¾ in. square alloy and drill the securing hole ¼ in., and the other two holes to be tapped for the tool locking screws.

In use the toolpost is straightforward, and gives good access and plenty of room for turning the largest diameters of workpiece accommodated by the lathe.

Large diameter running centre

A useful accessory, simple to make, is a large diameter running centre for turning the outsides of jobs already bored. By boring jobs first and then proceeding to turn the outside, better concentricity of work can be obtained than when doing the job in the reverse order, and using this accessory is easier than plugging the bore and recentring. The centre works from the tailstock ram, fitting into the hole, and runs on a single ball-bearing, well lubricated. The centre is constructed from a short $\frac{5}{8}$ in. Whitworth bolt, and will work into bores up to just over 1 in. from just under where the standard dead centres leave off.

The bolt is held by the head in the three-jaw chuck and the end is drilled with a No. 2 centre drill to be held by the live centre for turning down the outside to get rid of the thread (so avoid high tensile bolts). Drill to an approximate depth, 4mm, then drill accurately to depth, 9mm. Put the No. 3 centre drill in the drill chuck, protruding just the right amount, and drill in up to the drill chuck; this is the seat for the ball. Use soluble oil at 10:1 dilution for all the drilling and turning of this job.

Turn a piece of ½ in. diameter mild steel down to fit the hole in the tailstock, to be the same length as on the standard centres, take off the corner, and lightly groove the inner part. Reverse in the chuck and centre drill to centre up and turn down this end to fit the 9mm hole, taking off the sharp corner and redrilling with the No. 3 to take the ball bearing. Wash out with a cleaning agent before lubricating, fitting the ball, and assembling. If you have made it right the oiled head will pop back out, and the same should happen when the body is inserted into the tailstock.

Tailstock dieholders

When making fittings of threaded parts which need to be accurate it is essential to have the threads cut clean and straight, and by using a tailstock dieholder it is possible to make accurate threads so that when work in screwed together it remains concentric and in line. When tapping the tap can be held in the drill chuck, but a die needs to be adjusted, first cut being well open, yet remain concentric with the work. For either job the Unimat should not, of course, be driven but the headstock pulley used as a handwheel to turn the work, and the tap or die advanced, initially, by means of the tailstock handwheel until the thread is established, when the tailstock bed-lock can be loosened and the thread self-fed.

Cut a piece of 1 ¼" diameter duralumin, or light alloy, rod, as a 13/16 in. slice and turn one end flat in the three-jaw chuck, jaws reversed, and last ¼ in. of the outside to true. Reverse in the chuck and drill through ¼ in. to bring up the centre in the tailstock and turn most of this end flat and the last ¼ in. of the outside true. Drill through with a 13mm drill held in the four-jaw chuck, and with a boring tool in the toolpost bore out the first 5mm to 14mm diameter. Thread through with an internal tool and the 1mm leader and follower, using the threading attachment. If you wish to also make a dieholder to take 15/16 in. dies repeat this procedure with a piece of 1 ½ in. duralumin.

Screw the part onto the nose of the main spindle to bore the recess for the die, take off the sharp corners and take down the outside nice and clean. Remove the work from the headstock and screw it onto the tailstock, to use the vertical head for the drilling of the holes to be tapped for the screws, after marking a line around for positioning. The large hole is tapped ¼ in. B.S.F. (or ¼ in. × 32 M.E.) to take a silver steel bush as the alloy otherwise quickly strips threads in this position and doing this job. Fit 4 BA grub screws, and a 4 BA hex socket head screw to the lower, balance hole, so that a ¼ in. B.S.F. die can be fitted to the dieholder for threading the bush in the lathe. Thread the silver steel, centre drill and drill No. 31, $\frac{5}{16}$ in. deep, to tap 4 BA, with the motor on position 1 part off. Clean off, with Loctite 601 and screw the bush into place. Fit the one hex cap head screw and the grub screw, now, into the balance hole, all 4 BA. The hex cap head screw needs pointing at the end; fit two nuts, locked together to help turning the end to a point in the lathe.

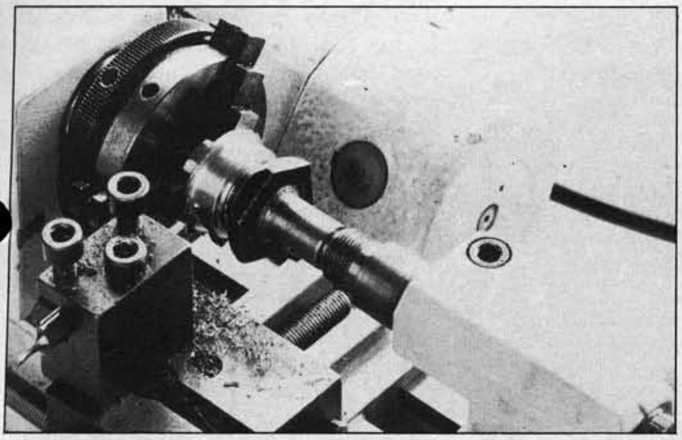
In use the die is fitted into the holder, first opened right up, and the balance screw is used, where necessary, to centralise the die. On steels it is essential to use some form of threading lubricant, such as Rocol Tapping Compound, and to continuously reverse direction to break up the chip.

In Conclusion

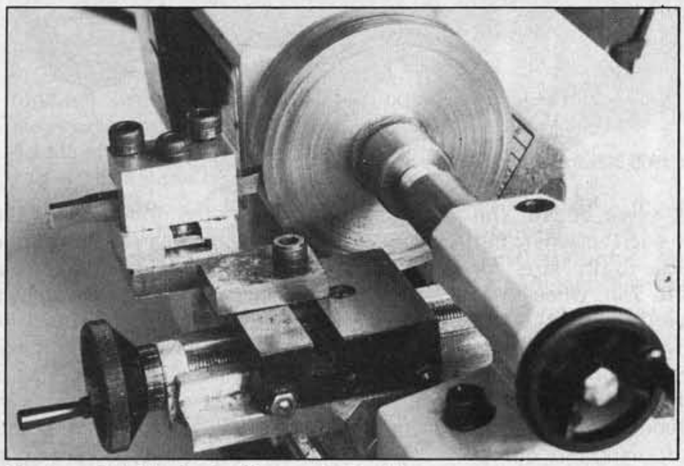
Grinding operations are best kept away from the lathe, altogether, as there is always a great deal of abrasive dust generated which is extremely difficult to keep out of the works and can do a great deal of damage.

When using the machine in the vertical mode always remove the chucks from the main spindle nose or they get in the way of the motor casing, brought down by the vertical movement.

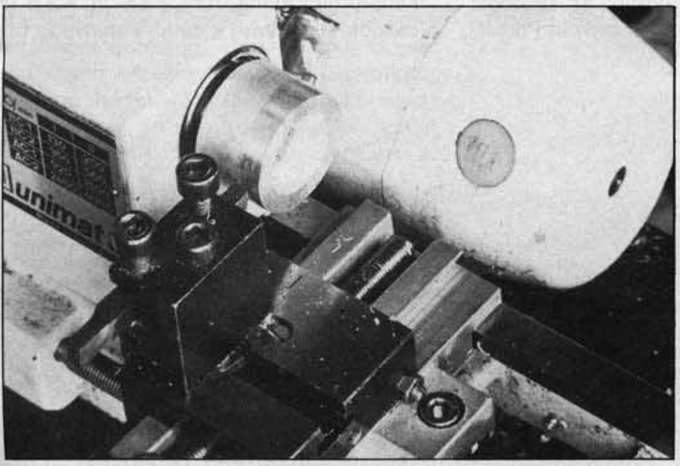
Always clamp the work onto the top of the cross-slide for drilling operations, even when drilling straightforward holes in flat workpieces. Unclamped work will bend expensive twist drill and slash unwary fingers, with no warning at all.



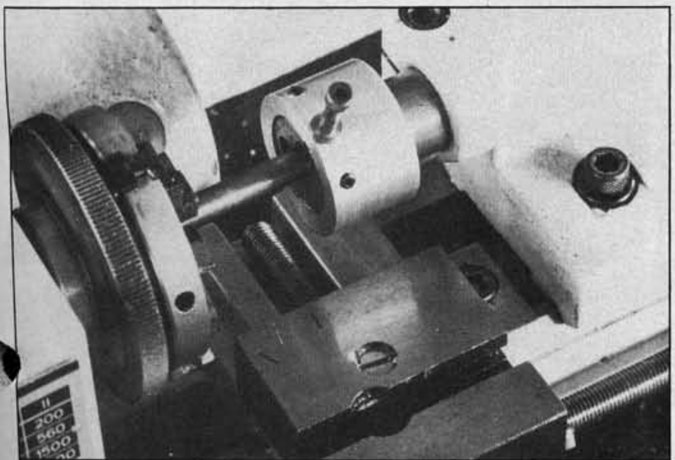
Large diameter centre in use.



Turning a 3-in. flywheel with extended toolpost



Turning the dieholder on the nose.



Tailstock dieholder in use.

Meccano

1905 Rolls-Royce from Argentina: Part 1

by Bert Love

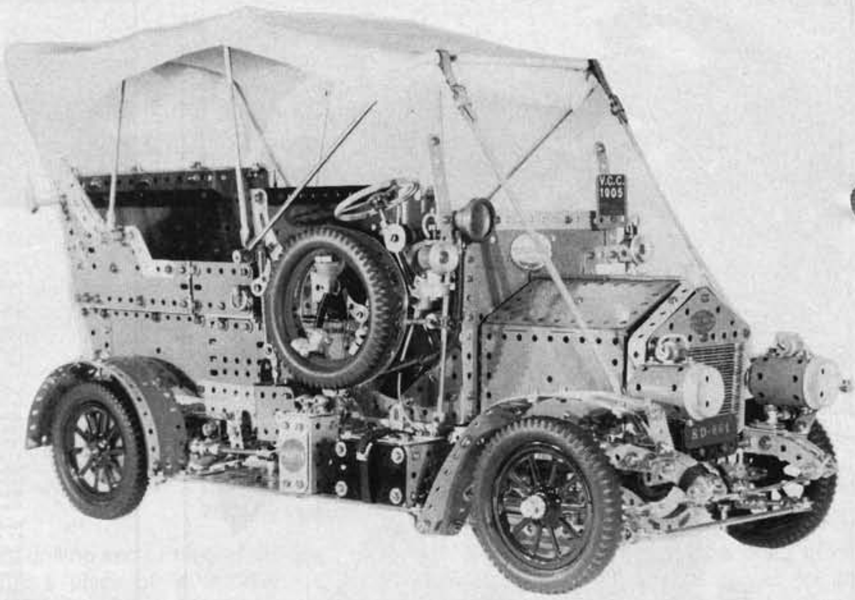


Fig. 1 *Meccano model of 1905 3-cylinder Rolls-Royce by Dr. Jorge Catella of Argentina.*

SUCH is the continuous and international appeal of Meccano modelling that many of our overseas enthusiasts have adopted it as their principal hobby. One such modeller is Dr. Jorge Catella of Buenos Aires who has a life-long love and knowledge of exotic motor cars and has produced a whole range of models in Meccano consisting of detailed models ranging from a 1901 giant Fiat Grand Prix winner to the ubiquitous U.S. Army Jeep. Jorge has chosen a very rare model from the Rolls stable in the form of a three-cylinder 1905 'convertible' for his excellent model which will be fully described in two parts for the benefit of the advanced constructor. Here are some of the basic facts about the original car, supplied in Jorge's notes.

1905 3-Cylinder Rolls-Royce. 15 h.p. Capacity 3,000 cc. Weight: 14 cwt. Wheelbase: 8 ft. 7 in. Track: 4 ft. Tyres: 810 × 90. Price: £459 10s. 0d. Number made: 6 Number surviving: 1. Last known owner (as at 1977): Adam McGregor-Dick Esq.

Figs. 1 and 2 give general views of the Meccano model and just a glance shows the realism and wealth of detail which Jorge has skilfully put into his reproduction. No really experienced Meccano modeller ever claims that his work "is to scale" (we leave the micrometer man to such claims) but Jorge has achieved close to $\frac{1}{6}$th "size" for his model. With an 8 ft. 7 in. wheelbase, pairs of 18½ in. Angle Girders, made up in channel section, form the main side frames of the chassis, spanning slightly over the model's wheelbase and these main members are extended to the rear by 2½ in. Curved Strips forming the 'dumb' irons. Cross supports for the chassis are made from 5½ in. Girders at strategic points and these will be shown in Part II, next month, when the underside of the model is dealt with fully. Semi-elliptic springs are provided at front and rear but additional rear suspension is provided by a transverse and inverted semi-elliptic spring secured in double cantilever mode across the rear chassis member. This is clearly shown in Fig. 3 and 4. The comparatively small luggage boot of this very expensive motor car is also shown in these illustrations complete with working hinged flap made from a 3½ in. × 2½ in. Flexible Plate with a catch consisting of a

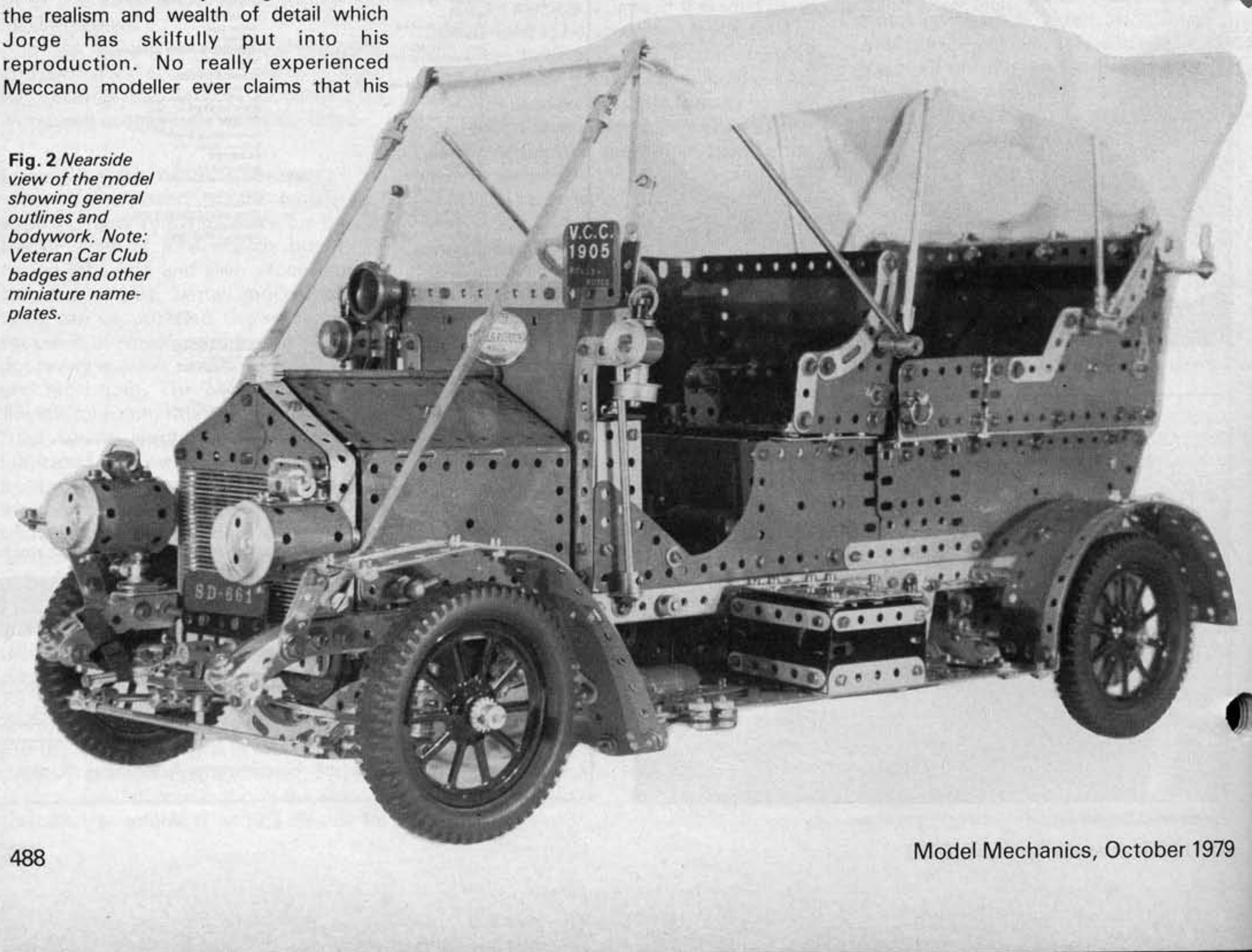


Fig. 2 *Nearside view of the model showing general outlines and bodywork. Note: Veteran Car Club badges and other miniature name-plates.*

Handrail Support, packed outside with Washers and carrying a lock-nutted Fishplate inside. It will be noted from many of the illustrations that various lamps and handles on doors etc., are fitted with hand rings and in each case these are made from short lengths of Meccano Spring Cord, reinforced internally with Meccano Tinned Copper Wire. (A harder wire may be used as a core if the modeller expects his model to be handled).

Carriage work rises vertically from the chassis side frames, Fig. 4 showing this clearly, where a 2½ in. rise is uniformly maintained by Flexible Plates. Reinforcing of the top edge in the first part of the body is carried out by a 5½ in. Angle Girder each side with its slotted hole flange outwards as can be seen from the inside view in Fig. 5. This gives the required 'overhang' effect for continuing the curved rear of the carriage work, details of which can also be seen in Figs. 3 and 4. "Stepped" passenger doors are built up from 2½ in. × 1½ in. Flexible Plates joined by pairs of inverted 2½ in. Girders to continue the line of the rear 5½ in. Girders. Handles are fitted similar to the one on the luggage boot, but this time only one thin Brass Electrical Washer is used as outside packing, the shank of the Handrail Support being screwed into a Collar and locked by a Grub Screw inserted from the far side of the Collar. Again, if this part is to be subjected to frequent handling, the Collar may be replaced by a "Spider" from a Meccano universal Coupling. This has four tapped holes and will allow extra Grub Screws for locking the thread of the Handrail Support quite firmly. In use, the Collar or Spider engages with the Fishplate attached to the side of the driver's compartment. Note the "vanity" box built on the inside of the door for "Mi'lady's convenience!"

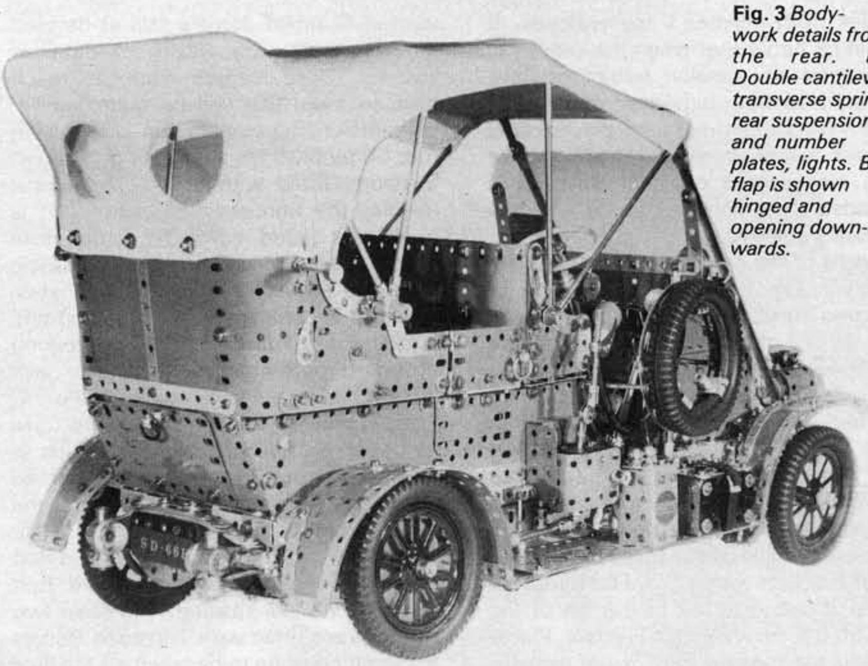


Fig. 3 *Bodywork details from the rear. Note: Double cantilever transverse spring for rear suspension and number plates, lights. Boot flap is shown hinged and opening downwards.*

All five illustrations so far show the general form of the convertible canopy, the framework consisting entirely of standard Meccano parts. The hinging point is a 1½ in. Strip at the top side of the rear carriagework and this is fitted with a ¾ in. Bolt held in place by a lock-nut. Axle Rods of suitable length form the four stays for the canopy on each side, Rod & Strip Connectors being fitted on each Rod. Curvature across the canopy top is achieved by extending each stay with a Rod Connector carrying a Meccano Flexible Coupling Unit which looks like a very tightly rolled spring some 2 in. long and by further Rod Connectors, additional Axle Rods are fitted over the top. Wherever possible, Jorge makes do with standard Meccano parts (this is what the "art" of Meccano modelling is all about) but his canopy was a labour of love by his good wife and the front 'leather' straps are cut from scraps and fitted with

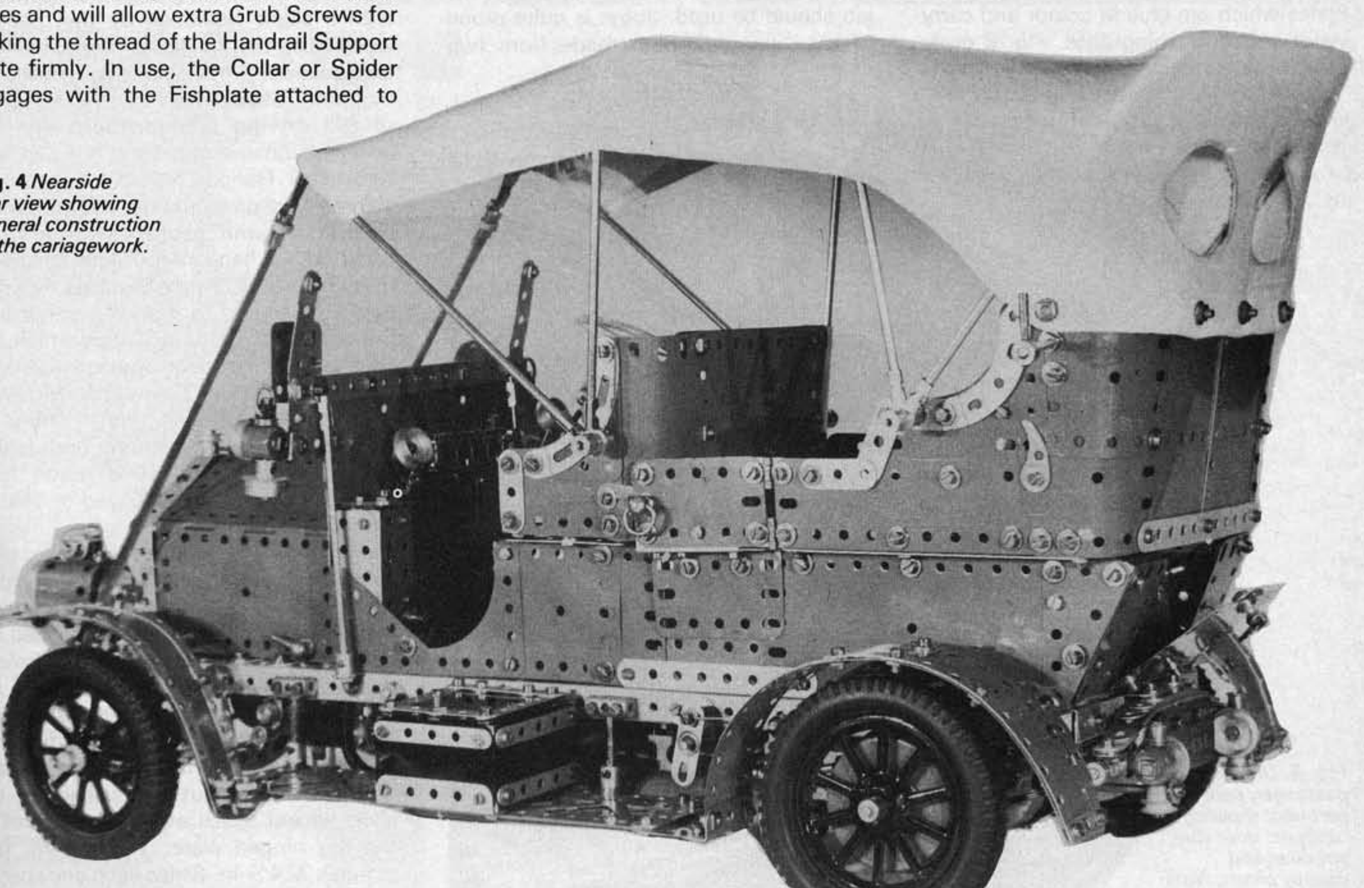


Fig. 4 *Nearside rear view showing general construction of the cariagework.*

buckles from children's toy watches. It should be noted that when the canopy is in the "stowed" position, two of the stays are removed from similar pivots outside the driving compartment and placed upon the rear pivots. In either condition, the stays are secured on their Bolts by a Threaded Boss screwed on to give the necessary rigidity.

Details of the driver's compartment are shown in Fig. 6 and the application of Meccano Flexible Plates is well exploited here as in moulding the rear of the carriagework. A 4½ in. Girder gives support to the leading edge of the driving seat and the overlaid "upholstery at that point and at the shoulder height of the back rest is a black fibre perforated strip (5½ in. in each casè) from the Meccano Electrical series of parts. A glove box complete with lid, make up of 2 in. × 1 in. Girder Brackets with a 2 in. Flat Girder for the lid is bolted to the centre lap of the pair of 3½ in. × 2½ in. Flexible Plates forming the forward part of the seating. Further similar Flexible Plates continue the seat rearwards to make up a seven-hole span from front to back. The gearbox oil pot and the fire extinguisher can be seen modelled in Sleeve Pieces and Chimney Adaptors, secured to the lower front seat panel via bolts passing through a 5½ in. Double Angle Strip used to secure the floor. Readers will note a "criss-cross" pattern on the decking to simulate the hatched metal footrest of the period and this has been simulated in Jorge's model by selecting a pre-war (1936) pair of 5½ in. × 2½ in. Flexible Plates which are blue in colour and carry yellow cross-hatching lines. Fig. 8 gives us a close-up of Jorge's skill at detailed modelling where a wealth of detail is shown. Those readers who can reach back to the 1930s will be quite familiar with PRATTS petrol in the U.K. Using four Girder brackets and a pair of Handrail Supports fitted with a 1 in. Rod as a handle, the unmistakable petrol can is neatly modelled while the small tool chest, fronted by a Black Plastic Flexible Plate has ends of 1½ in. Square Plates. Again, it is complete with hinged lid and buckle strap. Full details of the working outboard gate-change gear lever and ratchet handbrake will be given in Part II. Figs. 1 and 3 show the spare tyre mounted on its Stepney ring which is made from four 2½ in. Stepped Curved Strips in a circle having a fixed lug at the "12 o'clock" position made from a ½ in. Angle Bracket holding a Right-angled Rod & Strip Connector on a standard Bolt with two Washer spacing. The other two tyre lugs are fitted with Threaded Bosses to permit pressure to be taken off the lugs for tyre removal. Readers may be wondering about the tyres and their attachments to the wheels which are standard Meccano "Artillery" wheels with flat rims. To make the standard Meccano 3 in. Tyre fit, it is necessary to trim the "Vee" of rubber from inside the tyre to give a tight, flat fit on to the wheel rims but that tyre used as the 'spare' should not be trimmed. If a fairly permanent attachment is required (these "period" spoked wheels for car occur frequently in the advanced modellers' sphere) then one of the contact adhesives suitable for the job should be used. Jorge is quite proud of the "serpent" horn made from two Meccano Tension Springs, A short Coupling, a mouth from a Christmas tree bell and a bulb from a baby's dummy!

Fig. 7 shows further examples of Jorge's attention to detail with prototype details reproduced at the front end. Veteran Car Club insignia and Rolls-Royce maker's mark are reproduced in miniature on the scuttle. These printed embellishments and similar ones elsewhere are the result of patience and skill by the builder in using adhesive lettering, trade prints from magazines and local skills for producing the impossible! The pair of 2½ in. Curved Strips which form the dumb irons at the front of the chassis frame are overlaid by 3 in. Formed Slotted Strips and secured at the front by ½ in. Double Brackets. Fixing Bolts are stood off by Washers to prevent the shank from fouling the short Axle Rods also fitted at this point to carry the semi-elliptic front suspension. Each of the main headlamps are rolled from a pair of 2½ in. × 1½ in. Flexible Plates to form a compound cylinder which is fixed to a Short Threaded Pin carried in a Slide Piece with boss. One Small Flanged Wheel and a Wheel Disc are joined by a suitable Axle Rod to a large Flanged Wheel at the front of the lamp. Ornate handles are provided by aa suitable Axle Rod to a large Flanged Wheel at the front of the lamp. Ornate handles are provided by an early type Meccano Octagonal Coupling fitted with Spring Cord hand ring as described previously. At the front end of the horizontal chassis members, a Fishplate is bolted on top at each side with a slight clearance by thin packing washers so that the lips of the Slide Piece can be held firmly when the lamps are mounted. Side lamps fitted to the scuttle of the driving compartment are also ornately constructed. Each is made from two small Flanged Wheels bolted to a chimney Adaptor as shown in the various illustrations and capped with a Collar fitted with a hand ring. These lamps are fitted with ½ in. Angle Brackets by which they are secured to the wing uprights of the windscreen, 3½ in. Strips which also help to trap the sheet of acetate used as the windshield. Standard Meccano Transparent Flexible Plates may be substituted if the constructor prefers this. A fully hinged bonnet is made from three Meccano Hinged Plates, 4½ in. × 2½ in. but only one Bolt and Nut is used to secure the first hinged plate to the second on each side. To maintain the top hinging facility of these special plates, the hinge rod must be pushed out slightly to lodge in the rear screw hole of the ½ in. Fixed brass Pulley forming the water filler cap. To make up for the lost portion of the hinge pin at the other end, a 6 BA bolt is passed through the scuttle, fitted with a lock-nut and pushed into the short vacant space at the scuttle end of the top hinged plate. The radiator grill requires 32 4½ in. Strips each one spaced by a single flat washer on 2½ in. Screwed Rods forming vertical supports at either

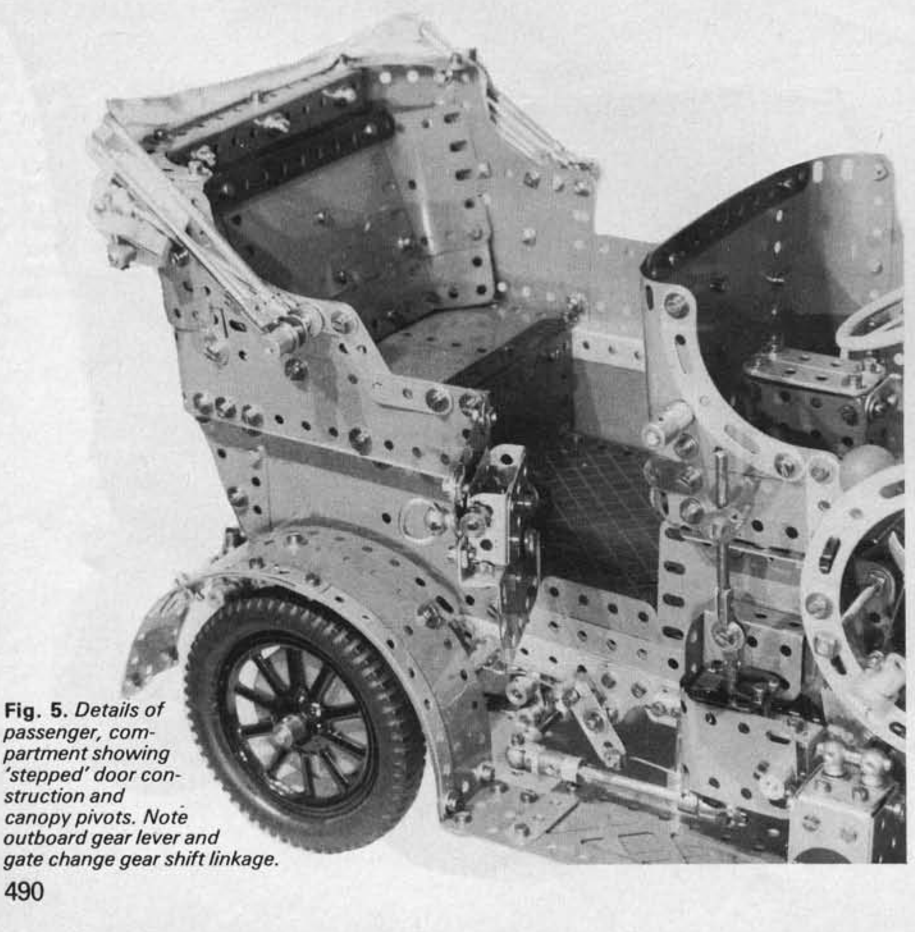


Fig. 5. *Details of passenger, compartment showing 'stepped' door construction and canopy pivots. Note outboard gear lever and gate change gear shift linkage.*

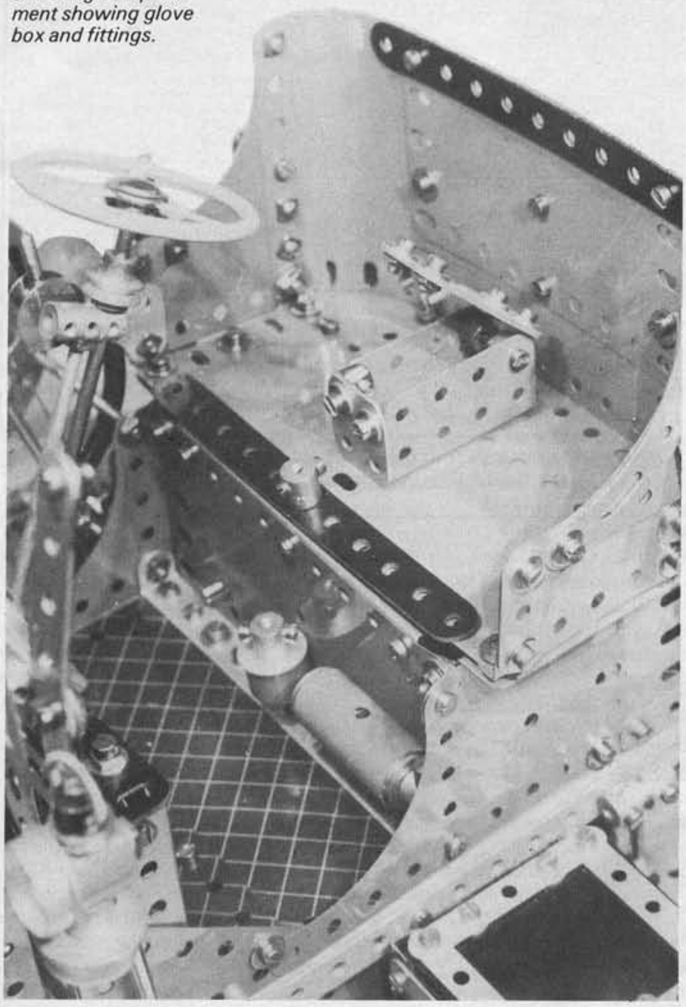


Fig. 6 *Construction of driving compartment showing glove box and fittings.*

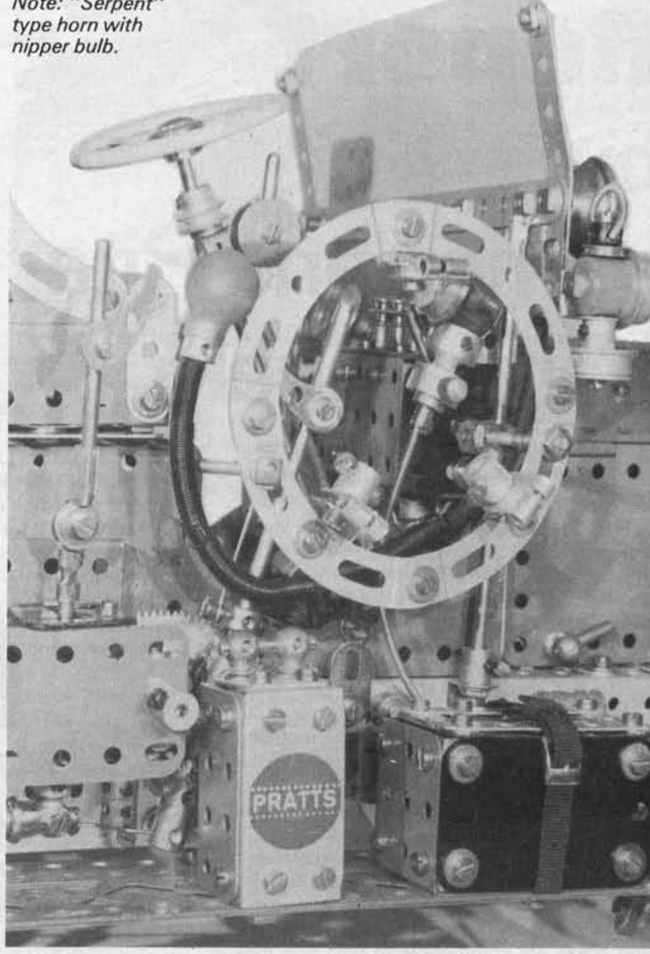


Fig. 8 *Stowage for spare tyre and details of petrol can and small tool box. Note: "Serpent" type horn with nipper bulb.*

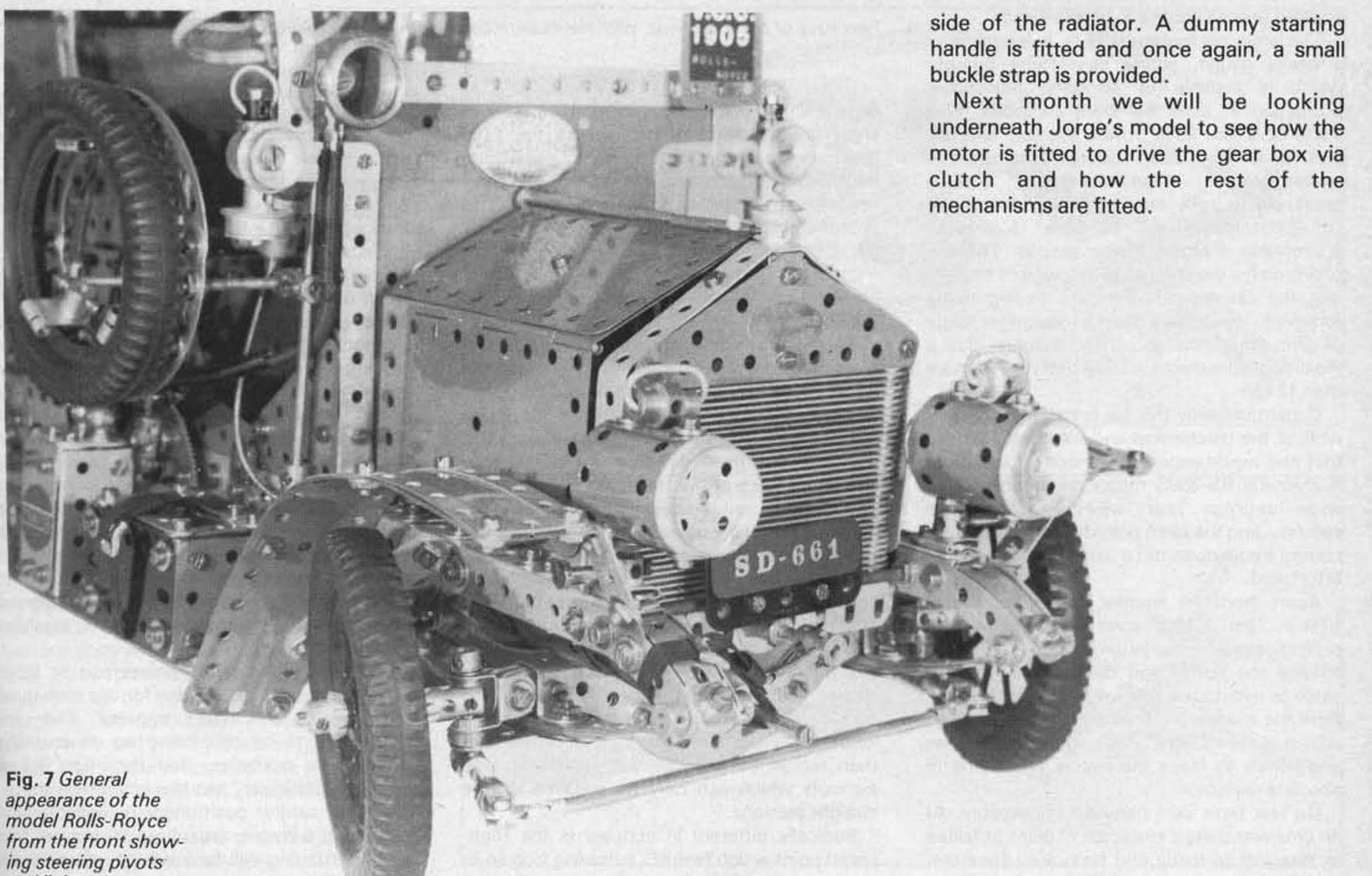
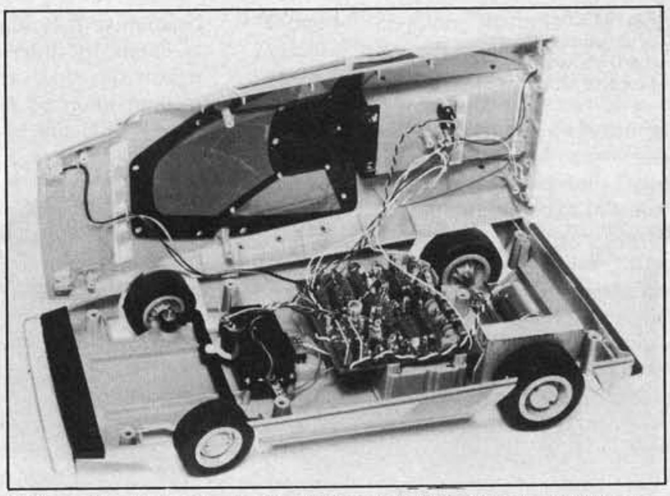


Fig. 7 *General appearance of the model Rolls-Royce from the front showing steering pivots and links.*

side of the radiator. A dummy starting handle is fitted and once again, a small buckle strap is provided.

Next month we will be looking underneath Jorge's model to see how the motor is fitted to drive the gear box via clutch and how the rest of the mechanisms are fitted.

Check and Report by James and Rita Vanderbeek



High quality electronics in this R/C Lamborghini. Note the additional wiring to the working flashers.

Ready to drive Lamborghinis in two sizes

Being in the right place at the right time can prove to be very useful. In this case it enabled us to borrow two of the first samples of the new Dome Models Lamborghinis to reach U.K. from their Japanese makers. Regardless of competitive pricing, these cars are excellent examples of what can now be achieved in quantity production, by a maker who is determined to secure a full share of the ready-to-drive R/C model market.

The cars are 1/15th and 1/12th scale, both with beautifully tooled injection moulded plastics bodies and undertrays, and with the smaller Lamborghini having single channel radio with stick control and semi-proportional steering. The larger 1/12th model has 2-channel radio, with fully proportional steering and speed control. The stick equipped unit has trimmers for both channels and a warning diode glows red when the unit is switched on. Both boxes are comfortable to hold and they enabled precise control to be exercised.

Two sizes of Lamborghinis, with their controllers. Both feature injection moulded bodies.

The larger car measures 16 in. in length, plus a heavy gauge, spring steel, wire bumper which is capable of affording reasonable protection at even full bore collisions. Five Varta cells No. 2614 power the car, with six pen cells No. 2606 being used in the transmitter. Alternatively, Ni-Cad rechargeable cells may be installed and the U.K. distributors will be able to provide appropriate chargers in due course. There is provision for the charger to be plugged straight into the car without the cells having to be removed. The makers claim a transmitter range of 60m. outdoors and 15m. indoors plus a maximum speed with Ni-Cad batteries of more than 12 kph.

Constructionally this car is bang up-to-date, with all the mechanical and electrical features that one would expect in a model of this type. A mabuchi RS-380S motor drives one of the wide section rear wheels—which are sprung—and the radio provides for six different control frequencies to be available, all in the 27 MHz band.

Apart from its smaller overall length of 10¾ in. the 1/15th scale lamborghini is a perfect partner to the larger car. Four 1.5v cells provide the power and there is even a neat catch to extend the dummy headlamp fairings. Both the models are finished in metallic silver, with a series of very neatly applied trim strips and panels to make the overall effect one of absolute realism.

On test both cars behaved impeccably. At no time was there a suspicion of delay or failure to respond correctly and both are, therefore, suitable for beginners to R/C motoring or very experienced drivers. All concerned are likely to enjoy these Lamborghinis, whilst the final touch, on the larger model, of amber flashers which operate in conjunction with steering and reversing movements caused no little approbation. These Dome cars are good—very good!

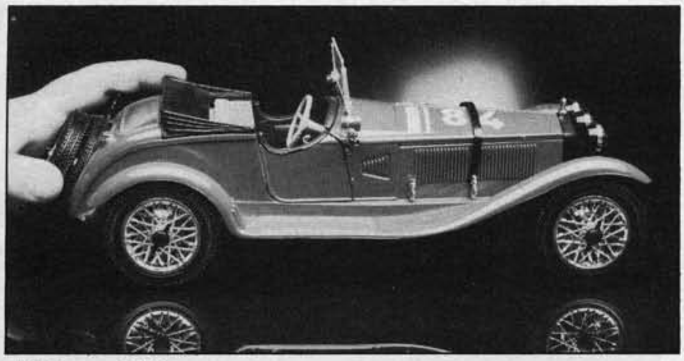
New type HO/OO track from Fleischmann

By the time these words appear in Model Mechanics many enthusiasts will have had the opportunity, at the Central Hall, European Festival of Model Railways, to see the latest exaples of Fleischmann HO/OO trackwork. Although the main development is the now available choice of the traditional brass or new nickel silver rail sections, three pieces of pointwork which feature in the latest range are all worthy of special note. The first two items can contribute materially to the efficient use of space on a layout. The 3-way turnout enables passing loops, sidings or combinations of both to have what amounts to overlapping access to the through tracks. A curved point acts in similar space-saving manner, for it enables subsidiary tracks such as sidings or passing loops to be started earlier and finished later than would be possible with standard type turnouts which can only be installed on the straight sections.

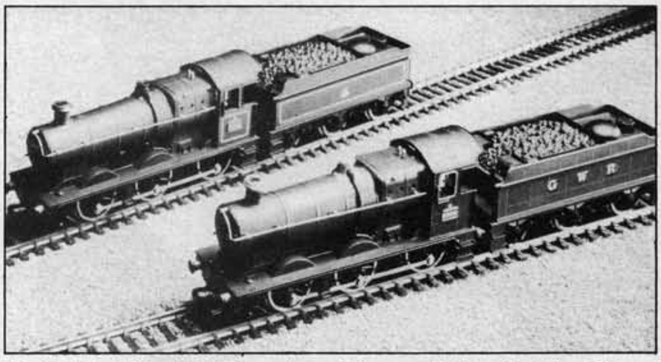
Radically different in concept is the High-speed point which features a moving frog so as to provide an unbroken rail pattern, through which trains may pass at speeds which otherwise would be unsafe. Full-size points of this type are already operational in Germany and, with the accent on speed so noticeable on British Rail, it will be surprising if similar trackwork is not introduced here.

Tests with all three types of three turnouts were carried out using locomotives and rolling stock of a number of popular brands, besides some of our more recent Fleischmann test subjects such as the HO scale diesel railcar set in its new turquoise and cream livery. our varied test trains ran beautifully through the points at all speeds and with a complete absence of any sort of shudder or vibration. In the case of the moving frog High Speed point, we purposely chose one or two locomotives whose maximum speeds are so much in excess of scale that they are prone to derailment if taken through curves or points at anything like full bore. Both negotiated the High Speed point repeatedly without any apparent sign of instability—a performance which we regarded as quite remarkable.

All these Fleischmann points can be fitted with motors and are suitable for use with most of the main U.K. track systems. They are thoroughly to be recommended as ensuring trouble-free operation, and the High Speed point, in particular, has the advantage that it may be safely positioned in inaccessible corners of a layout, regardless of whether fast or slow running will be involved—derailments simply will not occur.



Alfa Romeo 1750.



The British Rail and GWR versions of the new Palitoy Mainline OO scale Class 2251 Locomotives.

Latest Polistil Car Models offer special finish potential

The four Polistil diecast/plastic cars which are gracing our desk at the moment represent some of the world's finest pieces of such machinery—both vintage and present-day. Pride of place must go to the 1/16th scale Alfa Romeo 1750, which is based on the car driven by Nuvolari in the 1930 Mille Miglia and, appropriately, is in racing trim with strapped-down bonnet, special lights and the red finished wings which were a feature of this particular vehicle. Racing numbers are carried on the bonnet top. The same car in road trim and with erected hood also comes in 1/43rd scale. It has all the character of the larger Alfa but, inevitably, some of the features are simplified.

Superb present day engineering is typified in the Ferrari 308GTS sports/coupé, with rear-mounted engine under a lift-up cowling, and the very popular Mercedes Pagoda 2+2 coupé. Like the vintage models, these 1/25th scale models have opening doors, bonnets and boots, plus accurately fitted-out interiors and all the external trim of the prototypes.

It was the unusually high quality of these latest additions to the Polistil range which made us consider them, not only as collector's pieces, but as models which merit the full attention of the enthusiast's brush to pick out even more of the detail that is incorporated in the castings and mouldings and thereby take the cars a stage or two nearer to exhibition model finish. This seems to us to be not only possible, but eminently practical. All are beautifully made in the factory, so why not use that quality as the basis of a one-off version!

Great Western 0-6-0 Locos in Palitoy's Mainline System

A recent batch of test models from Palitoy included both GWR and BR versions of a type which has long been a particular favourite of ours. About 120 of the GWR 2251 Class tender locomotives were built and were in service from 1930 until well after World War II. The basis of the design was the inevitable 0-6-0 Pannier tank, but in the form modelled by Mainline, was one of the most attractive locos to be seen on any branch or cross-country line.

Mechanically and electrically the 2251 models are to the well-established Mainline series standards, but we feel that the toolmakers have done a particularly fine job in the loco body and tender mouldings. The locos look right close-up; they are beautifully proportioned on the track and, with the large numbers of individually applied detail parts—from the brake pipes and hooks on the buffer beams, the articulated side rods and the tender brake standards, these models are superbly turned out.

The same high praise must be applied to their running characteristics, for both the GWR green and the BR black models proved to be as tractable and smooth running as their prototypes. They are very good value—especially at discounted prices—and likely to be best-sellers in the coming months.

Interesting Airfix Kits

In recent years the Airfix development team, headed by Jack Armitage and Barry Wheeler, has worked wonders with the kit range. Each succeeding batch of models incorporates new features, which render them even more realistic and accurate than previous examples, or they may be easier to build with, for instance, improved alignment or interlocking of the parts.

The first of the new Airfix kits to be mentioned here is a real modelling favourite—the North American P-51B Mustang, long-range fighter of World War II. So many kits have been produced featuring the Mustang in its various marks, that it is set fair to rival the Spitfire and Me109 in overall popularity but, in this version with its original type canopy, long-range Berlin tanks, cuffed airscrew blades, Merlin cowling, improved undercarriage detail and the markings of an aircraft flown by one of the top scorers in the European theatre, this model should be exceptionally popular.

Larger and much more complex is the Lockheed S-3A Viking, a carrier-based twin-jet machine which, because of its nuclear and conventional submarine killing task, is as technically complex as they come. The white moulded Airfix 1/72nd scale replica provides for Vikings from USS America or USS J. F. Kennedy to be produced, and even the most critical plastics modellers will have trouble criticising any part of this quite remarkable Navy machine.

Third in this Airfix kit group is a new version of the 1914 Dennis Fire Engine. There are over 140 red finished moulded parts in this kit—covering the chassis, engine, body, pumps, escape ladder and crew figures so, perhaps, comment on this one is best restricted to remarking that not only is this a very rare kit subject, but a real collector's piece in its own right.

It had to happen . . . once Commander 007 James Bond heard about the U.S. space shuttle he just had to have one in his latest film.

Merlin engined Mustang P-51B to 1/72nd scale.

Superb sub-hunter-Lockheed's Viking to 1/72nd scale by Airfix.

Finished model from the new Airfix 1914 Dennis fire-engine kit.

James Bond 007 Moonraker spaceship from the 1/144th scale Airfix kit.

Moonraker, as this 1/144th scale spacecraft has been named, looks like an exact replica of the soon to be launched American vehicle and has many of the now familiar externally attached parts, such as the fuel tank and boosters. All the parts are again moulded in white and there is a special set of Moonraker markings. For James Bond Enthusiasts—and that must include many modellers—this kit is a natural!

Electronic Toys and Models will make Christmas News

Over the years, numerous leisure-time products have had a rough passage, as far as securing acceptance by many of the more conservatively-minded adult buyers was concerned. This Christmas, however, things are liable to be quite different, because the revolution (it is hardly less) that has taken place in electronics development means that a large percentage of new playthings will incorporate very advanced circuitry.

One of the companies which has so identified its whole 1979 range is Actiongable limited—the providers of our three test subjects.

First is an electronic calculator—nothing in this, until you realise that the Enterprex International BJ.21 is something of a wolf in sheep's clothing. This nicely-styled unit measures just $5\frac{9}{16}$ in. × $3\frac{1}{8}$ in. × $\frac{9}{16}$ in., combines 10-digit calculations with acting as a highly-skilled electronic opponent in the game of Blackjack, so changing work to play with one movement of a selector switch.

A neat folder provides full instructions on both modes and the BJ.21 can be operated either by a trio of Ever Ready HP16 cells, or via the separate AC mains adaptor which is an optional extra. Throughout extended tests the calculator performed with complete accuracy and reliability. The digits are easy to read, the calculator has a most attractive brushed-metal surface finish and is supplied in a useful wrap-around leather-effect case.

George is a real fun model—full of electronics and programmed to go 'left', 'straight', 'right', or 'stop' at the driver's command. This 11 in. long truck is finished in bright yellow, has a rather special black, blue and red paint job and oversize Goodyear tyres. only when the body is eased off the moulded chassis is the real technical interest of this new model apparent. Behind the driving seats is a printed circuit board, a foam enclosed Sony condenser microphone and a 3v. DC motor with belt and worm drive to a fifth road wheel, mounted below the cab to provide the steering action. A second, larger motor has its drive-shaft bearing directly on to a flexible plastic rim incorporated in the right-hand rear wheel. Three batteries are required—a 9v cell for the electronics and two 1.5v 'D' cells for the traction motor.

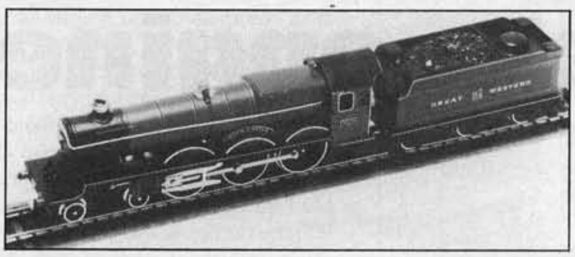
Driving George was as much fun as the makers claim! The exact words used as commands are not important but, unless the model has positioned itself so that the microphone is masked, response to audible commands is immediate.

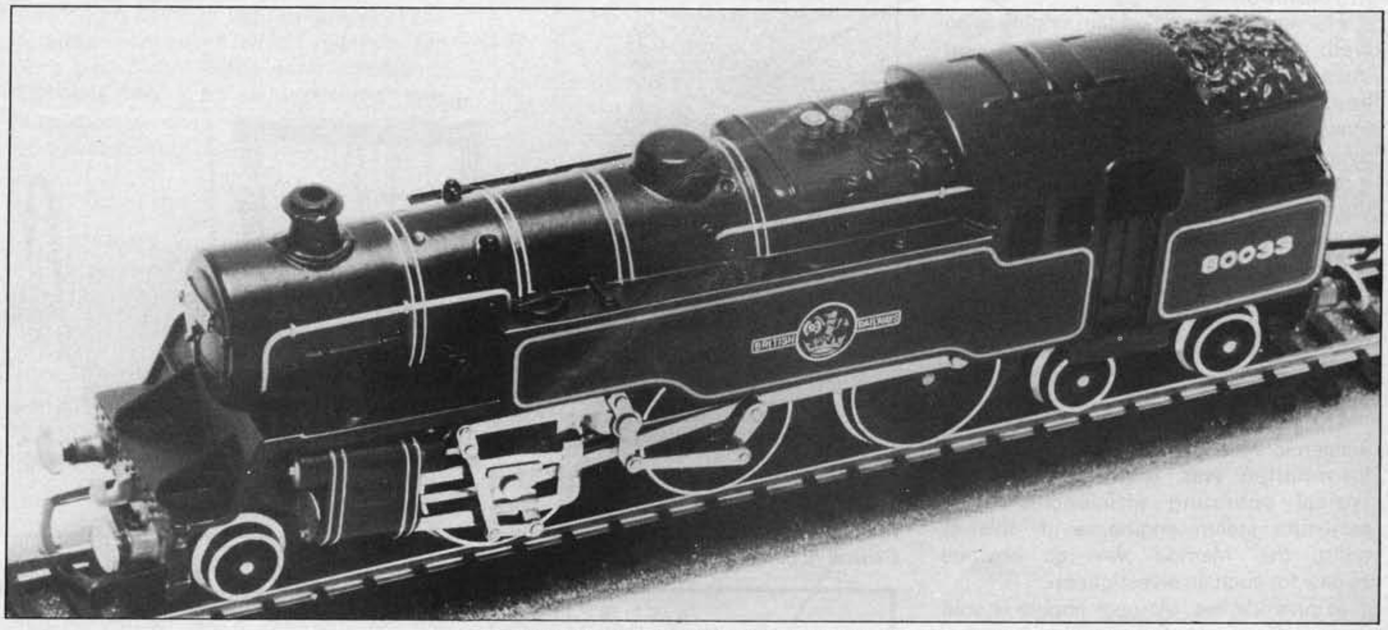
From electronic van to sonic dog was only a matter of opening another carton. Actiongable's canine is about 12 in. long, a Dachshund with dark brown coat, large brown eyes and red tongue, and can be switched on simply by pulling the lead. The sonic response equipment is very neatly enclosed in the dog's tummy and responds to suitable impact noise, such as clapping hands or a plastic whistle-cum-hammer provided with the toy. Each instruction sequences the action and we were surprised to note the rapid response and ease of command transmission that was achieved through walking, stopping, tail-wagging and barking.

The Enterprise International BJ21.

Above George an 11 in. long customised van with full voice control system and fifth wheel steering.

Left sonic response dog.





Diecast metal bodies, lathe-turned wheels, ring-field motors and a high degree of hand finishing characterise these Wrenn 00 models.

About OO Locos in Metal

Nowadays, almost every new type of OO/HO locomotive seems to have a moulded plastic body. This applies to steam, diesel and electric outline models and all incorporate quite astonishing amounts of fine and authentic detail. Plastic bodies, then, have just about become the norm.

It is the more surprising, therefore, that Wrenn Railways continue to prosper, with steadily increasing demand, with a range largely based upon diecast metal loco bodies and which, as a direct result of both tool age and the limitations of the zinc-based metal casting process, incorporate rather less detail than their main competitors.

Wrenn remain proud of the fact that the metal bodies date back to the original Hornby Dublo models (all of which are now collector's pieces) and, whilst it would be an overstatement to say that they could not care less about the greater detail in the plastic varieties, they are total believers in the long-term future of metal locos. Wrenn also claim greater model strength, longer working life, smoother running and better stability—which add up to quite a list!

Having tested these models, from Hornby Dublo 3-rail, plus the Dublo 2-rail developments, and through all stages of Wrenn production, it must be stated that a 1979 metal-bodied loco bears little engineering resemblance to the original Hornby product. The brothers Wrenn have carried out a continuous programme of tool refurbishing and rebuilding ever since they took over the range and it is for this reason that present-day quality is so high. Admittedly there are departures from true scale outline, and some of the models need more added bits and pieces to be perfect but, nevertheless, it is one of the most impressive facts in the U.K. industry that these pre- and immediately post-war basic designs should have stood up so well to the improvement programme.

In recent months we have checked and tested the latest versions of the LNER/BR Class A4 Pacific, the BR Class 4MT 2-6-4 tank and the LMS/BR Stanier Pacific. All responded like old friends directly the speed control was opened up. Especially interesting is their progressive acceleration, with the heavier loco bodies and more evenly distributed weight contributing to really good load-hauling capacity. Wrenn are reluctant to fit traction tyres and, from our experience, they are hardly necessary. The all-up weight also pays dividends when the inertia and braking facilities of the power unit are applied to exercise very fine control, whilst speed changes more true to prototype are achieved than with lighter locos.

Once the models are on the track, points of criticism about scale dimensions and external detail seem of lesser importance—but then we have never believed in rivet counting. Suffice to conclude these notes by remarking on the fact that, as with so many hand-finished articles, no two Wrenn locomotives are ever absolutely identical—perhaps this Essex-based manufacturer has another point there.

Shown here in flight, the Revell Enterprise kit also provides parts for the launch pad base.

Enterprise with Rockets and Launch pad

One of the most impressive kits of the year from Revell must be the 1/144th scale space shuttle flight system—with the Enterprise craft plus its huge external fuel tank, the two solid propellant rocket boosters and the crawler-equiped, mobile launch pad base on which the entire flight module is mounted in its vertical launch position.

Not until the completed model is compared with something of familiar proportions is the bulk of the space shuttle system apparent. A British outline N-gauge train is not so very different in scale and certainly emphasises the point. Revell has done a first-class job in its series of space shuttle kits—of which this is the largest—and the enthusiast now has the opportunity of deciding whether Moonraker or Enterprise shall be his modelling choice.

Mamod steam engine Test

By Dr. Keith Sherwin

Introduction

The small 'Mamod' steam engine is so well known that it requires no introduction. It has provided an introduction to model engineering for many small boys, and not so small boys, over a considerable number of years. That it remains a firm favourite is evident from the fact that it is sold in most model shops around the country.

Although the engine is so well known the performance characteristics are not and it is therefore considered that the test results derived from a typical, off-the-shelf, 'Mamod' engine are of some general interest.

The tests were performed as part of an academic research programme because information was required regarding typical operating efficiencies of a miniature steam engine. With this in mind, the 'Mamod' was an obvious choice for such an investigation.

In practice the 'Mamod' engine is sold as a self-contained unit with its own boiler. However, as the tests were too prolonged for the capacity of the 'Mamod' boiler the engine was coupled to a larger 9Kw electrically-heated boiler within the laboratory.

Apparatus

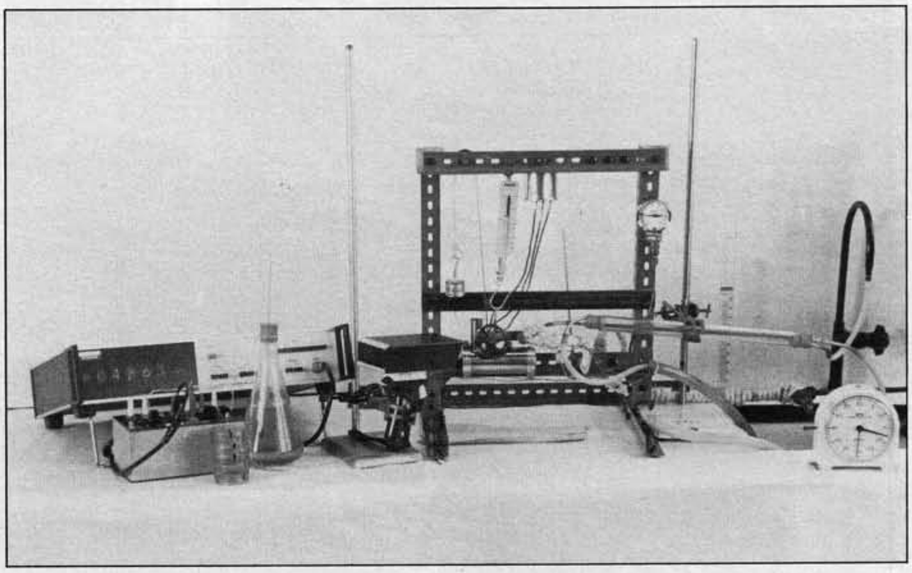
A schematic diagram of the test arrangement is shown in Fig. 1. The condition of the steam was monitored by means of a pressure gauge and a thermo-couple. The thermo-couple was soldered to the inlet pipe of the engine cylinder in order to measure the temperature of the steam at that position. Similarly, a thermo-couple was soldered to the outlet pipe to measure the temperature of the exhaust steam at that point.

The cold junctions of each thermocouple were immersed in an ice-water mixture and the reading from each thermo-couple measured by means of a digital voltmeter.

A water-cooled glass tube exchanger was used to condense the exhaust steam and the flow of condensate measured using a graduated measuring cylinder.

Throughout the tests, the temperature of the exhaust steam only varied by a small amount between 206° and 209°F, indicating that the exhaust conditions were very close to atmospheric and that the condenser had negligible influence on the running of the engine.

Power output of the engine was measured by means of a 'rope' brake around the engine output shaft. In practice, due to the small size of the engine, lightweight string was used for the 'rope'. The string was wrapped once around the shaft and was anchored at one end by a 0-100 gram spring balance whilst the load was attached to a hanger at the other end.



General Apparatus set-up.

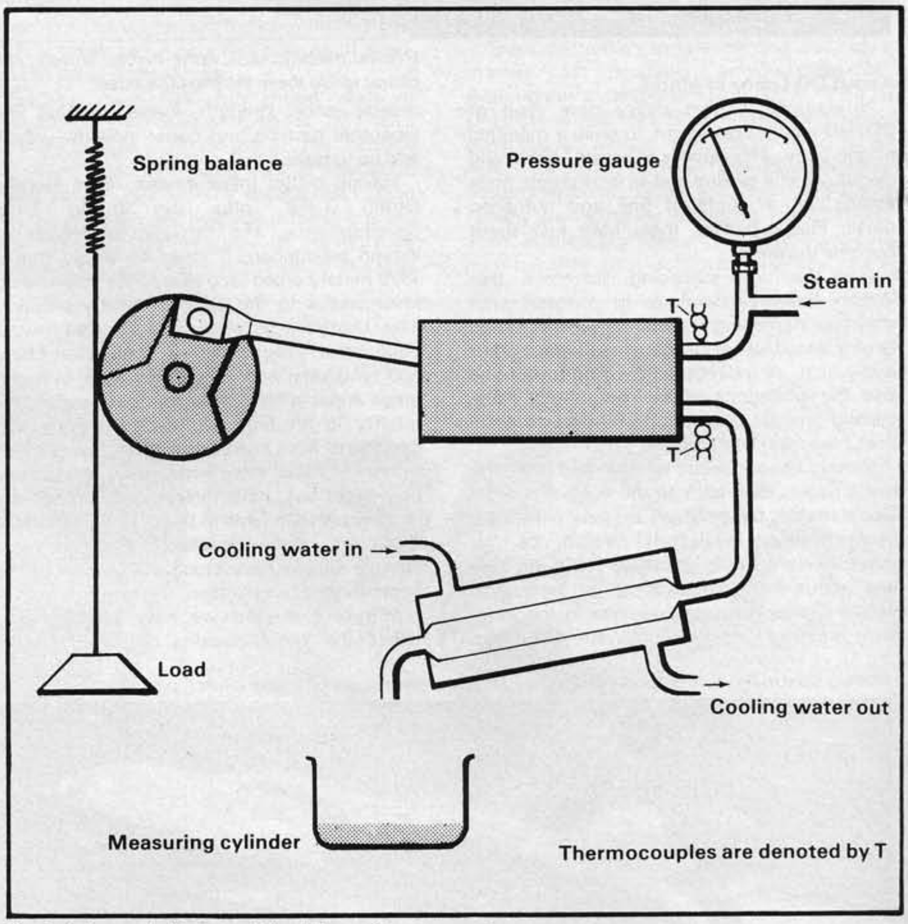


Fig. 1 *Schematic diagram of the 'Mamod' test apparatus.*

Loads of between 0 and 600 grams were used, being increased in 50 gram increments until the engine eventually stalled. The nett load on the shaft was found as the difference between the applied load and the spring balance reading.

At each load setting, the rotational

speed of the engine was measured. This posed some problems as the engine had too small a power output for a conventional rev-counter to be used.

During preliminary tests a stroboscope was used, but for the actual tests, this was discarded in favour of a 'light beam' tachometer. This instrument can be held in the hand and gives a direct digital reading of the speed. It operates by directing a beam of light on a part of the rotating mechanism which redirects the light beam back once each revolution. The time interval for each revolution was then monitored and the rotational speed computed within the tachometer.

Tests

Preliminary running of the engine indicated that the performance was critically dependent on the state of lubrication of three major parts of engine, the shaft bearing, the big end and the oscillating cylinder, when undergoing prolonged testing. In view of this a simple drip feed oiling system was constructed in order to ensure an adequate supply of lubricant throughout the tests.

Two series of tests were performed at steam pressures of 10 p.s.i. and 15 p.s.i. gauge respectively. Figure 2 shows curves of the actual measured output of the engine plotted as a function of the rotational speed. As the power output was so small the numerical values are given as thousandth's of a horse power.

Putting these measured outputs into perspective, the maximum power output at 15 p.s.i. is still below 1½ watts, insufficient power for a torch bulb.

The characteristics of the engine are well defined by the curver in Figure 2 with maximum output at about 1,750 r.p.m. for both steam pressures. Above this speed, the power falls off rapidly until at no-load conditions a maximum speed of 2,700 r.p.m. was achieved at 10 p.s.i., this being increased to 3,250 r.p.m. with a steam pressure of 15 p.s.i.

As the tests were initially performed to check on operating efficiencies, it is worth noting that these were very low, a figure of 0.6% being the best achieved at 10 p.s.i. whilst a slightly improved figure of 0.9% was achieved at 15 p.s.i.

These figures represent the overall thermal efficiency, being a measure of the output power as a percentage of the thermal input in the steam.

At best, these figures can only be estimates as the values were calculated on the basis of the condensate flow rate and no measure could be made of the steam escaping past the oscillating cylinder. However, some allowance for this loss was made during the calculations and it is anticipated that such efficiency values are realistic.

Discussion

The 'Mamod' engine operates as an oscillating cylinder engine. At top-dead-centre the steam port into the cylinder is

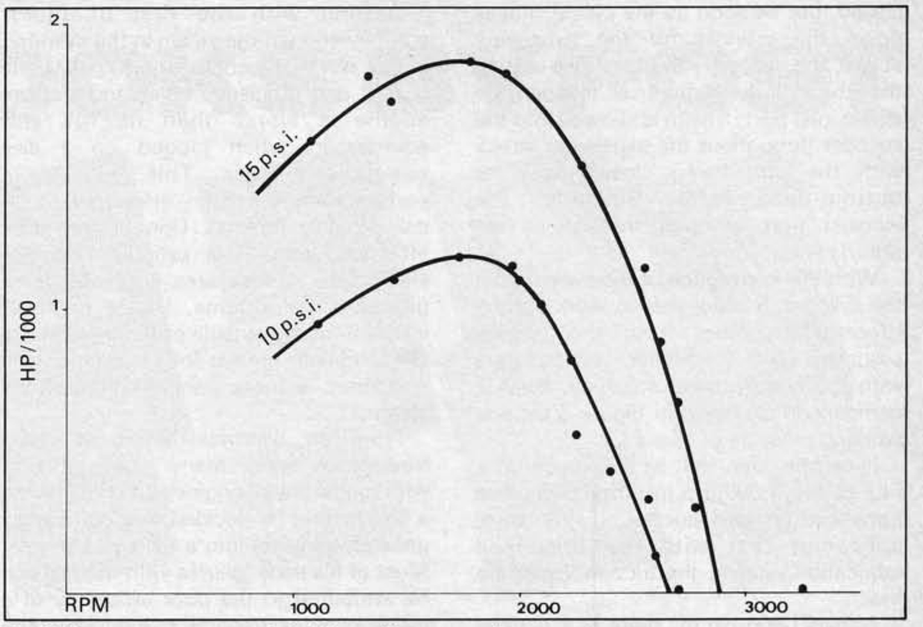


Fig. 2 *Power output curves of the 'Mamod' steam engine.*

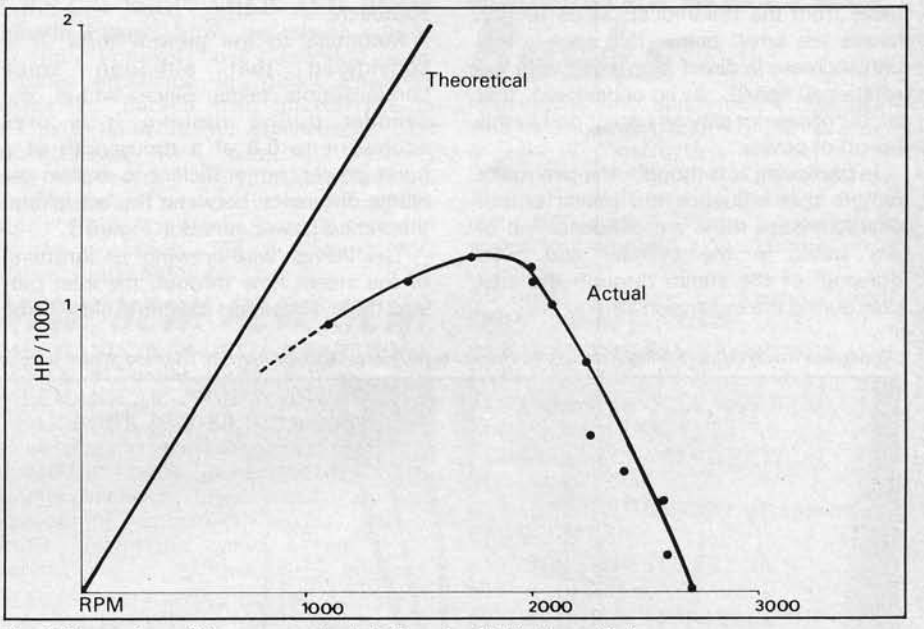


Fig. 3 *Comparison of the power output at 10 p.s.i. with the theoretical power.*

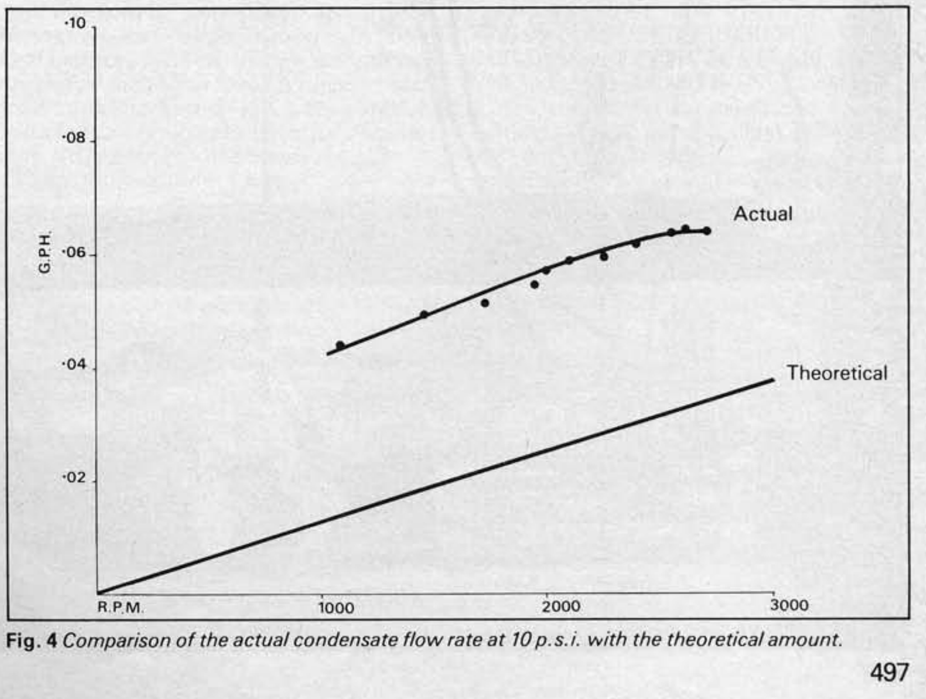


Fig. 4 *Comparison of the actual condensate flow rate at 10 p.s.i. with the theoretical amount.*

closed, but as soon as the piston moves down the cylinder for the expansion stroke, the geometry of the engine is such that the cylinder slides over to open the steam inlet port. Steam is allowed into the cylinder throughout the expansion stroke with the port being closed again at bottom-dead-centre. Similarly, the exhaust port is open throughout the return cycle.

With this knowledge of the cycle within the cylinder, it is possible to work out the theoretical power from the engine assuming ideal conditions, and compare with the actual power achieved. Such a comparison is shown in Figure 3 for one working pressure of 10 p.s.i.

It can be seen that at low revolutions i.e. below 1,000 r.p.m., the difference between the two curves is very small indicating that with the drip feed lubrication system, the friction losses are low.

Above 1,000 r.p.m. there is a marked divergence of the actual power curve away from the theoretical. Since friction losses are small below this speed, and only increase in direct proportion with the rotational speed, it is considered that friction does not play any great part in this fall off of power.

In particular, it is thought the two major factors that influence the power output characteristics most are condensation of the steam in the cylinder and 'wire drawing' of the steam through the inlet port during the expansion stroke.

Dealing with the first of these, condensation of the steam in the cylinder, it has always been recognised that the output and efficiency of a model steam engine is worse than its full size counterpart when judged on a size comparison basis. This fall off in performance has been attributed to so called 'scale effects'. One of the scale effects is that as a cylinder becomes smaller the surface area is greater for a given internal volume. Hence the heat losses from the outside of the cylinder are proportionally greater for a smaller engine and there is more condensation of the steam.

From an historical point of view, Newcomen spent many years working with model steam engines before evolving a design that he decided was sufficiently good to translate into a full-sized engine. Most of his early failures with models can be attributed to the poor efficiency of a model engine compared to a full-size one, rather than any real defect in his design approach.

Returning to the present tests, it is considered that although some condensation takes place within the cylinder during running it is only equivalent to 0.3 of a thousandth of a horse power, not sufficient to explain the whole difference between the actual and theoretical power curves in Figure 3.

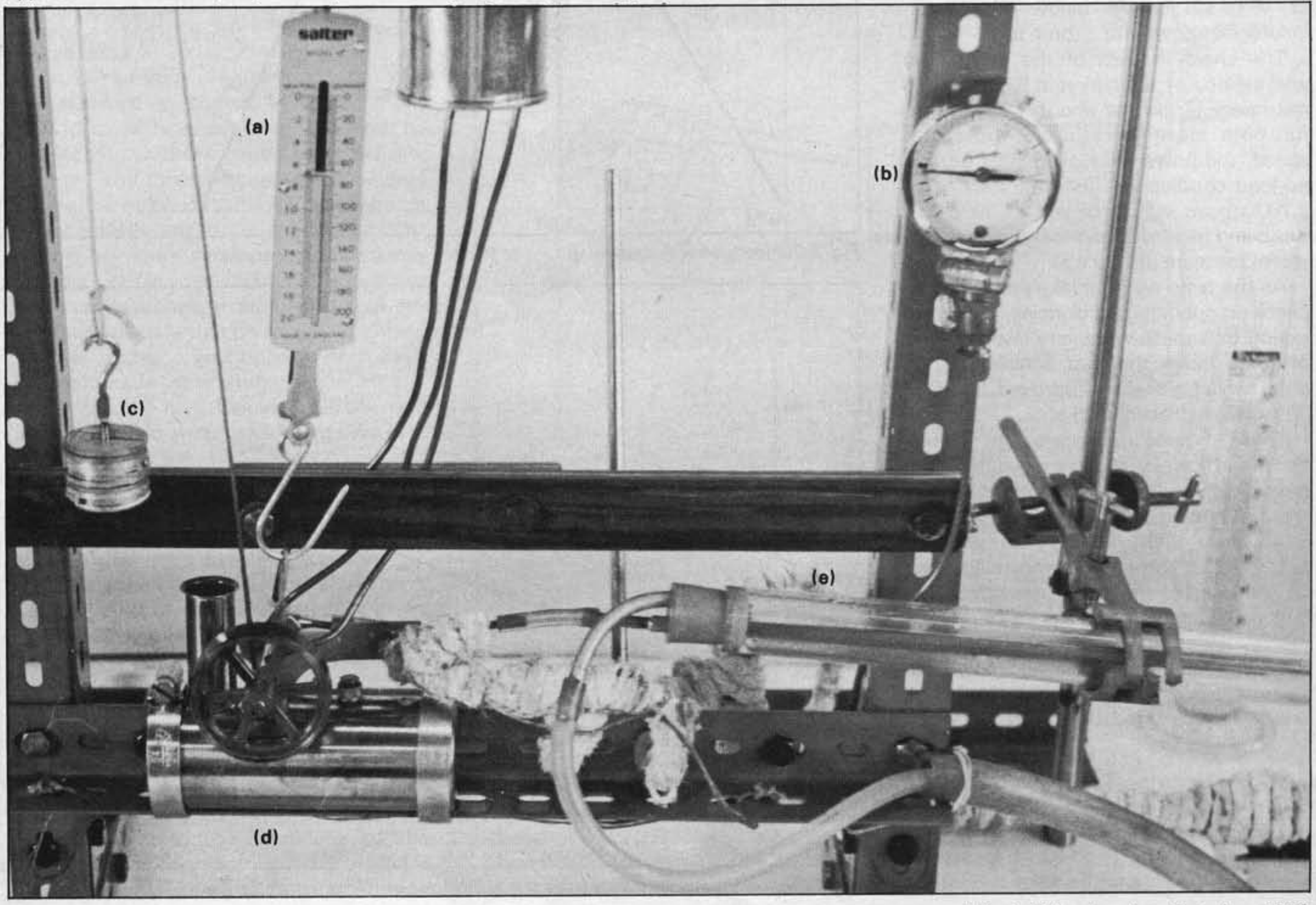
This leaves 'wire-drawing' or throttling of the steam flow through the inlet port into the cylinder and also throttling of the exhaust steam leaving the cylinder. Although the inlet port and similarly, the exhaust port, are open throughout virtually the whole stroke, they are not completely open except at the mid-point of the stroke. Near top and bottom dead centres the port is only slightly open and at these positions, the steam flow is restricted. This throttling process becomes more noticeable as the rotational speed of the engine increases, hence the fall off of power shown in Figures 2 and 3.

The influence of this throttling can be seen quite clearly from Figure 4 which shows the flow of condensate from the engine. Although this in no way takes into account the loss of steam escaping from the joint between the inlet port and the cylinder, it does provide a realistic measure of the steam used during the power cycle within the cylinder.

It can be seen that the actual condensate flow rate is higher than predicted by theory. This is compatible with the low operating efficiency and can be accounted for by the boiler supplying wet steam to the engine together with increased condensation within the cylinder.

What is perhaps more notable is that there is only a comparatively small increase in condensate showing that throttling is also increased through the ports at higher speeds. This is particularly evident by the levelling off of the curve at the maximum speed achieved.

Apparatus involved: a. Spring balance; b. Pressure gauge; c. Applied load; d. Mamod steam engine; e. Condenser.



A Working Savery Pumping Engine

By Tubal Cain

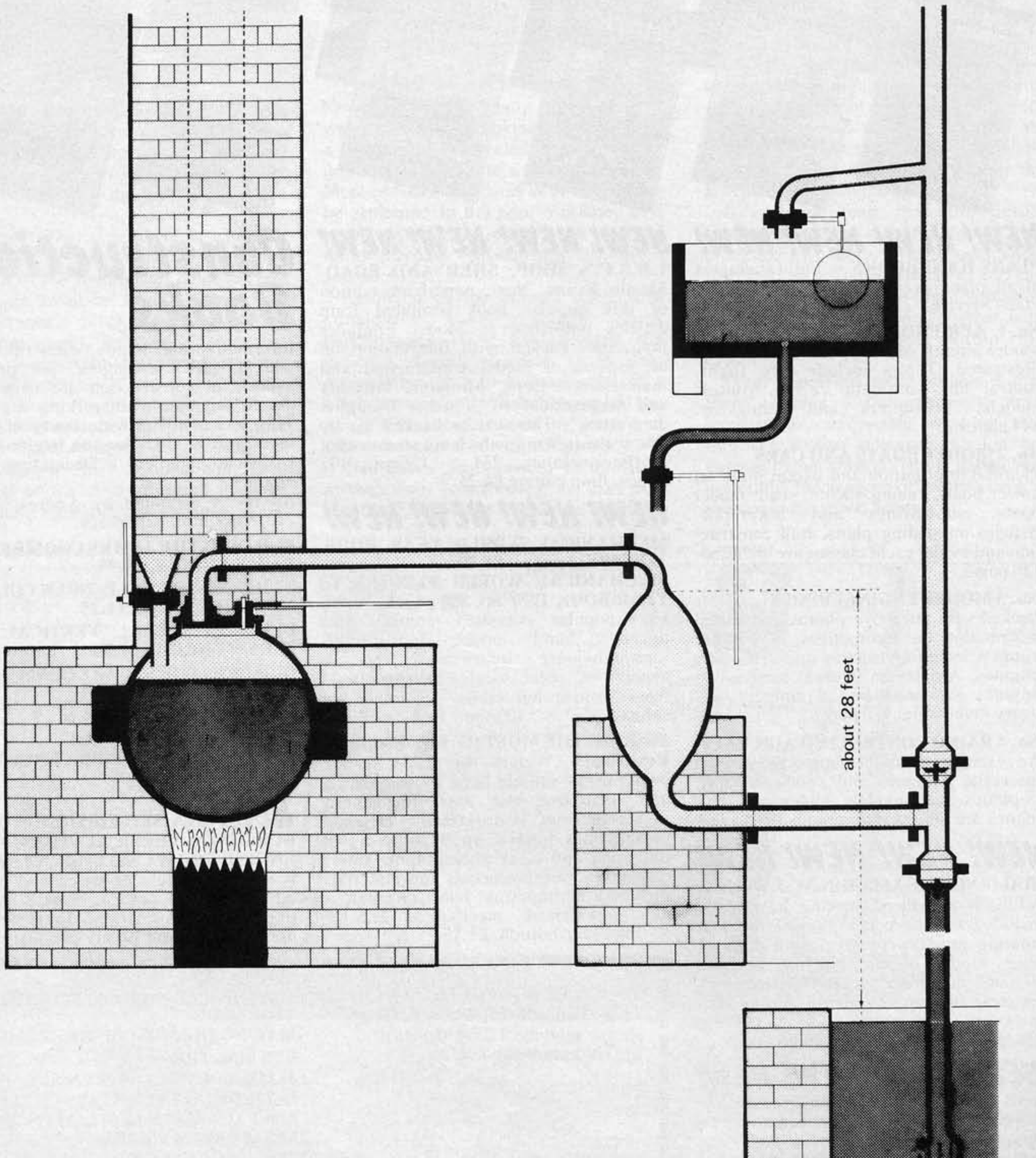


Fig. 1 *The principle of Thomas Savery's steam pump of 1698.*

(Drawing by courtesy of the Science Museum)

This model was built to illustrate a lecture on the History of the Steam Engine, and was put together out of odds and ends in a very short time. Hence the very "domestic" appearance of the boiler and receiver! However, it does work, and that was the main object of the exercise.

The Savery engine, which he called "The Miner's Friend", was the first effective steam powered pump. True, there were earlier attempts which did in fact discharge water but all had the disadvantage that this water was almost boiling; when used to drive a fountain, for example, the fish didn't like it at all. The second snag was that all required the fire to be put out, and the boiler recharged with water, at every "stroke" of the apparatus. The Savery machine by contrast, could work more or less continuously. Fig. 1 is a diagram to show the principle. On the left is the boiler with an internal valve to the steam supply pipe worked by a lever. When this valve was opened steam entered the receiver and drove out the water contained therein. As soon as steam emerged from the rising discharge pipe, indicating that the receiver was empty, the steam valve was closed and a stream of cold water was poured over the receiver from the cistern above. This condensed the steam within the receiver, causing a vacuum, which draw up water from the sump, refilling the receiver again. The valve to the cistern was then closed and the steam valve opened — and so the process continued. By using two receivers served by the one boiler, and duplicating the valve and pipe system the machinery could be arranged to deliver an almost continuous stream of water, one receiver emptying as the other filled. The suction lift was about 28ft, and the discharge as much as the boiler could be made to stand. As the safety valve had not yet been invented it was this last limitation that gave the user — and operator — much food for thought!

However, the engine did work, and several were installed. Not in mines, for even in those days miners were not too happy at the idea of having a large fire at the bottom of the pit. But London Waterworks had one at Kensington, and several others were built. It preceded the Newcomen engine by about 12 years (though some believe that Newcomen was working on his experimental engine before the date of the Savery) and as Savery's patent covered the use of the "alternate rarefaction and condensation of steam" for pumping water Newcomen was forced to accept that this patent covered his far superior engine. Fig 2 is an engraving of the engine installed at Kensington in 1712, the same year that Newcomen installed his first engine at Dudley Castle.

The model need not cost you a great deal as Fig 3 shows! However, there is no reason why, having made up this one and found out the way it works, that you should not be able to make one that looks very much more like the original machine.

Valve box

The valve box is made from a compression-type Tee-union as used on motor-cycles etc. for oil-pipes but is used with conical nipples — see fig 4. The hole through is about $\frac{3}{16}$" (actually 4.6 mm) dia and should not be much more than this — it has to make a seat for the $\frac{7}{32}$" ball. The necessary modifications are shown on the drawing — a $\frac{1}{16}$" hole is drilled across and a piece of brass rod soldered in to stop the ball from seating within the union on the suction side; the seat here is in or on the nipple of the suction union. There is a similar bar soldered across the delivery union *nipple* for the same reason. In short, you want the ball to seat in the tee-piece on the delivery (upper) end and on the nipple at the lower, suction, end. The balls I used are $\frac{7}{32}$" stainless steel ones, but hard bronze will do just as well. Indeed, you can use ordinary ball-bearings if you like, provided you replace them as they get rusty. I used these to form the seat — drop in a hard $\frac{7}{32}$" ball, give it a tap on the seat with a light hammer and a punch, and then replace with the proper ball. You may find that at

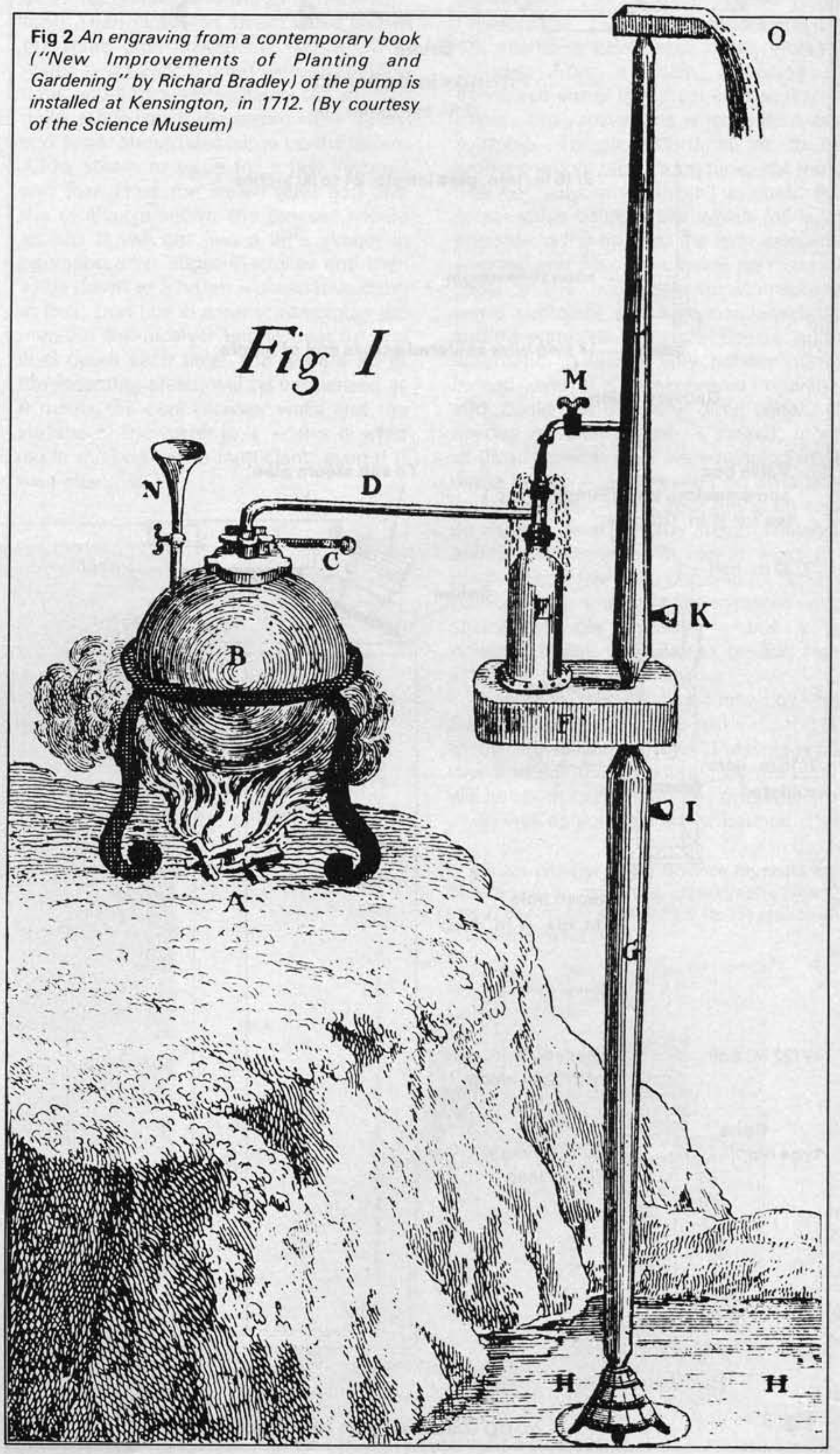


Fig 2 *An engraving from a contemporary book ("New Improvements of Planting and Gardening" by Richard Bradley) of the pump is installed at Kensington, in 1712. (By courtesy of the Science Museum)*

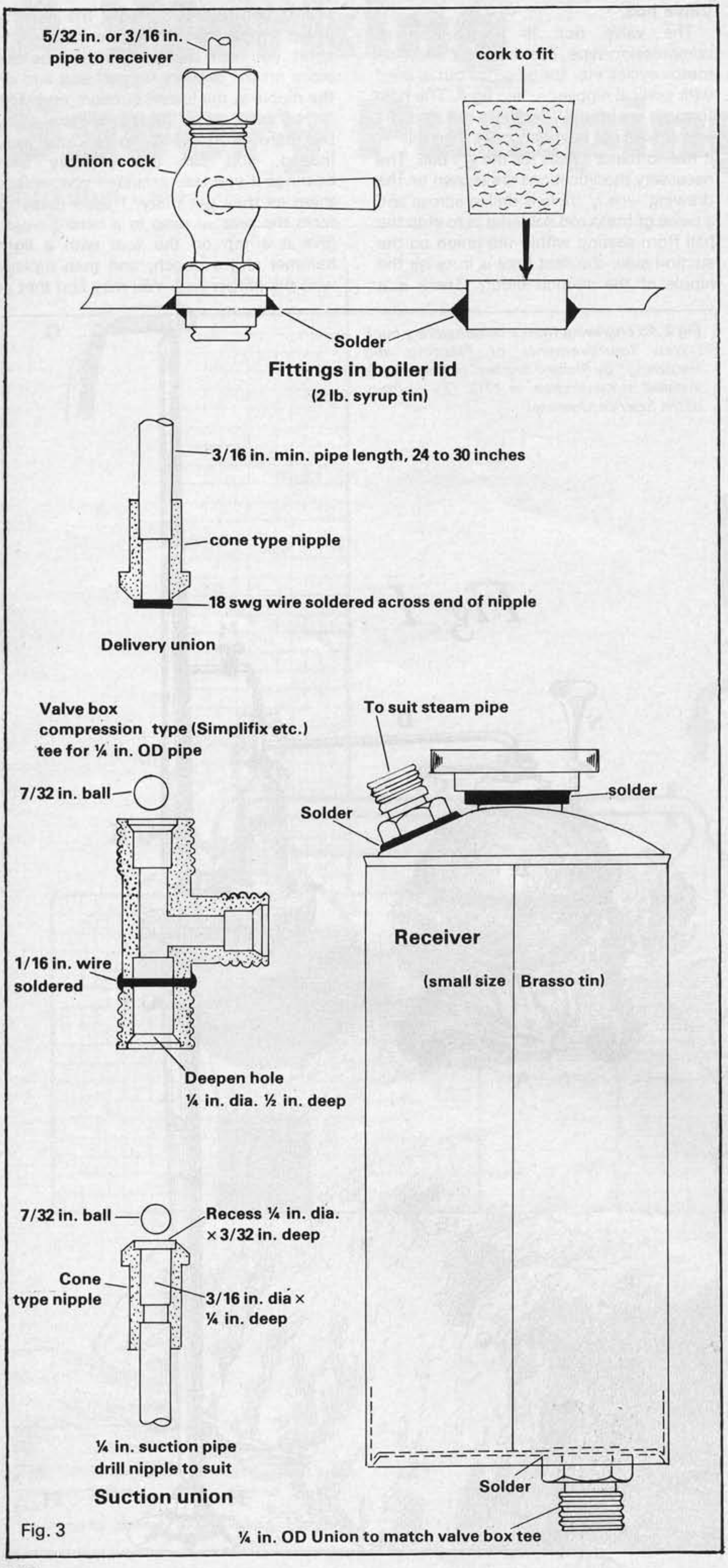


Fig. 3

first the valves do leak a little. This should cure itself after a dozen "strokes" or so, but if not, repeat the above treatment.

You can, of course, make a proper valve-box with mitre seated valves if you like. If you do so, keep the valves as light as possible especially on the suction side. This can make the difference between working and failure. The valves must be vacuum tight, as must all joints and the steam valve. Leakage of air into the receiver will stop the pump dead.

The suction and discharge pipes may be made to suit yourself. When at work mine draws from a glass beaker and discharges usually into an empty cocoa tin, so that the audience can see the water level drop as the engine works — they are a suspicious lot often enough, and to prove it is pumping I put a drop of ink in the suction vessel after a few strokes so that they can see the water change to blue from the outlet as it gets up there.

My model shows no cistern, valve and pipe for the cooling water. This is because it all has to be rigged up in a hurry and the fewer parts the better. You may see a little squirter with a rubber bulb in the photo — this is used to squirt a drop of water onto the brasso tin at the right time. It only needs a squirt, as the cold water from the suction hastens the condensation as soon as it begins to suck. However, you can rig up a cistern easily enough — you don't need me to tell you how to do it. On my model Newcomen engine the cooling water pipe is quite small — about ⅛" bore — and is controlled with a Union Cock as used for cylinder drain cocks — came from Stuart Turners, I think, but most of the usual castings suppliers can provide them.

The drawing of mine is shown as Fig. 4. The boiler is the standard Lyle's Golden Syrup tin, 2-lb. size. After washing it out, fill it three parts with water and boil it on the gas ring for 20 minutes or so, to get rid of the syrup in the lower seam — if this remains you will have priming trouble when working. You can't see any "safety valve" in the photo, but it is shown on the drawing; just a short piece of copper pipe about ¾" dia in which a cork is fitted. This serves to fill the boiler, and if the pressure gets too high the cork blows out — as simple as that. The first one I made I simply relied on the lid blowing off, but this upset the rest of the "engine" in so doing! The steam delivery valve is a radiator drain tap, obtainable (when I built mine) from Halfords and similar motor parts dealers. This comes with a screwed nipple, which is soldered into the lid of the tin. Mine is $\frac{3}{16}$" bore, but its not critical. The one recommendation I would make, however, is to file the handle parallel and fix a wooden handle — just drill a hole in a piece of dowel, nicely shaped, and attach with Araldite; this makes it cooler to the fingers. The steam-pipe is $\frac{3}{16}$" bore and terminates in the nipple of a $\frac{3}{16}$" union.

The brasso-tin (smallest size) will need more attention. First clean it out and then boil it as before, but this time put in just a little detergent — Daz or Drive etc — to get rid of the oily base of the polish. You need two union connections here — one in the top to suit the steam pipe and one in the bottom for the water; the latter must not be less than $\frac{3}{16}$'' pipe. Any smaller will cause too much friction. These are soft soldered in (as are those in the boiler) and you must also solder on the lid — the receiver must be absolutely steam and vacuum tight. In this connection you may have a slight problem. Brasso tins are quite "Brasso-proof" but I did find on the first one I made that the junction of the vertical seam and that at the base let in air. So, test for leaks and if there is one here seal it with a dab of solder or even araldite.

Burner

The burner shown in the photo is not the one normally used — it belts out about 20HP in heat! But it was all I had by me when the photo was taken. Normally I use just on ordinary bunsen burner on the towns gas supply, but if this isn't available then the small Camping Gaz picnic stove or its small Primus paraffin equivalent is quite potent enough. The size doesn't really matter so long as it will raise some steam. If its small, then you have to work the engine slowly; if bigger, you can work it fast — and if too big, then the cork blows out! This applied to the original machine, the speed of working was controlled — or determined — by the size of the fire. You don't want it to work too fast or you will not be able to keep up with manipulating the handles. I have had a perfect demonstration with the spirit burner from my little steam crane, with three $\frac{5}{16}$'' wicks. In fact, this worked it at a comfortable speed, but to save time the water was boiled in a kettle just before starting up. (I think the audience thought I was going to have a brew-up!).

To operate. Light the fire with the steam valve on the boiler open. Allow steam to issue from the water outlet pipe for a couple of minutes to get rid of all the air in the system (and the air in the water, too). Then close the steam valve and at the same time dowse the receiver with water — it needs a good wetting the first time, you'll find. Immediately the sucking noise stops, open the steam valve again, and water should discharge up the spout. Allow steam to issue for a few seconds and then close the steam valve and give the receiver a squirt; the process should repeat. It will get just a little slower in operation after about 4 strokes and then settle down to a rythm — keep it working at that. Don't be in a hurry; remember the metal in the receiver has to heat up and cool down each time, and quite a lot of the incoming steam will be condensed as it meets the cool receiver walls and the surface of the water in it — this is what made the original so inefficient, even if it was effective.

You may meet one peculiar and, at first, disconcerting phenomenon; the machine will "work by itself", first discharging water and then delivering it, with the steam valve open. This is due to the steam supply not being quite great enough and as the surface of the receiver is exposed more and more as the water is discharged, condensation overtakes the steam supply. A little more steam, or a little less, and the machine will revert to normal working. But the interest lies in the fact that a "Savery" self-acting steam pump using this phenomenon was introduced in 1872 called the "Pulsometer" pump and I understand it is still made. I have seen these working hanging from a chain disposing of unwanted sump water on steelworks, in mines, and excavations where steam was available. To go into detail as to its working would take a long time, but there was no "valve mechanism" as such, the steam valve being a ball which fell from one side to the other as the twin receivers emptied and filled; there was no external cooling, the heat loss to atmosphere being sufficient to cause condensation; and the water valve were, of course, quite automatic. It was a very reliable pump indeed, even if a bit expensive in steam, and could handle very dirty water. It needed no foundations — indeed, most of those I saw at work were hanging from crane hooks — and needed no attention whilst at work — just kept going on and on as long as there was steam available and water to pump. In recent years no doubt the portable I.C. Engined pump has replaced it — there are fewer places with steam available anyway — but it is doubtful if any will give as trouble free service.

It will be the 300th birthday of the Savery invention in a few year's time. It is to be hoped that a few "Pulsometers" (the firm still makes pumps, by the way) will be about to celebrate the tri-centenary — as well as your model, of course!

We are grateful to the Science Museum for allowing us to reproduce photographs Figs 1 and 2. also to Mr A. Walshaw for his replica of a Savery Engine Fig 5.

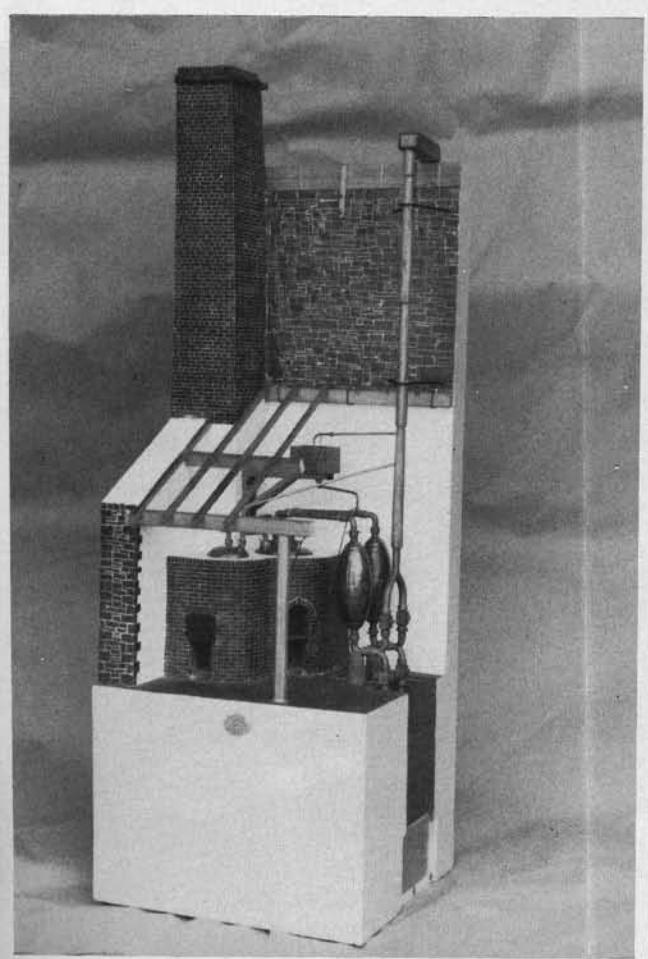


Fig 5 *Model of the Kensington Savery engine.*

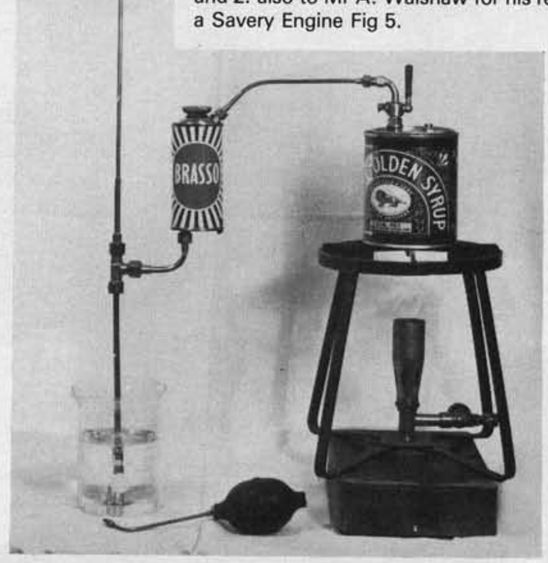


Fig 4 *The demonstration Savery engine.*

Back to the Drawing Board

by Rex Tingey

The model maker may need to resort to the drawing board for a variety of reasons. He may wish to change the scale of a model, to draw a modification to a machine, to design a table-top layout or the table itself, or he may wish to draw up a completed model he has made so that others may make it. In every case the draughtsman will wish to make as good a job as possible, as easily as possible. With modern techniques and drawing equipment the task is so much simpler than it was in the past, and this article is intended to explain what is now available to assist the unpracticed as well as those more expert.

The wooden drawing board with the T-square, set squares, and the lined case of drawing instruments can be things of the past. A modern era of precision designed, matching, drawing tools is with us, giving a wide choice of accurate, easily used instruments to be used on plastic drawing boards with fittings which will be difficult to better.

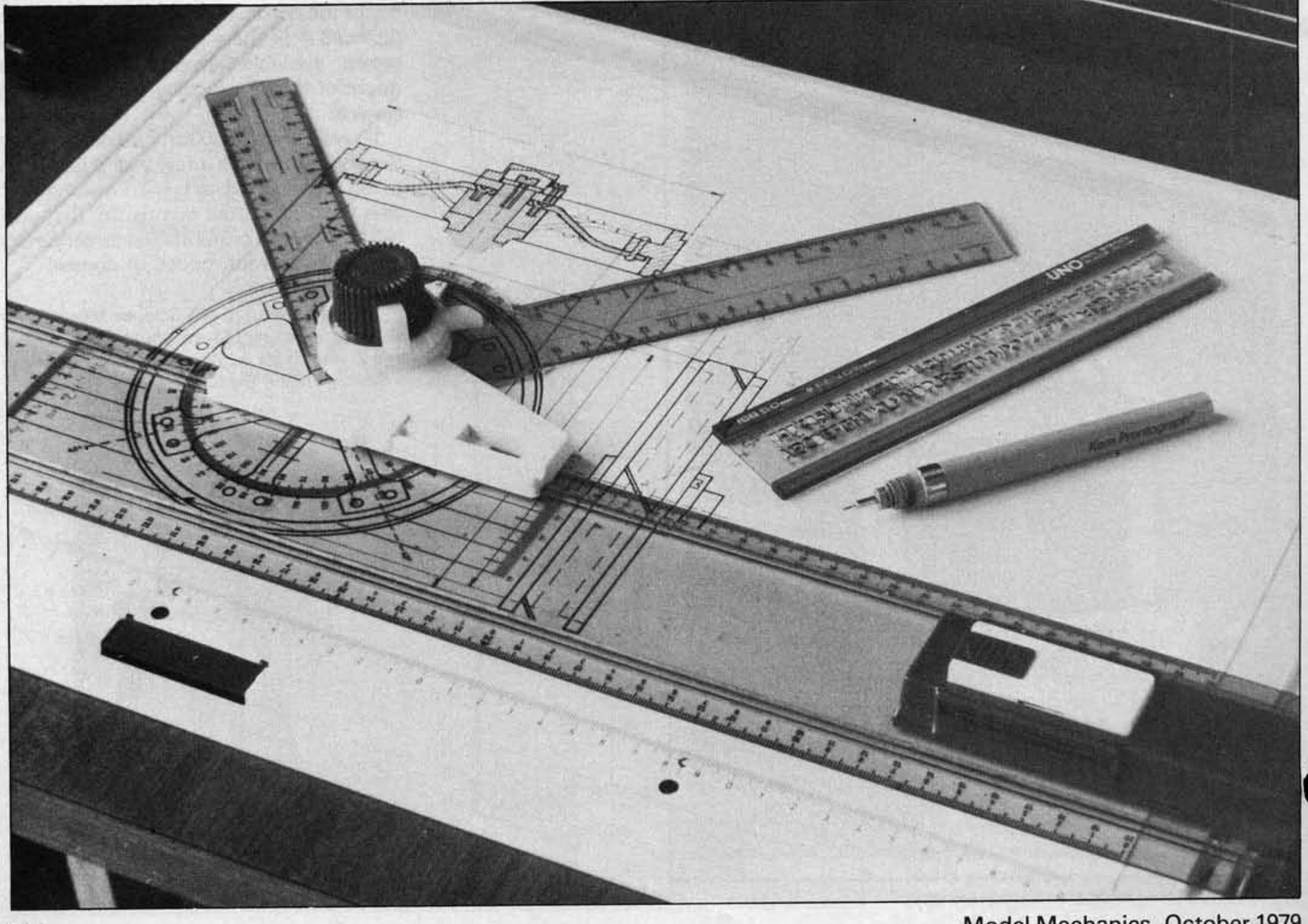
The old wooden type of drawing board is heavy, its surface is vulnerable to pinholes and indentations which then reproduce as faults in lines drawn over them. Usually only one edge is true for the T-square, and the need for securing clips or drawing pins for the paper limits the use of the edge. The wooden T-square is easily damaged, draws ink under its edge unless modified, tends to slip down the board when working, and has only one useful edge. The old ruling pen, used for ruling lines and in the compass, is difficult to adjust and readjust accurately, and can damage the paper surface, producing faulty lines.

Modern drawing instruments are centred around internationally decided designs, conforming to various ISO standards, and corresponding German DIN specifications based on the ISO standards, but they encompass products from various countries, including the UK. For example, the modern drawing boards are designed to take the International Standard sizes of paper, A1, A2, A3, etc., and several firms produce a range of plastic boards marked to correspond to the A series.

Workshop drawing today

The modern plastic drawing board is light, portable and more-or-less unbreakable, it is scratchproof and very easily cleaned. But its real advantage comes with the fact that it is a dimensionally stable moulding, so that moulded-in rails on all four sides can be used to guide a straight-edge accurately and smoothly, and to lock. Further, the moulding incorporates a paper clamp, set low to allow a straight-edge to pass over it, eliminating the need for pins or clips above the surface. The paper clamp has a hinged magnetic action, and will hold up to ten sheets of paper. The paper clamp and the left-hand edge of the board are marked in millimetres, and incorporate calibration marks for the particular maximum size of paper. The clamp also has four holes to allow registration marks to be made on a drawing for re-location purposes. The photographs are of the Rotring Rapide A3 size drawing board, which I use. Under the board are rubber feet which hold the board well on a surface, even at an angle. The board is

A modern Plastic A3 drawing board with straight edge and drawing head.



rigid for all practical purposes.

Straight edge

The board comes complete with its parallel straight-edge, described as multipurpose with a stop-and-go mechanism. The straight-edge is double edged, and both edges are raised slightly from the under-surface so that lines may be ruled direct, without the ink running under. Both edges are calibrated in millimetres, matching the board's scales, and a protractor is built in. On one end of the straight-edge is a mechanism to lock onto the rail of the drawing board so that templates and stencils can be used, and lines drawn, with accuracy. A slight pressure on the white key unlocks the straight-edge when it can be readily slid to a new position; the key can be held unlocked by means of a catch for quick parallel pencil work, or for ink shading. A rapid scale, like a ruler, which attaches to a rail on the straight-edge either vertical or horizontal, is supplied with the board for drawing perpendiculars and for scaling measurements not lining-up with the fixed scales.

Drawing Head

The most useful accessory with this fine drawing board is the drawing head. The drawing head has two arms at 90 deg., rotating about a lockable centre, which is attached to the straight-edge rail. The arms have parallel sides with millimetre scales, and can rotate through 90 deg., to be locked at any angle. By adjusting a lever on the centre the arms can be made to engage in 15 deg. increments, useful for finding the 30 and 60 deg. angles quickly. The part fitting the straight-edge has a lock to hold the head firmly, and an aperture to read the straight-edge divisions so that hatching may be evenly spaced when ruling with the arms at a particular angle.

The drawing board and its equipment are all very portable, and a satchel-type soft case can be obtained for storing and carrying them.

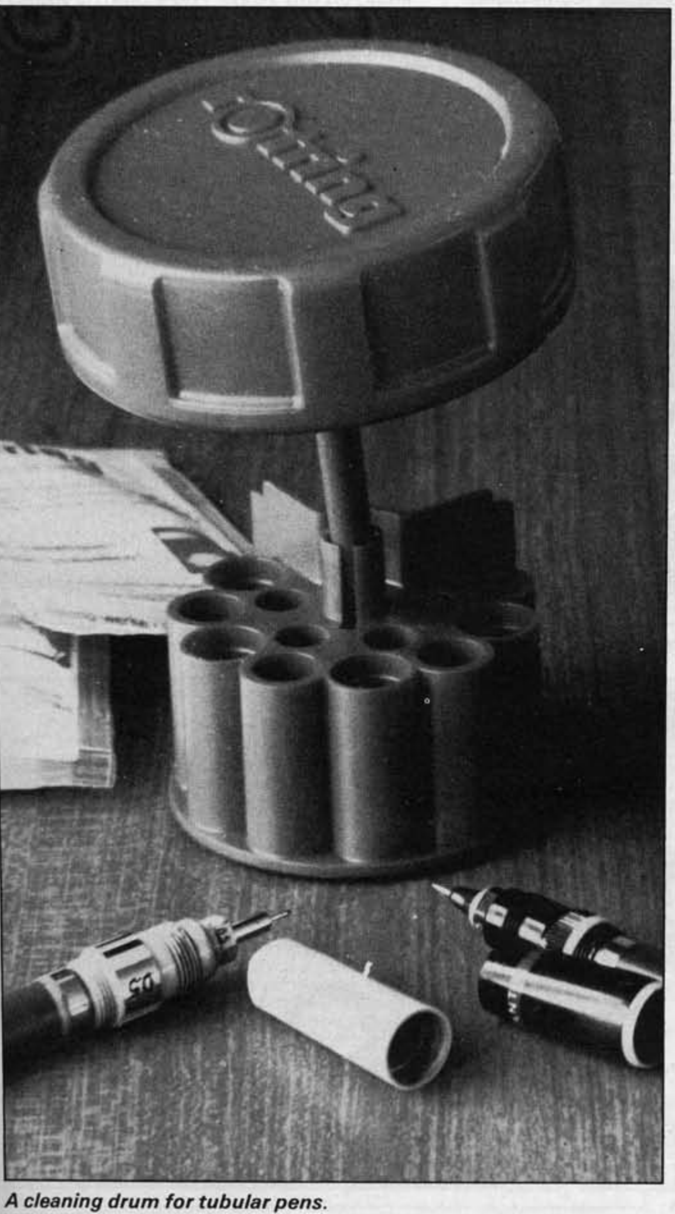
Drawing Pens

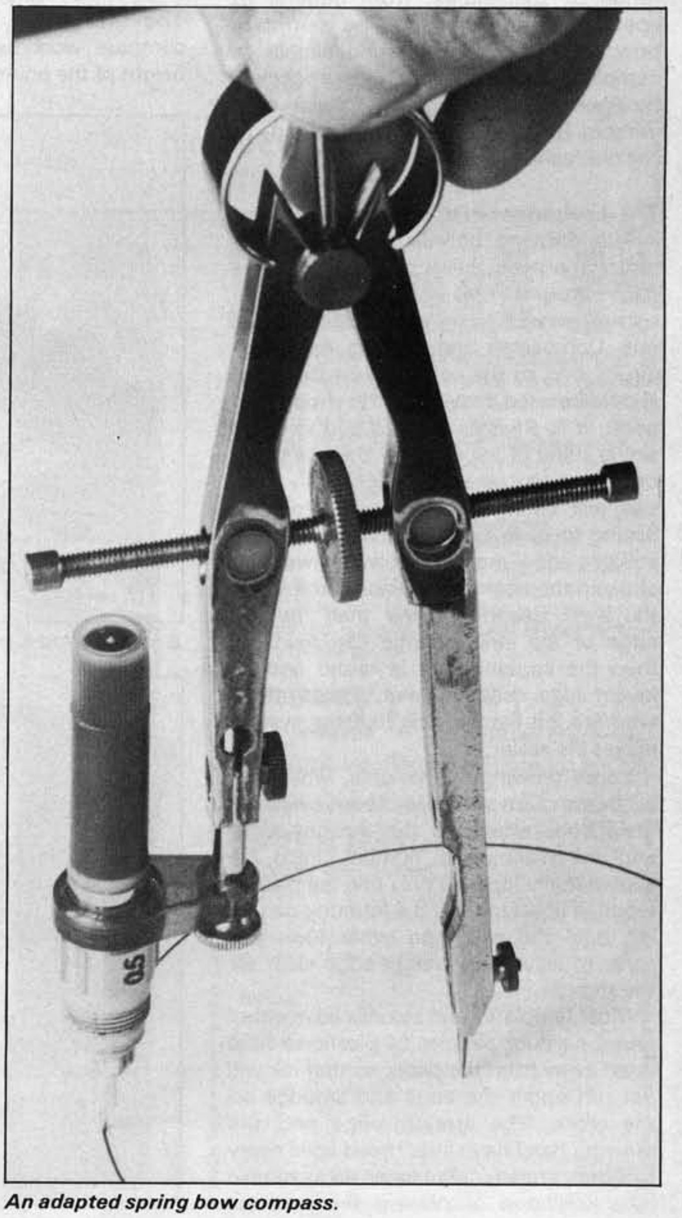
In the past I have used Uno pens, Kern pens and Rotring pens of the tubular type, and each one has given its own particular sort of trouble, even when handled carefully, and with consideration. However, Rotring has recently introduced a new series of tubular drawing pen called the 2000 Isograph which really do overcome all the old difficulties.

Pen accessories

To keep the tubular pens working whilst at the drawing board it is not possible to leave them lying around with their caps removed, for a length of time, as the ink will dry in the points. By the way, it is always best to use the drawing ink recommended by manufacturers for use in tubular pens—Indian ink must not be used. To keep the ink from drying on the points, when on the desk, Rotring make "rapidomats". These are boxes with a number of positions to hold uncapped drawing pens ready for use by maintaining a damp atmosphere at the tips of the pens. The simplest type, which I use, has four ready-pen positions and four carrying positions, so it can be used as a storage or carrying case as well as a humidifier.

To enable circles to be drawn, various compasses are made to take the tubular


A cleaning drum for tubular pens.


An adapted spring bow compass.

pen. For those with a box of drawing instruments already available, it is far cheaper to just buy an attachment, to fit the compass, which takes the head of the tubular pen; make sure that the correct peg size is bought.

Lettering stencils

There is a new standard ISO 3098 lettering stencil, designed to replace the other lettering standards at present in use. The new standard has a different shape of letter and figure and a greater ratio letter-height to line-thickness. The new shapes are designed to rule out confusion between similar letters and figures, to reduce unnecessary curves and so minimise clogging at character intersections, giving clearer results on photographic and other reproduction. The 10 to 1 height to thickness ratio is also designed for maximum legibility.

The stencils are, of course, designed to be used with a particular size of pen, and the ISO stencils are colour coded.

Templates

Templates are available to cover a wide range of specialities, from general to specific symbol types. The template brings a method of creating simple to complex shapes, such as elipses, circles, hexagons, etc., using the tubular pen, without having to resort to freehand, or the old-fashioned French curve.

The equipment in use

The drawing boards are easily kept clean, the main nuisance being that the gaps around the edge rails capture erasure swarf and are not readily brushed out. Compasses and dividers no longer dig in, and so the spike end of the point should be used, instead of the shouldered point; it is advisable to use and re-use a single sheet of paper under the one being drawn on, to take the point firmly. The use will soon become accustomed to having four edges from which to use the straight-edge, a great help when working close to the edge of the paper, and when the work becomes lower than the top edge of the straight-edge can manage, then the straight-edge is raised and its lower edge used, instead. Those of us who are left-handed will find the system makes life easier.

Loose drawing instruments, which get in the way, are no longer about since the main ones attach to the straight-edge, and are minimum in number. Pens are kept in their slots and only one template is required at a time. All the lettering can be left until the end, and other tools put away to leave the straight-edge clear for the stencils.

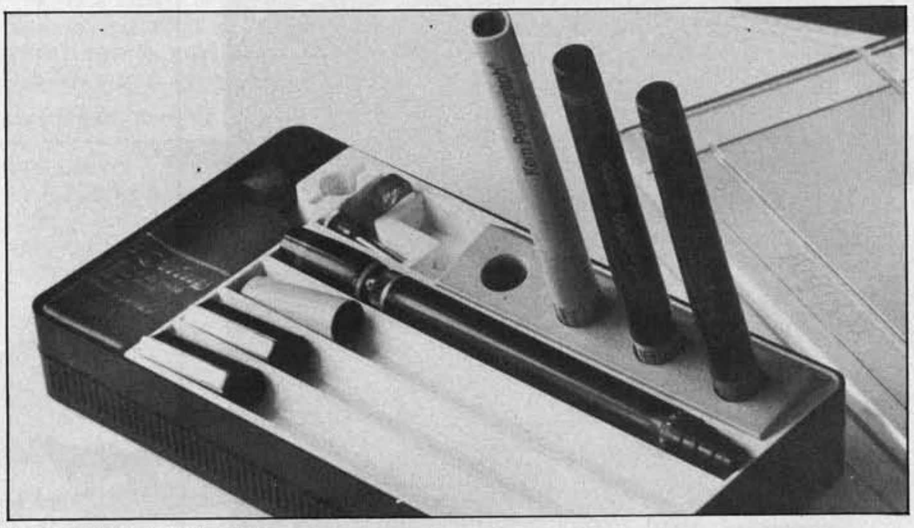
Most templates and stencils have either raised parts or pimples of plastic to hold them away from the paper so that ink will not run under the edge and smudge on the work. The straight-edge and the drawing head have little raised lines every so often, strategically placed so as to give little likelihood of placing them across wet drawn lines, but a certain amount of care must be taken, raising the straight-edge a little when repositioning.

Maintenance

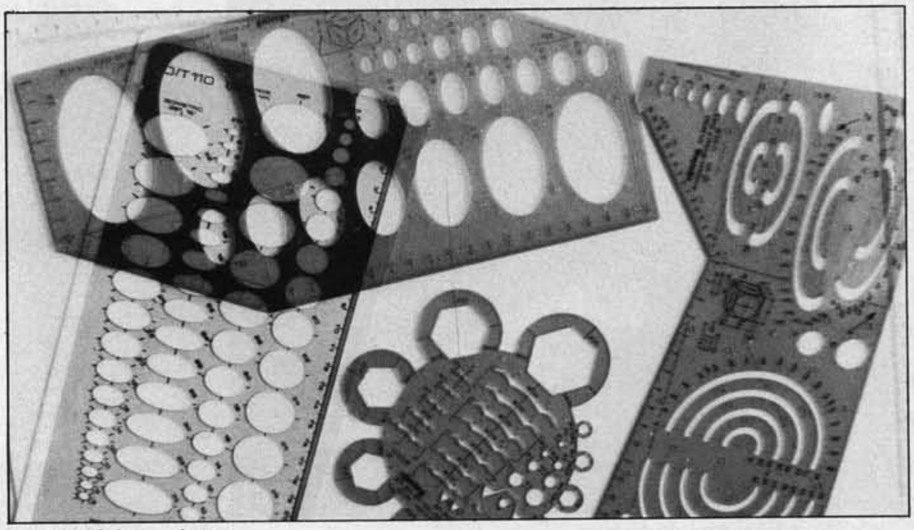
The pens give little trouble. To assist in the maintenance of the pens the Rotring people make a cleaning unit used with a special cleaning concentrate, which will take the parts of four pens, except the long holders, and will readily clean out all the dried-up ink. Do not put the caps onto the back ends of pens, but put them to one side, while the pens are in use. Always replace caps on pens which are not in use, or not in the humidifier, after all, the system is a great deal easier than using ink from an open bottle, with the danger of spillage.

According to the makers, the tubular pen can be used at quite an angle from the vertical, and in the pump compass the head is tilted at about 25 deg. However, the larger sizes of point tend to give a thinner line when used at an angle, and, on cartridge paper, the outer edge of the line may be ragged. For most work the maximum size of point diameter for use at angle will be .35mm, I would recommend. The tilting can be avoided for most compass work by adjusting the relative height of the points.

Staying with the A3 size of drawing board a range of five sizes of drawing pen can cover most tasks, from the finest line to the largest size of stencilled letter. Drawing practice recommends that a line thickness ratio of minimum 2 to 1, and maximum 3 to 1, be adopted between outline and guide line in a drawing, and the pens from .25 up to 1.0mm will provide the minimum over a range of three scales and the maximum over two. The next size up, 1.4mm, is rather too thick for A3 size, and the next size down, .18mm, really too fine, and does not flow well on drawing paper, tending to scratch. The 1.0mm is used on the 10mm high letter which are large enough for the main title of a drawing, of A3 size. The .35 is right for most guide-line and dimensioning work, including stencilling to this size with letters 3.5mm high. The 0.7 is about right for outlining, and with the 7mm stencil for part naming, so that most work is carried out with just the .35mm and the 0.7. The technical templates are designed to take the 0.5mm pen, and so projection work will need this pen and the 0.25 for guide and dimension lines, on this work. The 0.5mm is useful to give a thinner line than the 0.7mm on concentric circles where lines drawn close together would tend to block in.



A humidifying pen holder



Four useful templates

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The 'Eagle'

A simple 2½ in. gauge 4-4-0 Locomotive. Part 7

by Martin Evans

WE SHOULD NOW BE READY for the first silver-soldering operation on the boiler. First immerse the barrel/outer firebox wrapper assembly in the "pickle" tank for about 15 minutes, then wash thoroughly in hot water. Set it upside down in the brazing hearth, apply flux, which should be freshly mixed with clean cold water to the consistency of cream, and get busy with the blowpipe, bringing the job to a dull red heat as quickly as possible. The silver-solder is now applied, and if the boiler is at the correct heat, it should run freely along the joints.

Do not try to melt the solder by the direct heat of the flame, this will only cause it to form into little balls which will promptly run everywhere except where it is wanted. The boiler itself must be hot enough to melt the solder. If the solder still does not flow freely, dip the end of the stick of solder into some dry flux and try again. Form a good fillet round the seam, especially immediately underneath the barrel, then with the large tongs, turn the boiler right side up, applying more flux to the joint between barrel and wrapper.

When satisfied with the soldered joints, allow the boiler to cool, to somewhere around the boiling point of water (100 deg. C.), then dunk it into the acid pickle—mind the splashes! Don't try dunking the boiler when still almost red hot; I have seen this advised, but it can be dangerous and is quite unnecessary; even a stone-cold boiler will be dealt with by the pickle if given time, 15 minutes should be ample. This dunking business is done mainly to remove excess flux, but also to leave a nice clean surface, enabling the builder to see whether the solder has "taken" properly.

Give the boiler assembly a good wash in hot water, plus a little "Vim" or similar cleaning powder, then examine the joints made so far. It should be possible to see a good silver line all round the barrel/wrapper joint and between throatplate, barrel and wrapper. If any places look skimped, don't be tempted to chance it, but go over the whole process again, fluxing the faulty place thoroughly before heating. We now need four more flanged plates—the firebox tubeplate and backplate, the smokebox tubeplate and the backhead. The two firebox plates are made from 1.5 mm. thick copper sheet, the smokebox tubeplate and the backhead from 2 mm. copper. Formers should now be made, as described for the throatplate, and the copper sheet cut out, allowing sufficient all round for the flange. Making a start on the firebox tubeplate, mark out the positions of the superheater and the seven firetubes and drill $\frac{3}{32}$ in. only at this stage.

Anneal the copper thoroughly, clamp the sheet to the appropriate former and clamp the two in the bench vice with a piece of flat steel against the copper, so that the vice jaws cannot mark the soft metal. The flange can now be beaten over with the soft hammer. Take some time over this, re-annealing immediately the metal goes hard. It may be necessary to anneal two or three times before the flanging is complete. Clean up the edges of the flange with a coarse file, then tackle the firebox backplate, which can be flanged on the same former. only one hole is required in this, for the firehole, which can be drilled out to ½ in. dia. or so and then bored in the lathe to $1\frac{1}{8}$ in. dia. The plate can be held in the 4-jaw chuck for this operation.

To flange the smokebox tubeplate, we need something about 2¾ in. diameter and about $\frac{5}{16}$ in. thick; possibly an old casting may be found which would be suitable for this, if not use the steel and wood combination again, cutting them somewhere near round and then turning the two, fixed together, in the lathe; one edge should be slightly rounded.

After flanging, set the smoekbox tubeplate up in the lathe, holding it with the chuck jaws inside the flange, and turn the outside to a nice tight fit in the boiler barrel. Now clamp the firebox tubeplate to the smokebox tubeplate in their correct relative position allowing for the rise of the tubes from the firebox to the smokebox, and run a $\frac{3}{32}$ in. drill through the holes in the firebox tubeplate. Dismantle the smokebox tubeplate and open out the holes, $\frac{3}{8}$ in. for six of the firetubes and $\frac{7}{16}$ in. dia. for the odd one, plus ¾ in. for the superheater flue. Repeat for the holes in the firebox tubeplate, but do not drill to full size—leave all the holes a shade undersize, say about 10 thou less—also file a few nicks in all these holes, four nicks not deeper than 10 thou or so. The idea of this is to ensure that the silver-solder penetrates properly.

The smokebox tubeplate requires a threaded bush, for the main steam pipe, also two tapped holes, on ¼ in. × 40t, for the end of the solid longitudinal stay and one $\frac{5}{16}$ in. × 40t. for the hollow blower stay. The bush, turned from ½ in. dia. drawn gunmetal, is threaded $\frac{3}{8}$ in. × 40t. and is best silver-soldered in place before the tubeplate is fitted, but before doing this, the firehole ring must be fitted to the firebox backplate and the firebox inner wrapper cut out and fitted.

The firehole ring is made from thick-walled copper tube 1¼ in. outside diameter and 1 in. bore. A suitable short piece can be obtained from most of the Trade houses specialising in locomotives (Reeves, Kennions etc.). Chuck this and turn down a step at each end to $1\frac{1}{8}$ in. dia. The step which is to be inserted into the hole we have in the firebox backplate should be a bare $\frac{1}{8}$ in. long, but the step for the end which is to be fitted into the backhead should be $\frac{5}{32}$ in. long, the reason being that after inserting the ring in the plates, the part that protrudes through the plate can be lightly flanged over.

Fit the firehole ring to the firebox backplate now, and silver solder it in place, after flanging as above, remembering to give each part a good rub with coarse emery cloth and a few minutes in the pickle bath beforehand, which will ensure good clean joints.

The sides and crown of the inner firebox are made in one piece, from the same $\frac{1}{16}$ in. copper sheet. To make sure that the right length is cut, obtain a length of soft iron wire about $\frac{1}{16}$ in. copper sheet. To make sure that the right length is cut, obtain a length of soft iron wire about $\frac{1}{16}$ in. thick (most ironmongers stock this) and bend it around the firebox tubeplate and firebox backplate in turn, then straightening it out to measure the length. Then cut the copper sheet accordingly, but to be on the safe side, add an extra $\frac{1}{16}$ in. This can always be trimmed off afterwards if necessary.

Anneal the copper thoroughly, then mark it with a soft pencil to show where the bends are required. The large radius on the top of the crown can be bent easily by hand, but for the corners, which are approximately $\frac{9}{32}$ in. radius, a piece of ¼ in. dia. silver steel will be required, the copper sheet being bent over this. This will not be possible with a single annealing operation, so don't try to achieve this small radius in one "go". If the metal is "offered up" to the two flanged plates while the bending is in progress, it will not be difficult to see if the bends are going to come out in the right place, and to take correcting action before too late.

When the shape of the firebox wrapper looks about right, it is riveted to the two flanged plates, using just enough $\frac{1}{16}$ in. copper snaphead rivets to hold things together ready for silver soldering. Begin at the top and work downwards, first one side, then the other. If difficulty is experienced in getting the riveting "dolly" inside, to suppert the rivet, use a screw instead. This must be gunmetal, not brass. Turn up a few 8 BA screws from $\frac{1}{8}$ in. dia. drawn gunmetal, drill through both wrapper and flange with No. 50 drill, open out the wrapper only with No. 43 drill, then put a 8 BA tap through. When putting one of these screws in, do not over-tighten as threads cut in copper are easily stripped.

Make the crownstays next; there are two L-shaped members, cut from 2 mm.

thick copper, with a short piece bent up to fit between the two. Note that the L-shaped pieces must be the full length of the firebox.

Rivet the L-shaped members to the top of the firebox crown first—two $\frac{1}{16}$ in. rivets should be sufficient, then cut and fit the little cross piece, which can be bolted to the two L-shaped members, which is much easier than riveting in this position, but be sure to use the home-made gunmetal screws, not brass.

The inner forebox can now be silver-soldered, taking the same precautions as before as regards cleanliness, etc. Solder the wrapper to the two flanged plates first, then deal with the crownstays, running a fillet of the solder all along the joints between the L-shaped members and the wrapper, and also over the little connecting piece, which will make a very strong job.

Now for the tubes. Cut them all to such a length that they will protrude through the plates at both ends by a good $\frac{1}{16}$ in. Square the ends in the lathe and clean up with coarse emery cloth for a length of about ½ in. at each end. Next, put each tube in the 3-jaw chuck, and take a very light cut over the end that is to go into the firebox tubeplate for a length of $\frac{1}{8}$ in. full. Only remove just enough to allow the tube to be twisted into its hole in the tubeplate. The idea of course is to make sure that the tube doesn't work out or slip right through in the middle of the silver-soldering operation, which would be a minor disaster!

When dealing with the ¾ in. dia. superheater flue in this way, it will probably be found that this is too large to pass through the lathe spindle, a steady of some kind will therefore be required.

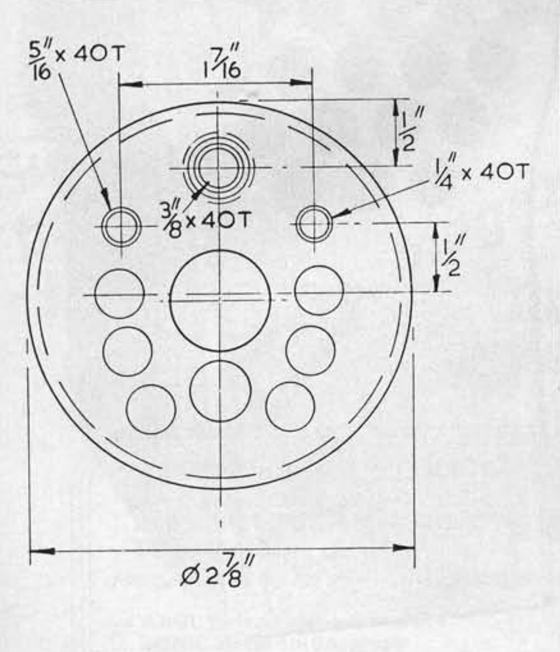
Now press all the tubes and the flue into the holes in the firebox tubeplate, and set the assembly up in the brazing pan with the tubes pointing skywards, get some Easyflo silver-solder in wire form (this can be obtained in $\frac{1}{32}$ in. dia. which will do nicely) and wrap this round each tube three times, hard up against the tubeplate. The smokebox tubeplate now comes in useful to hold the outer ends of the tubes in line while the silver-soldering operation is carried out. The sharp end of an ordinary pencil will be found helpful in getting all the tubes through. Apply plenty of flux, making sure that it flows round the base of all the tubes, then get busy with the blowpipe, directing this mainly inside the firebox, and bringing the whole tubeplate to a dull red heat. Allow to cool, pickle and wash and examine the job carefully; there should be a nice silvery ring around every tube on the *inside* of the firebox, showing that the solder has run through, but if not, don't take any chances, but go over the doubtful place again, fluxing well and applying more solder to the spot.

Pull off the smokebox tubeplate, and anneal the outer ends of the tubes. We can now fit the inner firebox assembly to the outer wrapper/barrel. Cut some lengths of ¼ in. square copper, bevel these on the lower edges and clean up with coarse emery. Fit the front section and the two side pieces of the foundation ring, using just enough $\frac{1}{16}$ in. rivets to hold them in place. Now press the smokebox tubeplate into place, after a short spell in the acid pickle, arranging it so that the tubes protrude by about $\frac{1}{16}$ in. Secure the tubeplate by three or four gunmetal (or copper) screws about 6 BA, put in around the periphery of the barrel, into the flange of the tubeplate. Next, lightly expand the ends of the tubes and flues. This is an easy job by the use of some home-made taper drifts, which can be in mild steel. Grease them well and tap in with a light hammer, but don't be too fierce, or the screws holding the tubeplate will be sheared off. The smokebox tubeplate may now be silver-soldered. To do this set the boiler with the smokebox end pointing upwards, and pack coke around the whole boiler and up to about 2 in. of the front end, taking care not to get any coke or dust on the inside. Flux thoroughly around the tubeplate and around all the tube ends, and bring the whole end to a dull red heat, when there should be no difficulty in getting the silver-solder to run and form good fillets around all the tubes.

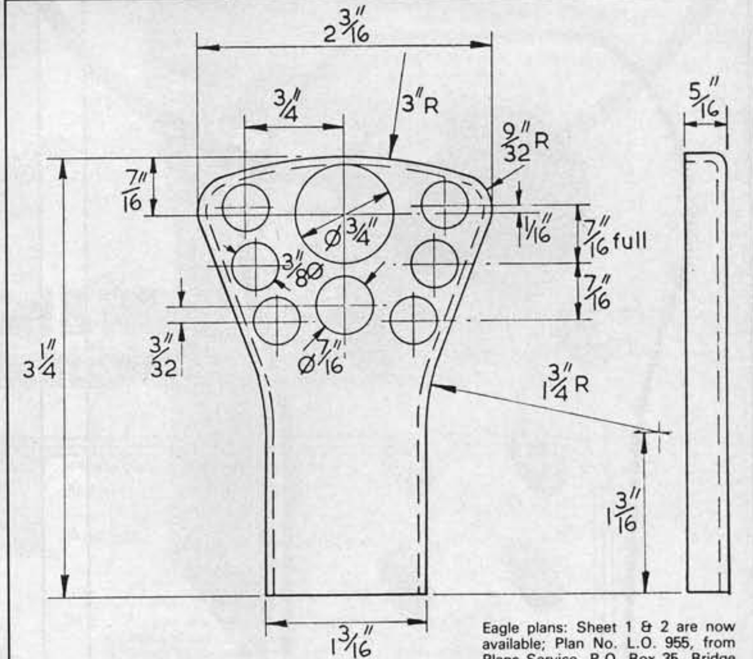
The backhead can now be prepared; there are four bushes to be fitted to this, plus the large flanged bush for the regulator, and these are best fitted and silver-soldered to the plate before fitting to the boiler. But first, offer up the flanged backhead to the boiler and mark on it where the hole for the firehole ring has to be cut.

The regulator bush can be turned from 1 in. dia. gunmetal, the blower bush from $\frac{3}{8}$ in. dia., and the other three bushes from $\frac{5}{16}$ in. dia. gunmetal. These last three are for the lower water gauge fitting, the clack or check valve for water feed from the tender hand pump, and for the cab end of the solid stay. Perhaps I should mention at this point that this last bush is by no means essential, a ¼ in. × 40t. tapped hole will be quite satisfactory as it will not be necessary to disturb the stay, once fitted.

To hold the backhead in position while silver-soldering, a few of our home-made gunmetal screws may be used, fitted as described for the inner firebox assembly. The remaining section of the foundation ring can now be cut, its bottom edges bevelled and fitted in place. Two $\frac{1}{16}$ in. rivets will hold it firmly. At this point,



Smokebox Tubeplate
$\frac{3}{32}$ or 2 mm. copper.



Firebox Tubeplate
$\frac{1}{16}$ in. or 1.5 mm.

Eagle plans: Sheet 1 & 2 are now available; Plan No. L.O. 955, from Plans Service, P.O. Box 35, Bridge Stret, Hemel Hempstead, Herts. Sheet 1 & 2 priced at £1.80 each plus 20p postage & packing.

check that there are no gaps around the foundation ring through which the molten solder might find a way. If any gaps are found, drive in little "splinters" of copper, the solder will do the rest. Next, lightly flange the firehole ring against the backhead. This is quite easy to do with a light hammer, supporting the firebox backplate on something solid held in the vice.

Builders who have sufficient "blowpipe power" will be able to silver solder the foundation ring and backhead joints without the need to pack the job with coke, but those with smaller blowpipes will find coke packing a great help in raising the boiler to the required red heat. Lay the boiler on its back, after fluxing all round the foundation ring, backhead and firehole flange, leaving the backhead clear. Put some pieces of asbestos sheet inside the firebox, against the crown and across the tubeplate, to protect the ends of the tubes. Heat up the whole firebox, then concentrate the flame on the foundation ring, working right round this and building up a nice fillet. Then quickly pull the boiler up with the big tongs so that the backhead lies level, and carry on with the backhead flange and around the firehole, adding more flux if the solder seems reluctant to flow properly. Cool, pickle once more, wash and examine. If all is well, the worst of the job is now over!

There are six bushes to be fitted now. A ¼ in. × 40t. bush for the clack valve for the feed water from the axle pump, a large bush for the regulator (not threaded), two safety valve bushes, a bush on the rear end of the firebox for the "manifold" (the fitting which carries unions for blower, pressure gauge and whistle valve) and a special "angle" bush to take the top fitting of the water gauge. All these should be turned to a tight fit in the boiler and silver-soldered in place. The water gauge bush can however be made a screw fit, say ¼ in. × 40t. as it is placed over the flange of the backhead, giving us a thickness of metal at this point of $\frac{5}{32}$ in. It can be sealed with a high-melting point soft solder (which we shall be using to seal the stays shortly) if preferred.

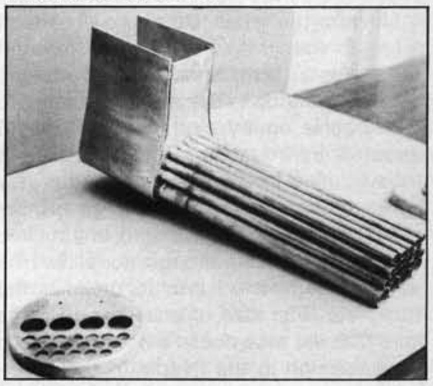
A preliminary water test can now be given. Turn up a couple of temporary covers to go over the dome bush and the regulator bush. These could be made in steel and drilled No. 43, so that they can be used as drilling jigs when making the actual fittings. Put washers of Hallite or something similar under them. All other bushes can be plugged with temporary brass plugs, the threads of these being given a dose of plumber's jointing, to prevent possible leakage during the test.

A large and reliable pressure gauge will be necessary—don't on any account use one of the small "model" pressure gauges for testing purposes—and this can be attached to one of the safety valve bushes. A hand pump will also be needed and this is connected to another bush, one of those on he backhead being convenient.

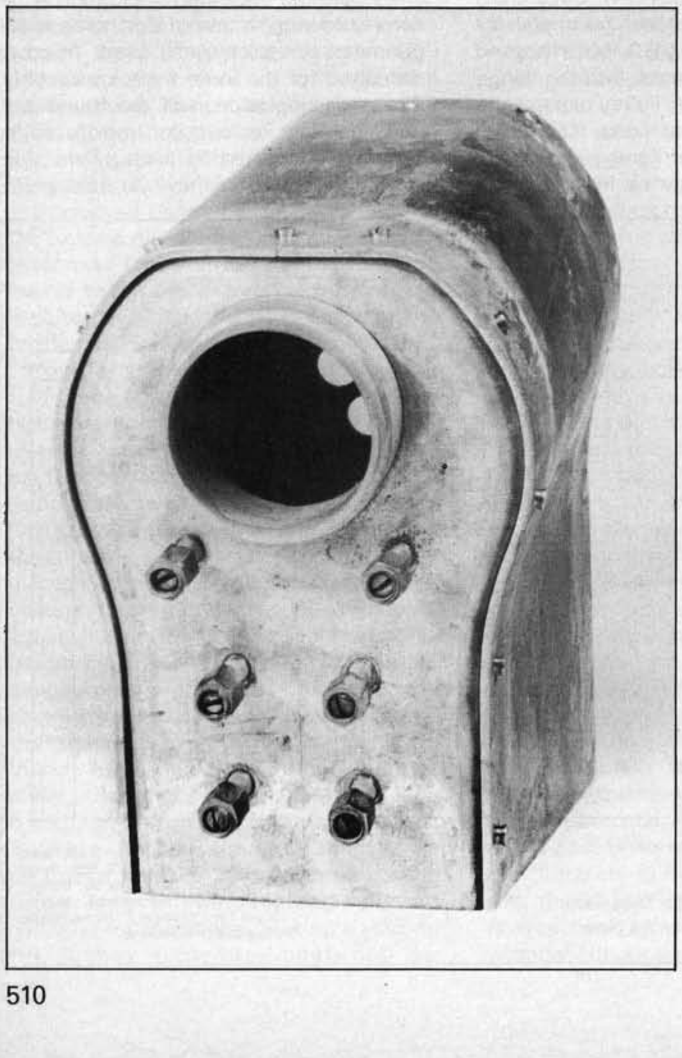
Fill the boiler completely with cold water, excluding any air, and bring the pressure up to not more than 25 p.s.i., as the stays have not yet been fitted. This is ample to show up any leaks, which must now be attended to. Leaks at this stage are not usually a worry; even skilled boiler makers sometimes find one or two. The cure must depend on their position, but very ofen they can be cured by simply drilling and tapping say 10 BA at the offending spot and screwing in a little plug of copper threaded to match, but with the threads slightly tapered, so that the plug goes in really tightly.

Next time, we will deal with the staying of the boiler and the final hydraulic test.

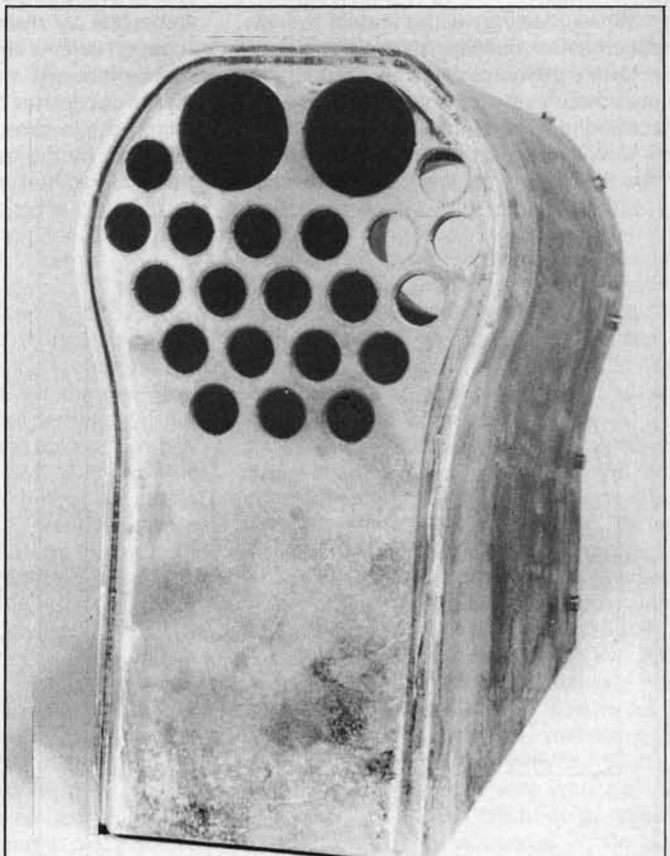
Inner firebox and tubes.



Firebox backplate before brazing.



Firebox tubeplate after silver-soldering.



A. J. Reeves & Co. of Birmingham, supply flange plates and ultimately full boiler sets for 'Eagle'.

Basics in the Workshop by John Wheeler

Drilling

However you do your drilling, the most important requirement is a correctly sharpened twist drill bit. The twist drill bit is designed to cut only at its working end, the two cutting edges producing the swarf. These cutting lips must be as near equal in length and angle as possible, in order to cut way the material from the hole evenly. With cutting lips of different lengths, or angle, one lip will cut more than the other and the drill bit will not rotate about its true centre, hence the eccentric rotation will produce a hole of a larger size than that which the drill size should actually drill. Any attempt to sharpen the sides or lands of the drill will reduce its diameter and certainly lead to the drill jamming in the hole. These lands are meant to act as guide edges for the drill bit as it penetrates deeper into the material, and should not be ground or sharpened. Check the working end of the drill bit with Fig. 1. Note there are 5 points that must be correct for the drill to cut efficiently.

1. Cutting lips at correct angle.
2. Cutting lips of equal length.
3. Chisel edge—central, short length, correct angle.
4. Clearance rake of about 10°.
5. Cutting edges not chipped or broken especially at the outside corners.

Drill bits can be sharpened by 'off-hand' grinding to cut fairly effectively. An experienced modeller or engineer may be able to show you, but it is a skill that is difficult to acquire or copy. For best results, a well-designed jig or tool grinder is necessary to give the correct angles. 'Off-hand' grinding is holding the cutting tool in the hand and applying the tool carefully to the rotating grinding wheel, the hand and wrist giving as near correct an angle as possible to the ground face.

I would recommend that you only buy High Speed Steel (H.S.S.) drill bits as they can withstand a lot more abuse and even if they run very hot, because you are using a higher speed than is correct, they will not lose their hardness, or as it is technically known, "have their temper drawn". You know that this has happened when the end of a carbon steel twist bit becomes hot enough to turn the end blue. A high-speed steel twist bit will cool down and regain its hardness; it may need re-sharpening; but a carbon twist bit will have lost all its hardness and simple sharpening will not restore the hard cutting edge. Moral—use the correct speed according to the drill diameter and the material being drilled, which can be obtained from the many published tables.

Generally the larger the diameter of drill and the harder the material then the slower the drill must rotate. Conversely, the softer materials and smaller diameter drill bits can rotate at higher speeds. Beware, however, as generalisation often fails, for acrylic sheet if drilled at high speeds will 'melt' clog the drill and crack the material.

Drilling can be treated like any other cutting or machining operation, as far as cutting fluid is concerned, because heat is generated. This can be minimised by swamping the hole with a cutting fluid, except of course for brass or cast iron, which should still be machined and drilled dry. Always give the drill a fair chance of starting in the required position by 'centre-punching', which makes the depression into which the drill chisel edge can bite and rotate true. If the centre punch mark is not there, the drill will want to wander all over the metal, eventually leading to a bent or broken drill. This is most marked when using the smaller diameter drills. A drill bit which is bent or has a damaged shank makes accurate drilling near impossible. A bent drill can sometimes be straightened by rolling it on a flat metal surface and tapping it on the high spot with a hammer. The plain shank is left 'soft' i.e., it is not hardened, and so will give or bend a little. It will also allow you to file away any light burrs on the shank, produced when the drill bit twists inside the chuck jaws or in more severe cases, to put the twist section into a 3-jaw chuck on the lathe and turn a fresh clean surface on the shank. However, don't overdo this and turn the shank down to too small a diameter, because, in use, the twist section will shear off from the turned down shank under load! With safety in mind if a shank requires too much metal removed in order to true it up, to a good gripping surface, it is better to throw that particular drill away and buy a new one. Then remember to check each time that the gripping chuck jaws are tight and avoid jamming the drill bit in a hole. With Morse taper shank drills, slight damage to the surface of the taper can be carefully filed or stoned away, but excessive damage will render the gripping power of the Morse taper inoperative. Correctly with these drills, it is the Morse taper that gives the gripping and turning force; hence a good fit is essential. The tang is there to aid the removal of the drill when using a drift.

For safe and accurate drilling, whenever possible, grip the work in a machine vice; a hand vice for thin sheet metal, or bolt the work to the drilling machine table using the slots provided. When the piece to be drilled is held in the hand, a drill seizure is certain to occur, pulling the work out of your hand, letting it flail around, possibly gashing your fingers, even breaking the drill and sending the work into orbit around the workshop.

Yes, it happens to all of us, even the work knocking over the cutting fluid pot and splashing that all over the floor. Extra

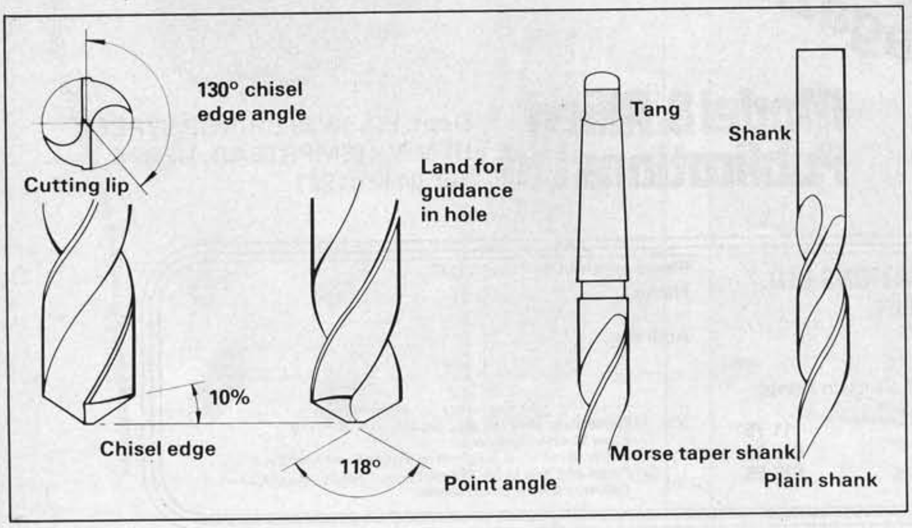


Fig. 1 *Twist Drills.*

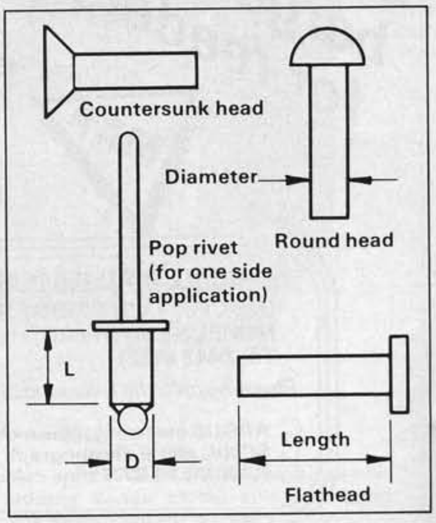


Fig. 2 *Types of rivets.*

clear up time and many curses!

I have several methods of drilling available; by hand using a wheel brace, useful for those awkward places; under power using my pistol drill held in a vertical stand; or using my lathe. The pistol drill set up is not accurate enough for many of my jobs so more often I find myself drilling using the lathe, either by holding the work in a chuck and the drill bit in the tailstock chuck, or more commonly by revolving the drill which is held in a 3-jaw chuck or head stock mandrel and supporting the work by bolting it to the cross-slide, or vertical slide, or probably holding the workpiece in a machine vice bolted to a faceplate arrangement fitted into the tailstock barrel. For this last method I have made up a short length of 3/16 in. dia. silver steel rod with a 60° cone point on it, that I grip in the 3-jaw chuck and line up the centre punched mark on the work, with it, whilst bolting down the machine vice to the faceplate. Then I remove the pointer, replace it with a centre drill and centre drill the workpiece to ensure a good start for the subsequent drills.

If you have a large hole to drill say above ½ in. dia. it is better engineering practice to "pilot drill" first with a drill bit just slightly larger than the diameter described by the chisel edge of the larger drill. This will ease the cutting load and the larger drill will follow the route of the smaller hole. You can even open out to the larger diameter required in successive stages. I cannot over emphasise the need for safe working—drilling seems to be such an easy operation, but an orbiting piece of metal with a broken-off drill stuck in it can create quite a dent or gash in the human form.

Rivetting

This is a method of permanently joining metal pieces together using round pieces of softer metal, fitted into drilled holes, these pieces are then hammered to enlarge the ends and hold the main work pieces tightly together. Some rivets are even fitted whilst red hot so that contraction on cooling also aids the tightness of adjacent pieces. Actually, the modellers practice is nowhere near as complicated as the above description sounds. The main rivet shapes available to the model maker are shown in Fig. 2, and at the moment they are only available in Imperial sizes, e.g., $\frac{1}{16}$ in., $\frac{3}{32}$ in., $\frac{1}{8}$ in., $\frac{3}{16}$ in., ¼ in. etc., and lengths ranging from ¼ in. up to 1½ in.

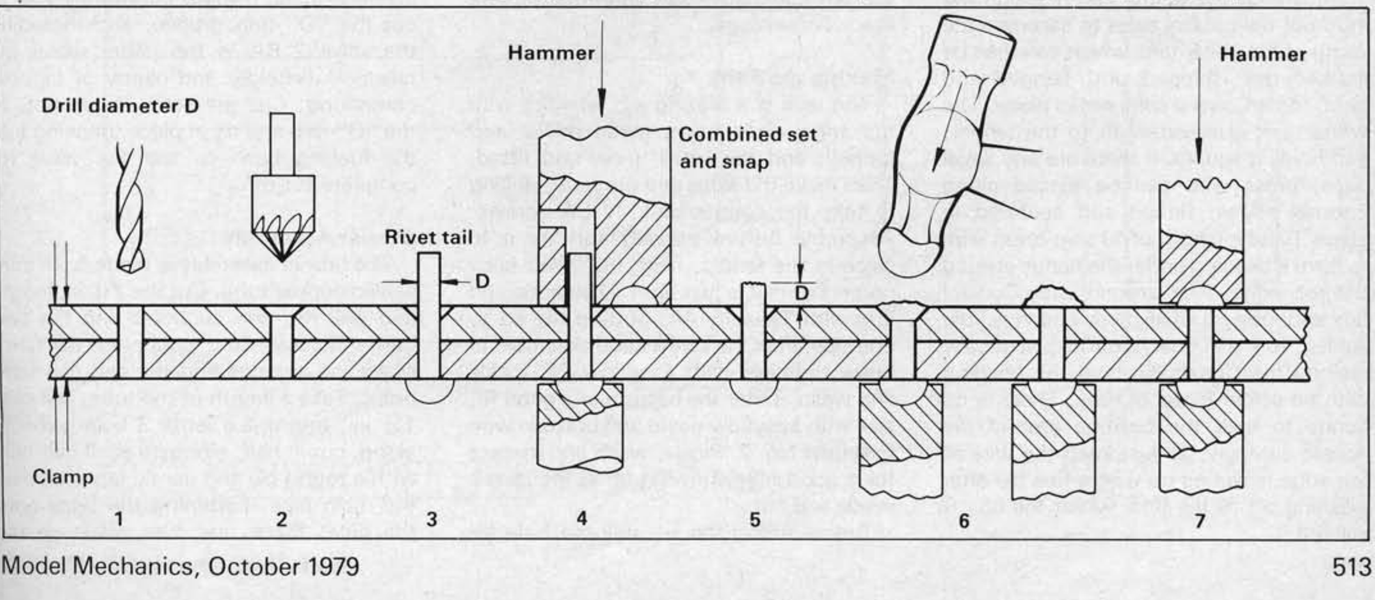
The material from which the rivet is made is generally chosen to match the main workpieces although sometimes it is useful to put in 'soft' rivets, e.g. copper rivets in mild steel; when holding two plates together for shaping or drilling as a matching pair. This happens with locomotive mainframes that are secured together with rivets, one side is marked out, all shaping and drilling completed and the frames separated by filing down the rivet heads and then punching or drilling out the shanks.

The sequence of forming a rivet is shown in Fig. 3. One face of the work is marked out and centre punched, the pieces firmly clamped together and the hole drilled to match the rivet shank diameter. One or both sides may be countersunk, to a diameter approximately one-and-a-half times that of the hole, if a flush finish is required and when the rivet is fitted through the plates, they are then closed tight together using a rivet 'set'. The rivet tail is cut off to give an approximate amount to fill the countersinking or form a round head, and then the tail is hammered down using the ball-pein end of the hammer whilst the head is supported. A countersunk head rivet will need supporting on a flat surface, whereas a round-head rivet must be supported in a cup-shaped recess of a commercial or home-made rivet snap that matches the rivet head. A countersunk rivet is left slightly proud of the surface on completion of the hammering down, so that it can be levelled off by filing down to the main surface and should become practically invisible on final cleaning down, whereas a round-head rivet is given a good form after hammering by closing a second snap on to it.

The most common method of multiple rivetting is to mark out for the rivet positions on one piece of metal as shown by the drawing, to centre punch all the hole positions, clamp the workpieces firmly together and drill one hole into which one rivet is fitted and hammered down. Now the work is checked for alignment reclamped if necessary and another rivet hole drilled as far away from the first as the marked positions will allow. A second rivet is fitted, the clamps are removed and all the other rivet positions completed, as the workpieces should not move. However, when a long narrow piece has to be rivetted in place extra clamping may still be necessary.

If you want to make up your own rivet snap, set up a piece of silver steel of approximately 2-3 times the diameter of the rivet shank in the lathe. Face the end and chamfer the sharp corner, centre drill lightly and if necessary drill in a little until a steel ball-bearing of a matching size to the round head of the rivet will sit in by about ⅓ depth. Grip this embryo snap vertically in a bench vice, place the ball-bearing in the depression, cover it with a thin cloth, which is not to protect the ball, but just to stop it flying about the workshop and becoming lost, then give the covered ball a good thump with a hammer. Remove and you should have a hemispherical depression into which the round head of the rivet nearly sits. Don't make it exact depth or too deep because the snap will mark the metal surrounding the rivet every time you use it. I don't harden mine as in use they take on a nice polish in the cup. It takes no time at all to make a special shape to support that hard to get at rivet, and I have even used mild steel when I have only a few rivets to support.

Fig. 3 *Sequence for riveting.*
1 Drill hole
2 Countersink if required
3 Fit rivet
4 Set together support rivet head in snap
5 Cut tail to length
6 Hammer down into CSK or round head
7 Finish round head with snap



Sweet Sixteen

Traction Engine

By Rex Tingey

The Tender

The tender is constructed from 23 swg brass sheet, rivetted and Comsol soldered, and has an integral water tank, and various external fittings; it also holds the fuel tank as a removable component. Brass sheet is easily worked and soldered as a box, but care must be taken when thicker brass is soldered onto the thin sheet, at the higher temperature used for Comsol, as the heat becomes localised and can cause bad buckling of the thin brass. The only thick brass to be soldered onto the tender is the by-pass plate and this should be soldered in place after the side has been flanged and drilled.

Cut out two sides with tin-snips and mark out one completely for the off-side, clamping the near-side beneath this for the drilling of the main bearing hole and the four securing holes; check against the hornplate for the top hole as this may have been misplaced during gear fitting. Mark out the near-side as shown, cutting out the doorway. Drill all the holes.

Anneal the two sides and flange the $\frac{1}{8}$ in. part back and the $\frac{1}{16}$ in. part, at the top, forward. To assist the flanging of the curves little triangles may be cut out, but it can be done without this, either way the flat sides must match and be flat. Solder on the by-pass plate and file out the water-hole. Cut out the back-to-underneath from the brass sheet, flange one end and use this end, flange protruding, for the top back, bending the rest to shape along the back curves. Rivet around the top curve with three rivets per side, as shown, using $\frac{3}{64}$ in. brass rivets. Keep the sides parallel, and almost cover the flanges with the edges of this back piece. Rivet in the three lower rivets of the back, coming down to the lower curve, but before proceeding check where the underneath will end, cutting off any surplus and making the $\frac{1}{16}$ in. flange to be downwards at the end of the run.

Square off the tender and measure the inside of the parallel sides to ascertain the width of the water tank which can then be marked out, snipped out, flanged and bent, to be Comsol soldered in place. The water tank gives strength to the tender, and holds it square. If there are any small gaps, brass wire can be placed along internal edges, fluxed and soldered in place. Bend a length of 13 swg brass wire to form a beading under the flange around the top edge. Flux around with Comsol flux and, using a small flame and very little solder, run the heat around just locally melting the Comsol to hold the beading with no solder blobs or runs. There is no flange to hold the beading around the access cutaway, so just keep the wire at the edge, cleaning up with a fine file after washing off all the flux, whilst the box is still hot.

Fit the tender over the main axle bearings after removing the screws and pushing the bearings in. One screw each side, of the third shaft bearings must also be removed. Screw the off-side up tight and measure any gap on the near-side to make two plates of suitable thickness to fill this gap, between them. Make the draw straps with long tails, then the plates and the straps can be drilled, in their pairs, for the bearing holes.

The Gas Tank and Burner

The firing system consists of a fuel tank, a jet block and a tubular burner, the tank being fuelled by means of a standard Ronson fuelling valve. Made mainly of thick brass the tank is very strong and capable of withstanding great pressures, but the only reason for this is that it is easier to make, employing brazed butt joints on thick brass; butane is a low pressure gas.

To simplify construction brass angle is used at the ends to hold side plates with 10 BA screws, the back end having a length of reversed angle to allow for the bottom curve of the tender. At the rear of the assembly is a bush to take the Ronson adaptor, threaded $\frac{5}{16}$ in. × 40. To prevent liquid fuel being transferred to the burner a dome is incorporated at the front top of the tank, and this has a tube leading to the bottom of the jet block which is separate and has a thin gasket between it and the tank. The jet block inlet has a stainless steel valve sealed with an "O" ring, and when the valve is opened gas rises to escape through a jet with an aperture of .018 in. dia. The gas stream goes to two burners, past two holes where it draws in air to give a good hot flame. So that the flame will be even, out of the two burners, and not all burn at the far one, a restrictor annulus is fitted between them. This is a compromise and will not completely suit very high or very low valve settings.

Making the Tank

The tank is a brazing job, starting with the angle ends being made drilled and tapped, and the small under-end fitted. Then make the sides and top to fit, drilling to take the countersunk 10 BA screws. Assemble before brazing and try it in place in the tender, filing the lower back corners until it is just right. Dismantle and flux with Tenacity 4A, putting the lid to one side. Flux the screws and assemble to braze together with Easyflow 24. Pickle and wash. Tailor the bottom to a good fit, flux with Easyflow paste and braze in with Easyflow No. 2. Pickle, wash and inspect for a good fillet showing at all the seams inside and out.

Before fitting the lid, drill the hole for the dome and make the dome, drilled letter A; do not drill for the gas tube at this stage. Drill for the fuelling bush and turn the bush, and tap in the lathe, but re-run the tap into the bush after brazing. Paint the fittings and lid with Easyflow paint, and braze in place, applying some thin stick Easyflow, well fluxed. Pickle, wash and inspect. Drill a ¼ in. hole in the rear of the tender where the bush should emerge and fit the tank to see where it comes, enlarging the hole until the bush emerges. The front part of the angle should be butted against the lower front flange of the tender. Test the tank by inserting the fuelling valve, and filling the tank with a little butane; listen and smell for leaks, followed by a check with a lit taper for minute leaks, if there are no obvious larger leaks. Remove the valve—after removing the flame!

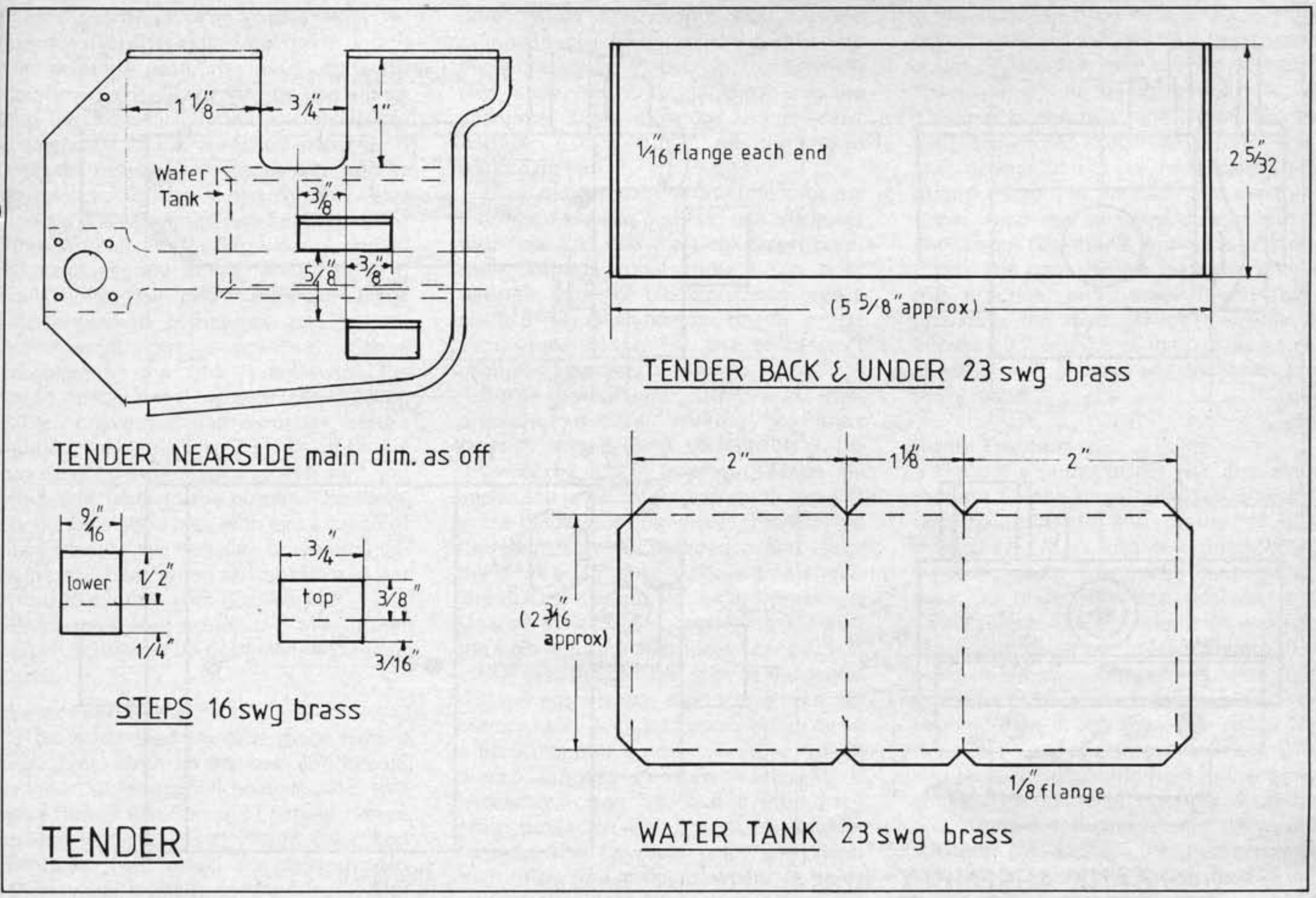
Make the jet block, milling a piece of brass to shape with the cut-away channel milled to take the tube so that it does not protrude too far. Drill the gas valve complex hole and the cross-hole, to be plugged, before drilling the angled hole for the tube and the ¼ in. hole for the jet. There are two securing holes, 8 BA, 1 in. apart, whose position is shown on the rear view drawing. Make the jet in the lathe, then secure it in three-jaw with the ¼ in. part forward, and drill the larger hole, to depth. With a pin chuck held in the drill chuck, hold a No. 77 drill and drill the gas jet hole, withdrawing the drill often, and applying little force.

Paint the jet and a plug with Easyflow paint and push them into place to braze, pickle and wash. Anneal a length of $\frac{1}{8}$ in. copper tube, drill the dome and Comsol solder the tube in place. Wash and blow into the fuelling bush end to make sure it is free from obstruction. Manipulate the tube to fit into the jet block when in position, apply Comsol paint and secure the block to the tank before soldering. Make the fixing block from dural, moving the tank aside to fit it before cutting a paper gasket and securing the jet block to the tank. Drill the tender and try the assembly in place with two brass screws.

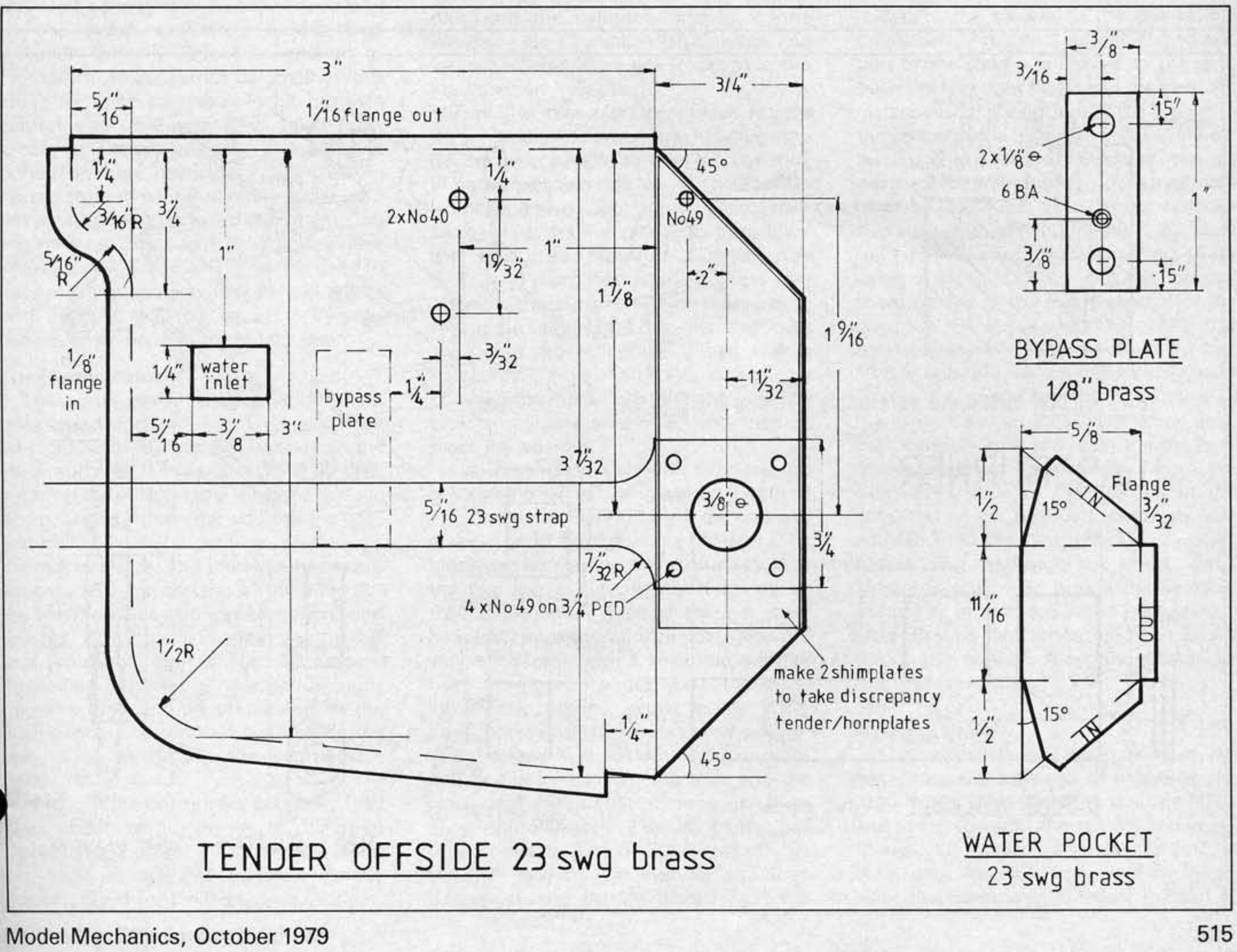
Turn the gas valve from a length of stainless steel, using a parting-off tool to cut the "O" ring groove, and threading the valve 2 BA in the lathe, using the tailstock dieholder and plenty of tapping compound. Cut the screwdriver slot, fit the "O" ring and try in place, blowing into the fuelling bush to test the valve for complete cut-off.

Burner Assembly

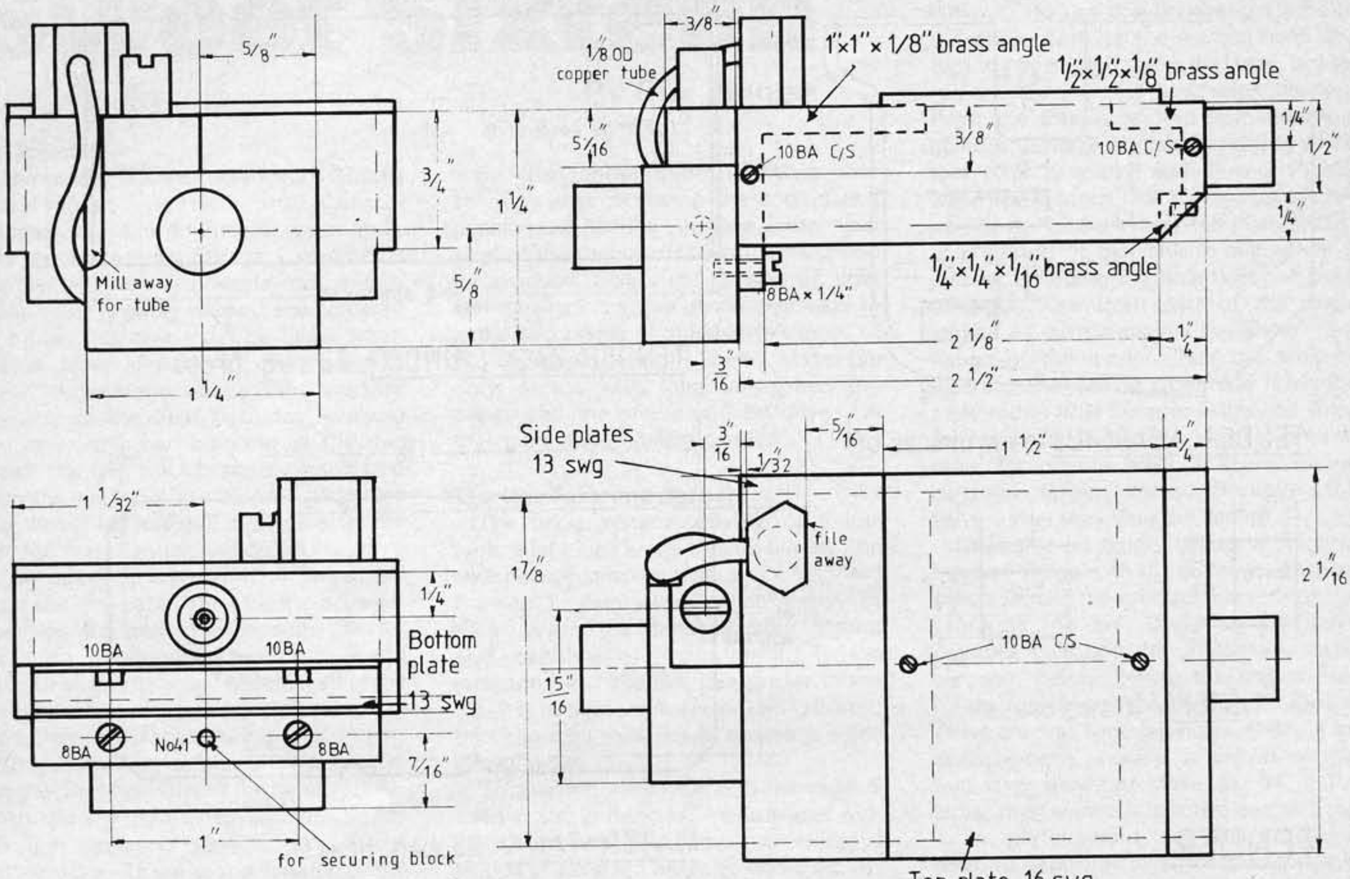
The burner assembly is made from thin-walled copper tube. Cut the 2½ in. length and drill the two air holes and the two burner holes while the copper is still hard. Make the annulus and the end cap from brass. Take a length of the tube, just over 1½ in., and drill a letter Z hole half-way along, cut in half, elongate each half-hole with a round file and gently tap each over the main pipe, flattening the sides onto the pipe. Place one side down on the



1 1/8"
3/4"
1"
Water Tank
3/8"
5/8"
3/8"
TENDER NEARSIDE main dim. as off
1/16" flange each end
2 5/32"
(5 5/8" approx)
TENDER BACK & UNDER 23 swg brass
9/16"
lower
1/2"
1/4"
3/4"
top
3/8"
3/16"
STEPS 16 swg brass
2"
1 1/8"
2"
(2 3/16" approx)
1/8" flange
TENDER
WATER TANK 23 swg brass

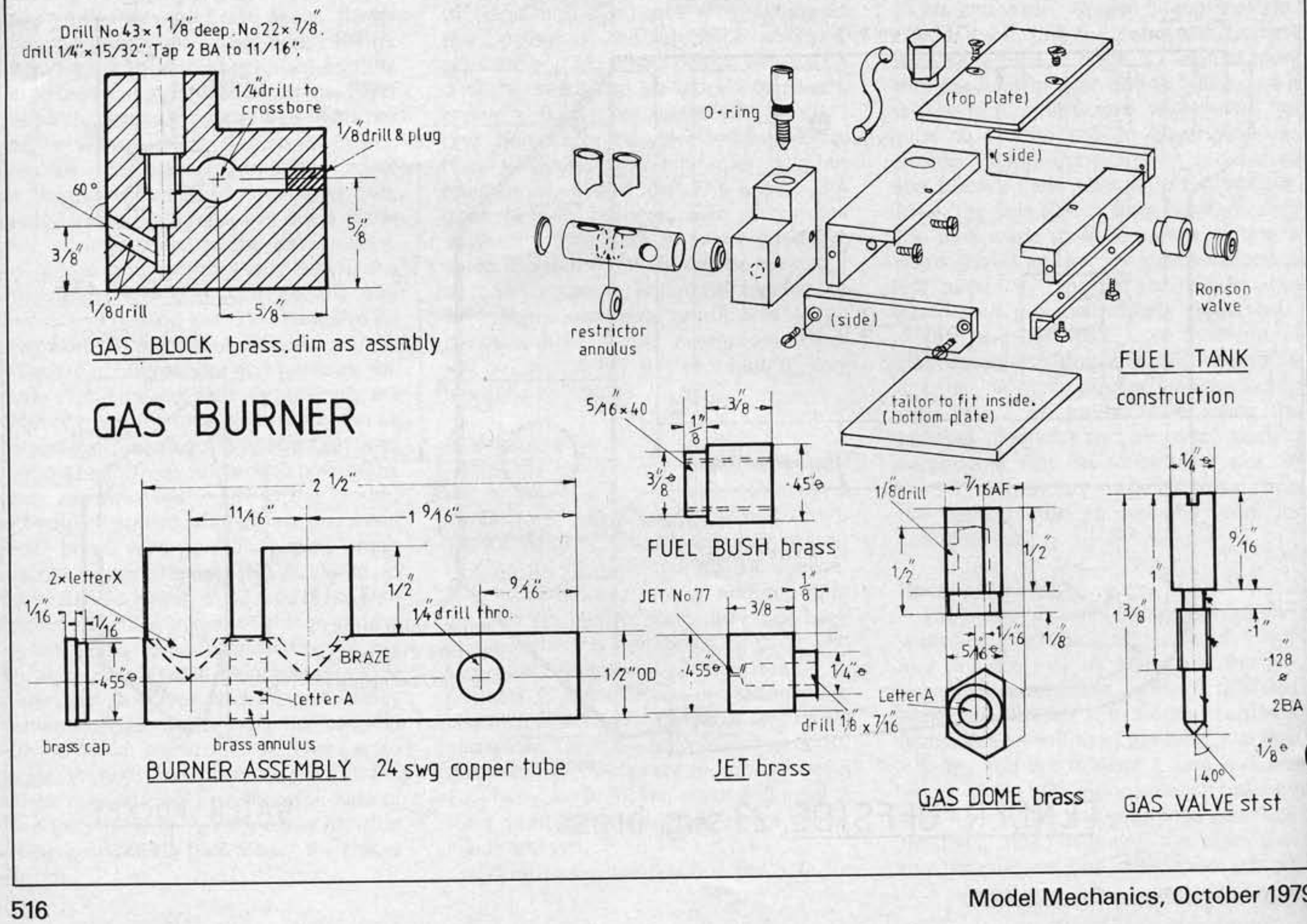


3"
5/16"
1/16 flange out
3/4"
1/4"
3/16"R
3/4"
5/16" R
1"
1/4"
2xNo40
45°
No49
1"
19/32"
1 7/8"
·2"
1 9/16"
1/8" flange in
1/4"
water inlet
bypass plate
1/4"
3/32"
1 1/32"
5/16"
3/8"
3"
3 1/32"
3/8"
5/16 23 swg strap
3/4"
7/32"R
4 x No 49 on 3/4" PCD
1 1/2"R
make 2 shimplates to take discrepancy tender/hornplates
1/4"
45°
TENDER OFFSIDE 23 swg brass
3/8"
3/16"
·15"
2x1/8"
6 BA
1"
3/8"
·15"
BYPASS PLATE
1/8" brass
5/8"
1/2"
15°
Flange
3/32"
11/16"
1/2"
15°
WATER POCKET
23 swg brass



GAS TANK ASSEMBLY brass

GAS BURNER



hearth and braze with Phosphalloy; flip over for the other side. Cool down and fit the annulus and the end-cap with Easyflow paint. Braze the end-cap with a little Easyflow stick and the paint will hold the annulus. Pickle, wash and inspect.

Fit the burner onto the jet with Loctite Screwlock. Tighten in the Ronson valve and the gas valve, and fuel the tank with a 10-second fill. For fuelling the tank should be tilted slightly down, about 10 deg. from horizontal, and the butane filling nozzle pushed completely and quickly home as straight as possible. With a complete fill the tank is full when the liquid fuel spurts back at the fuelling valve. Leave for half-a-minute before lighting, every fuelling. To light, open the gas valve no more than a quarter turn and apply a lit taper to the burner. The flame should be a good blue with just a touch of orange at the tip. Regulate down until the flame is all blue, when the tank should last about 10 minutes with this short fill.

Warning: *Always turn off the burner before refuelling. Do not fuel near a naked flame.*

Water Feed Pump

The water feed pump is made from a brass block with an inserted and brazed cylinder of phosphor bronze, and two valve fittings inserted and Loctited. These are the water inlet non-return valve and the boiler feed valve, the second non-return valve is made in the block. With this method it is easy to check each part of the pump separately before final assembly when it would be difficult to pin-point a fault. Pumps as small as this are prone to air and steam locks, but with careful use of the by-pass valve most problems can be avoided. The pump is bolted to the boiler and will rise in temperature to near that of the boiler, and the passages will be full of steam until the engine is run, then, with the by-pass valve left open, the first running can be used to pass cooling water through the pump until feed is required, and the by-pass closed, when no locking should occur.

The Pump Block

The pump block is made from ½ in. thick brass. Cut out the piece and make one long edge square and finished to the stock surfaces. Clamp to a good 90 deg. angle on the milling table, finished surface down, and mill the other side using a $\frac{3}{16}$ in. end mill. Mill the angle from one end in the machine vice, and then the other end, square. mark out the top of the block for the second clack and centre punch, and drill No. 22 for the $\frac{5}{16}$ in. Remove the drill and replace it with a No. 41 without disturbing anything, and drill right through. Mark and punch the end for the 30 deg. hole and centre drill a start before using a No. 41 drill into the second clack hole.

Mark out the bottom for the boiler feed clack insert, centre punch to drill right through No. 1. Wind the cross-slide along and back, to drill into the hole already present, No. 1 for the inlet valve, just $\frac{1}{8}$ in. deep. Mark and centre pop for the cylinder bore, which can be drilled with the work set at 45 deg. in the machine vice, Letter K drill to just break into the inlet bore. Remove the drill and replace it with a $\frac{5}{16}$ in. × 40 second tap, then bottoming tap.

Mark out the back of the block for the four No. 41 holes, and first drill the boiler feed hole just into the clack insert bore, then drill the other three holes right through, with the block clamped onto a piece of scrap aluminium on the cross-slide—just watch for the drill swarf changing from yellow to silver.

Turn the cylinder from $\frac{5}{16}$ in. dia. phosphor bronze, making the ends square, and drilling through No. 13, followed by a $\frac{3}{16}$ in. reamer. Thread the end in the lathe before trying the cylinder in the block. Turn the sharp corners from the stainless steel pump ram and make the small end by hand, finally clamping it and drilling the end No. 54 in the vertical Unimat. When drilling stainless steel start the hole with the appropriate centre drill, in this case the smallest size, as the centre drill will not wander, then follow with the correct twist drill using neat cutting oil as a lubricant and coolant. Try the ram in place, running it in with Brasso if necessary: clean off. Cut a plug from brass rod and paint it and the cylinder threads with Easyflow paint and insert both. Flux the cylinder where it holds against the block and silver solder the plug and the cylinder, adding a little Easyflow No. 2 stick. Pickle, wash and inspect. Clamp the block in the vice and tap the insert holes.

Turn the inlet and boiler clack fittings from ¼ in. AF hex. brass using the hollow main spindle to feed the material. In both cases first drill No. 41 to just over-length, then No. 22 to precise depth, then bringing up the live centre to turn down the hex., as required. Thread the ¼ in. × 40 part, then tap 2 BA and part off. Hold the inlet valve in the three-jaw to thread the lower end 2 BA, then the boiler clack, but protecting the thread with a soft alloy sleeve. With the sleeve still covering the thread secure in the machine vice to drill the side hole, and then to make the saw-cut.

Use a stainless steel ball to make the seats of the valves, using a short length of $\frac{1}{8}$ in. brass rod as a drift over the ball and giving a good thwack with a hammer. The block can be held on a hard surface, and the two inserts held lightly in a vice by their 2 BA ends. Replace the $\frac{1}{8}$ in. steel balls with phosphor bronze balls. Test the valves for leaks with a suck and a blow, from the bottom ends! Make the caps, inserts and fittings, screw in the boiler clack insert with Loctite screwlock and re-drill the feed hole. Set the balls in place and fit the inlet insert, the inlet and the clack caps with Loctite Screwlock, all to allow approximately $\frac{1}{32}$ in. lift to the ball (one complete turn of 2 BA thread). Fit the "O" ring on the cylinder and then Screwlock the cap in place. Test the pump with the oiled ram in place, inlet under water and a finger over the by-pass outlet. When the ram is worked water should pump from the boiler feed hole.

Screw in the inlet and outlet fittings with Screwlock; these are to take $\frac{5}{32}$ in. O.D. copper tube as are the by-pass valve fittings. Note that the ball valve seats are made using the standard drill-tip angle, and are not flat, that is, not made with the D-bit. The conservative may shudder at this practice, but I have found that, providing the diameter of the hole is between 0.7 and 0.8 of the ball diameter, it works well in use, and the seats are easily made.

Pump Erection

Place the pump on its pad and mark through for the three holes, aligning the ram to point to the centre of the crankshaft. Mark out the three holes properly, using the marks as a guide, mark the boiler feed hole position, and centre punch. Drill the four holes, tapping the three securing holes. Secure the pump in position temporarily, and turn the eccentric sheave from phosphor bronze. Turn in the three-jaw chuck for the outside and the groove, part off. Drill and ream the eccentric hole in the 4-jaw chuck. The centre of the hole is off-set $\frac{1}{16}$ in. from the sheave centre to give a stroke of $\frac{1}{8}$ in. Drill for the grub screw in the vertical mode, the sheave held in the machine vice.

Secure the sheave to the end of the crankshaft and turn it so that the widest part of the sheave is closest to the ram, push the ram right home and measure the distance from the bottom of the groove to the centre of the hole in the ram, it should be 25/32 in., but deficiencies can be adjusted for when making the strap; care must be taken not to make the distance oversize—if in doubt deduct $\frac{1}{64}$ in. Mark out $\frac{1}{8}$ in. mild steel for the eccentric strap, using marking-out blue. Cut out and drill the top edge in the machine vice for the two No. 54 holes right through. Cut across with a fine saw, tap the lower half 10 BA, and drill the top half to clearance. Secure the pieces together with steel 10 BA screws and punch a number on each half, carefully drill and ream the big end. Measure across the diameter, from the side of the hole to the position of the small end centre, as found previously, drill and file to fit the ram, checking in place before filing. Assemble and check, if the sheave is tight, run it in with the strap using a ¼ in. mandrel in the lathe, with a little Brasso and then oil. Clean off thoroughly and oil. Assemble the tender onto the hornplates.

By-Pass Valve

The by-pass valve is made from $\frac{3}{8}$ in. AF hex. brass with one pair of flats filed off. Turn in the 4-jaw chuck to drill the holes and to tap them for the spindle and lower fitting, and to turn down the top for the dural cap. No "O" ring need be fitted since the water level is below the top of the body. Make the fittings and the spindle, threading the spindle in the lathe. Ensure that the body holes, when drilled, line up with those on the tender plate. Use Loctite Screwlock as a gasket for the valve, and now, for resecuring the pump. Bend the copper tubes to fit and secure them with Loctite 641.

Test Run

Fill the boiler with water to half the water gauge glass, and fill the tender. Use *only* distilled or purified water in this engine. Close the by-pass valve and turn the flywheel to pump water to a two-thirds level in the gauge glass, open the by-pass valve. Fill the lubricator with steam oil and oil the motion. Check that the burner valve is closed and fuel the tank with a 10-second fill from a butane refill. Add water to the tender tank and clamp the boiler in a secure vice, or in secured lab. clamps.

Open the burner valve and light the gas with a taper, turning back the valve to stop the flame spilling out and around the firebox. Check that the regulator is closed and wait for steam pressure to build to around 25 psi. Turn the engine over with the flywheel before opening the regulator a little, and turn the flywheel again for the steam to take over. The steam will now be drawing up the flame and the gas can be turned up a little, open up the regulator and close the by-pass to see the water level rise in the gauge glass with the pump working. Adjust the by-pass to keep the level about right, and the flame to keep the steam pressure above 25 psi; vary the speed of running with the regulator to see the effects. You should have at least five minutes of running with the gas fill given.

The Wheels

The wheels present no particular problem, given a reasonable ability to rivet, and a great deal of patience during the turning procedures and the hand work. The rear wheel rims are turned from standard "Minnie" front wheel castings, and the front wheels are turned from solid . Both pair require a few hours work at the Unimat and the rear wheel requires an increased swing mode to be fitted to both the Model 3 and to the SL. The increased swing for the SL has been shown in a previous article in Model Engineer and is the subject of a chapter in my book "Making the Most of the Unimat". My increased swing design for the Unimat 3 may not have appeared by the time of publication of this part of the "Sweet Sixteen" write up, and the faster worker may have to wait for it.

The wheels are made up on a wooden jig to get good centring without wobble, and this is simplified by having the hub and the rim flat to each other on one side; the jig can be flat. The spokes are of mild steel, secured into the hubs with countersunk brass screws before Comsol soldering in place, together with hub-plates. Wheel hubs are to be reamed through after finishing, and all the wheels are free on their axles, the rear wheels being driven by driving pins through the hub plates. My front wheels have spokes which cross over, rim to hub, this is not general in practice, so the purist may deviate from my design by making straight spokes. The rear wheels are straked, and the direction of straking is reversed, near to off-side wheel, so that when the traction engine is driving forwards the wheels tend to be forced inwards.

The Rear Wheels

Obtain the castings and measure them to ensure that the outer diameter is capable of producing a finished wheel of the correct diameter. Mark off inside at 120 degs. and file flats on the inside diameter with the three flats measuring the same to the outer diameter with set calipers. Check the casting on the three-jaw chuck, jaws reversed and across the inside diameter, spin to see that the wheel runs true. If all is well, remove and drill, to take the three screws for plates to limit the fit of the casting over the jaws, and keep the wheel in alignment, as seen in the photograph.

Using the round the corner toolpost accessory, and a round-nose tool, take down the outside diameter of the wheel to concentric, and with the normal toolpost and the same tool face the rim. Make the double-ended tool shown in the drawing and use it to groove out the side as far as possible. Make three same size blocks to fit the turned rim and reverse the wheel on the chuck; the new rim should now limit the fit. Turn the side to completion including the central groove when the unwanted annulus drops out. Recover the three plates to be screwed to the other wheel, which can now be turned.

All the holes on the rim are drilled $\frac{3}{64}$ in. for the rivets, using the 36 position plate in the indexing attachment. Buy at least six $\frac{3}{64}$ in. twist drill as they are easily broken, and to minimise the number of broken drills stake out a circumference of holes first, each time, using the tip of the smallest centre drill before proceeding with a now non-wandering drill. Make a few holes in a piece of $\frac{1}{8}$ in. dural and obtain some rivetting practice. You will need a 40 oz. ball-pein hammer, and a rivetting snap, the type with both a hole and a cup in the end. A specially shaped rivetting dolly will have to be made from ¼ in. steel to hold in the vice, with a cup made with a twist drill, for the rivets to be held within the rim when spoking, and around the rim when straking. Buy $200 \times \frac{3}{64}$ in. brass rivets, $\frac{3}{8}$ in. or ½ in. long; they have to be cut down on the job with diagonal cutters. Practice cutting the right length above the work to get a good head with no spread brass (too much left) or just a pimple (too much cut off). The strake rivet heads are made in countersinks, which is easier.

The strakes are made from mild steel sheet cut in lengths to the correct width on a guillotine, if possible. They can then be snipped off to the 15 deg. angle marked out as lengths along the material with protractor, rule and scriber. Set up a jig on the cross-slide using the arms of the milling clamps over an alloy drilling plate to drill the holes; use a good cutting oil. Thirty-six of the strakes require countersinking to one hand and 36 to the other, use a small HSS countersink and soluble oil. Rivet the strakes in place: bad rivetting can be rectified in the steel by drilling out and replacing the rivet, but when fitting the spokes the head is formed on alloy and must be right first time.

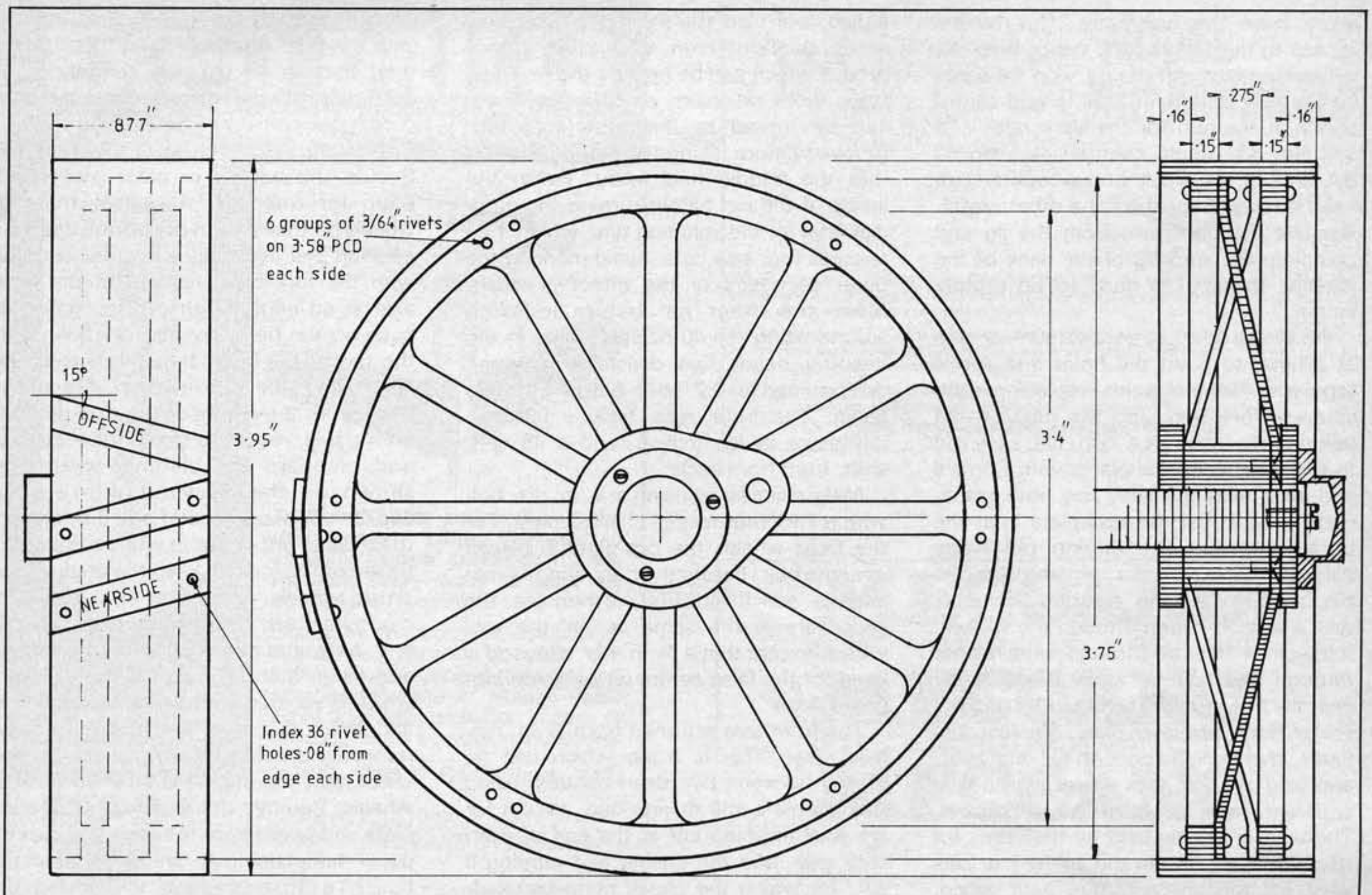
The spokes are most easily made in batches of eight, cut from ½ in. 18-gauge mild steel, snipped out after careful marking out. Clamp eight together in the vice, a marked surface showing either end and file to shape with a round and a flat file. Use two of these as patterns for the other batches. Make a jig for the rivet holes, as before, and drill them, leaving the countersunk holes for drilling in situ. later.

Make the hub plates from the two thicknesses of brass sheet after marking out carefully and centre punching lightly. The plates are shaped by hand after cutting them out with an Abrafile before drilling the axle hole. Cut a length of $\frac{5}{16}$ in. dia. and $\frac{1}{8}$ in. dia. material, and slide the plates onto the larger, to line up the eccentrics, clamp and drill the $\frac{1}{8}$ in. holes through, pushing through the pin. Make sure there is a marked out surface front and back, and clamp in the vice to file to shape with a good file. Index and drill the front plates No. 54, but do not tap the holes until after re-drilling upon assembly.

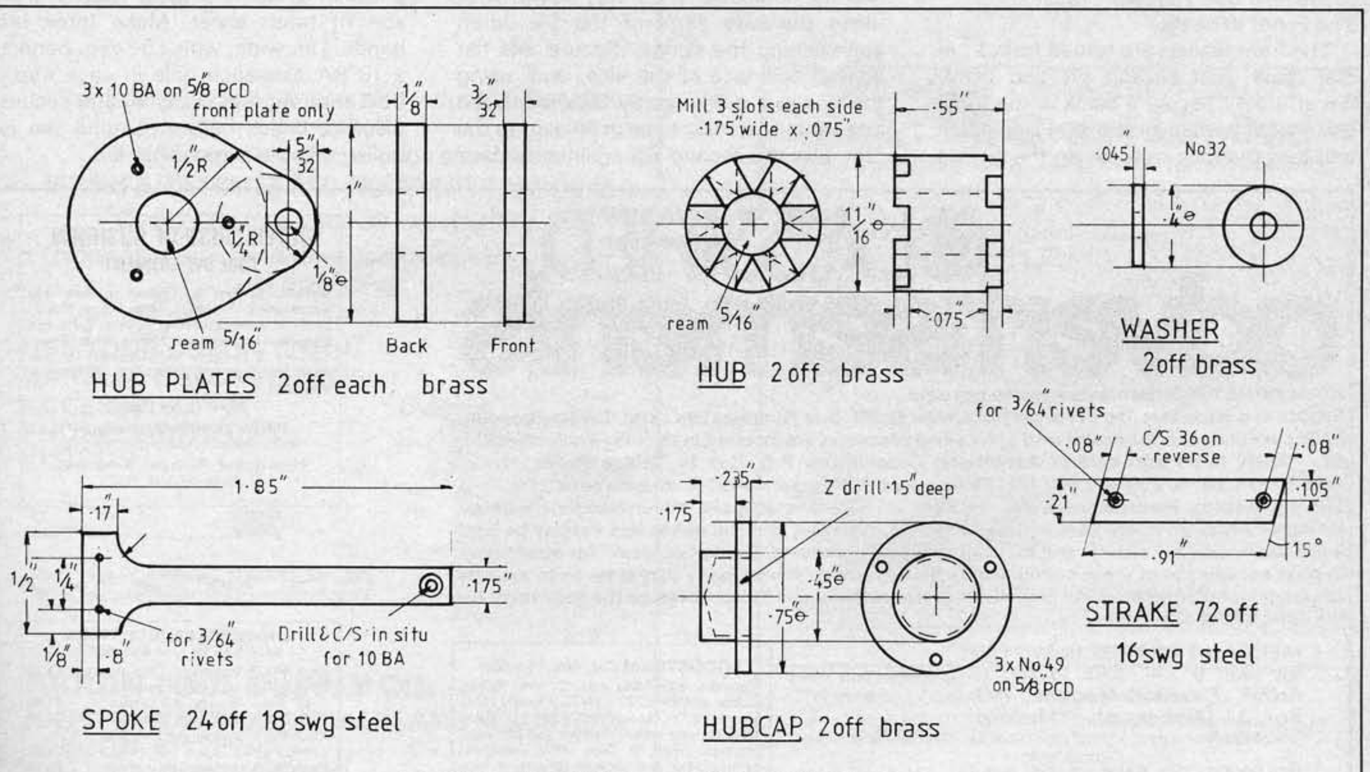
Turn the hubs down from ¾ in. dia. brass and drill through before parting off and securing the first in the three-jaw on the indexing attachment with the 36 plate in place. With a $\frac{5}{32}$ in. end mill, mill across the diameter and back, check with a vernier caliper set to 0.175 in. when you may be surprised to find that the inside caliper fits, if not take a little more from each side; an end mill cuts a slot wider than its diameter. Index around six and repeat, and repeat again. Before removing from the chuck, mark the position of one jaw on the hub, loosen the chuck to turn the hub upside-down, lining up the mark on the same jaw. Index around three teeth and repeat the milling operation.

Make the spoking jig from a piece of good 5-ply, drawing a circle the size of the straked wheel with a pair of compasses. Drill out the exact centre to take a $\frac{5}{16}$ in. dia. bolt shank with about 1 in. unthreaded, and fit this through from the back, and stick on two blocks, top and bottom of the back to balance the bolt-head. Adhere three woodblocks equi-spaced around the drawn circle, just on the line, and when set, try the rim in place; it should be a tight fit.

Fit a backplate and a hub to try one spoke in place, bending it to be flat on the rim and on the hub, scribe to length just



REAR WHEEL 2 off alloy casting



REAR WHEEL COMPONENTS

away from the hub bore. Cut twelve spokes to this length, and bend. Rivet six spokes in place, off the jig, and try again on the hub in the jig. If all is well centre punch at the hub for the six screws and drill No. 53, lightly countersink. Tap 10 BA and fit six short brass countersunk head screws. Repeat for the other wheel. Remove the backplate from the jig and complete the spoking of the back of the wheels; the spokes need to be slightly longer.

Off the jig take out the hub screws, one at a time, to paint the holes and spoke tops with Comsol paint, replacing each screw before removing the next. Avoid painting the bore. Fit a $\frac{5}{16}$ in. dia. alloy rod to the bore, paint the plates with Comsol and slide over the alloy rod, into place, making sure that the backplate is at the back, and that the driving pin holes coincide. Fit a $\frac{1}{8}$ in. dia. pin through the pin holes and clamp the hub assembly with a small G-clamp through the spokes. If the pin will not go through run a reamer through first. With a small flame gently heat the hub until the flux bubbles and the solder flows at either plate. Remove the flame, there will be enough residual heat, and add a little stick Comsol into any apparent gaps; avoid excess and flows. The wheels can be held by their rims for this operation. When the solder just sets wipe off the still soft flux with calico. Remove the clamp and the rods which may need tapping out, and ream. Drill the hub-cap securing screw holes to about ¼ in. deep, and tap 10 BA, make the hub caps and washers. Fit a wheel to each end of the axle and try rolling it on flat ground to see how true your work runs.

The Front Wheels

The front wheels are turned from 2$\frac{5}{8}$ in. dia. dural, first sawing off two blanks 0.6 in. thick. Secure a blank in the three-jaw chuck, jaws reversed, best side down, and turn the face true. Using the double-ended tool turn the inner rim, grooving across to about ½ in. to produce a ring-groove which can be held by the reversed jaws, work reversed, so that the wheel can be turned to thickness and ring-grooved before taking the tool through so that the middle falls away. Finish the inside of the rim before turning the outer diameter for the imitation tyre, which then requires four saw cuts: avoid marking the outer diameters or the effect is spoilt. Make the other rim before indexing around using the 40 position plate in the dividing head, five divisions between drilling, and a 0.2 shift before dividing again. The hubs now have a 90 deg. difference in the milling, and a 45 deg. shift, front from back.

Make a similar jig using a ¼ in. dia. bolt with a 1 in. unthreaded shank length. For the front wheels the cap-plate is placed over the bolt, before the hub, and the rear spokes are fitted first, otherwise the procedure is the same as for the rear wheel, except that a ¼ in. dia. alloy rod is used for the false centre whilst soldering.

Front Axle

The front axle is turned from ½ in. dia. mild steel. This is a job which can be turned between two dead centres, using the faceplate and driving dog, except for the final finishing cut at the end of each stub axle, and the drilling and tapping 8 BA, for which the chuck must be used. The stub axles are turned first after centring up, then the flanges, and the 0.335 in. diameters just started. By manipulation turn a taper at each end of the inside part to an approximation of the drawing. Finish and drill the ends. The first flat is filed for the front, right across using the safe edge of the file when approaching the flange. Secure this flat against one face of the vice, and, using the vice as a guide, partly file the top flat just straight across, to be at 90 deg. to the first. Use the second flat against the face of the vice and make the third flat parallel with the first. Alternate filing the first and third flats to be parallel, central to the axles, and to the correct distance apart before completing the other two.

Drill and tap the holes as required. Secure the wheels in place and check them for trueness. Assemble the rear wheels on their axle in the hornplates, and position the assembly on a flat surface, with the fork bush resting on the front axle at an edge. With a 6 in. steel rule push up the boiler by the fork bush until the top of the boiler is parallel, checking also with the hornplates. Mark the position of the centre of the axle-pin hole on the rule, repeat to check for accuracy, and compare the distance with that shown on the drawing ($\frac{9}{16}$ in. + $\frac{3}{32}$ in.) 21/32 in. Make a note of any discrepancy to be taken out or put in when turning the flange of the fork, to keep the engine level on its wheels. Make the fork from $\frac{5}{8}$ in. dia. mild steel, turning down the spindle end, only, and making the fork by sawing and filing, drill the hole for the axle pin, which is secured with a nut. Make the pin and the fork collar, and assemble after removing a perch bracket cover. Oil and check that the engine is level on its four wheels. Remove the engine unit, motion plate and pump from the pads and make a paper template to fit snugly around the boiler, a little overlong to overlap the ends. Cut a piece of $\frac{1}{32}$ in. Hallite sheet to the size of the template and fit this insulation to the boiler, cutting a butt join underneath. Using thin brass lagging sheet cut a piece to fit with a little overlap beneath; the paper template should be checked over the lagging for the precise size of brass sheet. Make three brass bands, $\frac{1}{8}$ in. wide, with a 90 deg. bend and a 10 BA clearance hole in each end, to hold the cladding in place, and secure in place to check before painting the clad boiler, and the engine unit, etc.

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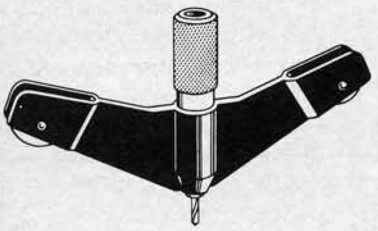

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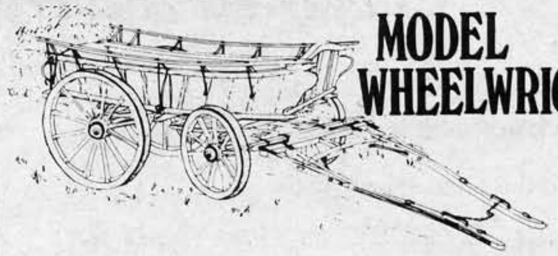

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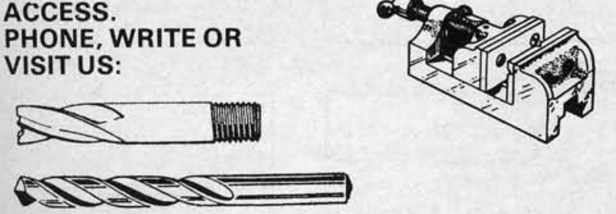

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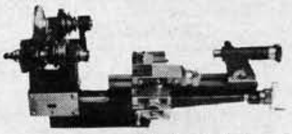

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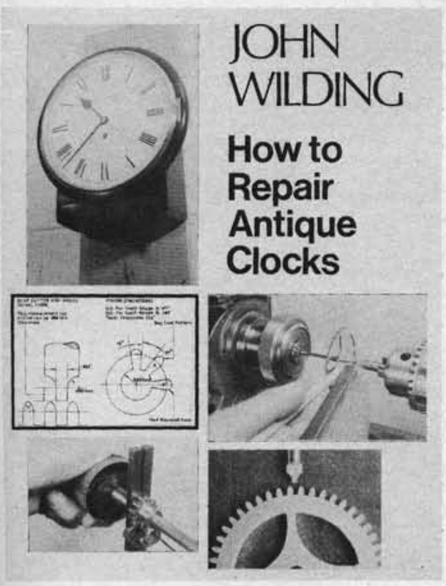

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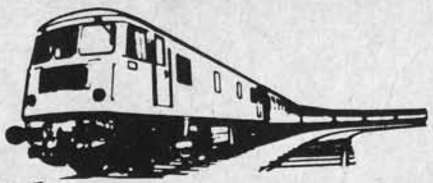

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R449 Lighting Unit	£1.85	£1.20
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R640 LH Point	£2.65	£2.20
R641 RH Point	£2.65	£2.20
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ALA Diesel Green	£7.99
AL6 Overhead Loco	£7.99
Minitrix 2-10-0 Black	£22.00
Minitrix Dock Tank	£8.99

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Peak Blue	£13.49	£9.99
Preserved Scot	£21.38	£15.99
LMS Scot Black	£21.00	£15.00
BR Scot Green	£21.00	£15.00
LNER J72 Tank	£9.80	£6.99
BR J72 Tank	£9.30	£6.99
Blue Grey Coach	£3.45	£2.60
Blue Grey Brake	£3.45	£2.60
Maroon Coach	£3.45	£2.60
Maroon Brake	£3.45	£2.60
Choc/Cream Coach	£3.45	£2.60
Choc/Cream Brake	£3.45	£2.60
Cream/Crimson Coach	£3.45	£2.60
Grey/Crimson Brake	£3.45	£2.60
LMS Coach	£4.30	£3.30
LMS Brake	£4.30	£3.30
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Fowler Black LMS	£13.75	£9.99
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14 XX BR Tank	£11.95	£8.99
GWR Prairie	£12.50	£7.99
BR Prairie	£12.50	£7.99
ALA Diesel Blue	£11.50	£6.99
ALA Diesel Green	£11.50	£6.99
Intercity Coach 1st	£3.75	£2.60
Intercity Coach/Brake	£3.75	£2.60
GWR B Coach	£3.75	£2.60
GWR Autocoach	£4.25	£3.30
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LMS Coach Corridor	£3.75	£2.60
LMS Coach Brake	£3.75	£2.60
BR Red Cream Coach	£3.75	£2.60
BR Red Cream Brake	£3.75	£2.60

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H & M Flyer	£10.99	£8.00

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J50 Black	£8.99	£5.99
J50 Green	£8.99	£5.99
GWR Prairie	£10.95	£6.99
BR Prairie	£10.95	£6.99
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