

MODEL ENGINEER

Vol. 195 No. 4259

28 October-10 November 2005

75TH MODEL
ENGINEER
EXHIBITION

29-31 December

SANDOWN PARK
ESHER
SURREY

SUPER BRISTOL SHOW

GREAT WHEEL CLOCK

SMEE AT SANDOWN



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continues with the parts for the
rhombic drive.
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On the cover ...

On hand at the recent Bristol Model
Engineering and Hobbies Exhibition to
discuss model engineering and his
interest in building models of historical
stationary steam engines was our regular
contributor Anthony Mount.

On display was a selection of the many
models he has built and described in this
and other journals over the years. All
would have made good subjects for our
front cover but the little Benson vertical
steam engine from the 1860s was chosen
for its clean and elegant lines. The
chosen colour seems to suit it too.

For a full report on this popular event, the
fourth show in the current series, turn to
page 492 of this issue.

(Photograph by Neil Read)

MG TC

Work on this superb model of a favourite
1940s sports car continues with the
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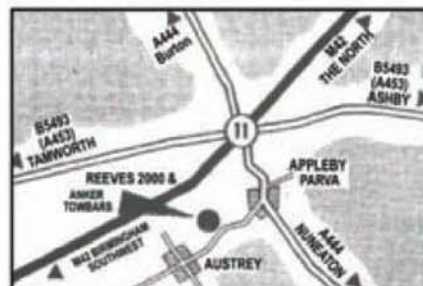


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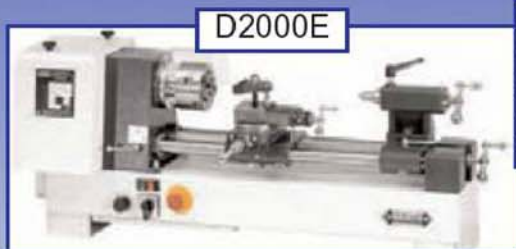
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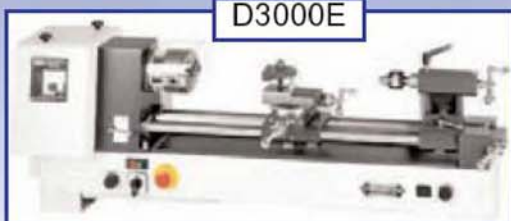
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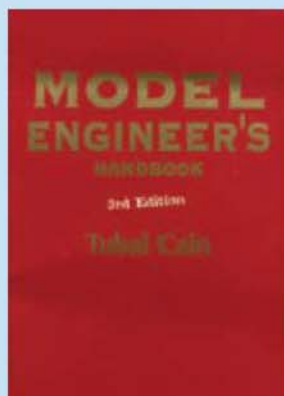
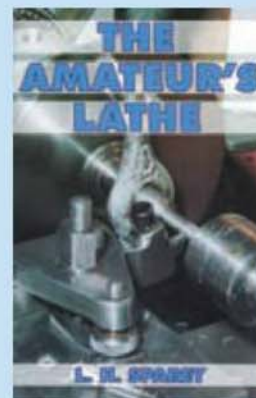
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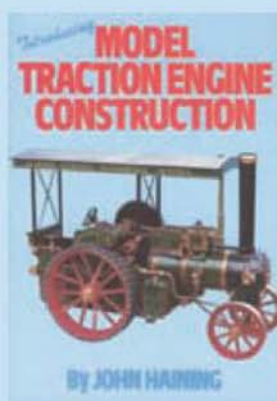
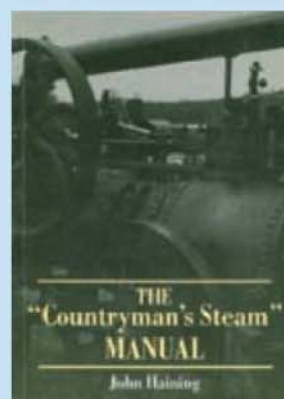
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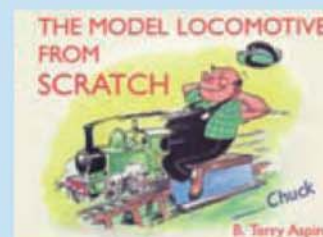
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SMOKE RINGS

With the Editors

Appendix

Let the number of sides be X .

In Fig 5.2 join AB and OB.

Now angle BOC = $(360/x)$ deg.

So angle BOd = angle $1/2$ BOC = $(180/x)$ deg.

Also angle BAd = angle $1/2$ BOd = $(90/x)$ deg.

Let $(180/x) = \theta$ and $(90/x) = \theta/2$

So angle BOd = θ and from this

$\sin \theta = Bd/BO$(1) because $BP=Bd/\sin \theta$

and angle BAd = $\theta/2$ and from this

$\sin \theta/2 = Bd/BA$(2) because $BA=Bd/\sin 1/2\theta$

Also from Fig 5.2 ef = Of - Oe

add AO to each, then

$ef = (Of + OA) - (Oe + OA)$

$= 2 AO - Ae$

$= 2 OB - AB$(3)

Now $OB = Bd/\sin \theta$..from(1) above.....(4)

and $AB = Bd/\sin 1/2\theta$ from(2) above.....(5)

by construction(above) we made side BC = 2, so:

$Bd = 1$

So $OB = 1/\sin \theta$..from (4) above.....(6)

and $AB = 1/\sin 1/2\theta$..from (5) above.....(7)

So $ef = [2/\sin \theta - 1/\sin 1/2\theta]$ from (3),(6),(7) above.

As required here where the length of the side is 2. For the general case where the side is a given then:-

Let the side length be S , so in fig 5:

$BC = S$ and $Bd = 1/2S$

and $OB = S/2 \sin \theta$

and $AB = S/2 \sin 1/2\theta$

So the throw (ef) = $(S/\sin \theta - S/2 \sin 1/2\theta)$ from (3) above

Therefore, to design a Reuleaux cam all that is necessary is to decide the throw required and from this calculate the necessary combination of number of sides and length of each side to satisfy it.

Reuleaux revision

It was a great pleasure to meet Ted Wale a few weeks back. It is always interesting to see Ted's articles, not least the most recent 'Some Strange But Useful Numbers' dealing with golden rectangles, Reuleaux polygons, and Fibonacci numbers.

Unfortunately, in the transposition from Ted's original text to our graphic file sent to the printers, things went slightly awry.

On page 222, *M.E.* 4254, the formula for the general solution for the pentagon shown in fig. 5 should read:

$T = (S/\sin \theta - S/2 \sin 1/2\theta)$

Ted also added a couple of helpful notes to the Appendix, which are shown above.

Six weeks to go

Writing this note at the end of September, the 2005 Model Engineer Exhibition at Sandown Park seems a long way off. However, by the time you read this it will be just a couple of months away, and there is just six weeks left to send in your entry form.

We know that there will be some stunning models on display. We also hope to see some novice's efforts, too. If you are pleased with your model share it with us. Today's Gold Medal winners all started somewhere, many of them encouraged by a minor award at the first showing.

Exhibition is the chance to meet and talk to model engineers with a wide variety of interests.

Don't forget that this is the 75th Exhibition, and we would like to make it one of the best. Preparations have gone well. Now it is up to you to enter your exhibit.

We would especially like to hear from previous winners of major awards, and owners of historically significant models from the famous names who have written for *Model Engineer* over the past hundred years or so.

Even closer for Dorset

Weymouth and District Model Engineering Society also has a dozen or more Gold and Silver medals going on display at an exhibition of engineering models of all types to be held at the Weymouth Museum, Brewer's Quay, Hope Square, from November 22 to December 23. Hint! Just in time for a quick polish before bringing them to Sandown Park for those of us who can't enjoy a late holiday in wonderful Weymouth.

Change at the top

Those who follow these things will be interested to know that in September, the Board of Highbury House Communications announced that Kelvin MacKenzie had accepted an offer to join the Board in the role of executive chairman. Mr. MacKenzie has acquired a substantial shareholding in the company. Simon Neathercoat, the non-executive chairman of the company stepped down from the Board, and Mark Simpson, currently chief executive officer, will also step down in due course.

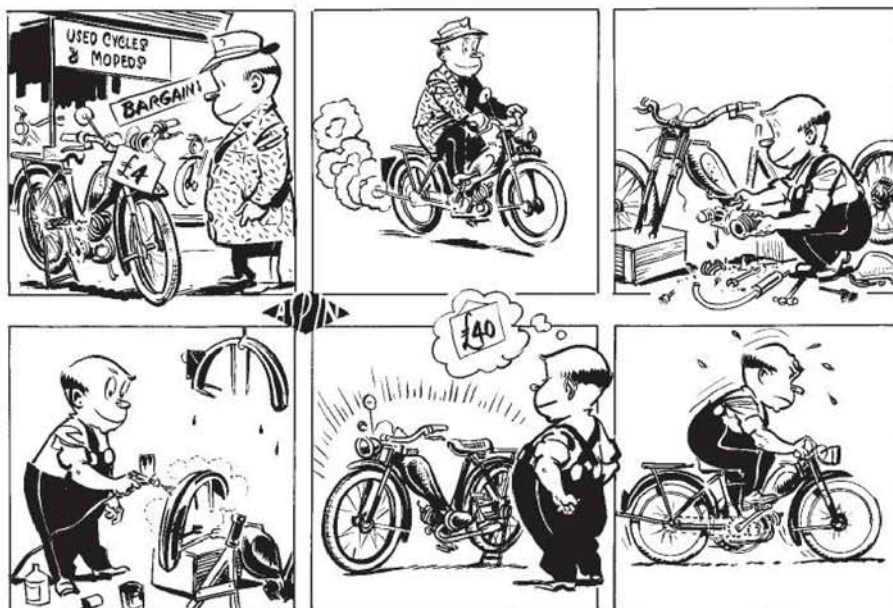
Radio entrepreneur and former editor of the *Sun*, Mr. MacKenzie, commented: "The company remains in a fragile state but at its heart are good titles and core profitability. I am hopeful we can build on this foundation."

Amen to that.

We have also been heartened by the number of clubs that have signed up for the 2005 Exhibition. One of the joys of visiting the

CHUCK, the MUDDLE ENGINEER

by B. TERRY ASPIN



POST BAG

IMLEC Comments

SIRS, - I enjoyed the recent weekend at the Northampton Club for the IMLEC competition; however I wish to make some comments.

Using a dynamometer car that only recorded some of the load is not acceptable. The locomotive had to pull the driver and sometimes another person to prevent derailment, and this load was not recorded. This of course was to the advantage of large engines with heavy loads. A light high tensile rod could have been used between the engine buffer beam and the dynamometer car such that the driving car was pushed rather than pulled. What value was used for the Calorific value of the coal?

We cannot compare the Northampton results with previous events.

Rule 1 is ambiguous; it says: "The competition is open to all 3 1/2 in. and 5 in. gauge steam locomotives" etc. What happens if someone brought a gas-fired locomotive along, there are a few about now!

Acknowledgements in the programme. The Leyland club is credited with the loan of scoreboards, sorry but these were made for the 1988 IMLEC at Eggborough and sign written by the works painter, at that event Venetian blind slats were used to write the results on but they were too flimsy and blew in the wind so on our next event in 1992 we had the metal strips made up for the results as well as a new board for axle weights. I suspect the framework for these scoreboards has been replaced at some time. I give full credit to the Leyland club for the construction of the finger board indicating the run number and driver's name.

For the record the 30 minute time clock was made by one of our

members for the 1988 event and the same man donated the ex-

post office scales for accurate weighing of the coal although they were available but not used this year.

Two other firsts by the Leeds Club, the IMLEC flag was first used in 1992 at the suggestion of Ted Joliffe and the first video of the event was made in 1988 - I have a copy but it was not on general sale.

The hog roast at Northampton was a plus and the camping arrangements good.

As I say I enjoyed the event and I pass these comments so that future clubs holding the event do not repeat mistakes. I shall be booking in my caravan for next year's event. **Arthur Bellamy, Yorkshire.**

Looking for a locomotive

SIRS, - KRATOS - Nigerian 2-8-2 - 3 1/2 in. gauge. About 20 years ago I was privileged to have on loan the 3 1/2 in. gauge locomotive pictured below. Unfortunately the owners decided to sell and I could not afford the price. Accordingly I would love to know where the engine is now and whether or not the owner is prepared to part with it. **Graham Warburton, Somerset.**

Splined couplings

SIRS, - Derek Moxley's letter re. Vernier couplings (*M.E.* 4253, 5 August 2005) has raised an interesting point (to me at least).

My first inclination if called upon to design such a coupling would have been to specify numbers of splines differing by only one tooth; for example, in this case to specify 20 and 21 teeth giving an angular movement of 0.86 degrees (360/20-360/21) when the splined shaft is moved forwards (or backwards) by one tooth in each splined socket.

A similar move with the numbers reported by Mr. Moxley (which I don't doubt are correct) would

result in an angular change of 1.80deg. (360/19-360/21) and this did not seem to line up with the claim of adjustment to less than 1 degree. However, a little more thought and playing with sketches showed that if the 21 tooth end of the shaft was advanced 10 teeth and the 19 tooth end advanced 9 teeth then an angular change of 0.90deg. indeed resulted (360*10/21-360*9/19). Further, changing these numbers to 11 and 10 respectively produced a change of 0.90deg. in the opposite direction. All well and good and Rolls-Royce had got it right after all!

The question in my mind is, why go for an arrangement where the finest adjustment requires the operator to turn the splined shaft through an angle approaching 180deg. and where an error in judging the angle would result in adjustment in the wrong direction. Having experienced R-R thought processes first hand, I know that this is not just a bit of thoughtlessness, there has to be a reason.

What have I missed, can anyone out there enlighten me?

Chris Hallaway, Cheltenham.

Eyebolts

SIRS, - My thanks to Mr. R. P. Wilson (no relation) for his letter (*M.E.* 4253, 5 August 2005) on eyebolts and lifting locomotives, he is perfectly right, however it is not always practical for me to describe every operation in complete detail, so frequently some things get missed.

For four years I was a designer in fork lift trucks, lifting platforms etc. so I know a little about lifting matters and about two years on special-purpose machinery, including a big machine for an atomic power station.

Never would I risk lifting a locomotive with only one or even two lifting points, an absolute minimum of four 'one at each

corner' is mandatory. In the case of tank locomotives, shaped 'yokes' of 1/4 in. mild steel go under the heads of buffers (so scoring no paint) at each end, and a 6ft. length of rectangular hollow section acts as a load spreader, heavily supported by stout chain at each end. Equally thoughtfully, it is carefully painted black, with 'GWR No. 9' and the standard working load stencilled in white. Lifting beam No. 9 was for the largest locomotives, and was sent down to Cardiff to load good old 6000 *King George V* onto 'his' transatlantic voyage in 1927. Any questions?

For tender locomotives, two hefty hooks fit under the rear buffer plates, with the yoke under the front buffers. Tenders are built with four lifting rings on the tank.

In the case of *Lillian* and *GWRillian*, one dynamo bolt in each buffer plate will only be used during chassis construction, and a bit of hand manipulation ensures 'which way up'. For handling the assembled engine, then four dynamo bolts - one at each corner - will be used.

The overhead electric powered hoist is a 125kg model, boosted to 500kg by hefty pulleys, no extra load on the hoist for they are mounted on the trolley, which in turn rides on an I-beam about 4.5 x 3 in. I have checked out the 'I' and the 'Z' of this and all is 'stressed' and calculated for a minimum safety factor of four.

Drawn to my attention by friend R. P. Wilson, I hope that this little discussion has been of assistance to builders of large locomotives.

When it is necessary to use a hoist like this to assemble a firebox c/w tubes into the outer shell, you are getting somewhere!

Keith Wilson.

Choosing a lathe

SIRS, - The letter from Brian Thompson (*M.E.* 4251, 8 July 2005) asking readers advice is almost parallel to a letter written by me (*M.E.* 4205). I am ever nearer to retirement now and have sold my Chinese lathe and am looking forward to my next lathe which will be British. In that letter I took issue with Anthony Mount's very well written series on fine tuning a Chinese BH600 lathe that wasn't a fine tune at all!

Seven of the editions referred to items which related to sloppy fits, making oil grooves or compensating for crude build etc. Several readers wrote in to support my views.



The KRATOS locomotive sought by Graham Warburton.

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Responses to published letters are forwarded as appropriate.

This Chinese vs. British debate has rattled around in *Post Bag* for many years and has rattled many readers also.

There are a few facts to take on board. A Chinese lathe will be worth a fraction of its bought price within a very short time. Most dealers won't touch them with a barge pole for all sorts of very good reasons.

I want a lathe that I can plug in and go. I don't want to spend dozens of hours getting a new lathe up to an acceptable standard. There are pages of advertisements in *M.E.* offering a huge range of machines and even more on the internet including one company in Hertfordshire the specialises in re-built Colchester lathes (usual disclaimer).

I hope this helps Brian Thompson, it won't be an easy decision but I've been there, I've bought one but I won't wear the T-shirt!

The next few editions of *M.E.* should prove interesting reading.

Terry White, Hertfordshire.

More advice on lathes

SIRS, - Re: *Post Bag* (*M.E.* 4252, 22 July) - Choosing a lathe. I was interested to read Brian Thompson's letter about choosing a lathe because I went through a similar process a couple of years ago and nothing has changed since that would lead me to a different conclusion.

The first question that needs to be addressed is what sort of models do you want to build, as the diversity of scale and complexity has grown significantly in recent years, so don't fall into the trap of under estimating your needs.

If you have already experienced the flexibility, power and rigidity of a Colchester Student I can understand you looking beyond the confines of a Myford. There is a good chance if you buy a good used machine that you will get most of your money back if you find you have done the wrong thing and need to sell it on. However, if you buy a new machine you stand to lose a lot more money if you find it unsuitable for your needs.

After much soul searching I decided to purchase a new Chinese lathe rather than a second hand Colchester and have been very satisfied with its capacity and performance. Whilst the Craftsman represents excellent value, it does have very real limitations on speed range and capacity if you are looking to build the larger size

models. I decided to stretch the budget and go for the Challenger (Warco version GH-1440) for the following reasons:

It can easily accommodate the large quarter scale traction engine that I am currently building, both in terms of swing and bed length, but it also has a useful speed range from 45 to 1800rpm. I am pretty sure it will also meet my future needs. You can purchase the machine with the longitudinal travel hand wheel on the right-hand side of the apron, which I find more comfortable especially when the hot chips are flying. It has an excellent brake, which seems to stop the machine instantly, very useful for certain screw cutting operations, and very reassuring on the odd occasion when things start to go wrong.

It not only handles the larger work, but fitted with a 125 rather than a 200 chuck, it handles the smaller sizes very well at speeds up to 1800rpm. It has a generous bed length and large capacity spindle bore. Clearance over the bed and saddle is good and with the gap removed it will easily accommodate a 450 diameter face plate with room to spare.

I run mine on a three phase supply with the standard two speed motor and find it responds to speed change and reverse running very well. The friend who kindly recommended the machine to me runs his with a three phase motor and a 240 volt inverter which delivers a very smooth soft-start and variable speed control from 0 to 2000rpm. This inverter solution to speed range and control would be well worth considering if you feel the Craftsman will meet all your needs. I would suggest you speak to Anthony Mount and read the very interesting articles he wrote on fine tuning his own BH-600 lathe.

It would be nice to think that these machines could be used in a home workshop straight out of the box, but they are far from ideal and I ended up doing the following modifications:

Made a replacement cross slide to better fit the Multi Fix tool holder system that I prefer and extend the slide travel.

Fitted a large tool tray on top of the headstock.

Made some long shaft chuck keys to avoid clashes with the headstock.

Fitted rubber slide covers to the front of the tail stock to help keep the bed contact clean.

Set the work light and coolant delivery tube mount further back with a blocking piece to provide more comfortable clearance for the tailstock. Also fitted a swivel elbow where the rigid coolant pipe joins to the flexible hose.

Removed the lead screw protector coil spring to accommodate close up working to the headstock.

Made a cover plate with an O-ring seal around the tail stock barrel to keep out stray particles, and fitted a simple digital readout to measure the barrel projection.

Put a rotary stop on the saddle clamp handle to prevent it from striking the tailstock when moving down the bed.

I shortened the power drive selection lever on the saddle to ensure full gear engagement.

Formed a front, rather than back access for the coolant tank within the lathe base, turned the tank around, reorganised the plumbing, provided a particle filter and a low pressure air feed to keep the contents sweet. Made the front cover between the two cast iron end columns a removable section and fitted a sheet metal shelf for additional storage.

Made cork faced steel pads and fitted screws for levelling the lathe.

I also made additional change wheel gears in order to extend the range of thread cutting option.

I fitted a Newell digital readout system.

With these modifications and a comprehensive range of chucks and tooling I find the lathe is a joy to use for both large and small size work.

Stuart Walker, Surrey.

Even more lathe advice

SIRS, - In reply to Mr. Brian Thompson's letter (*M.E.* 4252, 22 July 2005) on choosing a lathe. I found myself in the same position back in 2002 when I purchased a Craftsman lathe.

These Chinese machines seem to be very good value for money, mine is in use most days.

I would however advise Mr. Thompson to have an inverter

variable speed system fitted as this will save messing with belts and pulleys.

I have also purchased a 626 milling machine which I also run off the inverter (but not at the same time of course).

I hope this information is of some use to Mr. Thompson.

Michael Dodd, Staffordshire.

We have received several letters on this subject and the message seems to be in favour of these machines because of the cheapness. The quality may vary but we have also heard from one reader who was unhappy and the supplier took back the machine with no quibble. It would seem that these machines are good value and enable a workshop to be set up very cheaply but it may pay prospective purchasers to check them thoroughly and to contact the suppliers if you are at all unhappy with what is delivered.

Dynamometer car testing

SIRS, - Your IMLEC Report issue (*M.E.* 4254, 19 August 2005) shows that Chuck must have been with us in spirit sometime in early May.

We had got the Dynamometer car's load-measuring assembly fixed to a 2in. U-section beam, wound up ever so tightly in the long-suffering workshop vice. Below this dangled two 56lb weights, courtesy of a not-too-thick bit of galvanised wire (did you know that an old coat-hanger can take 1cwt in tension? That's a lot of dirty mags). Even wearing safety boots, we were very wary of approaching the contraption to discover whether it would accurately measure the addition and removal of a 6oz pair of pliers. (It did, thus demonstrating that it had enough resolution to measure the tractive effort of a small 3.5in. gauge locomotive as well as that of a narrow-gauge 5in. one, without any form of range-changing).

May we take this opportunity of thanking everyone for their appreciative and complimentary remarks about this project? We were very pleased it did the job properly - we had taken great care to design it for reliability, but failure would have been horribly public.

Incidentally, how are we to convince our work colleagues that we are NOT train spotters, now that 'the old firm' has appeared on the cover of *M.E.* beside Ballan's locomotive?

Carl Bailey, Garth Porter, Northampton SME.



1
This fine wheel-cutting engine was the work of Phil Bridgway of City of Newport MES.



2
Also on the City of Newport SME stand was this triple expansion marine engine by Julian Wood.

THE BRISTOL MODEL ENGINEERING AND HOBBIES EXHIBITION 2005

Neil Read

reports on the many items to see and enthral at Thornbury this year.

Now seemingly a permanent fixture in the model engineer's calendar, the Bristol show appears to go from strength to strength. This was the fourth in the current series and was naturally a popular venue for those from the more south-westerly regions of the British Isles. However, there are many from other parts of the country that make a point of visiting this event and with the quality and quantity of exhibits on display at this year's exhibition this is, perhaps, no surprise.

Let us start this report with a nicely made wheel-cutting engine (photo 1). This was the work of Phil Bridgway of City of Newport MES. This looked a sturdy machine and well suited to

making the wheels for larger types of clock. The City of Newport stand was well stocked with a wide variety of models and rubbing shoulders with Mr. Bridgway's wheel-cutting engine was a

very tidy triple expansion marine engine by Julian Wood (photo 2).

The making and running of gas turbine engines is a well-supported facet of the hobby but the casual observer is not always let into the secret of how such engines are made. James Hill of the Gas Turbine Builders Association obviously feels this should change as he had on display a selection of press tools for making axial flow compressor blades for one of these engines (photo 3).

It is always a pleasure to see the Society of Ornamental Turners at events. Not for them a few lifeless exhibits on a trestle table, they like to bring along their machines and show people what their hobby is about (photo 4).

Adjacent to the host society's stand, Bristol SMEE, was a small table displaying the popular tool and cutter grinders found in use in model engineer's workshops. Amongst these was a locally made one called the



3
Some press tooling used by James Hill of the Gas Turbine Builders Association to make axial flow compressor blades.



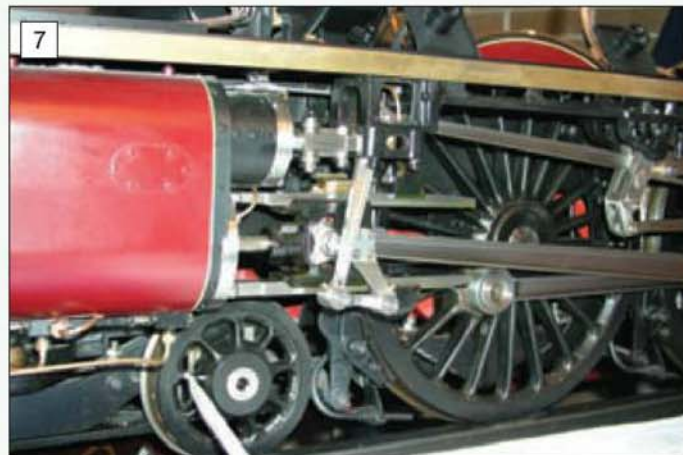
4
The energetic members for the Society of Ornamental Turners gave demonstrations throughout the show.



5
The neat Colyer/Caseley tool and cutter grinder attracted the attention of many visitors.



Seen on the Bristol SME stand was this 5in. gauge GER Claud Hamilton Class D56 by Roy Simmons.



The fine workmanship on Dave Parnell's part built 7 1/4in. gauge Duchess of Hamilton is evident in this photo.

Colyer/ Caseley after the collaborating members of Bristol SMEE who designed and made it (photo 5). Apparently one member looked after the grinding wheel head whilst the other produced the work holding arrangements. Whether they ever fell out about whose turn it was to have the tool and cutter grinder that evening is not recorded. Hopefully they both have one by now!

Bristol SMEE members had rallied round and had a most impressive display of their work on display. I particularly liked the look of the 5in. gauge GER Claud Hamilton Class D56 by Roy Simmons. This model was built by Roy from the works drawings (photo 6).

Adjacent to the Bristol stand was a display by Dave Parnell who was exhibiting his part built

7 1/4in. gauge *Duchess of Hamilton*. The standard of workmanship on this massive locomotive is very high indeed and I can only hope my photo (photo 7) gives some idea of the standard achieved.

One of the nice things about travelling to events like this is that you get to meet people who otherwise would just be names on your contributor list. I was therefore delighted to meet



This fine clock is the work of Peter Heimann and a series will appear in M.E. in the near future.



An example of Galileo's escapement made by Hywel Lambert.



A handsome 2in. to the foot Fowler traction engine by John Morgan of East Somerset SMEE.



An example of the ever popular Gnome monosoupape 100hp rotary aero engine by Charles Morgan.



A pair of 1:6 scale Fowler BB1 ploughing engines complete with their balance plough and made by Jack Brunson.



13
The neat light delivery van made by J. B. Prior of the Guild of Model Wheelwrights.



14
The replica of John Stringfellow's first steam powered model aircraft said to have flown in 1848.

up with Peter Heimann and have the opportunity to photograph his latest clock (photo 8). Peter has contributed several clock series to the magazine and his many fans will be glad to hear that this latest one has been written up and will appear in the not too distant future.

There were several other clock entries on display. Amongst several fine timepieces made by Hywel Lambert was a link with the past in the form of an example of Galileo's escapement to the design of John Wilding (photo 9).

A very fine Fowler 2in. to the foot scale

traction engine caught my eye on the East Somerset SMEE stand (photo 10). This was the work of member John Morgan who apparently built it in the space of two years. A Gnome monosoupape 100hp rotary engine (photo 11) was also seen on this stand made by Charles Morgan. Any relation I wonder?

The cable system of ploughing using two engines pulling the plough between them will be familiar to many readers and a superb miniature, ploughing outfit (photo 12) was on display made by Jack Brunsdon. Such an exhibit, of course,

involves the maker in building not one but two suitable engines and their implements so 'hats off' to Mr. Brunsdon for his endurance.

The Guild of Model Wheelwrights had their usual display of finely made models of horse drawn implements and vehicles. I do not recall seeing the light delivery van by J. B. Prior before and herewith offer a photo (photo 13) so that readers can admire its fine lines and sign written coach work.

The flurry of interest in steam-powered flight that has recently appeared in *M.E.* prompted me to examine the next exhibit with some interest. It



15
Road locomotives in 1:3 scale are impressive machines and this McLaren by K. Davies was superb.



16
LBSC's legacy continues to live on. A delightful 2 1/2 in. gauge Dyak exhibited by Dennis Lock.



17
Harry Paviour's fine 3 1/2 in. gauge model of the unusual Southern Railway Bullied Class Q1.



18
On loan from the Bristol Industrial Museum were this Garrett threshing machine and straw elevator built by F. G. Bettles in 1:12 scale.



19
A fine display of the models designed and built by Anthony Mount and described in this and other journals.



20
A close up view showing the attention to detail on Stan Compton's La France fire engine of 1900.

was a replica of the first steam powered model aircraft built by John Stringfellow (1799-1883) and believed to have flown in Chard, Somerset in 1848 (photo 14). It was built by past and present employees of Rolls Royce plc, Bristol. This model was the one featured in the BBC, Adam Hart-Davies television programme 'What the Victorians did for us' but failed to fly on that occasion due to engine problems. With an engine based on that built by Stringfellow it has now accomplished flights of up to 42 feet.

A walk back to the car to fetch something gave me the opportunity to look around the outdoor exhibits. The steam driven printing press printing toy money was good fun but I was also impressed with the appearance of Mr. K. Davies' splendid 1:3 scale McLaren road locomotive (photo 15). It could almost pass for a full size vehicle in the photo although the out of scale road fund license disc holder on the canopy does rather give the game away.

Returning to the hall I paused for a few moments to admire the exhibits on the 2 1/2" Gauge Association stand and in particular to take another look at the new *Ayesha*. This reminded me that I had passed another LBSC designed locomotive earlier and returned to photograph it (photo 16). This was a 2 1/2in. gauge Dyak by Dennis Lock and it is an attractive little engine - perhaps another for revival by the 2 1/2" Gauge Association.

I had always regarded our occasional contributor and esteemed judge at the Model Engineer Exhibition, Harry Paviour, as a confirmed 'road steam' man. However, it seems

that Harry has catholic tastes and I was introduced to his 3 1/2in. gauge model of the Southern Railway Bulleid Class Q1 (photo 17). This was a fine little model of this unconventional locomotive and I will remember not to jump to conclusions in the future.

It seems the organisers of the exhibition had left no stone unturned in obtaining interesting exhibits for the exhibition. Bristol Industrial Museum had provided a couple of fine models in the form of a Garrett threshing machine and straw elevator. These were built by F. G. Bettles and were in 1:12 scale (photo 18).



21
Also by Stan Compton was this 7 1/4in. gauge model of Stephenson's Locomotion of 1825.



22
Maurice Turnbull's tool post milling device with examples of threads milled in the foreground.



23
The neat little 5in. gauge NLR passenger tank locomotive No. 48 built by Nigel Dickinson.

Few have done more to promote the modelling of stationary steam engines than Anthony Mount, whose name will be familiar to most readers. Anthony was on hand at the exhibition to chat about his designs and had all his models on display (photo 19). A rare opportunity to check out the many and varied designs conjured up by our forebears.

The Hereford SME stand was always quite busy and it was not till later in the day I paid it a visit. It was worth the wait as amongst a number of fine exhibits were two exceptional models by member Stan Compton. The La France (USA) horse drawn steam fire engine of 1900 was magnificent and I include a close up which hopefully shows some of the detail (photo 20). Stan's 7 1/4in. gauge model of *Locomotion* of 1825 was also built to a very high standard (photo 21).

Time perhaps for some more tooling and I show a photograph (photo 22) of an interesting tool post milling attachment devised by Maurice Turnbull to enable him to thread mill some very fine leadscrews, examples of which were on display with the tool. How about a description for the magazine Maurice?

Our final model (photo 23) is a neat little tank engine, a 5in. gauge NLR 4-4-0 passenger tank No. 48 to be precise and this was built by Nigel Dickinson.

Well, we have run out of space before running out of models. I hope readers have enjoyed this brief visit to the Bristol Exhibition. If so why not give this exhibition a try yourself next year. It will run from 18 to 20 August 2006 so make a note in your diaries now.



The four frame feet were supplied in an as machined condition.



The feet were held between soft jaws in the bench vice for polishing.



A foot after being polished. Progressively finer grades of emery cloth are used then metal polish.

BUILDING THE FRENCH GREAT WHEEL CLOCK FROM CLASSIC CLOCK KITS

Ian Beilby

offers further advice on the hand polishing of the components.

●Part III continued from page 378
(M. E. 4257, 30 September 2005)

The four frame feet are shown in photo 27, and although the machining of the feet has been done very well, the feet still require polishing, hopefully to a mirror finish! It is no good just polishing the feet with polish and a cloth. The feet require a little more treatment than that. They still exhibit slight turning marks as can be seen in photo 27 and these will have to be removed with emery cloth before any effective polishing can take place.

I appreciate that model engineers would have no difficulty in mounting the feet on a stub arbor or mandrel on the lathe and performing the finishing operation in this way, and this is certainly the quickest and easiest way to perform this task. However, as I said earlier I deliberately

wanted to show how all the components of the clock could be finished by hand.

I therefore chose to grip the foot in the jaws of the bench vice as shown in photo 28 and remove the turning marks with strips of emery cloth. The cloth is applied in a seesaw fashion until the turning marks are removed. The foot is rotated in the jaws of the vice and the process repeated until the whole perimeter of the foot has been completed and is free from turning marks.

The secret is to use long thin strips of emery cloth and work quite quickly. Quite a bit of downward pressure can be employed, and the work is not as laborious as imagined. Different grades of cloth will be required, working down to the finest. When you are confident that all the marks have been removed, the polish can be applied and the foot buffed-up with strips of polishing cloth in the same way.

If all of the turning marks have not been removed, the polish has the effect of highlighting the marks, and it is simply a matter of working over this area again, photo 29. A comparison between two of the feet can be seen in photo 30. When all

four feet have been polished they can be screwed back onto the frames as shown in photo 31.

The frame pillars are the next items to be polished. Photograph 32 shows one of the pillars and as you can see the pillars have been machined very well, with the minimum of turning marks. However, they do require polishing.

Again, I appreciate that readers with a lathe could use it to speed up the work, however the pillars can be polished just as well in the same way that the frame feet were polished. The pillars are gripped in the bench vice and fine emery cloth used to remove any slight blemishes and impart a satin finish.

Photographs 33, 34 and 35 show the process. The pillars can then be polished. As before, the polish will highlight any marks and the process should be repeated until all the pillars are free from any marks and a fine polish obtained.

The screws used to assemble the frames and pillars are ordinary steel machine screws, and their finish does leave a little to be desired. Photograph 36 shows one of the screws. However, they are not difficult to polish and bring to a much more



Spot the difference? The machined finish on the foot is good but is improved by polishing.



The frames after being reunited with their polished feet.



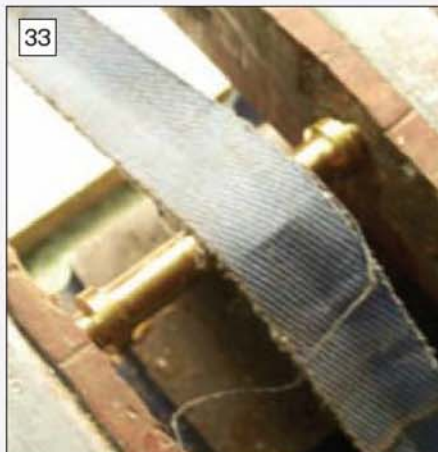
A pillar being gripped ready for polishing in the bench vice.

acceptable finish. A pin vice and emery papers are used as shown in **photo 37**. The head of the screw is rotated against the emery paper that is pinned to a wooded block.

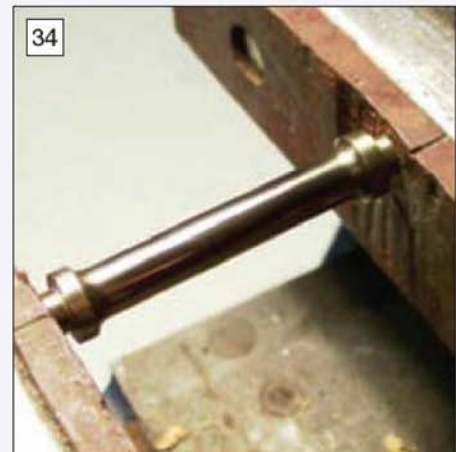
Progressively finer papers should be used and the heads of the screws finally polished with Solvol Autosol. **Photographs 38** and **39** show some of the screws after polishing. A photo of the assembled frames and pillars is given at **photo 40**, and hopefully this gives the reader some idea of the sort of finish to aim for.

The mainspring barrel rotates in two supports screwed to the base plate of the clock; both supports are independent of the frames of the movement and are made from castings. The supports were previously shown in photos 19 and 20. As you would expect from castings, the edges of the castings are not as well finished as the edges of the milled plates, and this can be seen in **photos 41** and **42**. The castings will require filing in order to remove some of the ragging and any minor blemishes.

The click and screw are removed from the front support, and any blemishes can then be removed from the internal and external edges of the casting with a No.6 or 4 half round file. The edges can then be brought to a good finish with fine emery papers wrapped around the file. **Photograph 43** shows the edge of one of the



The emery cloth can be worked to and fro to remove the machining marks.



If any machining marks show after polishing further work with emery cloth is called for.

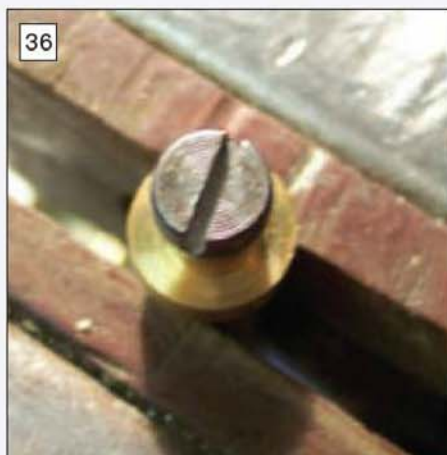


A finished pillar. It important to be patient when polishing and not try to rush the process.

supports prior to polishing and you can see all the casting blemishes have been removed.

In order to clean up the faces of the supports a sheet of emery paper should be fixed to a flat

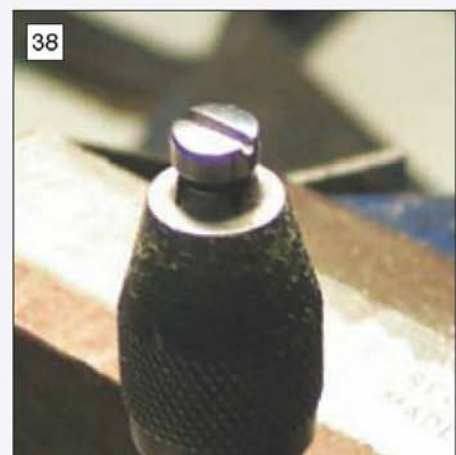
surface. The face of the support can then be worked first in one direction and then the other until all marks have been removed. Both supports should then be polished. Care should be taken to remove



The heads of commercial screws can be improved by polishing.



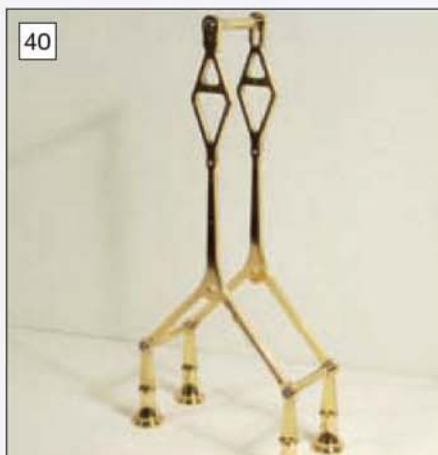
Here the screw is held in a pin chuck so the head can be polished.



A screw after some attention. Aim to keep the head square and not 'dubbed off'.



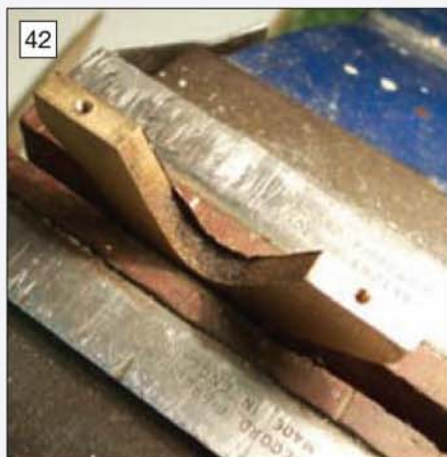
A selection of screws with their heads polished and ready for assembly.



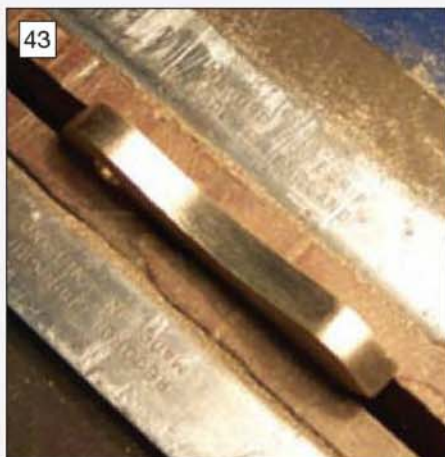
The polished frames assembled with the feet, pillars and screws.



Polishing the mainspring arbor supports. Some filing was necessary to remove the cast surface.



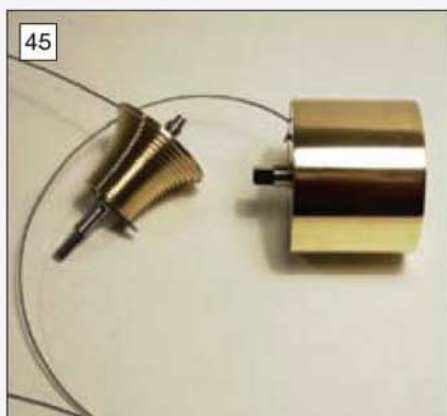
42
Some casting flash was still apparent on the arbor supports.



43
The finish achieved on one of the arbor supports after some polishing.



44
The finished arbor supports. The front one shows the polished click and screw.



45
The fusee and spring barrel were not separated for polishing.



46
The fusee was well machined but the grooves were polished.



47
Polishing the escape wheel assembly on a special, raised board.

any polish from the pivot holes in the supports. The finished supports can be seen in **photo 44**.

The mainspring barrel and fusee are still joined together by the steel fusee line as was shown in **photo 18**. The line is knotted at both ends, and although it does make it rather difficult to polish both these components whilst attached together, the line is perhaps best left attached. Tying small knots in steel wire is not the easiest of tasks, especially for someone not used to the job, and I would recommend that the line be left in place.

On no account should the mainspring be removed from the barrel. The spring is new and has been correctly fitted and lubricated and there is no need for its removal from the barrel. Without the use of a mainspring winder to remove or insert the spring this could prove to be most dangerous.

The barrel is placed between the jaws of the bench vice where the periphery of the barrel is finished and polished as before. The end-caps of the barrel are easily polished. Care should be taken to ensure that no polish enters the pivot holes in the caps.

The fusee is very well machined and requires no other finishing, however the surface and grooves of the fusee should be polished. Old toothbrushes dipped in liquid polish prove most effective in applying the polish. The fusee should be finally polished with a soft clock brush.

The fusee stop, which is made from steel, should be unscrewed and polished. The pivots of the fusee arbor are well finished and require no treatment. The winding square however should be well polished, and as the front of the square is particularly noticeable, this should be brought to a very high finish. Finally the fusee line should

be run through a clean cloth to remove any oil or dirt. The polished mainspring barrel and fusee can be seen in **photos 45 and 46**.

After polishing, the components should be handled as carefully as possible, as natural grease from your fingers will tarnish the brass leaving unsightly stains. I generally wrap the components in acid free paper until the clock is finally assembled.

It now only remains to polish the wheel work and several other small components before the clock can be re-assembled. The motion work, pallet arbor, crutch, fusee stop lever and dial bezel are all straightforward items to polish, and require no special treatment. The pallet faces were well polished and required no further work. The body of the pallets was cleaned up with fine emery sticks. The pallets should not be removed from the arbor. The fusee stop lever is made from steel and may require cleaning-up with emery papers.



48
The great wheel, centre wheel and escape wheel after polishing.

All the steel components of the clock should be brought to a polished finish, not just from an aesthetic point of view, but also to prevent rusting in future years. Some of the items are quite small and care should be taken not to misplace any of them.

Naturally the centre and escape wheels are ready mounted on their arbors, and one of the best ways to polish them is by mounting them on a suitable board with drilled holes to take the arbors. The wheels can then be polished with liquid polish and brushes in order to achieve a highly polished finish. A good quality soft clock brush should be used for the final polishing, and the wheel teeth should be carefully brushed to remove any excess polish. **Photograph 47** shows the escape wheel in the process of being polished. The spokes or crossings of the wheels should be burnished with an oval burnisher. The steel arbors and pinions should be polished with Solvol Autosol and care should be taken to ensure no trace of polishing compound remains in any of the leaves of the pinions. Any residual polish can be removed using paraffin or methylated spirit.

The great wheel requires polishing in the same way, and the fusee click and click spring should have been removed from the centre of the wheel. The wheels, as received, are very well finished and only require the minimum of work to produce perfectly acceptable results. The three train wheels after polishing can be seen in **photo 48**.

● *To be continued.*

Classic Clock Kits can be contacted at 75 Foxley Lane, Purley, CR8 3HP; tel: 02086 685 559; website: www.classicclockkits.com

LETTERS TO A GRANDSON

M. J. H. Ellis
discusses Dick Whittington and his
cat before returning to the subject
of length standards.

●Number 81

Dear Adrian, Before continuing the story of standards of measurement, I would just like to add a little to the tale of Dick Whittington, with which I ended my last letter. As you will have seen, the story is about a real character, but what I did not say was that it has become part of English folklore. Every little child has heard it, and I think that like the fairy-story 'Puss in Boots' it owes much of its charm to the cat. Little children have a natural affinity with animals. The story is such a favourite, in fact, that it is a common theme for pantomimes.

Reverting now to the standard bars, the Imperial Standard found its first home in the Exchequer Office, but was later transferred to the Board of Trade and has remained there ever since. The lesson of the conflagration of 1834 was taken to heart, and four copies were kept in different places. One was immured in the House of Commons, and so far as I know is still there. The others were bestowed on the Royal Mint, the Royal Society, and Greenwich Observatory.

Subsequent legislation was more concerned with the stability of the standard than with its safety. The Weights and Measures Act of 1878 decreed that the three copies, excluding the one walled up in the Houses of Parliament, were to be compared with each other every ten years, and with the Imperial Standard at intervals of 20 years. There is reason to think, however, that the Imperial Standard in fact participated in the ten-yearly get-together.

So far as I know, the stability of the Imperial Standard had been taken for granted until 1923. Then, Mr. J. E. Sears, Superintendent of the Metrology Department of the National Physical Laboratory, disclosed that a sixth bar, cast in 1878 (i.e., some 33 years after the 1855 bars), and which would have been inscribed to be of the same length as they were at the time when it was made, had shortened with respect to them. This was consistent with the hypothesis that all the bars shrank with time, but the rate of shrinkage diminished as time went by. This is illustrated in my sketch (fig 1). This suspicion was confirmed ten years later; I take it, on the occasion of the

next routine comparisons. I believe that the shrinkage over about 30 years was about 0.0002in., which works out at 0.0000066in. per annum on average, or 0.000018%. Not very much, but I imagine that it came as rather a bomb-shell to the scientific community, that there had been any change in length at all. I wonder what caused it; and I would be inclined to suspect that it was some slow physical change in the crystal structure of the metal.

What I think it would have done is, to have heightened the desire to find some truly invariable physical constant, not relating even to the earth itself. Later on, I shall expand on this theme, but for the present, I want to turn to the techniques used to sub-divide the standard yard into feet and inches. One final thought, though. I am reminded of a Latin 'tag' from my school-days, "*Quis custodiet ipsos custodes?*" (Who guards the guardians themselves?)

Before I found out how it was done, I exercised myself by trying to think how it *might* be done, but without hitting on the following scheme which is used in practice, although there may be alternatives to it.

Like it or lump it, it is necessary to work to an ultimate 'line' standard; and a line standard does have important advantages over an 'end' standard. The scribed lines are delicate, but they are in no way damaged or worn through being observed through a microscope. Moreover, accurate copies of it are easier to make than copies of an end standard. The ends of the latter type would have to be hardened in order to lessen the effect of wear, which would occur to a minute extent whenever the standard was used. There would also be difficulty in bringing it to the precise length, because this would require grinding of some sort, and the heat generated would cause the bar to expand. As we saw earlier, a small fraction of a degree Fahrenheit can be critical. But on the other hand, when it comes to sub-dividing the standard yard, which entails the production of two 18in. long bars of equal length, and between them, equal in length to a 36in. long standard, it would only be practicable to do so if all three were end-bars.

The method shows commendable resource. First of all, it is necessary to derive an end bar equal in length to the Imperial Standard. To this end, use is made of a piece of specialised equipment called a 'line standard comparator'. It comprises two microscopes, mounted on a carriage a yard apart, and the carriage is able to move sideways across a table, on which the line standard bar and the end standard bar to be compared with it are set side by side. No attempt is made to bring the latter to a precise length; on the contrary, it is made shorter than 36in. by a matter of 1/2 inch. At this stage there is no necessity for precision. If you look at my diagram, (fig 2) you will better understand what I am talking about.

G is a gauge, nominally 35 1/2 in. long, and having its two ends lapped flat and truly square to the axis of the bar. A and B are blocks, finished with their end faces nominally 1/2 in. apart, and flat and parallel to one another. Now comes the artful bit. Fine lines C, C₁, are scribed on the top faces of A and B, nominally half-way along. It is

these lines which will be observed by the two microscopes. The distance between the cross-wires of the two micrometers can be adjusted to a limited extent, and it is possible to tell by how much the difference between them differs from the distance between the two datum lines on the gold plugs of the master standard bar. The blocks A and B are wrung onto the ends of G, and a series of observations is taken, in the course of which A and B are turned round end-for-end, so as to cover all the four possible permutations.

Let the true length of the gauge-bar G be denoted by g, and the true distance between C and C₁, and the ends of their respective blocks be p, q, r, and s as shown. Then in the position shown in the diagram (fig 2), if the distance between C and C₁, is L,

$$L_1 = g + q + r \quad (1)$$

If block A is now turned round, in the same way we have

$$L_2 = g + p + r. \quad (2)$$

Let block B now be turned round, and the process repeated; in the same way we get

$$L_3 = g + q + s. \quad (3)$$

$$\text{and } L_4 = g + p + s. \quad (4)$$

By adding equations (1) and (4) we get

$$2g + (p + q + r + s) = L_1 + L_4$$

$$\text{So that } g + \frac{(p + q + r + s)}{2} = \frac{(L_1 + L_4)}{2} \quad (5)$$

Similarly from, equations (2) and (3) we can derive

$$g + \frac{(p + q + r + s)}{2} = \frac{(L_2 + L_3)}{2} \quad (6)$$

Supposing now that blocks A and B are made of precisely the same size, $p + q = r + s$. There is no need, by the way, to know what this length actually is, so they can be brought to the same length simply by means of a comparator, another piece of specialised equipment, capable of detecting differences of the order of 0.00001 of an inch.

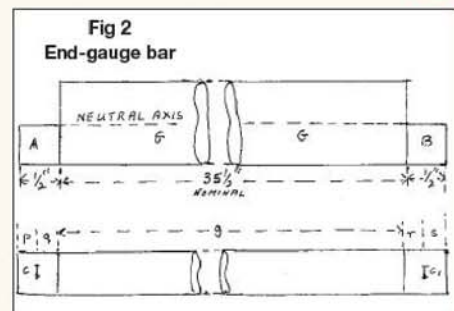
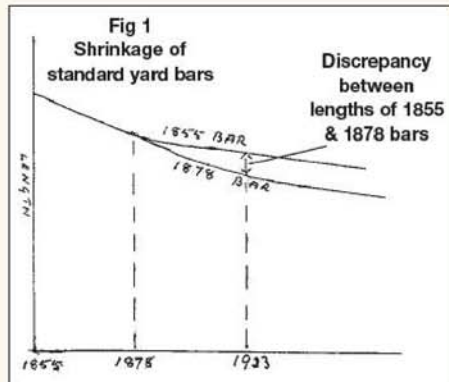
Equations (5) and (6) can now be re-written

$$g + (p + q) = \frac{(L_1 + L_4)}{2} = \frac{(L_2 + L_3)}{2}$$

It is now simply a matter of cautiously reducing the width of the blocks until the distance between C and C₁ is the same as that between the lines on the standard bar. The overall length of gauge-bar G, with one of the blocks wrung onto it will now be the same as that of the standard yard. An advantage of this method is, that if, in error, the width of blocks A and B is reduced too much, the bar G remains intact, and only the blocks have to be scrapped.

I do admire the simplicity and ingenuity of this method. I wonder how the fellow who thought of it sets about catching ducks.

Your affectionate Grandpa.





The engine cylinder block was cast from home made patterns. It is of the wet liner type.



The crankshaft was made from EN24B steel using a combination of turning and milling techniques.

AN AMERICAN STYLE 'BIG RIG' TRACTOR

Brian Proll

describes how his admiration for US style trucks or 'big rigs' led him into model engineering.

Phase 1 of this project started when I began work in engineering. I was given the opportunity, during 'quiet times', to make a start on what was quite an ambitious project for a beginner, which was to build a model US truck tractor unit - a Peterbilt 359. A large bar of aluminium alloy was bought at great expense (5in. x 2ft.). From this bar stock I started making the rims, two front and four rear doubles. The chassis rails were made as was the front axle and a V8 block with crankshaft.

Work stopped at this point and the call of beer, cars and women regrettably pushed the project into the background.

Phase 2

A few years passed and the construction bug bit me again. Out came the parts that I had made years earlier, these were checked for size and found to be wrong by a mile. The so called 1:6 scale turned out to be 5.38:1, way out!

The amount of work required to restart would have been colossal in terms of cost and time. In any case the original model of rig (359) had been superseded by the 379. The appearance of this vehicle is almost identical to the original except for minor tweaks.

The engine however, was totally revised. The V8 configuration has given way to a new, lighter, straight-6 layout albeit being more powerful from less capacity. This new layout is now used almost 98% exclusively across the globe. This 'dark horse' replacement is the 3406 Caterpillar engine. This engine was available in many guises (A, B, C and E) each having different power/torque characteristics and also OHV or OHC options. I chose the 3406E model which, in full size, offers 600hp and 2,010ft/lb of torque and is no lightweight at 1,250 kilograms.

Phase 3

Truck shows in the UK do not usually have many 379 'Petes' with 3406E engines, but one did! This turned out to be quite a bonus. By using plenty of grovelling and presenting an embroidered version of the model story, I obtained the permission of the owner to crawl all over this show truck armed with my trusty camera and a small notebook and pen!

Much information later I was at home turning out a copy of this chassis to scale with roughly 95% accuracy. Now having a rolling chassis it was here that I started on the engine. Caterpillar were very coy about giving me information of any sort and were worried about their trade secrets and the like. Much perseverance and many departments later the head of sales UK forwarded me some computer generated specification sheets to be going on with and these proved to be quite useful when enlarged on a photo-copier. However, more juicy information had to be acquired before I could start planning out my engine for the model. A few phone calls later, I was directed to a Caterpillar dealer close by and was told to approach them about my project. A lot of begging to a 'suit' in the office with my sad story had him telling me that I was to ask in the parts department for any such information I required. It was here that I was served by Jerry. He was full of enthusiasm about my engine plans. As time went by he served me all the time and each visit was a gold mine of information. Soon I was able to start construction of the cylinder block pattern.



The bearing surfaces of the crankshaft were finished ground using a tool post grinder on the lathe.



The finished crankshaft for the model's engine. The prototype engine is the Caterpillar 3406E.



One of the wheels its tyre made during phase 1 of the project.

Phase 4

Time ticked on and the wife and I moved house only to be situated across the road from my friend Jerry! Eventually a pattern for the block was made. This was constructed out of MDF and soft wood dowel. The pieces were shaped and glued together, leaving approximately $\frac{3}{16}$ in. extra on the faces to be machined. A whole 300ml can of gloss black spray paint was applied in consecutive layers to seal the pattern and give a good finish for release from the sand.

Next job was the core box and this was a tricky little thing to make, but with patience and lots of dust and decorators filler plus paint both were ready to be taken to a known foundry dealing with some low volume locomotive wheels, etc.

Two weeks past and then the casting was ready. Trent Castings was the company in Mansfield, Nottinghamshire; tel: 01623 622999. They actually manufacture fire grates for our real coal lounge fires!

Phase 5

Machining was carried out on the block, which utilises wet liners married to cast in water spaces in the block. The main bearings (7 off) were constructed with mild steel caps and were drilled, then line bored to size to ensure correct alignment.

The bearings were made from aluminium alloy bar flat section bolted together then turned and bored and parted off to form shells. This material is soft enough to withstand shock loads and durable enough to wear slowly to give good life.

The crank I feel is the most loaded item in any engine. Because of this I decided that a 'glued up' crankshaft was out of the question. I have used Loctite many times before for 'lesser' items but a 'hogged out' crankshaft is not only much stronger but also gives you a more rewarding feeling afterwards. Making a drilling jig to drill the 4 holes either end (radially aligned) was the only drawback.

Machining the EN24B material chosen for the crankshaft was a nightmare but by using a spindle speed of 80rpm maximum on the



The complex cylinder head was machined from solid, continuously cast iron.

lathe and a blade type part off tool it was eventually roughed out - despite there being some funny noises and poor finishes.

Machining was finished and the timing gear, already hardened, was Loctited in place and then pinned. Holes were required in both ends for fitting of the flywheel and pulley. This was carried out using a drilling jig and the holes were subsequently tapped.

The oil ways were drilled on a specially made jig bolted on my vertical slide giving good flexibility, a necessary requirement for the drilling positions required for these items!

Con-rods were made from bright drawn EN8 flat stock and machined to shape using jigs again to aid work holding and to give better repeatability. Bronze wrist pin bushes were used and, again, aluminium alloy shells were machined to fit (0.02in. wall thickness!) for big ends.

A suitable donor was found for piston material, an engine from a scrapped DAF tractor unit. The pistons in my engine are to be as per the prototype, and these are designed to be, what I believe is called, articulated. This required the skirt to be machined separate to the crown allowing less heat transfer to the skirt. This leads to less heat expansion allowing a better fit in the bore (less slap when cold). The donor material from the DAF pistons had to be used in its original form, not recast or it loses its properties.



The set of pistons and connecting rods prepared for the engine. The model's pistons were machined from material cut from full size pistons.



A view of the vehicle's chassis showing the rear axle and drive arrangements.

Rings were made, and wrist (gudgeon) pins were machined from silver steel, something readily available and at 9mm dia. they will not bend easily! They are also to scale. The head I have now started is made from solid (continually cast) iron. Its full of holes everywhere 24 valves, 26 head bolts, 24 block to head waterways, 6 injectors, 7 camshaft oil feed holes, 3 holes for the 3 rocker shafts drilled from a main oil gallery running the length of the head. The waterways proved to be tricky also requiring a 3mm drill at 10in. long. To drill these required much patience and accurate setting up as only 1.05mm per side was to be left after drilling the length of the head.

An oil pump has also been made. This is a gear type pump running under the crank and driven from the timing gear on the crank. It has a self contained pressure release valve that allows oil to re-circulate. This is operated by a spool that is forced open by output pressure. I have set mine to cut out at 20psi (roughly scale at 84psi).

Valves are next, to be made from Allen cap head bolts, roughly 8mm head dia. and 2mm shaft. From here the rockers can be made (utilising roller followers). The camshaft is also a real headache with an additional lobe per cylinder to drive the injectors. I will produce this using my rotary table on the milling machine giving flat flanks but slightly radiused near the point of maximum lift because, by using a roller follower, it takes the sting out of the initial rapid

acceleration giving satisfactory results. The full size engine also has roller followers.

I now conclude these notes for the time being and say that my wife and I are now (at the time of writing) proud parents of a one week old baby boy so my progress rate will be somewhat slower from now on.

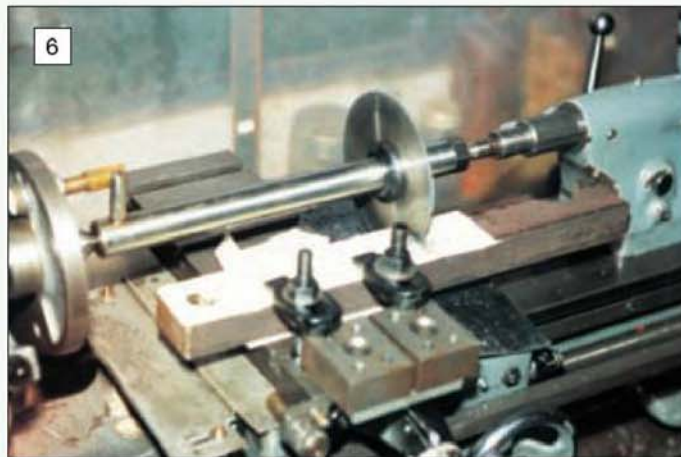
Oh yes, if asked, the tyres were made from scratch using a mould made from sewer pipe (new!) 10in. dia. aluminium alloy for the sides and centre hole in a cast iron pipe. The filling was polyurethane giving quite pleasing looks and rubber like grip after bedding in.

I would hope that my pictures do better justice to the project than my elementary text.





Marking out the ram mounting bracket on the surface plate using a surface gauge. Note the cork to protect the scriber points and prevent injury.



Cutting the material for the ram mounting bar to size using a slitting saw mounted on a between centres arbor in the lathe.

POWER SLOTTING ATTACHMENT

D. L. Walters

continues his description with the assembly of the ram head bracket.

●Part II continued from page 384
(M.E. 4257, 30 September 2005)

Fix the driven T-slot to the front of the head plate by three cap head screws 2BA x $\frac{1}{2}$ in. long, and loosely tighten. Make absolutely certain both are square and finally tighten and check squareness again. Fit the sole plate by three hexagon head 2BA x $\frac{5}{8}$ in. long screws, the first of which must be shortened to $\frac{7}{16}$ in. long. Then fit the 2BA x $\frac{1}{2}$ in. countersunk head screw ensuring the head is $\frac{1}{32}$ in. under flush. The head of the sole plate must be flush with the T-slot and head plate as shown on the side view of the G.A. drawing. File if necessary.

Ensure all the screws are dead tight. Set up the bracket assembly under the drilling machine and drill through the No.14 hole in the bottom of the T-slot into the front edge of the sole plate. Change to a $\frac{3}{16}$ in. dia. reamer and ream the hole to full depth. Blow out and fit a dowel, which must be a light drive fit, to finish $\frac{1}{16}$ in. proud of the surface.

No photo is shown of this assembly as it was thought best to describe the procedure with reference to the G.A. drawing. It may sound complicated but in reality it only needs careful work to ensure that it is dead square and rigid.

The ram can now be screwed to this bracket by two 2BA x $\frac{3}{4}$ in. long cap head screws,

Ram mounting block. This can be made from black or bright mild steel. Perhaps even cast iron could be used should a large lump be in the scrap box. However, mine came into being from bright mild bar size $2\frac{1}{2}$ in. (63.5mm) square. Cut off a slice $1\frac{5}{8}$ in. (42mm) long. Mount it up in the large 4-jaw and machine one side down to $2\frac{1}{4}$ in. (57mm). Next take out and set up to face down to $1\frac{1}{2}$ in. (38mm) thick. This face is to be square to the base by 0.001in. (0.025mm). Mark out for the $\frac{3}{4}$ in. dia. hole. Mount in the 4-jaw chuck and pick up the marked centre and centre drill. Drill through and open up to $\frac{3}{4}$ in. diameter. The location recess is then bored. Remove from the chuck and mark out the two tapped holes in the sides for the locking screws and pegs. **Photograph 5** shows the block. Put aside now and wait for the mounting bar.

Ram mounting bar. I made my bar from a bit of black bar in the scrap box size 40mm x 25mm cut

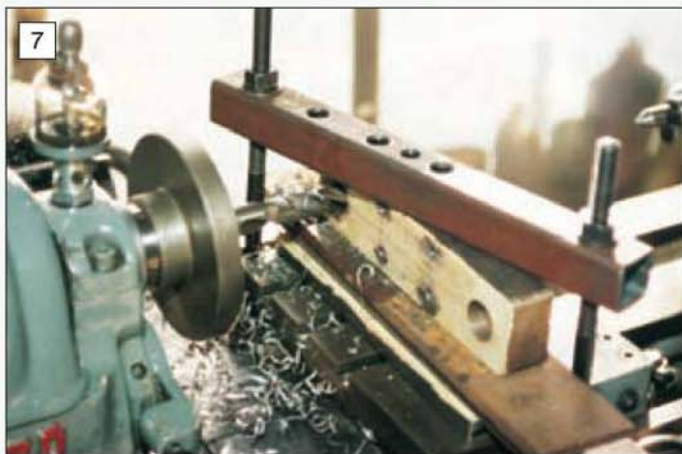
165mm long. **Photograph 6** shows how I cut mine to length in my lathe. A 6in. dia. x $\frac{3}{32}$ in. wide slitting saw was mounted on the Myford, between centres milling arbor with the bar on a bit of paper firmly clamped to the cross slide. It was run in second back gear speed and 'brush suds' lubricated.

Next, mark out all the holes and centre them. The bar can now be put up in the drilling machine or packed up to the required height and drilled in the lathe as shown in **photo 7**.

I usually fit a chuck back plate or similar to act as a flywheel when using large drills in my lathe. The two large end holes must be deburred 2mm x 45deg. on both sides. The four small holes are to be drilled tapping size. Clean off the bar and ram mount block with petrol or similar.

Line up the centre of both components by the lines with the faces dead flush as shown on the G.A. drawing and fix with Araldite Rapid leaving overnight to ensure a good bond. Next set up square under the drill as **photo 8** and drill through using the four centre holes as a jig. Drill tapping size x 1in. (25mm) deep.

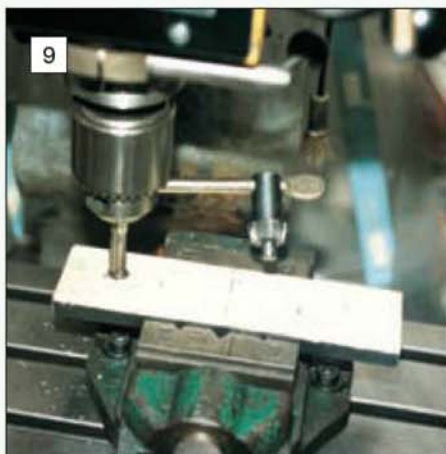
A sharp blow with a lead mallet will part the two. The four holes in the block can now be tapped to $\frac{3}{4}$ in. (19mm) deep then counter bore dia. $\frac{3}{8}$ x $\frac{5}{16}$ in. deep for $\frac{1}{4}$ in. UNF cap head screws.



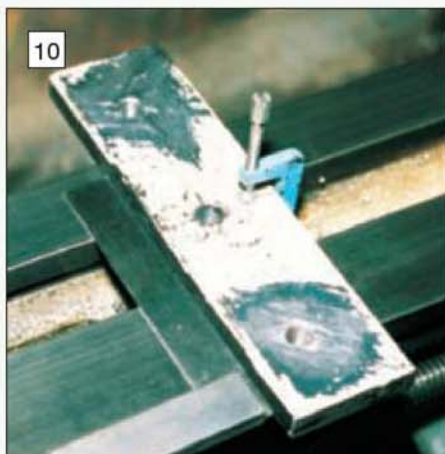
Drilling the ram mounting bar holes in the lathe. Note the use of a back plate on the lathe mandrel nose to act as a flywheel.



Spotting the ram mounting bar holes into the ram mounting block using the mounting bar itself as a drill jig.



Tapping the holes in the base plate using the mill/drill to start the tap square.



Checking the alignment of the base location plate on the base plate before joining together.



The pillars were turned between centre to give good concentricity and parallelism.

the key to bar the chuck around. Back off frequently (see **photo 9**). Similarly, the two alternate screw holes in the centre, drill 4mm dia. and the dowel holes No.14. The clamp screw hole is drilled through $\frac{3}{8}$ in. diameter. Put aside for the time being.

Mount base location plate. This is best made from Dural as it will be less likely to damage the shears when fitting the attachment to the lathe, just in case it may be inadvertently bumped down.

Cut it from Dural plate or strip $1\frac{3}{8}$ in. wide x $2\frac{1}{8}$ in. long x $\frac{3}{8}$ in. thick. Roughen one side and apply two spots of Super Glue. Align the centre line with that of the mounting base plate so the front edge is flush and clamp up so the mount plate is square to the bed ways as in **photo 10**. Allow at least an hour then drill 4mm dia. through the alternate screw holes and No.14 through the dowel hole. A sharp tap with a nylon mallet will separate them. Open the screw holes up to $\frac{13}{64}$ in. dia. in the mount base. Tap these holes 2BA in the location plate. Screw the two together by 2BA x $\frac{3}{4}$ in. long cap head screws. Ream the No.14 hole through $\frac{3}{16}$ in. dia. and light drive fit the dowel. Drill the $\frac{7}{16}$ in. dia. centre hole.

Clamp plate. Make this plate to drawing from Dural (for the same reason as the location plate).



Cutting the threads on the pillars using the tailstock die holder and lathe mandrel handle.

The screw is steel hex. head by $2\frac{1}{4}$ in. long and threaded for its entire length.

Collar. This is made from ENIA steel (20mm dia.) in the usual way.

Pillars. I turned the pillars between centres in order to get the end threads concentric with the body. This can be seen in **photo 11** although the driver and centre are partly shielded by the Perspex guard. Both ends were then screwed $\frac{3}{8}$ in. BSF using the tailstock die holder and mandrel handle as in **photo 12**. Screw the short thread into

the outer holes in the mount base plate and ensure it is about $\frac{1}{32}$ in. under flush. Remove, treat the thread with Loctite 270 or 601 and screw firmly to fit flush on the top surface and be at 90deg. to the plate.

Pillar adjusting washers. These large washers are to vary the height of the ram setting. The ones in the photos of the prototype were used as spacers and being surplus to the job were acquired as I thought they might be useful one day. They are turned from 40mm or 50mm dia. ENIA steel bar. The overall thickness is important to prevent height variation between the pillars. Both faces must be parallel and at 90deg. to the bore which could be drilled $\frac{49}{64}$ in. diameter. If any large hexagon bar is available this could be used but do not use material less than 30mm across flats or the assembly may lose rigidity. A mix is suitable as in the prototype.

I suggest that they you sort out the stacks into two piles to within 0.002in height. Those in one stack can all be marked with a centre punch on the periphery.

Pillar top washer. Made from 25mm dia. ENIA bright mild steel bar.

Pillar nut. Standard commercial quality hexagon steel nut.

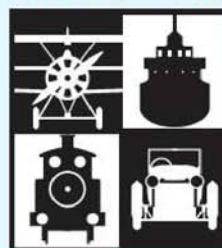
● *To be continued.*

IN THE NEXT ISSUE



- Alan Clark's Aircraft
- Gauge 1 Locomotive
- Red Wing Farm Engine
- Ornamental turning
- Regulator Clock

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D.A.G. Brown and Mark Smithers now come to the final parts of the locomotive starting with the mechanical lubricator; with connections between engine and tender being held over until the tender is described.

●Part XXI continued from page 388
(M.E. 4257, 30 September 2005)

You will recall that in the construction of the steam pipe work within the Smokebox, the two flanges at the base of the Main Steam Pipe each contained a short length of $\frac{3}{32}$ in. dia. pipe, which at the time was flagged "fit oil injection pipes thus". This is their big moment. These pipes are connected to the delivery side of a twin ram variable output lubricator. All those who have driven my Hunslet agree that this design provides just the right amount of oil where it is needed, without causing faces blackened by oil smuts, a desirable property these days when many people have forgotten that odd habit of steam locomotives. An oil pipe terminating in the middle of the main steam pipe causes the oil to sparge into the fast-moving stream of steam, that is to say it breaks up into a fine mist, rather than crawling along the surface of the metal.

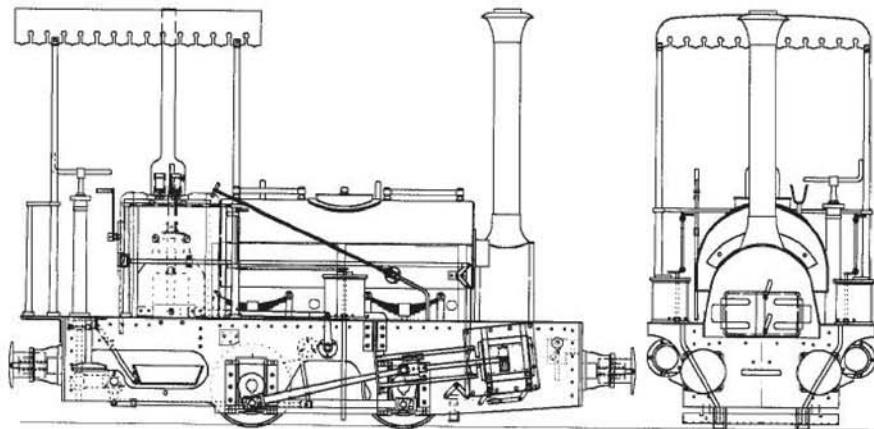
Starting with the tank, when fabricating it from brass sheet, make sure that the top and bottom panels are cut, say, $\frac{1}{8}$ in. too big. They can be trimmed to size after silver-soldering and the solder can be applied on the outside of the box, with all the other bits and pieces in place for treatment at the one heating.

The fixing member of the Tank is constructed from a 4in. length of brass angle, machined to fit within the tank body and on its bottom edge to bring it to $\frac{7}{8}$ in. high, with holes drilled by co-ordinates and fitted with blind bushes. Going back to the original buffer beam drawing, you provided a short length of 1 x 1in. angle with two matching holes for these bushes, so that the whole caboodle can be detached easily.

The top of the Tank has a large hole in it for access and for a hinged Lid. The hinge is made from copper tube, silver soldered to both the Tank Top and the Lid. Each of the five segments of hinge is $\frac{3}{8}$ in. long, two being soldered to the Tank Top, so cut one tube $1\frac{1}{8}$ in. long and silver solder it into place perched on the Tank Top. Remove the middle $\frac{3}{8}$ in. of material, cutting the supporting metal of the Tank Top itself away, both in this gap and at the two ends, where the mating bits of hinge will eventually fit. Carry out the same procedure with the Lid, but starting with a $1\frac{7}{8}$ in. long tube and making two gaps after silver soldering. You now have a good dirt tight assembly. It remains to thread a silver steel rod for a hinge pin through the five pieces of copper.

Although I have not specified the gauge of the brass, I have used 20 gauge and found it to be rigid enough after softening by silver soldering. You will appreciate that an oil tight assembly must be fabricated, but this should not be difficult if the joints all start close.

As I have drawn things, the $\frac{7}{16}$ in. hole to support the mechanism is on the right side of the



ANNA A MANNING WARDLE LOCOMOTIVE FOR $7\frac{1}{4}$ in. GAUGE

box only. Not drawn are two $\frac{1}{4}$ in. dia. holes for union connections for the two oil delivery pipes. These are best positioned in the rear wall of the tank after the mechanism has been fitted.

Mechanism from the bottom up

First take a look at the General Arrangement at the top left corner. All the various bits are flagged to aid identification, so we shall start with the Cylinder Block, a neat piece of solid brass. From the four views of this, the finished size is 1.000x1.030x1.464in., so you can determine the stock size from which it can best be taken. The block is furnished with two cylinders and glands and two pairs of valve chambers associated with them, not forgetting the associated short lengths of passages.

Start by producing the finished overall sizes then hold in the machine vice and mill a $\frac{3}{8}$ in. slot 0.344in. above the bottom face to a depth of 0.375 inch. The sole purpose of this slot is to provide accommodation for a couple of 2BA nuts which hold the mechanism together. Now here is a fine design point. If you look at the position of the $\frac{3}{16}$ in. dia. holes, which break into this slot, there is more than enough room to house washers under the nuts. It enables an open ended spanner to operate easily; this is just one of the detail points which I hold dear to my heart for ease of assembly.

Next hold the block in the upright position, mill away $\frac{1}{8}$ in. to leave the step in the top surface and establish datum points for the hole positions. The task is to place two sets of three holes at precisely 0.500in. apart. Those into the slot, which we have just discussed, need no amplification but the others should finish $\frac{5}{64}$ in. from the bottom surface to allow the eventual drilling of the passageways without wandering. The 'cylinders' should be drilled 4mm to this full depth and reamed $\frac{3}{16}$ in. dia. with a D-bit fitted with a depth stop. Follow this up with a $\frac{5}{16}$ in. dia. slot-drill, again with its depth restrained to form the O-ring seating. Finally enlarge to $\frac{11}{32}$ in. dia. with either an appropriate slot-drill, or a boring head, before putting in the $\frac{3}{8}$ in. x 40 thread with a plug tap, again restraining its depth with a suitable stop.

In order to carry out these tricky operations to

depth, say with a slot-drill, I set the vertical micrometer dial to 0 and bring down the quill on the milling machine so that the cutter just touches the work. I then lock the quill stop at this position and check that there is no appreciable tool contact when the spindle rotates. The cut depth is then applied by means of the vertical micrometer, and the actual cutting process is controlled by moving the quill up to its stop. It is quite easy by such means to achieve accuracy of ± 0.001 in. on depth, thus suitable for the likes of O-rings.

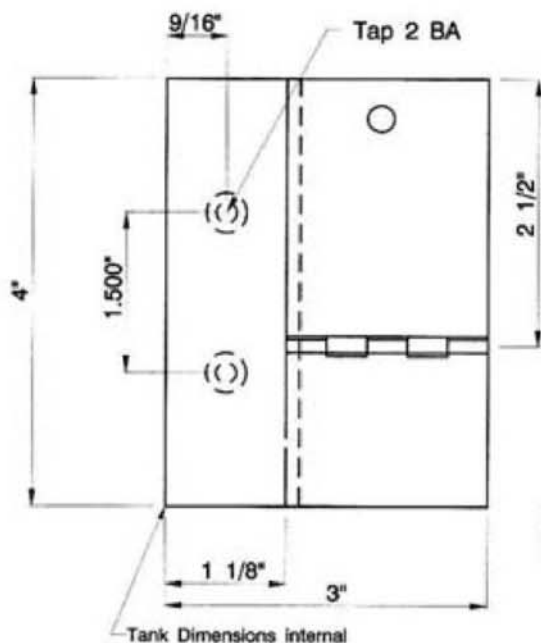
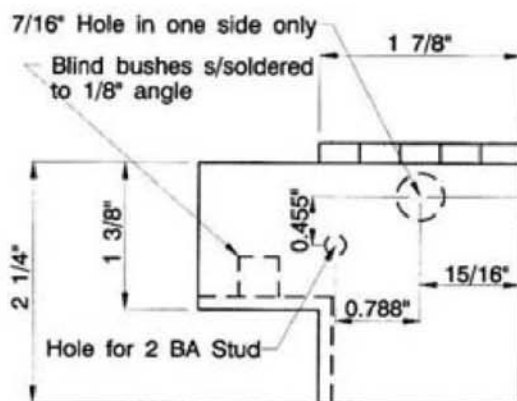
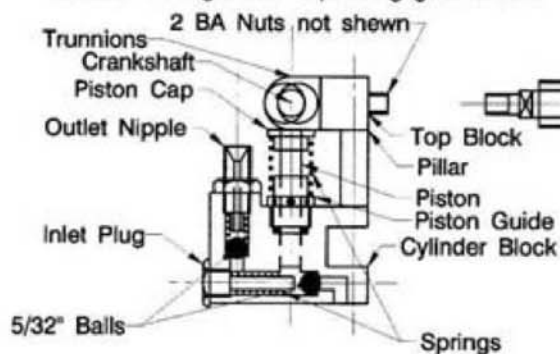
Should your $\frac{3}{8}$ in. x 40 plug tap not be up to it you should be prepared to re-mount the job in the 4-jaw chuck and screw cut as discussed before. The other holes are similarly treated, save for their bottoms, which should be formed by a $\frac{7}{32}$ in. D-bit as a ball seating. This size allows for tapping $\frac{1}{4}$ in. x 40 for the outlet nozzle, which in itself is a straightforward job requiring no further comment. Having finished the six holes in the top surfaces of the Block, turn it through 90deg., pick up the co-ordinates again and drill and tap the two horizontal holes, first with a No.32 drill to a depth of $\frac{15}{16}$ in., followed by opening up with $\frac{13}{64}$ in. dia. for D-bitting to finished depth for the ball seats, finally reaming $\frac{1}{8}$ in. dia., and tapping $\frac{1}{4}$ in. x 40 for six threads.

The Block should now be mounted upside down for the drilling of the two oil inlet holes. I hope the wisdom of rotating the Block 90deg. at a time while holding it by the two side faces makes itself clear. By so doing you need set up the (Y) datum once only, and all the holes will be an identical distance from the datum face. The logical complementary step is to align the piece with say the left edge of the vice each time so that, again, only one X datum setting is needed.

The various other pieces need little amplification; just stick to the dimensions drawn and all will fall into place. The short spigot on the bottom of the Outlet Nipple fits a light spring which keeps the delivery ball in place when not pumping.

I have specified a very light spring for the Inlet Plug, to keep the ball in place after the induction stroke. Just a word about what this means should clear the air. The purpose of this spring is to keep the ball on its seat most of the time, but to lift

General Arrangement - operating gear omitted



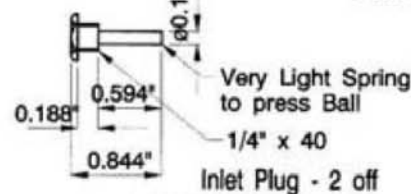
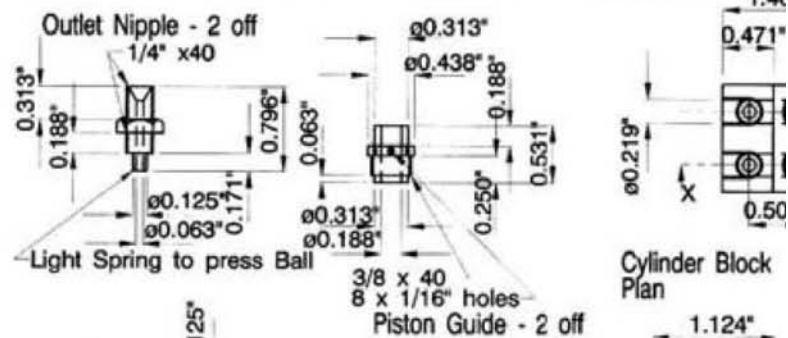
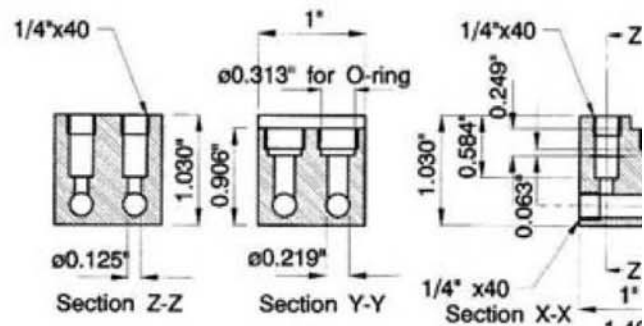
Tank - Brass

Mechanical Lubricator

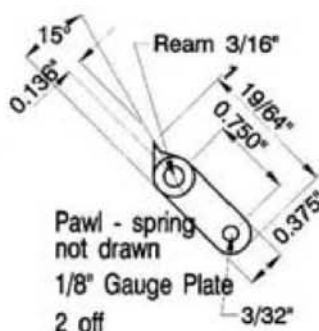
All Components Brass unless otherwise stated

Drawings, castings and laser cut components for this locomotive are available from the designers.

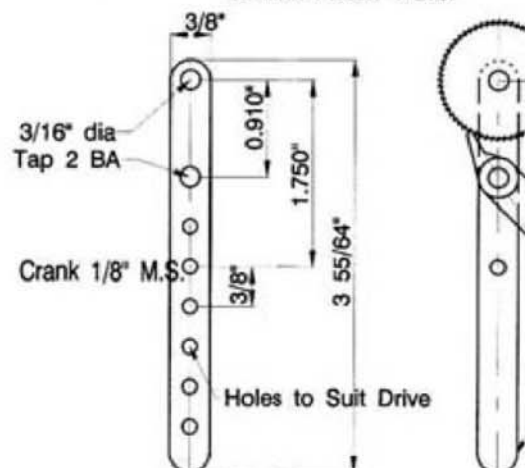
Contact D. A. G. Brown, tel: 01780-753162,
e-mail: dag.brown@btopenworld.com
or Mark Smithers tel: 01609-773734
e-mail: marks_northall.yorks@tiscali.co.uk



Crankshaft Silver Steel



Pawl - spring not drawn
1/8" Gauge Plate
2 off



whenever oil is required to pass the valve on its way to the piston. Atmospheric pressure achieves this, so it follows that the valve must lift under a pressure difference of less than one atmosphere (14.7psi at sea level). Now the valve seat has a diameter of 0.125in., which means an area of:

$$\pi \times 0.125^2 / 4 = 0.01227\text{in}^2$$

Such an area requires a pull of:

$$0.01227 \times 14.7 \times 16 = 2.886\text{oz. to pull a vacuum and stop the flow of oil.}$$

In practice it makes sense to limit the strength of the spring to no more than 1 1/2oz., or 40g and it is easy to check the strength of any unsuspecting spring on a set of kitchen scales. On a practical note we are best looking for a spring wound from steel wire of no more than 0.010in. diameter, or a flimsy bronze spring cannibalised from an old carbon brush set.

The top of the Piston is fitted with a Cap whose purpose is to maintain upwards pressure from a compression spring and to ensure that the piston always returns after every power stroke. The bottom of that spring reacts against the top of the Piston Guide and this component also maintains a seal from the O-ring fitted beneath it. The Top Block is fitted with two 8BA cap screws and these can be adjusted to limit the stroke of the Pistons, and hence the volume of the pump delivery.

Crankshaft

This component, from 1/2in. dia. silver steel, has two cranks of dia. 3/8in. and throw 1/16 in. Since it is essential that the two throws are 180deg. apart, here is a suggested way of achieving it. Start with a 2 3/4in. length of material and hold in a V-block so that you can gain access to both ends. Mount the V-block in a machine vice with the silver steel vertical; pick up the centre of the bar as a datum, move 0.063in. and sink a No.1 centre-drill. Move the slide by 0.063in. the other side of the centre-line and sink the centre-drill to make the other hole. Taking advantage of the symmetry offered by the V-block, turn it through 180deg. in the vice and repeat the operation on the other end of the work. Now hold the embryo shaft in a collet and turn the three concentric sections, starting with the longest one, but avoiding the end 1/4in. of shaft. The presence of these two extra end bits gives scope for the collet to hold material of adequate length to avoid wander; a wide parting tool is probably the best thing to achieve the desired results.

Now mount the piece between centres and form the two throws, reducing the diameter locally to 0.375 inch. You can now remove the extra end bits and form the 2BA thread and 3/16in. square on the business end. To hold the shaft for these operations, drill a 5/8in. length of 5/8in. dia bar and ream 3/16in. dia., slit three-quarters of the way through it on centre-line and use it as a slave collet just for this purpose.

Ratchet drive

My choice of a traditional ratchet drive reminds me of my days developing ICI's film extrusion processes. Molten polymer was extruded under



A fine example of Anna under construction. This one is by Bob Thomson of Bristol SMEE, photographed at the Bristol Exhibition this year.

high pressure through a die, before being drawn continuously into film. It had, on the way, to be filtered through sintered bronze elements and filter life greatly affected the number of days before an expensive shut-down. So I designed a significant improvement in the filtration area, but had to get the idea through Owen, the fiery Welsh section manager, whose word in these matters was law. He had his own idea, which was actually daft, but three days of arguing with him would not dent his resolve. So in the end he came up with a Celtic compromise, in his own inimitable words: "Okay boy-o, do it both ways, but do it my ***** way first!" So that is just what we did. His filter fell to pieces as it came up to pressure and mine lived up to its promise, significantly extending filter life. You can imagine the stories that went around the plant after that episode. One of the process operators was a cartoonist and he had a whale of a time at our expense. Yes, there are many ways of skinning a cat.

Back to the drive, the only piece worthy of comment is the wheel, whose teeth are cut with a 60deg. dovetail cutter approaching the job on centre line, whilst it is held in a dividing head. I have not found it desirable to harden the ratchet teeth, although that should be done for the pawl tip. The crank is furnished with several holes and I have left you to figure out how best to link it up to the valve gear, but my preference is for a simple rod fixed flexibly to one valve spindle. The only disadvantage here is that as the gear links up, so the rod travel reduces, thus it is necessary to choose the hole which just gives one click when in the fully notched-up position. It is acceptable for no oil to be pumped when in mid gear. When setting the ratchet to operate, make sure that it swings equally on both sides of the mid point, so that the click is 'in beat', rather like you do for a clock pendulum.

Lead the deliveries from the Outlet Nipples by means of 3/32in. pipes to the steam pipe flanges, providing suitable joints to allow for subsequent stripping for maintenance. You will notice that the two 8BA screws in the Top Block project down to touch the upper surfaces of the Piston Caps; this enables you to limit the upwards travel of the pistons every stroke, thereby controlling the rate of oil delivery. I find that, by imposing perhaps a 30% restriction on the stroke, a tankful of oil is good for at least 40 or 50 miles running. In practice I never let it get less than 50% below full capacity.

Having completed the lubricator, it is necessary to bleed the lines until it feeds reliably

on each stroke. Start with a thin oil (say spindle oil), which will find its way through the tortuous passages. When that is working, tip out the thin oil and fill the tank with steam oil, checking that it will still feed on both barrels. This is not a job to be carried out on the drawing-room carpet; you are sure to land up with some sort of a leakage before being satisfied with the result. Since the locomotive is not superheated it is quite correct to run it on the thinner grade of steam oil and this is certainly easier to feed through the system.

Steam brake equipment

The locomotive is fitted with a steam brake, which is very useful for working on its own, although the tender is going to be fitted with a vacuum brake, piped through to the train. I know that a combination valve is possible, to control both braking circuits from the single lever, but that is not the way I have gone at present. Maybe I shall be persuaded one day to design one! So here are details for a progressive steam brake valve, which enables the driver to control the steam pressure in the system from zero to boiler pressure.

The Valve Block is a brass masterpiece, all the holes being drilled and reamed to coordinates, as per drawing. Above the Block the Cover supports the Operating Lever and Cam. A pin sticking out of the side of the Cam operates the relief valve when the Lever is just past the vertical position and limits the clockwise movement when it comes up against a stop pin in the position shown.

The Right Spindle pushes down on a spring which keeps the ball on its seat. It follows that the spring is compressed when the Handle is in the vertical, or running position and the cam is pointing downwards. Turning the handle clockwise lets the spring extend and the valve admits steam. The Inlet Valve, with its Locknut enables adjustment to be made to the pressure, which is required for the steam to lift the ball. I have chosen a stock size of spring that has the correct rating, so don't try and guess it! The relief spring is similar, only cropped to length. I leave the fixing to the constructor, but I favour somewhere near the Reversing Lever.

In plumbing up the device, steam is taken from one of the supplies on the top of the dome, the other being destined to feed the Vacuum Brake, which will be dealt with under the Tender Design in the next couple of parts of this series. Set the compression on the valve so that 90psig just keeps the valve on its seat; when pulled about 3/4 of the way down the available stroke, the braking effort will be as great as the steam pressure will allow. Lead the left hand delivery line, in 1/4in. pipe, directly to the brake cylinder with a T off for a pressure gauge; finally the exhaust line should squirt down towards the track.

If you feel so inclined, engrave the curved cover plate with 'Off, Run and On' at positions on the drawing of 11, 12 and 4 o'clock. A nick in the cam surface at bottom dead centre will guide you to the Running position with a reassuring feel.

●To be continued.



A small grit blasting unit made to the design of a friend of the author and utilising a plastic storage container.



A view inside the grit blasting unit showing the rubber gloves used to hold the work, the grit and nozzle.

CHANGING HINDSIGHT INTO FORESIGHT

Mick Appleyard

now deals with the preservation of model components.

●Part III continued from page 398
(M.E. 4257, 30 September 2005)

One of my biggest frustrations has been the making of components in the early years of the project without thought to the long-term storage or when will they be required, only to find many years down the line that they are of no use because of deterioration. These components then required remaking.

As I have already stated, the building of the model can take many years. It is therefore important that components manufactured in the early stages are properly preserved and stored in order that they will be suitable for use when required. The problem that the builder faces is getting a balance between painting items early and risking getting some scuff/ chips on the paint or allowing nature to rust them. I am a great believer in painting as you go and giving the paint a final touch up at a later stage.

I was fortunate to purchase a book called *Finishing Touch* by Robert G. Shepherd published by Robert G. Shepherd and purchased through Precision Paints. This book is a must when you come to paint your model. It deals with all aspects of the painting from beginning to end, it is well written and easy to follow. It is also the best book that I have read on the subject and will give you all the information you require to paint the model to a professional standard.

Preparation

In addition to the information detailed in the above book I offer the following additional information. All the components made will require protection of some type. In order to achieve a good level of protection it is essential to have good preparation. Remember here that if you have any defects in the surface finish the paint will not fill them up, in fact they look ten times worse than they are. It is therefore essential to fill these and rub them down and remove all dust before thinking of painting. The basic

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The articles can be obtained in book form from the author together with a CD-Rom containing the photographs.

preparation is not difficult to achieve providing you follow a few basic rules.

1. Remove all mill scale.
2. Paint and varnish does not like adhering to sharp corners. Get into the habit of removing these as a matter of course during manufacture.
3. Clean the surface using files, a wire brush, emery cloth or grit blasting as necessary.
4. Carry out an initial preparation of the surfaces of the batch of items for painting.
5. On the day planned for painting reclean the surfaces of the batch of items and degrease with cellulose thinners and do not touch the surface to be painted. Allow items to dry for about 30 minutes.
6. Apply the coating as soon as possible after your preparation.

Cellulose thinners is an aggressive cleaner. If you do not use gloves it will dry up your skin very quickly. I use surgical rubber gloves when cleaning as they fit tightly and are less bulky than others. They can be purchased at your local chemist. You should also wear a suitable face mask since the fumes are very strong but make sure that it contains the correct filter.

Cleaning should be carried out in a well-ventilated area, preferably outside in the open air. The method that I use for degreasing smaller items consists of using two suitable glass jars. The components are put inside the first jar and the thinners are poured in, and the lid replaced. The items are swilled around for a few minutes before the lid is removed and the thinners decanted off into the second jar and its lid replaced. The items are then poured onto a clean piece of industrial paper towel where they are spread out to dry.

Grit blasting

The best form of preparation for painting is grit blasting. If you do not have access to this facility try talking to your local garage. You will be surprised what interest you will get when you mention scale models. If you are fortunate to be allowed to use this equipment remember electricity does not come free and offer to pay for it. Having my own compressor, I have made a small blasting cabinet out of a plastic storage box; the design came from a very good friend of mine. Details can be supplied through my friend at a small cost.

The grit blasting process gives the surface a very good key for the paint to adhere to. Note: when blasting steel flash rusting will form within one hour. It will therefore be necessary to prime the steel with a stabilising primer.

Which paint

Non-Ferrous materials:

These will require a coat of self-etching primer before the top coat can be applied. A note here is self-etch primer cannot be applied over other paints as it will cause them to lift.

Steel:

Some enamel paints can be applied directly onto clean steel without the use of a primer. Check with your paint supplier. If you choose to grit blast the items then a coat of rust stabilising primer will need to be applied due to the flash rusting that will take place.

Varnish

For those items to be finished as natural steel, brass, copper, etc. complete the component, and polish/ draw file as necessary. Degrease as detailed above. I spray mine with a varnish product called Frigilene. This is used for finishing clock and silver materials and dries to a clear finish.

When dry, wrap in old cotton material and seal in a container. Frigilene is manufactured by a company called MacDermid of Birmingham (tel: 0121 236 8621). This company will only supply in quantities over 5 litres. If you give them a ring they be able to give you the name of a local supplier. In my case this was H. S. Walsh & Sons Ltd, Beckenham Road, Beckenham, Kent BR3



An example of the lining applied to one of the author's model traction engine wheels. Note how the templates described in the text are used.



Further examples of lining templates. It is recommended that these templates are cut from Plasticard.

4TS (tel: 0208 778 7061). They were able to supply Frigilene and the special Frigilene reducer in 125ml cans.

Grease and wrap

Apply light grease to the component, wrap in old cotton material and seal in a container. When the component requires painting or varnishing thorough degreasing will be required before this can be carried out. Do not place unwrapped items into the container as the trapped moisture in the air will cause rusting. No not forget to periodically check the condition of the items.

Painting

Plan to paint components in batches. Complete the components, remove sharp edges and degrease with cellulose thinners.

I aim to grit blast components in the morning (as applicable) and prime in the afternoon with the topcoat applied after 24-48 hours depending on the primer used. These are then left to dry for a couple of days. After any preparation always prime as soon as possible and certainly within 24 hours after preparation. My advice is to always try to complete the whole process. Do not just prime and leave the top coat to a later date as this will mean that the item will have to be at least degreased, before repainting, an unnecessary step.

You do not need to purchase an expensive airbrush for this operation; I have obtained very good results with a basic Badger airbrush at a cost of £12. If you do plan to purchase a better one make sure that it will paint wide bands, say adjustable up to 1in. wide will do. This will ensure you get a good coverage. If you are not experienced in painting make sure you read the book detailed earlier.

When I was preparing to paint my model I was unable to find the correct paint and went to a local supplier and had some paint mixed. I was fortunate to notice an advertisement for Precision Paints before I collected the mixed paint. After giving them a call I put the mixed paint in the garage. Remember that the model will take many years to build and will cost many thousands of pounds to produce so do not fall into the trap, which I nearly did in skimping on the paint. Authentic paint might be a little expensive but it goes a long way and when finished looks excellent together with the fact that it is an authentic colour.

Lining

Nothing sets off the appearance of your model more than good quality paint lining. This you

may be surprised to know is not that difficult to do. The key to its success is the manufacture of good guide templates, together with having a good quality lining pen. I make my templates from 0.020in. Plasticard. They are cut with a Stanley knife and filed to shape. On the back of the template I glue a piece of Plasticard about 1/16in from the edge all round. This is to lift the template off the surface such that when paint is applied through your lining pen it will not smudge. Do not forget to make a couple of straight templates of different lengths. Note that when you paint your first components prepare several pieces of steel/ brass plate and paint these in the batch. Now when you are ready to line the model you will have something to practice on. I purchased a Bob Moore's Master lining pen - New Park Works, The Old Forge, Stapleford, Melton Mowbray, Leicestershire. LE14 2SF; tel: (01572) 787261. This comes with full practical instructions and tips on how to line your model and without this advice I could not have achieved such an excellent standard. I mainly use the 0.020in. pen, and a 0.035in. pen that I manufactured myself. This is very easy to use and you will find that after about 30 minutes practice you will be keen to have a go. Go steady do not rush and follow Bob Moore's instructions. If you do make an error, then wipe it off with a rag with thinners. Leave this to dry before relining.

As I have mentioned the making of the templates is the key to success therefore spend a little time to get them right before you start. Remember that where you are lining a double line around a radius then you will need a separate template for each radius. When lining always line the outer radius first, you can then line the inner one without waiting for the other to dry. You can also use your templates for cutting out masking tape shapes e.g. where we have a black band around the edge of a component then place low tack masking tape around the edge, place the template on top and, using a small modelling knife, cut around the template. You can now remove the tape from the section to be painted. When the background paint has dried and the masking tape removed the same template can now be used for drawing your first line.

As a note of encouragement, I had never used a lining pen before but have lined both my complete traction engines without any mistakes and to a very high standard. As I have mentioned above one of my lines was 0.035in. wide and a pen is not available in this size, however the author can supply one at a cost.

Workshop preparation

Here are a few more notes on preparing to paint your components to accompany the Finishing Touches book. They have been detailed as a reminder; since you will be surprised how many one forgets when spraying is infrequent.

1. Clean up the workshop area where the components will be left to dry.
2. I have assembled a drying rail (a piece of 1/2in. square bar supported on two angle brackets (about 3ft. long). Here I can hang small components on wire hooks. In addition I have a pair of car axle stands which I span with a piece of bar for the same purpose.
3. Make about 50 wire hooks (S-shape) before painting commences. Old wire coat hangers are good for this.
4. I have made several wooden blocks and pieces of sheet material for painting small items on. These have a series of holes drilled in them in which to stand small bolts/ rods, etc. Another item is a flat board for laying nuts and flat objects on. The items are placed into position on them and then all painted together. Also have a piece of flat board to use for test spraying, you will find that you can use this to set the spray width and paint quantity before component spraying commences.
5. Consider what items are being painted and how you will hold them during painting and drying. You may have to make special supports for these.
6. Collect a few small food jars for decanting and mixing small quantities of paint and a plastic milk bottle for collecting used white spirit for disposal. On those jars which will be used for mixing paint, place a piece of masking tape up one side then fill the jar attached to your air brush with water and decant into the jar. You can now mark the level of one airbrush jar on the side. Repeat with a couple more jars full. You could sub divide these say into four to gauge the amount of thinners to be added. This will now make it easier to judge how much paint and thinners to mix up. Unless you are using small cans of paint and intend to use it all then do not add thinners to the tin. Always decant the required quantity and add thinners to this. This will keep the original paint in good order and never add any left over thinned paint to the original tin.
7. Check that your airbrush connections fit the compressor and that the hose will reach the spraying area.
8. Make sure that you have a suitable holder to hold your airbrush. This will prevent the air hose

from causing the brush to tip and fall on the floor.

9. The day before painting I vacuum clean all surfaces and the floor. I have an old vacuum cleaner for this - do not use the household one. Any dust disturbed will settle before painting starts.

10. Cover any other dusty areas with polythene dust sheets. You can purchase these from your local DIY store very cheaply.

11. Prepare an area to mix your paint.

12. I use surgical rubber gloves when spraying as they fit tightly and are less bulky than others. Suitable gloves can be purchased at your local chemist. You should also wear an appropriate face mask.

13. I install a portable fan in the workshop to blow out paint fumes from the drying process. I cannot stress too strongly the need for good ventilation. I tend to leave the fan running for three to four hours after painting and do not work in the workshop until the next day.

14. I always carry out my painting on a plastic covered Workmate bench outside the workshop

to prevent a paint fume build up. The only disadvantage is that you need a dry day without too much wind.

15. When spraying in batches it is inevitable that, at some stage, you will get a blocked spray jet. I keep a jar of cellulose thinners and a piece of 5-amp fuse wire (0.010in. dia.) handy for cleaning nozzles. Place a piece of masking tape on one end of the fuse wire so that you can locate it. If possible purchase a spare nozzle.

16. When you purchase your paint/ varnish/ thinners always ask for the Control of Substances Hazardous to Health (COSHH) technical data sheet. This will detail any special safety precautions to be taken when using the product.

Preservation containers

Modern day food packaging includes a wide range of plastic containers, which are very good for long-term storage. Some of the most useful are the two and four litre ice cream containers. I suggest that you build up a supply of various

types. I have found it best to have a container for each major area, i.e. smoke box, front axle, cylinder etc. You will also need to label the container with its contents. Most supermarkets sell self-adhesive food labels, which are good for this purpose. Do not store unprotected items in these as the trapped moisture in the air will cause rusting.

Paint storage

Remember if your workshop is a wooden, shed-type building then your paint can see extremes of temperature, which can cause damage to it. When not in use store it in stable temperature conditions.

Photographs

If your model is a copy of a full size machine try, if possible to photograph it. These photos will be invaluable when it comes to fine details and painting.

●To be continued.

DIVIDING BY CO-ORDINATES

Tutor

describes a method applicable to any number of divisions.

A circle can be divided into any number of divisions using the following method. For example, assume we would like to make a dividing plate to give 67 divisions for an authentic scale model gearwheel. "Oh dear", you might say (or words to that effect). "No dividing device in the workshop can do that". Ah, but there are several ways of getting around that problem with varying degrees of accuracy.

The most accurate way, however, is to use calculated co-ordinates to position the hole centres on a vertical milling machine or lathe attachment fitted with suitable index dials. All we have to do is to position the machine's table so that our index plate finishes up with all of its holes in a circle. Yes, that is all! It is however, necessary to do some sums to achieve this. I know that many of you can do the sums, but let us help those who have got a bit rusty around the memory box,

We need a scientific calculator or a computer to do the calculations, as I am not going to use trigonometrical tables. Look at fig.1, try to stay awake, then look at these formulae: -

$$x = r(\sin a)$$

$$y = r(\cos a)$$

Set the calculator to radians mode. This is important as we require the correct answers for a complete circle including the conventional x and y axis signs. As an example we are going to do the sums for a dividing plate with 67 holes and a 6in. pitch circle diameter.

Our formulae are now:

$$x = 3(\sin(2\pi(1/67)))$$

$$y = 3(\cos(2\pi(1/67))) \text{ for hole 1}$$

and:

$$x = 3(\sin(2\pi(2/67)))$$

$$y = 3(\cos(2\pi(2/67))) \text{ for hole 2}$$

Now we just keep adding one to the multiplier in the brackets until our last position is given by:

$$x = 3(\sin(2\pi(67/67)))$$

$$y = 3(\cos(2\pi(67/67))) \text{ for hole 67}$$

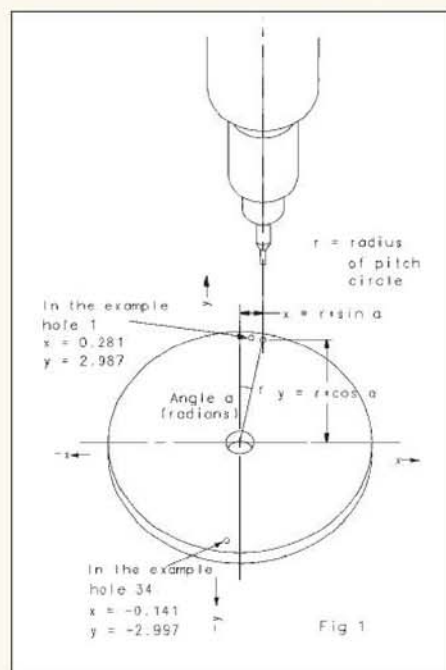
The results can now be tabulated for ease of use. For those with the facilities, these

calculations could be done on a computer and printed out neatly in a table.

To drill the dividing plate, set its central hole precisely under the machine's spindle and adjust the index dials to zero, noting the backlash directions. Now measure out the calculated positions for the first hole by turning each handle the appropriate amount. Do not re-adjust the dials again, as we may need to find our original start position again if we get lost on the way round the circle. Most of us get lost somewhere trying to keep the backlash eliminated.

Now for some hints and tips:

1. Note that all calculated dimensions are from the centre lines of the circle, which in our case is a dividing-plate blank. This means that backlash in the slides must be allowed for.
2. It is quicker to use a centre drill to spot all the holes and then drill them all through on a drilling machine but accuracy may well be reduced.
3. The blank should have a central hole. Use it to set the blank up under the centre of the spindle and set the index dials on the x and y axes noting the backlash direction. This will give you a datum to reset to if you get lost.
4. This dividing method can be used on objects that will not fit into your other dividing devices.
5. You could set a datum position outside the work piece and just add it to the calculated co-ordinates to keep the index dial readings always in the same direction to reduce backlash headaches. The method would work well with the digital readout systems that measure slide positions directly and thus avoid backlash issues.



RHOMBIC HOT AIR ENGINE

Les Kerr

of Australia continues the description of this delightful engine starting with the top rhombic link.

●Part II continued from page 374
(M.E. 4257, 30 September 2005)

The top rhombic link is probably one of the most critical parts as it connects the piston to the rhombic drive. If it is off centre then the piston will bind in the cylinder.

To keep the weight down it is made from aluminium alloy. I found a piece of plate in my junk box that was very close to 0.3in. thick. Using my saw and the vertical milling machine I cut out a piece 0.98in. wide x 2 1/4in. long. In this operation, I took quite a bit of time to make sure the sides were parallel and the whole piece was true. Next I mounted the piece in the milling machine ensuring it was level by using the dial gauge. The two holes to mount the ball races were then drilled. Their

centres being found using an edge finder and rotating the milling machine dials to the correct dimension. A centre drill was used first followed by a 3mm drill and finally a 3.2mm drill.

Using a dial gauge and 4-jaw chuck mount the piece so that it is concentric with its axis. Turn down the 1/4in. dia length for 1in. and drill the 4mm hole.

Bottom rhombic Link

This again is made of aluminium alloy in a similar way to the upper link. It is fitted with an M3 x 3mm grub screw that anchors the displacer rod.

Displacer rod

This is a length of 1/8in. dia. stainless steel. Make sure it is exactly true, as any warp will cause binding of the displacer or power piston. Use a collet or 4-jaw chuck to hold the piece when machining and cutting the thread.

Balance weights

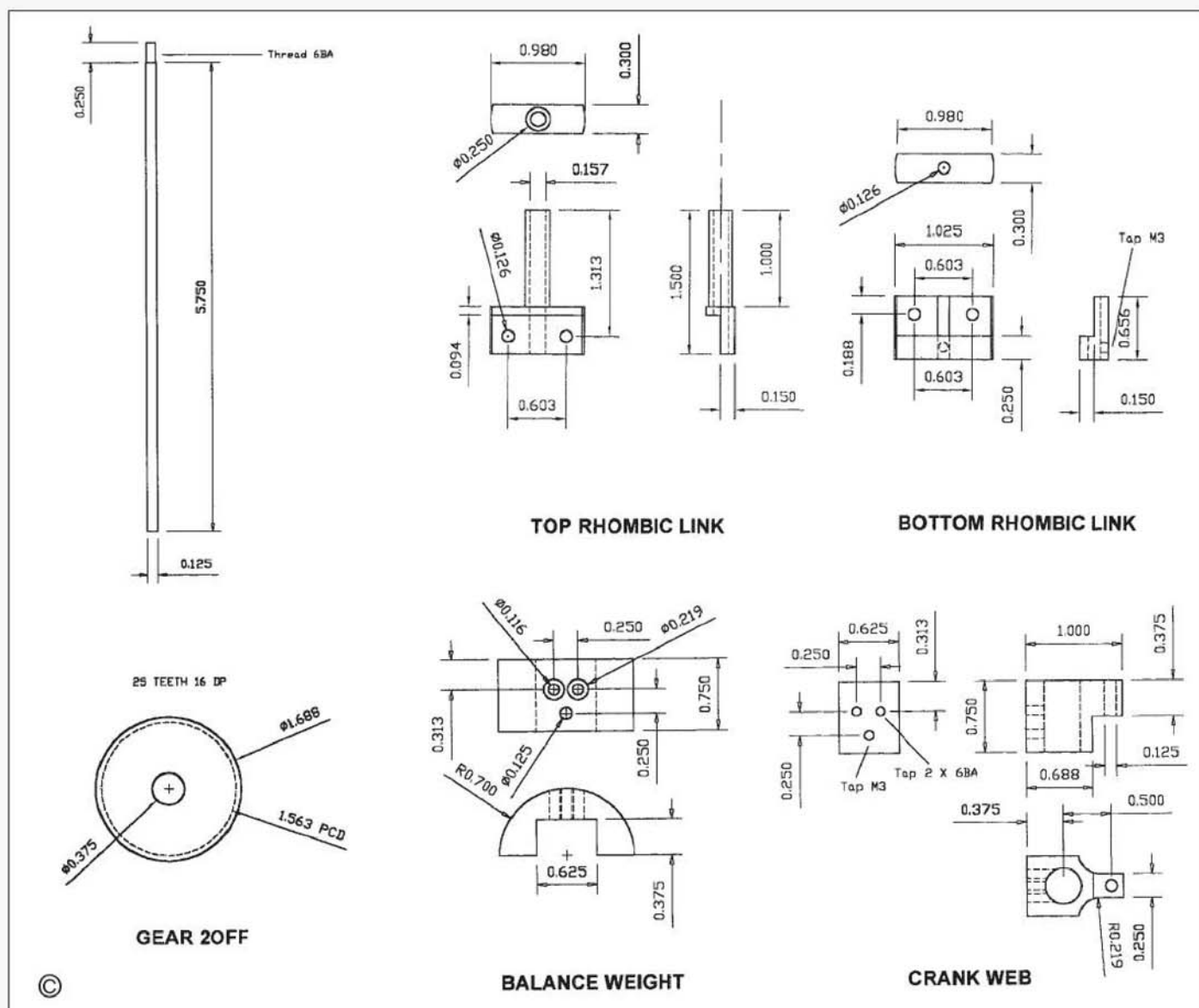
Two of these are required. Chuck a piece of cast

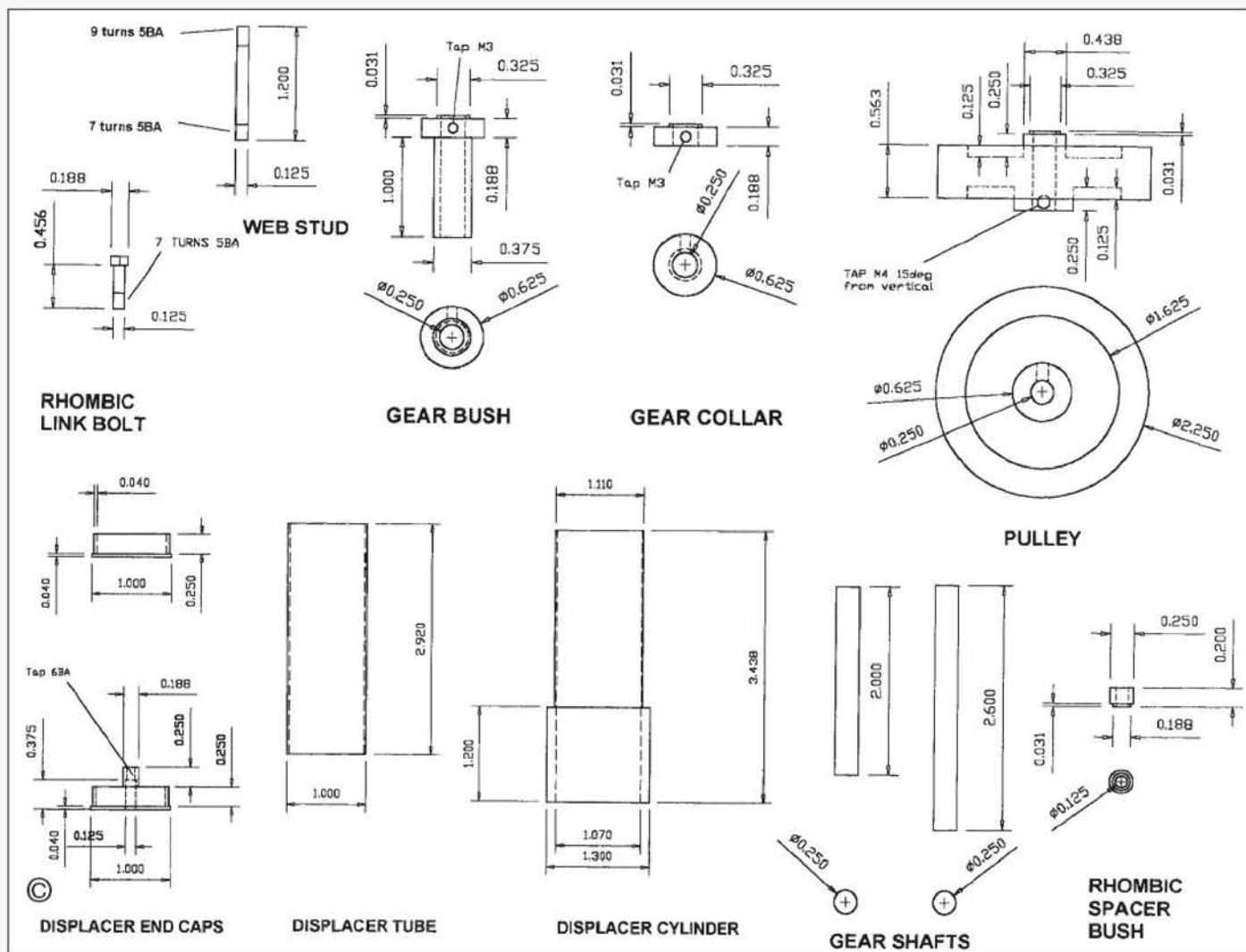
iron greater than 1.4in. dia. and for a length of 3/4in. turn down the diameter to 1.4in., part off. By mounting the piece end on in the 4-jaw chuck turn down its width to half diameter. Transfer the piece to the milling machine and cut out the 5/8in. groove. The holes for the screws are drilled later.

Crank webs

Two off required. Mount a piece of 3/4in. square brass horizontally in the milling machine vice. Face the protruding end. Using an edge finder pick up the end then drill and ream the 1/8in. and 3/8in. holes. Using a 7/16in. long series end mill reduce the sides symmetrically for at least 1in. until the piece just fits into the balance weight. From the end for a length of 1/2in further reduce the width symmetrically to 1/4 inch. Finally machine the top from the end to 3/8in. thickness for a length of 5/16 inch.

To drill and tap the holes for the screws, fit the balance weight and mount the assembly in the milling machine vice. Use a small diameter slot drill to produce a flat surface for the screws to





mount on. Do this before you drill the holes so that you have a flat surface for the drill to start on.

Gear

Two required. Material cast iron.

Gear Bush

Two required. The balance weight bush is a simple turning job. I made mine from $\frac{1}{2}$ in. dia. brass.

Gear collar

Made from brass.

Pulley

The pulley was made of brass and as the manufacture of similar ones have been described in these pages before I won't bore you by repeating it. The only thing to note is that the hole for the M4 grub screw is drilled 15deg. from the vertical. To start the drill first make a flat with a small slot drill.

Gear shafts

These were made from $\frac{1}{4}$ in. 304 stainless steel.

Rhombic spacer bush

Two required. Both were made from brass. If when you assemble the engine and the height of the cylinder is slightly out from the height of the centre line of the rhombic drive then the variation can be removed by altering the thickness of the spacer bush.

Web stud

Two required. Mine were made from brass. Mild steel could be used.

Rhombic link bolt

Two required. Made from $\frac{3}{16}$ in. hexagon mild steel.

Displacer tube

This was made from a length of stainless steel tube 1in. O/D with a wall thickness of approximately 0.025 inch.

Displacer end caps

These were made from brass. The internal boss being turned with the tool shown in photo 2.

Displacer cylinder

This was made from a length of 304 stainless

steel pipe with a nominal I/D of 1in. and wall thickness of $\frac{1}{8}$ inch. Mount a $4\frac{1}{8}$ in length in your 3-jaw chuck. Use a fixed steady at the end if you have one. Face the end then bore out to 1.07 inch. As the wall thickness of the pipe for 2.238in. has to be reduced to 0.015in. this operation has to be performed in $\frac{3}{8}$ in. sections one at a time, starting from the tailstock end. This way you will avoid the tool digging in and destroying the job. In other words set the fixed steady back $\frac{3}{8}$ in. from the end, and then reduce the diameter of that to the right of the steady to 1.110in. diameter. Now move the steady back towards the chuck a further $\frac{3}{8}$ in. and reduce the exposed section to 1.110in. diameter. Repeat until the whole 2.238in. is reduced. Polish the surface with emery cloth. Reduce the remaining dia. for 1.2in. to 1.3in. diameter.

Hot cap

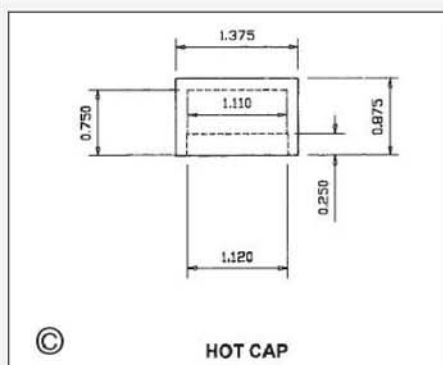
The hot cap was made from brass so that it is a slide fit onto the displacer cylinder. To leave a space for the silver solder to penetrate, the bore for a $\frac{1}{4}$ in. from the end was enlarged by 0.01 inch.

Heat sink mounting bush

This was made from brass. The mounting holes were drilled after it was fitted to the heat sink. Its internal hole should be bored so that it is a slide fit on the cylinder.

Heat sink

The heat sink was turned from a length of brass. Using a parting off tool cut the grooves first then



bore out the internal diameters. These should be a slide fit for the heat sink mounting bush and a slide fit for the displacer. Fit the heat sink mounting bush, transfer to the dividing head and drill and tap the 6 x 6BA mounting holes. To increase its thermal properties the assembly was sprayed mat black.

Pulley mounting base

Mine was made from, so-called, 10mm aluminium alloy plate that turned out to be 0.38in. thick. The spacing of the holes for the gear bearings is critical and precision drilling should be used to achieve the required accuracy. If you have made your own gears, as I did, check that they run smoothly when set at a centre distance of 1.563 inch. In my case I found I had I had to increase this dimension by 0.01in. to achieve this. It is important to keep the other two holes equally spaced about the centre as this effects the alignment of the cylinder in the horizontal plane.

Pulley sub-assembly support

Again this was made from 0.38in. aluminium alloy plate. It has two grooves milled into its surface. The one that the spacer plate fits into should be exactly symmetrical about the centre line as it effects the alignment of the cylinder in horizontal plane.

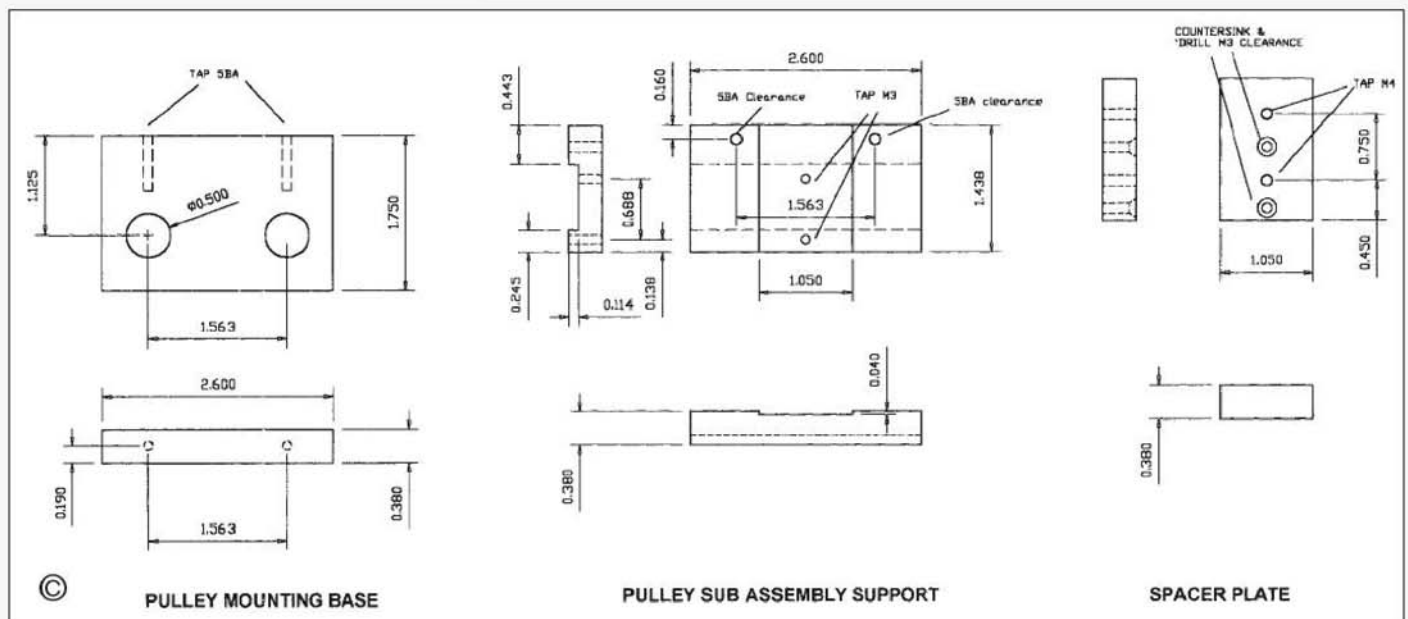
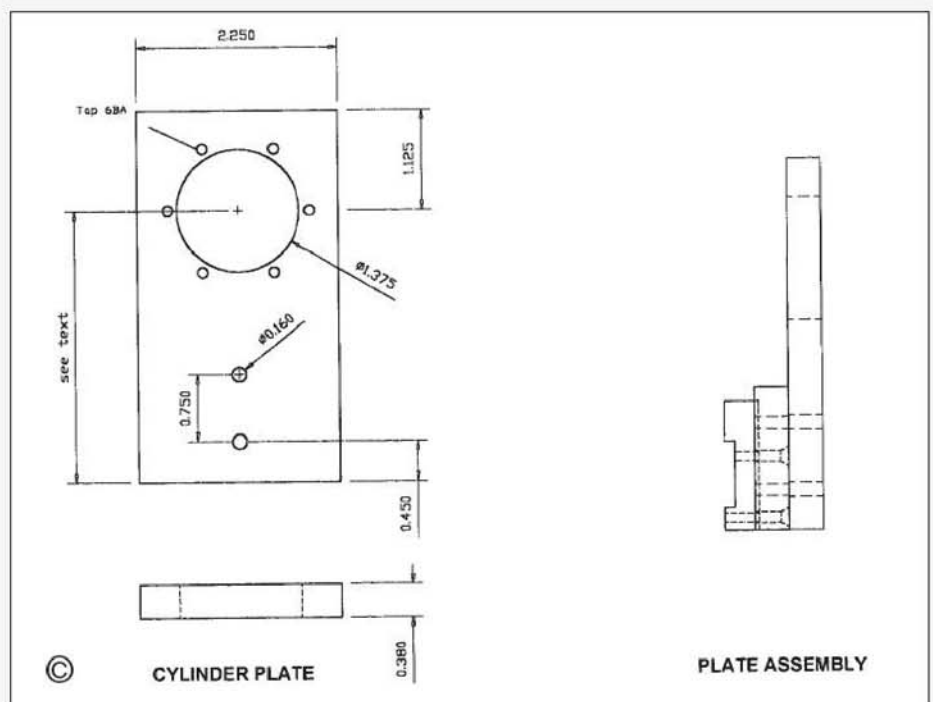
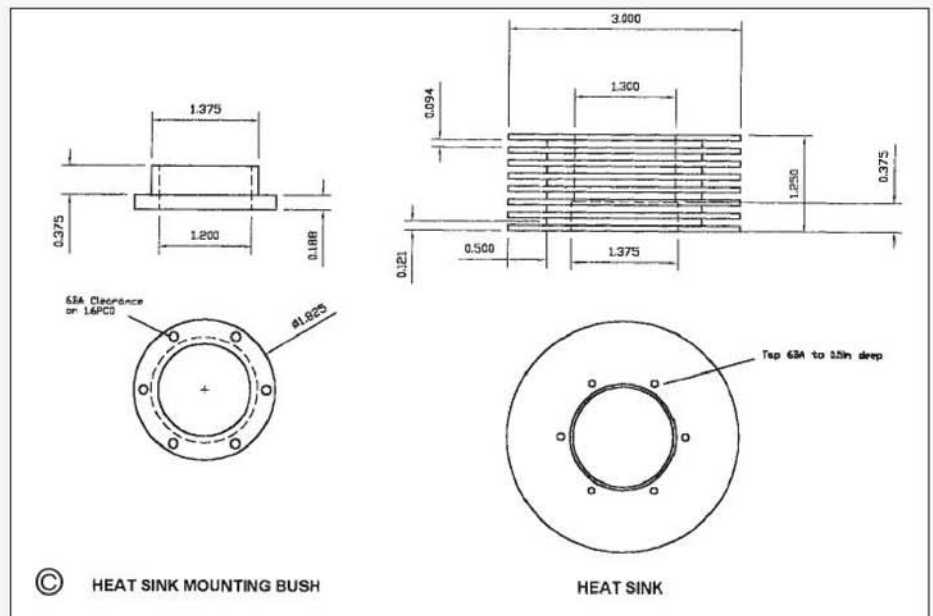
Spacer plate

I made it out of 0.38in. thick aluminium alloy. Its width should be adjusted so that it is a tight fit in the groove of the pulley sub assembly support (see plate assembly drawing).

Cylinder plate

Again this was made out of 0.38in. thick aluminium alloy. The position of the hole for the cylinder mounting bush is very critical as it effects the alignment of the cylinder. Before boring out this hole check its height as detailed in the assembly section under driver sub-assembly, which will be dealt with next time.

●To be continued.



Stephen Atkinson

now begins the fitting out of the cockpit starting with the dashboard and steering wheel.

●Part VI continued from page 391

(M.E. 4257, 30 September 2005)

The dashboard is a feature which is quite prominent in an open top sports car such as our MG TC. It is an appealing component which can really become a centre of attraction to oneself and to other viewers. The original was made of walnut, or perhaps walnut veneer, but it really is too small to consider veneering in this scale with all the problems of edges around the instruments etc. A piece of solid walnut then with as small a grain pattern as possible is the only possible choice. It needs to be around $\frac{3}{16}$ in. thick and made to fit accurately around the inside of the shaped top of the bodywork at this point. First, however, make a wooden background to support the dash panel and fix it inside the body at the appropriate position. The fit of this is not important providing it is well hidden by the final dashboard. Set it inside the shell of the body slightly more than $\frac{3}{16}$ in. from the top edges. This piece can have a straight lower edge finishing just above the lower edge of the dash panel. An epoxy resin adhesive is the most suitable for fixing pieces like this one.

Now for the dash panel itself. I have given a full size drawing which I used for my model (fig 25). Do check against your bodywork (the car's that is!) by pressing a piece of paper against the curved upper edges which surround the dash. Shape your piece of walnut to this template and check that it will fit nicely into its space. Around the upper curves of the wood there is to be a piece of trim sandwiched between the wood and the metal so leave just a fraction for this to be inserted.

The instruments are next, the two large and two small dials are first. Turn these from brass rod. A recess of approximately $\frac{1}{32}$ in. is made at



BUILDING A 1946 MG TC

the front to accommodate the paper dial and a thin piece of clear plastic. The body of the instrument is then $\frac{1}{16}$ in. in total. On the back of each one turn a short spigot $\frac{3}{32}$ in. diameter and slightly less in length than the thickness of the dash panel. The centre shaped piece which is finished in black has a very thin edging which like all the instruments is chrome plated. I went to our local model shop and purchased a piece of extremely thin brass sheet which was stocked amongst their fine tubes and rods. I also got at the same time a length of very thin brass rod from which the edge was produced. The sheet is 0.010in. thick and the rod 0.020in. diameter, they come from USA. Cut the brass sheet to approximately the required shape but about $\frac{1}{16}$ in. larger all round. You will need to use very sharp scissors or jewellers snips for this so that there is no distortion of the sheet. Now bend a piece of the thin rod to the outer shape required. Join the two ends with a minute amount of silver solder. This is probably the most delicate of silver-soldering job you will ever have tackled so take great care, remember that thin brass in sheet and rod will melt if overheated. I leave the excess

sheet around the outside so that I can apply the solder here so keeping the internal cavity clear. Once soldering is completed the spare sheet can be cut away leaving a nice round edge of wire.

There are various bits and pieces, six in all apart from the two small dials to be fitted inside this small panel. Details can be obtained from the photograph of the dash. Little pieces of black plastic rod will do to make most of these switches, all having a spigot at their rear for gluing into holes in the panel. Do take extreme care when drilling this panel as a drill could soon distort it and ruin all your work to date. I found that if it were fixed to a piece of scrap wood with double-sided adhesive tape it could be drilled with a little more safety, but *do be careful*.

There are two lights which are placed one on either side of the centre panel. They are straightforward turning in brass with a shaped piece of thin sheet placed onto their spigot before finally gluing into position (photos 47 and 48).

Now all these metal bits and pieces for the dash will require chrome plating along with numerous other pieces from around the car. It might be a good idea to visit your local plater and talk about what you are doing. They may offer to try out their work on the pieces for the dash and then you can assemble the whole thing and set it aside for a final assembly much later. Some firms I find, require all the small pieces to be connected by a fine brass wire before they will undertake the work, others prefer to do this themselves. If connection is requested, a very small touch of soft solder onto the backs of pieces is what is needed. Do keep it small as it needs to be melted apart when the plating is completed. The centre panel of course needs to be carefully painted black, avoiding the brass wire edge. The wood of the panel has to be varnished to a first-class gloss. I would fill the grain after all the necessary drilling is done, use a sanding cellulose sealer for this, it dries very quickly. Follow this with two or three coats of glass varnish, rubbing down between when completely dry. Once finished I am sure you will be pleased with your dash panel, it really sets off the interior of the car.

A short anecdote about my walnut dash. Many years ago I used to devise and present programmes on local TV on DIY and craftwork. In one series I covered lots of woodworking techniques, one of

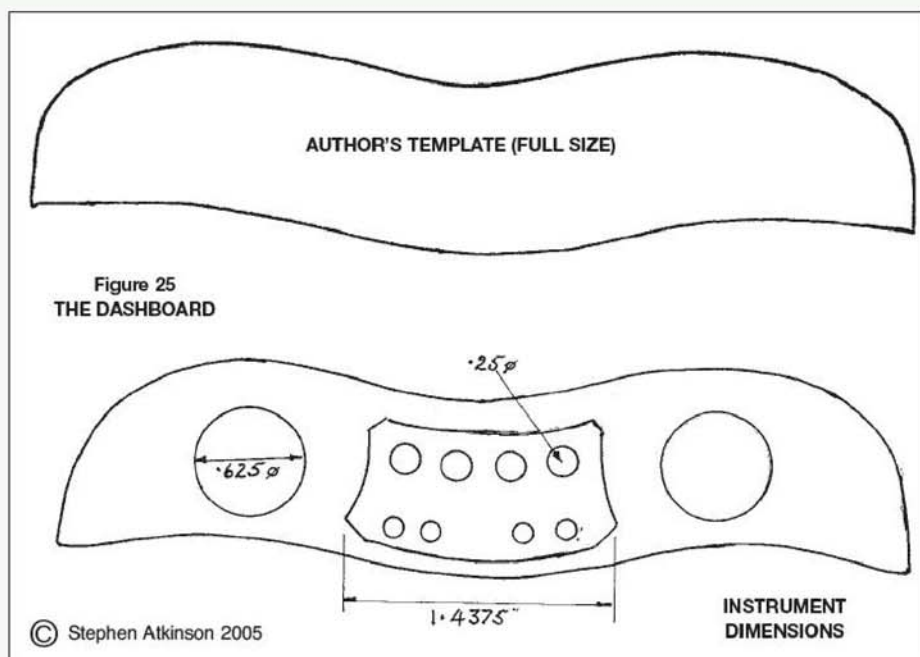


Figure 25
THE DASHBOARD

which was turning when I produced a bowl. After the transmission I had a call from a person who asked if I would like a walnut tree for further bowl making. He had a tree which was close to the runway of a small airport which was expanding. Air traffic control people said that the tree had to go when the runway was extended. The outcome was that I agreed to buy the huge tree. I had it felled and converted into planks of various thicknesses and that is where the dashboard of my MG TC came from. That tree has produced many items of furniture that I have made over the years, not forgetting numerous wooden car models, Gold Medal winners many of them in the International Woodworking Exhibition at Alexandra Palace each year sponsored by sister magazine *The Woodworker*.

Steering wheel

The Brooklands wheel with each of its four main spokes built up from five thin rods makes a truly impressive feature. Start by cutting a length of $\frac{3}{32}$ in. inch brass rod to 6.20in. long. File each end square and then bend it roughly round and silver solder the joint. At this stage providing the ends meet nice and true do not worry about the shape of the circle to be. Clean up the joint after the pickle in acid and a good wash with clean water.

a former of exactly the inside diameter of the finished rim you are making. You will be able to find the joint but not because there is a bump or other fault but just by the line of the solder. This is important when the time comes to solder the spoke sockets onto the inside of the rim. Important because the rim joint should be positioned between any two of the sockets.

Now to the really interesting part, drilling the sockets and the spaces through which the spoke rods pass on their way from rim to hub. Obviously both these parts are too small to firstly cut to size and then drill. The way I found possible was to prepare a length of brass for each of these, long enough to produce the required four and then quite a bit as spare and for practice.

The method I employed was to clamp the strip of brass to be drilled in the vice on the vertical slide so that accurate height could be adjusted.

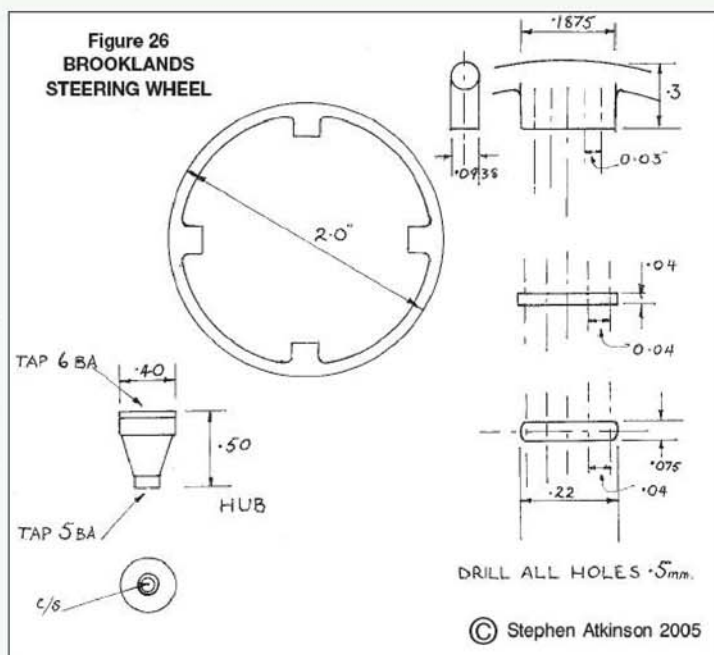
slight taper required so that the rods are wider apart at the hub than at the rim. When the drilling is completed, cut the sections apart and prepare the rim sockets for soldering to the rim. Set the whole thing out on a fire brick and flux each joint. If sufficient silver solder is used it will produce the nice curved fillet required at each position. Do remember about where the joint is located between two sockets. By this time even if your silver-soldering was not up to scratch when you began it will be improving by the time your steering wheel is finished.

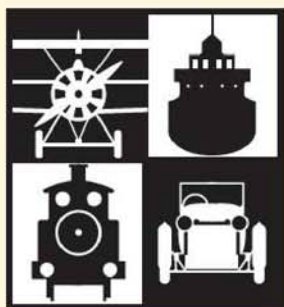
Cut lengths of 0.4mm wire to fit into the sockets, thread through the intermediate bars and meet at the centre leaving sufficient space for a 6BA screw to pass in between them all. Prepare the hub from a bit of brass rod with the upper half drilled and tapped 6BA and the lower half tapped 5BA to take a 1/8in. steering column. Make a washer the size of the top of the hub with a deep countersink to take a 6BA c/s screw.

Wooden parts

As with the frames inside the doors the drawing that will appear next time shows other parts of wood which have to be fitted to the inside of the body. These can all be glued into position with epoxy glue. These parts should be $\frac{3}{16}$ in. thick and made as good a fit as possible in their situation. Beech is a good and suitable hardwood for this job. This really completes the bodywork of the car then leaving us with other bits and pieces.

●*To be continued.*





THE MODEL ENGINEER EXHIBITION

Please return completed form to:
Model Engineer Competition, The Leys,
Church St., Twyford, Bucks. MK18 4EU

ENTRY NO.

OFFICE USE ONLY

CLASS

ENTRY NO.

ENTRY FORM - COMPETITION & LOAN MODELS

PERSONAL DETAILS (Please print)

Surname Forename(s) Age

Address

Post Code Home Tel: Daytime Tel:

Model Club or Association

Have you entered before? (Y/N)

Do you purchase or subscribe to a Highbury House Communications plc magazine? (Y/N)

How many years have you been a modeller?

Mail Order Protection - please tick this box if you would prefer not to receive mail from other companies which may be of interest to you ☐

MODEL DETAILS - PLEASE TICK BOX IF MODEL IS FOR LOAN ☐

Entry Class (competition entries only)

Model Title (to be used for catalogue and display card)

Model Description

Model Scale Length Width Height Weight

Type of construction

Parts not made by you and commercial items

Have you supplied a photograph? (Y/N)

Are you supplying Judges Notes? (Y/N)

Value of model (Highbury House Communications plc will not insure the model unless a value is entered) £

Name and address of local newspaper

NB Please make a copy of this form and any photographs enclosed for your own reference. Please note that Highbury House Communications plc will not accept liability for any loss of documents or photographs submitted with this form

TO HELP YOU GET THE BEST FROM THE MODEL ENGINEER EXHIBITION

These notes are written purely for guidance. Full information is contained in the Competitors' Information booklet which is sent to every entrant as part of the information package. If you have an item and are unsure as to the Class into which it should be entered, leave that section blank and we will take care of it. The Judges have the right to move any competition exhibit into another class if they feel that by doing so its chances of gaining higher marks or a more appropriate award are improved.

If the item is offered as a Loan exhibit please indicate this by writing Loan on the form in the box identifying the Class. Loan models are not judged but carry all other privileges associated with competition entries.

Part built models are particularly welcome in the Loan Section; visitors like to see work in progress, and entry does not preclude the item being entered in competition when completed.

The classes listed below are those associated with mainstream model engineering.

Club exhibits

Where a club is exhibiting, each model should be entered on a separate entry form and clearly identified as a club exhibit by entering Loan/Club in the class section box. This ensures that we have a full record of all models on display during the show and facilitates matters of administration and insurance.

Additional forms

If you do not wish to deface your copy of the magazine we are happy to receive photocopies of the entry form, one for each model. We will be pleased to send out extra forms if required, so if you know of a modeller who is not a reader of one of our magazines but who you think may wish to participate, please advise them to contact our Exhibitions Office, or simply photocopy the entry form for them.

The success of the show depends largely on the number of models on display. Your work could well be the stimulus which inspires someone else to start in the hobby. There can be no doubt that this event is our showcase on the world of modelling in all its aspects. Every modelling discipline needs more and more participants, and it is by displaying not only the crème-de-la-crème, but also examples of work of a more achievable standard, that people are encouraged to join into the wonderful world of modelling, in whatever aspect.

We look forward to seeing a sample of your work at the show!

COMPETITION CLASSES

Engineering Section

- A1 Hot air engines.
- A2 General engineering models (including stationary and marine engines).
- A3 Internal combustion engines.
- A4 Mechanical propelled road vehicles (including tractors).
- A5 Tools and workshop appliances.
- A6 Horological, scientific and optical apparatus.
- A7 General engineering exhibits — not covered by the above

Railway Section

- B1 Working steam locomotives 1in scale and over.
- B2 Working steam locomotives under 1in scale.
- B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
- B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered

steam prototypes.

- B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
- B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
- B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
- B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
- B9 Passenger or goods rolling stock, above 1in scale.
- B10 Passenger or goods rolling stock, under 1in scale.
- B11 Railway buildings and lineside accessories to any recognised model railway scale.
- B12 Tramway vehicles.

Marine Models

- C1 Working scale models of powered vessels (from any period). Scale 1:1 to 1:48
- C2 Working scale models of powered vessels (from any period). Scale 1:49 to 1:384
- C3 Non-working scale models (from any period). Scale 1:1 to 1:48
- C4 Non-working scale models (from any period). Scale 1:49 to 1:384
- C5 Sailing ships and oared vessels of any period - working.
- C6 Sailing ships and oared vessels of any period - non-working.
- C7 Non-scale powered functional models including hydroplanes.
- C8 Miniatures. Length of hull not to exceed 15in for 1:32 scale; 12in for 1:25 scale; 10in for 1:16 scale; 9in for 1:8 scale. No limit for smaller scales.
- C9 For any model boat built from a commercial kit. Before acceptance in this class the kit must have been readily available for at least 3 months prior to the opening date of the exhibition and at least 20 kits must have been sold either by mail order or through the retail trade.

Scale Aircraft Section

- D1 Scale radio control flying models
- D2 Scale flying control-line and free flight
- D3 Scale non-flying models, including kit and scratch-built
- D4 Scale flying radio controlled helicopters

Model Horse Drawn Vehicle Section

- G1 Carriages & other sprung vehicles. (Omnibuses, trade vans etc.) Wagons, carts and farm implements. Caravans.

Junior Section

- J1 For any type of model, mechanical or engineering work, by an under 14 year old.
- J2 For any type of model, mechanical or engineering work, by an under 16 year old.
- J3 For any type of model, mechanical or engineering work, by an under 18 year old.

All entries will be judged for standard of craftsmanship, regardless of the modelling discipline, i.e. a boat will not be competing against a military figure. Providing a model attains sufficient marks it will be awarded a gold, silver or bronze medals

Model Vehicle Section

- K1 Non-working cars, including small commercial vehicles (e.g. Ford Transit) all scales down to 1/42.
- K2 Non-working trucks, articulated tractor and trailer units, plus other large commercial vehicles based on truck-type chassis, all scales down to 1/42.
- K3 Non-working motor bikes, including push bikes, all scales down to 1/42.
- K4 Non-working emergency vehicles, fire, police and ambulance, all scales down to 1/42.
- K5 Non-working vehicles including small commercial vehicles (e.g. Ford Transit). Scale from 1/43 or smaller.
- K6 Any available body shells including Concours, in any scale or material, to be judged on appearance only.
- K7 Functional model cars/vehicles which must be able to move under its own power of any type. Can be either free-running, tethered radio controlled or slot car, but must represent a reasonable full size replica

DUKE OF EDINBURGH CHALLENGE TROPHY

Rules and Particulars

1. The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.
2. The trophy remains at all times the property of HIGHBURY HOUSE COMMUNICATIONS PLC.
3. The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of HIGHBURY HOUSE COMMUNICATIONS PLC in his/her possession until required for renovation and display at the following Model Engineer Exhibition.
4. Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by HIGHBURY HOUSE COMMUNICATIONS PLC.
5. No model may be entered more than once.
6. Entry shall be free. Competitors must state on the entry form:
 - (a) That exhibits are their own bona-fide work.
 - (b) Any parts or kits that were purchased or were not the outcome of their own work.
 - (c) That the model has not been structurally altered since winning the qualifying award.
7. HIGHBURY HOUSE COMMUNICATIONS PLC. may at their sole discretion vary the conditions of entry without notice.

COMPETITION RULES

1. Each entry shall be made separately on the official form and every question must be answered.

2. Competition Application Forms must be received by the stated closing date. LATE ENTRIES WILL ONLY BE ACCEPTED AT THE DISCRETION OF THE ORGANISERS.
3. Competitors must state on their form the following:
 - (a) Insured value of their model.
 - (b) The exhibit is their own work and property.
 - (c) Parts or kits purchased.
 - (d) Parts not the outcome of their own work.
 - (e) The origin of the design, in the case of a model that has been made by more than one person.

NOTE: Entry in the competition can only be made by one of the parties and only their work will be eligible for judging.

4. Models will be insured for the period during which they are in the custody of HIGHBURY HOUSE COMMUNICATIONS PLC
5. A junior shall mean a person under 18 years of age on December 31st in the year of entry.
6. Past Gold and Silver medal award winners at any of the exhibitions promoted by HIGHBURY HOUSE COMMUNICATIONS PLC. are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy.'

Past winners at any of the exhibitions promoted by HIGHBURY HOUSE COMMUNICATIONS PLC. will not be eligible for re-entry into the competition unless it has been substantially altered in any way.

7. HIGHBURY HOUSE COMMUNICATIONS PLC. reserve the right to:
 - (a) Transfer an entry to a more appropriate class.
 - (b) Describe and photograph any models entered for competition or display and to make use of any such photographs or descriptions in any way they may think fit.
 - (c) Refuse any entry or model on arrival at the exhibition and shall not be required to furnish a reason for doing so.

8. Entry into the competition sections is not permitted by:
 - (a) Professional model makers.
 - (b) Anyone who has a financial interest in the direct supply of materials and designs to the public.

NOTE: If unsure, please contact the Competition organisers, prior to the show.

9. The judges' decision is final. All awards are at the discretion of the judges and no correspondence regarding the awards will be entered into.
10. Exhibitors must present their model receipt for all models collected at the end of the exhibition and sign as retrieved.
11. The signed release for each model must be presented to security staff when leaving the exhibition complex with display model(s) after the close of the exhibition.

IMPORTANT NOTE PLEASE MAKE COPIES, INCLUDING PHOTOGRAPHS, OF ALL INFORMATION RELATING TO YOUR MODEL, AS HIGHBURY HOUSE COMMUNICATIONS PLC WILL NOT ACCEPT LIABILITY FOR ANY LOSS.

CLOSING DATE 12TH DECEMBER 2005



THE 75TH EXHIBITION



THE MODEL ENGINEER EXHIBITION

Sandown Park, 29-31 December 2005

COMPETITION DISPLAYS
WORLD CLASS MODELS FREE DAILY LECTURES
TRADE STANDS CLUBS AND SOCIETIES



OPENING TIMES

29.12.05 10AM TO 5PM

30.12.05 10AM TO 5PM

31.12.05 10AM TO 3PM

Prices

	On The Door	Advance*	Group**
ADULT 1 DAY	£8.00	£7.00	£6.00
CONCESSIONS 1 DAY	£7.00	£6.00	£5.00
CHILDREN 1 DAY (From 5-15 yrs)	£4.00	£3.50	£2.50
FAMILY 1 DAY (2 Adults & up to 3 children)	£18.00	£15.50	N/A
ADULT 2 DAY	£12.50	£10.50	N/A
CONCESSIONS 2 DAY	£10.50	£8.50	N/A
CHILDREN (from 5-15 yrs) 2 DAY	£4.50	£4.00	N/A

* The advance ticket line closes 16th December 2005.

** Group bookings only available in advance. One ticket free per 10 ordered.

TICKET HOTLINE **0870 1295 040**

WWW.MEEX.CO.UK

All attractions correct at time of going to press, but may be subject to change or cancellation.

KEITH'S COLUMN

Keith Wilson

starts with some photos of interest particularly to GWR fans before discussing the making of the injectors for *Lillian*.

●Part XIV continued from page 402
(M.E. 4257, 28 September 2005)

Although I am not over keen on shewing photographs of my own work unless they illustrate some point of construction, methought that the photos herewith might please any steam man, particularly Great Western enthusiasts. The multiple one (from left to right, King, Hall, Bulldog, small Prairie. I plead guilty to King and Bulldog) was taken recently at 'steam-up' on the Weston Park Railway; 1 1/4 miles long, 7 1/4 in. gauge. The other was taken at an event in Lancaster. Since the last Bulldogs (*Skylark* and *Starling*) were scrapped in 1951, this is the first time for over 50 years that a Bulldog piloting a King has been photographed. For many years, it was customary for a Dog to pilot the King on the Cornish Riviera Limited from Newton Abbot to Plymouth, and of course back again. Strictly, the picture is a fake, for only the King was in steam. However, it was too good a chance to miss, so the owner of both locomotives took the photograph.

Injectors

Now for a small, but somewhat important matter - drinking. Not alcohol (I never touch the stuff anyway) but nice clean water into our boiler(s).

There are several ways of doing this, good, bad, and indifferent. Much has been written and spoken, some most useful and some most 'tripeful'. The most ridiculous was a claim that the tender hand pump was the best and the injector by far the worst - on grounds of efficiency. According to this article (not in 'ours') the injector was only 2% efficient and the hand pump 100% efficient because it did not take anything from the boiler! True, but those who want to frantically waggle a hand pump all the time to keep water levels reasonable are welcome so to do. Include me out! For if the pump is big enough to feed a heavy teapot it is going to give you plenty of arm-ache - and how! If on the other

Taken at a 'steam up' at Weston Park, left to right King, Hall, Bulldog and small Prairie.



LILLIAN A NARROW GAUGE LOCOMOTIVE for 7 1/4 in. gauge

hand it can be operated easily by hand, then no way will it put enough in.

Of course, I could be wrong, and someone might just about manage to design and fit such a beastie, but I feel rather doubtful! I am of course referring to gauges from 5 to 7 1/4 inch.

A mechanical pump is possible, and in the case of GWR locomotives, the air pump for the vacuum brake system can be used, but there is a snag. If you want it for air-pump purposes, then of course nothing doing unless you double up.

However, for practical purposes, an ejector must be used, and since its capacity is much greater than an air pump, it is unlikely that a pump would of much use. For if you don't know it now you soon will, a vacuum system is a lot of leaks tied together with pipes.

Early locomotives were fed by pumps, because the injector hadn't been discovered. It was 'known' to be impossible, so no one bothered until it was found largely by accident. It is by far the best method of water input. For if running

MICROSOFT XL CHART

A	B	C	D
1	A	DELIVERY	0.0469
2	P.P.M.	CAPACITY	2.75
3	D	COMBINE	0.058625
4	B	STEAM	0.07035
5	C	0.0469	C1
6	D	0.058625	C1*5/4
7	E	0.7035	C1*1
8	F	0.26264	C1*5.6
9	G	0.06566	C1*1.4
10	H	0.16415	C1*3.5
11	J	0.6566	C1*14
12	K	0.8442	C1*18
13	L	2.1574	B7+B11+B12-C1
14	M	0.3283	B11-B9-B9
15	N	0.7973	B12-C1
16	CAP.	2.7495125	((C1*100)^2)/8
17	DELCONC	0.04690416	C1=((B*D)^0.5)/100



One for GWR fans, this photo shows a Bulldog piloting a King; a sight not seen in full size since 1951.

'dry', the only possible energy loss is heat radiated by the device itself plus a bit from the pipe work, it therefore follows that the squirt, jigger, 'puttinnerover' or injector is about 98% thermally efficient or even better. There are other big advantages for it is quite easy for a driver-fireman, who has to do everything, to get a bit low on water when limping back to the station. Result is with injectors you can fill up 'at leisure' when steam demands are low (engine stationary).

Now with gentle disagreement with many former writers of articles on injectors, they are not quite so vitally accurate as is often suggested. Many have been put off by the thought of super-accuracy (including me). Of course the nearer you are to design specification the better, but squirts are not quite so finicky as may be thought. 'Cos if they were, they would not have been discovered in the first place, for the odds against bits being put together precisely in the first place are astronomical. Also, if I can make them to work so can you. However, I have one or two tips for making them easier, especially if you make a batch of several (recommended).

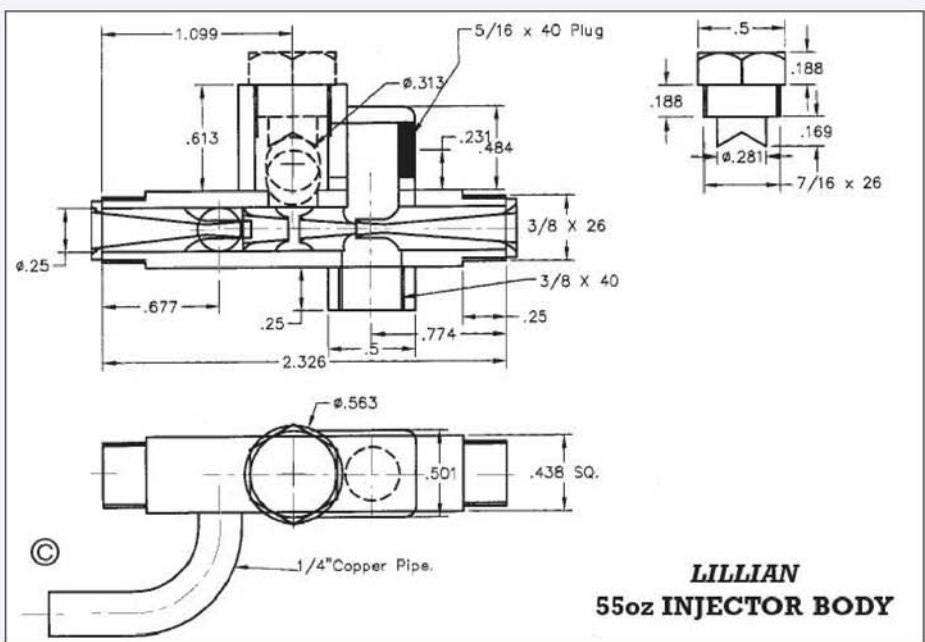
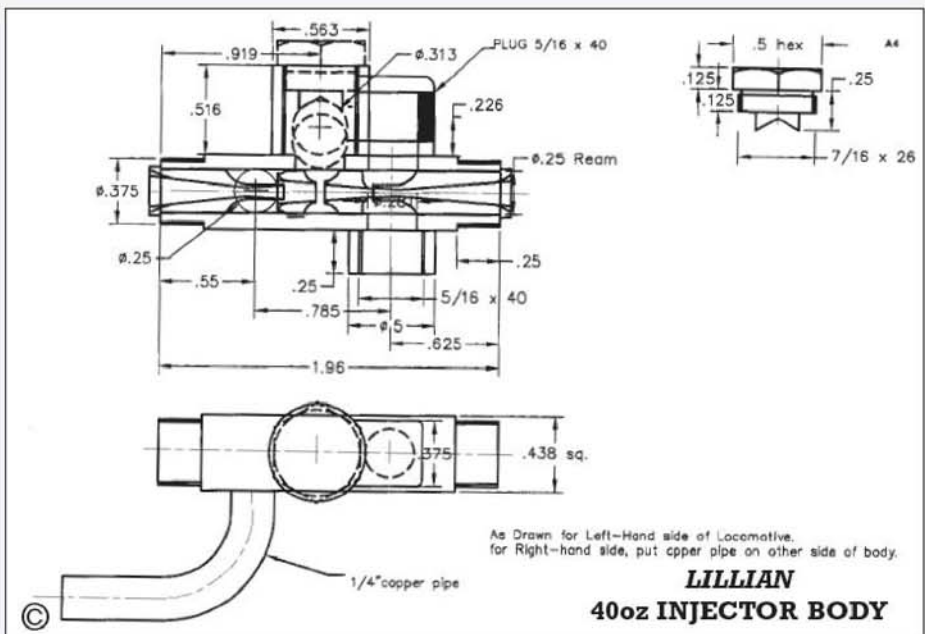
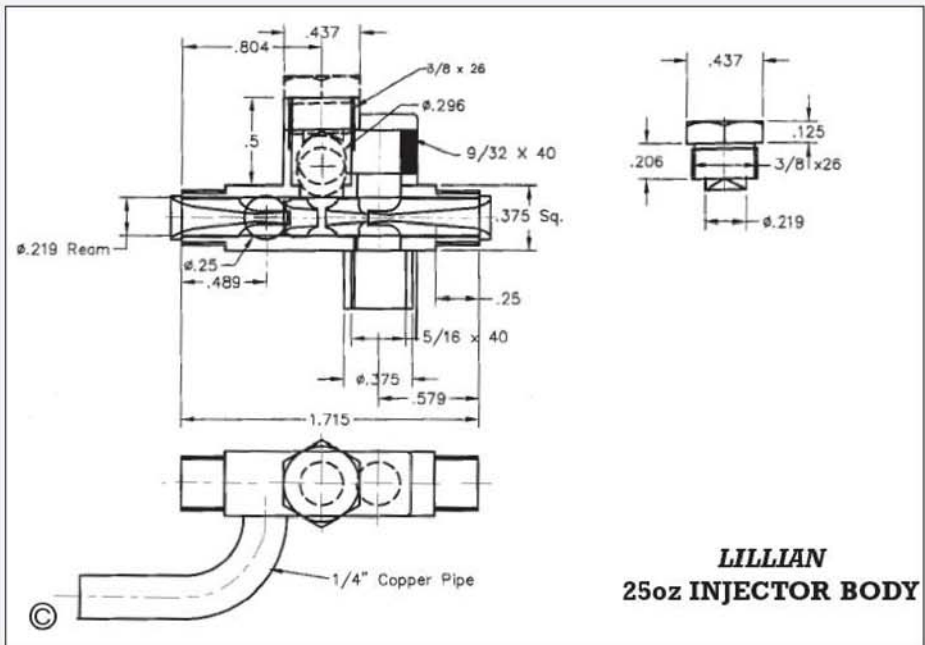
The little chart herewith is for Microsoft XL. If you load it in, but not quite as shewn, then the computer will do all the important calculations for you. The formulae shewn in column D below row 4 should be entered into Column C, each one being preceded by the '=' sign. If you then input into C1 the size of the delivery cone, C16 will shew the theoretical capacity in pints per minute. Alternatively, load desired capacity into C2, the required delivery cone size will appear in C17, likewise either will print out the theoretically correct important dimensions in Column C. Might be useful. Clearly, some rounding off will be necessary - such as to nearest drill sizes.

To start with, a casting may be used. I prefer to silver-braze from turned parts as it is a bit easier. The reference letters refer to those shewn on the attached drawing, in the long run, but needs care. If I describe how I've just done eight (should be enough to see me out) it may well serve to encourage others.

Begin with a piece of square brass bar. Chuck in lathe (self-centring 4-jaw is a very useful animal for these jobs) and turn one end down to required diameter, thread $\frac{3}{8}$ in. x 26, or $\frac{5}{16}$ in. x 32, (as required) centre and drill through $\frac{15}{64}$ in. or $\frac{13}{64}$ in. by 2in. deep for the present. Part off at correct distance from the end, repeat thread operation on other end after trimming - preferably to exact length.

The next stage is to locate three holes along the square part. I used the milling machine (t'mill) as a jig borer to get easier accuracy. Make these holes $\frac{5}{16}$ in. dia., reamed if possible, 'twill help later. Make sure the holes break through into the bore, note that one needs to go right through and out the other side,

Prepare the bits that will be permanently silver-brazed to the body. Leave a little spigot on the end of each one; this should be a light push fit into the main body. Note that the water feed into the body is into one side. This has several advantages, of which perhaps the best is the fact that the 'bottom entry' position is pretty near the track; it follows that when (not if!) a derailment occurs, pipe work can be nastily damaged. Therefore, side entry preferred. Admittedly, this





Milling the side of the tapered reamer to achieve the D-section. Care is needed to avoid damaging the work.



Two injector reamers fitted with collars to maintain the correct depth of penetration in the cone.

means right and left hand injectors, but better than crunched-up pipe work. I write from experience - as usual. To make the part that will be the overflow, use square brass and machine a 'scallop' along one side for a better fit. Easiest done with a 1/2in. dia. ball-nosed slot-drill.

Silver-braze the bits together - and you will soon see the advantages of the little spigots and the push fits. The water input is a short piece of 1/4in. copper tube bent - or rather curved - to 90 degrees. This is fitted to point towards the steam-end of the injector. It takes feed direct from the tender, or from the tanks as desired via a piece of transparent plastic tube.

After the silver-brazing operation (and pickling) some more machining is called for. The 1/4in. dia. hole in the top part might well need cleaning up, and the overflow holes need drilling out and partial plugging. After dealing with all the side or top holes, then is the time to ream out the main bore, this should be done last.

It is as far as I know a discovery of mine that the ideal overflow size is about 4 1/2 times the steam cone bore in diameter. This means that the injector is self-starting, or in other words connect the water pipe to a bucket of water a few feet below the squirt, turn on the steam and watch the water run up the pipe (hence desire for transparent pipe) until it hits the cones (a few seconds is all that is needed) and the injector picks up and feeds. It also means that if the squirt cuts out due to sudden braking or acceleration causing a surge in the supply line, just leave it alone and it will restart of itself (providing of course that there is water in the tender or tanks!).

Let me make it clear that - apart from the last paragraph - no credit is due to me for this design work. It is entirely the work of C. M. Keiller, who passed his research to Martin Evans, who in turn passed it on to me via his book 'Manual of Model Steam Locomotive Construction', a worthy reference book for all. I will accept being 'kicked' for my own errors but not for others. Also, I will not take credit for other people's work, so there!

A conical matter

The cones are the main cause for concern; they need to be 'pretty near the mark'. However, there are ways and means of

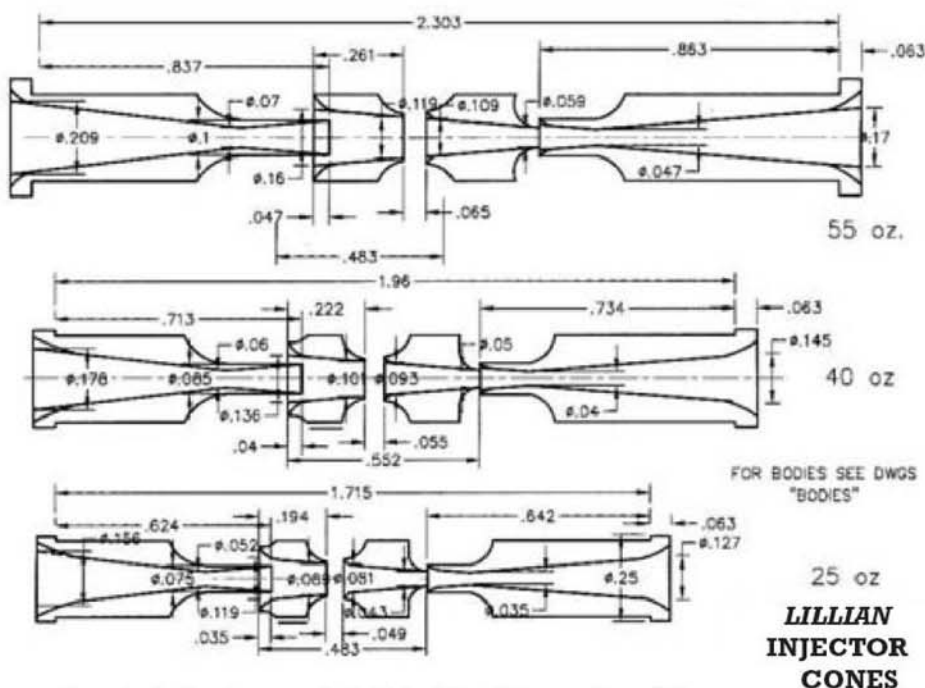
getting things done, rendering accuracy as not too difficult.

Only two cone reamers are needed. Although most designs shew the delivery cone as diverging with a 6deg. angle, the squirt will still work with 9 degrees. I have discussed this with D. A. G. Brown; he reckons that the 6deg. cone is a bit better when 'fine-tuning' an injector for absolutely best performance. My discovery that this angle was not very critical - like the injector discovery itself - was purely accidental. I had not noticed that I had picked up a 9deg. reamer by mistake, the squirts worked perfectly well and it was some time later that I realised the error. Since by far the main purpose of the jigger is to put water into the boiler, the fact that it may not be quite so good by a small degree (nice pun!) doesn't really matter. It saves making another reamer; also the smaller angle means a longer and thinner reamer - ugh! I have doubts as to

whether or not 13deg. is important for the steam cone, for LBSC had good results with a plain hole on the input side - i.e. no converging taper.

To make these reamers, a piece of 3/16in. dia. silver steel is required. You can of course use 1/4in. diameter, personal choice. Set the top-slide over to half the required angle; turn the end of the rod down to a bit smaller than the smallest bore. Do not part off, for it is far easier to hold the reamer in the flame of the blowlamp or torch (for hardening and tempering) in the hand.

When turning is finished, the taper part must be reduced to a 'D' shape by filing or milling. Milling may seem a bit drastic for such a thin object, but if tackled gently there is no problem. Use, if available, a 3/16in. dia. end mill, run it at about 820rpm and take cuts just 0.010in. deep. By choosing which side to mill, cutting is clearly much safer - arrange so that the point of the reamer is never fed into the cut. The photograph will help.



©

The entry for the steam cone (on left) should be 13 degrees. The exit from this cone (left to right) is 9deg., as are all other angles

Wilson's Words of Wisdom
*The truth makes you free when
 falsehood has lost its fascination.*
 H. Spencer Lewis.

Take several final traverses at the same setting, and for choice reduce the depth of cut to only 0.005in. when getting near the final size, which should be just half the diameter. In other words, if you arrange the job so that the cutter just touches the embryo reamer shank and take feeds as suggested above, the total depth of cut is just 0.093in. (for $\frac{3}{16}$ in. dia. silver steel), and it doesn't take as long to make as it did me to write how to do it. The photo above shews the best way to mill the flat.

Harden only the conical part - 'officially' temper to light straw colour. With a small job like this, it is well to remember the flame temperature of the oxy-acetylene torch is a long way above the flame temperature of the gas blowpipe or paraffin ditto; so heat with care. Quench in cold water. To temper, rub off some of the scale caused by heating so that you have a bright surface (fine emery paper recommended) then apply heat to the stock just short of the taper. Heat gently, and watch the change in colour as the heat runs up the tool. When the blue colour reaches about half way up the taper, remove from heat and quench in the water. You will note a discrepancy in this paragraph, to wit 'light straw' and 'light blue'.

Now I am fully aware that the theoretically correct temper colour for a reamer is light straw or 'full golden yellow'. However, in making this batch of cones, I made a total of eight off 9deg. reamers, tempering to light straw. They lasted on average one cone each. The tips invariably snapped off, since the reamer was only about $\frac{1}{32}$ in. dia. at the tip, one half removed for good measure, the tip was only too eager to snap off. Being somewhat ***** off by this, I left one unheat-treated. This did one delivery cone, and on trying another it turned (the reamer) into a splendid corkscrew. So I tempered the last one to dark blue - recommended for screwdrivers and punches, cold chisels etc. It is still going strong - sighs of relief.

If done with reasonable care, the reamer will require naught but cutting off the stock bar and a quick rub on an oilstone or fine emery paper. It has only to cut brass after all; nothing is to be gained by making cones out of anything else.

An interesting article has been forwarded to me by one Frederic Livesey; it appeared in *M.E.* 3537, May 21 1976, page 508. Using a slide-mounted grinder, 3-lobed taper reamers can be made direct from pre-hardened steel, even a high-speed tool bit. The article was written by Basil Palmer and he refers to some work by one Eric Rowbottom. The method looks good to me, and would avoid distortion caused by heat treatments - all too easy.

Make a couple of collars to fit the reamers, locate them with a setscrew, 6BA seems about right. To get the precise location of collar for setting depth of cut, drill a hole in a piece of metal, the diameter of the hole being the same as the larger end of the cone you are about to ream. I shew these sizes on the drawing, but take care to read them aright (Oh, all right then, I didn't).

Now if the tapered end of the reamer is inserted into this hole, it is quite easy to set depth of taper, this being quite important. In general, the combining cones (the two small ones



Drilling and reaming are speeded up if your tailstock is fitted with a capstan feed device.

roughly halfway along) are best made separately; it is easier in the long run. Made as one and parted later, it needs a carefully ground parting tool to get the right gap, or some extra re-sets in the lathe.

I do not think that there is anything to be gained by a complete description of machining the cones so I will just mention one or two hints. A very small centre drill, plus preferably a new drill of required size, is recommended, as is high speed in the lathe. Steam and delivery cones should be a close fit in the injector bodies, but no need to be tight. Combining cones however, must be rigidly fixed; the easiest way is by using Loctite 601. Make sure the outsides of these cones (and the main bore) are clean (acetone recommended) and then insert them as follows. Using a piece of $\frac{1}{4}$ in. dia. metal (brass or steel) turn it tapered to match the combining cone angle (9deg.). If the larger one of the two cones is placed on this taper, it is then easy to locate the exact position of the collar so that when both cones are 601-anointed, they can be pushed straight into the bore (get them the right way round!) and will remain there. A tiny touch of grease on the 'insert' is not without merit, and later on a weeny drop of 601 can be put onto the joints at the ends of the cones by means of a piece of wire.

Astute (or even awake!) readers may have noticed that a 'bell' shaped reamer has not been mentioned, for bellling out the ends of cone bores. Careful here. The entry end of the steam cone, both ends of the delivery cone, and the entrance end of both combining cones should be belled out. Only a tiny bell in the combining cones, but a good big one on the others. This is easiest to do by hand, using one of the taper reamers as a hand-held graver. - I think that's the right name. In fact, on both of my lathes (Myford long-bed ML7 and Colchester Student) a taper cone reamer lives permanently nearby, I have yet to find an easier way of removing sharp internal edges.

A good test for a jigger is to supply steam in the usual way, but water from a bucket on the ground well below the injector, connected by transparent pipe. Turn on the steam and watch the water suck up the tube until it picks up. A point to note here is that the location of the combining cones is set by their inside tapers, much more accurate than by measuring from

their ends. And, of course, it is the tapers that are of greatest importance.

The admission of air into the water supply will either prevent the thing from working at all, or coughing and spitting whilst working, depending on the amount of air. However, do not be too worried about a tiny stream of bubbles seen travelling with the feed water. The explanation is quite simple, for the water coming to the injector is pulled along by quite a powerful suction. This means of course that it is at lower than atmospheric pressure. A certain small amount of air is dissolved in the water, and the pressure reduction means that some of this air will be thrown out of solution - hence the bubbles. It is a good plane to have an O-ring round the water valve stem, to reduce the air intake - it will if it can!

In drilling and reaming these tiny holes to a relatively great depth - great depth relative to drill diameter - a capstan fitting on the tailstock will save much money in the shape of broken drills, 'gnurled' reamers, and lost time. Keep backing out after every $\frac{1}{16}$ in. or so - it will pay you well.

Although this is a lengthy article, a few words on pipe sizes may not come amiss. For any $\frac{7}{16}$ in. gauge locomotives, $\frac{1}{4}$ in. diameter copper pipe is about right, both for 'scale' appearance and capacity. I find that to offer the squirts more water and more steam than they actually need leads to success; after all, they know best! A steam valve of about $\frac{3}{32}$ in. diameter, and $\frac{3}{16}$ in. for the water valve should be okay. Have a fine-gauze filter just before the water valve, make it like a $\frac{3}{8}$ in. diameter cylinder about 3in. long, more than enough. There is no need to worry about cleaning the filters, just open the water valve and blow back through the outlet either with steam or with compressed air. A filter on the filler to the tender is okay but no substitute for the valve filter. It is not a bad idea to have jiggers of different sizes; a 25oz. is big enough for normal work, a 40 for times when water is urgently required in large quantities!

In the case of hard-water areas, the cones may fur up, in which case the easiest treatment is to disconnect it and leave overnight in citric acid (lemon). Vinegar will do it too, but citric is probably best.

There is no need to mount the injector in any way; the pipe work is adequate.

●To be continued.



SMEE Exhibition Organiser Ron Hough chats to visitors to the SMEE stand at Sandown.



Colin Ager proudly demonstrates the SMEE Wimshurst machine to a group of on-lookers.

SMEE GOES TO SANDOWN

As we look forward to the next one, **Mitch Barnes** outlines the work involved in setting up and running the SMEE stand at the Model Engineer Exhibition 2004.

The Society of Model & Experimental Engineers and the Model Engineer Exhibition have been inextricably linked since the earliest of days. The Model Engineer Exhibition started through the efforts of *Model Engineer* magazine editor and SMEE founder member Percival Marshall.

The aims of the Exhibition are many but one of the most important is to introduce newcomers to the creative pastime of model engineering. It does this by show-casing the work of model engineers and, in so doing, it also offers support to those already converted and inspires them to persevere and finish their ongoing projects. In addition, of course, where else can one find all those drawings, castings, metal billets, tools and machines under one roof?

When wandering around any show seeing those stands seemingly running with clockwork efficiency, it can be hard to appreciate the sheer effort that goes into putting up each stand. The weeks, and often months, before the event being

peppered with many late nights and weekends of preparation. Organising the SMEE stand is always a team effort and but it runs more smoothly if proper preparation takes place. The person who really should take credit for organising our stands at exhibitions in the southern half of the UK at least, is Ron Hough, for many years Secretary to the Society and now Exhibition Organiser. Under his avuncular leadership SMEE's attendance at exhibitions is deceptively easy, relaxed and largely trouble-free.

But how does one go about organising a stand at Sandown Park, and what is involved? For SMEE it usually starts three months or so beforehand, with a 'gee-up' from George Evans to members who want their, yet to be completed, models or other displays to be at the show. Why so long a lead-time? Why, the Craftsman's Golden Rule of course: *"It always takes at least twice as much work to complete the project than you thought it would"*.

In the weeks running up to the Exhibition, in addition to members models, a selection is made from the Society's extensive collection of models and tooling built or donated by members past and present. Being careful to avoid repetition from recent shows, we make a particular effort to show some unusual items whose operation (or lack of, in the case of our perpetual motion machine) one can explain to the public. We try to show a varied cross-section of these at each exhibition we attend but if there is particular interest in a model we will often give it a 'repeat' showing – a particular favourite is the Wimshurst machine, always popular with the crowds, especially if we can generate lightning between its contacts.

Of course, not all display items are completed by the time they are shown – it is just as interesting and useful for the model engineer to see a part constructed model, and on our stand for the last couple of years we have shown the steady progress of Maurice Turnbull's model of a Head Wrightson, vertical boiler, 0-4-0 locomotive. Last year it was also joined by a maquette of one of its accompanying coal wagons.

All these exhibits, of course, do not find their own way to the show, so another part of our preparation is collecting the models from various places around the country and bringing them together for the Exhibition. This is an

even more demanding task for SMEE than many other exhibitors as we are a society with worldwide membership. Our displays are comprised of models from all over the UK and overseas. Virtually all, engineering models have one thing in common – just like the real thing, they are heavy! Someone has to haul these models from storage, load them into member's cars, trailers and vans and drive them to the venue then heave them over to the stand once we arrive. To ease this heavy burden, some of the members who plan to man the stand bring exhibits with them and take them home again afterwards.

Build up day

On arrival at the exhibition space on build up day it is easy to wonder how, in the space of the few available hours, this area can be transformed into a model engineering heaven and not to get disheartened by the awesome task ahead. The recipe for success lies within the acres of anonymous boxes and packing crates disgorging the exquisite results of countless evenings and weekends of *not* going to the pub or sitting in front of the TV, as that team of willing helpers for each stand engages in a frantic blur of activity. Trade and club members alike give each other a hand if required: the show is not only a team effort from each exhibitor but also a team effort as a whole.



SMEE members busy themselves preparing the stand during build up day.



A live steam exhibit is always a popular attraction with the public.



Exhibition stalwart Tony Phillips giving a turning demonstration on the series 7 lathe loaned by Myford Ltd.

Every society seems to have a hard core of helpers who somehow appear as if by magic when the need arises and SMEE is no different. This regular team always comes to the rescue, all of them giving their time freely and enthusiastically with rarely a word of complaint whatever the task required.

Some hours and lots of backache later, everything is in place at the end of the build up day, the very last task being left for the moments prior to opening. A quick removal of the covers the following morning and we are ready to start meeting and greeting the Great British Public.

In common with other society stands, SMEE likes to showcase member's work - showing superlative models is also of course part of the Model Engineer Exhibition. But this is never to say "I'm better than you" - it is intended as a never-ending quest to inspire others to improve their standards or to give model making a try. After all, every medal winner was a beginner once and our displays include exhibits of all standards, made by members with every level of experience from beginner upwards.

Live exhibits

Engineered models come to life when they breathe vapour into their cylinders and movement is always an eye catcher for the general public, many of whom are captivated by the often hypnotic motion of valve gears and the quietly described motion of glittering connecting rods, crankshafts, eccentrics and flywheels. At the very least we try to have some exhibits running on compressed air when power for that supply is available. At Sandown, the hypnotic

motion of the little wall engine transfixed many people, and several asked if we ever ran models on live steam too. Imagine their surprise when one pointed out that just to their right, on the end of the stand was one of our vertical boilers, driving a very well engineered Stuart No.4. Most of those unaccustomed to live steam are surprised at the quietness with which its power is put out. In direct contrast, when Tony Phillips ran his hit and miss engine, most of the visitors at the other end of the building could hear it too and this would also bring the crowds to our stand.

New blood

To demonstrate to the uninitiated that 'having a go' is not necessarily as frightening as one might think when confronted by a milling machine or lathe, for many years a key aspect of the SMEE stand has been the workshop demonstration. To help us do this we are frequently kindly loaned a lathe by Myford Ltd. and this year a mill by Warco. Various tasks were demonstrated on both machines and this year we were blessed with the presence of Derek Brown on hand, showing how to use his tool and cutter grinder.

Of course, club stands are at the show to increase their membership and SMEE is no different. In their centenary year of 1998, when the Exhibition was held at Olympia, I joined and this was the best move I ever made. Up to that time I had not been aware that SMEE was keen to take beginners under their wing but actually it is a priority - without new blood, it is hard to expand and spread the knowledge that keeps our hobby alive. SMEE has many members with a breathtaking amount of knowledge they are happy



Derek Brown was available to help Exhibition visitors with problems they might be having with tool and cutter grinding.

to divulge and the society holds basic courses for beginners to get them over those first hurdles. Almost every task one has to tackle on any given project has been done before and there is always someone happy to proffer a guiding hand.

Lectures

Perhaps it is not on every visitor's agenda when attending the exhibition to listen in on a lecture, but this is a popular feature and SMEE is always happy to contribute. Standing room only is often the order of the day, because the subject matter is so interesting and useful and a wide range of subjects have been covered over the years.

It is worth remembering that SMEE's lectures are a regular event at our monthly meetings on the first Saturday of most months at SMEE's Marshall House headquarters. Anyone contemplating membership is welcome to turn up and have a look around and enjoy whatever presentation is being given.

A feature of the SMEE's exhibition involvement for many years has been the miniature railway track, rides on which were given in exchange for a donation to charity. Last year the tsunami disaster in the far east was helped by a total of £1363.33 raised by kind donations from the public during the show. It was also gratifying to see the Exhibition's organisers sending two of the retailer's stewards around the stands to swell the charity coffers.

But what do the visitors think? It's great fun talking to members of the public who like me, take photos of models on show, to act as inspiration for their own projects and to help them choose their next (or sometimes, first)



Care is taken to ensure a balance of exhibits on the SMEE stand. Both old and new items are usually displayed.



The lectures are an important part of the Model Engineer Exhibition. Here Peter Haycock talks to a packed house about nut and bolt manufacture.

model. It was at the first Model Engineer Exhibition I was able to visit, in 1988, that I caught the model-engineering bug, a condition known to be incurable. The purchase of a Stuart 10H machined kit after that show resulted in a successfully completed model and I was hooked!

All good things come to an end and what has been set up has to come down. The moment the exhibition closes, as the last visitor turns his or her back on the closing doors and makes their way home, a frenzy of activity takes place once again within the venue's walls.



Always popular, the miniature railway raised much money for the tsunami appeal.

Our team of helpers once again materialises as if from nowhere, and for about two hours the hall is a blur of activity the public never sees, as all those anonymous boxes reappear to swallow up their exquisite charges once again for safe passage home. Myriad boxes, trolleys and crates criss-cross the floor as they make their way to a fleet of waiting vehicles as stands and displays come apart in a concert of frantic activity.

And at the end of December, it will all happen for us again. Long may *Model Engineer*, the Model Engineer Exhibition and  SMEE continue.

CLUB DIARY

A minimum of 6 weeks notice is required for diary entries. Clubs and Societies are asked to include a telephone number for the assistance of would-be visitors.

OCTOBER

- 26-29 **Southern FMES. Myford Open House.**
Contact Brian Thompson: 01920-830629 (eve).
28 **Chichester DSME. OGM and Speaker.** Contact Brian Bird: 01243-536468.
28 **North London SME. Workshop Evening.**
Contact David Harris: 01707-326518.
29 **Brighton & Hove SMLE. Last Trackday of 2005.**
Contact Mick Funnell: 01323-892042.
29/30 **Furness MRC. Hazel Grove, Stockport Exhibition.**
Contact Fred Firth: 01229-821192 or Colin Burns 01229 837079.
29/30 **Furness MRC. Huddersfield Exhibition in Holmfirth.**
Contact Fred Firth: 01229-821192 or Colin Burns 01229 837079.
29 **Guildford MES. Halloween Night Run.** Contact Dave Longhurst: 01428-605424.
29 **Northampton SME. Running Night.** Contact Pete Jarman: 01234-708501 (eve).
29 **North London SME. Halloween Evening.** Contact David Harris: 01707-326518.
29 **Southern FMES. Autumn Models & Hobbies Show.**
Contact Brian Thompson: 01920-830629 (eve).
29 **Tyneside SMEE. Track work day.** Contact Ian Spencer, 0191-2843438.
29 **York City & DSME. David Hulse: Mill Engines & Housing.**
Contact Pat Martindale: 01262-676291.
30 **Leighton Buzzard NG Rly. Halloween Haunting.** Enquiries: 01525-373888.
30 **Maidstone MES (UK). Last Public Running Day.**
Contact Martin Parham: 01622-630298.
30 **MELSA. Sunday in the Park.** Contact Graham Chadbone: 07-4121-4341.
30 **Portsmouth MES. Last Day of Running Season.**
Contact John Warren: 023-9259-5354.
31 **Frimley & Ascot LC. Halloween. 6.00-8.00pm Evening Running.**
Contact Bob Dowman: 01252-835042.

NOVEMBER

- 1 **Romney Marsh MES. Jerry Ames & Arthur Wigley: Ashford Railway Works.**
Contact John Wimble: 01797-362295.
1 **South Durham SME. Running Day.** Contact B. Owens: 01325-721503.
1 **Taunton ME. Robin Goodchild: Braille Engineering Tools.**
Contact Don Martin: 01460-63162.
2 **Andover DMES. Meal to celebrate 60th Anniversary.**
Contact John Berry: 01960-882616.
2 **Bradford MES. Meeting.** Contact John Mills: 01943-467844.
2 **Leeds SMEE. Bonfire Night Steam-Up and Supper**
Contact Colin Abrey: 01132-649630.
2 **Tyneside SMEE. Guy Fawkes Steam-Up/ Soup & Hot Dogs.**
Contact Ian Spencer, 0191-2843438.
3 **Cardiff MES. An Evening with Tony Bird.**
Contact Trevor Jenkins: 029-2075-5568.
3 **SM&EE. Visit to Young's Ram Brewery.** Contact David Boote: 01202-745862.
3 **South Lakeland MES. Meeting.** Contact Adrian Dixon: 01229-869915.
4 **Maidstone MES (UK). Photo Competition.**
Contact Martin Parham: 01622-630298.
4 **North London SME. Our Section: Video Group.**
Contact David Harris: 01707-326518.
4 **North Norfolk MEC. Doug Hewson: More GL5 topics.**
Contact Gordon Ford: 01263-512350.
4 **Portsmouth MES. Bits & Pieces.** Contact John Warren: 023-9259-5354.
4 **Rochdale SMEE. Bits & Pieces.** Contact Mike Foster: 01706-360849.
4 **Romford MEC. Competition Night.** Contact Colin Hunt: 01708-709302.
5 **Brighton & Hove SMLE. Halloween Run & Fireworks.**
Contact Mick Funnell: 01323-892042.
5 **Cambridge MES. Bonfire Night Steam-Up.**
Contact Rex Mountfield: 01284-386128.
5 **Cardiff MES. Fireworks Display.** Contact Trevor Jenkins: 029-2075-5568.
5 **Erewash Valley MES. Bonfire Evening.** Contact Jim Matthews: 01332-705259.
5/6 **Furness MRC. Bolton Exhibition.** Contact Fred Firth: 01229-821192 or Colin Burns 01229 837079.
5 **Ickenham DSME. Public Running.** Contact David Sexton: 01895-630125.
5 **Isle of Wight MES. Track and Pond Afternoon.**
Contact Ken Stratton: 01983-531384.
5 **Malden DSME. Bonfire Night.** Contact John Mottram: 01483-473786.

- 5 **Peterborough SME. Guy Fawkes Run, Firework Display & Barbecue.**
Contact Tony Meek: 01778-345142.
5 **Romney Marsh MES. Bonfire Night Steam-Up & Barbecue.**
Contact John Wimble: 01797-362295.
5 **SM&EE. Paul Harding: Caught on Camera.** Contact David Boote: 01202-745862.
5 **Stockholes Farm MR. Bonfire Night.** Contact Ivan Smith: 01427-872723.
5 **York City & DSME. Bonfire Steam-Up & Running Day.**
Contact Pat Martindale: 01262-676291.
6 **Frimley & Ascot LC. Public Running.** Contact Bob Dowman: 01252-835042.
6 **Leicester SME. Bonfire Night Run.** Contact Raymond Wallis: 0116-285-8824.
6 **Reading SME. Public Running.** Contact Brian Joslyn: 01491-873393.
6 **South Durham SME. Running Day.** Contact B. Owens: 01325-721503.
7 **Peterborough SME. Bits & Pieces.** Contact Tony Meek: 01778-345142.
9 **High Wycombe MEC. Bits & Pieces.** Contact Eric Stevens: 01494-438761.
9 **Hull DSME. Table Sale or Auction.** Contact Tony Finn: 01482-898434.
9 **St. Albans DMES. Dr. Peter Brandham: Train Come - No Speak.**
Contact Roy Verden: 01923-220590.
10 **Cardiff MES. Forum.** Contact Trevor Jenkins: 029-2075-5568.
10 **Leyland SME. Graham Whitehead: The Railways of Peru.**
Contact A. P. Bibby: 01254-812049.
10 **N. W. Leicester SME. The History of A. J. Reeves & Co.**
Contact John Elliott: 01455-847040.
11/13 **Furness MRC. Pendle Forest Nelson Exhibition.**
Contact Fred Firth: 01229-821192 or Colin Burns 01229 837079.
12 **Cardiff MES. Steam-Up and Family Day.**
Contact Trevor Jenkins: 029-2075-5568.
12 **Glasgow & S.W. Rly Ass'n. G. A. Davidson: Poor but Honest - aspects of the LNER.** Contact Bruce Steven: 0141-810-3871.
12/13 **Hutt Valley MES. Tauranga Open Weekend.** Contact Gavin McCabe: 567-4487.
12 **SM&EE. Training Seminar.** Contact David Boote: 01202-745862.
14 **Bedford MES. R101, the story of a disaster.** Contact Ted Jolliffe: 01234-327791.
14 **Saffron Walden DSME. Club Night.** Contact Jack Setterfield: 01843-596822.
15 **Chesterfield MES. P. Crawley: Settle & Carlisle.**
Contact Mike Rhodes: 01623-648676.
15 **Nottingham SMEE. Noel Coates: The Lancashire & Yorkshire Railway.**
Contact Graham Davenport: 0115-8496703.
15 **Taunton ME. Auction.** Contact Don Martin: 01460-63162.
16 **Andover DMES. John Berry: Coastal Engineering.**
Contact John Berry: 01960-882616.
16 **Leeds SMEE. Jumble Sale.** Contact Colin Abrey: 01132-649630.
16 **MELSA. Meeting.** Contact Graham Chadbone: 07-4121-4341.
17 **Cardiff MES. Cyril Chandler: Film Night.**
Contact Trevor Jenkins: 029-2075-5568.
17 **East Somerset SMEE. Meeting.** Contact Roger Davis: 01749-677195.
17 **Frimley & Ascot LC. AGM.** Contact Bob Dowman: 01252-835042.
17 **Isle of Wight MES. AGM.** Contact Ken Stratton: 01983-531384.
18 **Canvey R&MEC. Meeting.** Contact Brian Baker: 01702-512752.
18 **North London SME. Work in Progress.** Contact David Harris: 01707-326518.
18 **Romford MEC. Photo Talk.** Contact Colin Hunt: 01708-709302.
19 **Chesterfield MES. Running Day.** Contact Mike Rhodes: 01623-648676.
19/20 **Furness MRC. Hazel Grove & New Mills Exhibition.**
Contact Fred Firth: 01229-821192 or Colin Burns 01229 837079.
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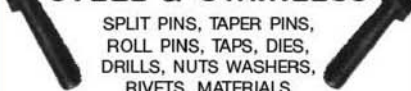
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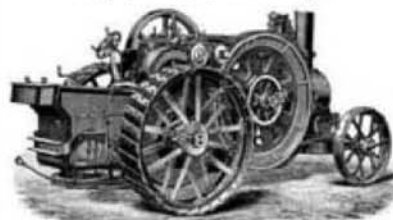
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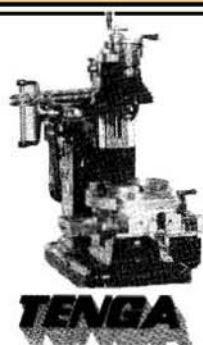
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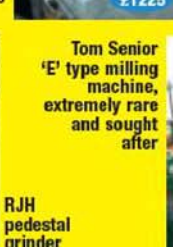
Flamefast PB250 power burner crucible furnace **£425**



Tom Senior 'S' type turret machine complete with quill head and 28" x 6 table **£2250**



Tom Senior 'E' type milling machine, extremely rare and sought after **£345**



RJH pedestal grinder **£3250**



Asquith 14-54 001 Mk.2 5MT radial drilling machine **£3950 Now special £2950**



L00-L0-D13 + 3 collets **Special £275 each**



Easi Blaster (sand) cabinet + 2HP compressor **£525**



Henry Mills 6 1/2" x 48" geared head, gearbox and gap bed + tooling just in off the lorry **£1225**



Boxford pedestal drill **£295**



Boxford 1130, 5 1/2" x 30" **£2450**



Boxford CUD Mk III centre lathe 5" x 22" in very nice order **£1250**



Mercer dial gauge imperial reads to .0005" Ex Mod complete still boxed (last few available) **£25 each**



Tom Senior M1 milling machine in very nice order **£1725**



Harrison M250 lathe complete with 3 and 4 jaw chucks, extra gears, with the high 2000rpm top speed almost as new **£3950**



Presto BSP set off taps and dies 1/2" - 1" boxed **£175**



Kingsland 50" box and pan folder **£1400**



Viceroy pedestal buffing machine **£245**



Crompton Parkinson Motors NEW 3/4HP ideal for Myford & Boxfords etc. **£150 Each**



Bridgeport variable speed R8 powered quill, 42" x 9" table powered + Mitutoyo read out **£2450**



Harrison M300 lathe complete gearbox, power feeds and Dickson tooling just in! **£2950**



Raglan 5"x24" lathe complete with gearbox, variable speed & power cross feed **£1400**



Pratt / Burnerd Boxford / Colchester / Harrison 6", 8", 10" 4 jaw chucks **From £90**



Myford Super 7B precision (gearbox) screwcutting lathe + power crossfeed, cabinet stand, drip tray & blocks and rare Hardened Bed **£3950**



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Standard Accessories

125mm, 3-Jaw Chuck
1-13mm Drill Chuck & MT3 Arbor
Set of 5 Carbide Lathe Tools
Combined Vice/Compound Slide

Specifications

Centre Height	210mm
Distance Between Centres	800mm
Spindle Taper	MT4
Milling Table Size	475x160mm
Lathe Motor	¼ hp
Milling Power	¼ hp
Net Weight	300kgs
Dimensions	1570x480x955mm



£936.17

+VAT & delivery

Centurion 3in1

Standard Accessories

125mm, 3-Jaw Chuck
1-13mm Drill Chuck & MT3 Arbor
Set of 5 Carbide Lathe Tools
Combined Vice/Compound Slide

Specifications

Centre Height	210mm
Distance Between Centres	520mm
Spindle Taper	MT4
Milling Table Size	475x160mm
Lathe Motor	¼ hp
Milling Power	¼ hp
Net Weight	250kgs
Dimensions	1270x480x955mm

(shown with optional tray)



£548.94

+VAT & delivery

Model B Super 3in1

Standard Accessories

3-Jaw Chuck
1-13mm Drill Chuck & Arbor
Dual Purpose Compound Slide/Machine Vice
Set of 5 Carbide Lathe Tools

Specifications

Centre Height	210mm
Distance Between Centres	520mm
Spindle Taper	MT3
Milling Table Size	300x150mm
Motor	¼ hp
Net Weight	155kg
Dimensions (HxWxL)	930x690x1090mm

(shown with optional tray)

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