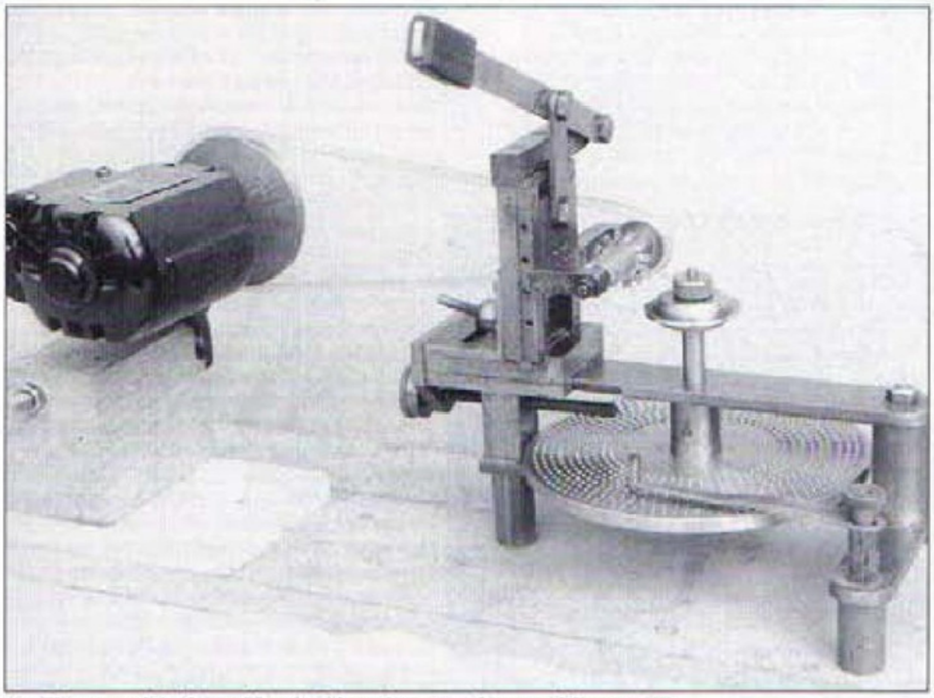
A Clock-Wheel Cutting Machine

George Swallow describes his version of a traditional purpose built device which will be found useful by the keen clockmaker

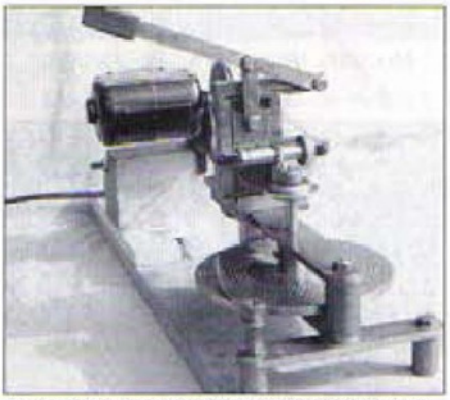


1. The completed machine is driven by a sewing machine motor

This machine, often called an engine, is a traditional tool of clockmakers, and there are many very old and exquisitely-constructed examples still in existence, usually hand-driven, which have become collectors' pieces in their own right.

However, the machine described here **(Photo. 1)** is sparsely functional, and it was made following the production of the division plates I wrote about in MEW24. It is similar to machines which have been offered commercially in the past, either complete or as self-assembly kits. Ideas for the design were gleaned from catalogues, although photographs were often very small and much of the detail had to be imagined.

It has to be said at the beginning that you do not need one of these machines if you are going to make only one clock. It is possible to cut clock wheels in the lathe, and methods of doing this have been described by John Stevens (ME Vol 108) and in several of the books and articles by John Wilding. Some form of independent high-speed spindle on the cross-slide is necessary, as ordinary turning speeds are not high enough, particularly when using fly-cutters. Once you have provided such a spindle, it needs to be driven so that it will keep going when you move the cross-slide, using either an overhead lineshaft, a motor on the cross-slide, or some arrangement with pulleys and springs to keep up the belt tension. On this machine, everything except the cutter frame is fixed in place whilst working.



2. A view showing the vertical slide and the division plate with its detente

The great advantage of a wheel-engine is the sheer speed of cutting wheels one after another. Once the blanks have been turned to size, cutting the teeth is easy, and the machine needs little resetting until you need a ratchet or an escape wheel. It works equally well with slitting saws and flycutters, and it will cut wheels up to about 5in. diameter. Apart from the cutter pivots and the spring, everything can be made from bright mild steel (BMS). As can be seen from the drawings, both slides are fabricated, and this has meant using lots of screws. You will need to stock up with these before you start, mainly 5BA and 2BA.

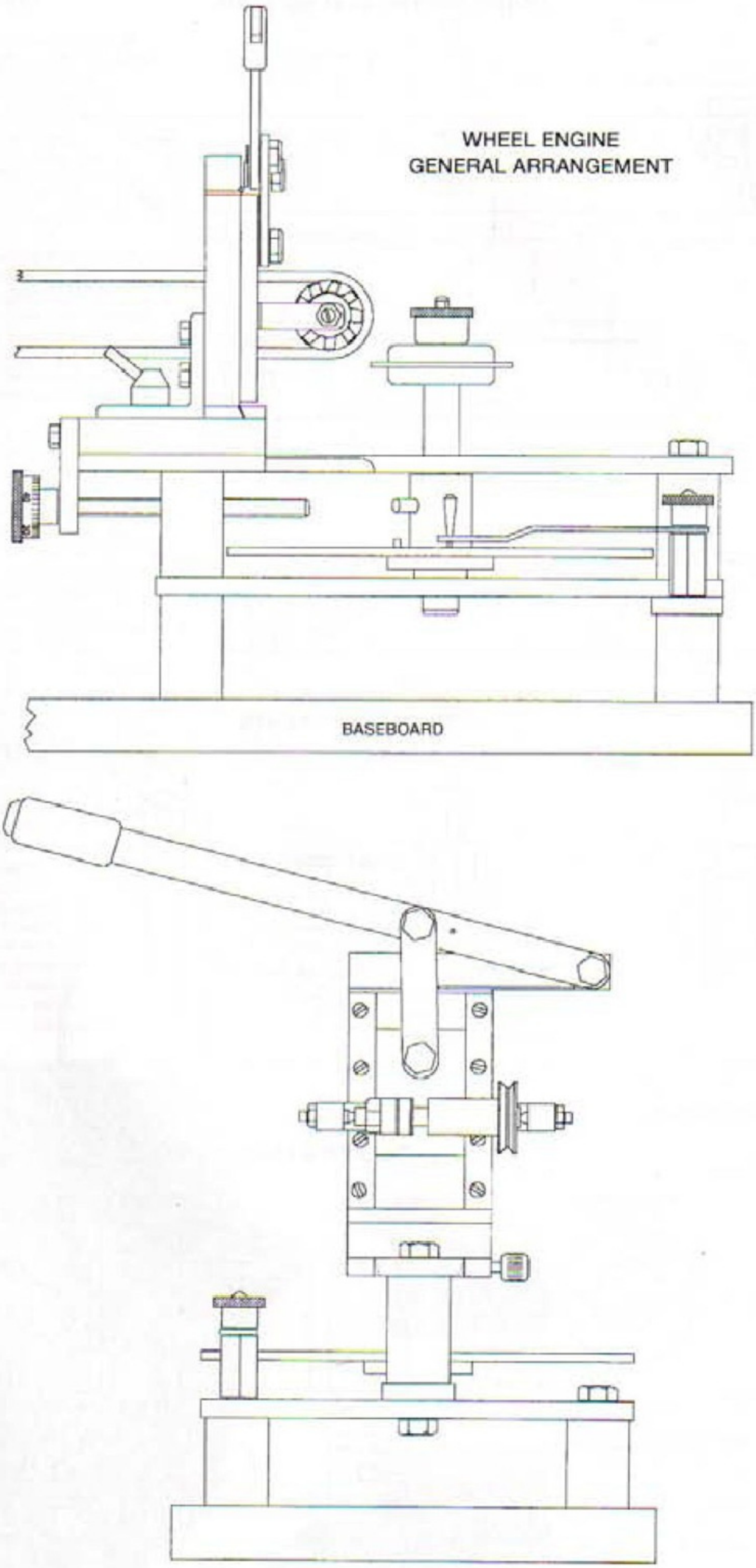
The drawings included in this article have been examined and sniffed at by a professional engineer, probably quite rightly, as not observing all the conventions. Perhaps the fit-as-you-go approach described here will horrify him even more. I would therefore stress that the drawings and the text need to be read together. I am full of admiration for real engineers but I am not one of them, having originally been an ordinary wood modeller enticed into engineering by LBSC's Tich many years ago.

Main Frame

The machine as drawn will accommodate division plates 6in. or less in diameter; if yours are bigger than this, the two frame pieces need to be lengthened to allow for it. The only commercial plate I own is 6in. across and originally had a 1/2in. bore that had to be enlarged to 7/8in. to fit this machine. There is nothing sacred about this latter dimension; if you already mount division plates on the headstock of your lathe, make the hub to fit them.

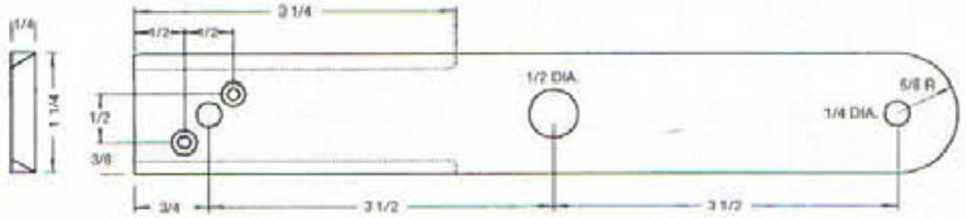
The two long frames should be clamped together to drill the 1/4in. holes at the ends and then bolted together through these holes to the faceplate to bore the 1/2in. central holes exactly in line. The frames can then be assembled with the two pillars to spot the 5BA tapping holes into the square pillar, which is first fixed to and lined up parallel to the edge of the bottom frame. The plain part of the hole in the square pillar is only used to accommodate a locating peg whilst these two screw-holes are spotted through. I used pieces of 1/4in. BSF studding as fixings for the legs and pillars, and the detente-holder serves as a nut for one of the legs. The legs are tapped 1/4in. BSF independently at each end, mainly because my tap was not long enough to go all the way through.

Now for the hard bit! Not having any means of milling at the time I made this machine, the 60 deg. angled section of the top frame (and of all the other parts needing it) were done with files. Modest accuracy was maintained by using a piece of 1in. A/F hexagon bar and clamps as a filing guide, but the main ingredients were frequent testing and endless patience.


WHEEL ENGINE
GENERAL ARRANGEMENT
BASEBOARD

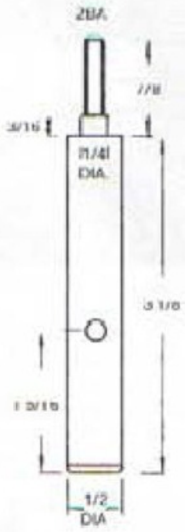
Main frame and spindle

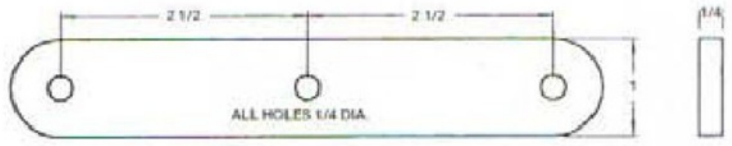
TOP FRAME



SPINDLE

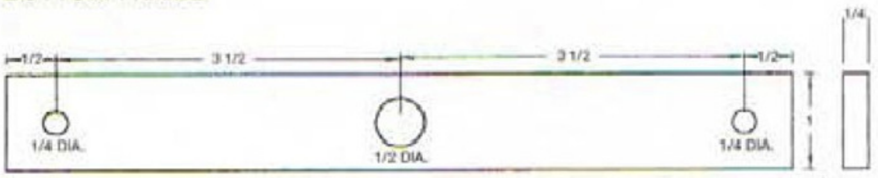
1/2" DIA. BMS



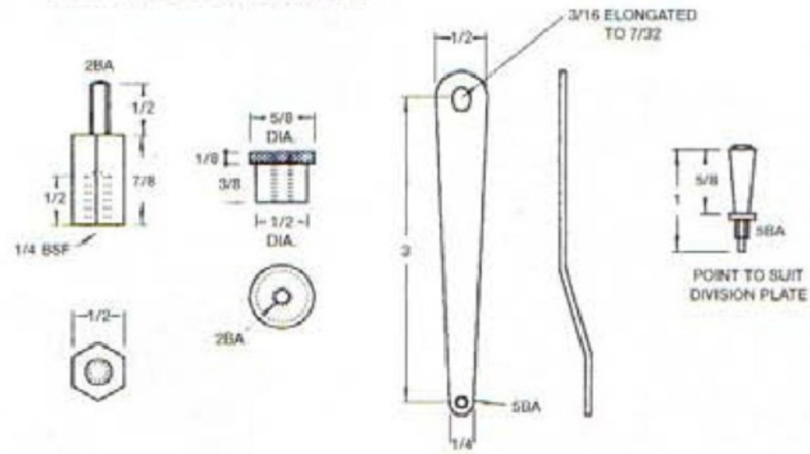


CROSS FRAME

BOTTOM FRAME

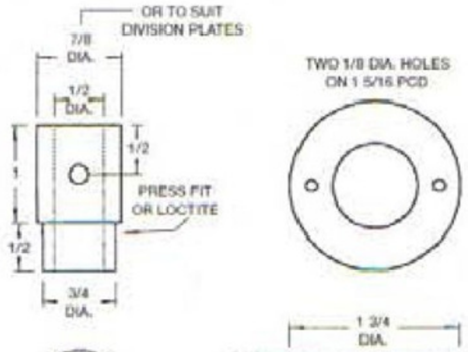


DETENTE COMPONENTS

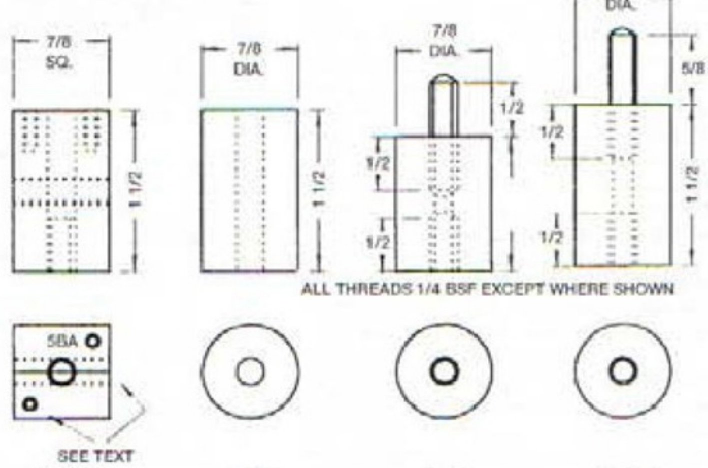


WHEEL CLAMP

HUB COMPONENTS



PILLARS & LEGS SEE TEXT



Horizontal Slide

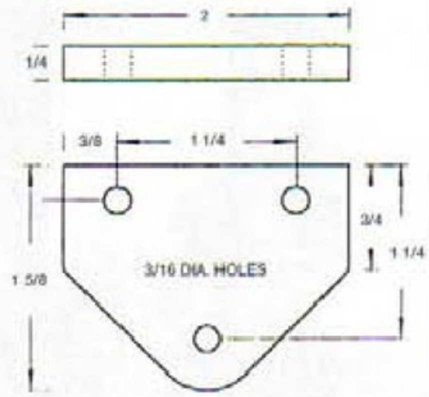
The narrower shears needing this 60 deg. angle may be produced more easily, and **Photo. 3** shows a method of producing them on the faceplate; they could probably be milled whilst held on an angle-plate on the cross-slide in a similar way. Whatever method is used, the difficulty of holding these small sections almost dictates making them on the edges of a larger piece and then sawing them off when complete.

The effort to show all the screw-holes in the bodies of the two slides of this machine has ably disproved the old adage that a picture is worth a thousand words. Suffice it to say that all the holes are spotted through from dimensioned parts, the 1/4in. BSF hole can be drilled right through, and all the others are drilled 3/8in. deep.

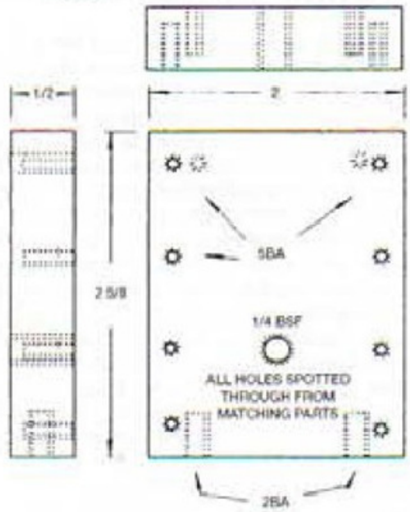
Before the holes are spotted through to the body, the shears should be tried in place with the frame and gib strip, to make sure that the sum of the widths can be accommodated without anything projecting beyond the 2in. width of the slide body. The shears can then be fixed in place with 5BA bolts or CH screws and the gib fitted with socket grub screws. The dimples in the gib to hold it in place should be spotted through whilst it is held by one of the grub screws and then enlarged afterwards to 1/8in.. Once a good sliding fit is achieved, the apron can be fixed to the slide and assembled on the frame to spot the hole through for the feed screw, choosing between metric and Imperial. There is a rare meeting here between the two, because the fifty divisions on the feed knob will do equally well for both 1/4in. BSW (20 tpi) and 6mm (1mm pitch) studding. Because of the gib strip, the hole for the feed screw may not be central in the pillar but this does not matter. The graduations on the feed knob were made with a screwcutting tool held sideways, and using one of the brand-new division plates just then completed.

Finally, the cross-shear can be fixed in place, but drilling the 1/4in. BSF hole for the bracket must await the completion of the vertical slide.

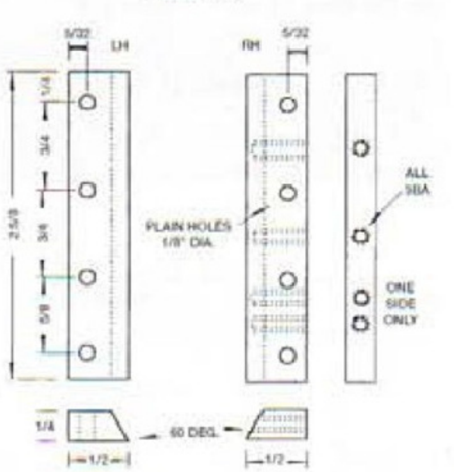
APRON



BODY

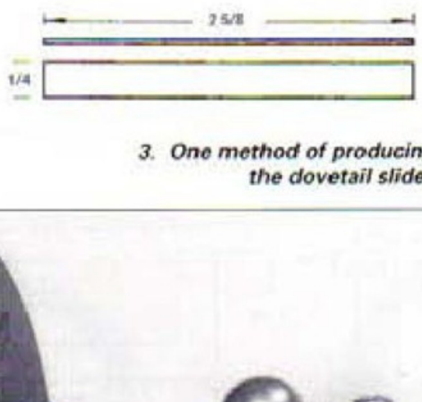


SHEARS

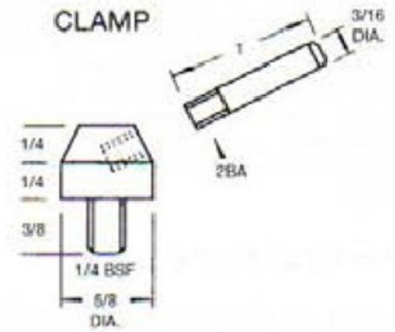


GIB STRIP

16SWG

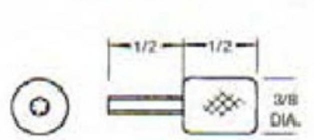


CLAMP

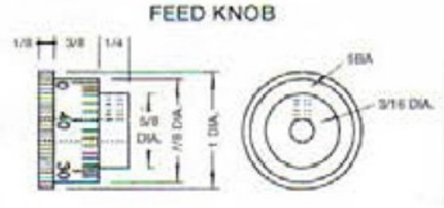


FEED SCREW

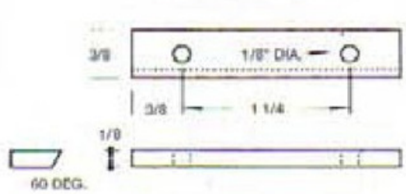
GIB LOCK



FEED KNOB



CROSS SHEAR



3. One method of producing the dovetail slides

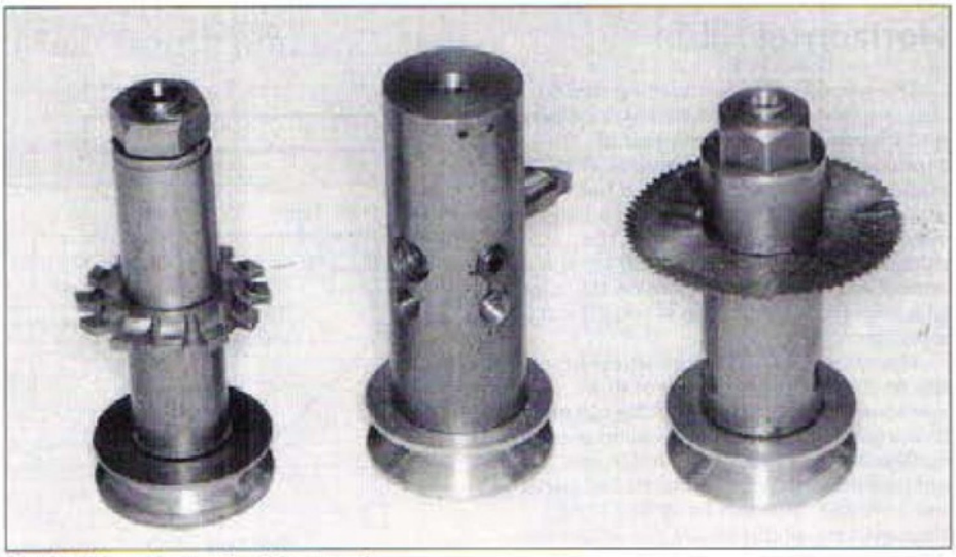
The hub and spindle

The hub which carries the spindle and the division plate includes a separate collar which is fixed with Loctite or pressed on, and then trued up on a mandrel. This was made in two pieces only for economy; it can of course be turned from the solid if you prefer. The spindle has to be removable to change division plates and is locked to the hub by a pin, the hole for this being drilled with the spindle in place (the Nutlock variety of Loctite will hold it temporarily). The two location holes in the collar can then be spotted through to each of the division plates to be used. **Photo. 4** shows the finished hub and spindle. So far, I have made only one spindle, and all my clock wheels have started with a 3/16in. hole to fit it. The hole can be bored larger afterwards by holding the wheel by the teeth in a cavity bored in a piece of wood held on the faceplate. This apparent back-to-front sequence seems to be the usual method, and it may be another one of those not-very-proper engineering customs that clockmakers love, like rattling-fit pivots. We must remember that clockmakers knew what they were doing long before 'proper' engineering ever got going!

Vertical Slide

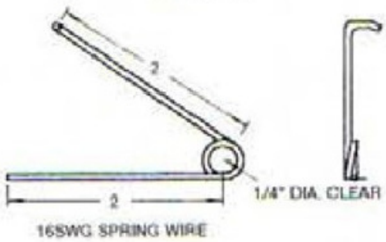
The 60 deg. angled parts of the vertical slide, including what I have called the foot, can all be produced in the same way as already mentioned, but this time they all need countersunk holes. Once the foot has been fitted, the bracket can be fitted as well, making sure that the slide stands up at 90 deg. The position of the 1/4in. BSF hole in the horizontal slide can then be marked, drilled, and tapped. The bracket should then be fixed in place with the clamp screw (no handle yet) finger tight, so that the position of the handle can then be marked to give 90 deg. turn each way. Don't reach for the Loctite here; the handle needs to be removable until the machine is finished.

The part I have called the Stop is fixed under the pivot block to limit the return travel of the slide, and as a rest for the spring. The spring is merely one turn of 16swg spring wire round a 1/4in. bolt held in the vice, and one end is bent to be anchored in the handle. The part of the pivot block shown as shaded is a bevel, filed just wide enough to tuck in the bottom end of the spring, so that it does not foul the handle in operation.

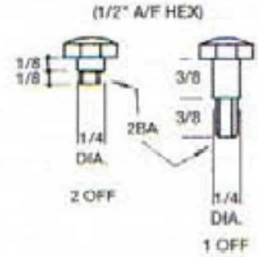


4. The three types of cutters used

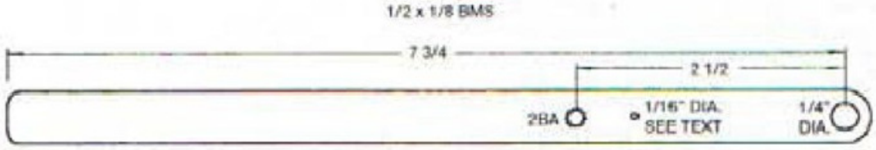
SPRING



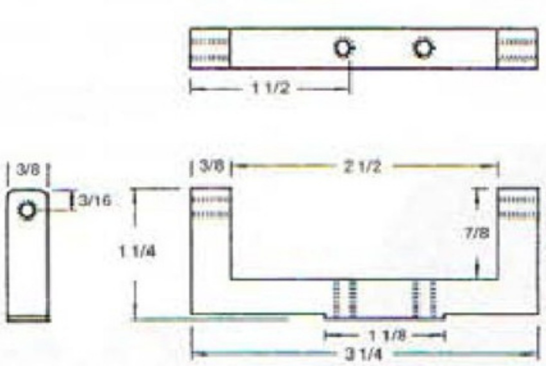
HANDLE PIVOTS

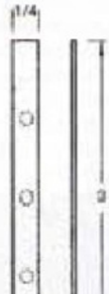


HANDLE



CUTTER FRAME

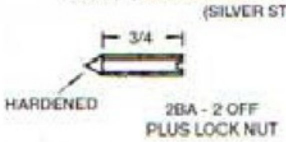




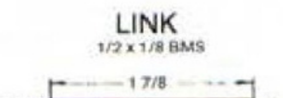
GIB STRIP

16 SWG

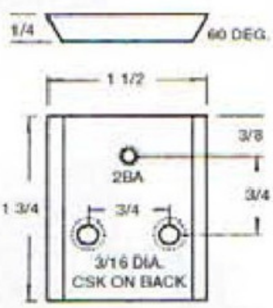
CUTTER PIVOTS



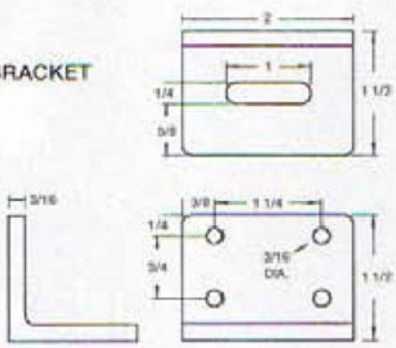
LINK

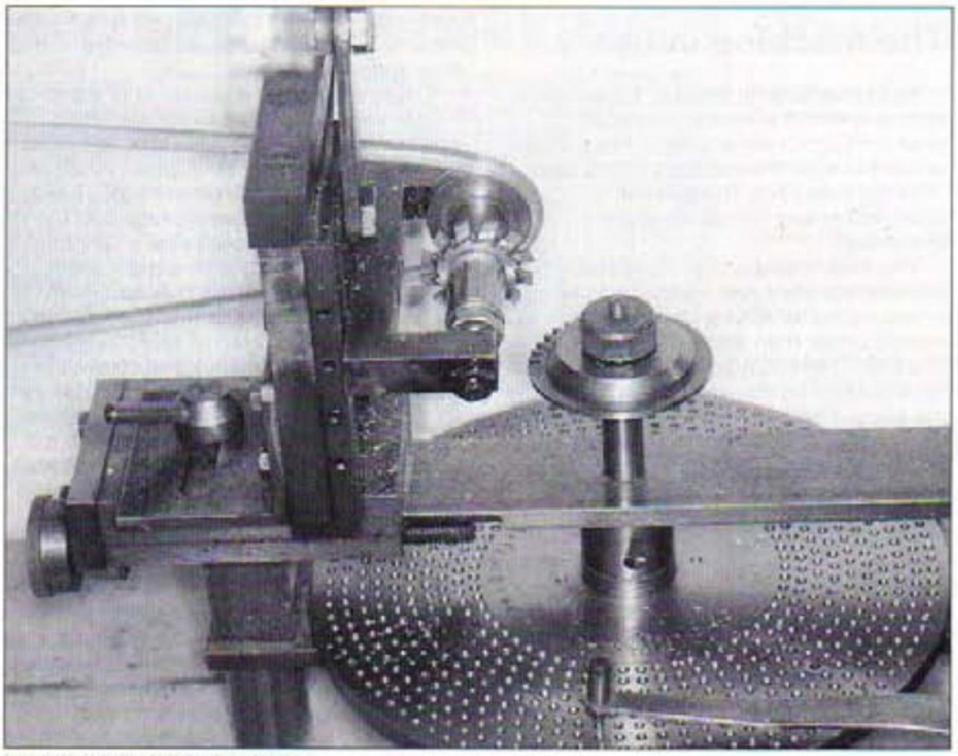


SLIDE



BRACKET



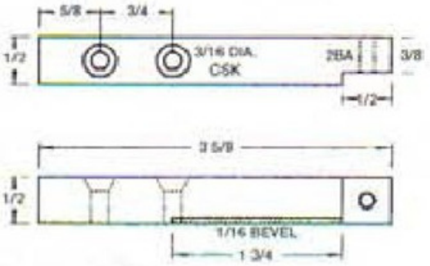


5. Wheelcutting in progress

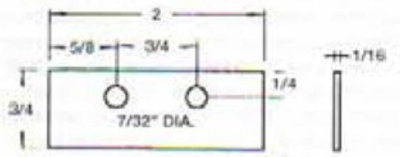
Cutter frame

The cutter-frame is a plain sawing and filing job, and I am grateful to Mr Wagstaff (MEW 56) for the reminder that if the motor to be used runs clockwise, the cutter frame needs to be fixed the other way up, with the pulley on the other side. Although not shown on the drawings, I have had to file a notch in my cutter frame to accommodate the smallest slitting saw I have.

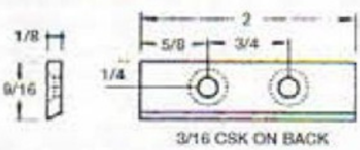
PIVOT BLOCK

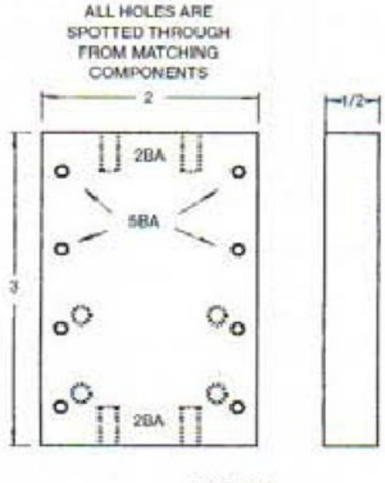


STOP

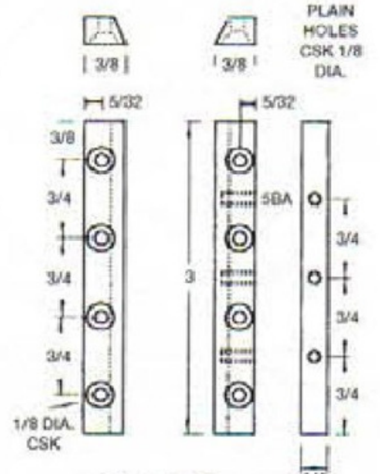


SLIDE FOOT



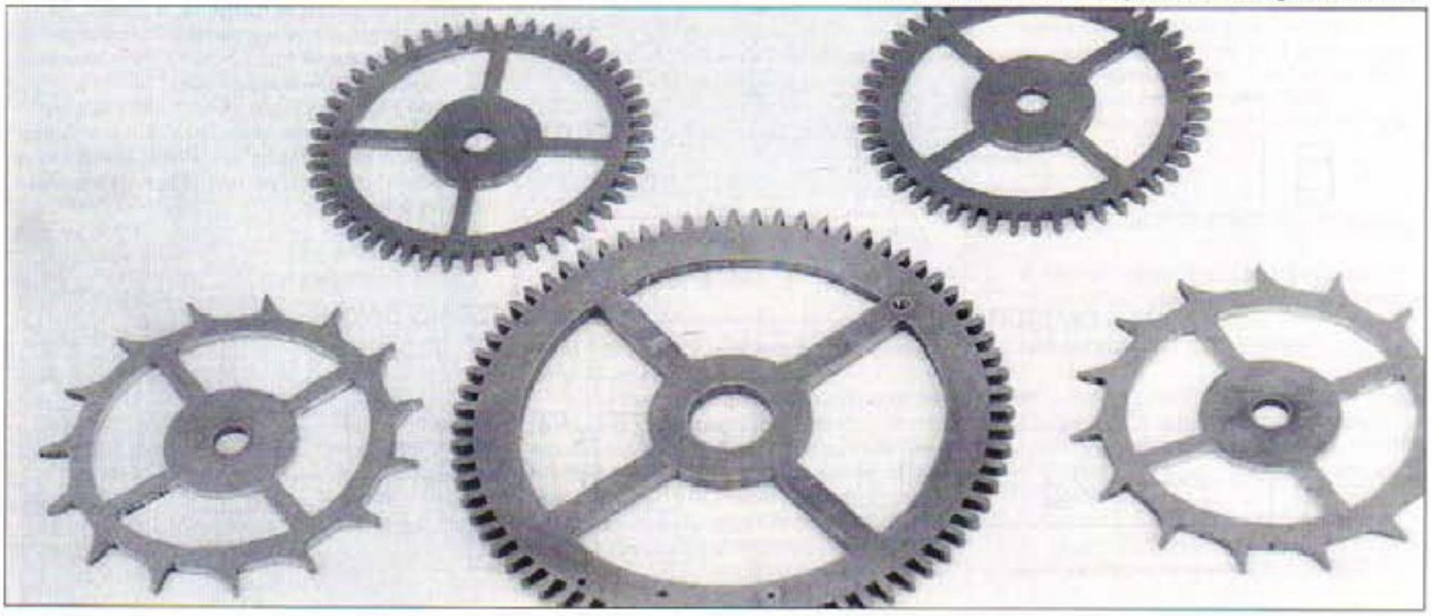


BODY



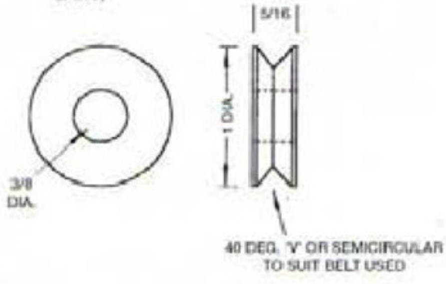
SHEARS

6. A selection of wheels produced using the machine



Accessories

PULLEY
(3 OFF)



The machine in use

As can be seen in **Photo. 1**, I am using a sewing machine motor on a sliding platform behind the machine, fixed when in use but accommodating varying sizes of wheel being cut. The belt will comfortably accommodate some stretching.

The thick washers used to support the wheel blank are a real necessity, in order to reduce the vibration. I have not cut wheels larger than 4in. yet, but beyond this size, I think that an additional support fixed to the frame near the periphery of the blank might be necessary. Using commercial cutters, the only sounds are the motor and the hissing from the cutter. If there are any knocks, thumps, or noisy vibration, then something is wrong.

It will be noted that there is no clamping of the division plate when in use other than by the detente pin. This must therefore be a very close fit in the hole, and you may need to make more than one detente arm if your division plates are from different sources.

I have shown the three kinds of cutter-holder that I have used so far, including one for a small slitting saw. This latter one was first made to cut an escape wheel, and the bulk of metal was removed afterwards with a fretsaw. This may be regarded by those in the know as a coward's way out, but I feared that with such slender teeth, removing so much metal between them with a fly-cutter might come to grief on the very last and unsupported tooth!

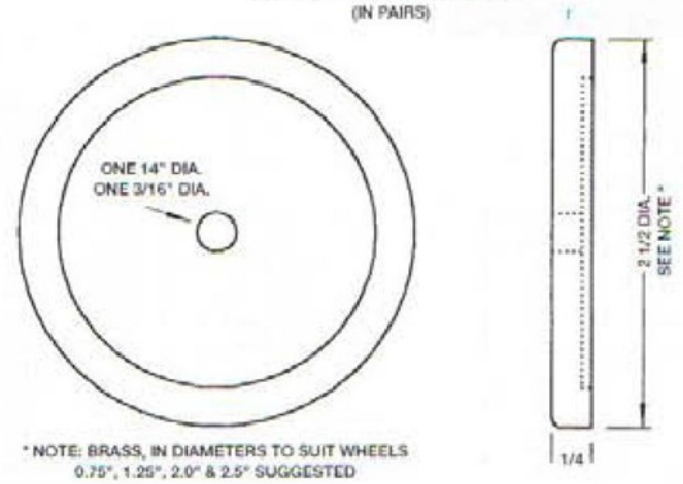
According to your choice of screw, the feed knob allows adjustment of 0.001in. or 0.02mm, but in practice it is not needed to cut ordinary clock teeth. The precision job is that of turning the wheel blank exactly to size, using the formula (No of Teeth + 2.7) x Module. The blank for a 64-tooth wheel using .75 Module, for instance, therefore needs to be 50.02mm in diameter.

The cutter is positioned approximately to cut two adjacent teeth (two adjacent gaps really) and the feed is then increased with successive cuts until the flat on the end of the tooth being produced just disappears. It helps if the edge of the wheel is marked with blue first. The horizontal slide is then locked and all the other teeth can then be cut in one pass each. **Photo. 5** shows a wheel being cut and **Photo. 6** some others that have been made.

Of course, using commercial cutters gives the best results, but it becomes frightfully expensive if you need a range of modules and more than one size within each. On wheels, but not pinions, the width of each tooth and the gap between them on the PCD are supposed to be equal, which means that theoretically, each size of wheel within the same module requires a differently shaped gap between the teeth and a different cutter. In practice, about a dozen sizes of cutter deal with the entire range up to a rack, and for wheels even this can be fudged. On the Wilding alarm clock I am currently making, the No 2 cutter for 55T-134T is recommended for the whole clock, the two 39T wheels that mesh with each other being accommodated by a second pass of the cutter with the division plate slightly offset. This is the reason for the slotted hole in the detente of this machine, a small adjustment allowing the second pass to shave the tooth form closer to the ideal.

Sensible precautions must be taken when cutting wheels: wear safety specs, keep your fingers away from the revolving cutter, and try not to use wheel blanks made of ordinary stringy brass, especially with a fly-cutter.

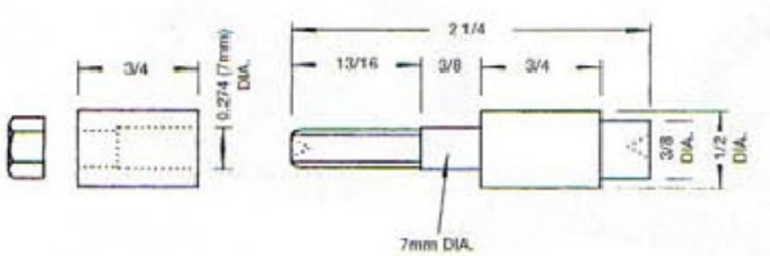
WHEEL SUPPORTS
(IN PAIRS)



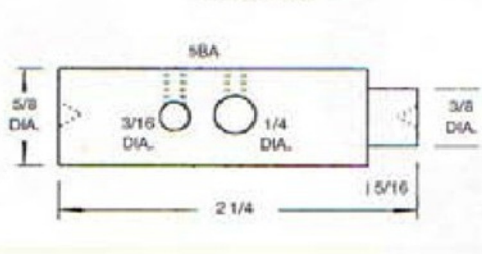
* NOTE: BRASS, IN DIAMETERS TO SUIT WHEELS
0.75", 1.25", 2.0" & 2.5" SUGGESTED

Cutter holders

GEAR CUTTER
1/2" DIA. BMS



FLY CUTTER
5/8 DIA. BMS



SLITTING SAW
5/8 DIA. BMS