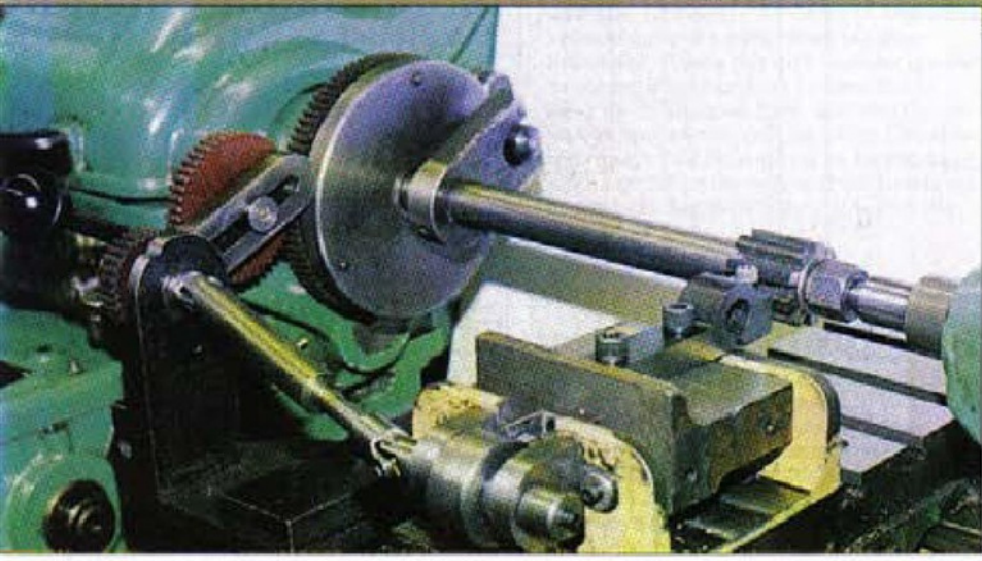
GEAR HOBBING IN THE HOME WORKSHOP

Part 2 - A DEVICE FOR MAKING GEAR CUTTING HOBS

The next stage of the gear hobbing process is to produce a suitable hob. Dr. Giles Parkes describes a lathe attachment which will form the teeth on a gashed hob blank



1. The device set up to cut and back off the teeth on a gashed hob blank

As discussed by Ivan Law in Part 1 of this series, a gear cutting hob is basically a worm with helical gashes and backed off teeth. The device to be described **(Figure 1)** produces a worm with axial gashes and backed off teeth, the cutting and backing off being done at the same time. The problem of cutting and backing off teeth on helical gashes is beyond me, but this device works, as do the hobs it produces, although not perhaps to professional tool room standards.

A hob with nine teeth on its circumference will need a device to produce it which puts cut on and retracts the tool nine times per revolution. This action is provided by a ninety tooth gear on the back of the catch plate **(Figure 2)** driving, via an idler, a thirty tooth gear mounted on a spindle revolving in a column attached to the lathe bed; this in turn drives a three lobed cam via a flexibly jointed shaft, the cam pushing the tool forward nine times per revolution, with springs pushing it back **(Photo. 1)**.

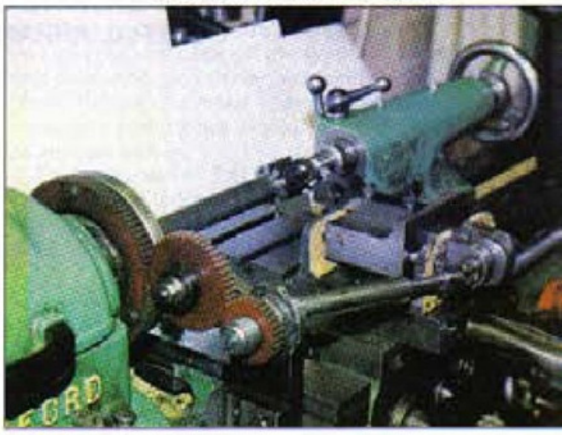
The device

You first require the ninety tooth gear and, being in a chicken and egg situation, you will have to cut this gear one tooth at a time. Great accuracy does not matter in the first instance as you will soon be able to cut an accurate one when you have a hob and hobbing machine. This device is designed to fit a Myford Super 7: Myford gears are 20DP 14.5 deg. Pressure Angle (see Issue 56), so the blank for your ninety tooth gear needs to be 4.6in. diameter. It will need to have its centre removed so that it fits over the lathe register and the nut of the catch plate peg and it is then fixed concentrically onto the back of the catch plate with 2BA screws and 1/8in. spacers. I drilled and tapped the fixing holes first in both gear and catch plate and took the centre out with the gear fixed to the front of the catch plate. That is all the gear cutting done, as you use the Myford thirty tooth gear and any appropriate size gear for the idler.

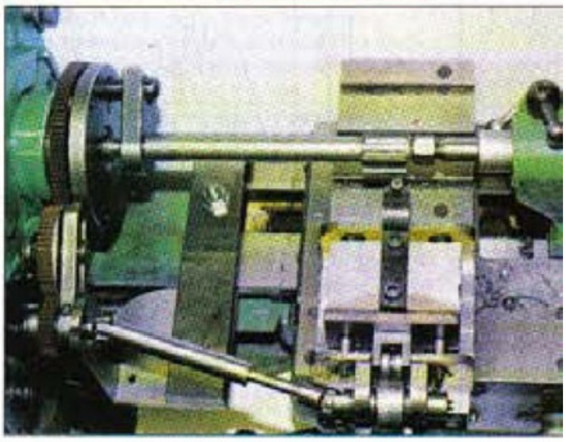
The thirty tooth gear is keyed to a spindle which runs in a column attached to the front of the lathe bed **(Photo. 2)**. The latheway bracket (13) fixes to the lathe bed and supports a horizontal pillar bracket (16) on which the pillar (18) stands. A banjo (17) is also attached to the column to carry the idler **(Photo. 3)**. The universal joint on the gear spindle (19) and the spindle itself are made from 5/8in. bar with a 5/16 x 7/16in. slot in its end, the 3/8in. spindle being turned on the other end. The other side of the first UJ (24) is 5/8in bar, also with the 5/16in. slot. It is drilled axially 5/16in. and slotted 1/8in. for most of its length. The lugs of the UJs are cross drilled 3mm or 3.15mm if you must, and just opened out with the tip of a 1/8in. hand reamer. The swivel is made from 5/16in. square 1/4in. long and cross drilled 1/8in. in both 5/16in. dimensions. 1/8in. silver steel is used for the pins, one of which is 5/8in. long, but the other two are 1/4in. each with 1/8in. knurl on one end. The long pin is pressed in first, using the vice, followed by one short one from each side, knurled end going in last of course. I am told that commercial UJs in this size have only external lubrication, which is what these home made ones are going to get.

The other end of the drive for the cam is a second UJ (25) but this time the long arm is 5/16in. round with a hole cross drilled for a 1/8in. pin which slides in the hole and slot in the first UJ long arm (24) **(Photo. 4)**. The other end of the 5/16in. is glued into the 5/8in. bar which forms one side of the second UJ, the other end of which provides the spindle (7) for the cam, 3/8in. diameter running in two cheeks attached to a section of channel. The cam (6) is keyed to the spindle and retained

2. Tufnol gears are used in this gear train. The ninety tooth wheel is attached to the rear of the catch plate



3. The angled bracket which supports the gear train is clamped to the bed of the lathe



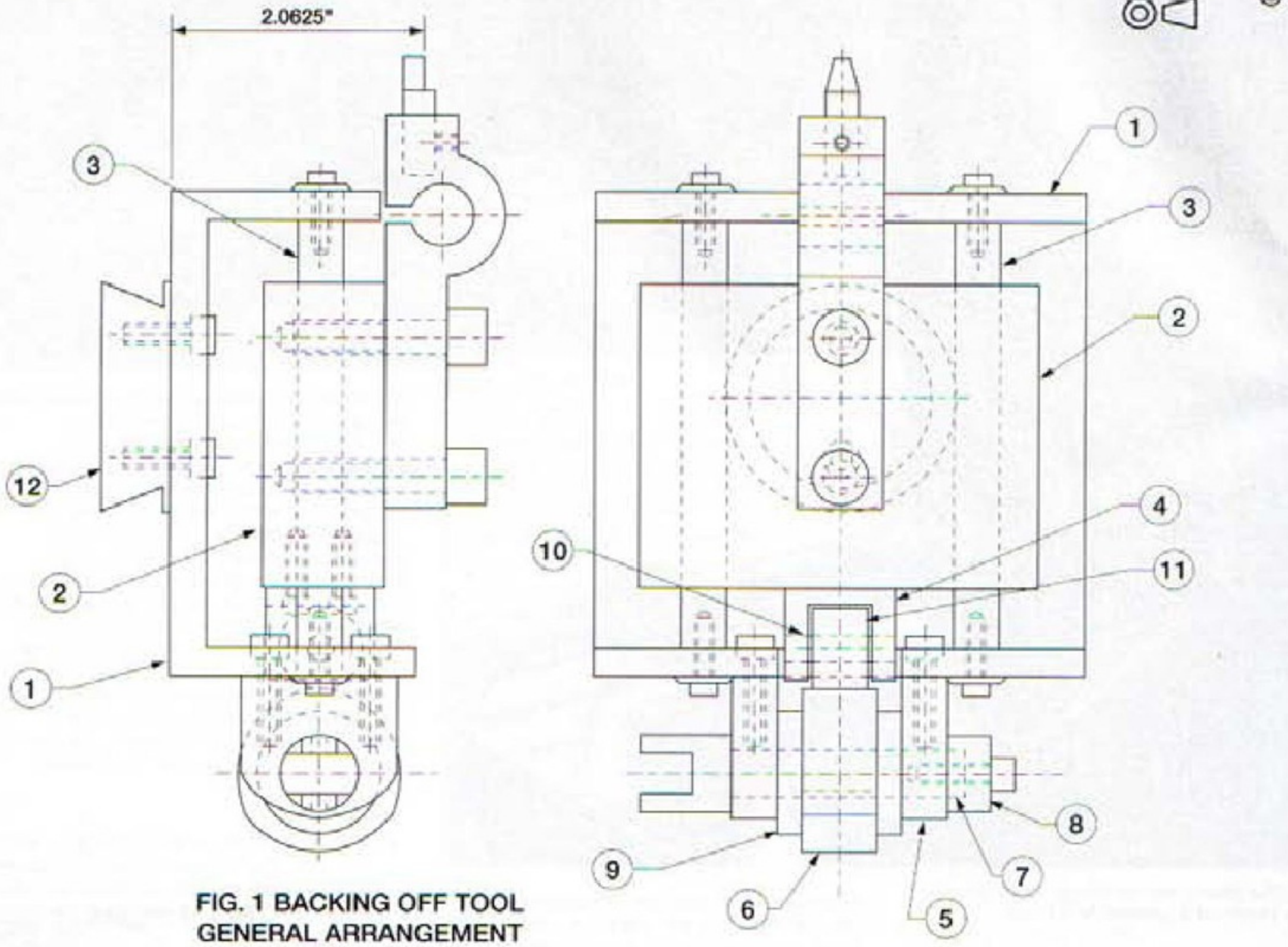


FIG. 1 BACKING OFF TOOL
GENERAL ARRANGEMENT

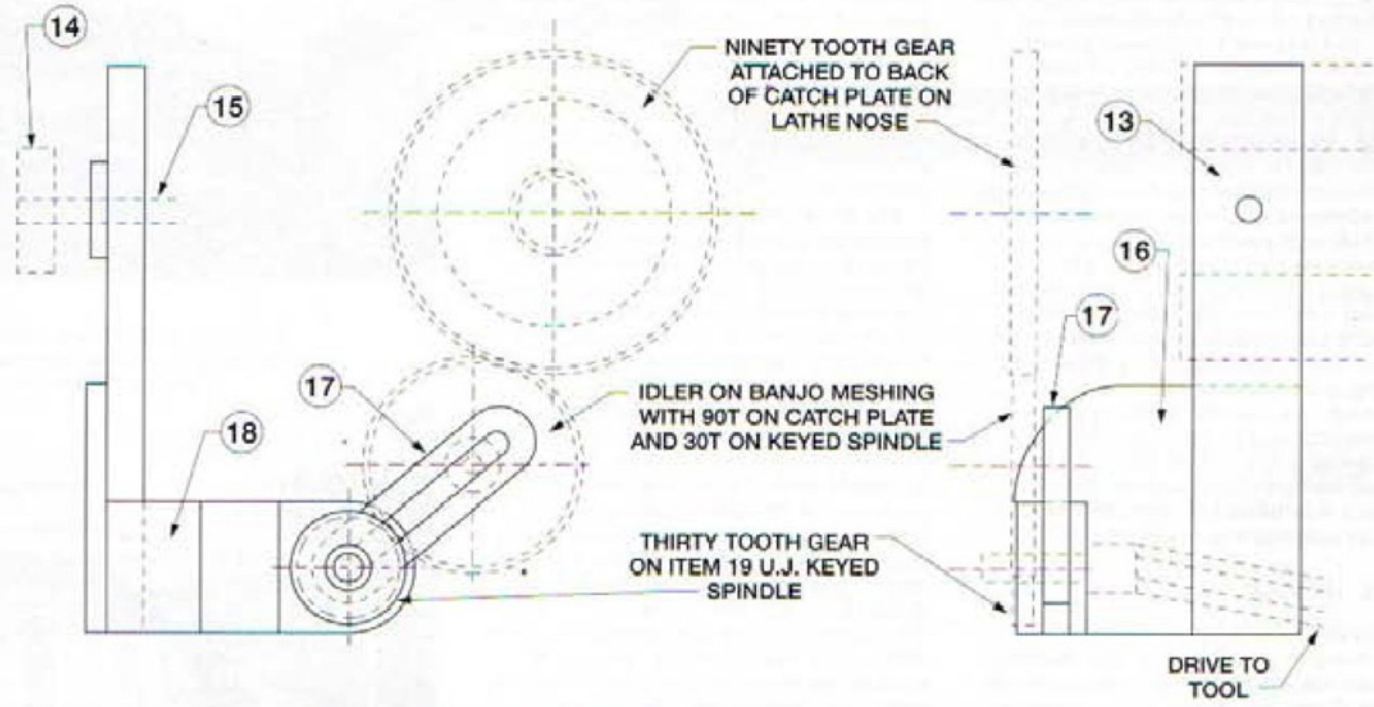


FIG. 2. BACKING OFF TOOL
GEAR TRAIN BRACKET
GENERAL ARRANGEMENT

between the cheeks by a cap (8) on the end of the spindle. Spacers (9) make it all snug **(Photo. 5)**. The cam (6) itself has three high spots and is made from a piece of 1.4in. diameter x 5/8in. mild steel. It is perhaps better left slightly larger on diameter and bored and reamed 3/8in. then a 1/8in keyway cut in it to a depth of 1/16in. A mandrel is made from any conveniently sized piece of hexagon which is turned down and keyed to be a good fit in the cam blank which, when fitted, is turned to 1.4in.. Marks are then scribed on the blank circumference at 120 deg. spacing, but these must be in correct relationship to the flats on the hexagon. With the hexagon in the three jaw chuck and one jaw towards you, clamp a square to the hexagon so that the long arm of the square is parallel to the lathe bed, across the ways; the face of the hexagon should thus be vertical and a line can be scribed on the circumference of the cam at centre height. You may find that the mandrel lock will secure the chuck in exactly the right position. If so, loosen the hexagon and turn it 120 deg. and scribe another line on the cam then repeat for the third line. If the mandrel does not lock in a suitable position another method of dividing will have to be used - e. g. - a mandrel dividing head. We now come to turning the cam throws: pack the jaw of the chuck which has a line on the blank in line with it with a 3mm packing and tighten the chuck. Machine the blank to a depth of 30 thou. and each end of the cut should touch a line. If they do not you will have to increase the thickness of the packing with shims, but do not be tempted to increase the depth of cut. Leaving the packing against the jaw, move the hexagon round 120 deg., repeat the cut for the other two cam faces and you should have a fairly accurate three lobed cam. If the cam faces extend beyond the scribed lines, all is not lost, but you will end up with a slightly smaller cam with a slightly different throw. This can be compensated for by the relative position of the carriage - up to a point! Don't case harden the cam yet as the tips may not all be concentric; stoning the tips when the tool is set up produces a practical solution to the problem, and the cam can then be hardened.

The chassis (1) of the tool is a piece of 4in. x 2in. channel with the bottom machined flat, both inside and out. A slot will be needed in one side for the eccentric device, the cheeks (5) of which are fixed to the side of the channel with cap head screws. A spigot (12) is fixed to the bottom to fit the hole in the Myford cross slide.

The carriage (2) is a block of cast iron. It needs both top and bottom to be machined flat and is then clamped to the Myford cross slide together with the chassis, parallel spacers between to bring the carriage to correct height for drilling. The holes for the two rails are drilled and reamed right through both chassis and carriage. You may have to improvise a long enough drill which will go right through at one setting. I used a normal machine reamer to its full depth first and then a home-made silver steel reamer with an oblique face to follow it for the last bit. Two 3/8in. silver steel or PGMS rails (3) were cut to length and held in the chassis by screws in the ends and washers, after spot facing the chassis holes. The carriage must be a good sliding fit on the rails.

Fixed to the back of the carriage is a bracket (4) for the roller onto which the cam bears. It is straightforward and I used two 5/8in. x 1/4in. roller bearings with a spacer between for the roller (10).

The tool holder is the swan necked device described in MEW No 29 and is held onto the cast iron carriage with 5/16in. BSW cap heads. A second tool holder, with the tool offset from the centre line, makes life very simple for backing off the crests and need not be swan necked.

The return springs on the two rails between the chassis and carriage at the front are each half of the spring from the Myford tool post and seem about the right strength. Obviously the order in which the various parts are assembled is rather important. Finally the tool must be ground to shape; it is important for the tool to have nil or negative back rake and I used an old 1/4in. centre drill, of which I have far too many! The tip width is as for the axial pitch and DP of the hob and the tool is set to the helix angle by a datum flat on the side.

The hob

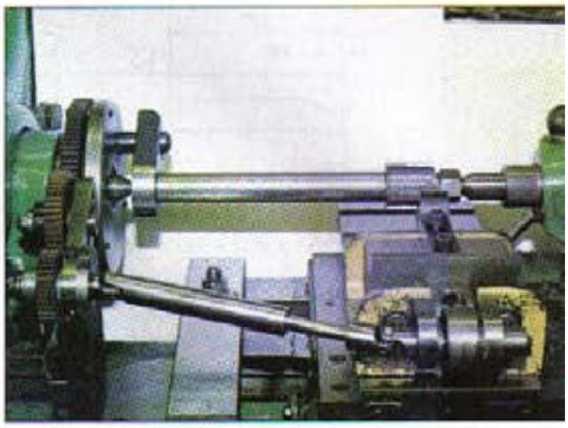
First and foremost is the question of what material to use for the hob. 20 carbon steel case hardened will probably be adequate for cutting gears in aluminium, brass or Tufnol, so this is where I started. Having made one hob, I progressed to thinking about silver steel and high speed steel. Both are possibilities but the necessary heat treatment is not easy to arrange although it is hoped that one supplier will be able to organise something in this direction. My hob blank is made from 1 1/4in. inch bar of 20 carbon steel which was cut to length - about one inch - and drilled and reamed 3/8in. to fit the hobbing machine hob spindle.

Gashing the hob

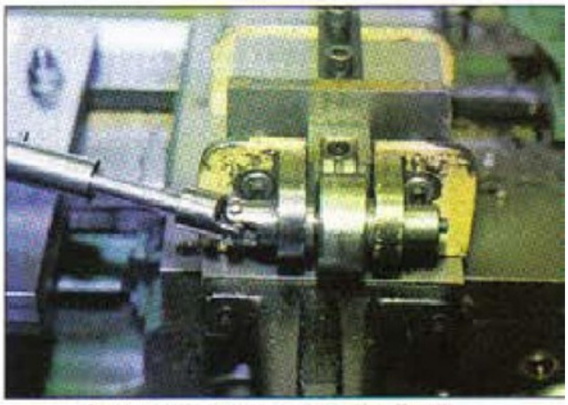
The blank is set up on a mandrel in a dividing device and nine equal axial gashes are cut. The 1.25in. bar has a circumference of 3.928in. and dividing this by 18 gives 0.218in. for each tooth and each gash. To allow for each tooth to be fully backed off, every gash should be slightly wider than every tooth - say 0.225in. for the gashes. Using a 0.075in. slitting saw - because I have one - in the vertical mill, the blank is gashed 0.145in. deep so that the top edge of the cut is on a radial line: the blank is then indexed round for the next cut and so on, until nine are complete. The cutter is then lowered 0.075in. and a further nine cuts made to 0.155in. depth. The cutter is then raised 0.35in. and a further nine cuts made to a depth where the tip of the saw just meets the previous gashes. The cutting edges of the hob will, of course, be the radial slits and it is important that the gashes are marginally wider than the teeth.

Cutting the teeth

The emergent hob is mounted between centres on a mandrel and the gear train set up for the required DP, module or pitch. What you are basically cutting is a worm with the gashes already in it, but you have a choice; you can either cut the worm first



4. A telescopic shaft, equipped with universal joints, transmits the drive to the cam



5. The cam bears on a roller fitted to the end of the tool holder.

and then gash it and back off the teeth or you can cut and back off the teeth all in one operation on a previously gashed blank. Before you make your choice, consider carefully the Slow Drive Train paragraph below.

To cut the worm first, the tool is set up in the normal toolpost and set over to the helix angle of the worm and the worm is cut in the normal way to correct tooth depth, and the worm is then gashed. The tool is then set at the correct helix angle in the spring tool holder on the backing off device which is set up on the cross slide and geared to the mandrel. You have to fiddle with the tumbler gears with the leadscrew engaged so that the tool will cut evenly on both sides of the worm and you also have to fiddle with the engagement of the idler with the catch plate gear so that the tool begins to retract just after it reaches the back edge of the tooth. This fiddling is best done by turning the mandrel with a handle and with the back gear disengaged; it may be unorthodox but you will soon get the idea, and it works. (Incidentally, the cross slide is always returned to the right by disengaging the back gear and turning the mandrel handle). You then put on the cut so that it is only just cutting on the back edge of the tooth and continue to put on cuts at one thou. increments until the cut starts at the front edge of the tooth. Zero the dial and continue backing off to full tooth depth. Do not disengage tumbler or leadscrew, as you still have to back off the crests of the teeth.

I prefer the second option and cut and

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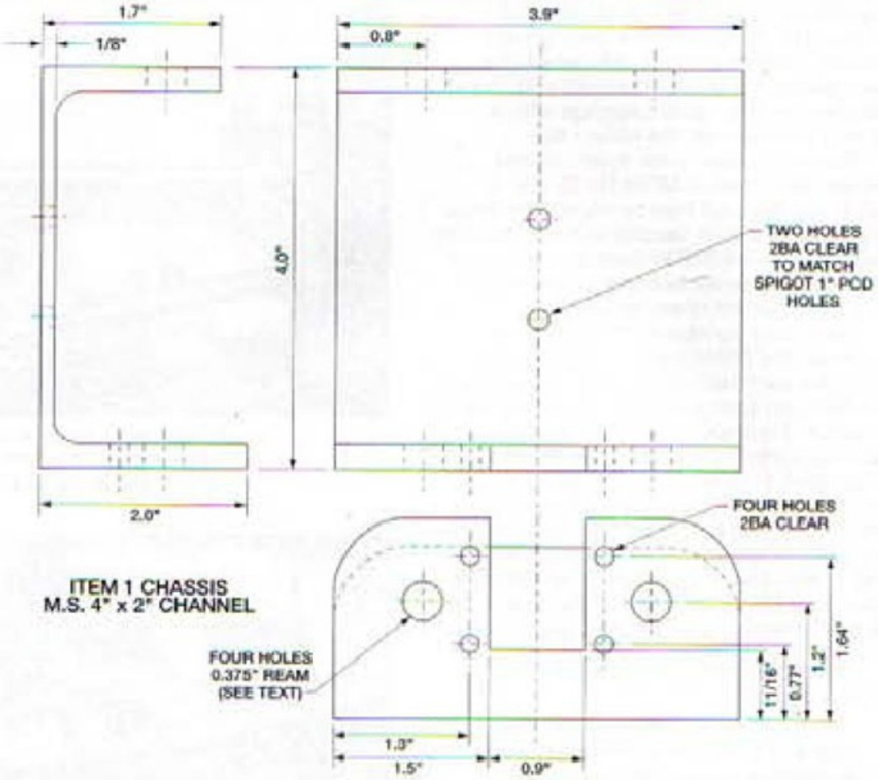
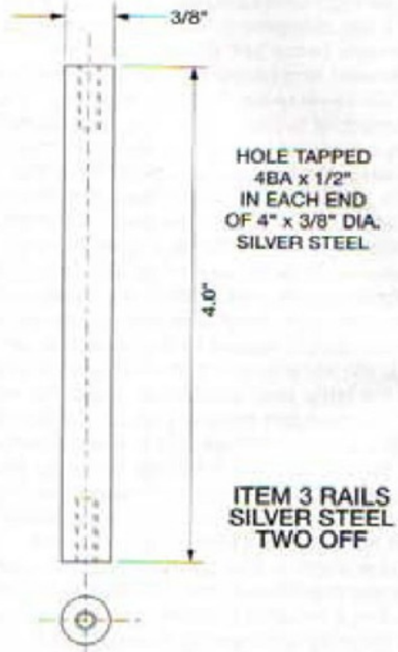
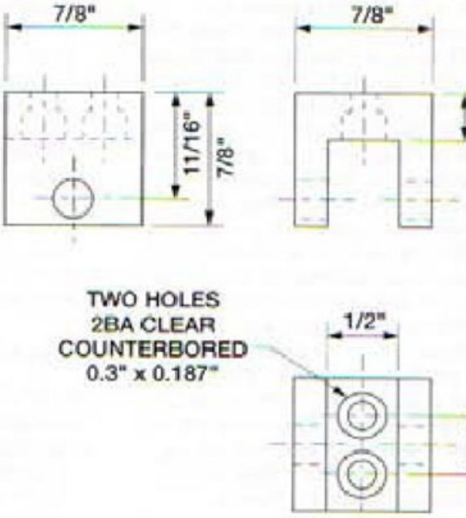


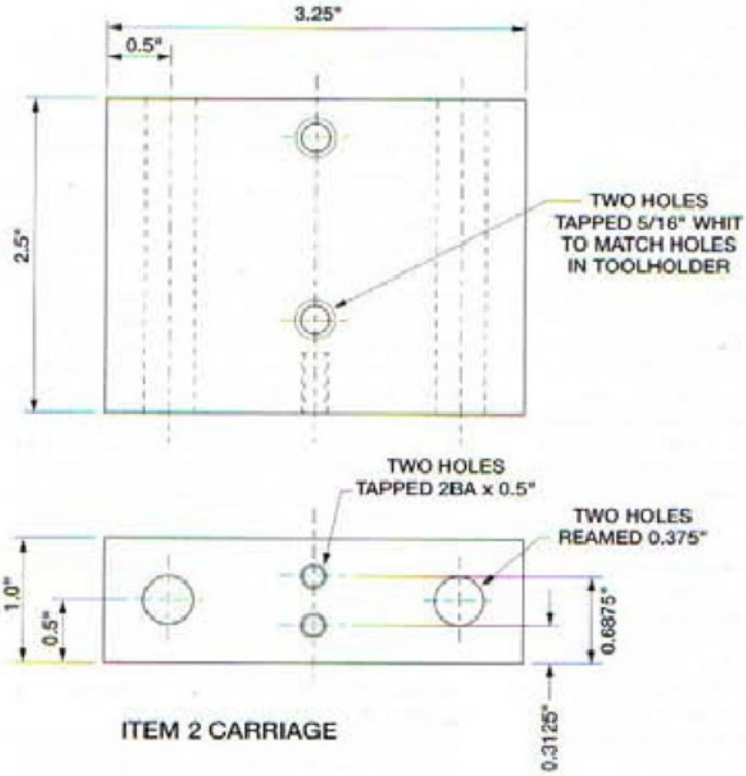
ITEM 1 CHASSIS
M.S. 4" x 2" CHANNEL



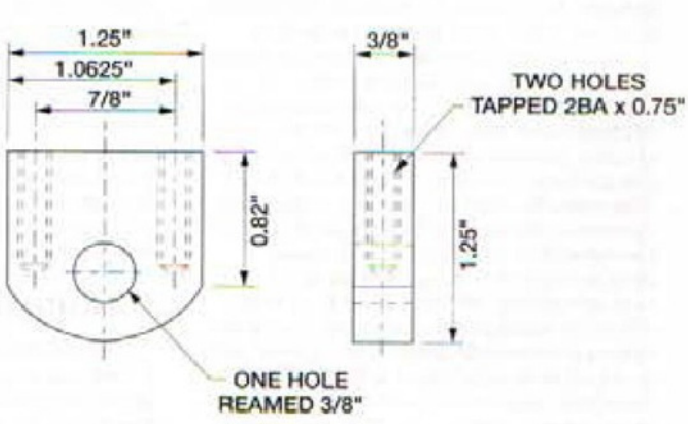
ITEM 3 RAILS
SILVER STEEL
TWO OFF



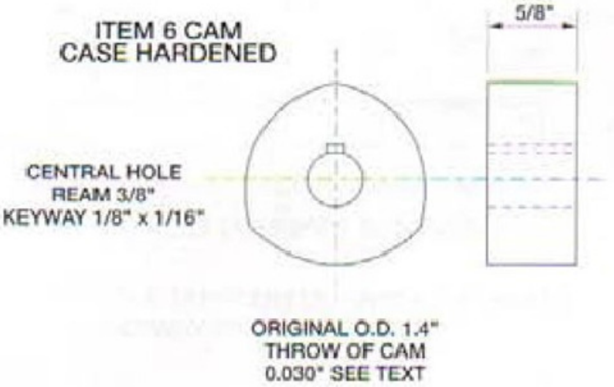
ITEM 4 ROLLER BRACKET
M/S



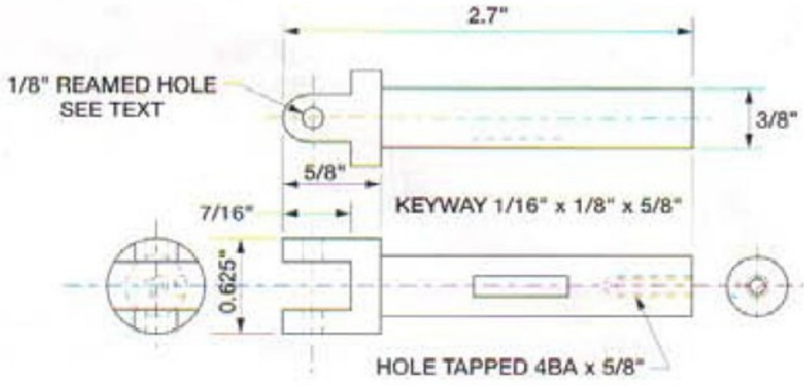
ITEM 2 CARRIAGE



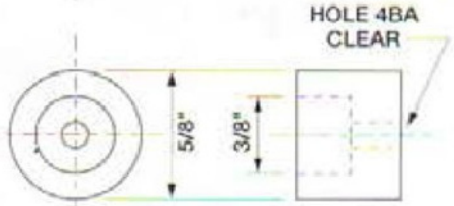
ITEM 5 CAMSHAFT CHEEKS
TWO OFF M/S



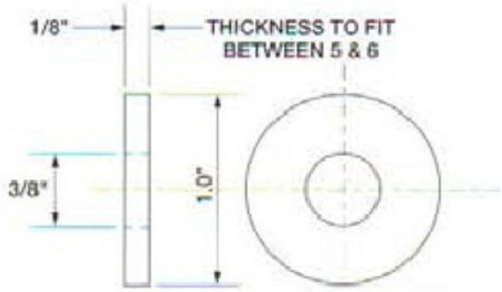
ITEM 6 CAM
CASE HARDENED



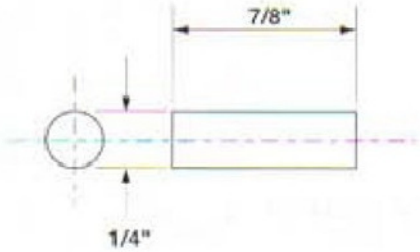
ITEM 7 CAMSHAFT
M/S



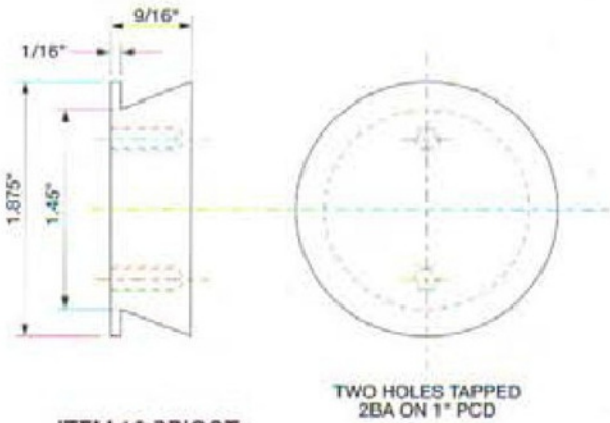
ITEM 8 CAMSHAFT CAP
M/S



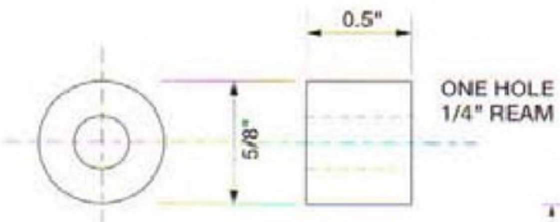
ITEM 9 SPACERS
M/S TWO OFF



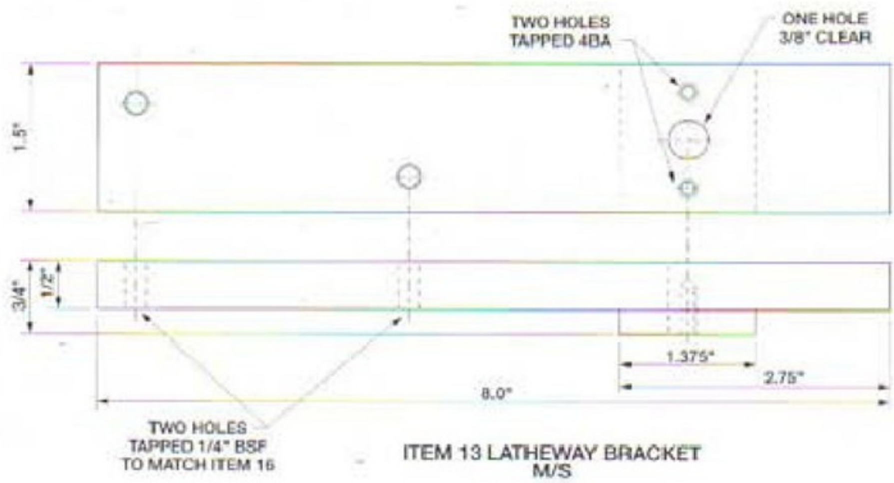
ITEM 10 ROLLER SPINDLE
M/S



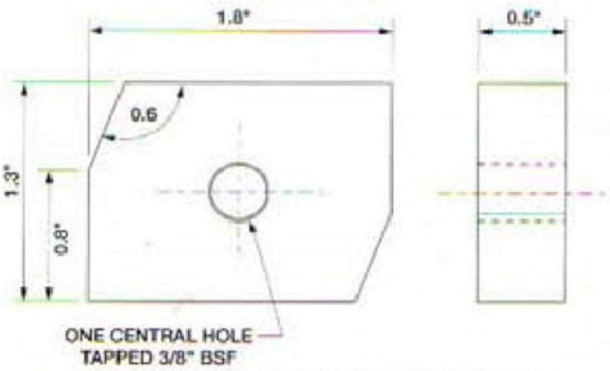
ITEM 12 SPIGOT
M/S



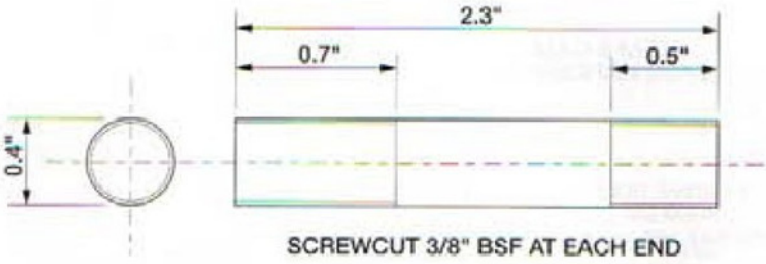
ITEM 11
ROLLER



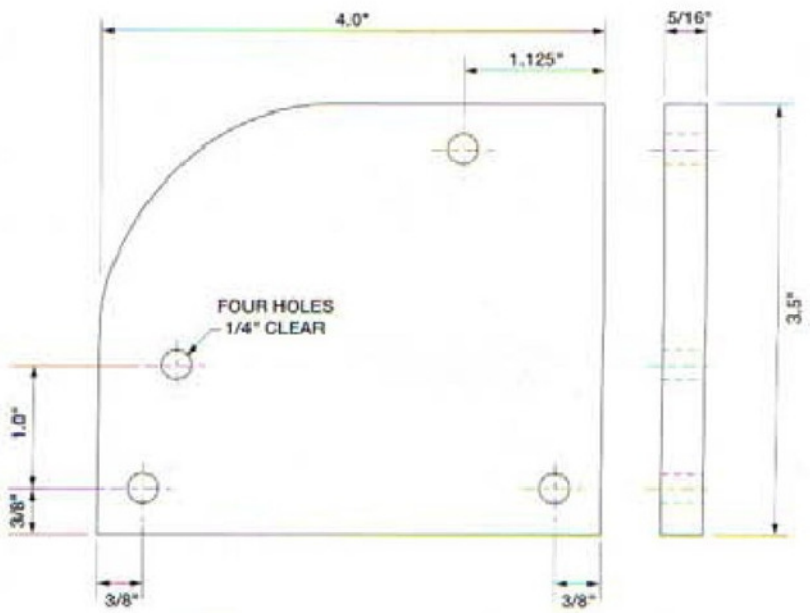
ITEM 13 LATHEWAY BRACKET
M/S



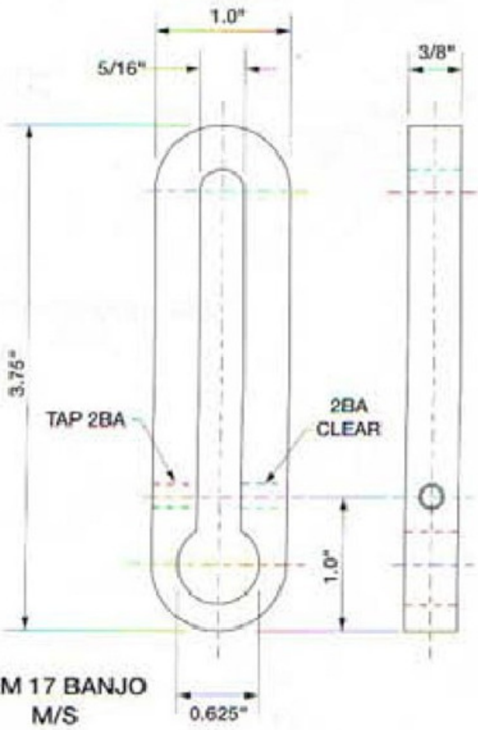
ITEM 14 LATHEWAY BRACKET CLAMP
M/S



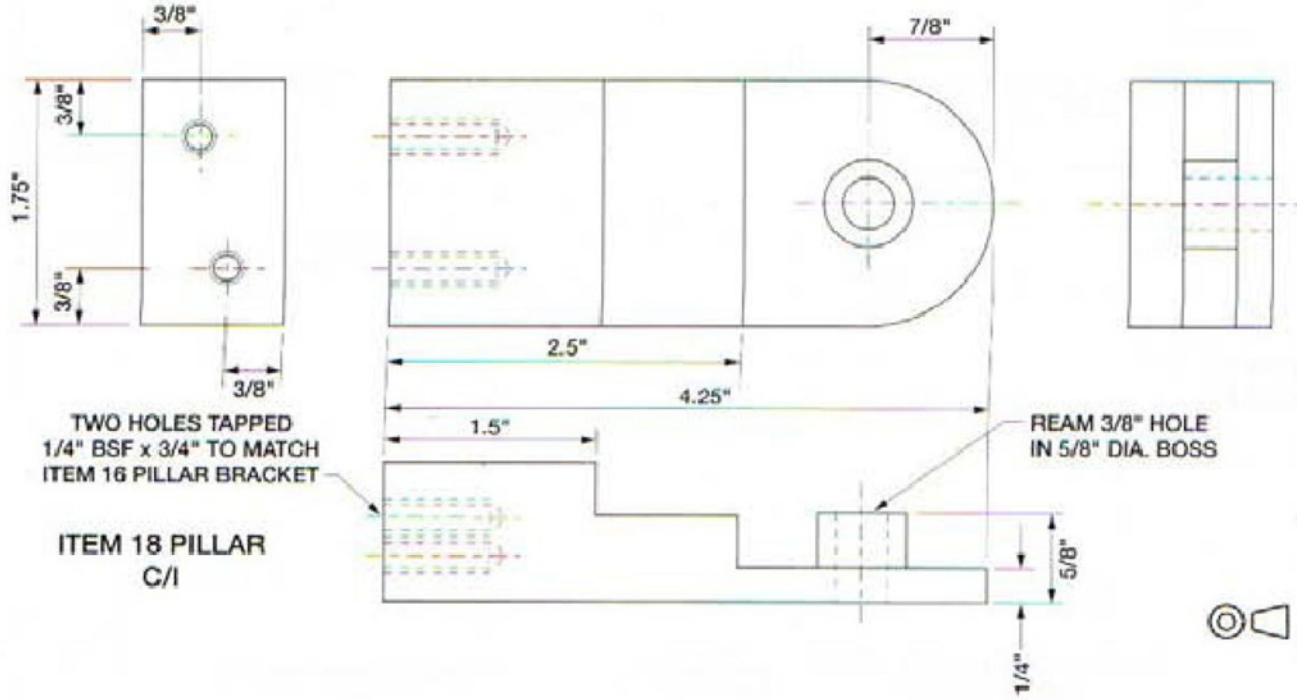
ITEM 15 CLAMP STUD
M/S



ITEM 16 PILLAR BRACKET
M/S



ITEM 17 BANJO
M/S



ITEM 18 PILLAR
C/I

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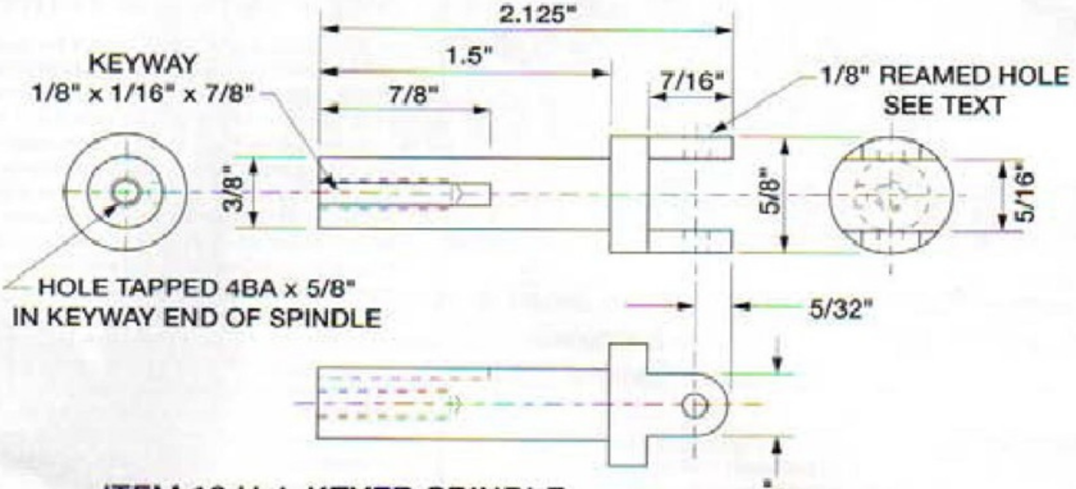
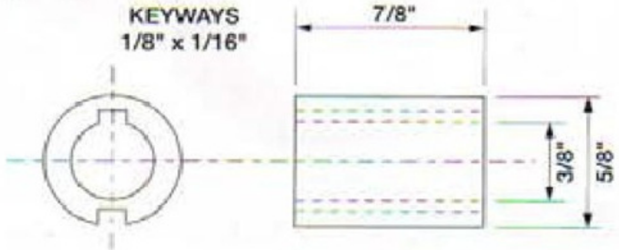
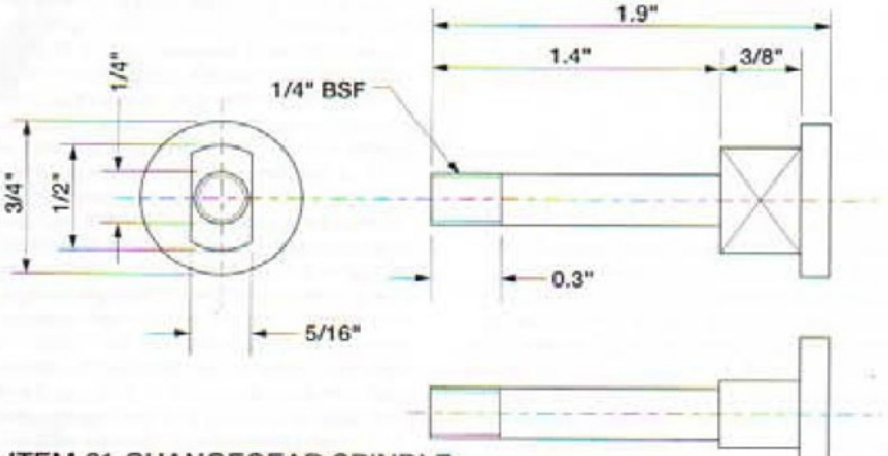


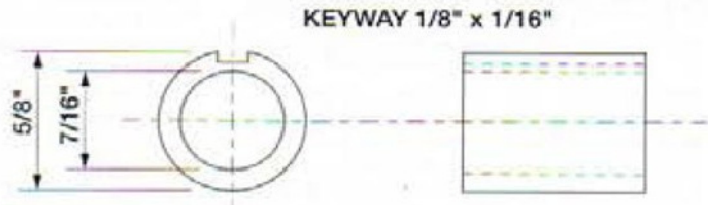
ITEM 19 U.J. KEYED SPINDLE
M/S



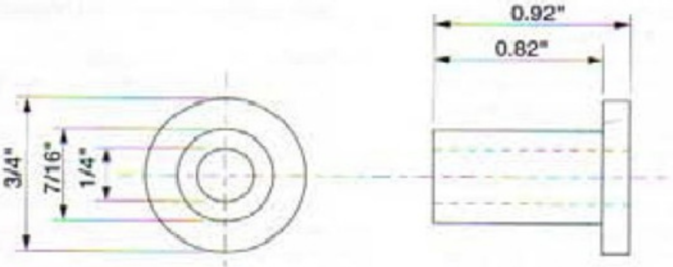
ITEM 19 DOUBLE KEYED BUSH
M/S (TO FIT ITEM 19)



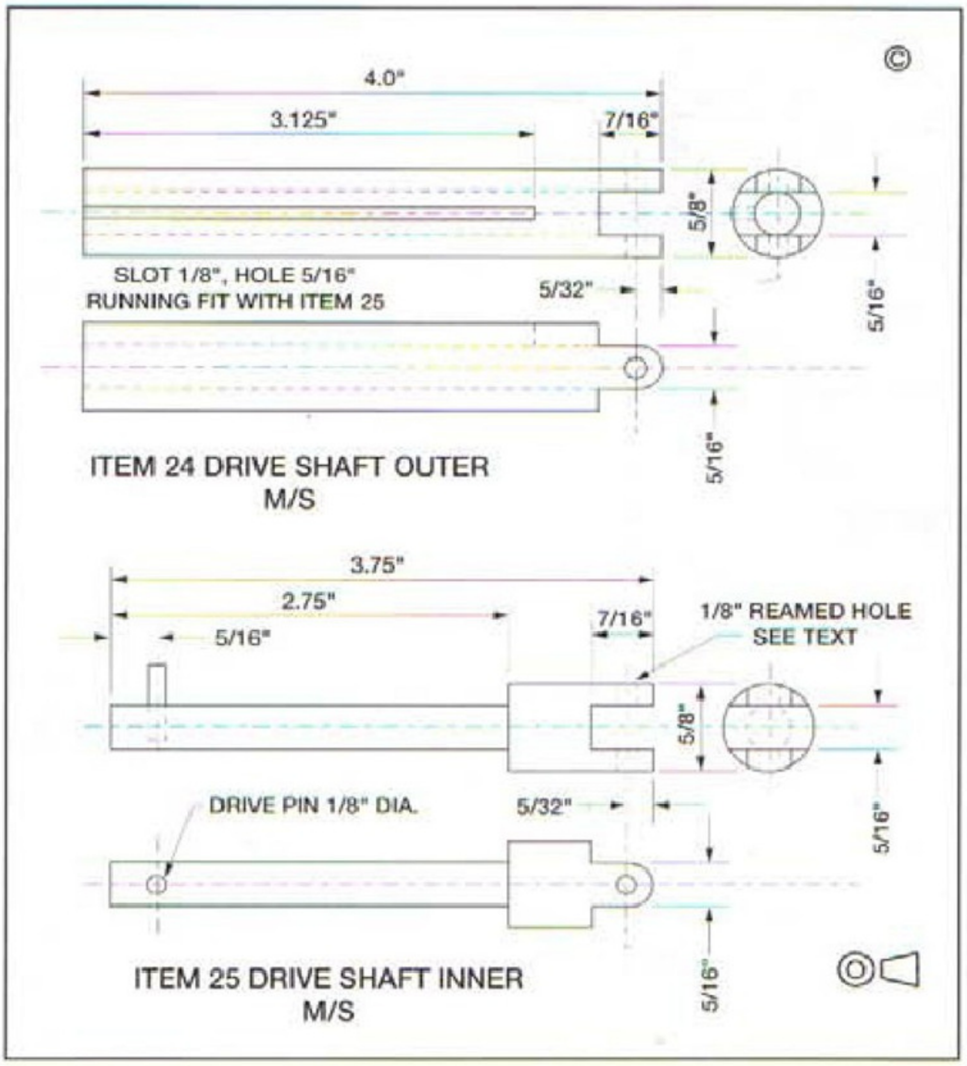
ITEM 21 CHANGEGEAR SPINDLE
M/S



ITEM 22 CHANGEGEAR BUSH
M/S



ITEM 23 CHANGEGEAR SPINDLE BEARING
PH/BRONZE



back off at the same time. With the hob on the mandrel between centres and the backing off device on the cross slide, the catch plate and idler gears have to be meshed so that the tool starts to retract just after passing the back edge of the tooth, as before, and I find it easiest again to use the mandrel handle with back gear disengaged. In this second method, the leadscrew is not engaged until cutting starts. The cross slide is now positioned to the right of the work and the tumbler and leadscrew are engaged and both are left engaged until the job is finished. A first cut of about one thou. at the back edge of the tooth seems sensible and the mandrel can be turned by the handle for the first traverse. The tool is withdrawn via the cross slide screw and the saddle is wound back to its starting position. The next cut is put on - about two and a half thou. - and this time the back gear lever is engaged and the clutch let in: at the end of the cut the clutch is disengaged, the tool retracted, the back gear lever is disengaged and the saddle is again wound back by hand. The back-gear lever is engaged again by fiddling with it - it is well worth making an extension to the back gear lever to bring the knob to a handy position - the next cut put on and away you go again. When the tool starts its cut at the front edge of the tooth - dial reading about 30 thou., - zero the feed dial, carry on cutting in one thou. increments until the required depth of tooth is reached and you almost have a hob. Do not disengage the half nuts or the tumbler.

The next job is to back off the crest of each tooth with a wider flat ended tool. I found it convenient to remove the tool holder and replace it with one in which the tool is offset to one side in the holder by about the pitch of the worm, so that it cuts the crest of each tooth. The cross slide dial must be zeroed again with the tool just touching the back of a crest and it is obvious that the tool must be narrow enough to cut only one crest at a time! The whole procedure is then repeated as before until the tool starts its cut at the front edge of each tooth. If all is well you can now disengage everything.

My hob was then casehardened and I sharpened it on a Stent tool and cutter grinder because I am lazy and have neither the skill nor the elbow grease to sharpen it with a stone.

I have since made several hobs from machinable high speed steel which have subsequently been hardened professionally and they seem to be excellent. The original case hardened hob is still my favourite and I have cut spur gears in all materials with it, including cast iron and steel, the latter being done in twenty thou. increments to depth. Softer materials are cut at one pass.

Left hand hobs are cut just as easily, as in cutting a left hand worm, but the tool will need to be ground for that purpose. The worm wheel on the Helix /C.E.S. hobbing machine requires a left hand hob, but that is another story.

Single tooth gear cutters

This device is equally useful for backing off the teeth on single tooth gear cutters. Without modification, the gear train will back off nine tooth cutters and, by modifying the train, cutters with teeth that are multiples of three can be done - e. g. 12 and 18. A button tool is used to cut the requisite profile on the circumference of the blank which is then gashed with the requisite number of teeth and held on a mandrel between centres. The button tools described previously in M.E.W. No 7, pp59 - 63, and No 41, pp52 - 55 can be fixed on the carriage and the device used without the leadscrew being engaged. I fixed the buttons to a spring tool holder to avoid jams. Every tooth is backed off on every revolution of the headstock - as opposed to the Eureka Tool which cuts only one tooth on each revolution - so the lathe must be run very slowly to avoid a sort of machine gun effect. I used a mandrel handle for the purpose, but have now set up a slow drive train.

Slow drive train

It has been pointed out that the vibration caused by the reciprocating movement of the carriage and tool could upset the alignment of the lathe saddle with the lead screw and half nuts. The speed and frequency of the reciprocation seemed to be the cause of the concern and this, of course, is dependent on the rpm of the mandrel. The bottom back gear on the Super 7 gives a mandrel speed of 27 rpm and, without sophisticated electronic devices, it is difficult to lower this. The same objective can be achieved by an additional drive motor. I had a spare 1450 rpm 1/8 hp motor and so I fitted it with a pulley of 1.65in. outside diameter and section to match the Myford motor pulley. The motor was fixed in such a position as to allow it to drive the 4.3in. Myford motor pulley - the main motor switched off, of course, thus giving a mandrel speed of about 10.3 rpm in bottom back gear: I am advised that driving the main motor pulley with the additional motor has no ill effect on the main motor and the set-up works well: there is no longer danger of the machine gun effect!

Set up for 20DP hob 14.5 degree PA

Gear train;
Super 7, no gearbox:- Mandrel 55: banjo 35/40: leadscrew 50

Super 7B with gearbox:- Mandrel 55, two idlers, input 35, gearbox 4A Myford leaflet No. 712U gives trains with gearbox for DP and Module.

Tool;
29 deg. included angle with 0.048in. tip width, nil or slight negative back rake.

Depth of tooth; 0.108in.

A similar version of this device was first shown to me by Mr John Buckley of Helix Engineering. I am very grateful to him for the idea- all I am responsible for is a few minor modifications of detail and adapting the device to fit the Myford lathe.