M.E. 106 348 (1952) & 92 163 (1945)

METAL POLISHING IN THE HOME WORKSHOP

by A. R. Turpin

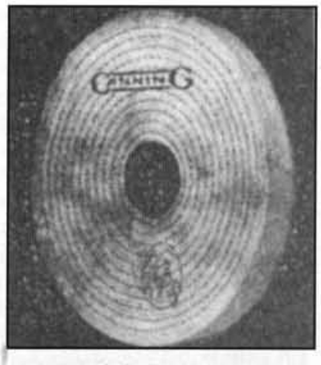
Polishing A. R. Turpin / G. H. Shackleford

Although covered in basic form in many modern volumes, some writings at the end of and just after the war give a good summary of the process and materials involved. Read both the articles and then tailor what you do to the amount of work you have to perform!

SOME three years ago I decided I would take up silversmith's work as another hobby, and if I was going to make any show, it would be necessary for me to know a lot more about the art of metal polishing than I knew then. But having obtained a couple of books from the library on the subject, I nearly abandoned all idea of a successful amateur's polishing shop when I read, "h.p. required two; periphery speeds 5,000 to 15,000 ft/min!"

However, I decided to read on and find out if it was not possible to reduce these figures somewhat, provided I was content to accept longer man-hours, and perhaps a slightly duller polish. At that time, like most other model engineers, the only equipment I possessed was a screwed spike on the other end of my grinding wheel spindle, driven by a ¼ h.p. motor by means of which I was able to obtain some sort of polish on brass sheet; but I was quite unable to polish out deep scratches, or hammer marks. So something had to be done, and I read on.

A leather-covered bob.



A stitched cotton mop.

The actual process of polishing consists first of grinding the article with repeatedly finer grades of abrasive, the abrasive having been glued to the periphery of a semi-resilient wheel; secondly, continuing the polishing process using softer wheels to which has been applied a composition made by mixing very fine abrasives with greases and waxes. During the first part of the process, metal is actually removed from the article, but during the second part the heat and pressure causes the metal to flow from the hills of the scratches into the valleys.

This skin is called the Bielby layer.

Before I proceed further describing the actual process of polishing in detail, I had better set out a short glossary of terms used in this article.

Bob. A semi-resilient polishing wheel, either constructed wholly of felt, of partly a wood centre, the periphery of which is covered with a strip of felt or leather.

Buffing. Usually applied to the final stages of polishing.

Colouring. The application of a very mild abrasive for the final polishing operation to bring up the true colour of the metal and impart a high finish.

Linisher. A machine employing an endless belt of abrasive material.

Mop. A resilient polishing wheel manufactured from discs of cotton fabric, loose except for the centre, or sewn together with spiral or concentric stitching. Usually used for the buffing and finishing operations.

Scratch brush. A rotary wire brush.

Scurfing. Usually applied to the grinding operation with bob or mop using "glued on" abrasive.

The chief abrasive materials used in polishing in a small workshop can be limited to the following.

A soft unbleached "Brown" calico mop, and green chrome composition. For finishing stainless-steel.

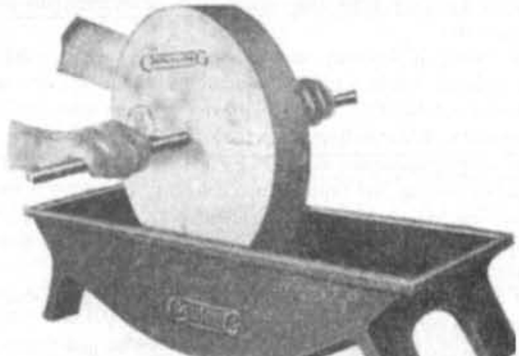
For scurfing: emery and Aloxite in the grades 80, 120 and 160 mesh.
For buffing: composition sticks of tripoli, crocus and rouge.
For colouring: rouge and Vienna lime.
A number of 10 in. x 1 in. and 6 in. x 1 in. bobs and loose leaf mops.

However, the prices of felt bobs have risen so greatly during the last year that the occasional user may consider the less efficient alternative, the stitched calico mop, but the polisher will have to look out for rounded corners.

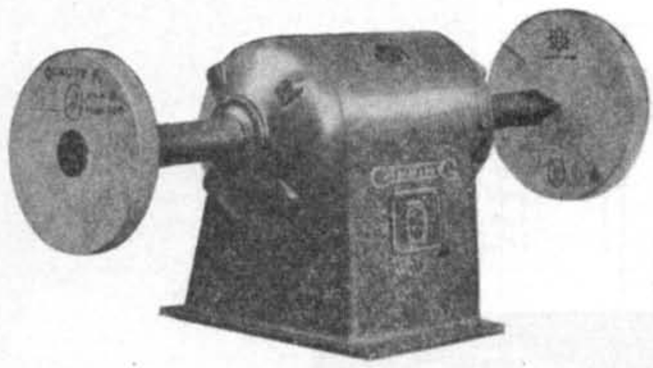
To dress a bob or mop with abrasive, first size the wheel using a weak glue for this purpose, and brushing it well into the surface, allow to dry and then true by running on the spindle whilst rubbing a coarse brick or pumice stone against it.

The bob or mop should now be heated on the periphery - this can best be done by revolving it on a hot plate - and it is then liberally coated with bobbing glue. The strength of the glue should vary with the fineness of the grit; one part of glue to two parts of water by weight for, say, 60 grit and three parts of water for 180 grit, intermediate sizes diluted pro rata.

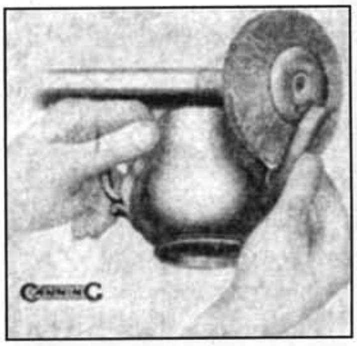
Meanwhile, the abrasive should also be heated, and the bob immediately rolled in it. This is easily carried out if a simple trough is made by nailing two battens of wood to the bench top, the width of the bob, or mop, apart. The warm abrasive is poured between the battens, and the bob rolled along between them; the advantage of this method is that the abrasive is not spread over the bench, and in the case of mops, the leaves are prevented opening and allowing the abrasive to get between them. With the larger size bobs it will be necessary to take two bites at it, unless the trough is very long, then press the abrasive well into the glue.



Rolling the bob in warmed emery.



Bench mounting polishing motor.



Dry scratchbrushing.

The bob is now set aside for 24 hours to dry.

When it is, a mop that has to be dressed and is required to retain some of its flexibility for contour polishing, the hard rim of glue should be broken up by striking it with a metal bar.

Always apply a newly coated bob to a scrap piece of metal; this helps to bed the abrasive down evenly, and at the same time gives a warning if it has been contaminated with the wrong size grit.

When the bob ceases to cut, it can be recoated on top of the old dressing unless that dressing is very uneven, in which case is should be removed. To do this, wrap a damp cloth round the periphery of the bob or mop, and let it remain for three or four hours until the glue has softened; it is then revolved on the spindle and scraped with a piece of hacksaw blade.

There are countless types and sizes of bobs and mops that can be purchased, but the four most useful types are as follows:-

Solid felt bobs or leather and felt-covered wheels with wood centres for scurfing and the early stages of buffing; stitched mops for scurfing contoured and irregularly shaped articles; loose leaf mops for buffing, and swansdown mops for finishing. The last, by the way, are not real swansdown but a very soft cotton.

A useful size is 6 in. dia. x 1 in. thick for scurfing and 10 in. x 1 in. for buffing on spindles running at 2,900 r.p.m.

To dress a mop for buffing, it is mounted on the polishing head, and rotated at polishing speed, and the stick of compo is then pressed against it for the friction to cause sufficient heat to melt the waxes, which will then adhere to the mop. By the way, it is surprising how stiff and hard even the most pliable mop appears to become under the influence of centrifugal force.

The process of polishing is best described by taking a practical example, such as the way a cast brass door handle would be commercially polished in small quantities.

The casting, if necessary, should be cleaned up with a solid grinding wheel; it should then be scurfed all over with a bob dressed with emery No. 90 followed with No. 120. This is followed with a mop using Tripoli compo, and coloured with Vienna lime compo on a swansdown mop.

The scurfing operations should be carried out at 5/6,000 ft./min. and the mopping or buffing, and finishing and colouring, at 7/8000 ft./min. Each operation should be carried out at right-angles to the last - this is not only more efficient, but also makes it easier to see when the scratches from the previous abrasive have been completely removed.

For other metals the operation and material may be somewhat different, and a guide to the more important is as follows:-

Cast-iron and steel. Scurf as for brass but finish for high polish with crocus compo.

Stainless-steel. Scurf with Aloxite No. 120 or coarser if necessary, then grease bob with 120 emery, followed by leather wheel with flour emery. Mop with hard mop and alumina compo, and finish with soft cotton mop and chromic oxide. Speeds should be 20 per cent higher than for brass.

Aluminium Castings. Scurf with bob dressed with No. 60 emery, follow with No. 80 and 120, used at right-angles to each other. The bobs should be lubricated with a touch of bobbing grease to stop dragging of the surface. Mop with loose leaf mop and soft Tripoli compo. Finish with swansdown mop and Vienna lime. The speeds may be 20 per cent slower than for brass.

Copper. As for brass, but may be finished with rouge compo.

Silver plate. Mop with swansdown mop and rouge compo, wash in a detergent, and finish with a very soft mop to which a paste of rouge powder and methylated spirit is applied with a stick. If the plate is at all rough, scratch brush first with a fine crimped nickel-silver wire wheel.

It will be obvious that it would be impossible to polish all articles with ordinary bobs and mops, and specially shaped ones are often used such as for polishing between the splines of forks; or small fingers to get round handles of jugs, etc.

Even then, there may be a considerable amount of work that must be carried out by hand in order to polish in the awkward places.

To do this, tool marks can first be removed with Water of Ayr stones, or by abrasives mixed with grease and rubbed on with pointed and shaped sticks. Polishing thread is used to polish inside of holes. Embossed and figured work can be polished with bristle wheels, the abrasive being applied to the wheel in the same way as to the mops when using compo.

Now the owner of a small workshop will look wistfully at the screwed spindle on his "grinder-come-polishing" head, and wonder if all this equipment is really necessary; the immediate answer is "No" if you have not to pay shareholders dividends. Whether you spend two or ten minutes polishing up a boiler dome is of no great importance to you, and anyway, the only metal you are likely to want to polish with a real mirror finish will be brass. So we can concentrate on that material, and if we are careful when fabricating the article, we shall need only one emery bob of No. 120 mesh; even quite deep scratches can be removed with this grade, provided you can spare the time.

Although the bobs are more efficient, in order to save money, we can use stitched calico mops for scurfing. For buffing we need a loose leaf mop and a stick of Tripoli compo, and in most cases the polish obtained with this will be sufficiently brilliant. So really all we need, at least for a start, is two mops. The polishing spindle should be somewhat more robust than those normally found in the amateur workshop; it should be at least ¾ in. dia. and preferably project at least 12 in. A ½ h.p. 2,900 r.p.m. motor is about the minimum power that can be used efficiently, and with this spindle speed we can use a 6 in. mop for scurfing, giving a surface speed of 4,550 ft./min., and for buffing a 10 in. dia. giving 7,600 ft./min.

A bench-type idler backstand.

When polishing, the article must be kept on the move the whole time, otherwise a distorted finish will result, and on no account should the mop be allowed to dwell in one spot to remove a deep scratch. When polishing with a ½ h.p. motor, it will be difficult to apply too much pressure before slowing the motor, except when finishing, when a comparatively small pressure is all that is required.

It is fatal to try to polish out deep pits or scratches by buffing, because you will find that they turn themselves into what is known as "tailheads" or "spearheads", depending on whether the pits have grown one, or two tails. All deep scratches and pits must be removed during the scurfing operation.

NOTE: One means of overcoming the need for a number of bobs coated with different grades of emery, is to use a "back stand" idler. This consists of an idler pulley mounted on a pillar directly behind the polishing bob; a Linisher band is then used instead of coating the bob, the band running round the bob, and back over the idler pulley; it then takes but a few seconds to remove one grade of band and replace by another; further, there is no wear on the expensive bob. Some difficulty may be experienced in getting a narrow band, but this may be overcome by cutting one of standard length.

Great care should be taken that the bob or mop does not snatch at the trailing edge of the work, if it does it will most likely snatch it from your hand and smash it on the floor, or even whirl it round the mop and smash it into your face - and this can be really dangerous. Any other machine tools in the workshop should be covered up during the polishing process to prevent the abrasives getting into the works with disastrous results. It is also as well to cover yourself up, especially your hair, for the same reason.

To mechanically polish plastics, great care must be taken, because it is extremely easy to burn it, or polish large chunks out of it before you know where you are.

The safest way is to start by hand and get rid of all tool marks by using finer and finer grades of glass paper, follow this with pumice compo on a canvas mop, and finish with a fine white polishing compo on a swansdown mop. But do be careful and try things out on some scrap first. At a push, ordinary metal polish, followed by silver polish will do quite a good job.

Finally, when in doubt, ask, and the people to ask are those experts who manufacture the hundreds of different materials to do the job, they have a reputation at stake and they will not let you down. Two of the foremast people in this line are W. Canning & Co. Ltd, Great Hampton Street, Birmingham, 18, and St Johns Street, Clerkenwell, London, EC1, and Grauer & Weil Ltd, 3 & 4 Hardwick Street, Clerkenwell, EC1.

February 15, 1945

TO BUFF AND TO POLISH

By G. H. Shackleford

PRODUCING a high-lustre finish on a piece of metal divides itself into three distinct processes; grinding, polishing proper and buffing. Grinding with an emery wheel leaves a multitude of fine scratches on the surface. Polishing simply removes these finer marks by grinding away small amounts of metal. Where a very fine finish is desired, the polishing operations are followed by buffing with a soft wheel and very fine abrasives, which removes even the fine marks left by the polishing abrasives and leaves a surface which is glass-smooth.

Polishing and buffing are similar processes, the only difference being that, in polishing, the abrasive is glued permanently to the wheel, while in buffing the abrasive is fed to the wheel during the operation. Polishing abrasives usually are identified by number, from No. 120 to No. 220, while buffing abrasives are numbered above 220. Polishing wheels are made from a number of materials. Wood faced with leather, sheepskin, bull neck and walrus leather, canvas, felt, muslin and flannel are materials commonly used. Leather-faced wooden wheels are, of course, rigid, and are suitable only for polishing flat work. For curved surfaces wheels faced with the more flexible materials are used. Soft buffs are made of discs of cloth or sheepskin loosely sewn together.

On polishing wheels such artificial grits as aluminium oxide, silicon carbide and natural emery are most commonly used. For buffing, a number of natural abrasives are used, these being in the form of a cake made of the abrasive and grease or tallow so that the grit may be applied to the buffing wheel by friction. The ordinary buffing compounds, in descending order of hardness and sharpness, are emery, Tripoli, pumice, crocus, lime and rouge.

Animal-hide glue in the ground form is generally used for applying abrasives to polishing wheels. It should be mixed with water by weight (as shown in the table), the water must be measured accurately on the basis of 1 oz. avoirdupois equals one fluid ounce. The glue should soak in cold water for one hour. After soaking, the glue solution is carefully heated to a temperature of 140 deg. F in either a water-jacketed gluepot or one electrically heated. Once the glue is melted, it should be applied quickly to the wheel with a brush. It is a good idea to have the wheel heated to the same temperature to avoid jelling and chilling the glue. The glue-coated wheel is then rolled through a sheet metal trough containing the abrasives until it is thoroughly and evenly coated. Let it dry for 24 hours. A new wheel should always be given a thin sizing coat of glue followed by two coats of abrasive. If an old wheel is to be re-coated, true it up with a silicon-carbide stick and then treat it as a new wheel.

COMPOSITION OF GLUE FOR POLISHING WHEELS

Abrasive grain size	Dry glue % by weight	Cold water % by weight
30 - 36	50	50
46 - 54	45	55
60 - 70	40	60
80 - 90	35	65
100 - 120	33	67
150	25	75
220	20	80

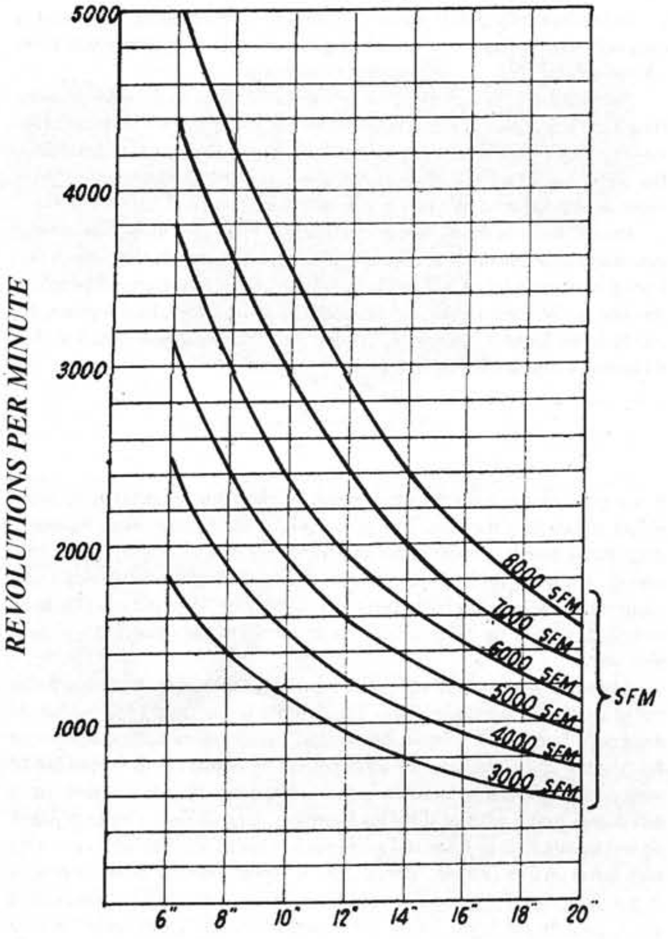
Abrasives used in buffing have special characteristics, each one being suited to its own particular uses. Emery-cake is sold in a great variety of degrees of fineness; it is frequently used as a preliminary buffing compound for "cutting down" the last fine scratches left by polishing. It should not be used on stainless-steels, however, as it contains iron. Tripoli is composed of soft porous grains without sharp hard surfaces; it produces a very high polish on soft metals such as brass and aluminium. Crocus is sometimes used for a high finish on iron or steel. Vienna lime or venetian lime is extensively used in polishing nickel plate, while rouge is one of the softest buffing compounds and is used for the finest finish. Chromium oxide, or "green rouge" is used for the final finish on stainless-steel, Monel-metal and nickel. The table below gives suggested motor sizes for operating wheels of various diameters. Although not essential, it is better to have the wheel to run clockwise as viewed from the operator's left, because this makes it handier to hold the larger work. In any case, the wheel should run towards the operator so that the work is below the horizontal centre line.

Wheels for both polishing and buffing are operated at speeds varying from 2,500 to 7,500 surface feet per minute, and sometimes higher, the most general practice being operation at 3,000 to 6,000 s.f.m. The graph shows how to convert surface feet per minute to revolutions per minute for various wheel sizes. To use the chart, find the diameter of the wheel on the bottom of the chart, then follow the vertical line corresponding to this diameter up the curve marked with the desired surface speed and from this point read straight across to the left-hand margin, where the r.p.m. can be found. Should a surface speed not shown be required, for example, a speed of 3,500 s.f.m., the r.p.m. can be found by averaging the next smaller and next larger values. These wheel speeds are only approximate, and there is no necessity for adjusting them closer than within 100 or 200 s.f.m.

MOTOR SIZES FOR POLISHING AND BUFFING

Diameter of wheels in inches	Horse-power required
6	¼
10	1
12	2
14	3

The sequence of operations followed in polishing and buffing any metal article must be determined by the condition of the work, the final finish desired, and the metal of which the article is made. Soft metals may need fewer operations than harder metals. A rough casting will require more polishing than a sheet of metal that is already quite smooth. If a mirror finish is



Wheel diameter

desired, operations must be continued down to the softest buffing materials; if a duller surface is satisfactory, perhaps no buffing operations at all will be needed. The skill of the operator has much to do with the final result. Naturally, a skillful workman will produce a given finish with fewer operations than a less experienced man; hence, the following suggestions are only general. In certain cases wheel speeds have been suggested; where they have not, a speed of 5,000 to 6,000 s.f.m. will be satisfactory.

For polishing steel, use a No. 120 abrasive on a dry rag wheel, followed by a No. 150 on a greased rag wheel, and finally with a No. 180 on a greased rag or sheepskin wheel. The article can then be buffed with a No. 180 cake or paste on a Tampico brush wheel. Rough steel castings or forgings can be given a preliminary rough polishing with a No. 60 polishing wheel. This gives a final polish which is suitable for plating. Generally, synthetic aluminium oxide grits are used for the polishing and the first buffing operations on stainless-steel. Tripoli may also be used for buffing, and the highest lustre developed with chromium oxide or green rouge. A suggested sequence of operations would be polishing with a No. 90 and No. 120 artificial alumina on dry rag polishing wheels, a final polish with No. 180 on a greased polishing wheel, and buffing with Tripoli. For a mirror-finish, the article is buffed again with very fine aluminium oxide buffing compound and finally with green rouge. For a satin-finish the final operation is brushing with pumice on a Tampico brush.

Brass, being softer, will usually require fewer polishing and buffing operations. Castings can be polished with a No. 80 and No. 120 and finally with No. 180 on a greased wheel, and then buffed with an emery grease compound. Stampings can be polished similarly at 5,000 or 6,000 s.f.m. and then buffed on a loose muslin buff at a slower speed, such as 4,000 s.f.m. Buffing may be done with fine Tripoli. For nickel plating, there should be a final buffing with lime on a muslin or linen wheel, after which the buffing compounds are cleaned off and the article is plated. Castings may be buffed also with Tripoli and lime.

Aluminium is very soft, and hence it is desirable to lubricate all the final polishing wheels used on aluminium to prevent tearing of the metal. All wheels finer than No. 120 used on aluminium should be greased. The wheel is greased by applying a tallow stick or cake to its surface while it is running; paraffin is sometimes used as a lubricant. Aluminium articles should be polished at 5,500] s.f.m. using Nos. 80, 120, and 180 grits on the wheels. The No. 80 wheel may be used dry. Then the work is buffed with Tripoli and lime on a muslin buff, and finally with rouge. The buffing operations can be carried out at a somewhat higher speed, 7,000 - 7,500 s.f.m. Scratch brushing at low speeds, 600 r.p.m. with a 6 in. brush, produces a dull grey finish. A satin finish can be produced by brushing with fine alumina on a Tampico brush at 3,000 s.f.m. A similar finish can be produced on brass or steel with pumice and water at 3,000 s.f.m.

Zinc die castings can be polished with No. 120 grits then buffed with Tripoli, and finally buffed at 6,000 s.f.m. with a soft buffing compound. As an alternative final operation, zinc articles can be brushed with fine pumice and water on a Tampico brush at a slow speed. Zinc-plated surfaces can be buffed with Tripoli and lime. Nickel and copper plated surfaces should be buffed with lime on a soft wheel, and then with rouge. A nickel surface which is to be chromium plated requires careful buffing, as the final finish will show up any marks left after buffing. Monel metal can be buffed with fine emery cake, then Tripoli, then with lime or chromium oxide rouge.

Where buffing and polishing is done with a small bench grinder, some precaution must be taken to assure safety as well as good work. First see that the guard is set to clear the work. Then make sure that the wheel is tight on the shaft and that it runs true. Some grinders of this type may require an extra washer to hold cloth buffing wheels. The wheel should always run off a square edge and never against it. Should the wheel run against a square edge or into a vee in the casting or other object, the work is likely to be thrown from the hands with dangerous force.

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Scraping Duplex / AEU

Much has been written over the years on the subject of hand scraping. In choosing these extracts, part of a series on finishing techniques by Duplex gives much of the information, but some additional material from earlier years by AEU reveals some useful tips.

SCRAPING

By Duplex

SCRAPING with a hand tool is used to form an accurate flat or even surface on parts that have been machined or filed as nearly true as possible by ordinary workshop methods.

This usually applies to the slides of machine tools which may have suffered some distortion, either by the machining stresses imposed or from the methods of clamping employed, when parts are dealt with in the shaping, planing or milling machine. Some components require to have truly flat surfaces to ensure accurate assembly or stability; for example, the base surface of the surface gauge and other appliances commonly used on the surface plate, as previously described. Commercial products of this kind are usually finished by a process of fine surface grinding in a machine of accurate and rigid construction, specially designed for the purpose. But this is beyond the scope and resources of the small workshop and is replaced by scraping with a hand tool in the form of a chisel, adapted for removing any local high spots on the work surface. After some practical experience, and by careful working, there should be no difficulty in obtaining very accurate results from this method of surface finishing. Milling in the lathe with multi-tooth cutters may give disappointing results as regards accuracy, owing to lack of rigidity in the slides and headstock bearings.

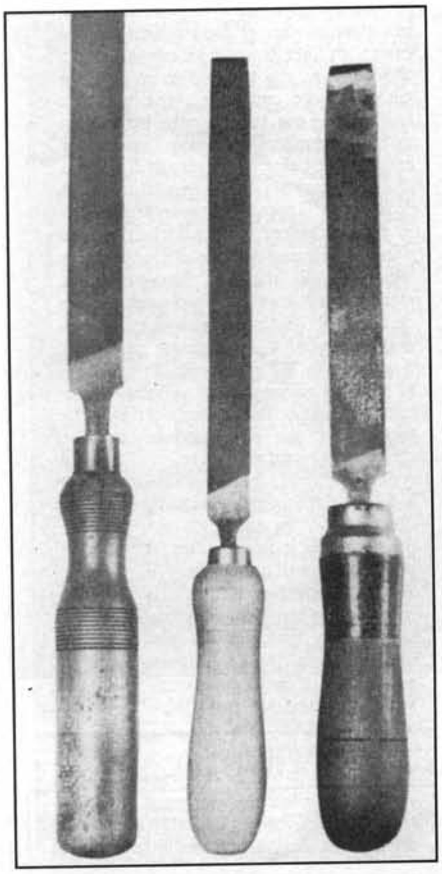


Fig. 1. Three flat scrapers.

A fly-cutter will usually give greater accuracy, since it imposes less cutting pressure, particularly when only light finishing cuts are taken with a tool-bit sharpened to a fine edge on an oilstone. However, the final result must depend on the inherent accuracy, or inaccuracy, of the machine itself. But errors from this source are readily corrected by hand-scraping. Scrapers produced commercially have not always proved satisfactory, and these tools are best made in the workshop from discarded Swiss files of fine cut.

The customary method of making scrapers like those shown in Fig. 1 is illustrated in Fig. 2. The finished scraper, Fig. A, should be fitted with a handle long enough to afford a firm grip. When grinding off the teeth and forming the side faces of the tool, Fig. B, the file is held at a tangent to the periphery of the wheel to hollow-grind the faces and so lessen the work of final sharpening on the oilstone.

By rocking the file against the periphery of the wheel, as shown in Fig. C, the end face is made slightly curved to avoid the corners digging into the work. During these grinding operations, care must be taken not to overheat the steel; for, if the temper is drawn, the tool will be useless for working on steel and cast iron. In the intervals of grinding, do not cool the tool by dipping it in water, since this may cause hair-cracks, resulting in fracture of the cutting edge.

The final sharpening, Fig. D, is carried out on an oilstone with the handle only slightly raised, as when sharpening a wood chisel. The curved end-face is finished by rocking the tool and, at the same time, moving it to and fro along the stone, as represented in Fig. E. A hard Arkansas oilstone is best for the honing operation, since it is not easily scored and retains its flatness in use. During scraping, particularly on hard cast iron, resharpening of the scraper will be found necessary to maintain free-cutting. The honing should then, for the most part, be restricted to the end-face, Fig. E; but when the blade in time becomes unduly thinned, regrinding will be necessary. To scrape the surface of the work to an accurate, flat finish, a reference surface is needed which is itself true in this respect. A grade A surface plate, which is true to within two ten-thousandths of an inch, is generally used for this purpose. When applying the work to the plate, the addition of marking paste is necessary to indicate the points of contact between the two opposed surfaces.

The paste can be applied to either the work or the surface plate, but the latter method has some advantages and is more often used. Tins of marking paste are obtainable from the tool merchant; but, failing this, a tube of Prussian blue oil colour is a good substitute, although it may have to be thinned by the addition of oil or turpentine. To obtain a reliable indication from the transference of the colouring material, it is essential to apply a thin, even coating to the surface plate.

If the surface of the work-piece has been inaccurately filed or machined, the part will rock when resting on the surface plate. Rub the work with a short movement lightly on the prepared surface plate, and the transfer marks will indicate the areas of contact representing the high spots. These are then levelled by taking bold but controlled strokes with the scraper. After again smoothing the paste coating with the applicator, a further trial is made and the process continued until, in time, all the transfer marks merge, showing that the accuracy of the work surface is equal to that of the surface plate itself. This result is all that is required to finish a component's base surface that is not normally in view; for example, a rule holder or surface gauge.

But exposed surfaces may be given a more ornamental and pleasing finish by the process of frosting illustrated in Fig. 4, which shows the upper, scraped surface of a lathe sole plate. The method of frosting the work is illustrated in Fig. 5. Horizontal lines of marks are first made by working the scraper at an oblique angle along the surface, as shown at the top of the left-hand figure. A second series of marks is made to cross the first set, and the process is continued until the uniform, frosted background shown in the right-hand figure is completed. This method of scraping results in the reflection of light in two directions, which adds greatly to the finished appearance.

A form of finish often given to machine slides

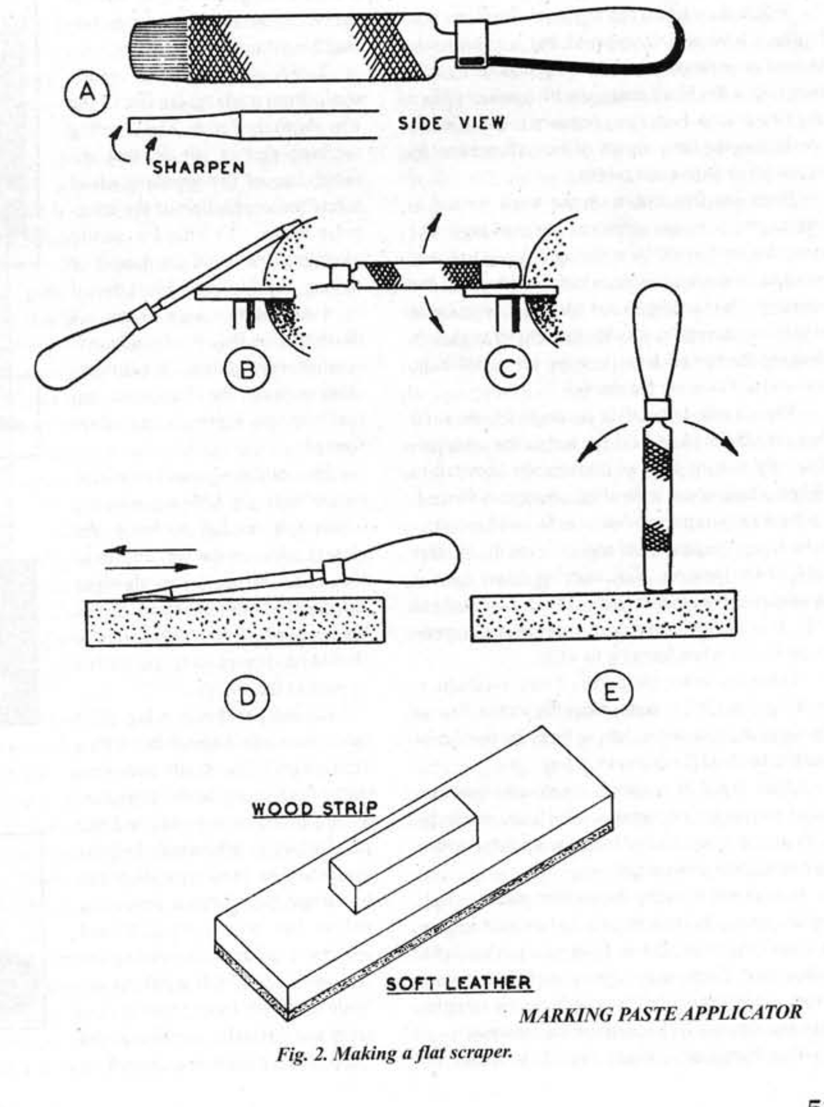


Fig. 2. Making a flat scraper.

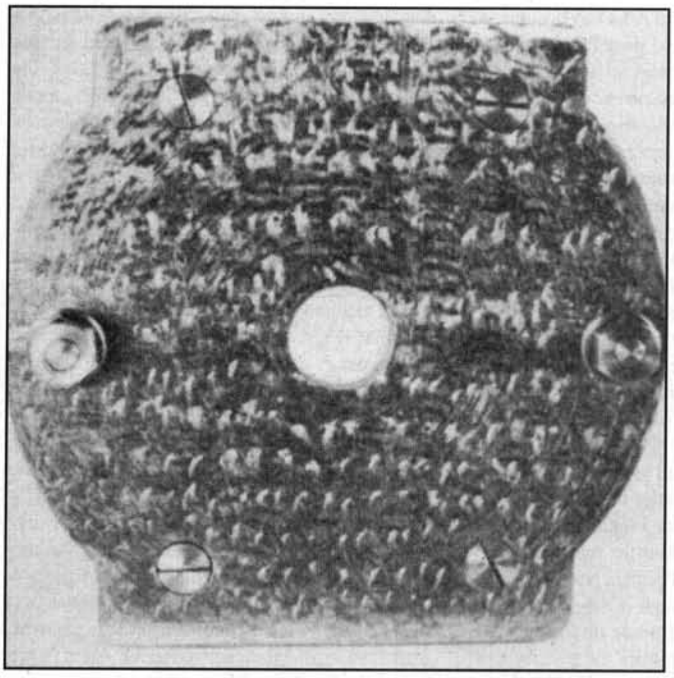


Fig. 4. Sole plate with scraped finish.

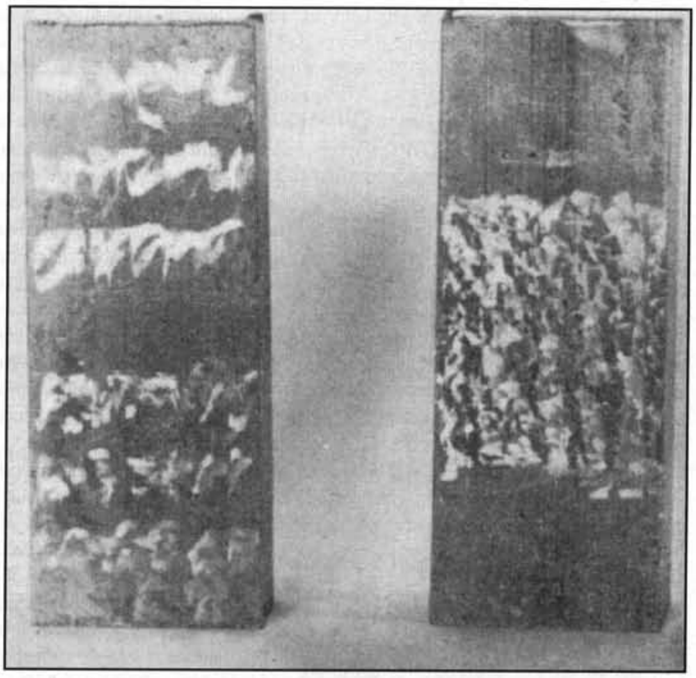


Fig. 5. Frosting a work surface.

is the making of crescent-shaped scraper marks on a plain background, as shown in Fig. 6.

Where the surface has a ground finish, no preliminary treatment is required, but a plain background on scraped work can be produced by rubbing with a flat block charged with a mixture of oil and fine emery. Care must be taken to avoid in any way destroying the accuracy of the surface either by excessive or haphazard rubbing.

Lines are first drawn on the work surface to indicate the positions of the rows of markings. The crescents are formed by applying heavy downward pressure to the scraper and drawing it towards the operator. The markings shown in Fig. 6 were made at the first attempt by moving the scraper as though drawing the capital letter U lying on its left side, and without twisting the wrists.

The scraper is tilted at an angle of about 60 deg., and the blade is held flat across the work surface. By moving the tool horizontally from left to right the thin, upper horn of the crescent is formed. As the scraper is moved downwards, its edge comes to lie across the line of cut and so forms the broader back of the crescent. The tapering, lower horn is formed as the scraper is finally drawn from right to left. It is largely a matter of practice and experiment, just as when learning to write.

There are other methods. Some mechanics, working from left to right, twist the wrists, first to the right and then to the left, to form the two limbs and the back of the crescent.

Other types of marking commonly used are small rectangles or squares, which are made by pushing the scraper away from the operator with a short thrusting movement.

In addition to using the surface plate for testing accuracy, the straight edge, when held in contact with the work and in front of a strong light, will check flatness or detect extremely small errors. This test is ideal for checking the straightness and flatness of a length of bar material.

The triangular scraper, Fig. 7, is useful for removing burrs from the edges of drilled or tapped holes, as well as for scraping other concave surfaces to eliminate high spots.

This form of scraper is readily made from a triangular file in the way shown in Fig. 8. The grinding machine rest is set so that the radial line of the grinding wheel meets the centre line of the triangular blade. To afford a secure mounting and avoid the danger of tipping, the file should be gripped by a toolmaker's vice clamp, as illustrated in Fig. 9. Grinding is continued on all three faces in succession, until the file teeth are removed and sharp cutting edges formed.

The hollow-ground surfaces ensure that very little work on the oilstone is needed to finish the cutting edges in the way shown in Fig. 11 C. Where the sharp edges extend towards the base of the blade, a piece of rubber tubing should be slipped on to the scriber to protect the fingers.

The scraper shown in Fig. 10 is made from a half-round file with a fine point. The teeth are first ground off on the back of the file, as illustrated in Fig. 11, and the flat surface is afterwards hollow-ground. The latter operation can be carried out off-hand; for once a hollow has been formed, it will serve as a guide for extending the concavity to the full width of the blade. If the off-hand grinding presents any difficulty, the file can be gripped in a clamp and centred on

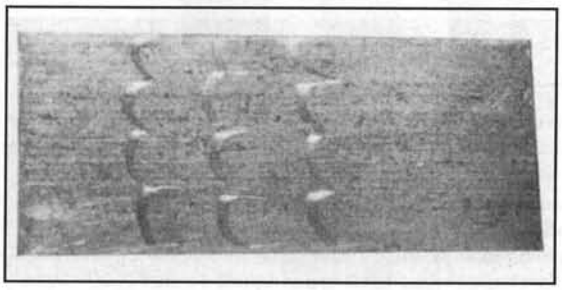


Fig. 6. Cresents shaped on finished work.

Fig. 7. Triangular scraper.

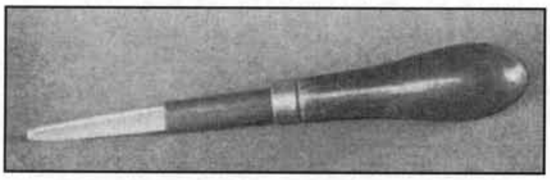


Fig. 8. Triangular scraper in the making.

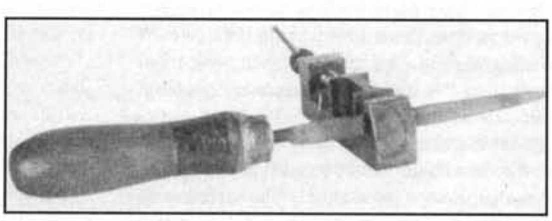


Fig. 9. Triangular file clamped for grinding.

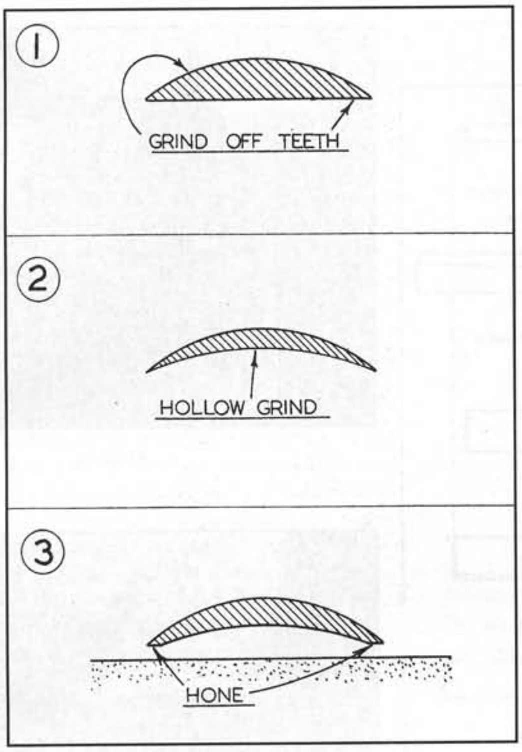
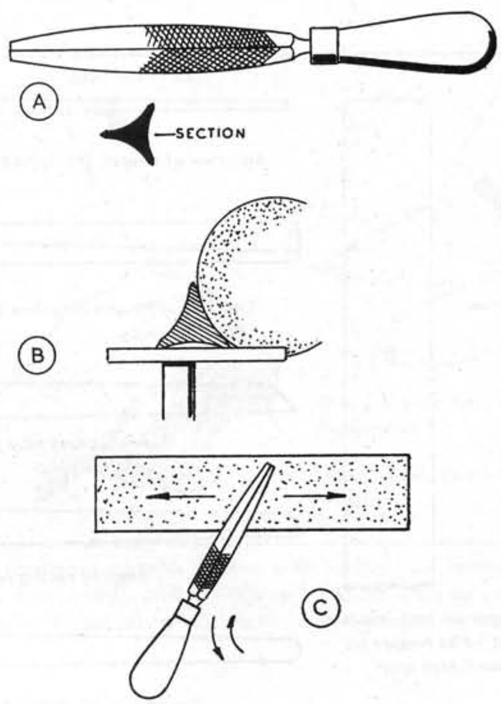


Fig. 10 Detail of half-round scraper.



Grinding the half-round scraper.

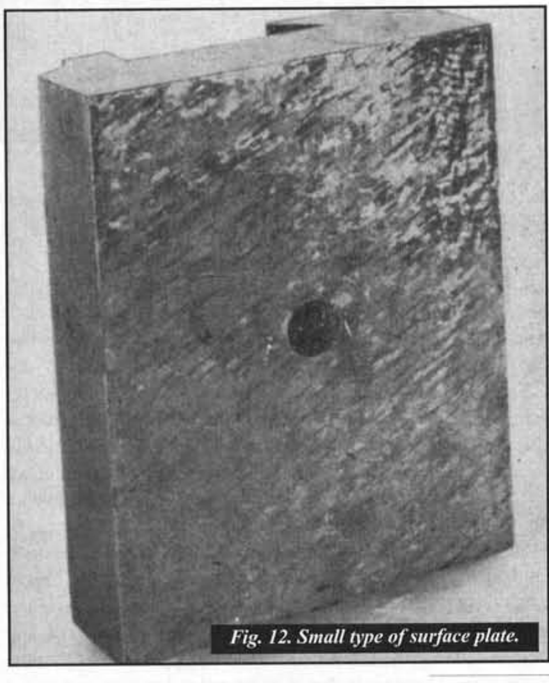


Fig. 12. Small type of surface plate.

the grinding wheel, as was done in the case of the triangular file. The final sharpening of the cutting edges is carried out on the oilstone, as in the previous instance.

To prevent damage to scrapers, it is advisable to protect their edges with a sleeve of rubber or plastic tubing.

An example of a small surface plate specially made for correcting a machined component is illustrated in Fig. 12. An iron casting was first machined and then scraped to form a flat main surface, with its sides also scraped true and at right angles. The finished plate enabled the machined surfaces of a commercial machine vice to be scraped flat and true.

Here, it is essential to make the bed surface of the vice truly flat and with the cast, standing jaw also flat and at right angles to the bed surface. After coating the small plate on its face and on one side with a thin, even layer of marking paste, it was applied to the vice casting and moved carefully from side to side to make transfer marks. Scraping was continued until accurate contact was established with both the bed surface and the fixed jaw of the vice. Finally the under side of the vice base was scraped with reference to the workshop surface plate to ensure an even bearing on the drilling machine table.

It should be added that for scraping cast iron no lubricant need be used; but, when working on steel, the addition of a soap and water solution will give a bright finish, which enhances the appearance of the work.

Carbide-tipped tools are sometimes made as scrapers, particularly for working on hard, cast iron. These do not always impart the high finish to the work obtained with their carbon-steel counterparts. Although the tipped scrapers retain their edge longer than others, they have the disadvantage that special abrasive wheels and stones are required when resharpening becomes necessary.

SCRAPING

by A.E.U.

Get your surfaces well scraped, mottled and bedded-in

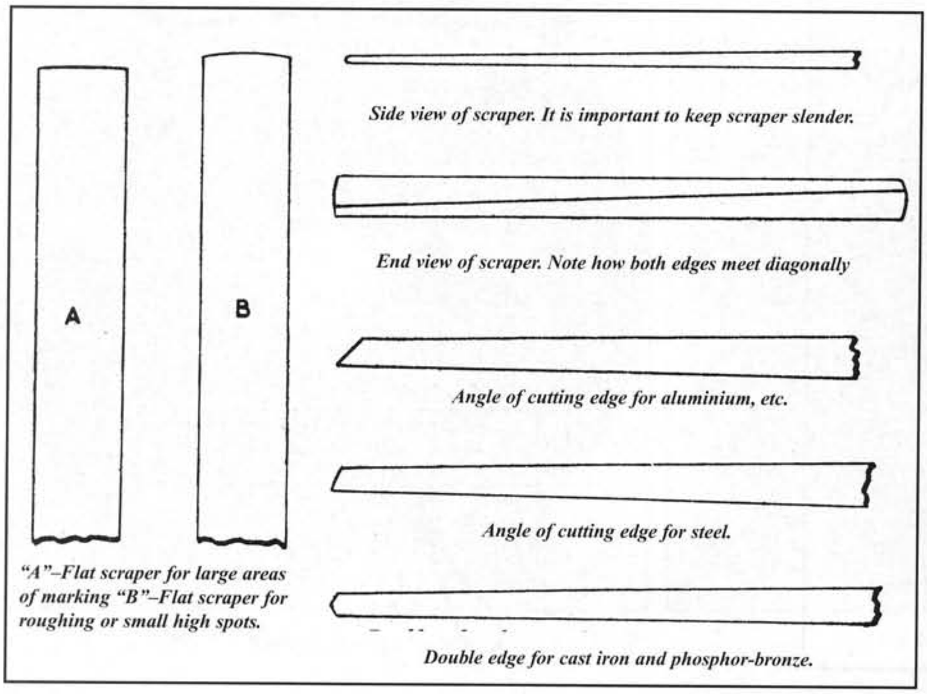
I BELIEVE that one of the most satisfying sights to an engineer, amateur or professional, is a well scraped surface, whether it be mottled, or just bedded-in without any frills.

The art of scraping depends on two things, practice and having good scrapers (and patience!). Scrapers for flat surfaces should be thin so as to have a certain amount of spring when applied to the surface to be scraped. When a scraper is "just right", it should, when applied firmly to the job, just shave the surface without digging in or chattering. Most commercial scrapers suffer from being too thick, and are unwieldy and dead!

From Old Files

Most fitters make their scrapers from old files, (usually for two reasons, cost and the fact that a scraper is an individual's tool and is best made by the individual who is to use it). Later in this article I will describe how.

One of the most important parts of a scraper is its cutting edge and the contour of that edge. For finishing work with broad areas of "bed" a scraper with a very nearly straight-edge is best (just how near to straight depends on the individual); for roughing out and removing large inaccuracies, a scraper with a fair radius is best. Remember, a straight or nearly so scraper will give a bed with broad areas of marking and shallow depressions in between high spots. A scraper with a fair radius will give a bed with small high spots and rather deep depressions between high spots. This type of bed is best for surfaces that have to act as bearings



Side view of scraper. It is important to keep scraper slender.

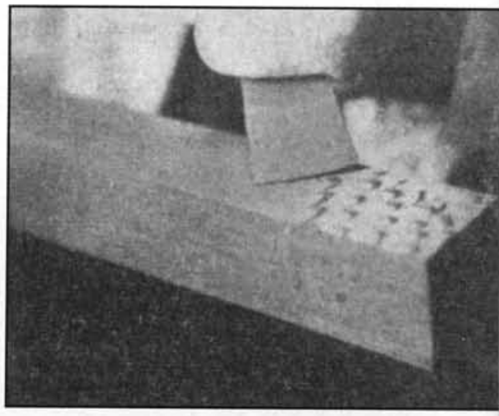
End view of scraper. Note how both edges meet diagonally

Angle of cutting edge for aluminium, etc.

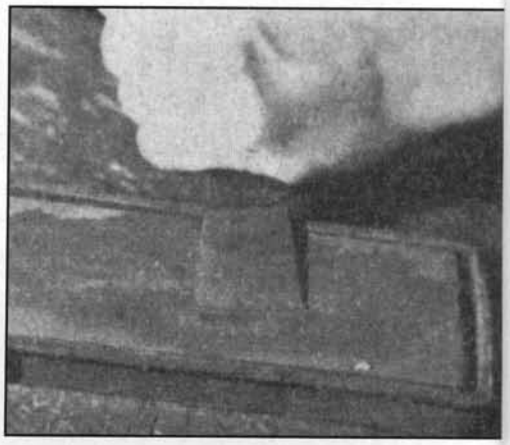
Angle of cutting edge for steel.

"A"–Flat scraper for large areas of marking "B"–Flat scraper for roughing or small high spots.

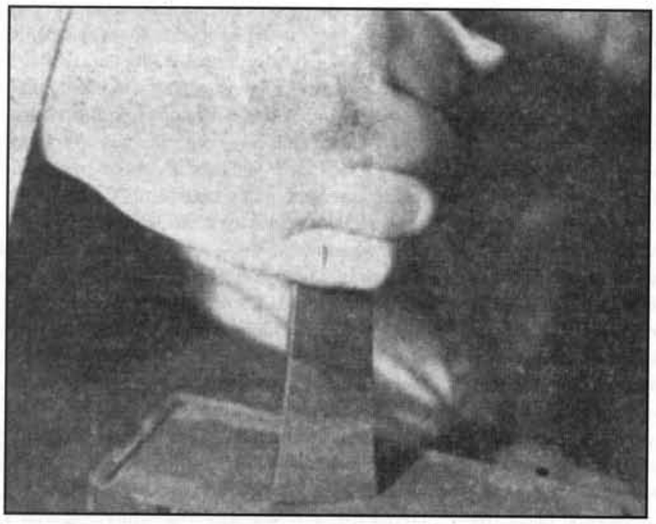
Double edge for cast iron and phosphor-bronze.



Mottling.



Lastly–Stone flats of scraper (for best results use paraffin on stone.)



First–stone end of scraper. (For iron the scraper should be worked diagonally across stone, dragging the scraper along at the same time.)

or machine slides, as it will retain the maximum of oil film. Most fitters, however, prefer one (a scraper of course!) between the two extremes.

To scrape a surface we need a "master" of some sort, a surface plate, straight-edge or special "rubbing block" and some form of marking, i.e., prussian blue oil paint (artists), engineers blue (same as prussian blue), printer's ink or red lead mixed with oil and paraffin. Only a very thin film of "marking" should be used. It is best applied to the master with a pad of rag and should be spread evenly and very sparingly, otherwise a false marking will result. If only the centre of the work-piece is marking, scrape away until the marking is only at the edges and then carefully scrape until the marking appears all over, otherwise it is easy to produce a convex surface that is marking all over! When scraping, the direction of cut should be altered at each marking so as to obviate ripples and to facilitate the removal of high spots.

Accurate surface

If a really accurate surface is required, when the surface is marked all over continue to rub the job with the master, whereupon the high spots will burnish and appear as highly polished spots; these should be removed very gently until they appear all over the job.

If you cannot obtain a master larger than the piece to be scraped, fair results can be obtained with a straight-edge and a small rubbing block. To check with a straight-edge proceed as follows: Check along the edges of the job with the straight-edge and three pieces of paper (cigarette papers are best), one paper at each end of the straight-edge and one paper to check the gap between the job and the straight-edge. After the edges have been checked, the diagonals should be checked. If all edges and diagonals are correct, the job is flat and requires but little scraping. (Use the rubbing block to find the high spots).

How to Make a Scraper

The best files to make scrapers from are smooth fine files, and for most purposes one about 8 in. long will be quite long enough, but for small surfaces like locomotive cylinder blocks (model ones, of course), files down to 4 in. will suffice. Smooth files are best because it is easier to remove the teeth marks (do not leave even a trace of the teeth on the part to be rehardened or forged). The marks will cause hardening cracks if not removed. The file should be heated to orange red and beaten out as shown in sketch (do not allow to blister). When satisfactory, cool and grind scraper to finished shape. To reharden the scraper it should be heated to between orange red and cherry red (the heat varies with the brand of file used) and then quenched in water and note! *Not tempered.*

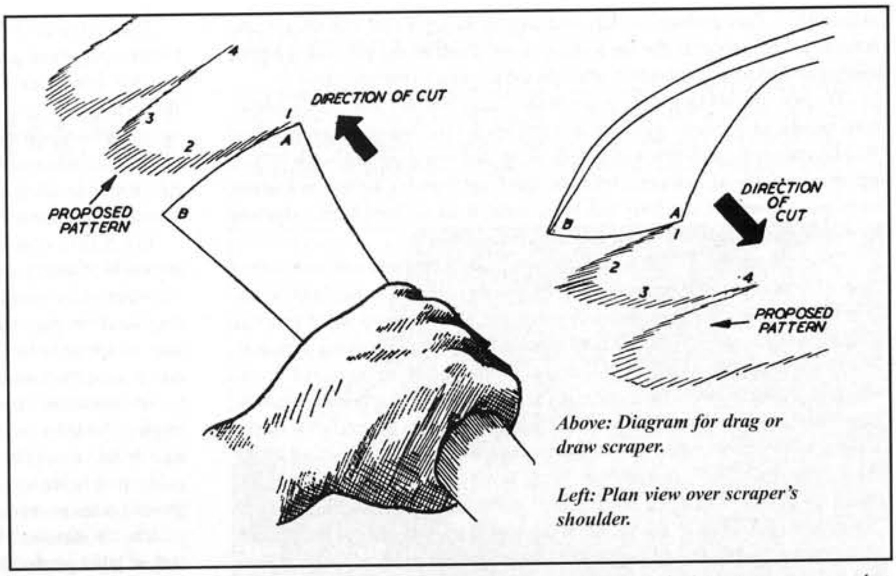
Sharpening

To sharpen the scraper, it should be ground and then stoned. The best stones are Norton India stones. I use a medium grade stone 8 in. x 2 in. x 1 in. (for procedures see photographs), always remembering to stone flats last before using the scraper.

Mottling or feathering are hard to describe with words, and the "way how" is best found by experiment and practice.

IN THE issue of The Model Engineer dated December 13th 1951, Mr Banyard asks for further information about scraping. It is very difficult to describe this process in words, as it is largely manipulative skill that produces the required results and this can only be acquired by practice. The diagrams and descriptions given here seem rather inadequate, but I trust they will be found helpful. The scraper is held down at A and rolled along its cutting edge to B, at the same time being moved forward, slowly at first, between the points 1 and 2, gaining momentum from 2 to 3 and slowing down as the scraper is rolled back from B to A between 3 and 4. Alternatively, the speed of traverse is kept constant and the speed of the rolling action varied. The pressure applied is lightest at A and heaviest at B. It sometimes helps to have the scraper slightly oblique to the line of travel.

The second diagram shows the method employed for producing the same results with a bent scraper, and a dragging action. These directions apply to either diagram.



Above: Diagram for drag or draw scraper.

Left: Plan view over scraper's shoulder.

The neat appearance of scraping is achieved by using the above action to remove single high spots, and so give a feathered or frosted appearance to the surface. It is, however, a process that requires a lot of practice and manipulative ability, not to mention strong wrists.

M. E. 163 633 (1989)

RUN'EM IN

Using the Non-imbedding Abrasives in modelmaking, to save time on assembly and running-in, described by G. A. Watt, B.Sc., C.Eng., M.I.Mech.E.

Non–embedding Abrashives G. A. Watts

Little has been written on this subject, but it is well worth considering in many applications. The addresses and prices have been brought up to date at the end of the article.

THE problems in modelmaking are the same as those appearing daily in industrial engineering; the machinery or tooling to make parts may not be in the possession of, or available to, the would-be user, the cost of such machinery is outside the financial reach of the would-be user, the machinery available is not able to produce parts to the degree of accuracy required. One then has to accept the best that machinery can produce and, at the later stage of assembly, put in work on the mating parts until they have the correct fit.

This fitting operation is basically one of lapping the parts using an abrasive powder mix so that the correct fit and/or surface quality is obtained. The lapping is usually done in one of two ways; by applying the abrasive, mixed with oil or grease, to a lap which is then rubbed over the surface being corrected or it is applied between two mating surfaces which are then rubbed together. Depending on the application, the lapping operation is also described by such words as "bedding" and "running-in".

The abrasive powder can be one of many types such as:

(1) Diamond and synthetic diamond. These are extremely hard and maintain their cutting power and grit size for a relatively long time. They are, however, very expensive.

(2) Silicon carbide, emery, aluminium oxide, ground glass etc. These vary in hardness and whilst not so hard as type (1) they have a good life and are very much cheaper.

(3) Non-imbedding. These are relatively soft compared to (1) and (2) but have the great advantage that they can be used, in complete safety, on white metal, brass, bronze, aluminium, stainless steel, chromium plating and other soft metals as well as on steels and cast irons. They also reduce in particle size while they are working, thus giving a progressively better finish, until they become inert.

The Difference

The types (1) and (2) abrasives tend to imbed into metals to a greater or lesser extent whereas the type (3) will positively not imbed.

The two properties of type (3), namely non-imbedding and particle size reduction, make them ideal for use in assembly of parts on two main counts;

(a) Parts may be bedded together in situ with only the minimum amount of dismantling, that is the amount required to enable the mixture to be applied to the parts involved;

(b) Because the abrasive has not imbedded and is, therefore, loose on the surfaces, cleaning is reduced, in the majority of cases, to a simple flushing operation or a wipe with a suitable cloth; again the dismantling being reduced to a minimum or nothing at all.

Very few modelmakers can have escaped, entirely, the frustration of assembling moving parts and then finding they are tight or, on start-up, finding that a bearing is heating up. The subsequent dismantling, refitting and reassembly are all time consuming and, in the majority of cases, unnecessary when non-imbedding abrasives are at hand.

These abrasives, which have been in engineering since 1919, are designed to be applied in situ, whenever this is practicable, so that the bedding of mating parts will be much nearer the running condition, particularly if the unit is running at the time of application, than if bedding takes place outside the assembly.

Successful Lapping

Where lapping, in the sense of using a lap as opposed to a mating part, is taking place the practice with types (1) and (2) abrasive mixes is to use a soft lap to enable to imbed itself into the lap. With the non-imbedding abrasives there is no point in using a soft lap and so the lap should be as hard as practicable. This enables the lap to maintain its form and size longer and reduces the tendency for the lap to take on the shape of the part being lapped instead of the converse which is, after all, the purpose of the operation.

The non-imbedding abrasives are in two categories; for soft metals and for hard metals, each category having four grit sizes. The soft metal type is used for plain bearings, (not thin wall types), worm and wheel gearing, slide valves, gib strips, crosshead shoes etc., while the hard metal type is for use on gearing, stainless steel valves, machine tool beds, metal to metal joint faces, adjusting screws, injectors, metallic packing to rods, etc.

The modelmaker will be aware that, when using conventional abrasives of types (1) and (2) on stainless steel, if great care is not taken in the lapping process it is very easy for the abrasive to put scores into the metal which can take a long time to remove. This does not happen with the non-imbedding abrasives.

If, when lapping with types (1) and (2) abrasives, it is considered necessary to use progressively finer grit sizes to obtain the surface quality required, the reader will be aware that it is also necessary to clean the surfaces, meticulously, to ensure that the coarser grit has been totally removed before applying a finer one. This "inter-grit" cleaning is not necessary with the type (3) abrasive because the particle size is reducing all the time it is working and also it may be found, for this reason, that it is not necessary to change the grit size to obtain the finish. The only time that cleaning could be beneficial is if there has been relatively heavy stock removal and, again, this would be a very simple operation.

Fast Bedding-in

Because of the relative softness of the non-imbedding abrasives they break down quickly under load. Depending on conditions this could be ½ minute to 2 minutes which means that the user must stay at the job and keep applying it until the correct fit is obtained. It could be that on small areas with little stock removal one application would be enough.

The end result of using the non-imbedding abrasives is faster fitting, fine finishes faster and greater safety in use.

Two typical examples of the saving of time using the non-imbedding abrasives are:

(a) A firm manufacturing and over-hauling reciprocating compressors specifies that the whitemetal crosshead slipper bearings must be bedded using a specific non-imbedding abrasive. The instruction manual states that 10 to 15 revolutions of the crankshaft will be sufficient to bed each bearing pad.

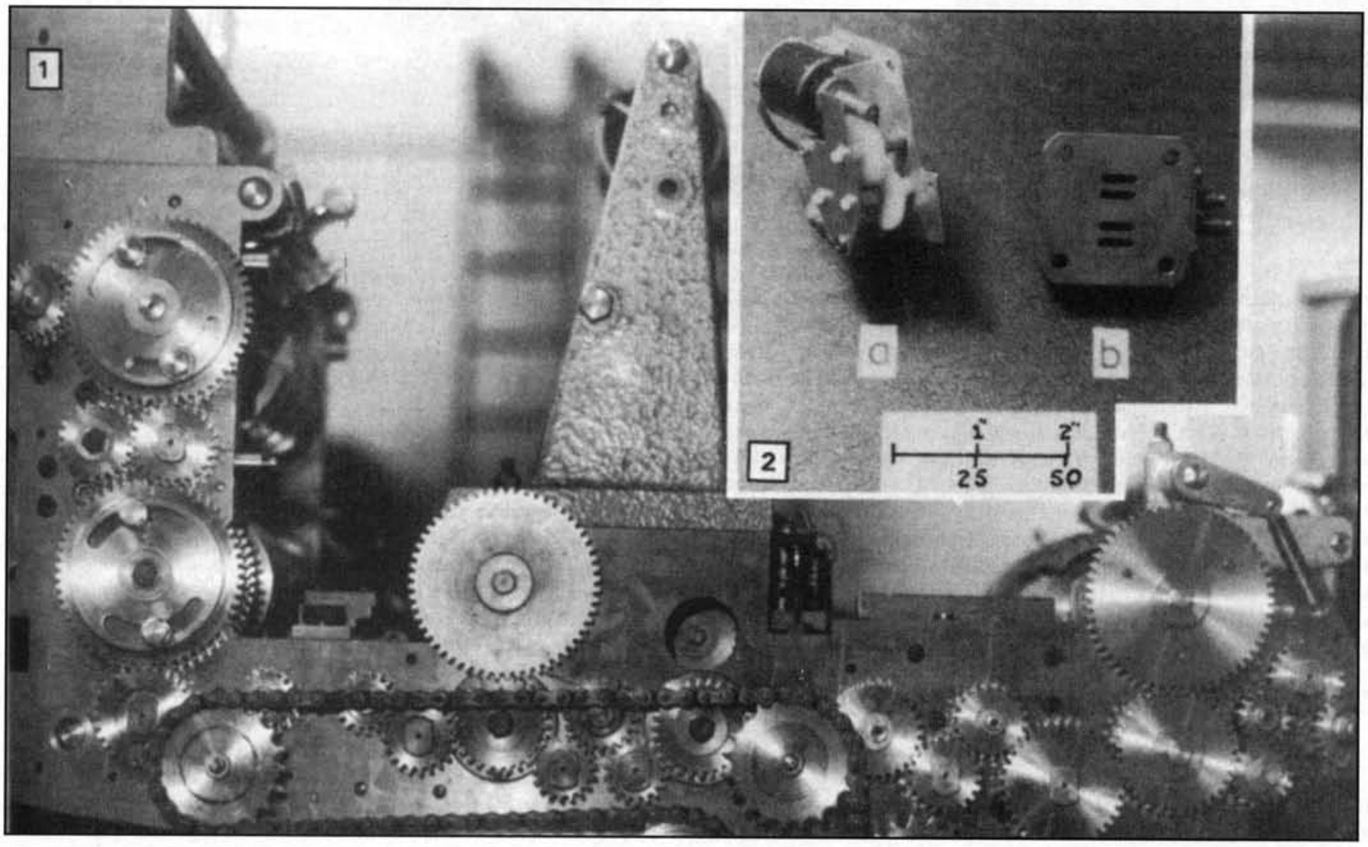
(b) A firm with a press shop can return presses with hot plain bearings to service in 15 minutes instead of 1½ days.

When it is considered that in each case, before they found the non-imbedding abrasives, the bedding process was to strip, "blue", scrape, blue, assemble, strip, scrape and so on until the bedding was obtained it will be seen that the savings now in down-time, labour and loss of production are quite spectacular.

In conclusion, where types (1) and (2) abrasives are being used for any lapping, bedding or running-in applications at present, it will be at least equally safe to use the non-imbedding types and, as can be seen from the foregoing, they bring a whole new dimension into the use of abrasive powders for these operations on the soft metals.

The "Timesaver" brand of Non-imbedding abrasives are available in the Yellow label grades for the hard metals, each colour having the four types; coarse, medium, fine and very fine. They are supplied in 4oz units each costing £12.00 inc. package and post and VAT from:

G. A. Watt
Engineers' Supplier
7 Woodbank Crofts
Westfield
W. Lothian
EH48 3AT
Tel/Fax: 01501 732310



1: This shows 35 wheel gear train which has been assembled using a non-imbedding abrasive. The method is to offer up the first two wheels and if they are tight to use the non-embedding abrasive until they are free, if they are not tight then offer the next wheel and so on until they are all free and bedded.
2a: Shows a gearbox with a 3000 to 3 reduction. The first stage comprises a steel worm on a plastic wheel and the other stages have plastic wheels. The first stage was run-in, as part of a production schedule, using non-imbedding abrasive to reduce the noise level.
2b: Shows the brass block with ports for a slide valve which has been bedded using a non-imbedding abrasive.

M.E. 112 283 (1955)

HOT LACQUERING

by "Micro"

Hot Lacquering Micro

Perhaps slightly esoteric as a subject, nevertheless useful to the model engineer who is making old models or instruments; it is also perhaps applicable to fittings on many engines which run hot and which are therefore inclined to lose their original bright lustre if left uncoated.

THE question of how to finish polished brass so that it will remain bright and give the most pleasing effect is one which arises frequently. Clear cellulose lacquer is often used, and there are other "cold" lacquers which doubtless are good. Where the object is to simulate the freshly-polished metal, as in ornamental brass work, a clear lacquer gives an appropriate effect, but for some types of work, particularly scientific instruments, it is apt to give a harsh unfinished appearance, very different from the warm golden tones which the instrument maker produces. Readers making instruments, and in particular microscopes, may like to try their hands at the real hot lacquering, which is not difficult if properly tackled. It has been used for well over two centuries, and is a most satisfying process which will not readily be abandoned by anyone who practises and becomes proficient at it. The lacquers used are based on a solution of shellac in spirit. Recipes can be found in the usual sources, but as it seems likely that, in fact, certain rather obscure rites are involved in the preparation, and since the lacquers are both inexpensive and readily available, it is recommended that they be purchased ready for use. They may be obtained from Messrs. Gedges, or from Cannings, both in St. John Street, Clerkenwell, London. A considerable range of shades is available, the lightest being known as Pale Gold; there are also Ross, Numbers 1, 2 and 3, which are of increasing depths of colour. Another shade is known as Mathematical Lacquer, and there are special coloured lacquers such as Green Bronze and Blue Steel.

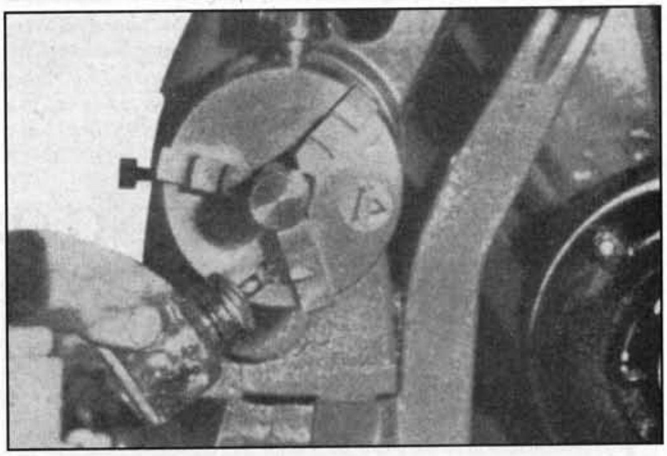
A good lacquer for general purposes, and the best for the beginner to use, is the Pale Gold. Being the most light tinted, slight differences in the thickness of the coat are less apparent with it than with the darker shades, and it is slightly thinner in consistency, which makes for ease of application. Ross No. 1 can also be recommended as giving a most pleasing result.

The other requirements are a small spirit lamp, some metal polish, a shallow tin or jar with a thin wire stretched across its mouth, and a lacquer brush. The latter is most important; it is a flat brush made of a very soft hair, and for general purposes one about ¾ in. wide will be found satisfactory. Although not expensive, the brush should be carefully looked after, since even the best brushes when new tend to shed an occasional hair, and this can spoil the work. After use, it should be washed in methylated spirit and put away out of the reach of dust.

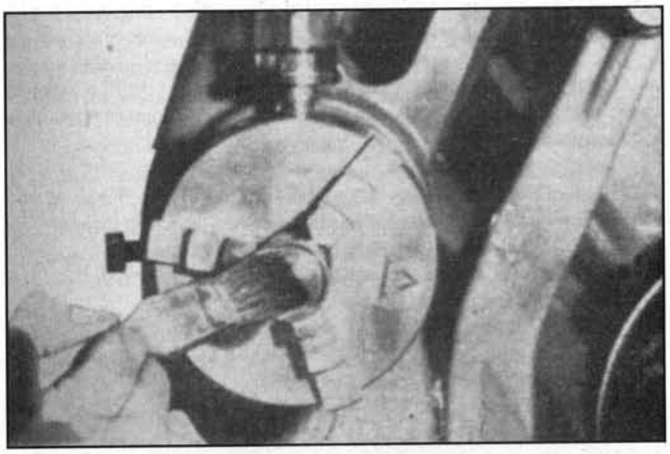
Round work is generally lacquered in the lathe. It goes without saying that good turning is a first requisite; from this stage the work is lightly papered, with the paper wrapped round a smooth file, which should be moved with a filing action and not simply pressed against the rotating work. If a grained finish is required, no more need be done, but for a grainless appearance the work must now be polished. The metal polish generally favoured is a paste which, applied to the fast turning work, quickly produces a high polish. When it has been used, lacquering must be preceded by a thorough degreasing of the work, using a couple of changes of clean rag, liberally wetted with methylated spirit. Use the rag on the rotating work so that the polished surface moves against it in the same manner as it did in the previous stage, and finish off with a dry clean cloth.

Warming Up

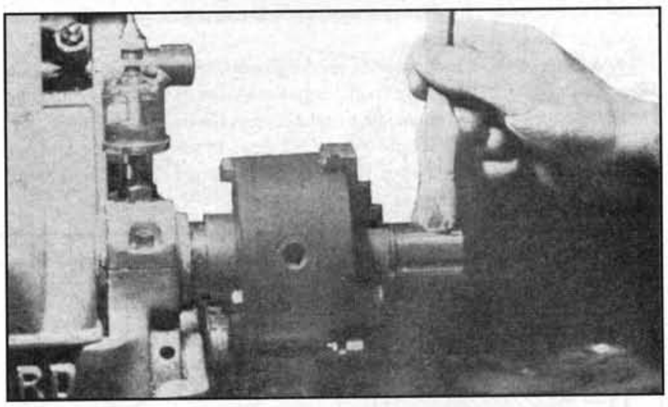
Now set the lathe to run slowly, and put the spirit lamp under the work. At first, water from the combustion of the spirit will condense on the cold surface, disappearing as the metal warms up. When it has gone, the work will be at about the right temperature for lacquering; test it by touching the edge with the inside of the wrist: it should just sting. The temperature of the work is very important, and it is worth giving some thought to its shape. If the piece is thick, the hot surface will be cooled rapidly by conduction to the colder metal behind, and the aim should be to get the job heated throughout, without, at the same time, overheating the surface. This is accomplished by applying the lamp for a minute or so, removing it for a similar period and repeating several times according to the size of the work. Thin tubes, of course, heat up quickly, but since they have a small heat capacity and large surface area, quickly cool down.



Heating the work with aid of a spirit lamp to obtain the correct temperature for lacquering.



Lacquering an end face.



Lacquering a tube. Note that the full width of the brush is not used.

Having by this means got the work hot, fill the brush with lacquer and then wipe it repeatedly across the wire and get it as dry as it is possible to do by this means. It is most unlikely that too little lacquer will be left in it; an almost invariable fault with beginners is to have the brush too wet. Apply the flame to the work again for a moment, then lay the brush on the revolving work, and move it steadily towards the end, the brush being tilted slightly so that the whole edge is not in contact with the work. The change in appearance of the surface where the lacquer has covered it is immediately obvious, and ideally this first coat may be sufficiently thin to show traces of iridescent colour (though this is not essential). Immediately the brush has been passed completely across, apply the flame again and put on a second coat. Three coats is the minimum number that should be used, and each should be thin. All the coats should go on smoothly and quietly; any tendency to hiss is a sign of too high a temperature, whilst an uneven or toffee-like appearance means that the work is too cold (or the brush too full). When lacquering is complete, apply the flame again to dry the lacquer off, and do not handle it until it is quite cold.

In lacquering flat work, the same principles apply, and the brush strokes should be in one direction, following the grain of the finish. It is here even more necessary to avoid having the brush too full in order to avoid "toffee edge".

If for any reason the lacquering does go wrong, it is best to clean off and start again, since it is seldom that faults in the coat can be touched out satisfactorily. When the coat is still freshly applied and the work warm, it can be removed quite easily with a rag liberally wetted with spirit.

Finally, do not burn spirit which has been used for washing the brush, etc., in the lamp. Impurities in the spirit tend to give a smoky flame which interferes with the lacquering process.

M.E. 100 748 & 101 266 (1949)

THE ANODISING OF ALUMINIUM AND ITS ALLOYS

by L. Camidge

Anodising . L. Camidge

A simple yet ignored process that may be useful if you are making components from aluminium alloys. I include another reader's letter of correction on polarity.

THE anodic oxidation or anodising of light alloys, although a fairly old process, has in recent years come to the fore and many household furnishings and utensils are now treated by this method.

The average model engineer can use the process in his own workshop on many of the component parts made of light alloys which go to make model boats, aircraft, etc., and require a corrosion resistant and coloured surface.

Briefly, the anodic film is purely an electrolytic process which thickens the oxide film already present on all light alloys. The depth of the film obtained by the process I am about to describe varies between 0.007mm and 0.015mm in thickness.

The properties of the anodic film are as follows:

(1) It has a high specific resistance to abrasion and is comparatively tough.
(2) The corrosion resistance is much higher than the parent metal.
(3) Heat is resisted up to melting point of the basis metal.
(4) It is an excellent base for paint.
(5) Resistance is high to the passage of an electric current.
(6) It will absorb dyes readily.

It is the first, second, and last properties which are the most interesting, both commercially and to the model engineer.

There are three main processes in use in the commercial field at the present time; the chromic acid, the sulphuric acid and the oxalic acid methods. For the requirements of the model engineer the sulphuric acid process is the one likely to be most useful as it gives a comparatively tough film which absorbs dyes readily. The film is transparent and colourless, which also makes it ideal for colour absorbing.

Either AC or DC current may be used in anodising light alloys, but as the DC process is superior from the model engineer's point of view, this is the one I shall describe. The maximum value of the current flowing through the object being treated should be at about 10 amps per sq. ft. of surface. A transformer and rectifier giving an output of 10/15 volts at 5 amps I find will cover the majority of small parts.

Equipment Required

A transformer and rectifier giving an output of 10/15 volts at a maximum of 5 to 10 amps, depending upon the area the user wishes to treat. An ammeter to check the current flow, together with a variable resistance of about 30 ohms in value capable of carrying the maximum current which will be used, to control the flow of current into the work.

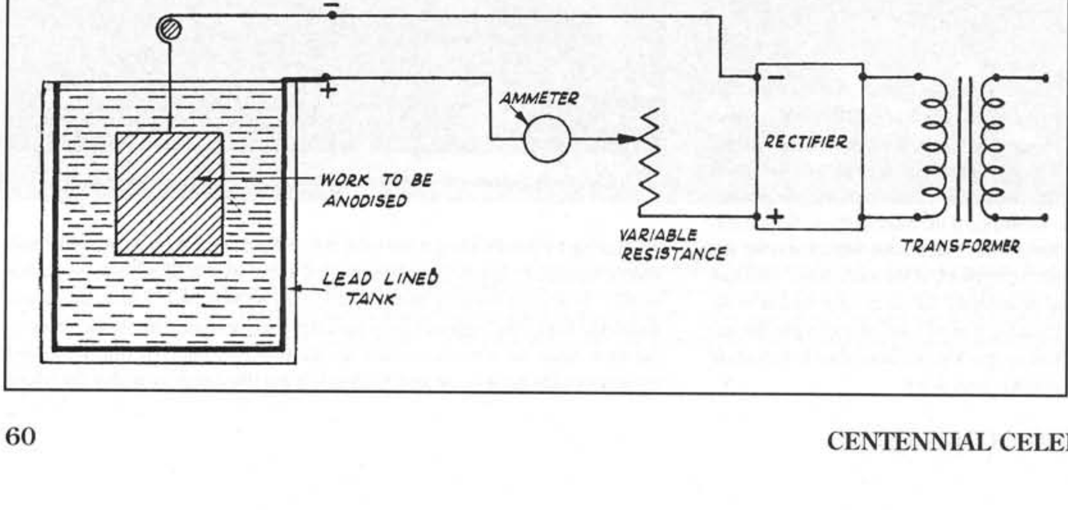
A lead lined tank or vat which must be acid resisting; an old glass accumulator cell of a suitable size serves the purpose very well. The lead with which the vat is lined should be of the high purity type, large enough to be level with the top of the glass cell. The edges of the box so formed when bent need not be joined together, a small lug is left on one edge for connection to the DC supply.

The diagram gives the necessary connections of the complete circuit. As it will be seen the positive side is connected to the vat, the lining of which acts as the anode, the negative side is connected to the work which is to be anodised.

Have the vat large enough to immerse the work completely leaving 1 or 2 in. all round in relation to the lead lining. The sulphuric acid should have a specific gravity of between 1,200 and 1,300 and the temperature of the acid kept down to about 25 deg. C. From time to time the acid will require renewing due to contamination by aluminium sulphate which is formed by the process of anodising and should not exceed 1 per cent.

The Process

The article which is to be anodised is first polished and scratch marks removed as these will be emphasised during treatment. An electrical connection is made to the work by means of an aluminium wire or strip. This connection must be good and preferably in a place which will be out of sight on the finished article. Copper connections will not be suitable as the copper is rapidly attacked by the electrolytic action and may break away from the work; it also absorbs current which should be flowing into the work.



The next step is the degreasing of the article. The importance of this cannot be too highly stressed and any trace of oil or grease and even finger marks will spoil the anodic film and in consequence give patchy dyeing. Once the work has been connected to the wire or strip, all handling must from now on, until the process is complete, be by means of the connecting wire or strip. Holding the article by this means it is thoroughly degreased in some degreasing agent such as trichlorethylene, carbon tetrachloride, or ethylene-de-chloride, by immersing and swilling in this liquid. It is then allowed to dry, after which it is lowered into the vat, care being taken to ensure that it is well covered by the electrolyte. An insulating strip of material resting across the top of the vat and the aluminium wire or strip wrapped around it will hold the work in position.

The vat is now connected up as shown in the diagram and after seeing that all the resistance is in circuit, switch on the current, and adjust the variable resistance until the correct current is flowing. The length of time of immersion should be from 25 to 30 minutes.

The correct amount of current to pass through any article or articles in the vat is at the rate of 10 amps per sq. ft. of surface. If a tube or any kind of hollow article is being anodised the area taken is both the inside and outside surfaces, the hollow surface should be towards the top of the vat to allow gases to have free escape.

After the period of 25 to 30 minutes has elapsed the current should be switched off, the article removed from the vat by means of the aluminium connecting wire or strip, being careful not to touch the anodised surface, and washed under clean cold running water until all trace of acid is removed.

If no other process such as dyeing is required and just a plain anodised surface wanted then the anodised article should be steamed over boiling water for 15 minutes, which will seal the film and the article can now be handled.

If it is required to dye the film then it must not be steamed or handled but immersed in the dye bath which should have been previously prepared.

Dyeing the Film

Some of the beautiful pastel shades or rich dark colours often seen on light alloy fruit bowls and various other articles can easily be obtained by the model engineer in his own workshop by using the previous anodising process and suitable dye solutions.

The same article can be given a multi-colour effect by dyeing a light shade then stopping off where the basic colour is to be retained, then dyeing the next darker shade or colour. Nitrocellulose lacquer is suitable for stopping off as this can be dissolved away by acetone when no longer required. Ordinary household dye is quite suitable for most purposes, and I find that two tubes of the dye to 2 pints of water with a teaspoonful of vinegar included gives a satisfactory solution.

For light colours the dye is used cold, the article being swilled about in it until the required shade is obtained, after which it is steamed off over boiling water for 15 minutes to seal the film. A coating of wax polish helps in sealing the film after the steaming and also gives a smooth finish.

Darker colours and black are dyed in a solution just below boiling point after which the treatment is the same as for cold dyeing.

The dye solution if made fairly thick may be applied by means of a brush and many fine multi-colour effects can be obtained by this method.

An old enamelled pan makes a good dye container and is preferable to iron or tin which may set up chemical action and spoil the dye solution.

A well ventilated room is advised when using the anodising process, as the acid fumes given off will irritate the throat.

PRACTICAL LETTERS

Anodising

Dear Sir - With reference to Mr L. Camidge's article "The Anodising of Aluminium and its Alloys" which appeared in the issue dated June 16th, I feel bound to point out a serious error.

Mr. Camidge states (and his sketch confirms) that the job is to be made cathode. If this were carried out, all that would occur on passing current would be the oxidation of the lead lining and a partial reduction of any oxides present on the surface of the aluminium, with, also, some embrittlement of the latter due to hydrogen absorption.

If DC is to be employed, the work must, as is indicated by the title of the process, be made anode.

The current density suggested is also much lower than is commonly used in present practice; the figure of 18 to 20 amps per sq. ft. being more usual. I would like, also, to suggest that boiling the anodised work in water for about 10 minutes is preferable to steaming, as the uniform temperature thus obtained tends to obviate any internal stresses in the anodic film, and gives better homogenisation and hydration.

Yours faithfully

Stockport LESLIE WARBURTON

M.E. 112 567 (1955)

STEEL BLUEING

By J Wood

Blueing J. Wood

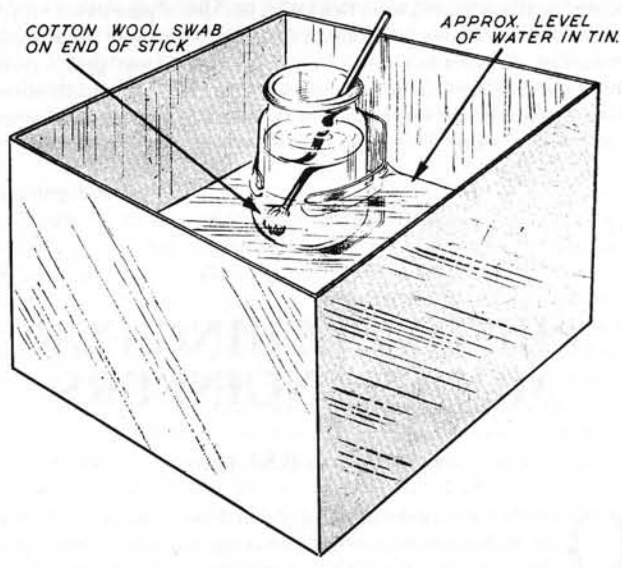
Another vintage article; some of the chemicals mentioned may be difficult to obtain these days, unless you have contacts in the chemical laboratories, but note: there are 437.5 grains in one ounce, or alternatively there are 15.4 grains in 1 gram!

APART from the more popular methods of blueing steel - heat, burning rag, and case-hardening (I mention this latter as it does cause steel to colour, but seldom, unfortunately, with any degree of even tone) - there are dozens of processes and solutions known to the gunsmith and gunmaker today. Those magnificent barrels of the better class of shotguns for example. The colour there, that deep satiny blue so often appraised by both shooter and engineer alike; it is surprisingly easy to achieve this blue .... and, at times, abominably difficult.

However, if one takes the trouble to observe the proper precautions, there is no earthly reason at all why any model engineer should not produce similar effects on those parts which he is anxious to preserve, both from rusting and dullness. Paint, provided it is carefully applied on model parts, is very pleasing to the eye. But paint can become dirty, tarnished, chipped even ... certainly scratched. Gun barrels are treated with blue for a variety of reasons, but that of preservation is the main one. And, strangely enough, this process of preservation is, in actual fact, a rusting process. There are two main methods - the hot rusting and the cold rusting.

Hot Rusting

Equipment: A container of a suitable size for the general run of parts to be treated. Don't make it too big if you can avoid it, as a huge container takes



The accessories required for steel blueing.

a long time to heat and boil the water you are going to use in it. A fairly heavy tin can will do at a pinch. Make it square if you like, as you require a small circular clip in one corner to hold a small jar which will hold the special blueing solution. A small pickle jar is what I use, please yourself, but it *must* be either of glass or earthenware.

A pair of rubber gloves, some fine steel wool, a supply of cotton wool swabs mounted on pieces of wood, and you are nearly ready to begin.

The first and most important item of all blueing processes is *cleanliness*.

We are about to blue a circular shaft of steel, 3 in. long, ½ in. diameter. The shaft must be entirely free of grease of any kind. Blue won't stick on grease! Boil your shaft in caustic soda if you like, polish it with new emery cloth, treat it with carbon-test, but clean it - thoroughly! And while doing this keep those *clean* rubber gloves on!

Neutralise all rusting after process is complete by dipping blued article in slightly warm, thin oil. I often leave parts in oil overnight in order to ensure that complete neutralising has taken place.

Now that it is clean, arrange some method of handling it. If it is bored anywhere, slip a piece of clean wire through the hole and use that to bring it to the water and out again. No hole? Use a clip or fine nosed pliers.

Fill in enough water in your container to cover the part and slip your glass jar of solution into the corner clip. Put a small wooden block under the jar if it isn't tall enough to clear the surface, for it is fatal to get the boiling water and the solution together. Pop the part into the water and turn on the heat. Boil it!

The solution will also be brought to the boil at the same time.

The part is boiled. It has a temperature of at least 200 deg.. F when you take it out by the wire, clip or pliers - with those clean rubber gloves on, remember. The surface moisture will dry off almost immediately. By the time this has happened you are ready with that swab in one hand. The swab has been immersed in the hot solution in the jar and the surplus solution allowed to drip off. Whenever the last trace of moisture has been evaporated, paint on the solution with the swab, carefully, evenly and thoroughly. Leave no part of the steel uncovered with solution. You will see a difference on the surface immediately. The colour will vary according to the type of solution used. A faint rust will form as the solution evaporates, for the steel shaft is still very hot if you haven't over done the swabbing.

Replace the swab in the jar or on a clean rack (I use a simple vee-block for a rack). Take the fine steel wool and proceed to card the rust gently. That is to say, remove the top surface rust gently with light, even strokes of the wool. You are now left with an incredibly fine coating of blue. You have completed what the trade call the first "pass". But the colour is not quite deep enough for you, perhaps. Very well, simply do the same thing again. Into the water, which has been kept on the boil, with the shaft. Allow to heat up again, remove and when the last trace of moisture is gone, get busy with that swab again and, once the rusting is dry, the gentle carding once more. After the second pass the colour is deeper. Carry on this simple process until you have got the depth of colour you desire.

Nothing very difficult about that? Perhaps not, if you take care and keep those utensils and gloves clean. Don't wipe that spot of perspiration off your brow with your gloves in the middle of the job. See that every bit of your little shaft gets an even covering of solution. Use the steel wool gently. Do not drop the swab on the floor between passes. Be sure the water is really boiling. If you find the solution is patchy, it often pays to thin down the solution with a little *distilled* water.

Space does not permit me to go into all the eradicating drills but, with a little experiment, you will find it is not so troublesome. But - to quote the Western Brothers - "Keep it clean, you chaps!"

Cold Rusting

Equipment: Any container that will hold the job for a thorough boiling, to remove all traces of grease or other dirt. Rinse in clean boiling water after that if you like. A swab, as before, and a jar of solution.

Your part is thoroughly clean - so are your gloves and the wire or similar method of handling work. Swab the solution carefully and hang up the article to dry well out of the way. Twelve hours is usually ample for the drying and rusting to take place.

The part is then carded as before, boiled in clean water for five minutes, dried off and swabbed again and hung up to dry and rust as before. Again, the colour depends on the number of passes.

I have dealt with the cold method very briefly as it is seldom used today for a variety of reasons, best known to the gun trade. But - and this is most important - when the hot process may fail with a particular type of steel the cold process will often come up to scratch and produce the most magnificent results.

I give several solutions for either method. One solution will perhaps give an entirely different colour to the other. There are dozens of colours of blue, believe it or not. Again, different steels react differently to the solutions. Thus, in order to give you a choice I include three solutions for each process.

Hot Rusting Solutions

1. Sodium nitrate ¼ oz., potassium nitrate ¼ oz., mercuric chloride ½ oz., potassium chlorate ½ oz., distilled water 10 oz., spirits of nitre ½ oz.

2. Sodium nitrate 100 grains, potassium nitrate 100 grains, mercuric chloride 200 grains, potassium chlorate 200 grains, distilled water 12 oz., spirits of nitre ⅓ oz.

3. (For hard steels). Sodium nitrate 110 grains, potassium nitrate 110 grains, mercuric chloride 200 grains, potassium chlorate 200 grains, distilled water 9 oz., spirits of nitre 1 oz., nitric acid ⅓ oz., tincture ferric chloride ⅓ oz.

Solution number 2 is actually a modified version of number 1 and is particularly suitable for soft steels.

Do not grind ingredients together with a pestle and mortar. The potassium chlorate will go off with a big bang and your efforts will be in vain. The distilled water ought to be warm but *not* hot. Add the spirits of nitre last of all and store in a dark coloured bottle. This last is most essential.

Cold Rusting Solutions

1. Bismuth chloride 10 grams (note - grams! not grains), mercuric chloride 20 grams, copper chloride 10 grams, hydrochloric acid 60 grams, grain alcohol (95 deg.) 50 c.c. distilled water 500 c.c. Care must be taken to avoid precipitation of bismuth salts by adding acid before salts.

2. Mercuric chloride 25 grams (grams again), ammonium chloride 25 grams, distilled water 500 c.c.

3. Iron chloride 100 grams, antimony chloride 100 grams, gallic acid 50 grams, distilled water 250 c.c.

Number 3 solution will give a rather light blue to normal mild steel. Any of the above solutions are easily available from any dispensing pharmacist. It is best to make a rule to keep each in a darkened bottle, brown or, if necessary, green.

M.E. 140 905 (1974)

PHOTO-ETCHING FOR MODEL ENGINEERS

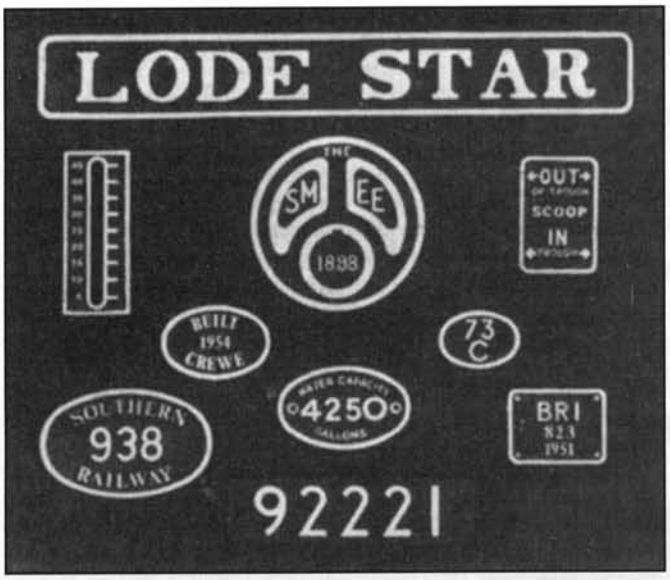
by J. Ewins, B.Sc. (Eng)

Photo-etching J. Ewins

Jim Ewin's article sets out quite clearly the process required to produce a realistic finish by means of this interesting procedure. Relatively little has been written over the years on the subject.

OF THE various techniques used for producing miniature nameplates, that of photo-etching offers the advantage that there is practically no limit to the fineness of the detail which may be produced with great accuracy. This article is intended to describe how the technique may be adapted by model engineers using simple equipment readily obtainable, or capable of construction in the amateur workshop.

The majority of nameplates have characters raised above a plain background, and the technique produces these by chemically etching away the metal between the characters. It is one of the limitations of the technique that, as the process proceeds, the sides of the characters are attacked and undercutting occurs. In practice this means that there is a maximum depth of etching beyond which the deterioration thus brought about becomes unacceptable; the



Some plates made by the author.

smaller the detail required, the sooner this limit is reached. My experience indicates that the results obtainable by the simple methods about to be described are quite satisfactory for the majority of nameplates appearing on model locomotives of 1 in. scale downwards, with the possible exception of some of the heavy cast plates where the prototype depth of lettering is as much as 3/8 in. These, if made to 1 in. scale, would require a depth of some 30 thou., which is beyond the scope of this technique, where the limit is around 15 thou. In respect of this depth of etch, commercial operators are able to do rather better than the amateur by the use of more sophisticated etching equipment and techniques.

Outline of the Technique

The process starts with a plate of metal (usually of brass or copper) of thickness equal to that of the finished plate and somewhat larger in area. Upon this is deposited a layer of material capable of resisting the chemical action of an etchant which, if allowed to come into contact with the metal, would dissolve it away. This layer is called a "resist", and it is necessary to remove those portions of this resist where the action is required. This usually means that for a conventional nameplate the spaces between the letters are removed, resulting in the letters being raised above the background when the etching takes place. In order to remove the resist selectively, it is exposed to light through a photographic film which has been prepared in such a way that those areas where the resist must remain (the characters) are clear areas on the film, thus allowing the light to pass to the resist and cause it to harden. Elsewhere the photographic film is intensely black, thus blocking the path of the light and allowing the resist to remain soft and capable of being easily dissolved away in a suitable solvent.

Preparation of the Photographic Film

The film is prepared by photographing an enlarged drawing of the proposed nameplate; this drawing has black letters on a white background, so that when photographed the negative will have clear letters on black. The size of this drawing will depend on the facilities, and also upon the focusing capability of the camera to be used. Generally, however, the larger the better so that small errors in the original become negligible in the final result. I have used cartridge paper and indian ink, as well as Letraset characters, for this purpose. Whilst preparing the drawing, it is as well to draw a rectangle around the design - or at least to mark the corners of such a rectangle - so that a check can be made with dividers during photographing to ensure that the image is square and of the correct size - tapered nameplates do not look very good!

The photographic process requires a camera having a format large enough to accommodate the size of the finished plate or plates. Thus for very small plates, a 35mm camera could be used, but usually a larger one is called for. An old plate camera is ideal, especially if fitted with a cut film adapter, as single shots on film can be taken; these cameras are usually provided with a focusing screen which permits adjustment of size and shape of the image visually. Plates may be used, but there is a certain disadvantage with these because the glass absorbs some of the ultra-violet light to which the resist is sensitive. The ideal film is a very contrasty one of the process type, and indeed special films are available for this purpose, but I have not found these to be strictly necessary for the class of work in hand. A trick to improve the contrast of ordinary films is to expose it until the "clear" parts are just not clear, and then to reduce in Farmer's reducer (potassium ferrocyanide) until they are.

Preparation of the Metal Plate

The plate is cut to a size rather larger than that of the job, and coated on one side (the back) with paint so that the etchant does not reduce the thickness from this side; any ordinary cellulose paint is suitable for this purpose. The front side is prepared using various grades of emery paper until all scratch marks are removed; a final finish is obtained by the use of an abrasive such as pumice powder or Vim. The abrasive provides a semi-matt surface to which the resist adheres well, but a further surface treatment consists of immersing the plate for 30 seconds in a 10% solution of hydrochloric acid. This operation is said to reduce undercutting during etching, but does not appear to me to be strictly necessary for our purpose. After the plate has been dried, for which purpose I use paper towelling, it is ready for coating with the resist.

Resist can be prepared with simple materials but the process is tedious, and in view of the excellent proprietary ones obtainable - albeit with difficulty - it is well worth the trouble of getting this material ready made. I have used Kodak Metal Etch Resist (K.M.E.R.), but unfortunately this is only normally sold by the quart and then only to those having an account with Messrs. Kodak. It is therefore necessary to order this through a photographic dealer and in view of the minimum quantity sold it would be advantageous for members of a club to get together for this purchase since an individual would need only a few c.c. for a whole batch of nameplates.

The K.M.E.R. as supplied is too thick for our use, and needs to be thinned. Special thinners are supplied, but I have used ordinary xylol for this purpose successfully. The best consistency is determined by experiment, but 50/50 is a good point to start with. If the resist is too thick, it is difficult to get an even coating on to the metal and if too thin the resist will not stand up against the action of the etchant sufficiently. Generally, the finer the detail required the thinner the resist needs to be to obtain this detail.

The method of coating I have used is called "whirling" and consists of rotating the plate about an axis perpendicular to its surface by means of an electric drill rotating at about 300 rpm, the plate having previously been covered with the resist by pouring on a surplus; the surplus is flung off by centrifugal action, and rotation should be continued for a minute or so to obtain an even coating. To attach the plate to the drill, I have made up a small faceplate having a spigot to fit the drill chuck. The nameplate is attached to this by means of double-sided adhesive tape. The drill is held with the plate uppermost to receive the resist which is poured on and rolled around until the whole surface is covered. The drill is then quickly inverted and switched on. To catch the spray which comes off, it is advisable to lower the job into the open end of a suitable cardboard box. After coating, the plate should be allowed to dry for about ten minutes away from bright light, and then lightly baked to drive off the surplus solvents. This baking can be carried out by simply holding the plate over a clean flame - I used a spirit lamp - until it reaches a temperature at which it is just uncomfortable when held against the back of the hand; one or two minutes at this temperature is satisfactory.

Exposing the Plate

The film needs to be held in close contact with the prepared resist during exposure, and this may be achieved by using an ordinary photographic printing frame in which the glass has been replaced by a sheet of "Perspex". Alternatively the metal plate and film may be sandwiched between a sheet of hardboard and the Perspex, the whole being held together by a couple of "Bulldog" clips. The K.M.E.R. is sensitive over a wide range of the spectrum, partly in the ultra-violet region and also in the visible. Ordinary daylight, especially direct sunlight, is quite effective for exposing the resist, except that being variable in intensity it is difficult to control the exposure. If one can get hold of an ultra-violet lamp, this is much to be preferred, as the exposure will be short and well defined. A few trials will soon establish the exposure necessary to harden the resist without burning through the opaque parts of the film. It is here that the more contrasty photographic results pay off.

After exposure, the image needs to be developed - which is simply dissolving away the soft parts of the resist in Xylol. This again is best done by immersing the plate without agitation for two minutes, followed by a vigorous washing under a running tap. At this stage the resist image will be quite fragile, and must be lightly baked to drive off the residual solvent and water. Again, for this part of the operation I find that it is quite sufficient to heat the plate over a clear flame as previously described. The plate is now ready for etching.

Etching

The most suitable etchant for brass and copper is ferric chloride; this can be obtained from a chemist in the form of powder, and is then dissolved in water. Various strengths of solution may be used, and generally speaking, the stronger the solution the slower the etching, but the better the result. A strength of 60% W/V i.e., 60 grams of solid dissolved in 100 c.c. of water, gives good results, but weaker solutions may be employed. Except for the shallowest results, the etchant must be agitated, and I have tried various arrangements to secure uniform results. The trouble seems to be that as the characters form, the flow of etchant forms eddies around them giving rise to preferential action at sharp corners, etc., this results in a degradation of the background which gets worse as the etching gets deeper. Commercially the etchant is sprayed on to the plates by paddles, or centrifugal devices so that the drops strike the plate perpendicularly and vigorously. This action reduces the effect mentioned above, but gives rise to another in which the characters are perched on hillocks. The ideal is, of course, that each character should have near perpendicular sides rising up from a plain background so as faithfully to represent a cast plate. However, for depths up to about 10 thou. a simple rocking action gives good results, especially if the plate is suspended face downwards thus allowing the products of the etching to fall away. I achieve this by sliding the plate into slots in two pieces of Perspex, which hold the plate about ¼ in. away from the bottom of an ordinary photographic dish containing the ferric chloride. The rocking action is obtained by resting the dish on a hinged board under which there is a small geared motor revolving a cam, the number of lobes on the cam being arranged to give a rocking frequency of about 30 per minute.

Finishing the Plate

When a sufficient depth of etching has been obtained, the plate should be washed off in a solution of soda in water, and then in clean water. After cutting and finishing the outline, it is necessary to fill the background with suitable colour; I use cellulose paint sprayed on for this purpose and it seems to adhere very well to the etched surface without a special preparation. The removal of the paint is done with fine grade wet and dry paper with plenty of soap and water. Finally the whole plate may be sprayed with clear lacquer. Certain nameplates on some prototypes are painted all over with one colour and the characters picked out in a contrasting colour, usually white on black. In small plates with fine detail, the reproduction of this effect presents difficulties but these may be easily resolved by using a rubber roller charged with the colour needed on the raised letters. A suitable medium for this purpose is that supplied for the reproduction of lino-cuts, which, I believe, is really an ink. If this is rolled out onto a glass or Perspex plate until the roller is uniformly coated, a single pass over the surface coats the letters and leaves the background clear.

The technique described above may sound complicated, but is very quickly mastered and the results well repay the trouble. For those prepared to experiment a little, I recommend that they turn their attention to the etching process with a view to devising a simple set-up which will project the etchant perpendicularly at the plate. This I believe will enable a greater depth to be achieved with less deterioration of the background.

Warning

Ferric chloride is a corrosive substance and should be handled carefully: it should not be allowed to come into contact with the skin. If it should get into the eyes, irrigate with clean water. If swallowed, drink plenty of water followed by milk of magnesia.

The solvents used with K.M.E.R. are of low toxicity, but prolonged exposure to them should be avoided. Therefore do not use them in a small closed workshop. Reproduced by courtesy of S.M.E.

M.E. 155 456 (1985)

Files and Filing Methods

Metal removal outlined by Les Oldridge

Miscellaneous Hand Techniques

This group of articles includes good advice on the use and care of simple everyday hand tools, as well as information about other precesses carried out in the model engineer's workshop.

Filies and Filing   Les Oldridge

Neglected, abused, badly handled and cut up for other uses at the end of its life. the humble file must be the metal working tool to which all model engineers are first introduced. In the earlier years of Model Engineer methods of re-sharpening files by acid etching were often printed, but a clear exposition of the breed itself was seldom to be found. This is a good example.

MODERN engineering workshops are so well equipped with machine tools that a file is rarely used. The amateur, however, is not so fortunate and in any case it is often quicker to bring a component to size by using a file than to spend time setting the job up in a milling machine or shaper, even if there is one available. Filing flat is not easy; it takes a lot of practice and its only by getting into the workshop and "having a go" that the beginner can become proficient. No amount of reading can teach anyone to file accurately but a few words to point the tyro in the right direction may be helpful.

Files are categorised by their length, section and cut and there are thousands of different types but the model engineer only requires a few. Exactly what he chooses to buy will depend on the work on which he is engaged. I have found it a good policy, with all hand tools, to buy them as the need arises, rather than to purchase several at the same time on the off-chance that they will come in handy at some future date. This spreads expenditure more evenly and ensures that only essential tools are purchased.

File Length and Cut

The length of a file is the measurement from the shoulder above the tang to the point. The exception to this rule is for needle files where the total length is measured. A file may have a single or double cut. In single cut files the teeth are parallel to each other and at an angle to the centre-line of the file. The double cut file has a second

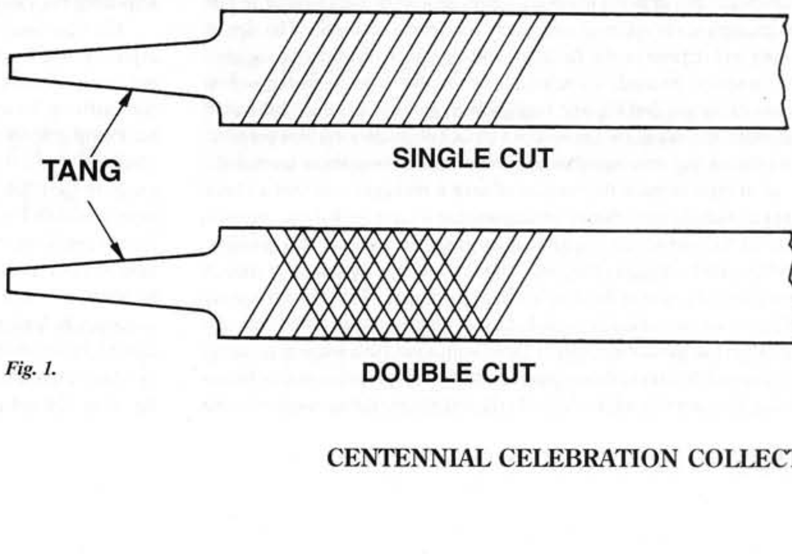


Fig. 1.

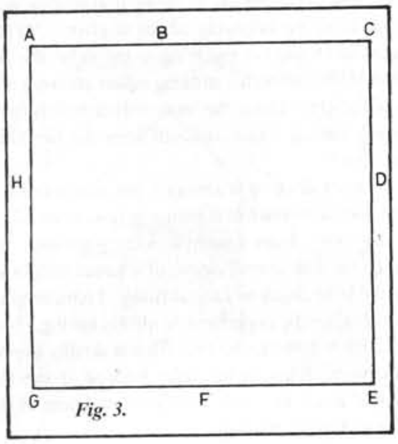


Fig. 3.

cut over the first. This produces small pyramid shaped teeth which have more cutting edges and it is the double cut which are in general use, see Fig.1.

The cut of a file varies from very coarse to extremely smooth. The ones in general use, and likely to be found in the model engineer's workshop, are the "Bastard" for heavy removal of material, leaving a fairly rough finish; second cut, a general purpose file for light removal and giving a fair finish; and smooth for fine finishing work. Two rather special cuts should be mentioned; the Dreadnought, especially useful for the rapid removal of softer metal such as aluminium, and the rasp which will deal with wood in a rough and ready sort of way.

File Sections

There are several different file sections, each designed for a particular type of work. Fig.2. shows the shape and section of a variety of files. The hand file is parallel throughout its length, viewed from the cutting face, but its thickness tapers towards the end. Both faces are double cut and one edge is single cut. The other edge is left smooth and forms a "safe" edge. This allows cuts to be made into corners without damaging the side against which the "safe" edge is in contact.

The flat file is tapered in both width and thickness, is double cut on both faces and has a single cut on its edges. The half round is a very useful shape but mis-named; it is not half round but only a small segment of a circle.

Square files are double cut on all four faces and are tapered for the first third of their length. They are useful to clear small corners and slots to form square holes. Three square or triangular files are the speciality of the "saw doctor" but are also useful for shaping holes with less than right-angle corners and for producing really sharp corners. The round file, colloquially known as the "rat tail" for obvious reasons, is tapered for the first third of its length and is used for enlarging holes.

Warding files are similar in shape and cut to the flat files but are much smaller. They are of uniform thickness throughout their length. Originally intended for making wards in the keys and locks they are very useful for dealing with the small components commonly found in the model engineer's workshop. The knife file shaped something like a wedge, is not generally in much demand by the model engineer but is useful in entering slots where standard files are unsuitable.

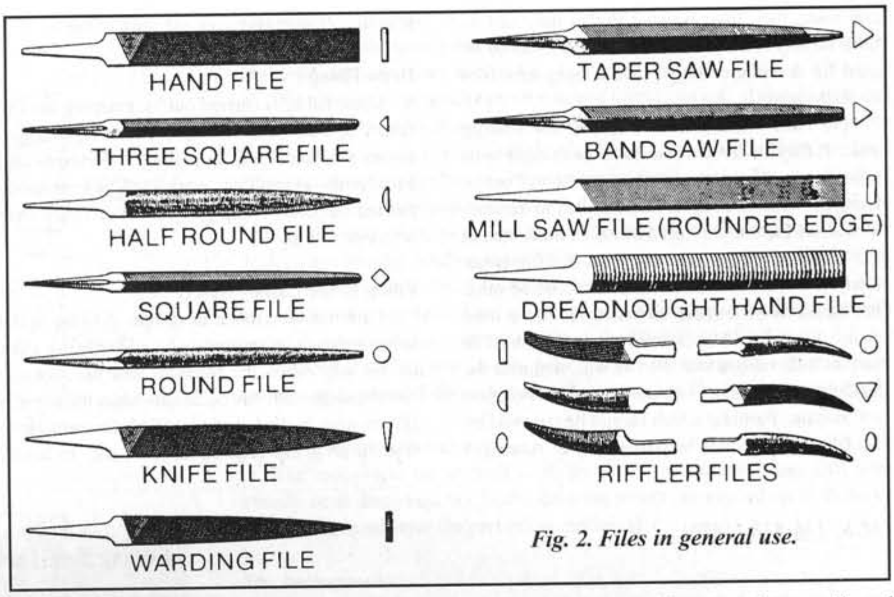


Fig. 2. Files in general use.

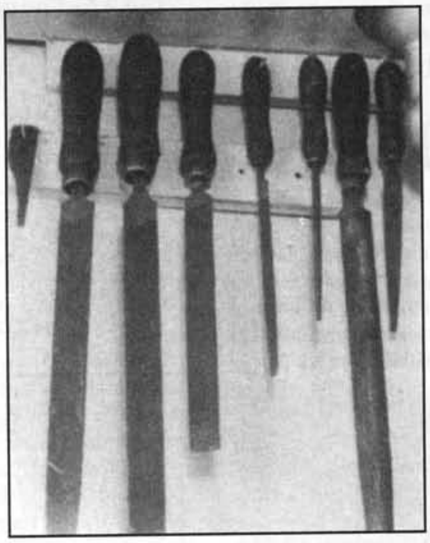


Fig. 4. When not in use files should be stored on a rack and kept free of rust.

Needle files are very small files of various shapes and sections which are used for very fine and delicate work. The tang is formed into a thin cylindrical shape and the pitch of the teeth range from 40 to over 200 teeth per inch. Riffler files are specially shaped to meet special requirements. They are used, for example, when tuning internal combustion engines, for enlarging and smoothing the exhaust and inlet ports.

Use and Care of Files

Files must never be used unless the tang is protected by a handle. The handle should fit the palm of the hand comfortably so as to give improved control and be firmly attached to the tang. Failure to fit the handle securely, or using the file without a handle, can lead to the tang penetrating the palm of the hand or wrist.

The most difficult part of using a file is to file flat, there being a tendency to use a rocking action so that a convex instead of flat surface is produced. A deliberate effort must be made, at first, to prevent the rocking action and, eventually, filing a surface flat will come quite naturally and without any special effort.

The following points will help to improve performance, reduce filing time and ensure an accurate and better finished surface.

(1) The vice in which the work is held should be level with the user's elbow so that the movement of the file will be horizontal. The work should be securely held in the vice using clamps to prevent damage to soft or finished surfaces by the checkered jaws of the vice.

(2) Choose the right type of file for the job; use as big a file as is practical, do not nibble at the job with a small file. Use steady strokes maintaining a steady pressure just enough for the file to bite comfortably into the work. Too much pressure encourages the rocking movement mentioned earlier and can cause excessive wear on the file - too little pressure allows the file to slide over the metal, which will blunt the teeth of the file and not remove the metal as fast as when correct pressure is applied. The file must be lifted on the return stroke.

Files are commonly used at too fast a speed; a file is a cutting tool and, being made of carbon steel, the correct cutting speed is quite low. Keep checking the work with a straight edge and/or square so that if an error is being made it will be discovered early enough for there to be enough metal left for correction. By changing the direction in which the file is working it is possible to check how the metal is being removed by watching the marks made on the work by the file. In Fig.3. a square of metal is shown. If the file is used on the square from F to B a set of file marks will be produced at right angles to G-E. If the file is now used from E to A it will be found that the original marks are not being completely obliterated and it can be seen where the low spots are likely to be and the necessary corrections made.

The file can then be used from G to C when a fresh set of marks will appear. By constantly changing the direction of the strokes of the file in this way and by frequent checking of the work with a square and/or straightedge accurate work can be produced. Do not try and hurry the job. Slow steady strokes with an even pressure will remove the metal at a good rate.

(3) Use new files for such soft metals as brass

and when they have become dulled they can be used on steel and iron. Very old files should be used for dressing castings. Avoid using new files on sharp edges.

(4) Files are expensive and pay for looking after. If they are thrown in a drawer with other tools there is a danger that damage to the teeth will occur. Hang the files on a rack. Holes drilled in the handles allow them to be stored safely as illustrated in Fig 4. Rust will damage teeth and if a file is not likely to be used for some time it should be oiled but the oil must be removed before the file is used again. Files should be cleaned regularly with a file card. Chalk rubbed into the file will minimise the tendency to clogging, especially when working on soft metals. Particles which cannot be removed by the file card can often be pushed out by running a strip of soft metal between the rows of teeth.

Draw Filing

Draw filing is carried out by grasping the file firmly at both ends and laying it at right angles across the work and propelling it forwards and backwards along the work. When properly carried out draw filing gives a better finish than ordinary filing.

Filing in the Lathe - Safety

I am not very much in favour of filing in the lathe, in fact as an apprentice I could only use a file in this way when the foreman was not looking. Nevertheless, there are occasions when the use of a file on work in the lathe is justified, for example to take off the sharp edge on turned work. In Neill's Tool User's Handbook, in the section dealing with Stub files, the following advice is given. "When work to be filed is revolving in the lathe, the file should be used with a stroking action allowing it to glide slightly along the work. This will help to avoid making ridges and will keep the file clear of chips".

Loose clothing is always a potential hazard in the workshop and this is particularly so when filing in the lathe. I saw a nasty accident some time ago when the torn overall sleeve of a turner caught up in the lathe chuck as he was filing. I have emphasised earlier the importance of always having a handle firmly fitted to the file. This is doubly important when filing in the lathe because if the file should strike the chuck the unprotected tang of the file will pierce the hand.

M.E. 136 818 (1970)

Cutting Tool Angles   Ian Bradley

Such a fundamental subject as this has really received little dedicated coverage over the years, so this 30 year old article is chosen as an excellent reference work. The author was of course the longer surviving member of the Duplex team.

Ian Bradley talks about

Lathe Tools

THE NUMBER OF tools necessary to perform work satisfactorily in the lathe is really very few. At one time very comprehensive sets of tools were offered for sale, many if not most of which the eventual purchaser never used. These sets also had the disadvantage that the shanks of the tools themselves were left in the rough forged condition, and not ground flat on their underside which is generally accepted as being best for ensuring a firm mounting in the toolpost.

Today, however, one can buy tool bits that are ground all over and, as they are bodily shaped, may be used as they are, or clamped in a holder if need be, the firmness of their mounting is assured, provided of course that the machine tool itself has no shortcomings in this respect.

In view of the advantages to be obtained from the use of high-speed steel, it is perhaps not surprising that tools made from carbon steel are losing their favour even in the amateur workshop. One form of carbon steel finds a use, however, this is silver steel, available in round bright bar varying diameters each 13 in. long. The material finds an application in the making of cutters for various purposes, since in the annealed state it is readily machined and subsequently hardened and tempered by quite primitive means. On the other hand, the hardening and tempering of high-speed steel calls for the employment of equipment most unlikely to be found in the average small workshop, so tool forming there is by a grinding process only.

Carbide-tipped tools

The amateur workshop for the most part cannot make the best use of carbide tools with one exception, that is the tool used for machining cast-iron. The reason for their failure, when used on the light type of lathe possessed by most amateurs, is that the carbide tip itself has little mechanical strength, so, when it is not possible to take a heavy cut, the chip produced by the turning operation impinges directly on the cutting edge, causing it to crumble.

When turning cast-iron, these conditions do not apply. The chip produced breaks up immediately on impact with the cutting edge and has then no ill effect upon it. Carbide tools suitable for use in the small workshop will be discussed later.

Before dealing with specific tool shapes the terms commonly applied to their angles must be considered. These are shown in Fig.1. From this illustration, where the tool is depicted in sections, it will be seen that in order to allow the tool to cut in the direction shown in the diagram A, side clearance must be given or the tool will rub on the work. Additionally to provide the correct cutting angle for the material being machined, side rake must be given to the tool point. Where viewed from above the point of the tool will be seen to have an angle of relief; this is needed to prevent "chatter" or vibration of the tool, the frontal area of the tool in contact with the work being reduced to the minimum consistent with obtaining a good finish to the work surface. Front clearance must also be given to the tool as shown at B, in order to provide a satisfactory cutting angle.

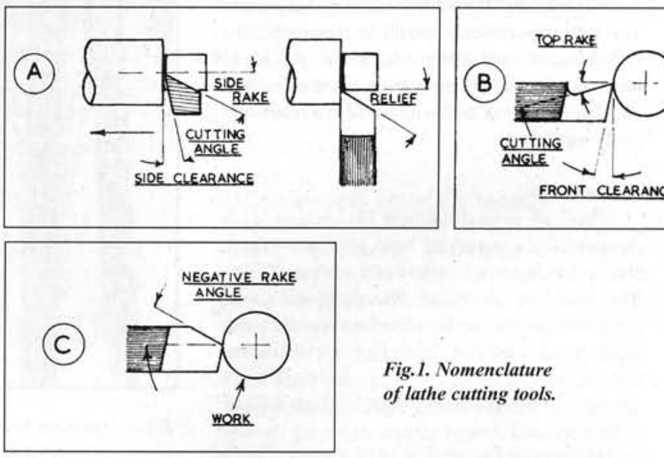


Fig.1. Nomenclature of lathe cutting tools.

Before leaving the subject of tool angle terminology, one further condition needs to be considered. This is the provision of negative rake to the tool point as illustrated in Fig.1 at C.

From this diagram it will be seen that the top surface of the tool is inclined at an angle above the centre-line of the work. This practice is often adopted industrially, but in the small workshop can be employed with success when machining the harder bronze alloys.

Tool shapes for external work

The basic tool shapes required are not many but the few there are can be applied to a variety of tools for both internal and external work. The first of these is the roughing tool which probably needs less power (despite its ability to take heavy cuts) than any other. As an example of its effectiveness Fig. 3 shows a roughing tool removing $\frac{7}{16}$ in. from a 3 in. billet of stainless steel. This machining operation was carried out at a mandrel speed of 60 r.p.m. taking a cut of 0.005 in. per revolution using a copious flow of neat cutting oil (Gulf Metsil E) as a coolant. The lathe used was a 4 in. Myford, now some 40 years old, and the driving motor fitted was a $\frac{1}{3}$ h.p. machine of a standard commercial type.

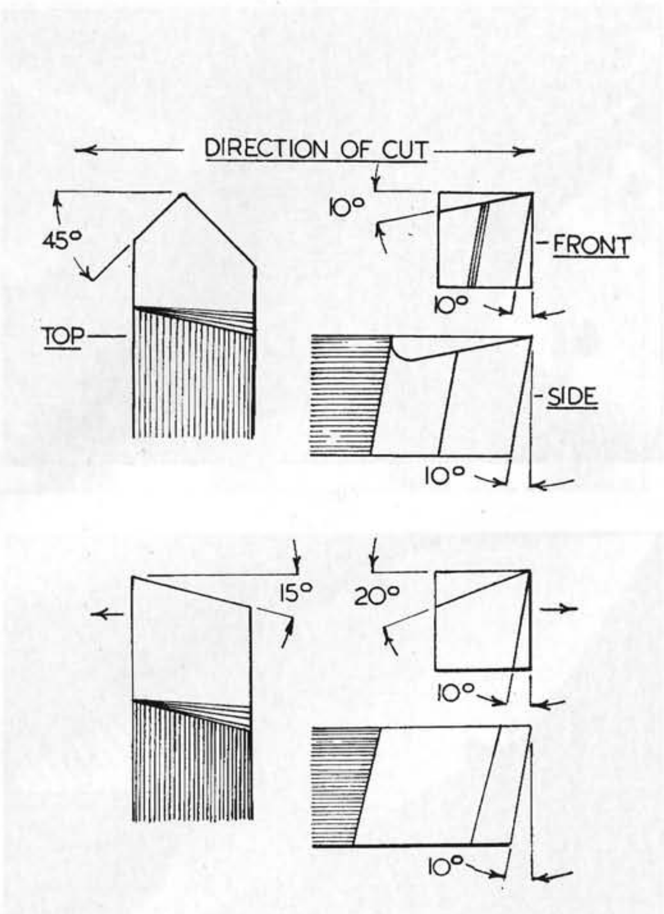


Fig. 2 Roughing and knife tools.

The knife tool

The most important weapon in the turner's armoury is the knife tool. It is found in both right-handed and left-handed forms. The right-handed knife tool cuts from right to left, that is to say it is fed towards the headstock of the lathe, whilst its counterpart the left-handed tool cuts in the opposite direction. Fig. 2 depicts the salient characteristics of a right-handed knife tool.

It is usual to grind a small flat land at the tip of the tool. This area is at right-angles to the cutting edge, helping to promote a good finish to the work. As it is sometimes necessary to form a rounded corner on shoulders machined by the knife tool, the flat land can be replaced by a radial point. For the amateur worker the radius of this point can probably be standardised at some convenient figure and it will therefore be convenient to have two right-handed knife tools to avoid the wastage of material and the time involved in altering the point of a single tool. An enlarged view of both forms of point is seen in Fig. 4.

The parting tool

Once the worker has completed the turning of a component he will need to sever it from the stock material. This he does with the parting tool, shown in Fig. 4. This is the form usually supplied in sets of turning tools, but experienced workers modify the point to ensure that the work is removed cleanly and this alteration is shown at A. This is the tool point commonly used in automatic lathes where, of course, it is absolutely essential that the parts produced are parted off cleanly.

Where much bar material turning is undertaken the parting tool is best mounted in a toolpost set on the cross-slide behind the work, thus leaving the top-slide itself for holding outer turning tools either singly or in a capstan head that may indexed accurately to bring a succession of tools to bear on the work as required. It is perhaps worth emphasising that the back toolpost, as it is called, is the ideal holder for parting tools in a light lathe because the forces then acting tend to force the faces of the cross-slide into closer contact. In this way vibration sometimes encountered in the front-of-work placing of the tool can be eliminated. Long ago "Duplex" advocated this position and designed a toolpost that itself possessed a capstan-head. Carrying a pair of tools, two operations regularly needed. A typical set-up embracing front and rear tool placings in capstan-heads is illustrated in Fig. 5.

The screwcutting tool

The last of the basic tools needed for external work is the screwcutting tool whose salient features are seen in Fig. 4.

The point angle depends upon the thread form to be cut. It should be noted however that as supplied, commercial single-point threading tools are not necessarily ground to any particular angle. One must be careful, therefore, to check this angle using the appropriate setting gauge for this purpose. This gauge, illustrated in Fig. 6, is provided with male and female cones of the correct angle so that the accuracy of the tool point can be checked. In addition the sides of the device have angular notches, again of the correct angle, machined in them to enable the turner to set the threading tool squarely with the work. This he does by placing the gauge against the side of the part and engaging the tool point with one of the notches in the manner shown by the illustration Fig. 7.

A piece of white paper or card placed below the tool point will enable the correct engagement of the tool point with the notch to be observed more easily.

Tool shapes for internal work

The tool points for internal work are much the same as those that have already been described, but in this case the points are grafted on to stalks or bars so they may enter the part being machined.

The boring tool

Commercially made boring tools are, for the most part, a one-piece production. A group of these tools are seen in Fig. 8. They are well adapted to work of either large or small dimensions. As will be observed, the points bear a strong resemblance to that of the knife tool, in fact the shape and angles used are, for the most part, those of a left-hand knife tool with a roughing tool variant similar to that already illustrated in Fig. 2. The two forms of tool points are illustrated in Fig. 7.

The front clearance is usually about 10 deg. and the top and side rake varies from zero in tools for use on brass to 15 deg. for those to be employed on light alloys. In addition extra clearance has often to be provided as shown in Fig. 9 or the boring tool will not enter the work. From this illustration it will be evident that, as seen at A, the boring tool will just about clear the work whilst as at B it will not enter unless a considerable portion of the underside of the tool is removed. The position of the cutting edge is somewhat above the

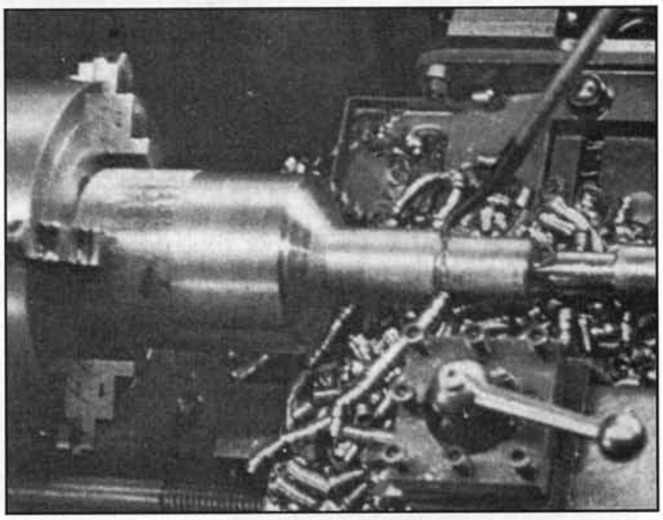


Fig. 3.

centre line as a preventive measure against "digging-in." This placing is satisfactory for parallel boring but not for machining tapers when the tool must be set truly central.

The undercutting tool

It is sometimes essential to provide clearance at the bottom of a blind bored hole. This can be achieved by the undercutting tool shown in Fig. 10. The form of this tool is the same as that of the parting tool already described. The width of the cutting edge should be kept as small as possible consistent with strength, at any rate for light lathes, because it is always possible to make two or more cuts to produce the degree of axial clearance needed.

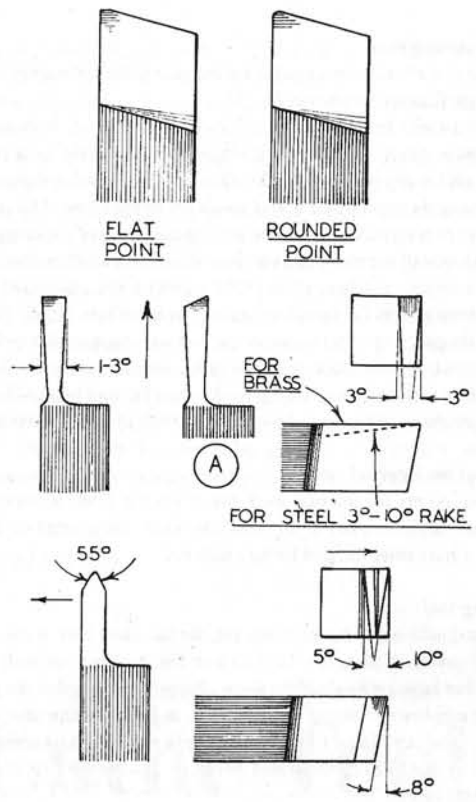


Fig. 4.

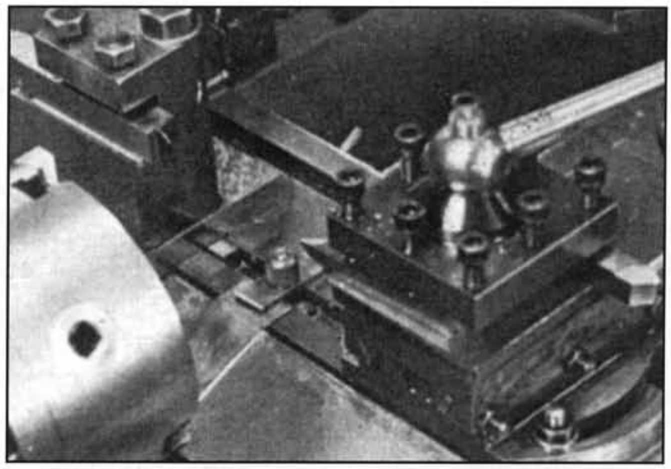


Fig. 5.

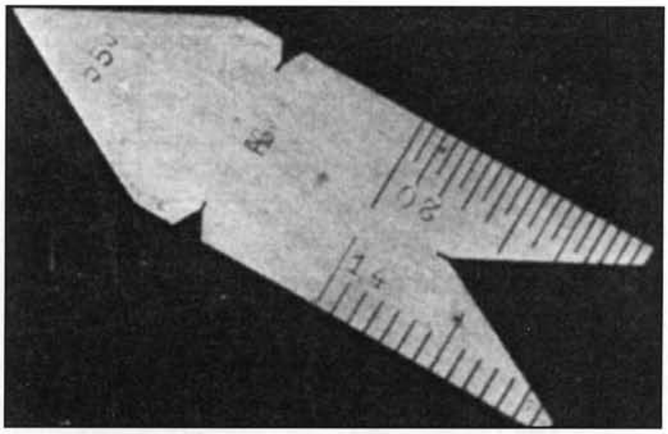


Fig. 6.

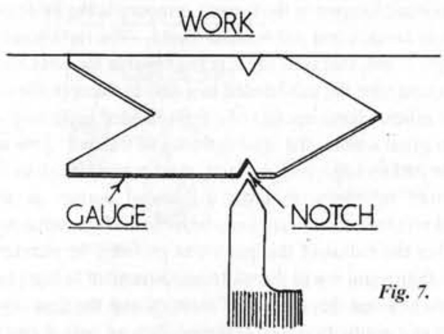
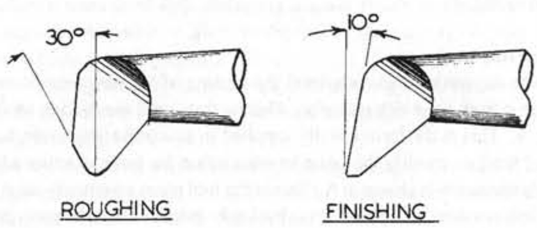


Fig. 7.



The threading tool

A tool for internal screw cutting is also depicted in Fig. 10. Here, again, the point follows the form used for external work having the same clearance and rake angles as the external tool, and as with this tool also requires to have its point set on the centre line. As before, the gauge previously illustrated is used to check and set the toolpoint.

The back facing tool

A type of boring tool that needs to be better known is that used for facing work inside the chuck.

The point is similar to that of a normal boring tool but is ground so that it cuts on the back face only. Obviously, the area of work that can be covered in this way is small. But the facility is sometimes needed and should be noted, though the back facing tool is not amongst those that are absolutely essential. It is shown in Fig. 10 whilst its employment is depicted in Fig. 9.

Clearly the tool point must not be brought into contact with the chuck jaws, so the small area left unmachined would need to be cleared by a subsequent chamfering operation.

Tool holders

In order to accept the high-speed steel tool bits mentioned previously, there are specially produced holders available. A typical example is that made by "Eclipse" to take square section tools and illustrated in Fig. 11. In addition the same firm supply holders to serve as mountings for their straight-sided and hollow-ground parting tools. These need to be secured rigidly and to be easily and rapidly adjusted in relation to the amount of their "stand out" from the tool holder.

Tool holders to take small cutters for boring operations are readily made in the private work-shop. A group of these is illustrated in Fig. 12.

The tools shown are of the type designed to take small cutters made from circular section material, but the holders will also accept one-piece boring tools similar to that illustrated in Fig. 13.

Carbide tipped tools

A group of these tools is illustrated in Fig. 16. They have been consistently employed on cast-iron, a material that does not affect the carbide tips, and can be relied upon to deal effectively with any hard spots in the castings themselves. In the illustration A and B are right-hand and left-hand off-set tools respectively. C is a roughing tool and D a round nosed tool for use both on bar work and castings. The tool indicated at E is a right-hand knife tool similar to that in Fig. 3 and is principally used on cast-iron bar.

Grinding equipment

It will be apparent that lathe tools, or indeed any other cutting tool, will not retain a keen edge indefinitely. It is necessary, therefore, to provide equipment, however simple, that will enable the grinding of tools to be carried out.

The most convenient machine for the purpose is an electric grinder usually having two wheels, one of coarse grit, the other fine, and a pair of rests to support the tools to be sharpened.

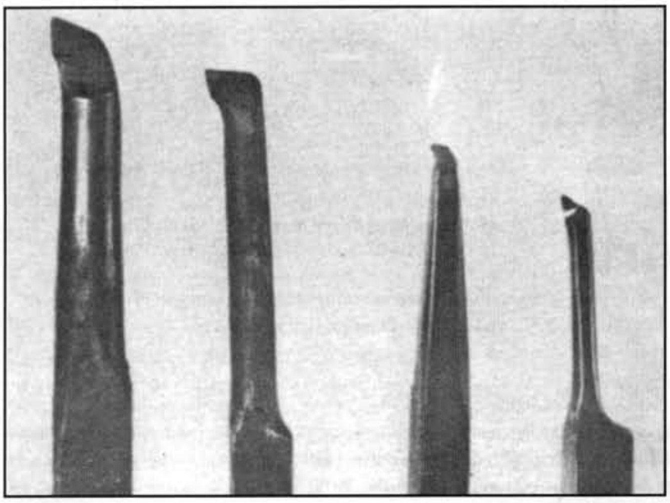


Fig. 8.

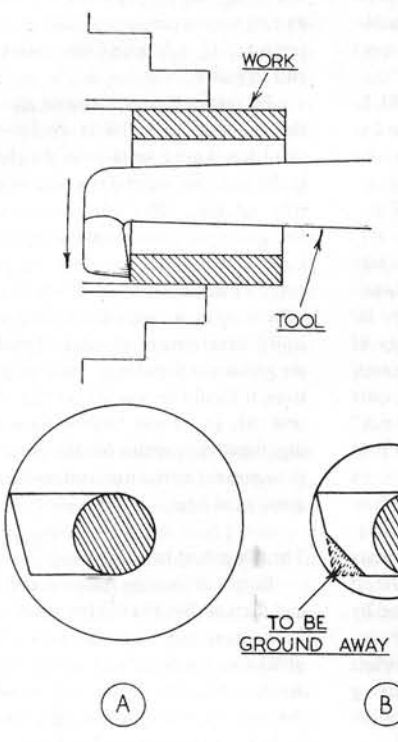


Fig. 9.

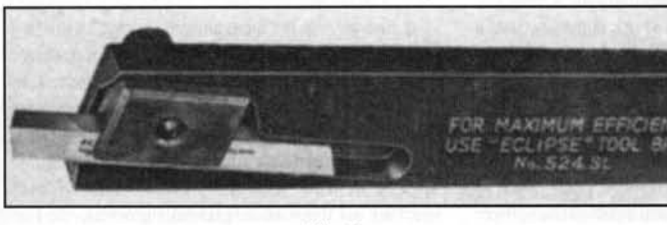


Fig. 11.

It is sometimes suggested that grinding should take place at the wheel's periphery. But unless the wheel is of large diameter, the tool itself will be needlessly hollow-ground. It is best therefore to grind on the side of the wheel when the resulting faces of the tool will be straight-sided and the tool's edge not weakened by hollow grinding.

Grinding on the side of the wheel requires a machine spindle without end float. Unfortunately, self-contained grinders of quality are expensive. The one reasonably-priced machine designed specifically for the amateur appears to have considerable end float, though it has been possible, by a simple modification, to remove this. In the main, therefore, the employment of a grinding spindle driven by an independent electric motor is the best solution to the problem.

The tool rest conventionally supplied with commercial grinders has a sur-

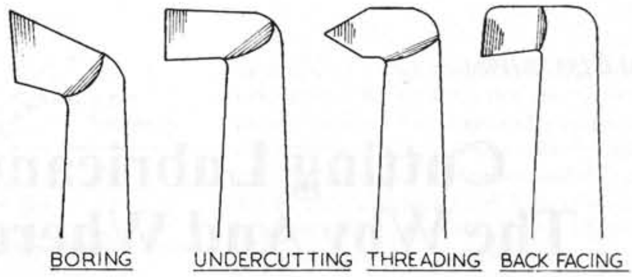


Fig. 10

face at right-angles to the side of the wheel. It follows that only the skill of the operator will ensure that the tool angles ground are approximately correct. In a large engineering works the general machinists are usually adept enough to grind tools of sufficient accuracy free hand, but the tool room is called on to treat expensive carbide tipped tools whose angles are somewhat critical. An angular grinding rest is used for this purpose, so the provision of a simple device enabling the amateur to ensure correct angularity is fully justified both by precedent and practice.

Setting the angular rest

It is not always easy to adjust the angle of the rest using a protractor for the purpose as the latter may easily foul any wheel guards that may be in place. It is best, therefore, to use a simple template. One or more of these are readily made from brass sheet, cut to the angles most commonly needed, and mounted on a base so that they may be set on the tool rest and applied to the side of the wheel. In this way rapid setting of the correct angle can be achieved without difficulty. In an alternative form of the simple angular tool rest the rest is divided so that its individual tables can be tilted to permit grinding to be carried out on either side of the wheel without having to re-set the rest each time a change of side is necessary. Little comment is needed to explain the workings of the double rest. It follows the principal details of the simple angular rest with the addition of a cross bar on which to mount the separate tables.

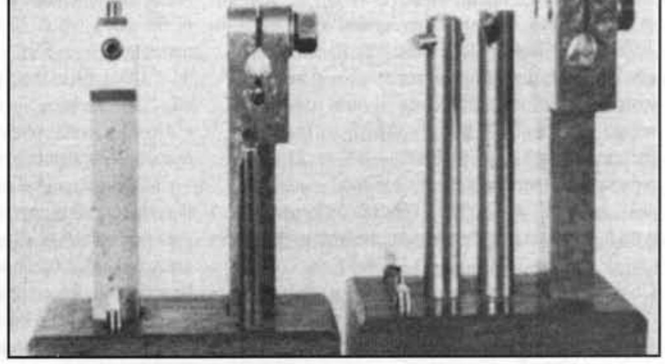
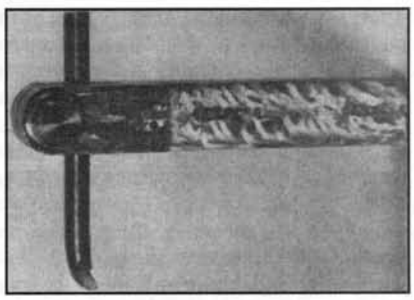
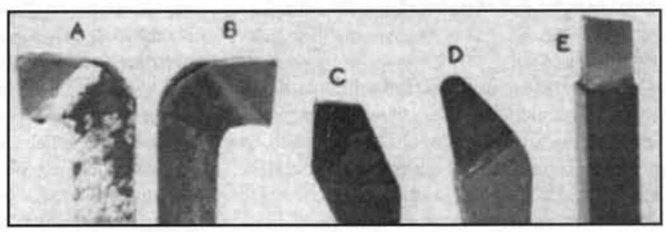


Fig. 12.

Fig. 13.



Below: Fig. 16.



M.E.153 79 (1984)

Cutting Lubricants. The Why And Wherefore

by Derwent Mercer

Cutting Oils Derwent Mercer

So often I have heard people mix up cutting tool lubrication with cooling; both effects are important and in this example the correct discrimination is made. If you do things properly, not only is the finish better but cutting edges last longer.

Introduction

Why do we need cutting lubricants anyway? After all, many metal-cutting processes go on quite well with out them. When we are filing, scraping or - occasionally - using a cold chisel, we don't normally use any lubricant. But turn to the lathe or the milling machine, and suddenly there are all sorts of "soups", all kinds of instructions and recommendations, and people's strong preferences.

"Well, it's the speed of cutting" we say; but push a 10 in. file at a hundred strokes a, minute and - as has been pointed out by "Tubal Cain" in these pages - one is cutting at a speed of some 80 feet per minute, a speed comparable to that used in a lathe for steel. So it isn't just cutting speed; why, then? We can give a number of reasons as follows:

1. Cooling the work piece
2. Cooling the tool
3. Reducing friction, hence also reducing both tool wear and power required
4. Protecting the work against rusting
5. Washing away the swarf

Of these, No. 5 - the disposal of swarf is generally a negligible factor on an amateur's machine, although of great importance in industry with the very high metal-removal rates today. So we are left with the first three, which are basically concerned with one problem - the removal or reduction of the heat generated in the cutting process; and No. 4, rusting. This one is best dealt with later, so let us first consider the heat removal.

Cooling the Workpiece

Very early in lathework we learn that a workpiece, under heavy cutting, will get hot. Now a steel rod 1.000 in. dia. will expand to about 1.001 in. dia. for a rise of 100 deg. C; if the rod were brass or aluminium it would expand about half as much again. 100 deg. C is not a large temperature rise when heavy turning is carried out, and such a dimensional change may be serious if the work is machined to a measured diameter while it is hot, and then cools down. One could also have the situation of apparently turning a cylindrical workpiece which in fact comes out tapered with the smaller diameter nearer the chuck; as the diameter of the bar has increased due to the heating, the tool has cut more deeply into the hotter metal near the end of its travel.

Cooling the Tool

We all know that carbon steel softens markedly as the temperature increases; above approximately 250 deg. C, a lathe tool would be too soft to cut properly. However even high-speed steels, and the harder materials used in industry, do deteriorate to some extent as the temperature rises, leading to a reduction in the period for which the tool will cut before it needs re-sharpening or replacing. There is also the sideline that if a tool is heated and cooled intermittently, the expansion due to heat followed by contraction - which may be non-uniformly distributed due to sudden cooling - could cause it to crack. Milling cutters, by the nature of their operation, are particularly susceptible to this trouble; although at "amateur" speeds and feeds, this is not likely to be a problem.

There is also a similar effect, it should be noted, to that discussed just above with regard to dimensional changes; as the tool expands, the dimensions of the workpiece may alter.

Oil-in-water Emulsions

Having dealt with these two problems, we turn naturally to the best means of minimising them - the use of - "water soluble oils". These are by far the best for cooling, since the heat capacity of water, weight for weight, is considerably greater than that of any other substance (a hot water bottle holds far more heat than grandmother's "hot brick" of the same weight?) Now water by itself would naturally cause severe rusting so, in order to avoid this, it is used in the form of an emulsion with an oil. An "emulsion" is the technical term for a liquid in which one component is dispersed in another in such a way that one of them - in this case, the oil - exists as extremely small droplets surrounded by the other - in this case the water. (A familiar example of an emulsion is milk, in which the fat droplets are surrounded by water; the process of churning breaks down the emulsion, causing the fat droplets to coalesce to form butter.)

Such a configuration, incidentally , doesn't "just happen" even when emulsifying agents are used; for instance in a soluble oil, if the mixing is done incorrectly, or if too much water evaporates, one can get an "invert emulsion" of water droplets surrounded by oil - which may in fact be visually indistinguishable from the correct emulsion. Always follow in detail the manufacturer's instructions in mixing the oil and water. (This stricture goes in fact for many chemical formulations; there are usually excellent reasons for statements such as "first dissolve this, then that..." etc, and if they are ignored, a useless substance may be obtained.) In the case of soluble oil, one manufacturer recommends that the oil should be poured into the water at such a rate as to form a stream "like a thick piece of string" - and that "thick" is fairly critical.

A problem with a soluble oil is that, even though many have rust inhibitors, in the sort of conditions in which we work when the lathe may be left for a week or two at a time - some discolouration or corrosion may take place. Some manufacturers do claim that their products do not rust; but others admit that the problem is not completely solved. If a machine has to be left for a long time with soluble oil on it, first make sure that the surfaces are clean and dry - not oily; see that they are covered with the soluble oil; and do not apply ordinary oil on top of the soluble oil, since this may prevent the water evaporating, and rusting may occur. Items such as fixtures may be protected by a lithium-base grease containing a rust inhibitor.

For completeness, it should also be mentioned that the term "soluble" is a misnomer, since an emulsion is not a solution in the chemical sense - in the way that sugar dissolving in tea produces a true solution. But now certain chemicals are being used as water-based cutting fluids; they cool better, and as they have no "droplet size" they carry the additives to the tool-work interface more effectively than emulsions do. Advances are rapid in the development of these chemicals, and they are gaining in popularity. Referring again to additives, it should be pointed out that while some soluble oils are simply tailored for maximum cooling, many do contain certain of the special additives present in the true cutting lubricants - to be considered later.

The Chip-tool Interface

Before discussing the aspect of reducing wear and friction (No.3 in the Introduction) and the use of additives, it is necessary to look in a little more detail (the whole subject would take a couple of articles at least!) at the way in which the chip flows over the top face (usually referred to as the "rake face") of the tool. No, the word "flows" was not a misprint for "slides"; a great deal of modern research on the topic has shown that the motion of the chip is very far from simple sliding, in the way that, for example, a wood shaving slides over the plane iron. It is found that the chip is forced, by the very high cutting stresses, into intimate contact with the rake face of the tool.

This is shown by the fact that if the chip is peeled from the tool, it reproduces exactly on its surface all the marks (grinding grooves, etc.) on the rake face of the tool. This intimate contact is virtually the condition for pressure-welding, and the metal of the chip around this area is distorted so much, under the extremely high forces, that it is actually flowing - in much the same way that the bitumen at the edge of a road will flow on a hot summer's day. It is this rapid and extreme distortion of the metal which is responsible for the very high temperatures generated at the chip/tool interface - frequently in excess of 1000 deg. C. As the chip progresses along the rake face of the tool beyond the seized area, it rubs and slides; and similar rubbing and sliding takes place along the

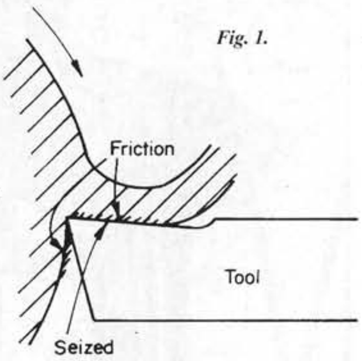


Fig. 1.

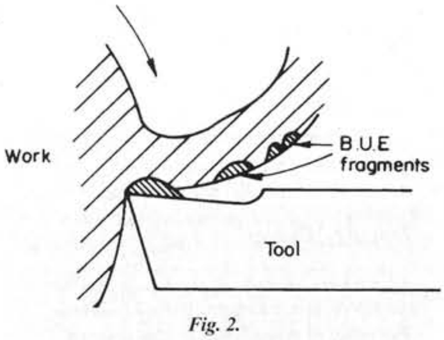


Fig. 2.

clearance face of the tool; both causing friction and heat. Figure 1 gives some idea of the situation. A further problem connected with this situation, is one which is all too common, the "built-up edge". This shows as a little "pip" on the upper surface of the tool, right at the nose, which is in fact some of the chip virtually welded to the rake face of the tool. This could be thought to be a good thing, as it protects the sharp edge of the tool! and in certain circumstances this does happen; but much more commonly this build-up edge breaks away erratically (the occasional "crack" which we may hear while turning) and this erratic break-away upsets the cutting action and causes irregularities in the surface finish. The "rings" which we get in cutting mild steel are often attributable to this cause. Figure 2 gives an idea of the situation. One of the advantages of using cutting oils, even at the sort of speeds and feeds which we use, is that they can frequently reduce this welding effect of the chip to the tool, and give a better surface finish.

Cutting Lubricants

Now to the action of true cutting lubricants, as opposed to those which simple carry away the heat. It is first necessary to remember that the chip, newly separated from the workpiece, is a highly stressed and work-hardened piece of metal; it has also a freshly-formed metal surface, which in chemical terms is highly reactive and ready to enter into chemical combination with any likely material present. It is also very hot - for a very short time its under surface may well be at red heat - and this means that any lubricant present can readily be decomposed, and some of the products so formed can combine with the fresh metal surface. It may be reiterated that all this takes place in the areas of sliding and friction; nothing can get into the seized areas. Now the true cutting lubricants are carefully tailored to this situation, with "extreme-pressure" components (similar to those used in lubricating the back axle of your car, in which there are also highly loaded sliding surfaces). These components react with the metal of the chip to form weak solids, which can shear readily under load, and so reduce the frictional forces. (It may be noted here that even hack sawing can benefit from a good semi-fluid EP lubricant; it can reduce the work needed in cutting say 2 in. by 2 in. by ¼ in. angle.).

The verification of this highly important point is that, in cutting metal, certain oils which we would regard as being good lubricants are quite ineffective, while liquids can work extraordinarily well. Certain chlorinated cleaning fluids if used as cutting lubricants, can reduce the friction, and hence the motor power required to drive the lathe, in a spectacular way, because as they decompose, the chlorine combines with the metal to form a slippery surface. But PLEASE DO NOT TRY THEM - in many circumstances they can produce poisonous fumes. They should be used only for research work, under very strict control.

As you can guess, the foregoing is a very condensed description of a highly complex process, and it may be said here that at low speeds and feeds, some of the older lubricants such as lard oil - which is a particularly "slippery" oil - do in fact work quite well. It has also been pointed out to me that unless cutting is so heavy that the chips are blue, the EP components in the oil do not operate, and an intermittent supply is all that is needed; but in severe cutting conditions we do need to choose an appropriate modern lubricant.

Incidentally, some of them cause staining on brass and copper; this may not be serious on parts which are not seen, or which need to be polished, but it is a point to watch. It is also interesting to note that, in these days, lubricants are recommended for cutting cast iron.

Incidentally, conservation has made the work of the oil companies much more difficult - sperm whale oil used to be an important constituent of these oils, but now it must not be used.

One of the problems in industry is the contamination of these highly specialised oils with the normal lubricating oils used in the machine bearings, etc. While of course any oil has some lubricating properties, some are better then others, and many other companies are producing oils so blended that they are good lubricants as well as cutting oils. I am finding one such, Texaco's "Dualtex" (usual disclaimer) a very convenient one; it is handy to have just one oilcan which can be used for the cutting tool, headstock bearings, feedscrews, etc. Castrol Universal Oil 430 is similar; and for professional lathes it can also be used as a hydraulic medium. One of our problems is that many of these oils are available in 25-litre drums at the smallest - a clear case for clubs and societies to buy them and re-sell the smaller amounts, (But see the concluding section below).

Application of Cutting Oils

A big problem with coolant is how to apply it. It may be repeated that the areas most destructive to the tool - under the seized part of the chip- cannot be affected by anything we do, since no oil can get to it; but of course the surrounding areas are also hot, and the temperatures in these regions can be reduced with benefit to tool life. From the point of view of cooling, a little coolant splashing on to the top of the tool may not be very effective - the chip is in the way! In large industrial machines, the coolant may be directed under the tool, between the clearance face and the workpiece, from which it can more readily get into the area required. It is interesting to realise the quantities necessary; one recommendation (of course for the very high speeds and feeds of modern industrial production) is between 3 and 10 gallons per minute. A check on our kitchen tap, which is directly on to a fairly high-pressure main, showed that it gave about 3 gallons per minute - imagine a quantity of coolant three times as great as that! It is far better, incidentally, to have a properly directed copious low-pressure flow than a high-pressure jet, which may splash and bounce and so not reach the very area to which it is directed.

A few other possibilities may be mentioned; a tool - or more usually a drill - may have had a hole bored through it so as to deliver the coolant in just the right place; "mist" cooling has been found to be effective, as has also a jet of carbon dioxide gas, which of course cools as it expands, giving a further degree of cooling. These are used in modern production, although not to the same extent as the conventional methods.

Conclusion

In trying to sum up a situation which is very fluid (sorry about that!) we should remember that the oil companies are continually making advances in their products, with a wide variety of applications and an equally wide set of recommendations in different conditions; and as of course these claims are geared to modern industrial production, the behaviour of lubricants in our situations could be rather different. Model engineers' lathes and working conditions differ widely, and even in professional engineering the oil companies find that a lubricant which works well in one factory will "fall down" when put in a virtually identical machine in another plant.

It is however probably safe to say that; any lubricant is better than none; for heavy rouging work, a true lubricant will pay dividends in fewer tool re-sharpens; and "difficult" materials such as silver steel can be greatly improved in surface finish if the right lubricant is found. How to find the "right" one?

Following the last paragraph, it is worth trying several (perhaps small quantities borrowed from club member friends), and if still in difficulty, the oil companies are generous with their advice (see next section). Meanwhile, I am keeping in touch with the oil companies, and will - with the Editor's permission - report any developments which might be of value to us.

Acknowledgements

I am grateful to the oil companies which have given considerable help in the preparation of this article; in particular BP Oil Limited, and Texaco Ltd. Burmah-Castrol (UK) Ltd (Pipers Way, Swindon, Wilts) have generously said that they will deal with amateur enquiries - despite the fact that, to them, commercial returns are unlikely to be high from this source; and Metcut (Great Britain) Ltd, (38 Freeth Street, Birmingham) will sell small quantities direct - a very useful service. (It was also fascinating to discover several model engineers among oil companies' specialists!)

M.E. 132 220 (1966)

TAPPING

BY DUPLEX

Tapping Duplex

Advice here on keeping the tap normal to the job certainly helps to reduce breakage, The relief of thread ends is also covered.

WE COME now to the subject of tapping, but before doing so some points in connection with screw threads need to be considered. As it is important to know the size of the hole that must be drilled to tap it to a given dimension, some consideration must now be given to the factors governing this matter and the choice of drill to be used.

The two main factors that control the drill size are the pitch of the thread and the thread angle illustrated in Fig. 1. The angle of the thread is constant for any series of threads such as British Standard Whitworth, British Association, and British Standard Fine threads. But the pitch of these threads varies with their diameter. As a result the depth of the thread and hence the core diameter varies, therefore the core diameter of a fine thread is greater than that of a coarse pitch thread of the same size. A comparison between coarse and fine threads is illustrated in Fig. 2.

If we take an ordinary nut and bolt as an example, theoretically the diameter of the hole to be tapped in the nut should be the same size as the core diameter of the bolt. Such a procedure would, of course, be impractical as it would result in what is known as 100 per cent engagement of the mating threads of both bolt and nut, preventing them from working together. This state of affairs is illustrated in Fig. 3 at A.

Since components threaded in this way have no practical use, a compromise is reached and parts are produced having 75, 80 or 90 per cent thread engagement according to the duty imposed upon them. A thread engagement of 70 per cent is illustrated in Fig. 3 at B. Here, it will be seen that, contrary to the conditions at A, the crown of the nut thread does not reach the full depth of the thread of the screw or bolt. The thread in the nut is then said to be truncated. This has the advantage that there is now somewhere for the dirt to lodge and this simplifies the assembly of the two mating threads.

Whilst it is a fairly simple matter to calculate the correct tapping size of drill, there are plenty of tables giving these sizes.

Alignment of the tap

If a hole is to be correctly tapped it is important to make sure that the tap enters the hole squarely. This is by no means automatic, though at one time there were available taper taps that went a long way to fulfil this requirement. These taps had noses provided with a length of parallel unthreaded portion, having a diameter that would fit the drilled hole closely. Thus this part of the tap acted as a guide and kept the tap itself square with the work. Modern taps do not appear to have this provision, so other means of keeping them upright must be sought.

It is possible to ensure that the tap is entering the work squarely by checking its alignment with a try-square. But this is a time-eating performance and not likely to find much favour when a whole series of holes has to be threaded. The simple device illustrated in Fig. 4 is one way to ensure that the tap will enter the work squarely. The conical body of the tool is provided with interchangeable bushes through which the taps are passed while the body is held against the work by the forefinger and thumb of the left hand. This leaves the right hand free to turn the tap and pass the tap into the work.

An alternative though somewhat similar method is to use bushes that may either be held or clamped against the work. They should have sufficient contact area to ensure that they cannot be displaced or rocked out of alignment. The bore of the bushes should be plain and of a diameter that will allow the tap to pass without shake.

Tapping in machines

A good method of ensuring accurate alignment of the tap is to make use of a machine. For the most

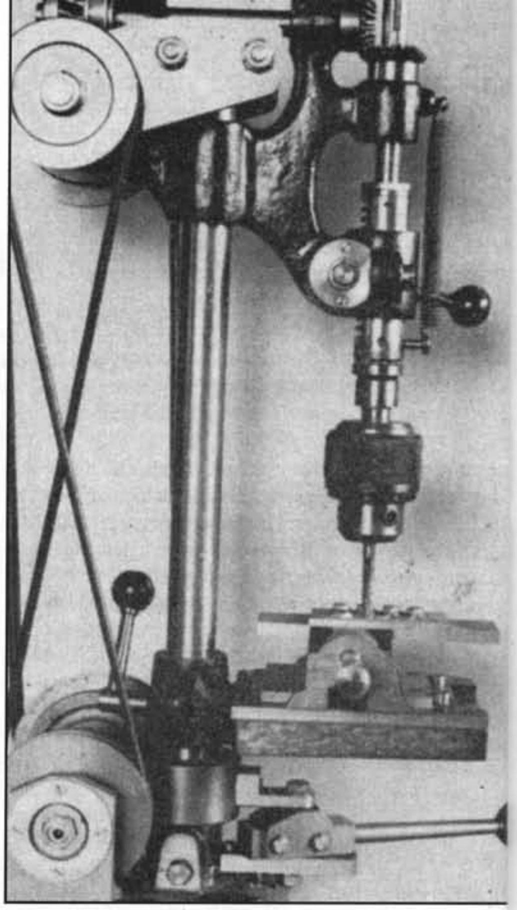


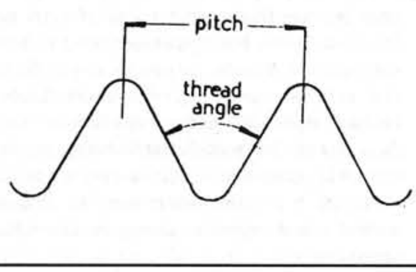
Fig. 8. A tapping machine.

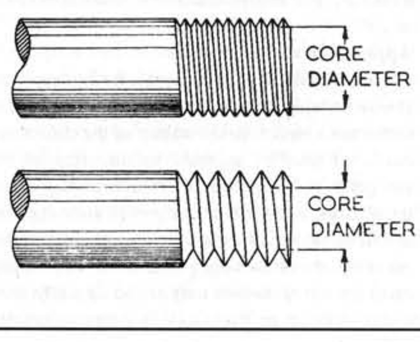
part this work can be carried out in the drilling machine, though a tapping machine, designed specifically for the purpose, provides rather more flexibility.

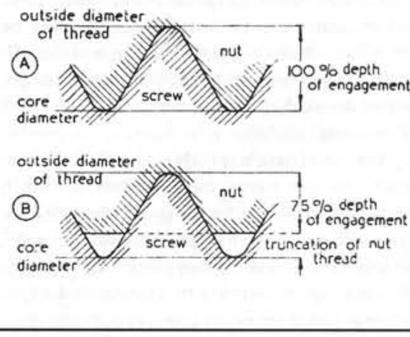
The simplest method of tapping in a small drilling machine is to equip it with a handle that may be attached to the top of the machine spindle as seen in Fig. 5. Work may then be held in a vice mounted on the drilling machine table or directly on the table itself. Fitting a handle is only applicable to the simple type of machine or one having a spindle extension that will allow this to be done.

The Rawlplug De-Speeder, a device for reducing the speed of electric hand drills and referred to in an earlier article, may also be used for tapping in the drilling machine. The De-Speeder consists of a small epicyclic gearbox having an input shaft that is gripped in the chuck of the drilling machine whilst the output shaft carries a chuck for holding the tools. Five types of De-Speeder are manufactured by the Rawlplug Company, the primary object being to provide a

Below: left to right, Fig. 1. pitch and thread angle, 2. fine and course threads, and 3, thread engagement.







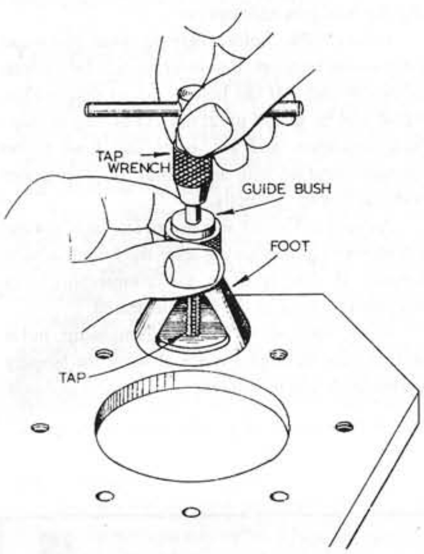


Fig. 4. Tool for ensuring that a tap enters the work squarely.

device that will allow high-speed electric hand drills to perform operations needing a much lower spindle speed than is normally provided.

The latest of these devices has a reversing mechanism incorporated in the gearbox. The forward speed reduction is in the ratio 12:1, while the reversing mechanism itself has a speed reduction of 4:1. There is no need to stop the drilling machine to obtain the reverse action. If the upper of the two knurled rings, seen in Fig. 6 is held, the chuck attached to the De-Speeder will reverse; if the lower ring is gripped, it will turn right-handed, driving any tool held in the chuck into the work. Thus the De-Speeder is well suited to tapping work, as well as to other operations requiring a low forward speed with the facility of rapid reversal.

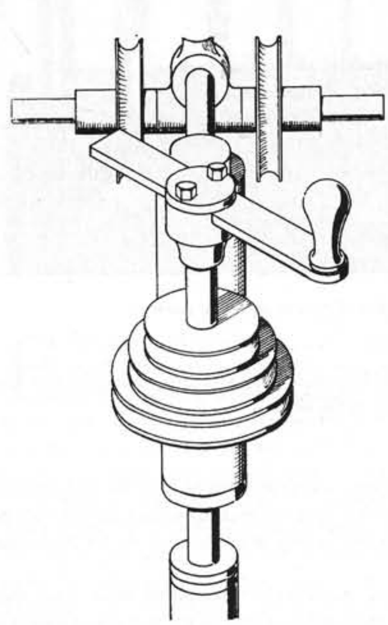


Fig. 5. Handle for drilling machine spindle.

Using a tap wrench in the machine

Fig. 7 shows a method that may be used to secure alignment of the tap when threading larger holes. In this case, the work is bolted to the table of the drilling machine, and an ordinary lathe centre, preferably mounted in a Morse taper sleeve to ensure its easy removal, is mounted in the drilling machine spindle. A tap wrench is used to work the tap into the hole, and the tap itself is aligned by allowing the lathe centre in the drill spindle to engage the female centre formed in the shank of the tap. It is of course essential that the work is directly under the centre of the machine spindle, otherwise alignment will have been lost from the outset.

To secure this, the simplest way is to place the tapping size drill in the drill chuck and lower it into the hole previously drilled in the work. The spindle of the drilling machine is then locked so that it cannot fly back and the work is then bolted to the machine table.

When the work has been secured, the procedure for tapping the hole may then be applied without fear of the set-up being out of alignment.

While tapping, the drilling machine spindle should be free to fall by its own weight. So that it may do so, the return spring adjustment fitted to the feed lever of some drilling machines should be completely released; this will allow the spindle to fall freely. This is important, otherwise it will be necessary to keep feeding the spindle down by hand, a procedure involving two people: one to see that the centre is kept in contact with the shank of the tap while the other handles the tap wrench and taps the hole.

No power is used in the operation; the drilling machine is simply there to secure alignment.

An alternative method of securing axial alignment is to make use of the lathe centre referred to earlier. This centre engages the drilled hole and is held in contact with it while the work is being bolted to the table of the drilling machine.

Many large drilling machines have means for reversing the direction of the spindle. With a machine such as this it is possible to grip the tap in an ordinary drill chuck and, after having tapped the hole under power, to back the tap out by means of the reversing gear.

Tapping attachments

There are now on the market many tapping attachments. For the most part these consist of a special chuck fitted with an overload device enabling the tap to be relieved of the torque imparted by the drilling machine spindle. If the load becomes excessive and to an extent that would otherwise break the tap, the overload device operates and allows the drive to slip. These tapping attachments may be adjusted to accommodate quite a wide range of tap sizes; they are usually provided with a Morse taper shank for fitting directly to the drilling machine spindle.

Tapping machines

At one time machines specially designed for tapping were much in vogue and such a machine made by an amateur is seen in Fig. 8. The advantage of a machine of this type is that being provided with a clutch drive, it is possible to vary the

Fig. 6. Rawplug's De-speeder.

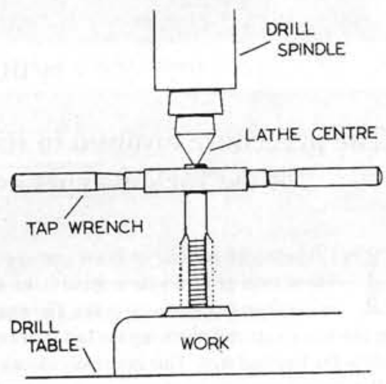


Fig. 7. A method of ensuring sweet axial alignment when using the drilling machine for tapping large holes.

torque applied to the tap and so make sure that neither the speed of tapping nor the twisting motion imparted is excessive. Moreover, by using a clutch arrangement, reversing a tap to bring it out of the work is a very easy matter.

Tapping thin material

When tapping thin material, wherever possible the work should first be dimpled as seen in Fig. 9. This is best carried out after the work is first marked off, by drilling a small hole, that is one a good deal smaller than tapping size; then using a centre punch or other suitable means, forming the hole to the dimple required. When the dimple has been formed it may be found that, though the hole has become enlarged it is still not up to tapping size. The hole will therefore have to be drilled out to the correct size before tapping can take place.

During the dimpling process the work should rest either on a lead bolster or one made from soft aluminium. In this way the risk of damaging the work by excessive use of the punch will be avoided. If a number of holes are to be tapped in

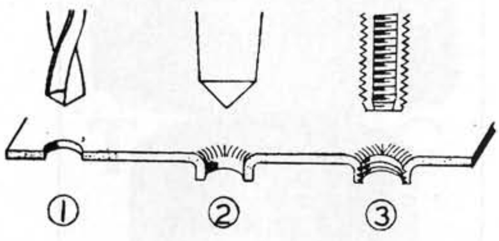


Fig. 9. Tapping thin material.

thin material it pays to make a special bolster. This may consist of a piece of mild steel with a countersunk hole formed in it. This will allow the surface of the work to be driven into the countersink without fear of breaking through and enlarging the hole past redemption.

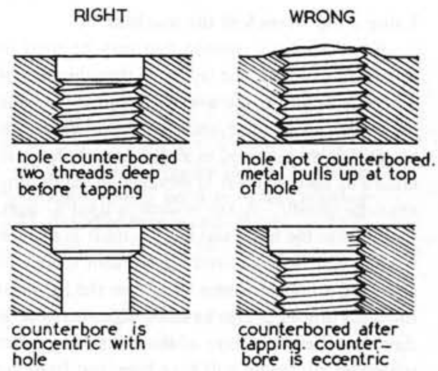


Fig. 10. Relieving the entry of a hole before tapping.

In any work, before tapping takes place the hole should be relieved to clearing size for a depth of two threads. If the hole is not so relieved the metal will be pulled up at the top during the tapping operation, and any parts that have to be screwed together will, as a result, fail to register with each other correctly.

As seen in Fig. 10, it is useless to carry out the counterboring or relieving *after* the hole has been tapped. If this is done the counterbore will become eccentric in the way illustrated.

In the interests of good workmanship, holes drilled clear through a piece of work for tapping purposes should be relieved at both entry and exit.

M.E. 113 801 (1955)

Reamers and reaming

by DUPLEX

Reaming Duplex

This is just good sound advice, describing the variations of design and some useful hints about sharpening.

The procedure involved in reaming with hand tools and details of the various types available are dealt with here.

THE parallel hand-reamer is the type most often used in the workshop. These tools generally have spiral flutes and are bought in sets ranging in diameter from ⅛ in. to ½ in. The reamer is often misused by making too heavy cuts and removing the last fraction of material to bring a drilled hole to the finished size. This invariably causes the formation of an irregular, bell-mouthed bore, as hand-reamers are intended for removing only a few thousandths of an inch of material

When the reamer is used on steel, it should be well lubricated with cutting or lard oil and it must be entered and withdrawn by turning in the forward direction only. To turn a reamer in the reverse direction during withdrawal tends to blunt the cutting edges.

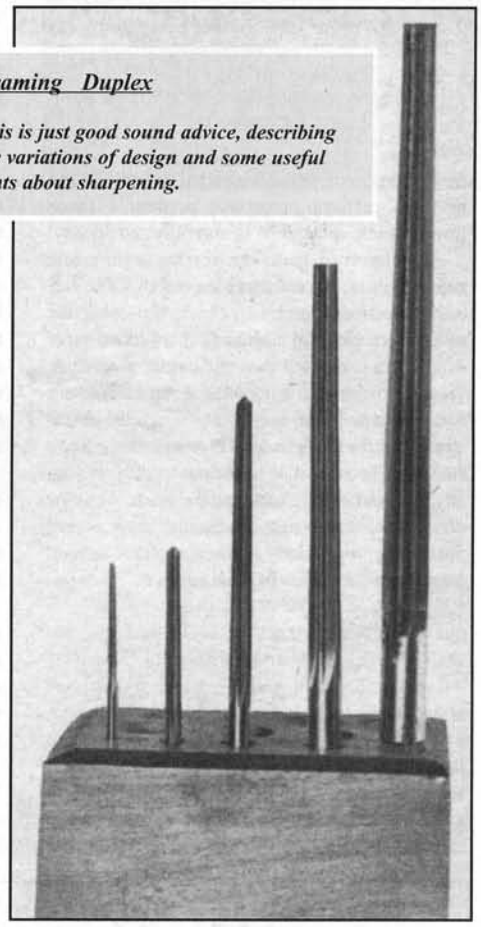


Fig. 1. A selection of typical taper pin reamers.

Reaming lathe work

The hand-reamer is often for finishing the bore of a part machined in the lathe and, if an accurate smooth finish is to be obtained, it is essential to adopt the correct procedure. The cutting edges of a new reamer are often left slightly rough in the final grinding operation. To correct this, they should be lightly honed with an oilstone slip, taking care not to reduce the necessary clearance angles.

After considerable use, the cutting edges usually become slightly worn and in that condition will impart a better finish to the work. Before starting to ream a valuable piece of work it is advisable to make trials on scrap material to learn the technique. The component is first bored a few thousandths of an inch undersize, so that the tapered lead on the reamer will just enter.

The lathe should be run at a moderate speed and the rear end of the reamer, to which a lathe carrier has been attached, is held firmly against the tailstock centre. A rack-feed or lever tailstock is ideal for feeding the reamer into the work, as it affords quick movement and sensitive control. Where the ordinary type of tailstock is used, better control is obtained by sliding the tailstock itself along the lathe bed, rather than relying on the screw feed.

To avoid forming rings in the bore, there must be no dwell in the forward feeding motion or during withdrawal of the reamer. Lard oil is an excellent lubricant and can be used for reaming any metal except cast iron. Machine reamers are largely used commercially for the final sizing operation on drilled or bored holes, but they should be mounted in a floating holder so that they can align themselves accurately in the bore.

Reaming drilled holes

Drills of the Number and Letter sizes can often be used for drilling holes preparatory to reaming to size, but there are exceptions and certainly all the fractional-inch drills are unsuitable, as they would leave 1/64 in. for the reamer to remove.

When these difficulties arise, particularly in diameters above ¼ in., metric-size drills will have to be used, unless a drill of the nominal diameter is ground down to about 0.004 in. under this size. Standard metric drills are made in a wide range of sizes, increasing by increments of 0.05mm, which is equivalent to approximately 0.002 in.

Expanding reamers

Reamers of the expanding type are most useful for sizing holes to an exact diameter. The Morse (Fig. 3) is, perhaps, the most reliable form of expanding reamer as rigidity is obtained by making the blades part of the body and these are expanded by a tapered adjusting screw. The only disadvantage of these reamers is that the range of expansion is only 0.005 in the sizes up to ½ in. dia.

The second type of expanding reamer (Fig. 2) has five or six removable blades, held in place by a cup-nut at either end and supported in the middle by a slotted guide-piece. Although these reamers have a range of expansion amounting to 1/16 in., they are not so rigid as the Morse type.

Another variety of this type of reamer (Fig. 2) is furnished with spirally-ground blades. Both types of reamers are set by adjusting the cup-nuts to slide the tapered blades endways in their retaining slots. Expanding reamers with inserted blades can be bought in sets ranging in size from ¼ in. to 15/32 in. and a second set brings the capacity up to 1¼ in.

Taper reamers

Reamers for enlarging drill holes to receive taper pins are illustrated in Fig. 1; these range in size from No. 6/0, which is 1/16 in. dia., to No. 6 of 9/32 in dia.

The cutting edges are of the same form as those of the ordinary hand-reamer and this type of tool cuts more quickly and more accurately than the less expensive taper broach used by clockmakers. When fitting a taper pin, a hole is first drilled slightly larger in diameter than the small end of the reamer. The reamer is then carefully worked in by turning it in a clockwise direction and applying light pressure.

From time to time the reamer should be withdrawn and the flutes cleared of chips.

Larger reamers are made for finishing bores to the Morse taper or other standard forms. When rectifying a worn or damaged taper bore, care must be taken to maintain the reamer in true axial alignment and, after a single turn, it should be withdrawn and the operation repeated until the smooth surface of the bore is restored.

To form a Morse taper bore in a machine spindle, the bore is first roughed out by step-drilling and then machined to the correct angle of taper. Finally, the bore is corrected with a reamer, which should be supported at its rear end in exact axial alignment.

Fig. 2. A set of hand reamers.

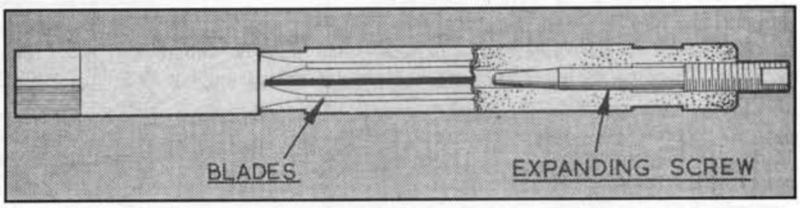


Fig. 3. Constructional details of the Morse expanding reamer.

M.E. 138 1235 (1972) & 115 482 (1956)

Hardening and tempering R.F. Willetts / J. Whitton

Many articles over the years have contained helpful advice on this subject, but these two old entries have most of the important points. I have included the second entry since it relates temper colours to temperatures.

HARDENING AND TEMPERING

by R F Willetts

EXPERIENCED tradesmen have numerous methods of determining heat treatment temperatures, indeed one could write a book on this subject alone - many have! - without recourse to the instruments available to industry. Since amateurs have neither the instruments nor the experience, it is felt that a few hints on this subject will assist in obtaining satisfactory results with silver steel, ground stock, spring steel and coil springs.

A quick word or two on the phenomenon of hardening may put the matter into perspective. The temperature at which a high carbon steel can be hardened by rapid cooling occurs over a comparatively narrow range, called the upper and lower critical temperatures. If we quench at the lower temperature, hardening may be problematical or even a failure. At the higher temperature hardening will be sure and effective. The human eye, even an experienced one, is hard put to detecting this from the colour, and frequently, "to make sure", this temperature is exceeded, bringing in its train cracking, de-carburisation (or loss of carbon), and grain growth. Fortunately, as any metallurgist will confirm, at the correct temperature the steel becomes non-magnetic, and we can thus, by testing with a magnet, determine when to quench to a nicety. This is far better than "cherry-red" methods (whatever colour *that* may be!).

Industry uses atmosphere-controlled furnaces to protect the heated steel; we cannot, so do not "cook" your work slowly in an inadequate flame, but using say, a 1½ in propane torch as for boiler work, heat the steel evenly but quickly with firebricks surround if needed, and have a deep, adequate volume of coolant near to hand. For silver steel and similar high carbon steels, use ordinary tap water. A more severe quench can be achieved in a 10% brine solution, and for every delicate work, oil quenching, but for most needs, water is best. Test with a file - you *could* have picked up mild steel! For gauge steel (ground stock) always quench in oil. Plunge deep and decisively, don't mess about, leave until cool. Flat springs from annealed stock, oil harden, do not clean these - for reasons which will become apparent later. Coil springs are not quench hardened - the wire is in a hard drawn condition and must be heat treated after coiling - more on this later.