MODEL ENGINEER

CENTENNIAL CELEBRATION COLLECTION

9: SHAPING & PLANING MACHINES

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Cover shot:
Bryan Webster takes advantage of a Saturday Model Engineering class, to gain access to a 14in. Ormerod Shaping Machine.

MODEL ENGINEER

CENTENNIAL CELEBRATION COLLECTION

In the early days of the Model Engineer there were regular features describing and illustrating model engineers' workshops. To our eyes today these workshops were very primitive. Many were without mains electricity, the machinery being treadle driven or powered by a steam or gas engine driving overhead belting. A number had a steam engine driving a dynamo the vertical boiler standing in the fireplace, the exhaust using the domestic chimney. Power and workshop heating being provided by one unit, although it must have been unbearable in the summer.

One item of machinery that is common to the 1890's workshop and today is the lathe. Model engineers of the past would be at home with today's machine, the design concept has changed little proving that the designer of yesterday got the basics right from the start. The modern machine is heavier and sturdier and with current manufacturing techniques more accurate. One advantage is that with electric drive there is a constant, even power available over an infinite period unlike the treadle operated machines of yore. One thing that the manpowered workshop taught was the ability to sharpen tools accurately, if a cutter was incorrectly sharpened, set or was allowed to get blunt, it meant more leg power for the operator. You soon learnt the benefit of properly ground and honed lathe tools.

The milling machines common in today's workshop, were unusual in the early workshops. This is not to say our predecessors did not carry out milling operations, they did, but they used the time honoured procedure used by model engineers today using the lathe with a vertical slide mounted on the cross slide. A large number of amateurs' workshops had either a shaper or planer, often hand or treadle driven, although those with overhead shafting meant it was an easy matter to provide a belt drive, especially to a planing machine.

It is easy to see why the shaper and planer were so popular. They were easier to manufacture, the accuracy being in straight slides, they were easy to maintain, the adjustments of the gib strips being similar to that of a lathe and, of course, it did not require any expensive cutters, the common carbon steel could be forged and ground as required.

I can see why the planer has fallen out of use. A medium sized machine requires a lot of room, which, in the average model engineers' workshop is not available. If the machine is to be of a useful size the table has to be substantial which increases the momentum and energy stored in the table while it is in use. However, it is a most useful piece of workshop equipment, although I have not seen a second-hand example available for many years. Dr. John Bradbury Winter had a 24" stroke example for many years and he records that when he acquired his machine he spent six months refining parts of his model locomotive "Como" taking the merest shavings from the components to improve their finish. This shows that fine, accurate work can be carried out on such a machine.

If you cannot find such a machine, a shaper is a good substitute and they appear regularly in the adverts of second-hand tool dealers. For the production of flat surfaces they have no equal and I am surprised that they do not feature more in the enthusiast's workshop. They have the same advantage as the planer, cheap and easily sharpened cutters. Most types have a self-acting transverse feed which means you can get on with other work while the machine is in operation, and we all know that time is precious for most model engineers.

The milling machine has gained a wide foothold in the amateurs' workshop in the last few years and the reason is not hard to find. There are available relatively compact machines designed with the smaller workshop in mind, and imports of reasonably priced machines from the Far East which suits the pocket of the average model engineer. There are also large quantities of good quality end mills and slot drills available at small cost. For clearing up castings or milling large flat surfaces a fly cutter employs a high speed tool bit which can be produced easily on the off hand grinder.

Milling spindles were widely used on ornamental turning lathes at the turn of the century so it is not surprising that model engineers adapted these for machining metal. There were many designs published in the Model Engineer of the period showing that the magazine was at the forefront of the hobby. Today automation is taking over the professional machine shop and again the Model Engineer and Model Engineers' Workshop is taking the lead with articles and designs to enable the amateur to take advantage of modern techniques and practices. Long may they continue.

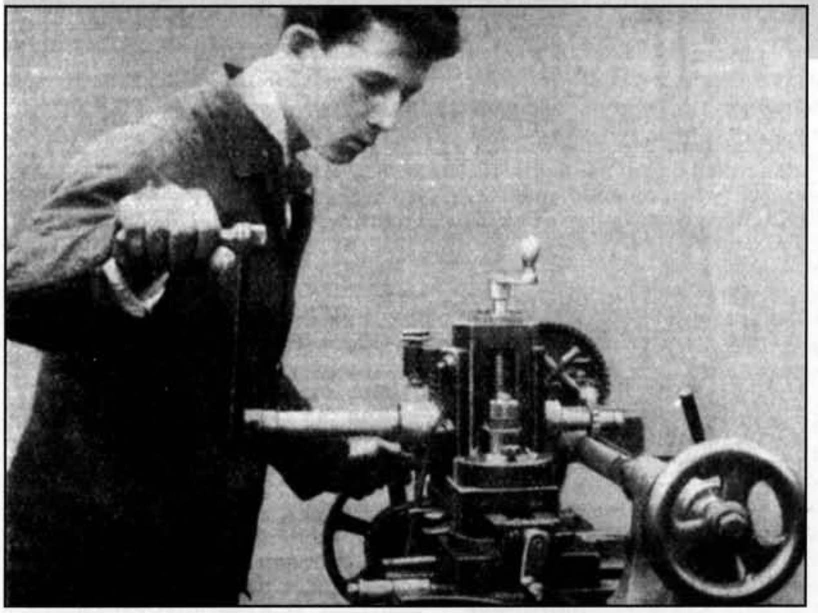
Gerry Collins

Readers are asked to note that some of the designs featured are from an age when rules and regulations were far more relaxed than today. Anyone contemplating building any of the designs shown should satisfy themselves that the information given meets with today's design and safety requirements. The publishers and editors cannot be held legally responsible for the information published herein.

One of the first articles on milling appeared in the October 1898 issue. It was entitled "The Lathe as a Milling Machine", a practice that is widely used in the amateur's workshop even today.

In the April 1899 issue, J. Smart & Co. of Erith, Kent, showed a new milling attachment for the lathe. Work up to five feet long was claimed although being hand operated it must have been a stretch for one operator.

A machine rarely seen in workshops today is the planing machine. In the July 1899 issue, Francis W. Shaw described the building of a hand operated machine. I have not included the full series of articles, anyone interested can obtain the details from back numbers but I commend to anyone this most useful piece of workshop equipment although I would recommend electric drive.



April, 1899.

A Simple Milling Appliance.

Messrs. J. Smart & Co, North End, Erith, Kent, send us a fully descriptive list of their improved milling and wheel-cutting attachment for the lathe. The apparatus, as we can testify from a personal inspection, can be readily and effectively used for all descriptions of small milling, such as fluting taps, making milling-cutters, cutting gear wheels, cutting keyways, ratchet wheels, etc. It is attached to the lathe slide-rest, and worked by a long lever handle, whilst the feed motion is given by turning the leading screw of lathe by means of the change wheel. Work up to five feet long has been done with this useful appliance, several views of which, as well as sketches of work done and much interesting information, are given in this sheet. Further particulars will be readily sent to readers of THE MODEL ENGINEER on application as above.

July, 1899.

How To Make A Hand-Planing Machine.

By Francis W. Shaw.

WHEN the amateur has gratified his ambition by either making or buying a lathe, and is thereby enabled to turn his shafts, screws, pins, piston-rods, and to bore his cylinders, flywheels, &c., he begins to find out that the production of the many plane surfaces necessary in his constructions involves a lot of painstaking effort when it has to be done by means of chipping, filing, and scraping from the rough. Consequently, he looks out for some method whereby the hard hand and head work may be converted into plain, straightforward, and - it may almost be said - automatic machine work. He already has the lathe, and an attachment for doing this particular portion of his work by milling or shaping usually strikes his mind as being the easiest way out of the difficulty. The ideal of many amateurs seems to be to make the lathe as universal a tool as possible. This is an excellent aim in its way, looking at is from the stand point of pride, and the lathe is not doubt capable of being used far beyond its original intended purpose; but when the working out of this ideal results in a great waste of energy in overcoming a lot of unnecessary friction by his own exertions, and the loss of time occasioned by fixing up and removing his tackle, the amateur often thinks twice before he will take the trouble thus involved, and often reverts to the old method of doing the work by hand.

For surfacing areas of any size, I do not consider lathe milling and shaping attachments are capable of doing the work conveniently, if even well, for there is too much vibration, and when it is considered that a small planer, self-contained in every respect, can be built as cheaply, or even at less cost, than can first-class attachments, and is, at the finish, always ready to hand, it may be said, "The game is not worth the candle".

Having these facts well in mind, and also the general requirements of the amateur's class of work, I have devoted a great amount of time to designing and getting out patterns of a small machine which will bear out the conditions, &c., which I set before myself previous to commencing-viz., it must do all the planing necessary in the construction of model engines, locomotives, dynamos, motors, cutting keyways, internal and external, small slides, angular or parallel portions of small lathes; must be capable of taking a cut sufficiently large to get under the skin of castings, and of cutting any material softer than the tool itself, without vibration, and to be geared up to that there be no great strain on the muscular powers. It must also be strong enough to withstand accidental blows, and to do any such work that can possibly be done by hand without springing (an idea of the strength of the machine under description may be gathered from the fact that it is arranged to take 9-16ths in. square tools), and yet be light. To secure this latter advantage I have taken particular care to so distribute the metal as to make the portions which are under strain, as strong as possible. Lastly, its bearing surfaces must be large, and well proportioned, and all wearing parts adjustable to take up wear; the rough material must be capable of being fitted up well and easily; all attachments for securing work to be simply and easily fixed, with no long threads to adjust, and the machine, when finished, must have a neat, artistic appearance, in view of the fact that the amateur likes to take a pride in his workshop and appliances.

I do not purpose to describe how to make the patterns, as the castings may be obtained very cheaply; but if anyone desires to make the machine throughout, I shall be happy to afford him all the information that lies in my power. It will be necessary for those who have no planing machine to get them ready planed, or have them planed up by some friend, unless he cares to undertake to get them up by hand and "hard graft" the castings may be got up this way as only a small amount is allowed for planing, only just sufficient to clean them up. The machine will take articles up to 16 ins. in length, 7 ins. width, and 5 ins. deep.

I think it better, before proceeding to a detailed description of the several parts, to place the machine in its entirety - ready for use - as shown in the accompanying engraving from a photo - before my readers, in order that this first article may be as complete as possible, and that the experienced may sail right away, without wading through a lot of - to them - uninteresting matter.

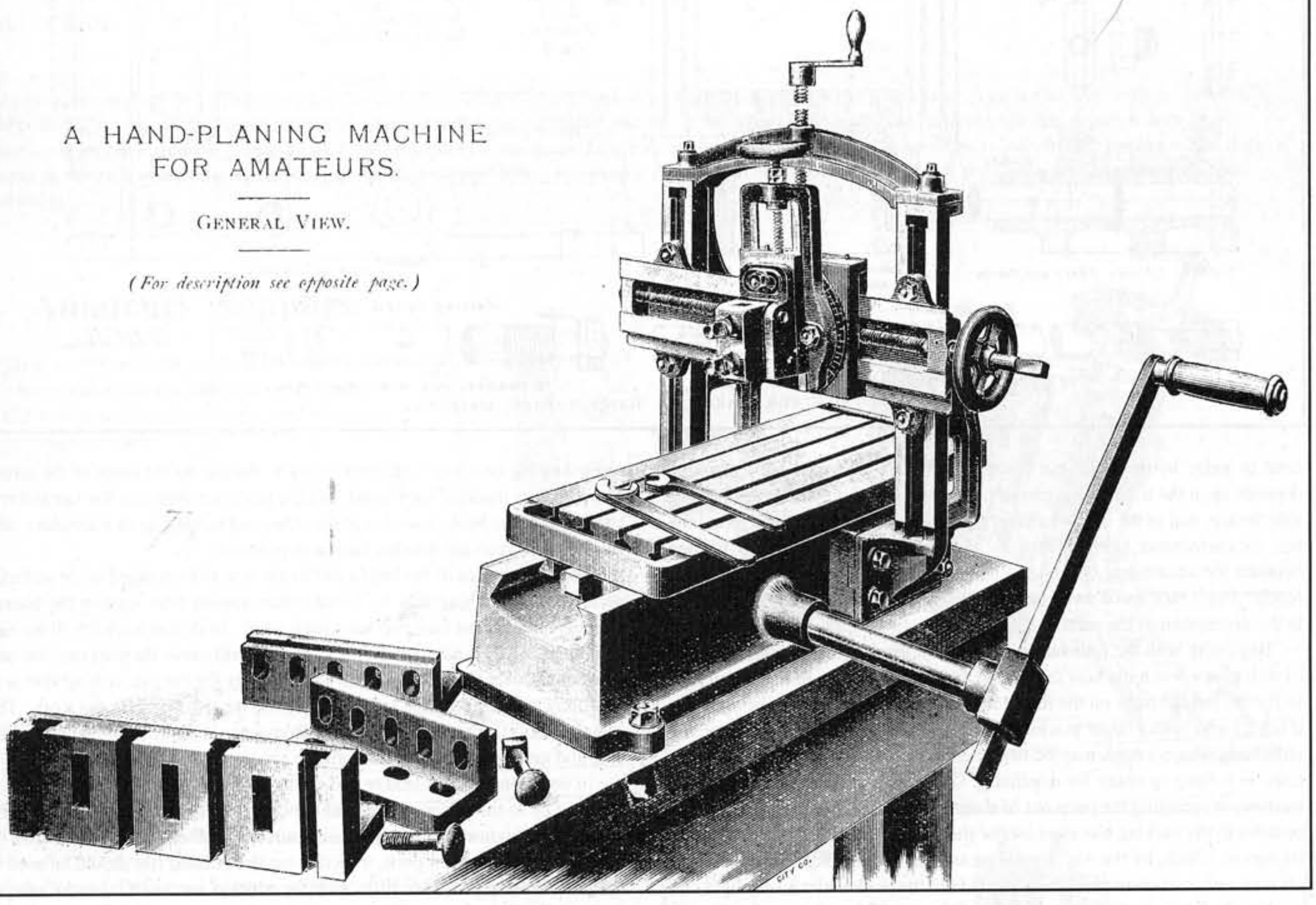
It will be noticed that the style of driving chosen is by rack and pinion, actuated by a hand lever, adjustable in its socket to obtain the requisite power for different degrees of cut or qualities of metal.

I make no apology for diverging so much from the ordinary pattern of handle - the capstan handle with four levers, or the single *straight* lever one - as by long experience in using a similar machine, with all three styles, I have been driven to the use of the one shown. By those who have used the capstan, it will, no doubt, have been noticed that the three levers not in use are constantly in the way and liable, at any time, to give one a nasty knock; and not only so, but the peculiar strain on the wrist entailed by using a radial lever is very painful, and does not allow one's full power to be exerted. It is true that the disadvantage is not felt while taking a short stroke, yet, when the length of cut necessitates a whole turn or more of the shaft, the disadvantage will be seen and felt to a painful degree.

The rack is secured to the table by three 5-16th in. nicked screws, let in from the top of the table in the centre slot (there are only three slots in this machine, although four are shown in the illustration), and the strain is taken by two ¼ in. pins let through the table into the back of the rack. The pinion is secured on to the driving shaft, which is 1⅛ in. bright steel rod, by a taper pin passing through the boss, which will be found on one side of the pinion, and also through the shaft. The pinion also acts as a collar by which the shaft is kept in its position. An adjusting strip is provided to take up wear, and is fitted in the usual manner.

usual way, having an adjusting strip similar to the one underneath the table. The leading screw is 9/16ths in. (or ½ in.) diameter; six or eight threads per inch left hand.

Having procured the set of castings mentioned the drawings and accompanying description should enable the "veriest tyro" to fit up a useful machine. But, before proceeding with the detailed description, I would say to those who may think it beyond their power to construct a workable machine, that however difficult this may appear, in reality, it is quite a simple matter. I have known lads who have only been a very short time at fitting, who could do very creditable work, and would not despair if fit to set up such a tool. I do not say - of course - that anyone is capable of fitting up an accurate machine, but I do say that anyone of ordinary intelligence, and with a bent in this direction, who is willing to put his whole care and attention into the matter, can fit up a machine that will plane approximately true plane surfaces, given the tools and plenty of spare time and patient carefulness. Patience is the primary factor, and nothing good can be accomplished without it. It would be well to try to bear in mind when working, that, in such work as this, when the body is there,



A HAND-PLANING MACHINE FOR AMATEURS.

General View.

(For description see opposite page.)

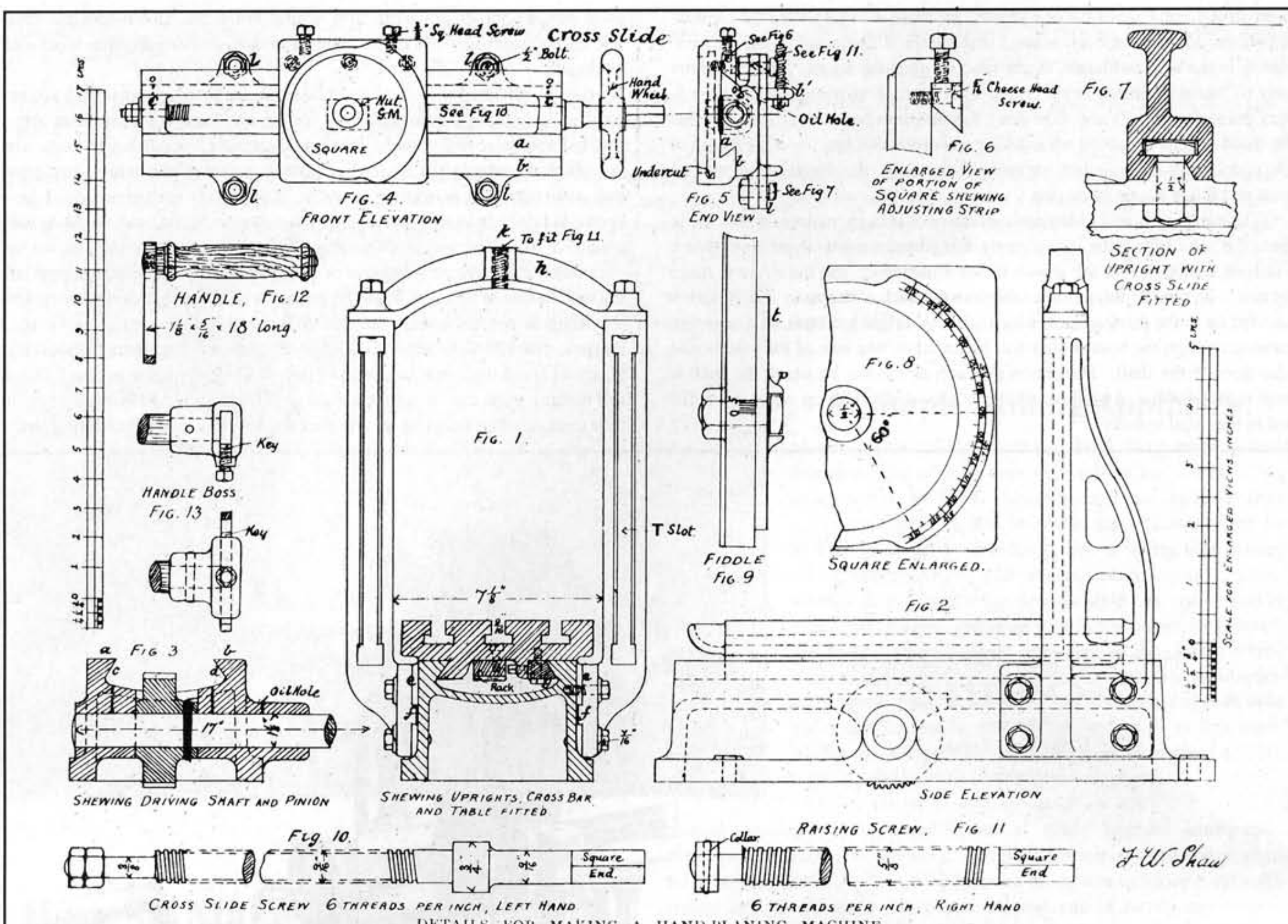
The uprights are tenoned into the sides of the bed, this method doing away with the strain which falls on the bolts when the uprights are fitted to the top of angle brackets cast on the sides of the bed, and each is secured by four hexagon headed set screws, ⅜ in. diameter. The slots which carry the bolts to bind the cross slide to the uprights are ⊥ shaped, and the outside of the slots are V-d to fit corresponding vees on the back of the cross slide, this ensuring that the cross slide will, when fitted up, maintain its original parallel position with respect to the machine table, and doing away with the constant need of adjustment - an adjustment usually effected by taking a cut over the table - usually required when it is held be two screws.

The uprights are stiffened sidewise by the top cross bar, which also serves the purpose of a nut for raising the cross slide, being tapped out to receive the square thread screw, which is ⅝ in. in diameter, 6 pitch.

The cross slide saddle - so called by reason of its shape - is fitted in the

there is absolutely no reason why it should be removed unless requisite. If the work is truly lined out, with care and attention, these lines may be worked to. In planing leave the lines in, that is, on no account, cut beyond the lines.

In drilling, if the hole starts to run outside the circle described around the centre to denote its position, stop drilling the very moment this is apparent, and with a small chisel chip a new centre hole coinciding with the circle. Always describe the circle a shade larger than the intended size of the hole to be drilled, and in the case of large holes, inscribe several smaller circles to act as a guide to the eye in determining the direction in which the drill is cutting. Occasionally a few small blowholes, however small, will pull the drill from its true position, and great care should be taken in this case, as the further the drill is allowed to go with out correction, the more difficult it is to rectify it. There will be many holes to tap, and care should be taken to get them tapped through square with the surfaces in which they are drilled. In most cases it is suffi-



DETAILS FOR MAKING A HAND-PLANING MACHINE.

cient to judge by the sight, but when the efficient working of the machine depends upon the truth of the tapped holes, a square should be placed alongside the tap, and in the case of a taper tap, in a least three positions round the tap, its correctness being judged by the similarity of the angles formed between the square upright and the tap. At the risk of being tedious I will repeat "Don't take metal away beyond the lines". And after this will pass on to the description of the parts.

Beginning with the foundation upon which the machine is built - the bed - I will give a few hints how to proceed, leaving the matter of tools, and how to fix the various parts on the machine table, as is probable that the majority, if not all who have a larger machine, will already be initiated into its use. The only thing which I think may be neglected is the care which should be exercised in bolting up ready for machining. This should be done so as to avoid warping or springing the parts out of shape. Let all bolts be placed as near as possible to the packing blocks or bits of sheet iron, &c. Before taking the finishing cut, which, by the way, should be as light as possible, slacken all bolts off until only sufficient pressure is left to hold the work under a very light cut.

Having fixed the bed, plane up the slides marked *a, b, c,* and *d,* Fig. 3, leaving a small amount to finish after planing the vertical faces *e,* Fig. 1, and slackening off the binding bolts and clamps. Plane out the grooves *f, f.* This will ensure that when the uprights are fitted they will be square with the face of the bed. All the angles are 55 degrees. The table is now to be planed to fit, and an adjusting strip planed to exactly fill the space left; the table is also planed underneath to give a level bearing for the rack, which is also planed. The top of the table may be planed up, or left until the machine is completed and planed up on itself. The hole for the driving shaft may be roughly drilled, and finished by a boring bar in the lathe, the bed being mounted on the saddle; size of hole, 1⅛ in. A piece of bright compressed steel shafting may be obtained for the driving shaft. Length of shaft 17 ins. turned down at one end to ⅞ in. to fit the handle boss (Fig.13), which is secured by a taper pin as shown. The handle lever is make from 1⅛ in. by $\frac{5}{16}$th in. flat bar iron, and slides in the boss, being secured in any required position by means of a set screw bearing on a key to prevent injury to the bar by the point of the screw. The handle is made of hard wood, and the pin is screwed into the bar and rivetted over at the back, a washer at the other end butting up to a shoulder, and riveted on to keep the wooden handle in position.

The top surfaces of the bed (*a* and *b*) are now to be scraped up or surfaced perfectly level. These may be found rather uneven after leaving the planer, although the greatest care may have been taken. To do this work it will be convenient to have a surface plate. A small one will serve the purpose, but one which will cover the entire surface will be better for the job; or if neither is at hand, any true surface, as a lathe bed, may be requisitioned for the work. The scraping tools (scrapers) may be made from any old flat files forged thin at the end, and ground so that the end forms equal angles to each side.

In commencing, red lead or red ochre, mixed with oil to a thick paste, is smeared on to the surface plate, and the casting is rubbed thereon. The parts which stand highest will become discoloured, or, rather, coloured with red. If this shows only in a few parts, a second cut flat or hand file should be used to rough it down quickly; but if the slide be covered nearly all over, the scraper is used for the purpose. The operation is repeated until the surfaces are clouded all over. At this stage the surfaces will be very nearly true, but if more perfection - if the term be possible - be desired, the colouring matter is smeared over the *casting* under operation, instead of the surface plate. In rubbing together the casting will become polished wherever a part projects for the normal surface, and these bright spots require scraping down. By degrees an approximately true plane is produced.

A surfacing strip the full length of the bed is now required, and for this the adjusting strip may be used, and, by surfacing in the manner already described the face which abuts the angular face *d,* "two birds will be killed with one stone." Using the strip as a guide, the face c is scraped level. Leave face d until the table is scraped up. Utilising now the bed as a surface plate, scrape up the faces under the table which lie upon *a, b,* and *c,* and it will be well to also true up roughly the part upon which the adjusting strip rests, and the top of the adjusting strip itself, for when the strip is tightened to the table by the set screws, if the fit is not good, the angular face will be warped. Blot the strip down with five $\frac{5}{16}$ th in. set screws (slot-headed), the two end ones to be about 1 in. from each end, and the others equally spaced between. To adjust the strip laterally to take up wear, four screw ends (threaded all the way) filed square at one end for the purpose of screwing in by a spanner, are fitted, as shown, in Fig.1. The end ones are placed near to the ends of the table, but not as near as the binding screws before described. The face of the strip has been surfaced, and it will now be an easy matter to complete the remaining face (*d*). Work at this until the slide will move freely along from end to end without noticeable side play or shake, when in its remote positions.

The rack and pinion had better be fitted next. The pinion is bored $1\frac{1}{8}$ in. to fit the driving shaft, and turned up until it will just drop between the facings inside the bed (previously faced up), then pinned to the shaft by a taper pin, as shown. The rack must be planed so that the thickness will allow it to slide in between the under side of the table and the pinion, without the least degree of tightness. The rack is bolted on by four 5-16th in. cheese-headed set screws, the end ones being placed $\frac{3}{4}$ in. from the ends. Drill the screw-holes as near to the left side of the ⊥ slot as possible. Place the rack in position and scribe off the holes, centre, and drill 17-64th. in. holes, or, instead of this, clamp the rack on and drill through the table into the rack - taking care not to go right through into the teeth - and open out the top holes to 5-16th. in. Countersink with a pin drill, so that the heads shall not project into the slot. Screw on the rack after tapping the holes, and drill two 5-16ths in. holes anywhere in its length through the table into the rack, and fit pins in to take the end thrust. Otherwise the screws, without this supplementary support, will, by reason of the constant strain which will be applied, gradually work loose. Drill oil holes through the bosses inside the bed, and also into the long boss outside.

All the drilling may - if nessessitated by shortness of tackle - be drilled in the lathe by blocking up the castings in the various positions required, and feeding them up by the poppet or tailstock screw, the drills being held by a chuck fitted to the nose end of the headstock. In some cases it will be necessary to punch a centre directly opposite the hole to be drilled. It is surprising what really can be done, given a little inventiveness, by poor machines, or machines otherwise unsuited to the job.

July 15, 1901.

In the issue of 15th July 1901 there appeared a press release from The Seneca Falls Manufacturing Company of Seneca Falls, New York, advertising a milling attachment for their Star lathes. This gadget is interesting in that the cutter traverses to apply the cut although this entails a long gear mounted on the mandrel in order to allow the necessary movement. Using a commercial dividing head it would be relatively easy for the model engineer to devise a similar attachment to suit most amateurs' lathes although a cover is strongly recommended over the open gears to prevent a nasty accident.

Amateurs' Supplies.

[The Editor will be pleased to receive for review under this heading samples and particulars of new tools, apparatus, and materials for amateur use.]

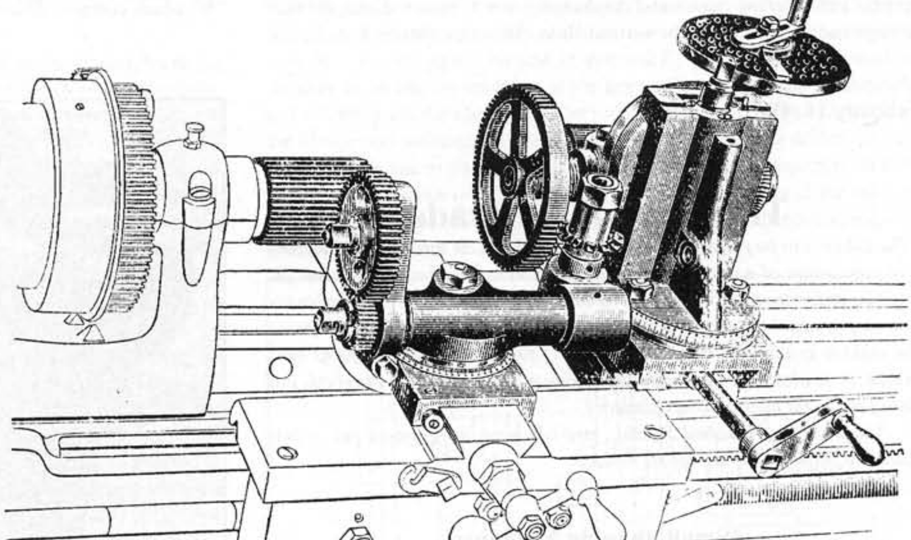
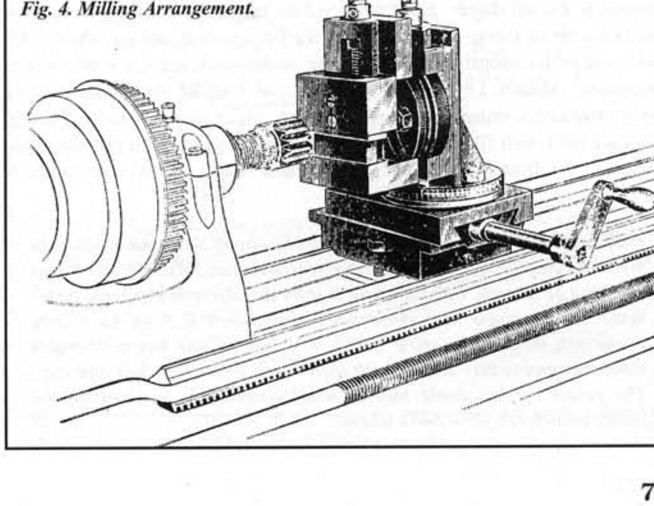


Fig. 1. Wheel Cutting Device for "Star" Lathes.

A New Universal Gear-cutting and Milling Attachment for Lathes.

THE accompanying cuts show a new attachment for lathes which has been designed to take the place of gear-cutting and milling machines for many kinds of work. It is designed for use by tool and model makers, experimental and all workers desiring to do fine, accurate work. The bracket piece which contains the driving mechanism is attached to the cross feed slide of the lathe in place of the regular tool block. The driving arbor which runs through this bracket piece transmits motion to the upright or cutter spindle by means of a pair of spiral gears which are encased so that they are free from dirt and chips. The driving arbor receives its motion from the headstock lathe spindle through a strain of three spur gears, one of which is screwed on to the nose of the lathe spindle and has a wide face which allows a longitudinal travel of 3 in. from the cutters. Any of the regular change gears furnished with the lathe may be used for the other two driving gears, and by using different combinations a

Fig. 4. Milling Arrangement.



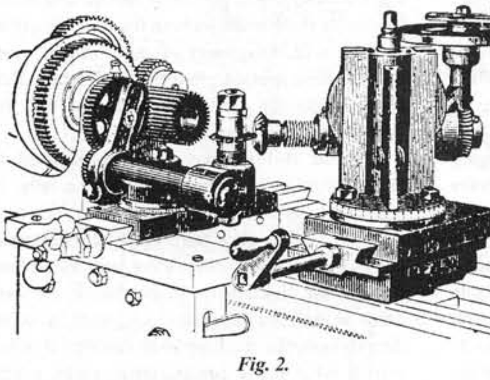


Fig. 2.

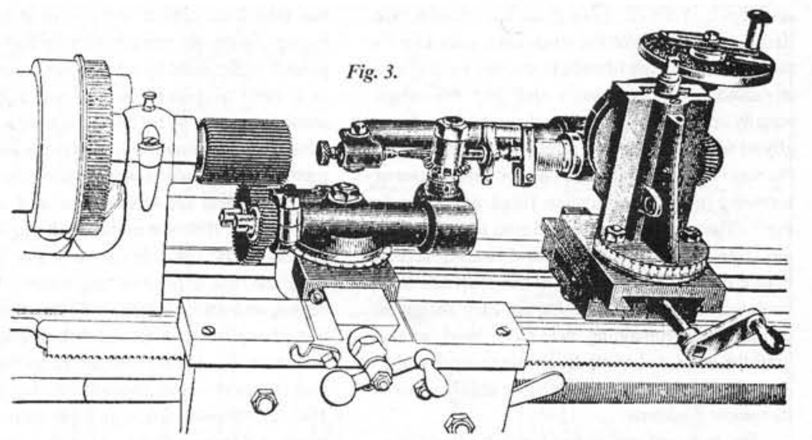


Fig. 3.

large number of speeds for the cutter may be secured. The intermediate gear is on an adjustable quadrant which swivels on the frame piece and allows a cross movement of the entire frame piece and slide-rest and accommodates the cutters to the various sizes of work. The automatic longitudinal feed or the hand crank, may be used to feed the cutter to the work. The base of the swivel dividing head is securely clamped to the lathe bed by means of two bolts and a binder plate, and has cross and vertical feeds which are operated by a hand crank. The upright part swivels on the cross feed slide, which is graduated and renders is capable of fine adjustment to any horizontal angle. The frame piece containing the spindle, indexing mechanism and the overhanging arm swivels on the vertical feed side, which is graduated and allows fine adjustments to any vertical angle. By means of these two feed adjustments and the cross and vertical feeds, cuts of any desired angle may be made. For milling operations requiring a vice the frame piece containing spindle and indexing device and overhanging arm is removed and the vice arrangement is attached to the vertical slide. This may also be swivelled to any angle. In using this vice arrangement, the milling cutters may be driven by the headstock spindle. Chucks, centres, etc. may be used on both the headstock spindle of the lathe and the spindle of the swivel dividing head, as the taper holes and those of both spindles are of the same size. Gears may be cut as large as the swing of the lathe. A complete index is finished and all number of teeth may be cut from 1 to 50 and nearly all numbers up to 360. Brown & Sharpe or any standard milling and gear cutters can be used. Figs. No. 1 and No.2. show the attachment arranged for cutting spur, bevel or mitre gears, milling cutters, etc. Fig.3. shows the attachment arranged for cutting flats in taps, reamers, etc. and Fig. 4. shows it arranged for slabbing and various milling operations requiring a vice. This attachment is designed by The Seneca Falls Manufacturing Company, 560, Water Street Seneca Falls, N.Y., U.S.A., for use on their well-known "Star" Foot and Power Engine Lathes 9 in. to 13 in. swing. Readers interested should write them for their catalogue "B" which contains valuable information.

February 16, 1905.

The News of the Trade.

[The Editor will be pleased to receive for review under this heading samples and particulars of new tools, apparatus, and materials for amateur use. It must be understood that these reviews are free expressions of Editorial opinion, no payment of any kind being required or accepted. The Editor reserves the right to criticise or commend according to the merits of the goods submitted, or to abstain from inserting a review in any case where the goods are not of sufficient interest to his readers.]

**Reviews distinguished by the asterisk have been based on actual Editorial inspection of the goods noticed.*

*Small Shaping Machines.

AFTER the lathe we suppose the most useful machine tool the amateur can possess is a small shaper. Not having had the long practice of the engine fitter in the art of filing, the home mechanic finds such a tool an inestimable boon and with reasonable care in marking out his work in every way is much improved. Messrs. Leyland, Barlow & Co. of Trafford Road, Manchester, have produced a cheap and simple machine, which has the merit of being strongly built, well fitted and of good finish. It is supplied in two forms as shown in the illustration herewith. In the hand shaper the lever actuates the

With this I am being very self-indulgent as one of these machines is in my workshop. Until I started the research for this volume I was unaware of its age. I heard about it from an advert in our local paper some 25 years ago and subsequently purchased it from an elderly gentleman who was moving house. It is one of the power operated machines and is very solidly built with a heavy cast iron bed and ram. The power version could also be hand operated by substituting the pulley and clutch for a hand wheel.

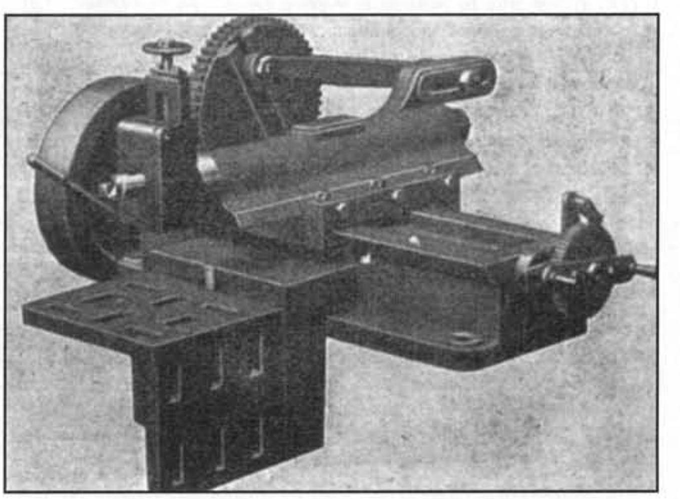
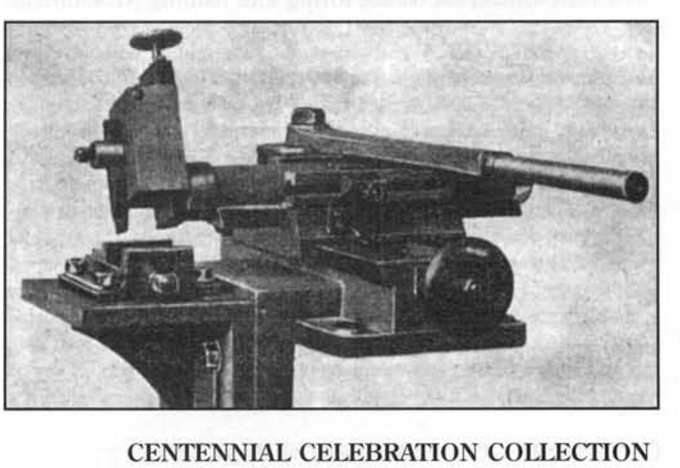


Fig. 1. Leyland, Barlow & Co.'s Self-Acting Power Shaping Machine.



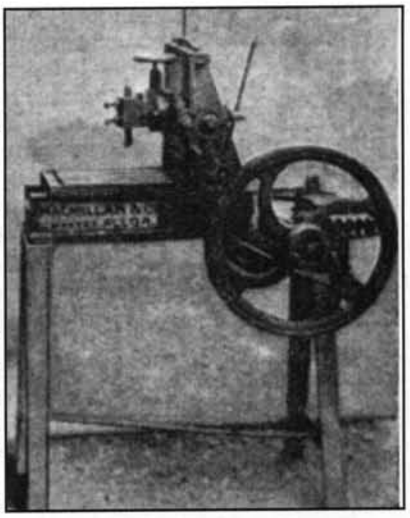
slide through a rack and part pinion. The surface of the work table is kept square with the tool by a tenon sliding in a groove; this tenon, however, can be removed and the table placed at any angle, while by entirely detaching the table, large work can be bolted directly to the machine. The automatic variable feed motion is reversible in a moment and the hand traverse is readily effected. A hole 2 ins. in diameter is provided through the body of the shaper for machining key ways in shafts and similar articles. The swivel tool holder may be adjusted to any angle for cutting vees. The power machine, which is eminently suitable for small engineering workshops, has a specially designed clutch and pulley and is intended to be driven direct from the main shafting, but if desired a three-speed cone can be fitted and countershaft supplied at moderate extra cost. All gears are cut from the solid. The stroke is 6ins., traverse 12 ins., width of belt 2 ins., size of work table, 6 by 8 ins., tools ½-in square.

January 24, 1907.

The News of the Trade.

[The Editor will be pleased to receive for review under this heading samples and particulars of new tools, apparatus and materials for amateur use. It must be understood that these reviews are free expressions of Editorial opinion, no payment of any kind being required or accepted. The Editor reserves the right to criticise or comment according to the merits of the goods submitted, or to abstain from inserting a review in any case where the goods are not of sufficient interest to his readers.]

**Reviews distinguished by the asterisk have been based on actual Editorial inspection of the goods noticed.*



Macmillan & Co's Planing Machine.

Small Planing Machines.

We illustrate herewith the "ideal" Planing Machine, manufactured by W. Macmillan & Co., Mar Street, Alloa. N.B. The table is operated by a worm and worm-wheel with connecting-rod, adjustable for different lengths of travel. Work can be planed up to the following sizes - 16 ins. by 8¾ ins. by 9 ins. high and tools up to ⅝ in. square can be used. The hinged tool box can be set to any angle independent of swivel slide-rest. Readers in want of a small power planing machine should write for further particulars to the above firm.

February 21, 1907.

A Simple Slotting and Planing Machine.

By H. Casselton.

THE following is a description of a small machine I have made for doing small planing and slotting, and which I have found to act splendidly. Two iron castings should be obtained, as shown at A and B, A being a bridge to fit over top of lathe bed, and 2½ ins. wide, with two bosses on top 3 ins. apart as shown. B (Fig. 2) is the travelling tool-holder, which slides up and down the guide rods. This should be 4 ins. wide, 2½ ins. long, ½ in. thick, with a lug at each corner (1½ ins. by ½ in.), and a lug in the middle to hold the tool. Continuing from the back should be a projecting arm 3 ins. long, ¾ in. wide on top, as shown at B.

The lugs should be 1½ ins. high. Fig.1 shows the front and side elevations. A piece of iron should now be obtained 1½ ins. by ½ in., 4 ins. long; this is for the top, into which two ⅜ in. holes are drilled 3 ins. apart. Into the bosses on the top of A drill and tap two holes ⅜-in. Whitworth, exactly the same distance apart as in the top plate. Great care must be taken to get both sets of holes exactly the same distance apart, as the guide rods which fit them must be quite parallel. Two pieces of smooth round iron should now be obtained 1 ft long. The ends of these should be centered truly, and on one end of each a ⅜ in. thread ¾ in long is cut to screw in A. On the other end a plain ⅜ in. pivot is cut, with a ⅜ in thread on ½ in long. These pivots fit in the holes in the top plate, and clamp it tight by the nuts. The base A is clamped on the lathe-bed in the usual way - by a nut and bolt. Holes are now drilled through the lugs on the slide B 3 ins. apart, to fit on the 1 in. rods. This slide must now be made to slide freely up and down the rods. In the centre boss a hole is drilled and filed ⅜ in square to hold the tool. A hole is drilled from the top into the square hole, and tapped 5-16ths in. Whitworth for about to hold the tool tight. Into the projecting piece continuing from the back a hole is drilled and tapped ⅜ in., and a ⅜ in pin 2 ins.. long, with a thread on ½ in. long is screwed very tight. Into a face plate to fit on the lathe a hole is drilled 2½ ins. from the centre, and tapped ⅜ in. A strong shoulder screw is now made to fit in this hole, and having a plain part ½ in. in diameter, ¼ in. long, under the head. A piece of iron 1 in. by ¼, 5½ ins. long, should now have a ⅜ in, hole drilled through ¾ in. from one end and a ½-in. hole drilled through 1 in. from the other end. This is the connecting-rod with the holes, in which work the pin in B and the shoulder screw in the face plate. A tool should now be held to the square hole in B, projecting about ½ in. and held tight by the bolt in the top. The machine is now finished, and by screwing the face plate on the nose of the lathe and clamping the tool down on the bed by means of the nut and bolt underneath and the connecting-rod fixed, when the lathe is revolved towards you the eccentric pin in the face plate causes the connecting-rod to move the slide up and down the guide rods. The work to be planed or slotted is held under the toolpost, or on an angle-piece screwed on the slide-rest. The feed is taken by travelling slide-rest towards the cutter, and the cut taken across with the lathe revolving. For cutting keyways in wheels a piece of iron should be obtained ½ in. by ¼ in., and should be bent as shown at C. This should be screwed on the slide B. A file the thickness of the keyway required should be obtained, and a slot filed in the ends of the iron rod in which the file fits. The ends of the file are now softened, and, holding it in the slots, a hold is drilled through each end for a pin, as shown. For large wheels the iron will require to be bent more, so that it spans over half the wheel while the file works in the hole. It will be found the tool only takes a few minutes to fit up ready for use, and will save its cost in a very short time.

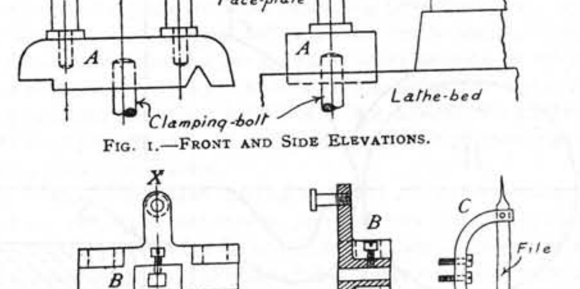


FIG. 1.—FRONT AND SIDE ELEVATIONS.

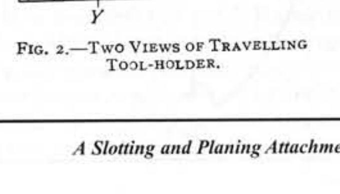


FIG. 2.—TWO VIEWS OF TRAVELLING TOOL-HOLDER.

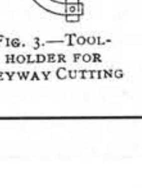


FIG. 3.—TOOL-HOLDER FOR KEYWAY CUTTING

A Slotting and Planing Attachment.

April 18, 1907.

Planing and Shaping for Amateurs.

By A.W.M.

In the issue of 18th April 1907 Percival Marshall's brother Alfred commenced a series of articles entitled Planing and Shaping for Amateurs. This series ran until 27th June and is as applicable today as when it was written, particularly the advice on work holding. Although the horizontal forces are higher in planing and shaping there are still considerable horizontal forces at work in the milling process and precautions still have to be made, and the fixtures and fittings are applicable to the milling machine. I have reprinted the introductory article together with some of the illustrations from the section on work holding. I strongly recommend that you obtain the complete series, you will find it most useful.

I - Introduction.

THE work done by planing and shaping machines is the same in each case, and principally consists in the production of flat surfaces. Yet the two kinds of machine are quite different in design and method of operation. The planing machine is an instance of the idea of fixing the cutting tool and moving the work to meet it. The shaping machine is an instance of the converse idea, namely fixing the work and giving movement to the cutting tool. Both machines accomplish their work by the copying principle - that is, the cutting tool produces a copy of some part of the machine. The planing machine imparts a copy of the surfaces of the slides upon which the table moves to all cuts made by the tool in a longitudinal direction and a copy of the cross and vertical slides to all cuts made in a transverse or perpendicular direction. The shaping machine imparts a copy of the surfaces of the slides upon which the tool moves to the cuts made longitudinally and transversely and of its vertical tool slide as well to cuts made vertically. If these surfaces which are copied by the tool during its cutting action are not truly flat, the planed surface produced on the work will not be true. The irregularities of the machine slide surfaces will, in fact, be reproduced upon the work. To produce accurate planed surfaces, therefore, the first condition is to secure an accurately made machine. When buying a planer or shaper the purchaser should examine the slide surfaces, as upon the condition of these will depend primarily the accuracy of the cuts made by the tool. If these surfaces are found to be hollow or uneven, the machine will not plane flat. This need not mean that the machine is useless because, the irregularity upon the surfaces produced may not amount to much; if the surfaces are small it is possible and not unusual to correct the irregularities by means of a file or scraper (see THE MODEL ENGINEER for March 10th, 1994, page 221) but the fewer these irregularities are the less will be the supplementary correction required. Therefore, try to obtain an accurate machine if possible. A great deal of planing is done which seems to have come from machines whose operators have been instructed to "just knock the lumps off" as the workshop phrase goes. In factories where cost of machining is brought very low and for certain classes of work a single cut over the surface may be made to suffice. The writer graduated in a factory where planing was carried to a fine art, pieces being planed to gauges and fitted into place with little or no scraping adjustment at all.

Wrought-iron surfaces left the tool in a polished condition and would scarcely show the mark of the cut taken by the tool. The amateur, to whom cost of production is secondary and pleasure in doing the work of primary place, may find as great a delight in manipulating a planer or shaper as turning with his lathe. There is an art in planing a true and well-polished surface and much scope for ingenuity in fixing the work so that it can be manipulated with successful results. But take care of your fingers. Keep them away from the work or slides whilst the machine is in motion, and never clear away the shavings from the point of the tool except with a brush or something that you can spare if accidentally crushed or torn. Owing to the reciprocating movement of the work or tool, it is very easy to get your fingers caught between some projecting part and the cutting edge. There is often a temptation to touch the shavings whilst inspecting the surface as it is produced by the tool.

The machine should be fixed upon a firm foundation so that is can work steadily and the cutting tools made to correct shapes. These are similar to the tools used for lathes-in fact, lathe tools can be used for planing work, but the proper tools will give the best results. A lathe tool is used to cut material which is moving continually in one direction, and which, therefore, always moves in a direction from the point of the tool towards the back. With a planer or shaper, however, the relation of movement between the tool and the work is reversed at the conclusion of each cutting stroke. At each non-cutting stroke, therefore, the movement is in a direction from the back of the tool towards its point. Any rubbing which may then take place between the work and the tool will tend to break off the point. In order to relieve this effect the tool-holders of planers and shapers are provided with a hinge arranged so that whilst the tool cannot swing backwards from the vertical line it can do so forwards. It will thus trail lightly over the surface of the work when the movement is from back to front and the point is preserved. Some machines are provided, with a movement to open the hinge forward and lift the tool clear of the work when the non-cutting, or return stroke, as it is called, takes place; careful operators sometimes do this by hand when desirous of producing a very good surface. Under certain circumstances the tool must, however, be rigidly fixed, and this hinge movement cannot be used. It is necessary then for the operator to lock the tool-holder by some convenient means so that the hinge cannot open.

To economise the time taken up by the non-cutting stroke, planing and shaping machines are usually provided with a mechanism which increases the travel speed of the work or tool during this idle stroke as compared with the speed when the tool is cutting. It is called a quick return motion and is almost universal for single-cutting machines, as they are called - that is machines in which the tool only cuts during each alternate stroke or travel. To eliminate the idle time altogether, some machines are made to cut at each stroke or travel - they are called double-cutting machines. This method is used in the famous one introduced by Sir Joseph Whitworth: the tool is carried in a holder which can rotate horizontally through 180 degs.; by means of suitable gearing the

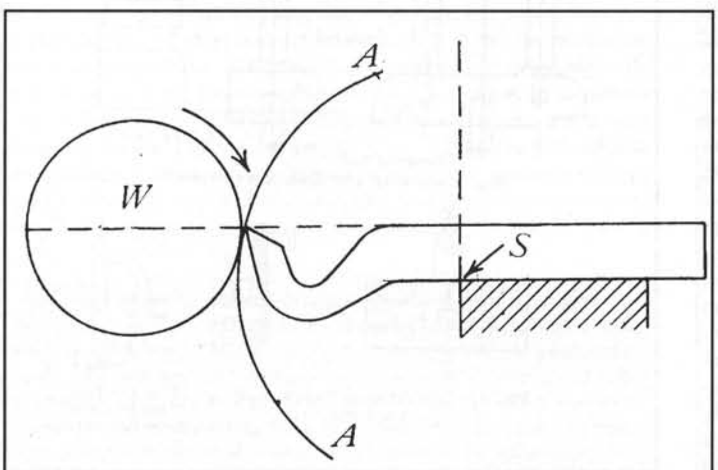


Fig. 1.

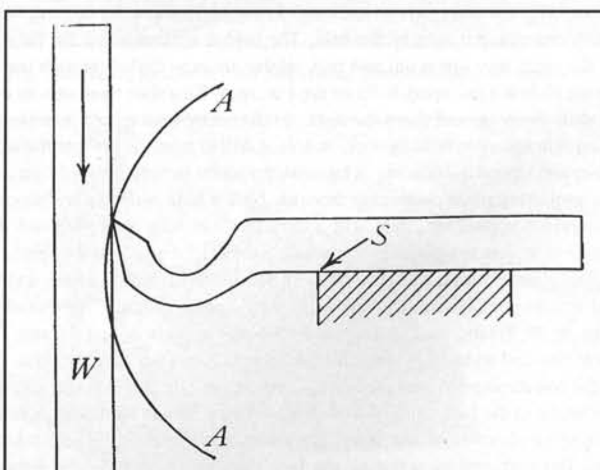


Fig. 2

tool is rotated by this amount at the end of each stroke and its point, therefore, presented in one direction and then in the reverse, so that it cuts during each stroke. The arrangement has received the name of "Jim Crow" tool-holder: presumably it acts like a personage of that name described in an old comic song, as it "turns about". Another method is to use two tools, one pointing each way and fixed in separate tool holders; the third method is to use a double-pointed-tool fixed in a holder which is tilted automatically so that one or the other point is brought into action according to the direction in which the work is travelling. Double-cutting is not usually applied to shaping machines; the speed of travel must, of course, be the same in each direction. Small machines are generally single-cutting and the planers likely to be used in amateurs' workshops are frequently so designed that they are practically equivalent to shaping machines. Whilst both planers and shapers produce the same kind of surface, the planer came into being for the production of comparatively large flat surfaces and the shaper to produce comparatively numerous small flat and curved surfaces. As time progressed the two types have become

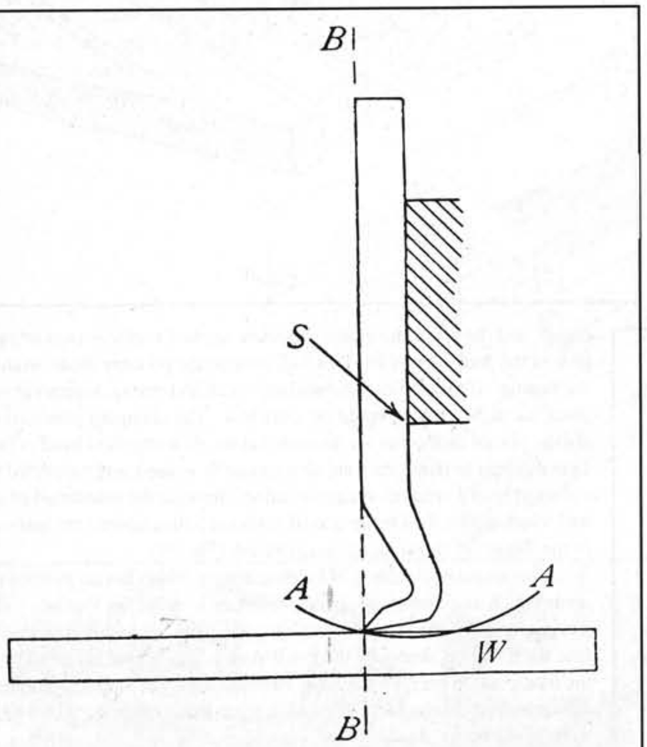


Fig. 3

merged together to some extent, and there are in use machines - called side-planers, wall or vertical planers, and so on - in which the tool moves and the work is fixed. These machines, however, are usually of very large size and are more suitably called planers, because a shaping machine is the idea of a mechanic's arm and file driven by engine power. James Nasmyth, the inventor of the steam hammer, was one of the first men to design and construct shaping machines, with the idea of creating a machine arm which could go on working all day without becoming tired and produce an even quality of work. One of the first planing machines originated in London early in the last century. The table (or platen, as it also called) moved upon wide rollers made and set with great accuracy; it was easier at that time to produce a large accurate straight surface by turning, the lathe and slide-rest being in existence; but lengths of flat surface were produced by hammer and chisel and filing. The term "chipping strip" which is even now in use, applied to the seatings for bearings, etc. was in fact at that time an accurate name, as the strip of metal was designed to enable a true seating to be cheaply produced by chipping with hammer and chisel. The old-timer fitter would chip over these strips with such skill that little filing was needed to ensure a straight smooth surface. Now the planer or shaper produces the same result in much less time but just as a gun depends upon the man behind it for good shooting so does the machine depend upon the operator, and if he is not skilled in his art the work produced may be inferior to that of the mechanic with his hammer, chisel and file.

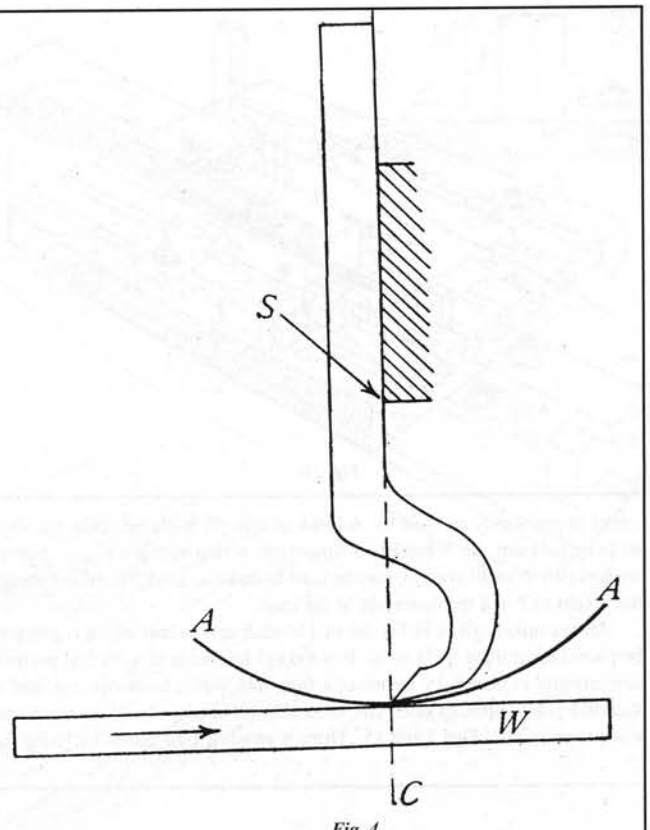


Fig. 4

Fig. 1 is a diagram of a lathe tool turning a cylindrical shaft. It is usual with lathe tools to make them so that the point or highest surface of the cutting edge is level with the top of the shank of the tool, as indicated. If any springing occurs during cutting, the point or leading edge moves on the arc of a circle A A, whose centre is the nearest point of support S. As the work W being cut is circular, the cutting edge of the tool will not tend so much to dig into the cut as to move out of it; when the bending takes place, due to the pressure of the metal against the edge, the tool tends to relieve itself. If, however, the tool is cutting upon a flat surface, as when facing a disc held in a chuck (see Fig. 2), the point does not tend to clear itself, but to dig in as shown by the arc A, and increase the pressure because the depth of cut will increase. If such a lathe tool is used in a planer - or shaper, it will be operating under the latter condition (see Fig. 3) and will be constantly tending to dig into the work, and therefore to impair the accuracy of the surface produced. If the cutting edge is brought in front of the line B B, this effect will be increased.

If the tool is made so that its cutting edge is behind the line B B, the effect will decrease. Planer and shaper tools are, therefore, preferably to be made with their cutting edges level with the under part of the shank so that the cutting action takes place on the line C C, Fig. 4. If any springing occurs, the tool point then moves over the arc A and clears itself rather than dig in. Many planer and shaper tools are made and used which merely consist of straight bars of steel having cutting edges ground or otherwise shaped at the end. Various patterns of cutter bars or tool-holders also quite ignore this idea of placing the cutting edge at the line C C, Fig. 4. It is, however the correct principle to adopt when the tools are specially intended for planing and shaping machines, but it is not essential.

Fig. 25 shows a method of clamping the casting, so that the top surface is without any obstruction, and may be planed all over with one operation. Wedges D are driven between the stops H and the casting, acting as keys to clamp it firmly in position. The wedges P P, are driven into the table slots and act as stops; they are shown as an illustration of their use in general. In the particular instance two stops of the pattern H could be very well used instead.

If the keyway is to be planed along the entire length of the shaft the clamping plates (Fig. 29) would obstruct the passage of the tool. This may be obviated by the arrangement of pairs of plates adjusted to press equally on either side of the centre line (Fig. 30), just sufficient space being left between the ends of the plates for the tool to pass. The shaft is shown supported in the

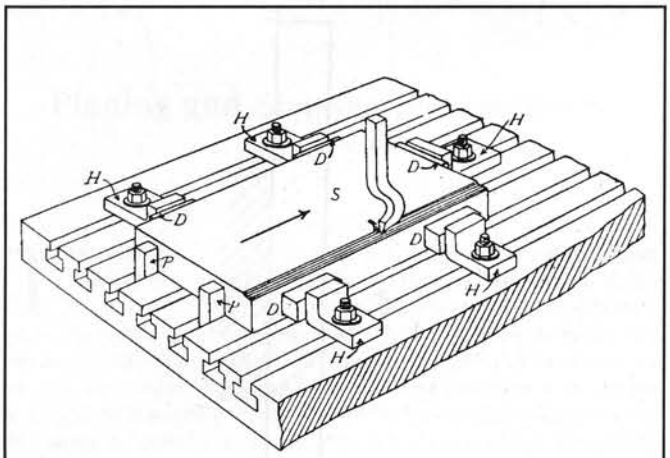


Fig. 25.

centre as previously referred to. A block of iron (P) is placed under the shaft midway between the V-blocks to support it; a thin wedge (W), or pair of wedges (W_2 in small sketch), may be used to make up any difference between the height of P and the underside of the shaft.

An example is given in Fig. 39 of a bracket or standard which requires to be planed upon three surfaces S. It is too tall for fixing in a vertical position conveniently to plan S_1 by means of a front tool with a horizontal cut, and is therefore placed upon its side. The surface S_1 will be planed with a vertical cut, using tools such as Figs 7 and 15. There is an advantage gained by fixing the

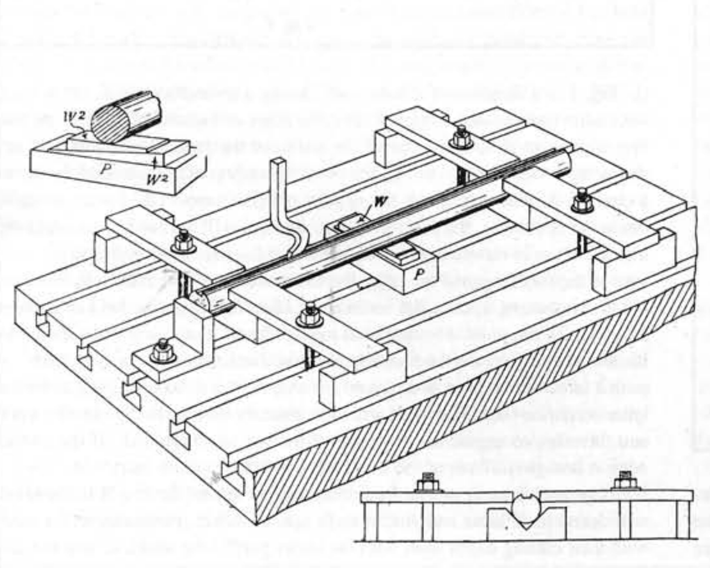


Fig. 30.

bracket in this position, and that is the three surfaces can be planed with one setting of the casting. To ensure that the web of the bracket shall be perpendicular to the surface to which it will be bolted, a centre line is marked completely round the casting as indicated by the dotted lines. If the bracket is set with this line parallel to the table of the machine the surface S_1 will be planed at a right angle to it, and the surfaces S_2 and S_3 will be planed parallel to it; they will consequently be at a right-angle to S_1. Packing pieces (PP) are placed under the web and adjusted in thickness until the centre line is parallel to the bed. It will be so when the scriber point of the surface gauge will touch the line at any part when set at one height. The Scriber point moves parallel to the table as the gauge slides over its surface; therefore if the line coincides with the point when the latter is applied to it at any place, the line must be parallel with the table.

Any particular arrangement of packing pieces, clamping plates, and stops, will vary according to circumstances. If the web of the casting is comparatively thin and weak it would require packing pieces to support it at several

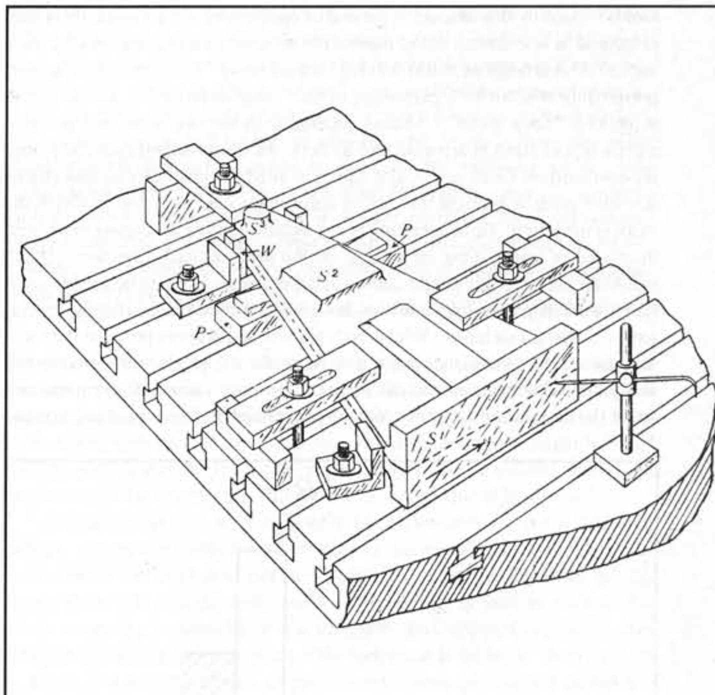


Fig. 39.

places, and the clamping plates should be applied at places over or very near to the packing pieces. This will prevent the pressure from bending the casting. If the web is comparatively thick and strong, support at one place, as in the sketch, would be sufficient. The clamping plates could also be placed as shown. We assume that no plate stop is at hand of sufficient height to reach the web, so a wedge W is used, and supported by a plate-stop as a precaution against tilting. To resist the side thrust of the tool when surface S_1 is being planed stops are bolted against the rear side of the flange, as shown in the small sketch (Fig. 39).

An example of a method of holding a piece which has no projections upon which the clamping plates can press is given in Fig. 43. The wedges W exert a vice-like action upon the sides, stops being placed to take the thrust, as shown by the small sketch. A clamp P bears upon an inclined plate S, keeping the work firmly against the stop T, and pressing it down upon the table to resist any tendency of the tool to lift the work whilst taking a cut.

A casting of the shape shown by the small sketch, Fig. 44, is to be

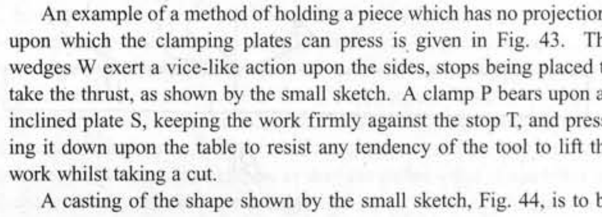
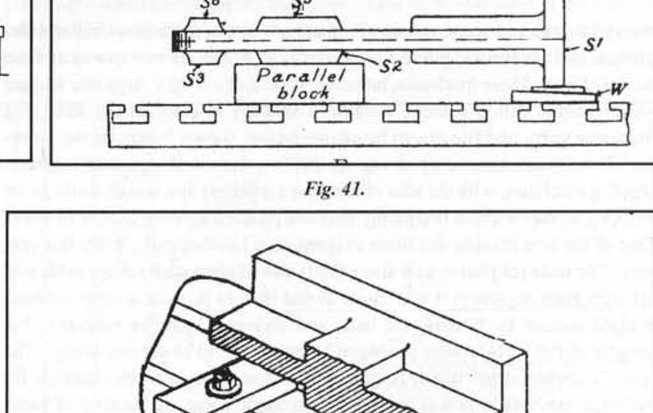


Fig. 41.



planed upon the surface S. It is of large size, and cannot be held in a vice. The surface S is beyond the capacity of the vertical slide of the machine, so that it must be planed by a horizontal cut. There are no holes or lugs by which it can be clamped down to the table. The diagram shows a method of dealing with the problem. A pair of angle-plates, or four smaller ones, placed one at each corner, will support the casting so that the web is clear of the table. Plates P P are bolted to the angle-plates to serve as tops and take the thrust of the tool. Two pairs of plates, B and C, are clamped upon the web at each end, distance pieces D E taking the pull of the bolts in conjunction with the web. Clamping plates G and H are bolted to press upon the plates B and C and hold the casting down upon the angle-plates. Packing wedges could be placed between the casting and the angle-plates to adjust the level of the surface if required, tests being made by a surface gauge as previously described.

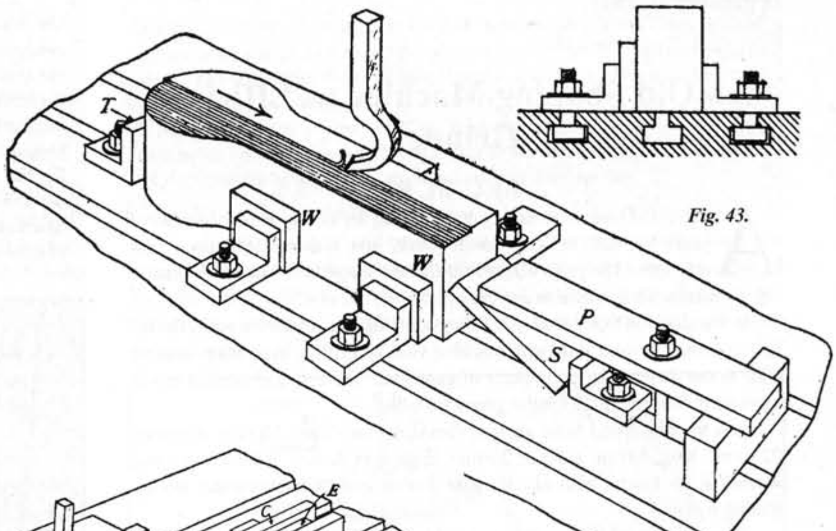


Fig. 43.

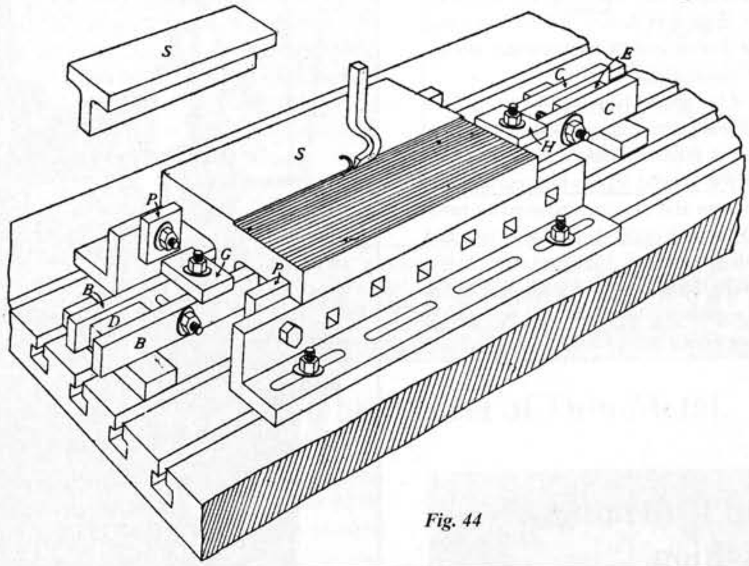


Fig. 44

September 21, 1911.

An Old Shaping Machine as Efficient Grinder

By C. M. R.

A SHAPING machine having done service for a considerable number of years, refused to do accurate work, and was replaced by a new machine. The price offered for the old shaper was not worth accepting, so means were sought to get yet some work out of it.

It was decided to try it as a grinding tool, and the alteration was effected by removing the front slide with machine vice, and fitting in its place another slide in the shape of an angle-piece of gunmetal. Traverse and vertical movement were thus provided for the gunmetal table.

Into the horizontal table an iron (wrought-iron) core, 50 mm. diameter, 275 mm. long, having a collar 20 mm. high, was driven, and its lower part wound in 10 layers, with D.C.C. wire 2mm. diameter, for current from a plating dynamo.

The tool-post of the vertical slide of the shaper had to make room for a ball-bearing grinding spindle, with overhead drive, emery wheel, 150 mm. dia., fitted to the spindle: this was driven at 3,000 revolutions per minute. As a preliminary, the top of the iron core was ground level whilst current was switched off. Current was then switched on and the machine tried on hardened steel (die plates). The magnet held the work perfectly level and tight, and the emery wheel produced an almost polished surface. Hardened steel blocks, 100 x 50 x 25 mm., were ground, and were found exact to dimensions, within 1-500th mm. No vice or setting up is required. The machine is in constant use, and saves many files and much hard work.

March 13, 1913.

Our "Workshop Difficulties" Competition

AS announced in previous issues, Mr. M. Grant-Dalton, M.Inst.CE., has kindly placed at our disposal a Drummond shaping machine and a Britannia Company' s bench drilling machine to be offered as prizes for the best articles on "Workshop Difficulties and how I overcame them". The shaping machine will be given as first prize and the drilling machine as second prize. In addition to these awards we are willing to give consolation prizes, varying in value, to such of the unsuccessful entries as we may consider to be worthy of publication, either wholly or in part. The two prizes given by Mr. Grant-Dalton, illustrated herewith, are now on view in our Laboratory, where they may be inspected while the competition is open, by any readers who are interested. They are not absolutely new tools, but have been very little used. The following are the conditions of the competition:

(1) All articles to be written in ink, or type-written, on one side of the paper only, and to be not less than 1,000 words in length.

(2) All drawings to be in black ink on white paper or cardboard, with all lettering and dimensions in pencil only. No coloured lines or washes to be used. Photographs may be included if desired.

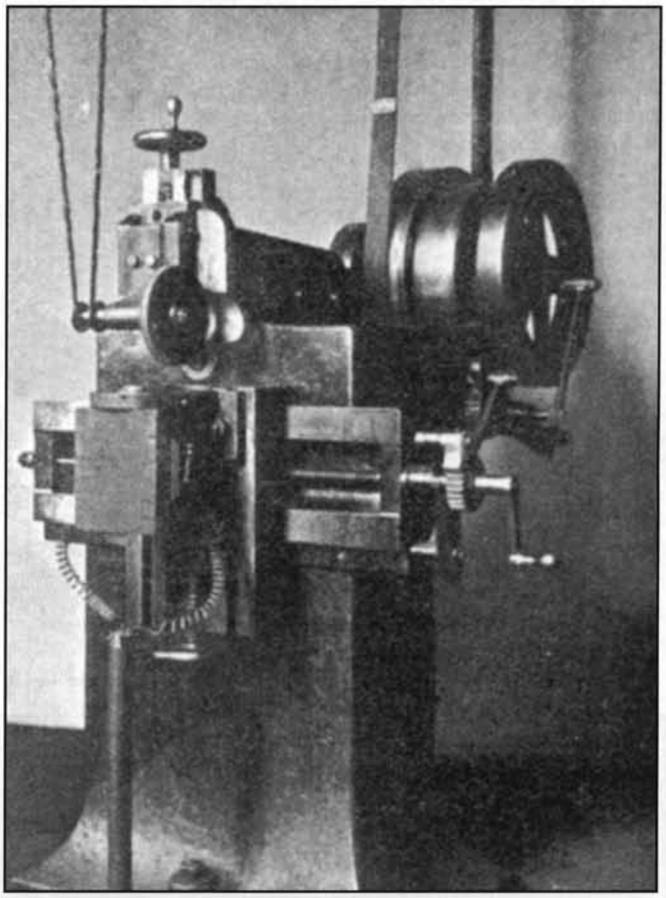
(3) All MS, and drawings or photographs to bear the sender's full name and address.

(4) The subject matter of the articles need not be limited to model making, but must not deal with large engineering work. The entries will be judged on the general interest of the jobs described, and not on their literary or artistic merits.

(5) The closing date of the competition will be March 31st, and all articles must be marked on the envelope or wrapper - "Workshop Difficulties Competition." They should be addressed to the Editor of THE MODEL ENGINEER, 26-29, Poppin's Court, Fleet Street, London, E.C.

(6) The Editor reserves the right to publish either the whole or any part of the articles to which either the first or second or a consolation prize is awarded.

On occasions a horizontal surface grinder is a most useful piece of equipment especially if you are toolmaking. Not many of us can afford the space for such a machine but in 1911 there was published an article to convert a shaper into a grinder. Not only that, using a homemade magnetic chuck. A similar machine could be made today using a toolpost grinder and a standard magnetic chuck.
In the other extract, this time from 1913, details are given for a workshop competition. The first prize is a Drummond Shaping Machine. We have all heard of the Drummond lathe, but here we illustrate another product from the Guildford works.



The shaping machine: to be 1st prize in our "Workshop Difficulties" competition.

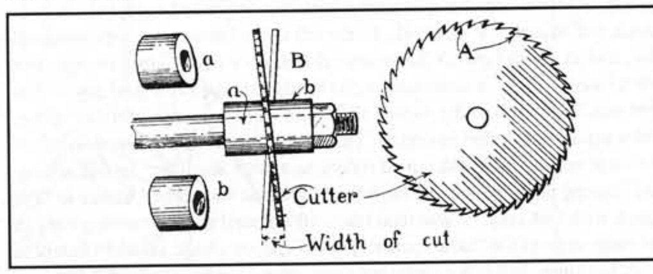
April 9, 1914.

Easy Method of Milling Slots for Keyways.

By John Heyes.

MOST amateur workers know the difficulty and expense of working cast steel, especially in making milling cutters by filing the teeth out. Cheap and effective milling cutters can be made from mild steel as follows: From an ordinary household fire shovel cut several roughly circular discs and bore to suit the mandrel or milling spindle. Thread them on a mandrel with a washer at each end and tighten them together in a mass; whilst thus secured they can be turned to size and the teeth filed, giving them some undercut as shown at A. Take each cutter separately and twisting a wire round it to hold it by, get it to a bright red heat and rub it in yellow prussiate of potash powdered until the potash melts and runs like glass. Again place in the fire and repeat the operation, and whilst red hot quench in water. The same operation must be performed on each cutter. They are now practically hardened cast steel with a soft centre. Several of these can be used together, the number depending on the slot width required, or each one can be used a shown at B. A screwed sleeve *a* is filed obliquely as shown, the angle depending on the width of the slot required. Another sleeve *b*, not screwed, is also filed similarly. A cutter is placed on the spindle between these sleeves and tightened with the nut. It will be seen that the cutter goes sideways twice the distance the edge of the teeth are from the vertical. This gives the width of the slot. On mild steel, iron or brass the cutters will be found to act splendidly, cutting an immense amount of metal away before showing signs of wear.

I have included this item from 1914 for two reasons. Firstly as a method of making special cutters. If you have a one off job it could be a useful hint. The other hint is the bevelled washers giving a wider slot than may otherwise be possible.
The second article is from 1927. Under the heading 'Workshop Topics' the series contained many hints useful to the model engineer. This one is particularly of interest to the clockmakers amongst us.



July 21, 1927.

WORKSHOP TOPICS

Making a Ratchet Wheel of Thin Metal.

A LIGHT thin ratchet, having thirty-one teeth, was required to fit to the calendar work of an old-English eight-day clock. The nature of the movement was such that the wheel could not be obtained from stock, and had to be made, but why, will be described in another place. It is essential that such a wheel should be as light and well-balanced as possible, therefore it was made in $\frac{1}{32}$nd-in. thick yellow brass place, and, because of this, and the fact that, relatively, the gear pitch is heavy, it was not possible to gear-cut it without deformation. This note is to describe how it was set up for cutting.

Fig. 1 is a photo of the finished wheel. It is $2\frac{5}{8}$ ins. diameter over the teeth, the gear is $\frac{1}{8}$ in. deep, and the circular pitch measured on the points of the teeth a trifle over $\frac{1}{4}$in. ($\frac{17}{64}$th in. about). It was actually cut in once over, using a $1\frac{1}{2}$-in. angular cutter of 68°. Fig. 2 shows the lathe setting used. In this a Goodman vertical slide dividing head is used, mounted on the rest, and carrying a jaw chuck on its nose, within the jaws of which a special hardwood chuck is held. Upon this chuck, which had to be quite true, the disc is mounted supported all over. The cutter, set with its vertical edge dead on the disc centre, is mounted running truly on a screw mandrel. This mandrel is chuck driven at the head end, and supported on the cone tail centre of lathe, which is a better setting for gear cutting than running the cutter mandrel between centres. The gear was produced on one cut, the vertical and longitudinal slides of the rest being locked, and the only feed used that of the cross-slide. The speed used was the slowest single gear drive of the lathe, which was treadle-driven.

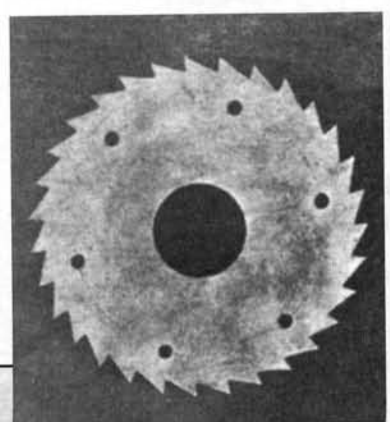


Fig. 1. A finished thin brass ratchet wheel.

A special row of holes had to be drilled in the division plate of dividing head. To avoid setting up an independent driven drilling-spindle for this purpose, the division plate was marked off accurately, dotted, and drilled to the dots on a drilling machine. This method involves a lot of care in the drilling, and came out nearly enough for the particular job. It is, however, not to be recommended for producing division plates as a general thing. The marking off was done as follows: The plate, mounted on its spindle was taken off the head, and set running truly in a lathe. The head end of

Fig. 2. Showing the setting up and operation of cutting a thin ratchet wheel on a foot lathe.

spindle was chucked truly, and tail supported on tail centre. A 60-wheel was used on mandrel tail, having, in gear with it, a worm dividing appliance. The appliance carried a hand-divided card of 31 divisions, the 31 divisions on the plate being obtained by turning the divided card 1 revolution and 29/31 per tooth. To get any number of divisions (teeth) n when worm dividing with a single-thread, and using a wormwheel having N number of teeth, the rule is $\frac{N}{n}$ = number of turns required of the worm. Thus 60 divided by 31 = 1 29/31 revs. of the worm, to get 31 divisions. A circle was first scribed on the plate, and it was crossed out with the 31 divisions by means of a scribing-block set dead on lathe centre, and operated standing on the boring-table of the lathe.

Fig. 3 shows how the hardwood chuck was made and mounted. It is of beech, and is part of a wire reel. To the left in the figure is seen the prepared disc, and in which how six holes were drilled on a circle, large enough, that when fitted with No. 4 wood screws, the heads just missed the gear circle. The disc was first cut from the sheet a trifle-over size, by means of a disc cutter, and a small hole drilled in centre. This was mounted on a screw mandrel of the same size as hole, and nutted tightly to a large shoulder. In this setting, and running between centres, the edge of the disc was turned to size at high speed, with fine cuts. It was then taken off mandrel and set running truly in the outer steps of the "lathe" pattern jaws of a scroll chuck, chucked lightly to avoid buckling. In this the centre hole was opened out by boring with fine cuts to $\frac{3}{4}$ in. bare (23/32). In the same setting the screw circle was scribed, and a guide circle for the tooth depth. The screw circle was then marked off in the same manner as the division plate into six parts using the division plate of the lathe. The final job with this, on removal from the lathe, was to dot out for the screw holes, and drill the same on a drilling machine, using a $\frac{7}{64}$th-in. straight-fluted drill.

To make the wood chuck, the reel was sawn in two, and the flange chucked to face off what is now the chucking shank. This was chucked, as indicated in the section of Fig. 3, and the chuck put on the nose of the gear-cutter spindle, the division plate being removed from the other end. This latter end was chucked truly and the bore of the wood chuck trued, so that, when supported on the tail centre by this hole, the spindle ran truly. In this setting the wood chuck flange was turned to match the disc, faced truly, and centre bossed to exactly take the disc. It was necessary to cut in at the centre of face slightly to ensure that the disc bore flatly on the wood face. When the disc had been screwed by the six screws to the chuck and the whole spindle, jaw chuck, and wood chuck set up on the gear cutter, the disc ran dead truly.

There is little more to say except that it was necessary to hold the jaw chuck up to its shoulder during the milling to avoid the jar loosening it on the screw nose of spindle. The milling cut was made against the feed of the lathe, and it was found necessary to stop the lathe before withdrawing the job to index it, because there was a tendency to catch up on the edge of the metal disc on the way back due to the excessive overhang of the gear cutter spindle by the two chucks on its nose.

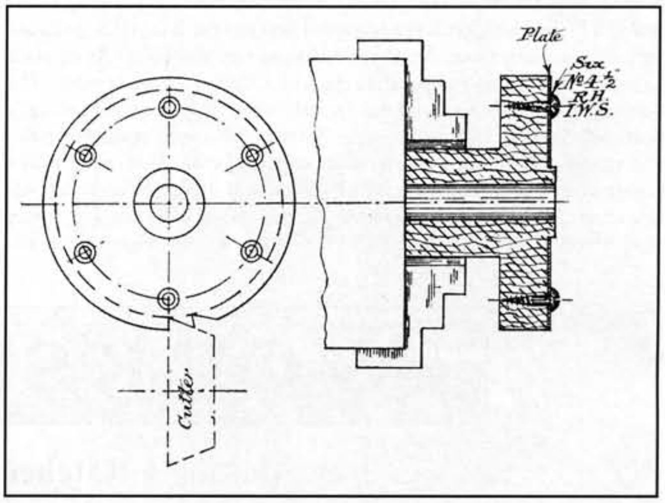


Fig. 3. Detail of Hardwood chuck forholding wheel blank.

February 10, 1916.

IN 1916 Fred Horner started a series "How Machine Tools Work". A number of the hints and tips were slanted very much to war works and mass production, a number of model engineers used their workshops in their spare time for the manufacture of fuse cases and other items urgently required for the war effort.

How Machine Tools Work.

By Fred Horner.

IV. - THE TURNING AND BORING MILL.

The Ancestry of the Turning and Boring Mill.

This machine, which was formerly more often termed a "vertical lathe," operates on precisely the same principle as the ancient potter's wheel. The essential difference, arising from the fact that metal instead of clay is dealt with, lies in holding the work with clamps or jaws, and cutting it with steel tools. So that really, though it came into general use at a later period than the ordinary lathe, its principle is older than that of the latter. And, to carry the comparison further, the same reason that prompted the ancients of some dim, undefinable date to "chuck" their clay on a table that revolved horizontally, still causes the modern engineer to lay flywheels, discs, and the thousand odd shapes that have to be turned and bored, upon a horizontal table. The turning and boring mill is far more convenient and rapid for dealing with the shapes of work for which it is employed than is the ordinary lathe. This is not only due to the fact that the faceplate lies horizontally - a more handy position to lay and adjust the pieces upon - but that it is possible to apply several tools simultaneously, which cannot be done with such facility from an ordinary slide-rest.

The Advantages of the Mill.

The term "vertical lathe" is somewhat misleading, because there is a vital difference between any lathe which is built with a horizontal spindle and the turning mill. In the latter the faceplate is supported upon an annular bearing of nearly the full diameter, which is never the case in an ordinary lathe. This fact alone accounts for the great superiority of the mill when dealing with heavy, bulky articles, on which heavy cuts with

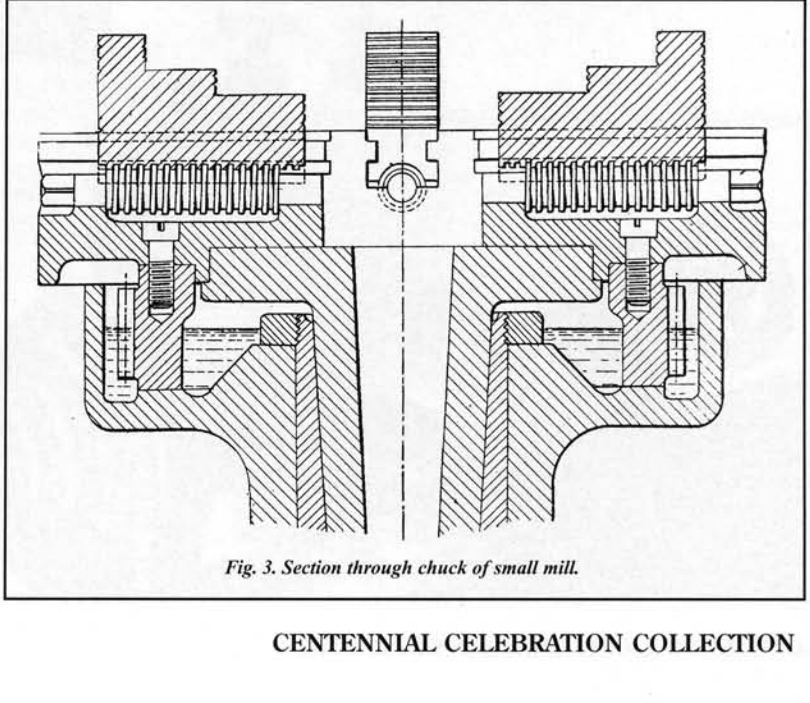


Fig. 3. Section through chuck of small mill.

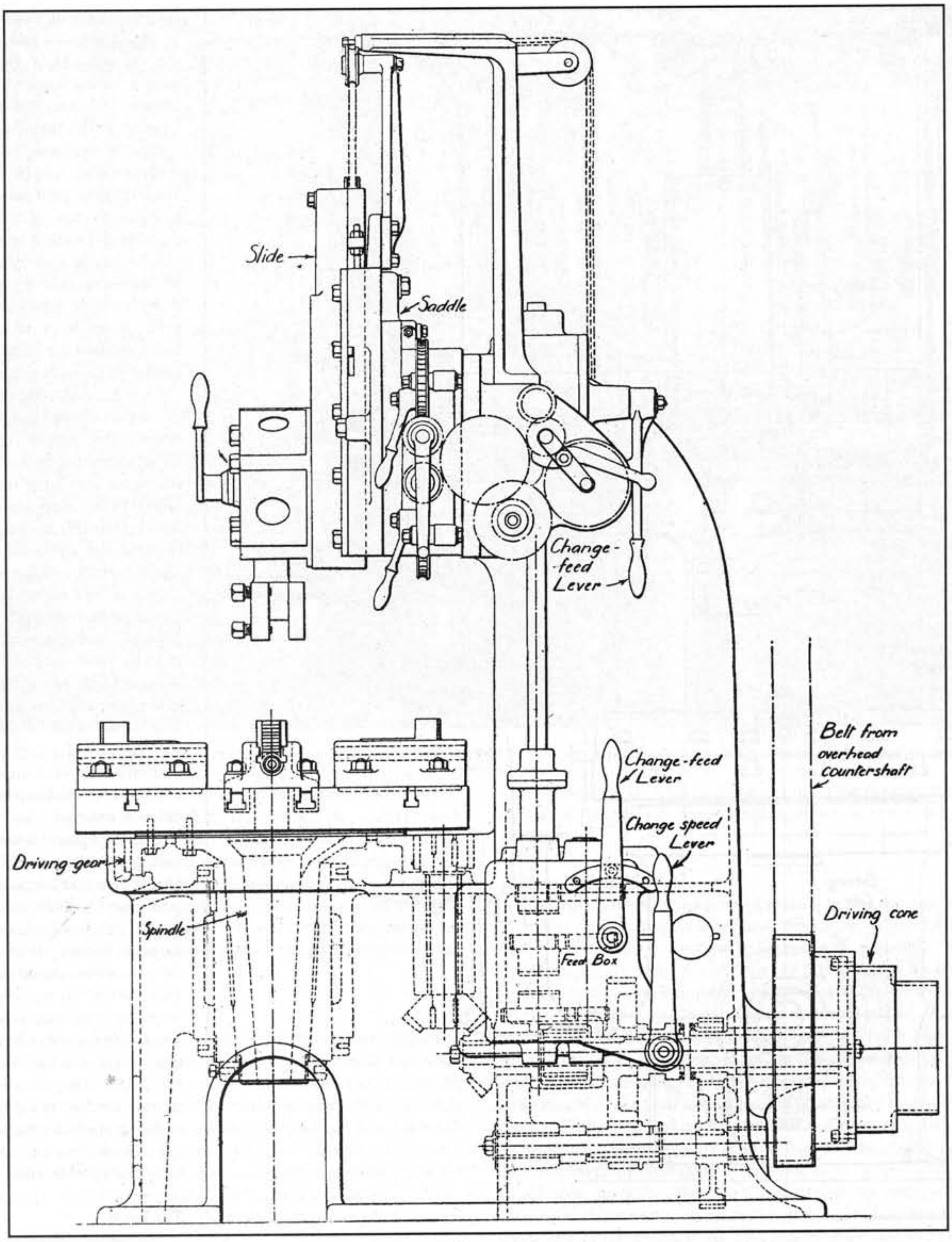


Fig. 1. Side elevation of a typical turning and boring mill.

two, three or more tools are taken. There is an absence of "spring" and vibration, and the weight of the work does not tend to produce untrue results. Neither is it necessary to "balance" the work with a weight bolted on to the other side of the faceplate to counteract the pull of a lop-sided part, as must be done in an ordinary lathe faceplate. But perhaps the greatest convenience is that the work does not move out of position if the clamps or jaws are released to adjust it, and the waste of time incurred from this cause in the vertically set face is completely done away with.

Also, in the heavier mills it is not necessary to keep a crane and attendant by until the piece is correctly adjusted and held. The facility of setting and adjustment enables the mill to be utilised for a kind of work that gives great output - that of facing over a number of pieces disposed around the plate - instead of doing each singly in a lathe. As the tools come down from above (or from the side in some mills with extra side toolholders), it is easier for the operator to adjust them and watch the progress of cutting.

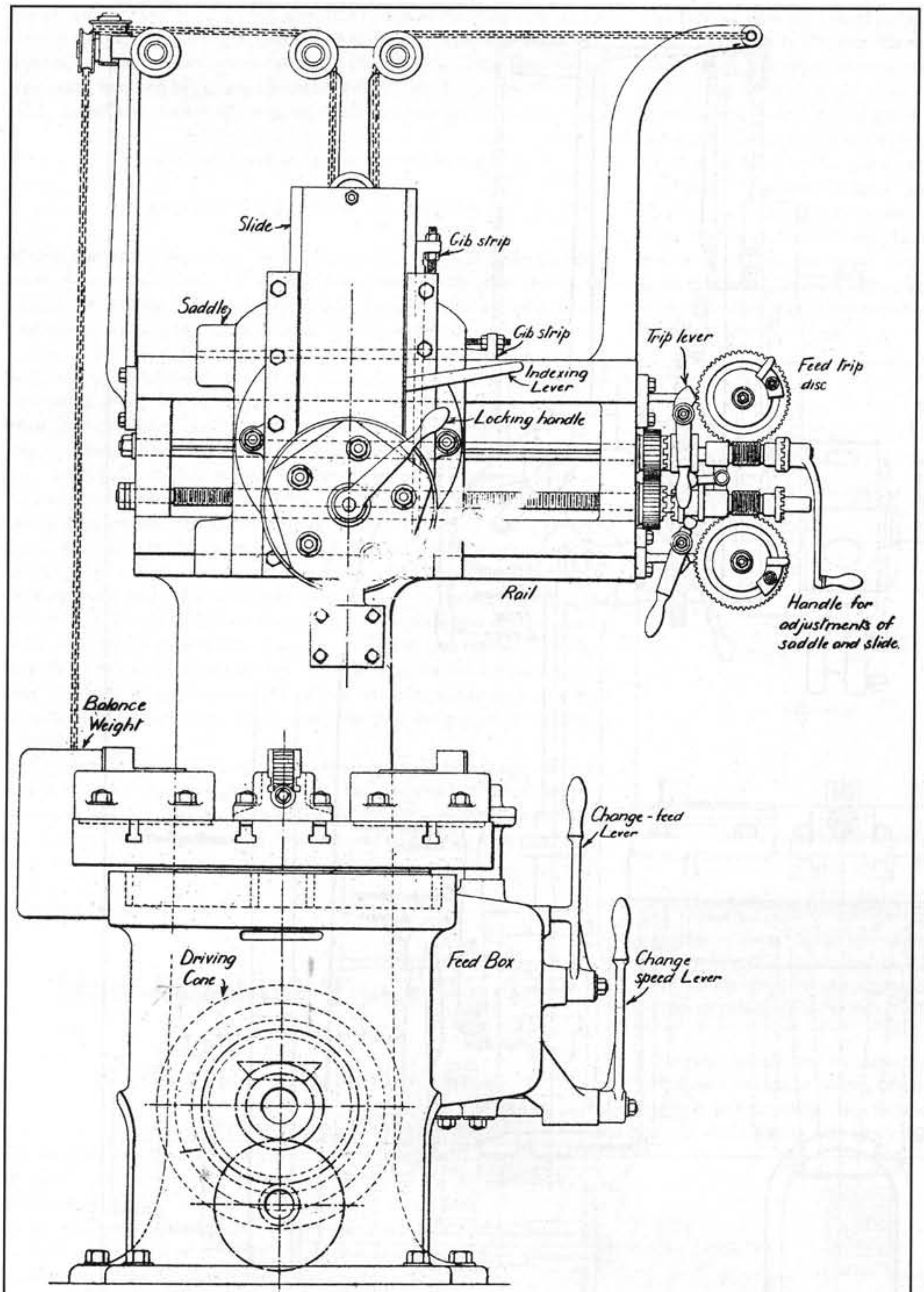
Types of Mills.

The mills range in size (the "size" is the largest diameter that it will take in) from about 18 ins. to 50ft. or upwards, and differ chiefly in the number of slides or "rams" on the end of which the tool-holders are arranged. A small machine may have one slide, a large one as many as five, two of these being set at the sides. Usually, in the small and medium-sized machines a turret is fitted on the end of the slide, so that four or five or six tools can be held and brought round in succession to perform different operations, such as various

A Typical Turning and Boring Mill.

Fig. 1 shows a mill of moderate dimensions, having a chuck of 30 ins. diameter, and taking work up to 34 ins. diameter. (Webster and Bennett, Ltd., Coventry.) The large diameter of the spindle, by comparison with that of an ordinary lathe, will be noticed; this alone tends to great steadiness when taking heavy cuts. But the weight of the table and work is received on the annular bearing path cast in the base, the spur-wheel (which is bolted to the underside of the table) running on this path. A supply of oil is maintained inside to flood the bearings and also lubricate the spindle bearing.

Sixteen speeds are obtainable for the table, ranging from the slowest when taking roughing cuts on the largest diameters to the quickest for drilling or boring, or reaming small holes. These sixteen changes are produced in a simple manner; First, there is a two-speed countershaft (not shown), which is thus able to give a choice of eight speeds to the driving cone at the base of the machine, and the eight are doubled by the use of the back gears seen dotted just inside the frame adjacent to the pulley. The lever outside throws them into action by means of a sliding collar, which has clutch teeth on one end, engaging with clutch teeth on the pinion. If slid to the left (as illustrated), the pinion rotates the wheel below it, and thence back to the large gear, giving a gain of power in the same manner as the back gear of an ordinary kind of lathe (see our issue of January 20th, page 53). But if the collar is slid so as to clutch the teeth, the drive from the pulley becomes direct at, of course, the same speed, and no gain of power there. When this happens, the pinion below the large wheel is automatically slid out of mesh with it by an extension (not shown) of a fork that also slides the collar. The mitre gears thence transmit the drive to the vertical shaft, on the top of which is the pinion engaging with the spur-ring already mentioned, bolted to the table.



Front elevation of a typical turning and boring mill.

kinds of turning and boring, or roughing and finishing, counter-boring, facing, screwing, etc.; and a large number of mills are now of duplex type, there being two tables and two tool rams, with independent driving and feeding mechanisms for each - really two separate machines, but mounted on one base casting. The advantage is that one man can attend to the two and produce a greater quantity of work, and many articles that need rechucking, to perform operations which cannot be done at one chucking, may be handled by the one attendant. Some amount of boring and turning and facing may be done while gripped on one table, and the remainder finished on the other table, each being always occupied. The close proximity of all the levers and handles enables the operator to give the greatest amount of attention with the minimum waste of time.

The Feeds.

Two feeding movements are necessary - one to move the tool radially across the face of the work, the other a downward or upward one. The first is effected by turning the screw seen inside the "rail" in the front view, so traversing the "saddle" along the rail; the second, by turning the key-grooved shaft just above the screw, this operating mitre gears and a screw which has the effect of making the turret-slide go up or down. The weight of the latter is balanced by the counter-weight seen suspended from the chains, thus preventing jerky movements of the tools, and their dropping while at work. The twelve changes of feed are obtained through the feedbox at the side, the drive for these being taken off the main shaft on which the cone pulley is mounted and the variations produced by shifting the lever which alters the meshings of the sets of feed-gears seen dotted inside the box. The vertical shaft transmits the motion up to other gears at the back of the rail, where a reversing motion is situated. As shown by the dotted gear circles in the side view, the

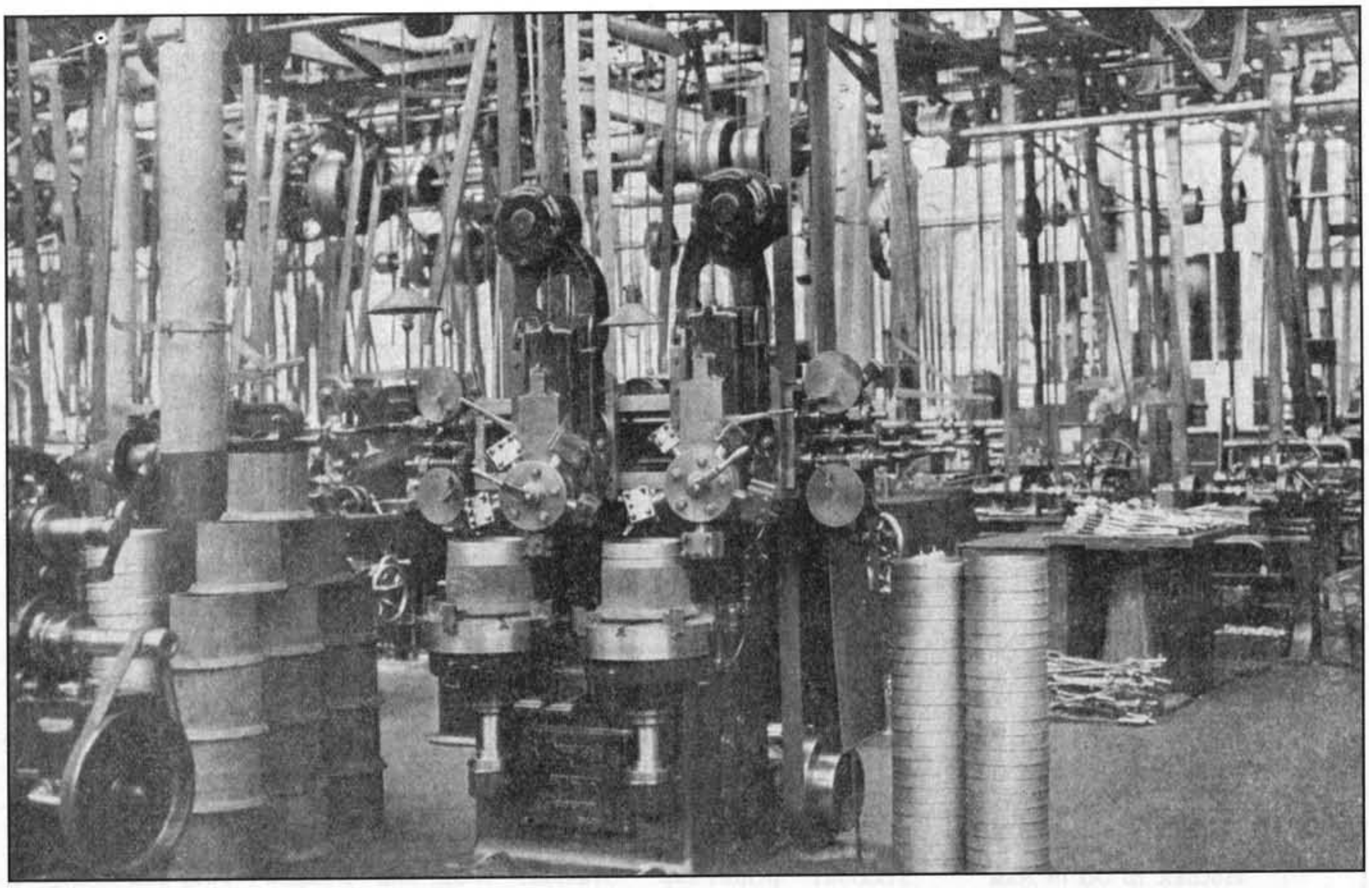


Fig. 2A. A view in a typical machine-tool shop. In the foreground is seen a Duplex Mill producing brake drums from castings long enough to cut several.

feeds are conveyed to two pinions - one on the shaft and one on the screw. There is a peculiar device for attesting the feed at any given position - a sort of clock - comprising a dial for shaft and for screw, the face of each dial being carefully graduated so that a striker or dog can be adjusted at any position around its circumference. Each dial is revolved slowly by a worm and wheel as the shaft or the screw turns. Then, at a predetermined position, according to the setting of the dog, this comes into contact with a nib on the end of a trip lever, and pushes the latter out of the way, causing it to jerk a claw-clutch out of engagement and stop the feed instantaneously.

The Turret.

There are five holes in the turret, and either one is brought into alignment with the axis of the spindle by first releasing the clamping handle, then withdrawing an indexing bolt by pulling back the index handle, then turning the turret by hand to bring the desired tool into position, after which the bolt is allowed to spring back into its notch, and the clamping handle is tightened. Ordinary cuts are made while the turret slide is set straight, as seen, but angular faces are turned or bored by loosening the two nuts on the top of the circular flange, and swivelling the slide to the required inclination.

Differences in Larger Mills.

The larger mills differ from these examples chiefly in the fact of having separate standards, upon the faces of which the rail moves up or down (to suite various depths of work), just as in a planing machine, while the tool-slides are made of rectangular or octagon section and are fed and adjusted up and down by racks, actuated by pinions turned by hand-wheels, or by the automatic feed from the key-grooved shaft within the rail. Sometimes one ram has a turret, while the other has not. And in very large mills an extra saddle is occasionally employed to carry a revolving boring spindle, which is thus enabled to cut at a suitable fast speed in a hole, while the machine table rotates at an appropriate rate for the ordinary turning and facing cuts. A side head on one upright, or one on each upright, often adds to the capacity of a mill, by giving two or more tools in action at the same time that the two rams above are engaged. A special feature in the heaviest tables is a provision for raising the table by means of a hand-wheel and gearing, and supporting its spindle upon a small central pivot. This takes the weight off the annular path and enables high-speed running to be done, for testing the setting of the work, or for doing small holes.

Holding Work on Tables

The method of gripping a piece of work for tooling depends, as in the ordinary lathe, upon its shape and relative simplicity or its awkwardness of outline. A large amount of work can be gripped in the jaws of the "independent" chuck (see Fig. 3), which is made just like that of a lathe, the jaws being traversed in or out by turning the screws with a wrench. Or a scroll is used to actuate all the jaws simultaneously for concentric action. Another resemblance to lathe practice is that of fitting loose jaws (as in Fig.1) to a slotted table, and so converting it into a chuck, the sliding part of the jaws being operated by a screw, as in Fig, 3. A large piece of work is shown in Fig. 4 held in loose jaws, with two tools ready for action. But very often the grip of the jaws is not sufficiently high to ensure a firm hold, and screw dogs are used to supplement them. These dogs are brackets bolted to the table slots, and having each a screw pointing slightly downwards, so as to tend to press the work firmly upon the table. Three or four such dogs are employed. Bolts and clamps are also necessary in numerous instances to keep the article pressed down, and, of course, the chuck jaws may be dispensed with if they do not offer any useful assistance, or if the shape of the piece is such that they cannot be accommodated under or around it. Examples of methods of holding will be seen in the specimens of tooling to be shown next week.

How Machine Tools Work.

By Fred Horner.

IV. - THE TURNING AND BORING MILL.

The Tools Used in Mills.

For all the ordinary work done on turning and boring mills the tool equipment is simple, the tools seen in Figs. 5 and 6 being sufficient for the whole range. For more unusual or special operations, modifications of these, or new types, have to be made. In Fig. 5 the holder, made of tough steel, is provided with setscrews to grip the tool shanks, which rest upon the serrated pads. The shape of this holder is the same, whether it fits into one of the holes in the turret (Fig. 1) or into a plain ram (Fig. 4).

Turning Tools.

The same principles of formation govern the turning tools as for those described in the previous issue, and the commonest shapes are those given in Fig. 5. The shanks are short, because the amount of projection is slight, and the holder is stumpy; in fact, many firms use lathe tools which have become too short to be used on the slide-rest of the lathe.

Boring Tools.

The cranked tools shown in Fig. 5 can be used for boring out fairly large holes, but for deep holes, or those of small diameter, the boring bars are

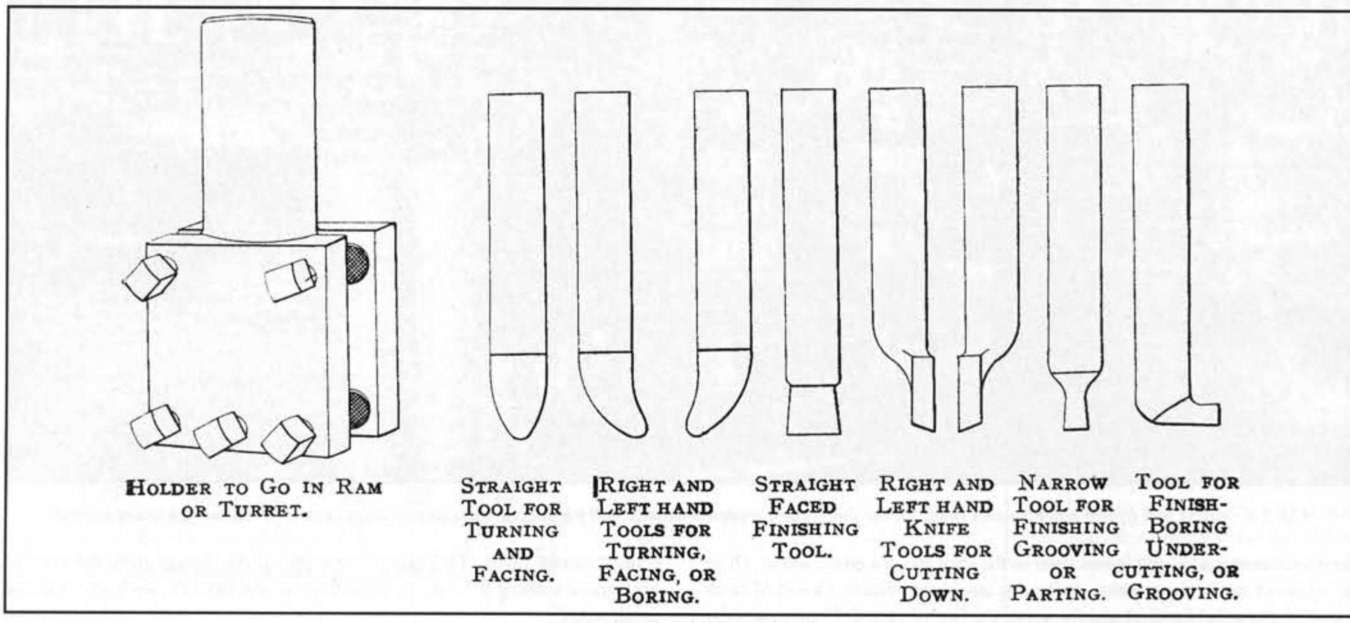


Fig. 5. Standard holder and tools.

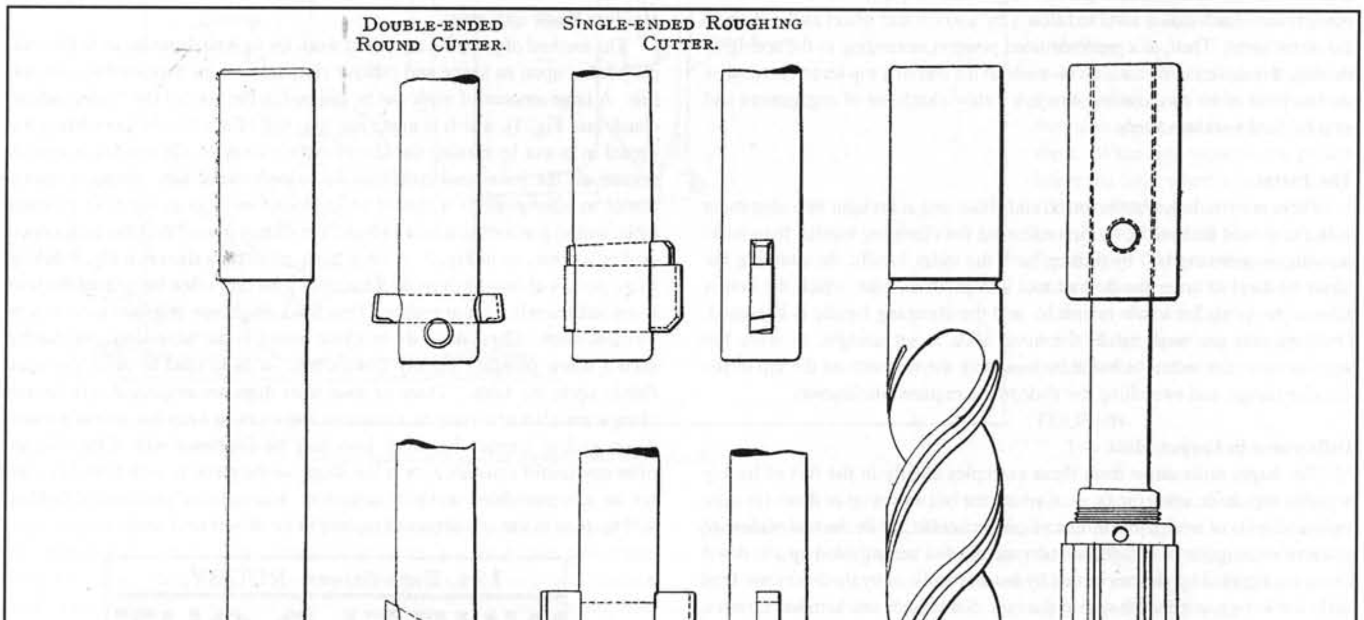


Fig. 6. Tools for roughing and finishing holes.

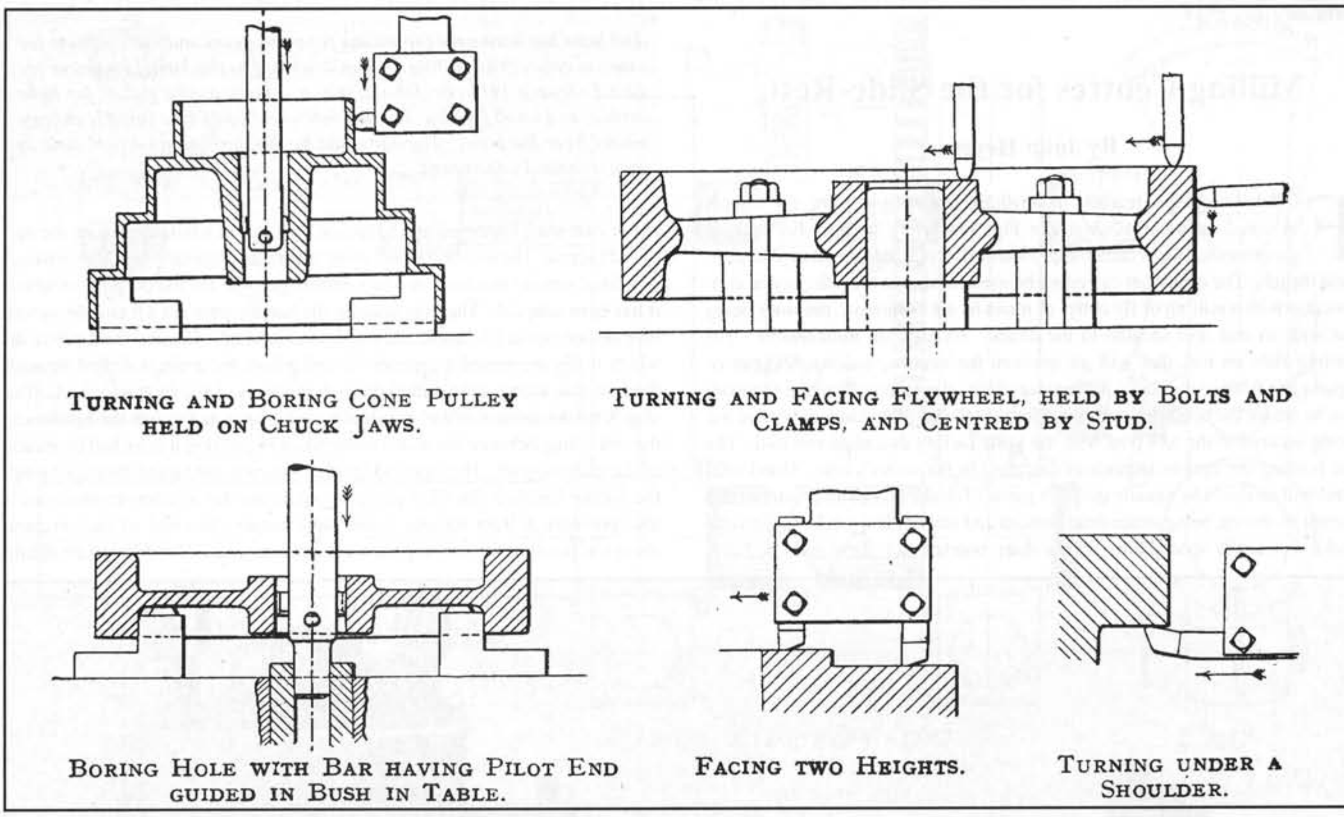
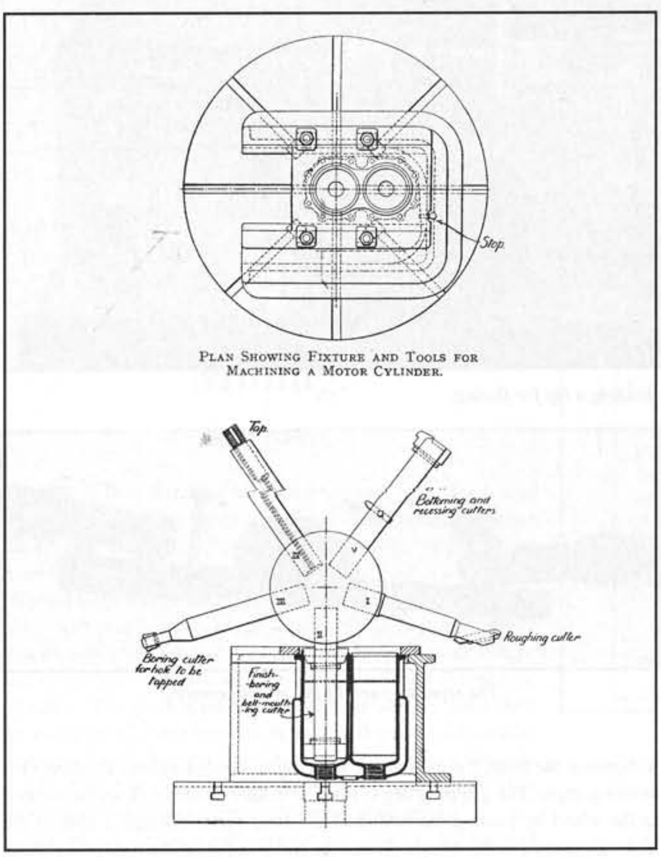
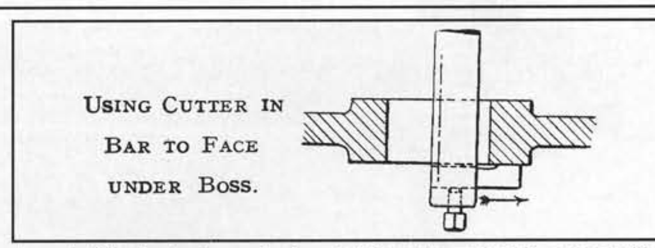


Fig. 7. Typical operations on turning and boring mills.



employed. These are gripped in the tool ram, or in the turret, and are made of suitable length to reach into average depths. Fig. 6 illustrates five different styles of cutters, the first view showing the complete bar, the others the ends broken off. The variations comprise a round single-ended cutter held with a setscrew, a double-ended cutter secured with a round pin having a flattened taper, a single-ended cutter set at an angle to reach to the bottom of a hole before



the end of the bar touches, a single-ended flat cutter wedged in, and a double-ended flat cutter locked with a taper-flatted pin. The cutter is notched out to locate it centrally. The three-grooved twist-drill is used for roughing out cored holes, while the reamer is for finishing to size and smoothness. It only removes a very slight amount of metal, the hole being previously brought within about three one-thousandths of the size by the double-ended boring cutter. The reamer is not held rigidly in its socket, but has a slight amount of play, and is held in with a pin or screw. This freedom (which gives the name of "floating" to the reamer) is necessary to allow for any slight want of alignment in the machine or the roughed-out hole, and it allows the reamer to set itself by the hole, and so just fulfil its function of giving a faint scrape out without cutting too large, as it would do if sprung to one side. The blades of the reamer are adjustable to bring them up to exact diameter after sharpening. In dealing with the larger holes, it is not practicable to spend the money on a reamer for each size if only a moderate number of similar sized holes are done, and in such cases the finish is accomplished with the double-ended boring cutter, some-times using a "pilot" to ensure steadiness and straightness, as illustrated in the specimen toolings.

Typical Examples of Boring.

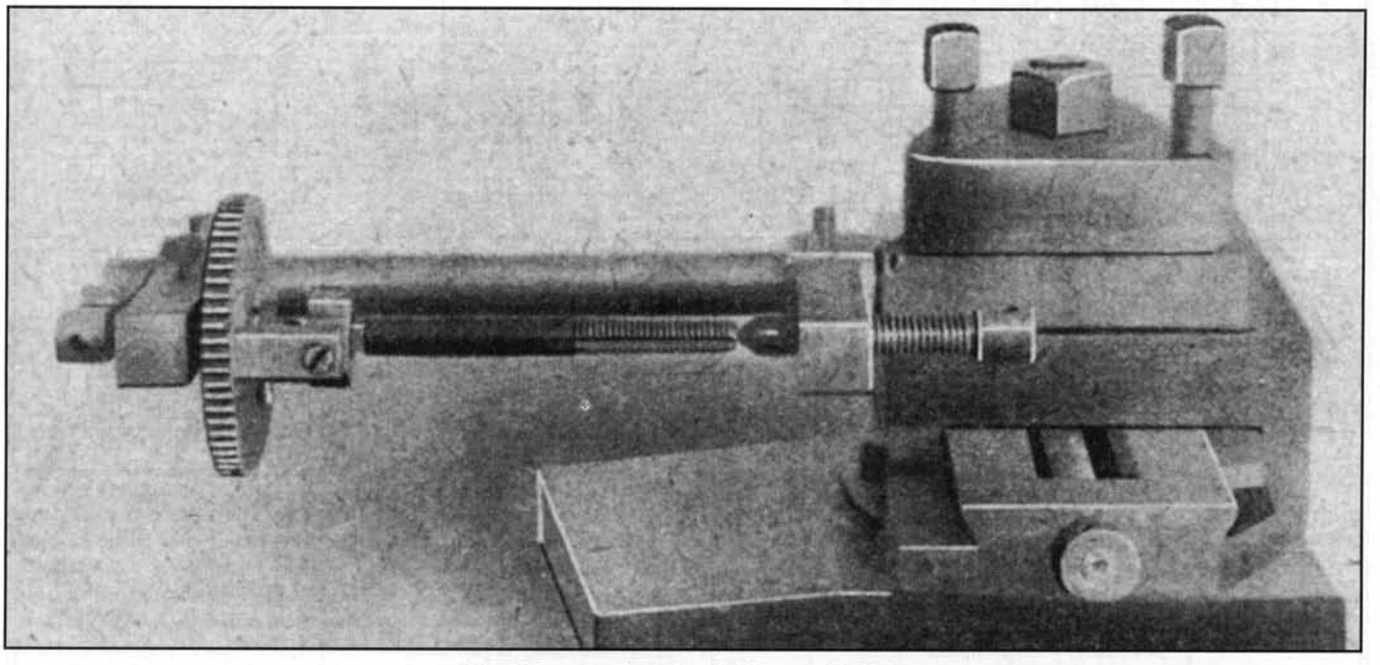
The views in Fig. 7 illustrate a few specimens of various ways of applying the tools, which are self-explanatory, and Fig. 8 offers an example of the employment of a "fixture" for holding a double motor cylinder. The fixture is bolted to the table by bolts and clamps (not shown), and carries a sliding plate, to the underside of which the flange of the cylinder is attached with a few setscrews. The sliding plate affords the means of reversing the cylinder, by pulling the plate and cylinder out of the fixture, turning them round and starting them in again. A little plug (seen in the plan view) locates the plate in such a way that each bore has to come in line with the axis of the boring mill. The four clamps, when tightened down by the nuts, bind the sliding plate, and so hold the cylinder firmly while the operations are in progress. The tools are numbered in their order of use.

Milling Centres for the Slide-Rest.

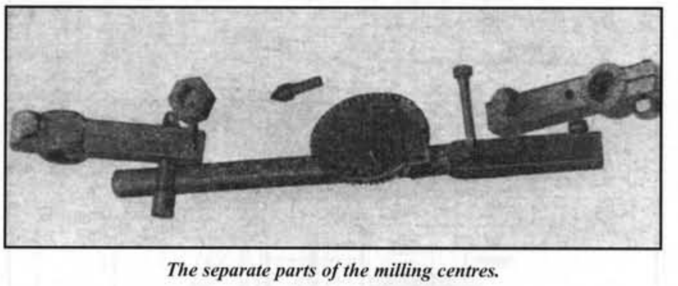
By John Heyes.

The lathe has been used for milling for many years and will continue for years to come. The milling centres described in the Model Engineer for 21st February 1918 by John Heyes is a most useful gadget for light milling and small fittings. The division wheel could be a suitable change wheel from the lathe. The bar could be mounted on a vertical slide to give a vertical adjustment.

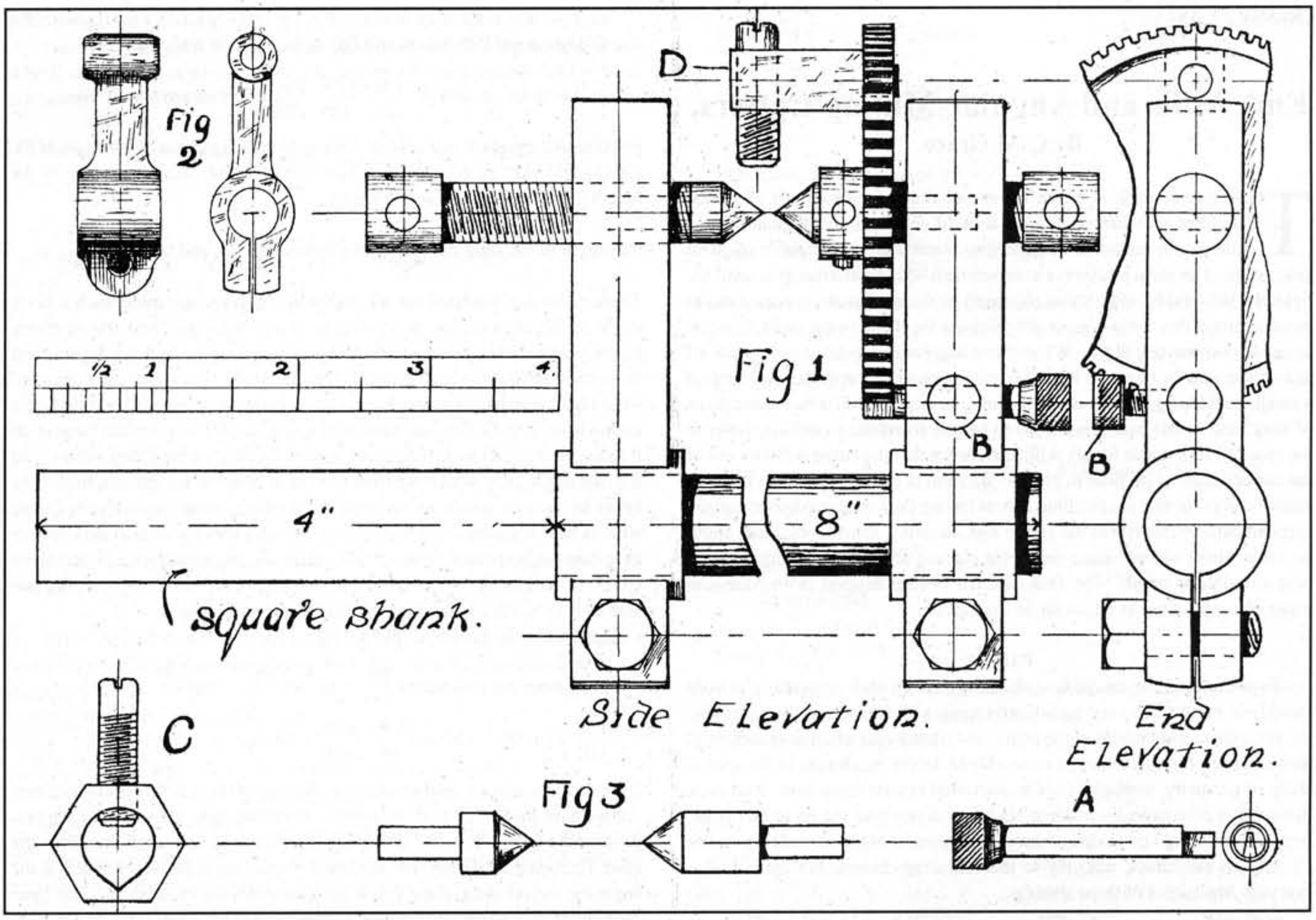
FOR holding taps, reamers or anything requiring slotting, the centres mounted on a bar as shown in Fig. 1 are very useful. For making grooves, etc., for ornamenting brasswork it is a convenient appliance to hold the job. The centre bar can either be used parallel to the lathe-bed in conjunction with a milling or fly cutter or it can be set crossways, the work being cut with an end mill secured in the chuck. Its uses are innumerable. For milling flats on rod, that will go between the centres, making hexagon or square bar from round metal, or slotting shafts, the ease with which the work can be set for the operation soon pays for the trouble of making, the centre bar being secured in the tool post with the same facility as a slide-rest tool. The bar holding the centres is made of cast steel in the writer's case. Good mild steel will no doubt be equally good. A piece 13-16ths in. square is centred and turned as shown, being made dead parallel and smooth and whilst in the lathe make six equally spaced lines with a sharp pointed tool; these must be fairly deep, and the burr scraped off. These lines are to set the centres parallel in line. The heads can either be built-up or forged in iron or steel or cast in gunmetal. As shown they are built-up of square iron, this method being the simplest - should they be forged or cast, they would look better, and be stronger if the shape in Fig. 2 was adopted. In building up these heads, pieces of iron were cut off ¾ in. square, and one end of each cut out to fit the boss of the headstock. These bosses are turned out of steel bar to 1⅛ in. diameter, and the square pieces brazed on; holes are drilled in the square ends, and also in the boss to hold tight-fitting ¼ in. pins; these latter keep the parts rigid whilst being brazed. To cut the ends of the square parts circular to fit on the bosses the former were gripped in the slide-rest (see Vice, M.E. No. 841), and with a cutter mounted in a boring bar set at 9-16ths radius the ends were milled out, care being taken to set them exactly at right angles and central with the boring bar. When built up the heads were mounted in the chuck, and the bosses bored a tight hand fit on the bar. The back lugs were then bored and the holes enlarged half way, the other part being tapped 5-16ths to take a set screw. The heads are mounted on the bar perfectly in line central with one of the lines on the bar, and the bar mounted in the lathe and the ends turned, taking light cuts with a fine pointed tool, a line being scribed at the same time two inches from the bed on each head; these lines are centred, and a hole drilled in each to take 7-16ths. In each of these holes a 7-16 cast steel screw is fitted. Interchangeable hollow and point centres are fitted as shown at Fig. 3. These are of cast-steel, hardened and tempered, and slip in a hole drilled up the end of each screw. The division wheel of 60 teeth was originally the driving wheel of a hand sewing machine, and is a convenient size for the purpose to which it has been adapted. The lugs holding the handle were cut off and the centre hole drilled out to 15-32nds, and the boss shortened. The cast steel centre on which it fits are turned a tightish fit, and a hole for a pin is drilled through them to line with a hole drilled through the boss of the toothed wheel. The stop A for the division wheel is a steel pin which passes through the headstock, the end fitting between the wheel teeth; when in position it is locked by means of the thumbscrews. The stop and knurled setscrew are turned from cast steel, the former having a flat filed along its length for the setscrew to press on; it also prevents it from turning round, thus keeping the end of the setscrew always in position for entering the tooth spaces. The end is filed to fit tightly in between the teeth, the extreme point being somewhat thinner to allow of it entering easily. The gripping dog C is made to take up to ⅝ rod, and is secured to the wheel by passing the cast steel pinching screw through a hole in the block D secured to the wheel. In use the collar is put on the rod to be milled, and the latter is fixed between the centres; the pinching screw is passed through the block and into the screw collar on the bar so that as the wheel is turned the work is also revolved. The division wheel teeth can be numbered if desired; it is, however, not necessary. When the bar to be milled is not centered the hollow centres are used. For holding square bar or any irregular shape the hollow centres can be butted up.



The milling centres in position holding a tap for fluting.



The separate parts of the milling centres.



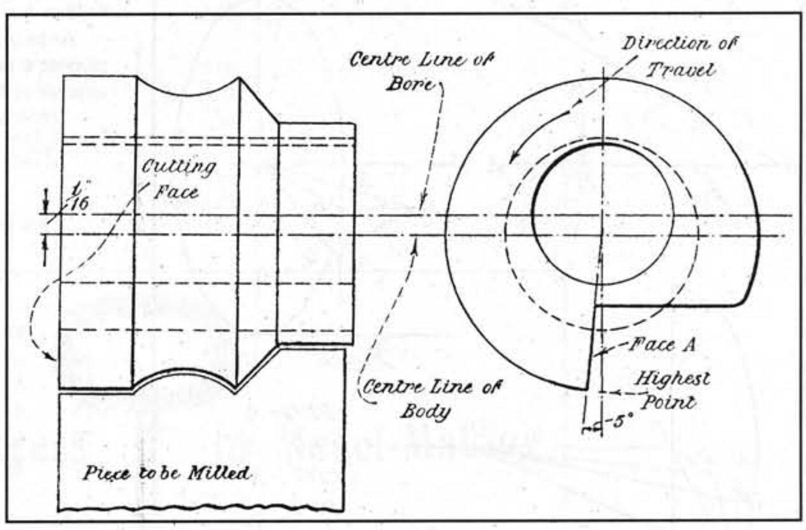
Detail drawings of milling centres for the slide-rest.

August 29, 1918.

An Eccentric Cutter for Milling.

By J Bailey.

I APPEND a sketch of a small form tool idea that I have made and used on various occasions for form milling on the lathe or milling machine, where the number of parts to be machined would not warrant the expense of buying a machine-relieved form tool and the means of making one are not available. The results obtained are equally good, bearing in mind that the operation takes longer, as it only has one point of contact for cutting instead of series as in the machine-relieved type of cutter. The great advantage it possesses over the hand-filed up and relieved cutter to insert in body is that it is easily made, and when finished it will retain its form until worn out, whereas the filed-up type requires a great amount of time and the skill of an experienced mechanic to obtain accurate results.



An Eccentric Cutter for Milling.

I think my sketch is self explanatory, as when dull the tool face at A can be ground as in ordinary form tool practice. It consists of the tool being turned up to required form and then set out of truth in chuck to exact amount required for eccentricity for cutting. A hole is then bored to suit mandrel that it has to be used on, a screwed one for preference. I usually adopt 1-16th in. eccentrics, but can be varied to suit requirements. Where the job lends itself it can be made with taper shank to suit taper in lathe nose. This is the most satisfactory method, as it alleviates chatter on work. In making the tool care must be taken to cut out, as shown in shaded portion of sketch, about five degrees behind highest point of contact. Care must also be taken when grinding to retain the cutting edge constant to the centre, although a slight undercut is beneficial to cutting properties where from is not considered of vital importance.

October 24, 1918.

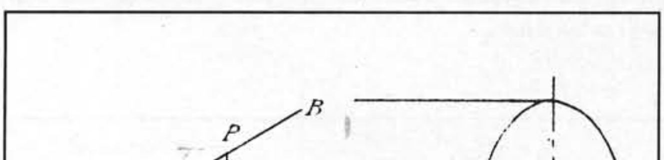
End Mills and Angular Milling Cutters.

By G M Grace.

THE correct angle at which the swivel slide of the tool rest of a lathe should be set when cutting the teeth of end mills and angular milling cutters, is a matter of considerable importance and capable of exact calculation. The usual practice is to experiment with different angles, until the right one is found by trial, but as the depth of the cut has at the same time to be ascertained, this method generally results in the blank being spoilt, or a cutter made of the wrong angle. When many angular cutters have to be made all alike, there may be room for the experimental process, but in the workshop of a small mechanic generally only one cutter is required to further some piece of work, and in this case it is a boon to be able to set the swivel slide over to the required angle once for all, with confidence that the cutter will turn out of the correct angle. I propose to give the solution in two parts; first treating the case of end mills, that is of milling cutters having their cutting edges in a plane perpendicular to the axis of the cutter: and, secondly, considering those angular mills whose cutting edges lie on the surface of a cone, making with the base any desired angle. The first case has been published in an American paper, the second not at all, as far as I am aware.

PART 1

To understand the calculation, the only mathematics required is to keep steadily in mind three very useful definitions with regard to any angle, viz., the sine cosine and tangent of the angle; and for the sake of those readers who have not been fortunate enough to be able to devote much time to the special study of geometry, perhaps I may be permitted to state them here. I do hope those non-mathematically inclined readers will not give me up at this point, because a working knowledge of these three ratios is of the utmost importance all through mechanics, not only to theoretical mechanics, but the ordinary, everyday mechanics of the workshop.



Setting out end mills and angular milling cutters.

Suppose any angle to be contained by the lines AO, OB, Fig. 1, and in the line OB any point P be taken, and PM drawn at right angles to OA:

the three ratios will $\frac{PM}{OP}$ $\frac{OM}{OP}$ $\frac{PM}{OM}$ be independent of the position of the point P, and only depend upon the magnitude of the angle AOB. Calling PM the "perp", OM the "base" and OP the "slant"' the sine is the length of the perpendicular divided by

the length of toe slant or $\frac{perp}{slant}$; the cosine $\frac{base}{slant}$; and tangent $\frac{perp}{base}$

These ratios are tabulated for all angles in any book of tables; such a book ought to be immediately accessible to every mechanic who has anything beyond dull repetition work to do. This preliminary point being settled, and these three definitions well in mind, the next thing to do is to get a grasp of what Fig. 2 is intended to represent; OP, OQ are two successive cutting edges on the front face; OPDN is a horizontal plane, and PT is a vertical tangent, at P to the circle. DO is the line along which the edge of the cutter moves, and it is the angle DOP which we have to find in order to cut the end mill. The cutter to be used which we will call the working cutter, is a truncated cone with its base horizontal and uppermost; it rotates about a vertical axis, and its base cuts the horizontal plane OPDN, while its curved surface cuts the plane OQD. If we draw PN perp. to OD and join the point T where OQ cuts the tangent at P to N, PNT will be the angle of the working cutter.

Let DOP = X; PNC = C; POQ = N

Then from our definitions $\frac{PT}{\quad}$ = tan N; $\frac{PT}{\quad}$ = tran C;

$\frac{NP}{OP}$ = Sin X. Hence $\frac{NP}{OP} = \frac{\tan N}{\tan C}$ = Sin X.

If we desire to place n cutting edges on the face of the mill N = 360/*n* degrees. All we have then to do is to look out in the table book the values of the tangents of the angles N and C, divide the former by the latter, and then from the book find what angle has the quotient for sine; the angle so obtained is the angle the swivel slide of the rest must make with the cross slide. The complement of this angle, that is the difference between this angle and a right angle is the necessary angle the slide must make with the axis of the lathe in order to cut the mill perfectly with all its cutting edges, OP, OQ, etc. in a plane. The right depth could also easily be calculated but when X is known, this depth is readily found by trial.

As an example: suppose we have a pin drill or counter-sink to make, and propose to put 10 cutting edges on the face. Also let the working cutter have an angle of 65°; then from the tables tan 36° =

.72654; tan 65° = 2.1445; Sin X = $\frac{.72654}{2.1445}$ = .338; x = 19° 48'.

A few results are appended.

n	C	sin X	X		n	C	X	
6	65	.807	53°	48'	6	70	39°	5'
8	65	.466	27°	48'	8	70	21°	21'
10	65	.338	19°	48'	10	70	15°	20'
12	65	.268	15°	36'	12	70	12°	7'
15	65	.207	12°		15	70	9°	20'
20	65	.151	8°	42'	20	70	6°	47'
30	65				30	70	4°	26'

A much quicker way of making the calculation, is to make use of the log tan tables, then only face of the cutter we want to make; CP, CQ, two successive cutting edges on the face, and PO, PQ, two corresponding edges on the curved surface. Of course it is not often that these edges PO and PQ have to be so far produced as to actually pass through O, though in the case of a countersink this would be so, but even when a cutter is truncated these cutting edges, if produced, should pass through a point O on the axis of the cone.,

A, angle of cutter to be made.

C, angle of cutter to be used.

N, number of cutting edges. $N = \frac{360}{n}$

X, angle which line along which the working cutter must be moved, makes with the face of the work.

Then, regarding OCP as a horizontal plane, and DO as the line along which working cutter moves, draw PN perp to DO, and produce DQ to meet the tangent at P in T, Let PDQ=φ.

From definitions $\tan\varphi = \frac{PT}{PD} = \frac{PT}{PN}\,\frac{PN}{PD} = \tan C \sin X$

also $\frac{\tan\ A}{\tan\ X} = \frac{CO}{CP} \div \frac{CO}{CD} = \frac{CD}{CP}$

From elementary trigonometry $\frac{\sin}{CQ}\quad \varphi = \frac{\sin(\varphi - N)}{CD}$

$\therefore \frac{CD}{CP} = \frac{\tan A}{\tan X} = \frac{\sin(\varphi - N)}{\sin.\ \varphi} = \cos.\ N \sim \frac{\sin\ N}{\tan\varphi} =$

$\cos.\ N \sim \frac{\sin\ X}{\tan \sin X}$

a subtraction is required: the values for X, when C = 70°, were found in this way.

PART II.

When we wish to produce an angular milling cutter, we meet with a problem of somewhat greater complexity, and shall have to introduce a few elementary

trigonometrical relations such as

$\frac{\sin A}{\cos A} = \tan A$; $\sin(A \text{ ---- } B) = \sin A \cos B - \text{os} A \sin B$

$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$ where A, B, and C are the angles and *a, b, c* the sides of any triangle. Such relations are demonstrated in any book on trigonometry. Then turning to Fig 3, C P Q is the

$\therefore \tan A \cos X = \cos [N \sin X \sim \frac{\sin N}{\tan C}$

or $\sin X \cos N - \cos X \tan = A\ \frac{\sin N}{\tan C}$

an expression from which we have to find X.

Dividing by cos N and finding the angle Y whose tangent is $\frac{\tan A}{\cos N}$ we obtain

$\sin X - \cos X \tan Y = \frac{\tan N}{\tan C}$ or $\sin X \cos Y$ —

$\cos X \sin Y = \frac{\tan N}{\tan C} \cos Y.$

Whence $\sin(X - Y) = \frac{\tan N}{\tan C} \cos.\ Y$

[These two statements $\tan Y = \frac{\tan N}{\cos N}$ (i)

and $\sin(X - Y) = \frac{\tan N}{\tan C} \cos Y$ (ii)

enable us to find the desired value of X, when N, C and A are given. From (i) we find Y, and then knowing Y we obtain X from (ii).

For example, suppose we have a cutter of 65° angle and wish to make one with 70°, having 20 cutting edges

Here A = 70°; C = 65°; N = 18°.

$\tan Y = \frac{\tan 70}{\cos 18} = \frac{2.74747}{.95105} = 2.889 = \tan 70° 54'$

$\sin(X - Y) = \frac{\tan 18}{\tan 65} \cos 52°\ 2' = \frac{.32492}{2.14450} x$

$.61520 = .093$

$= \sin 5°\ 21'$

Hence $X = Y + 5°\ 21' = 76°\ 15'$

This calculation is, like the preceding one, performed much more expeditiously, by making use of the log tan tables, etc.

A few results are appended.

Cutter 65°

A		N	Y	X
[60°	10	36°	64° 58'	71° 13'
	20	18°	61° 14'	65° 25'
	30	12°	60° 33'	63° 20'
65°	10	36°	69° 20'	76° 12'
	20	18°	66° 5'	69° 36'
	30	12°	65° 29'	67° 51'
70°	10	36°	73° 35'	79° 5'
	20	18°	70° 54'	73° 45'
	30	12°	70° 24'	72° 18'
[75°	10	36°	77° 48'	81° 54'
	20	18°	75° 41'	77° 50'
	30	12°	75° 19'	76° 45'