EMERY GRINDING MACHINERY.

EMERY GRINDING MACHINERY:

A TEXT BOOK

OF

WORKSHOP PRACTICE IN GENERAL TOOL GRINDING, AND THE DESIGN, CONSTRUCTION, AND APPLICATION OF THE MACHINES EMPLOYED.

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"MACHINES AND TOOLS EMPLOYED IN THE WORKING OF SHEET METALS."

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PREFACE.

THIS little handbook has been compiled by the author in the hope that it may prove of service to Manufacturers engaged in Mechanical and Metal-working Industries, to Tool-makers and Machinists, and to Students and Workshop Apprentices generally. The work lays no claim to originality in regard to the methods discussed, neither does it pretend to have exhausted the subjects to which it is devoted.

The author's sole aim has been to produce a handbook of workshop practice, and his endeavour has been to place descriptions of the machinery employed, and the methods adopted for grinding, sharpening and polishing metals by means of the emery wheel, in the manufacture of articles of commercial utility. He has had no interest, direct or indirect, in extending the sale of any of the machines described: where certain firms are mentioned by name, this has been done in order to describe leading types, and it is not in any way intended to suggest that such firms are the only makers of the tools under discussion. Conditions in America differ greatly from those prevailing in our own country, and American manufacturers have developed and specialised in certain directions, to an extent of which we have comparatively little conception in our own country. This specialisation has no-where had greater results than in machine-tool manufacture, and numerous machines of this description have found their way into British workshops, usually with the happiest results as regards economy and efficiency. This has led to an erroneous impression, which has been fastened and encouraged in our own technical and daily press, that British manufacturers and British methods have fallen far behind in the race. As regards grinding machinery this notion is certainly far from the truth, and for many years past machines of purely British manufacture have been procurable which compare favourably with those of the best American makers.

Amongst the American firms which have placed Emery Grinding Machines upon the market are—the Brown & Sharp Mfg. Co., the pioneers of the Universal Grinding Machine, and two other firms who have given considerable time and attention to special grinding tools, namely, the Pratt & Whitney Co., and the Norton Emery Wheel Co.

The author desires to avail himself of this opportunity of expressing his grateful acknowledgments to the following Firms—Messrs Buck & Hickman—The London Emery Works Co.—Mr James J. Guest—Messrs H. W. Ward & Co.—Messrs Luke & Spencer Ltd.—Messrs Wm. Muir & Co. Ltd.—and Messrs Geo. Richards & Co. Ltd.—for their kindness in placing at his disposal the blocks to illustrate their machines.

R. B. HODGSON.

KING'S-HEATH,
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EMERY GRINDING MACHINERY

INTRODUCTION.

It is questionable if any other class of machinery applied to uses in engineering and machine-tool workshops has developed so rapidly, or their use become so universal during recent years, as emery grinding machines.

Judging from the great number of specialities in this line which have been imported into the United Kingdom from America, there seems to be little doubt that for many years the American engineers have taken an extreme and intelligent interest in matters connected with the improving and perfecting of these machines. In numerous British engineering manufacturing establishments every known improvement in this direction has been utilised in actual practice, and for ordinary work the emery wheel has to all intents and purposes superseded planing and shaping machines in modern engineering workshops. The general manufacturer in the various branches of metal-working and allied trades unfortunately does not at present appear to have taken full advantage of the advantages offered by the use of the emery wheel.

The extensive introduction of milling and profiling machinery has created a field for special grinding machines required to sharpen the various forms of cutters used in such processes.

This demand has had the effect of raising these machines into undue prominence.

It is interesting, however, to observe that at the present time the British engineer is actually manufacturing his own specialities in grinding machinery, and that several of these have such meritorious features in their design as to render them superior to some of the American imported machines. This certainly indicates that when there is a sufficient demand the British engineer is ever ready to turn his attention to new fields.

The following particulars are compiled from stray notes collected from various sources and at various times. They are published in the hope that they may prove useful as a small book of reference to students, engineers, toolmakers and manufacturers who are interested in the emery wheel, but who may not be able to spare the time necessary to search for the information which is at present scattered throughout numerous technical publications and periodicals.

CHAPTER I.

TOOL GRINDING.

A review of Ancient and Modern Methods.

THE cutting edges of hardened tools are recovered and maintained by methods of grinding as diverse as are their shapes and the purposes for which the tools themselves are employed. And the classes of work that are included under the heading of press-work are so numerous, that it is quite as difficult to arrange any special or definite course to be followed in the maintenance of these classes of tools, as it is to define any special course to pursue in their actual production.

The necessity of keeping the cutting edges of tools sharp and in good order for the production of the *best result* is evident when a careful observation is made of the action of the tools used for cutting sheet metals, such as a cutting punch and bed, or a set of slitting shears.

The steels from which all such tools are made are of the same quality, that is, they have the same percentage of carbon and are soft enough to be readily worked into the shape required; any modification of hardness subsequently required is brought about by hardening and tempering.

When blanks are cut from thin sheet metals with a punch and bed, not only must the punch fit tightly and perfectly in the bed, but the cutting edges must be kept perfectly sharp; in such cases it is usual to make the steel of the cutting bed rather hard, and that of the punch softer, by tempering the former to a yellow and the latter to a blue colour.

This allows of the face of the punch being hammered out, smoothed over with a fine cut steel file and subsequently ground on an emery wheel; as also of the punch being forced into the bed so as to make it resume its original shape and

Fig. 1. Natural Grindstone.

fit the bed perfectly. As this process has to be repeated very often, the punches are worn away much more rapidly than the bed, which retains its shape for a much longer time, and seldom requires sharpening.

When thicker sheet metal is operated on, the punch and bed are tempered to nearly the same hardness; hence both these tools then require occasional grinding in order to make their cutting edge perfectly sharp and square. In the smaller establishments this is usually effected by holding the face of the punch or bed against a grinder or natural grinding stone (fig. 1), or an emery wheel.

The punch or bed is grasped in the workman's hand and pressed up against the side of the stone or emery wheel in the manner shown at fig. 2; then the tool face is tested to see if it is flat and square by trying with an ordinary steel try square

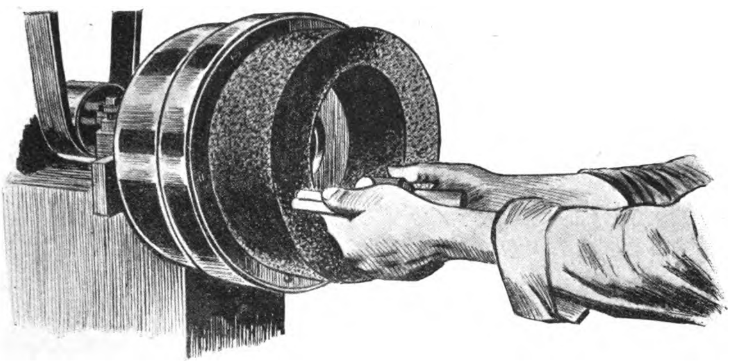


Fig. 2. Grinding a Press Tool by hand.

(fig. 3). As can readily be understood, the experienced workman will recover the edges in far less time and with less waste of material than the inexperienced. For instance, in the hands of the latter the first result may be as shown in fig. 3; while subsequent ones may be as represented in figs. 4, 5 and 6, so that by the time the tools have acquired the perfect form (fig. 6) much material has been wasted.

In ordinary practice, indeed, the loss of material undergone by the tools when actually cutting the blanks is far less than the loss caused by regrinding and sharpening them; hence their wear is mainly due to the latter operations.

The trouble that is experienced in grinding the face of a punch flat may be largely overcome by recessing the punch

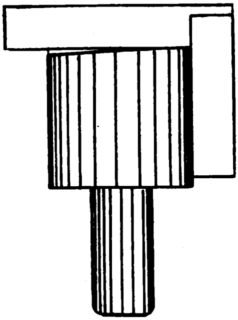


Fig. 3.

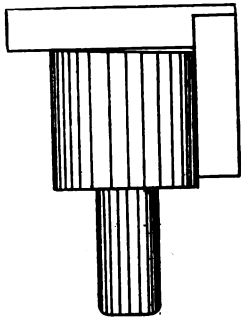


Fig. 4.

face as shown at A, fig. 7, as this makes it less liable to assume the shape seen at fig. 5.

Until comparatively recent years the natural grindstone was practically the only available means by which the edges of

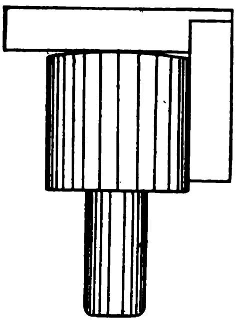


Fig. 5.

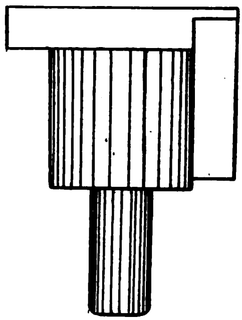


Fig. 6.

press tools could be recovered. It is, however, in many workshops now rapidly being replaced by the emery and corundum wheel, and there is good reason to believe that in time the natural grindstone will cease to be used for press tools. The special forms of emery wheel grinding machinery may now be seen in many workshops, their use having been found to be of the greatest possible advantage. The well known twist drill grinder and the universal grinding machine are used for sharpening milling cutters of all shapes, as also taps, reamers, etc.; while special grinding machines deal with cylindrical work, such as engine piston-rods, rollers and bushes, chilled rolls, cutter holes, male and female gauges, etc.; surface grinders and machines which deal with lathe and shaping tools, turning and boring tools; and others.

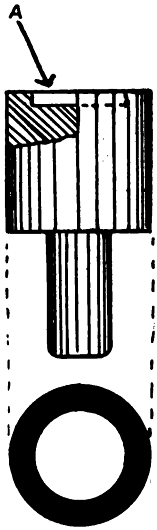


Fig. 7.

As mechanical should always be preferred to manual tool grinding, the following brief sketch of the leading types of grinding machinery will suffice to indicate the adaptability, superior efficiency and economy of the emery wheel grinding machine, even in the hands of an unskilled mechanic.

The tools used in making the interchangeable metallic parts of such mechanical arrangements as clocks, watches, musical boxes, typewriters, locks, electrical instruments, etc., in which accuracy is essential to their efficiency, and of which large quantities are required, must themselves have a high degree of excellence. There is a good field for the application of high grade machinery both for producing and maintaining the tools.

There are other classes of work—shovels, stove trimmings, kitchen utensils, hardware, coal hods, etc.—which, on account of the rough quality of the finished article or the comparatively small quantities of work required from the set of tools, do not warrant special machinery being introduced for grinding by mechanical means; tool-sharpening then is done by the readiest available means.

CHAPTER II.

EMERY WHEELS.

THE compositions used for emery wheels may be either soft, hard, fine, medium, or coarse, according to the requirements. Emery and corundum may be purchased in the form of emery

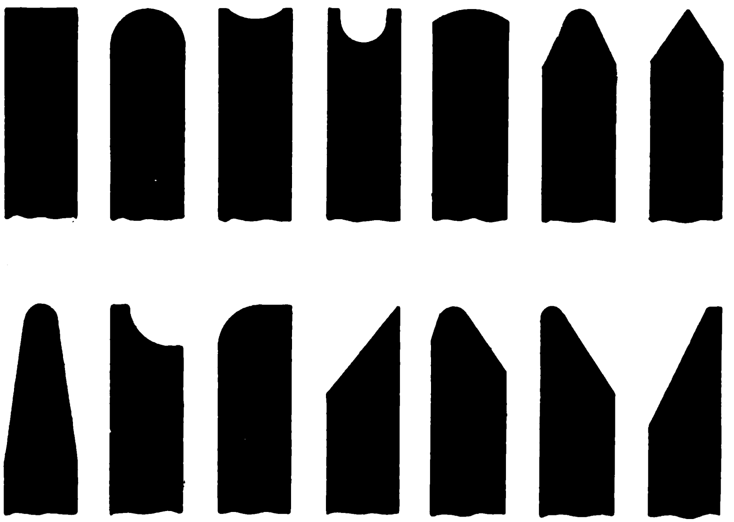


Fig. 8. Emery Wheels of special shapes and sections.

powder or dust, that is, emery crushed into grains. The old method of emery grinding was to mix the emery dust with some oil, forming a grinding paste; this paste was then placed between the two flat surfaces of iron or steel which needed grinding—for instance, locomotive slide valves and surface-plates—and the substances rubbed together, causing a grinding action. Again, a common method of grinding smooth the surface of a cylindrical hole is to cast a lead plug; then having covered the plug with emery and oil paste, it is rotated in the hole; this is called *lapping.* Then there are the emery paper and emery cloth, which consist of powdered emery cemented upon the paper or cloth, used by all engineers and toolmakers, fitters and turners, for producing the polished surface on metals.

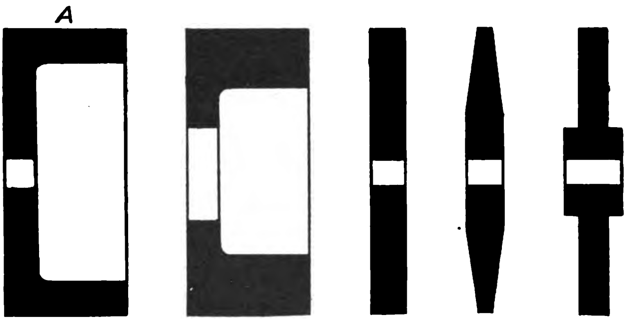


Fig. 9. Diagram of shapes.

Artificial wheels made from emery and corundum have been in use for many years, but it is only recently that their real value and usefulness has become generally known. Emery wheels consist of sharp particles of emery bound together by means of some cement into a disc, which may, of course, have any suitable shape given to it. Figs. 8, 9 and 11 represent wheels in common use. Figs. 10 and 12 are photographic views of the two emery wheels as shown at A, fig. 9 and fig. 11 respectively. Various cements are used, but formerly there was only one kind, viz., shellac and gums. Owing to the inability of this to resist the force of centrifugal action, and its liability to damage by wet or heat, it has been superseded by much stronger hydraulic cements, or by fusing the emery into the wheel at a high temperature.

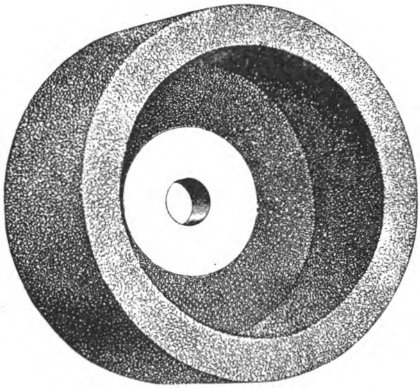


Fig. 10. Face Emery Wheel.

Emery wheels differ as regards the coarseness of the emery used and the strength of the cement. The former is distinguished by the *No.* of the emery (or the size of particles), and the latter is denominated *grade.*

The number of the emery is determined by the size of the meshes in the sieve through which it will pass; these run from 30 to 200. For example, No. 60 emery means emery which will pass through the meshes of a sieve with 60 to the square inch, and not through one with 80 to the inch. Some of the finer particles of emery are separated and numbered according to the time they take to settle as a sediment out of water. For example, ten minutes emery means emery which will settle in ten minutes after having been shaken up in water.

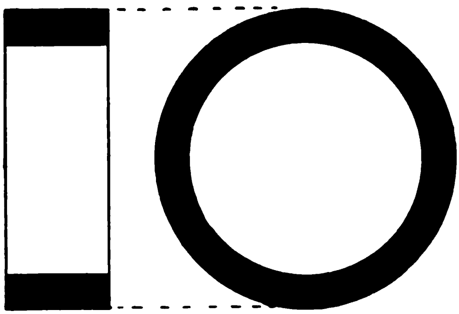


Fig. 11.

The difficulties in making emery wheels have now been overcome, and wheels of various kinds are now manufactured;

those made by the Norton Emery Wheel Co. are made by what is known as the *vitrified process*, in which wheels are subjected to an intense heat, much greater than it would be possible for inferior materials to withstand.

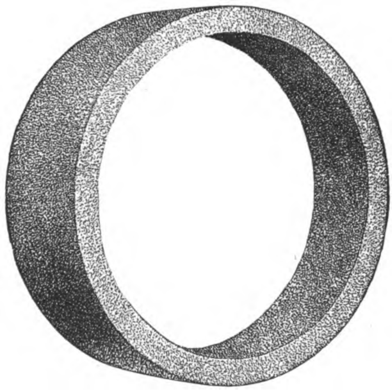


Fig. 12. Face Emery Wheel.

In the better class of wheels, as now made by this and other modern processes, every particle of the wheel cuts, whereas in the case of inferior wheels, or wheels made in the old way, there is a tendency to clog and glaze, which interferes with the cutting action of the wheel, as the bond has no abrasive properties.

Another artificial product, known as "carborundum," has during recent years been used for making wheels; these have in some cases, where the work has been of a special kind and the wheel has been run at a suitable speed, given results far better than those usually obtained by either emery or corundum.

Grades of Emery Wheels.—Each grade of wheel is not equally efficient for all kinds of work: hence various grades of hardness are supplied, adapted to the special work or phase of work required. When the grinding is heavy, it is found most economical to use a series of graded wheels, and to carefully select the grade for each particular stage of the grinding.

For instance, if too hard a wheel is used to sharpen the knife of a tool, the cutting edge would be destroyed by the heat generated. On the other hand, the grinding of tools without altering the temper of the metal must be done with a soft grade of wheel, but this would not be suitable for rough work. The grade should always be adapted to the material that is to be ground. When this and the purpose is known to the maker he can always supply the most suitable grade of wheel.

The Norton Emery Wheel Co. have adopted a system of lettering their makes of emery wheels to designate the many different grades in hardness; this is very convenient, enabling the user to note the mark on the particular wheel which he finds best suited to his requirements; he may then use the "*letter grade mark*" as a reference when renewing the old wheel.

The Norton grade list runs in letters of the alphabet from **A** to **Z.**

A—Extremely Soft.	**M**—Medium.
B	**N**
C	**O**
D	**P**
E—Soft.	**Q**—Medium Hard.
F	**R**
G	**S**
H	**T**
I—Medium Soft.	**U**—Hard.
J	**V**
K	**W**
L	**X**

Y and **Z**—Extremely Hard.

The intermediate letters between those designated as soft, medium soft, etc., indicate so many degrees harder or softer. For instance **L** is one grade or degree softer than medium; **O** is two degrees harder than medium but not quite medium hard. The finer emery, known as flour of emery, whether in the powder or made up into wheels, is usually designated as **F**, **FF**, **FFF**, and **SF**.

A frequent cause why the use of the emery wheel has not been so extensive and successful in some works as it should have been lies largely in the fact that an emery wheel of any grade, size, or number has often been used for grinding too great a variety of work, with the result that the wheel has not given the same satisfaction that it would have done had it been selected specially for the one class of work. Hence, as before said, it is always well, when ordering a wheel, to tell the maker what it is wanted for, in accordance with the following schedule.

(1) Description of work to be done by the wheel.

(2) Degree of hardness, coarseness, size of emery grain, or grade letter mark.

(3) Number of revolutions made per minute by the spindle which carries the wheel, or the peripheral speed in feet per minute.

(4) Diameter and thickness of the wheel, its shape, and the size of the arbor hole.

(5) Whether the work of the wheel is to be heavy or light, for sharpening tool cutting edges or for grinding surfaces.

(6) If the work is to be applied upon the side or edge of the wheel.

The most important items are 1, 5 and 6, as the wheel may be especially wanted for any of such materials as brass, compositions or alloys of copper and zinc, wrought iron, cast iron, soft steel, hard steel, twist drills, reamers, taps, milling cutters, bronze castings, lathe and planer tools, drop forgings, etc., etc., or for cases in which the work is applied to the wheel by hand pressure, or automatically by the aid of machinery, or for cases in which the work itself is rotated, as in grinding bushes or rollers; again, the surface on the work to be done may be required rough or very smooth, with a high polish, etc. Any of these points should be carefully noted. A wheel for sharpening a wood-working tool would be medium, neither too soft nor yet too hard; such a wheel would be useless for dealing with rough work, such as grinding a casting. A wheel may become glazed and refuse to cut, owing to its being too hard or driven at too high a speed. The necessity for proper instructions is shown by the following case. Suppose a wheel of suitable grade is run at the proper speed for its work. If the speed of this wheel is by any means materially increased it will glaze and refuse to cut. If, on the other hand, the speed be reduced, the wheel will wear away too quickly and appear to be too soft for the work. For example, an emery wheel 12 inches in diameter is started to work at 1592 revolutions per minute, giving it a peripheral speed of 5000 feet per minute; the wheel, after being in use some time, wears down to 8 inches diameter; its speed on the edge will now be only 3334 feet per minute; consequently, if this wheel is to give the same results as at first, the speed of the spindle carrying this wheel must be increased to 2387 revolutions in order to bring the peripheral speed up to 5000 feet per minute.

Most modern wheels can be used either wet or dry, but it is well, in trying a new make, to get the maker's guarantee, as all bonds will not stand water. It is to be noted that when water is used on a wheel, the speed should be somewhat less than when the same wheel is used dry. In cutter grinding it is the most frequent practice to grind dry, as, with a soft and free cutting wheel, the removal of the small amount of metal does not generate sufficient heat to draw the temper of the tool.

But for almost all other grinding it is far the better practice to use water.

The customary practice of grinding such work as reamers, mandrils, lathe spindles, etc. dry, in preference to wet, can only be explained by the inefficient protection of the grinding machine against the mixture of water and emery; for while several well known makes have the lower parts protected, the protection of the upper table seems to present great difficulties. The advantages of wet grinding over dry are, firstly, the greater accuracy of the work, for when a piece of steel is hardened it generally becomes distorted. For example, a circular steel rod, 1 inch in diameter and 6 inches long, would probably become bent in hardening; when ground straight, more metal has to be cut off one side than the other; consequently, this side is much hotter than the other, and the work, although straight, is very hot on one side and comparatively cool on the other. When the work cools, the hot side contracts more than the other and the work is again bent. If this trouble is to be avoided, the dry grinding has to be done so slowly that the consequent cost is, as a rule, commercially prohibitive. Secondly, the surface produced by wet grinding excels the surface produced by dry grinding to the same extent as a metal surface cut by tools under lubrication excels one cut dry. Thirdly, the small particles are carried away in the water, and are not carried by the air to places where it is a nuisance. It is interesting to note that a universal grinding machine was recently exhibited in Birmingham, where it was made. In this machine the difficulties of wet grinding have been very successfully overcome. The inventor, Mr James J. Guest of that city, has kindly supplied the photographs and description which appear in Chapter X.

CHAPTER III.

MOUNTING EMERY WHEELS.

If due precautions are taken in the mounting of a modern wheel no risk need occur as to its safety. An emery wheel should be mounted so as to run perfectly true, with an even balance, in order to ensure the best results in grinding rapidly and accurately being obtained. The high speed at which the wheel runs makes it essential that the spindle or arbor shall be of sufficient strength to carry the wheel without springing under ordinary working conditions, and should run perfectly true. The sizes usually regarded as safe in ordinary practice are, for wheels up to 6 inches in diameter, ½ inch spindle; for 7 inch to 10 inch wheels, ¾ inch spindle; for 12 inch to 14 inch wheels, 1 inch spindle; for 18 inch to 20 inch wheels, 1½ inch spindle; for 22 inch to 26 inch wheels, 2 inch spindle; but the safety largely depends upon the amount of overhang of the wheel.

The hole in the wheel should be of sufficient size to enable it to be passed freely over the arbor, but without shake or play. If the hole should happen to be too large, it will then be necessary to true-up the wheel every time it is mounted; whereas should the hole be too small or a tight fit on the arbor, it may be difficult to mount, and probably will not run true sideways (see fig. 13), and the setting up of the spindle nut may cause a springing or bending of the spindle; moreover, any stress caused in the wheel by crowding it on to its arbor adds directly to the stress produced by centrifugal action. Some makers leave the holes in their wheels slightly larger than the arbor, say $\frac{1}{2}$ an inch or more; the hole is then bushed with a soft metal bush (see fig. 14, at LB), the metal used being lead. The spindle should carry two malleable or cast iron washers or flanges (fig. 15), one for each side of the emery

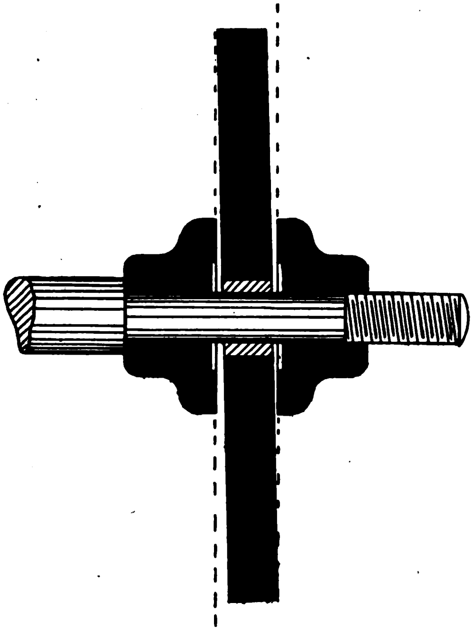


Fig. 13.

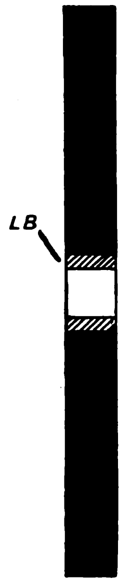


Fig. 14.

wheel. Wrought iron flanges are infinitely better, as they may be made half the weight, and much stronger than cast iron. The diameter of these flanges should be from one-third to one-half the diameter of the wheel, and the face of those which come against the side of the wheel should be turned slightly concave to enable the flange or washer at its side nearest the circumference to grip the side of the wheel (fig. 15, at A); whereas if made convex it would only touch at its centre (fig. 15, at *b*); and even should the washer be perfectly flat or straight across its face, it is not so certain to give such good results as when made slightly concave, unless its face F (fig. 15) is turned absolutely true square and correct with its hole H, a condition not usually found. These difficulties are largely overcome by making the flange face in the form shown at fig. 16, where the face is recessed at R; this is indeed the best known form of flange for general use. Some makes of emery wheels are provided with circular pads of pulp or thick blotting-

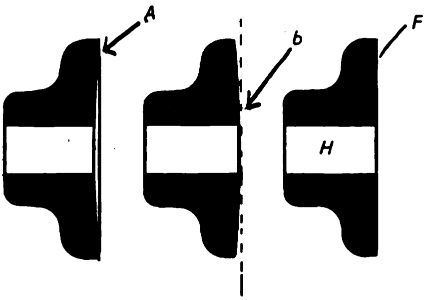


Fig. 15.

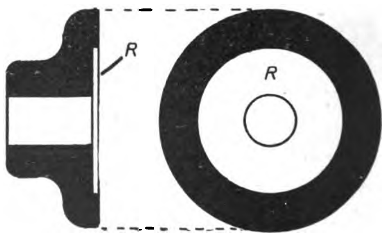


Fig. 16.

paper, which are fastened to the side of the wheel (see fig. 17, at P, P), forming a cushion between the emery wheel and the flanges (see fig. 18); this is a great improvement. When using wheels which are not provided with these pads, it is usual to insert a rubber or leather washer between the wheel and its two flanges (fig. 19, at W, W), and it is even desirable to use the rubber or leather in addition to the pulp pads, as this provision allows the spindle nut to be screwed well up without risk of breaking the wheel. Another reason why an emery wheel should never be mounted without the washers and flanges is, that if only the spindle nut is used to hold a wheel in position, the jar, shaking, or trembling of the machine may cause the nut to crawl; whereas when washers and flanges are used, the elastic action of the washers, due to being forced between the wheel and flange under considerable compression by the tightening of the nut, gives the nut much greater security.

Accidents.—The percentage of accidents is very small compared with the numbers of wheels now in operation. As previously mentioned, the old system of making wheels was

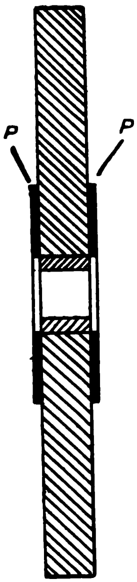


Fig. 17.

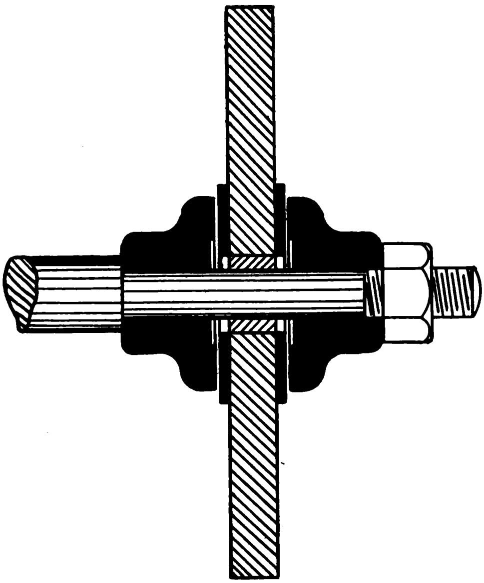


Fig. 18.

such that the particles of emery were not sufficiently coherent to enable the wheel to be run at the required speed with safety, as it could not stand either the strain due to the pressure required for cutting action or to the stress created in the wheel by centrifugal action. Formerly it was a very common occurrence for wheels to fly or break during working. To prevent this flying, some wheels were made with a wire gauze disc running straight through the centre of the wheel parallel to the side (fig. 20, at G); then, when a wheel burst or became broken, the portion of the wheel which had become detached would be held in a hanging position by the wire gauze until the machine could be stopped.

Modern methods, however, enable wheels to be made which will stand any reasonable pressure and speed; moreover, the wheels as now made by the best makers are usually subjected

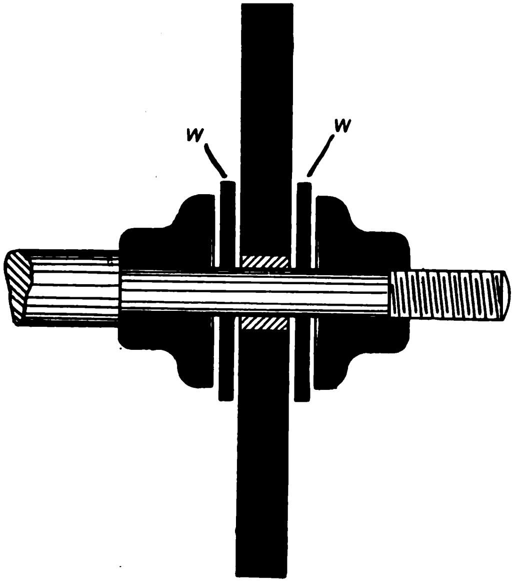


Fig. 19.

by them to tests for safety. This is done by running the wheel at a speed considerably higher than that required when in actual use, thereby giving them a factor of safety.

A good emery wheel is neither strained nor weakened by these tests, but a wheel with flaws will, when tested, break under the strain. The extensive experience gained by makers during many years of experiments justifies them in asserting that any wheel which will stand the test of being rotated at a speed of 9000 feet per minute is perfectly safe to stand the ordinary speed and stress of that in usual practice, say 5000 feet per minute. It may therefore be accepted that most of the accidents which have recently happened were the result of carelessness or ignorance on the part of the operator in the way of mounting and working the wheels.

The points to be observed in order to prevent accidents may be summed up as follows:—

(1) Wheels to be mounted upon strong machines, which are securely bolted down to give steady running.

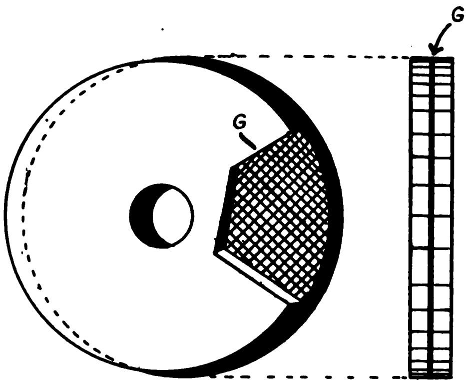


Fig. 20.

(2) Spindles which carry the emery wheel to be a good working fit in their bearings, thus reducing the vibration which would occur with a loosely fitting spindle.

(3) The use of suitable iron flanges and washers made from leather or rubber, instead of simply screwing the nut up against the wheel.

(4) Both the spindle and the flanges to be of sufficient strength for the diameter of the wheel.

(5) Care to be taken that any work which is being ground does not catch between the emery wheel and the slide rest, hand rest, or any chucking arrangement that happens to be

in use for holding or guiding the work during the operation of grinding.

(6) Wheels should be held up in one hand and carefully tapped lightly with a small hammer before mounting, so that any hidden cracks may be detected by the sound.

Table of Emery Wheel Speeds.

Diameter of Wheel.	Revolutions per Minute for a Circumferential Speed of 4000 Feet.	Revolutions per Minute for a Circumferential Speed of 5000 Feet.	Revolutions per Minute for a Circumferential Speed of 6000 Feet.
1	15279	19099	22918
2	7639	9549	11459
3	5093	6366	7639
4	3820	4775	5730
5	3056	3820	4584
6	2546	3183	3820
7	2183	2728	3274
8	1910	2387	2865
10	1528	1910	2292
12	1273	1592	1910
14	1091	1364	1637
16	955	1194	1432
18	849	1061	1273
20	764	955	1146
22	694	868	1042
24	637	796	955
30	509	637	764
36	425	531	639

The usual peripheral speed for an emery wheel employed upon ordinary work is 5000 feet per minute, but there are special cases when it is advisable to run the wheel at a higher or lower rate. The above table, compiled by the Norton Emery Wheel Co., gives the number of revolutions of the spindle to suit the various diameters of wheels, for the respective rates of 4000, 5000 and 6000 feet per minute.

CHAPTER IV.

EMERY RINGS AND CYLINDERS.

WHEN centrally-holed solid emery wheels are mounted on the spindle and firmly fixed by washers and flanges, the portion of the emery wheel situated on the inner side of the flange becomes useless, as by the time the wheel has been worn down to the flange diameter, the circumferential speed has been reduced considerably below that required for efficient working. This reduced speed is due to the wheel having been worn down to a small diameter. Assuming that specially small washers and flanges were at hand to lay bare the emery wheel for cutting, "it would still be necessary to have additional machines with accelerated speed for receiving these small wheels." Even then, there are practical difficulties in using a wheel which has been reduced from 12 inches to 4 inches in diameter, unless there happens to be a suitable range of grinding operations; generally speaking, however, there is a great waste of emery wheel, due to the fact that it is not an easy matter to use up the central portion.

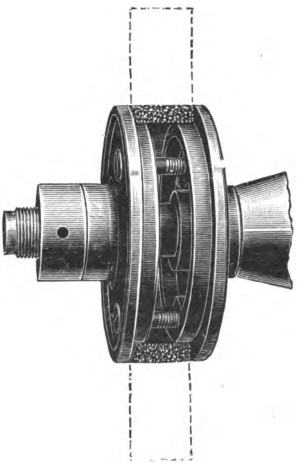


Fig. 21. Special Ring Flanges.

To obviate this loss, and at the same time considerably reduce the first cost of wheels, The London Emery Works Co. have introduced a neat and effective chucking arrangement, having special ring flanges which permit the use of emery rings, and emery wheels with much larger holes than usual. In fig. 21 the dotted lines show the section of the emery ring when first mounted; and it will here be noticed that the emery ring has been worn down to the ring flange, there being a very small portion only left as waste. Fig. 22 is another example of chuck by the same makers. In this case an emery cylinder is held by an iron ring on to an iron face plate. These two devices illustrate

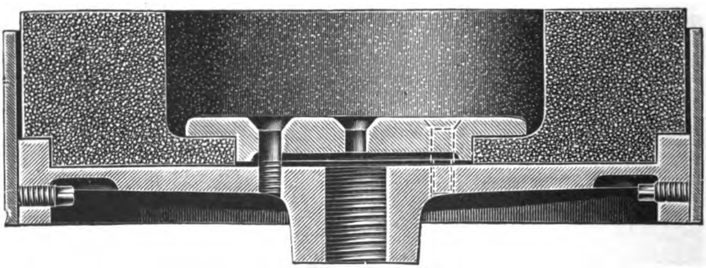


Fig. 22. Method for fixing Emery Rings and Cylinders. London Emery Works Company.

good practical examples of securely fixing the emery rings and cylinders, and when the conditions are arranged to suit their use, then the system is found to be both profitable and convenient, as reserve rings and cylinders may be stocked and quickly mounted.

Diamond Turning Tools.—The tool generally used for turning or truing-up an emery wheel consists of a black diamond mounted in an iron or steel rod (fig. 23); either the rod R is fixed in an ordinary wood handle at E, or the diamond may be mounted in a larger steel rod R_1, and fixed in a lathe slide rest; the diamond is seen at D and D (fig. 23). In using the diamond, care should be taken to bring the point very gradually to work, so as to prevent shock. A good hard diamond will withstand a great amount of friction without apparently any wear, but the harder diamonds are very brittle, and liable to chip or break away from the holder under sudden shocks; it is therefore

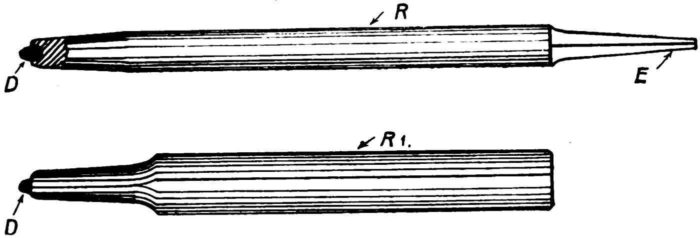


Fig. 23. Diamond for turning Emery Wheels.

advisable, when possible, to use the diamond tool by fixing it in the slide rest, as seen at fig. 24, and carefully work the handles as in metal-turning. In this manner the various forms

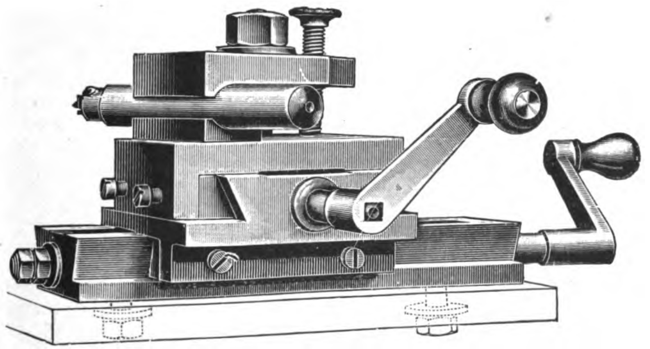


Fig. 24. Diamond Turning Tool and Slide Rest.

of ordinary emery wheels, emery rings, emery face wheels or cylinders, emery discs, emery rollers and curves, and plate or saucer wheels for special purposes, as represented in fig. 25, besides many round, curved, or other desired shapes, may be turned or bored. There are, however, special cases where peculiar shapes have to be turned on wheels, when it is advisable to work them out by hand; this is done by holding the diamond tool as in ordinary hand metal-turning, using a steady rest. Great care is required in doing this, and a deeper cut than $\frac{1}{32}$ of an inch should never be attempted.

Emery Wheel Dressers.—In addition to the diamond, there are other tools, known as emery wheel dressers, used for truing and dressing emery wheels; a variety of styles are seen at fig. 26; they may be purchased in various sizes to suit wheels of

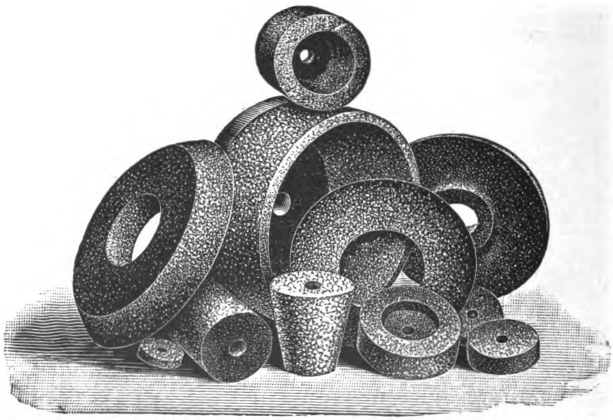


Fig. 25. Various forms of Emery Wheels.

different coarseness, hardness, and size. According to the general experience of many who are continually using these dressers, it is found that the Huntington style A is most suitable for very small and fine wheels. For the same wheels, or even for wheels that are a reasonable amount larger or coarser, the dresser, style B (fig. 26), with small twisted cutters, is very suitable. But for the larger and coarser wheels used in rougher classes of grinding, the dresser C, with corrugated cutters, would be used with advantage. Style D, with twisted cutters, is arranged as a lathe tool for slide rest work.

The emery wheel dresser and the diamond tool have their own spheres of usefulness, for while each may be used to dress and true the same emery wheels, there are certain purposes for

Fig. 26. Emery Wheel Dressers.

which the one is more useful than the other. For instance, in the case of truing-up fine soft wheels, such as would be used for recovering the cutting edges of fine tools, the diamond would be most suitable, as it could remove the emery more quickly from the wheel; but in the case of coarse hard wheels, or those used on rough grinding, the dresser is more handy, for if a diamond were used on such wheels, the diamond might be jerked out of its place in the steel rod and be lost, an occurrence by no means uncommon. One point in favour of the dresser is that an unskilled operator cannot easily damage the dresser, whereas he can easily damage or lose a diamond.

Speed for truing Emery Wheels.—With regard to the speed at which the wheel should be run for dressing and truing, this again depends somewhat upon the nature of the wheel itself; but it must be borne in mind that the authorities differ very widely on this point; one authority gives 75 feet per minute as the proper speed, whereas the author has successfully turned up wheels of various shapes when running at their usual rate of 5000 feet per minute; this higher speed has, however, been necessary for truing-up the wheels, by reason of there being so many wheels for one pair of hands to keep in trim. But, generally speaking, whilst 5000 feet per minute is far too great a rate for a wheel to run when being cut by a diamond or dresser, so slow a rate as 75 feet per minute is absolutely useless where the work has to be performed with rapidity by a skilled mechanic whose time is of value. The better plan is to use the speed best adapted to the kind of wheel in use and to the skill of the workman, since wheels can be dressed at any rate of speed between 75 and 5000 feet. This can be readily ascertained by short trials at gradually increasing speeds, by shifting the driving belt alternately from the driving pulley to the loose pulley and back again to the driving pulley.

CHAPTER V.

CONDITIONS TO ENSURE EFFICIENT WORKING.

THE efficiency of an emery grinding machine and its wheel depends to a great extent upon the amount of care and attention that they receive from those in whose care they are placed; in other words, the efficiency depends greatly upon the working conditions. Although we have mentioned various points, such as speed and grade of wheel, the student must never lose sight of the fact that the working conditions of all machinery vary so considerably, that when an operator or attendant receives any new machine under his charge, he should use his own judgment as to how it can give the best results.

It is frequently the case that even the most experienced workmen find it necessary to make experiments in order to ascertain the conditions conducive to the highest practical efficiency of a machine.

Referring again for a moment to the question of speed, an emery wheel if run much below its proper speed will crumble away; and if the speed is then gradually raised, a speed will be reached when it will be found that crumbling ceases. It is just before this speed is reached that the emery wheel is most efficient. The width or thickness of the wheel, or that part of the wheel which does the cutting, is another point that must be kept well in view, for the width of cutting surface is practically governed by the softness or hardness of the wheel.

A soft wheel ¾ inch thick may work comfortably and efficiently when the whole surface of its thickness is in contact with the work, whereas if a hard wheel is used upon the same work its thickness should be one-half or one-third that of the soft wheel. Generally speaking, it may be taken that the harder the emery wheel the less should be the surface in contact, and *vice versa.*

If a hard wheel, say ¾ inch thick, is being used, the work will become heated, and an unpleasant chattering noise may be produced, owing possibly to too great a surface of wheel being in contact with the work. To obviate this chattering and heating, it is usual to lessen the contact area by turning away a portion of the cutting surface of the wheel; but it would be far better and more economical to use a wheel of the proper grade and width.

Another important point is to adjust the feed to the surface of the work, using a coarser adjustment with the larger surfaces, because if the wheel is unduly narrow its diameter may be so decreased during its travel over the surface that the ultimate result is that the surface is not perfectly level or a cylinder so parallel as it should be, but wavy or fluted.

Again, should the wheel be run at too great a speed to suit its grade, the small particles of emery may become dull or glazed, and refuse to cut before it has passed over the whole area of the work; this is another instance where the emery wheel itself should be reduced in speed to prevent the glazing. It should be noted that in this case it is the rate of revolution of the wheel that is reduced, not the speed of feed or travel. When grinding tools, the shape and size of the tools themselves will often necessitate the use of an emery wheel having a narrow face. In other cases it is preferable to use a thick or wide wheel wherever possible if the wheel is soft enough for its work, because, as a rule, the wider the wheel the more perfect is the finish of the surface.

The speed of an emery wheel should be regulated by its character; thus, soft wheels should be run faster than hard ones. If the speed is above the proper rate for the particular wheel, the work may be damaged by the heat generated, and the wheel itself may become so glazed that it will refuse to cut; on the other hand, if the speed is below this standard, the wheel will crumble away, but it will cut the work freely without heating it.

Cleanliness and careful adjustment are, then, of the greatest importance in the efficient working of the emery grinding machine. It is true that in the case of a polishing or grinding shop, where the ordinary polishing or grinding *head and spindle* is employed upon such work as spades, forks and shovels, one cannot expect to find a high standard of cleanliness and order. But in a *tool-room*, where delicate and expensive machines are employed, it is absolutely necessary that the machines be kept clean and in proper working order.

In dry grinding it is hardly possible to prevent the distribution of some emery dust about the workroom, but all practicable means should be taken of minimising the amount. When it becomes necessary to remove any part of a machine, such as the caps of bearings or slides, special care should be taken to remove every trace of dust that may appear to settle on the working part before the caps are replaced. Where fine and accurate work is required, the bearings should "fit" as closely to the spindle as is consistent with free, yet perfectly true and steady running.

Drill Grinding.—The machine made twist drill has superseded old types of flat drill for all sizes, from the $\frac{1}{32}$ inch drill for watch-tool-making to drills over 3 inches in diameter made to fit the ratchet brace used by the machinery erector.

Formerly the twist drill (fig. 27), though used extensively, was ground by hand, a process requiring some considerable skill, a fine line being made down the exact centre of the drill as a guide for the true grinding of the drill. It was, however, seldom that a drill was perfectly ground, and usually the hole made by the twist drill was larger than the actual diameter of the drill itself. To overcome this difficulty it was a common practice to use two drills instead of one. For instance, suppose a $\frac{3}{8}$ inch hole was required, *first*, a $\frac{1}{4}$ inch drill would be used, and this would probably make a $\frac{5}{16}$ inch hole; *second*, the $\frac{3}{8}$ inch drill would then be run through, and as the centre portion of the $\frac{3}{8}$ inch drill could run freely, by reason of having no cutting to perform, only the portion of the lip at the circumference of the drill was required to cut; consequently the $\frac{3}{8}$ inch drill would drill a $\frac{3}{8}$ inch hole. From this it will be seen that hand drill grinding was expensive, as the work was performed in two operations; hence the time required to grind a drill was unreasonably great, and the amount of work that could be performed by the hand ground drill, without regrinding, was much less than that done with machine ground drills.

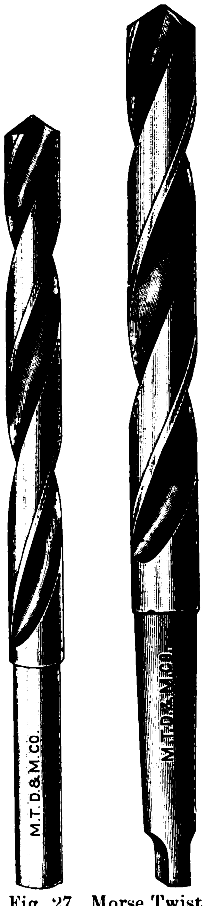


Fig. 27. Morse Twist Drills.

As illustrating the inaccuracy and amount of variation in the size of the hole due to the amount of error in drill grinding, Messrs Buck & Hickman give the example represented in fig. 28, which is a reproduction of an actual test with hand ground drills. Five holes A, B, C, D, E were drilled in a plate by the same $\frac{7}{16}$ inch drill. The drill was reground before drilling each hole. In drilling A, the drill was ground mechanically correct in a drill grinding machine; the hole fitted the drill perfectly without any looseness. Hole B has a slight amount of error, but is better than one formed by the usual hand grinding; hole C is about equal to the work done by the average hand ground drill; in hole D the error is slightly increased; and hole E is like one made with a badly hand ground drill. The author, looking back to his earlier experiences in the workshop, can remember instances quite as bad as those seen in fig. 28.

The modern drill grinder is a machine designed on scientific and mechanical principles; it has movements and adjustments relatively to the emery wheel such as will ensure the proper shape being given to the lip on the drill.

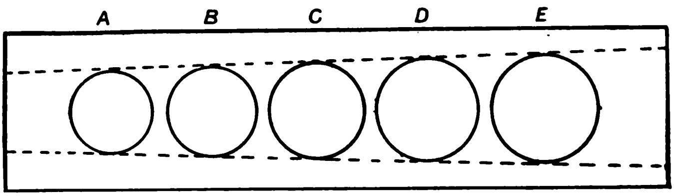


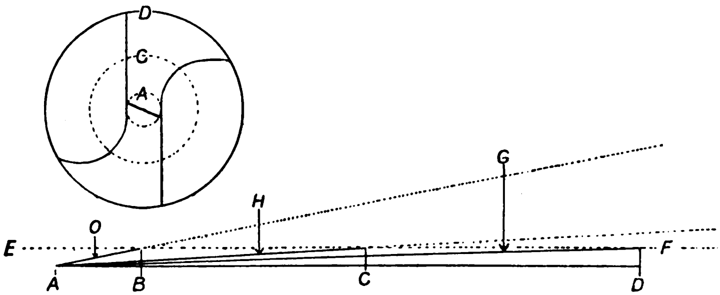
Fig. 28. Errors in Drill Grinding.

In a correctly ground drill the amount of clearance steadily increases from the periphery to the centre, the reason being that the nearer we approach the centre the smaller will be the circle described by any portion of the cutting edge; as the drill rotates, all parts of a drill advance with equal speed into the metal; but it is obvious that all portions of the lip cannot cut with equal freedom unless the clearance at any given point bears a proper relation to the circumference of the circle it describes while rotating, and the speed at which it is fed into the metal.

In a drill grinding machine having the necessary adjustments, flat, two, three, and four lipped drills can be ground, and it is possible to vary the angle of clearance, and yet maintain the proper ratio for every size within the range of the machine;

whilst, when the machine is set, the drill can be ground much more cheaply and correctly than is possible by hand grinding.

Drill Clearance.—To demonstrate what has been said about drill clearance, we reproduce another of Messrs Buck & Hickman's diagrams (fig. 29), in which are seen the circles described at three points on a $1\frac{1}{4}$ inch drill; in fig. 30 these three circles are supposed to be cut out and straightened. Let the line from A to B represent the length of the circle A (fig. 29) taken just where the lip begins to cut and where the oblique line constituting the drill point terminates. Let the line A to C represent the circle C and the line A to D the



Figs. 29 and 30. Drill Grinding Diagram.

peripheral circle D. Now, assume that a feed is used coarse enough to force the drill to advance so that the cut at each revolution is from the dotted line E–F to the lower line A–D (fig. 30), the line G would then represent the exact distance travelled at the peripheral circle D of the drill; it shows clearly how little clearance would be required at that portion of its cutting edge. The line H shows the travel of the portion represented by the circle C; and the clearance should be nearly double that required at D. The line O represents the distance travelled at the inner circle A, and shows plainly, in its exceedingly short travel, that it must advance into the metal the same distance as that portion of the peripheral circle

D does in travelling the long line from A to D. It is therefore apparent that to grind drills of *any size* for either hard or soft metals, coarse or fine feed, which will give this perfect ratio of clearance to either flat, two, three or four lipped drills, and yet

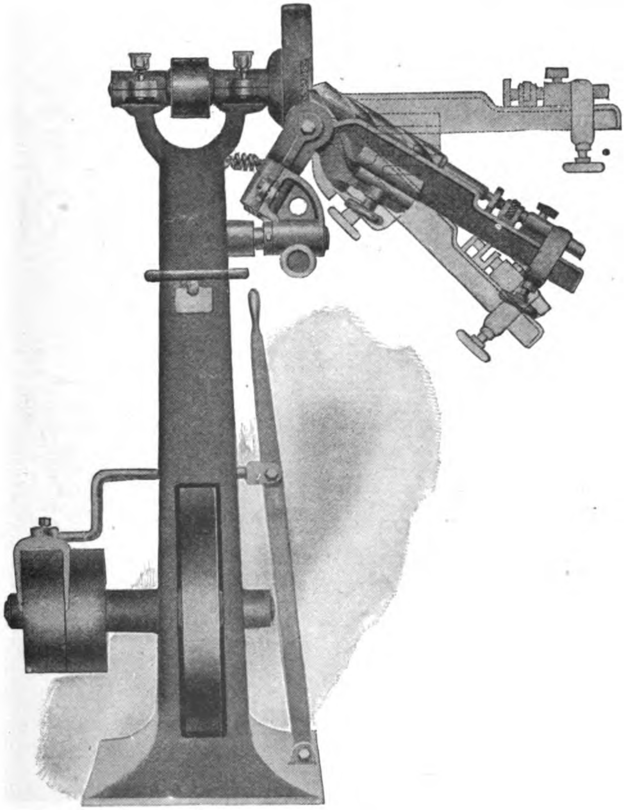


Fig. 31. New Yankee Twist Drill Grinder. Messrs Buck & Hickman.

allow of the *angle* of clearance being varied at pleasure, while still maintaining the proper ratio for every size within the range of the machine, without resetting for different sizes, is a mechanical operation well worth consideration.

It is said that the drill grinding machine known as "*The new Yankee*" is designed upon geometrical principles that ensure its producing these perfect results in drill clearance. The angle

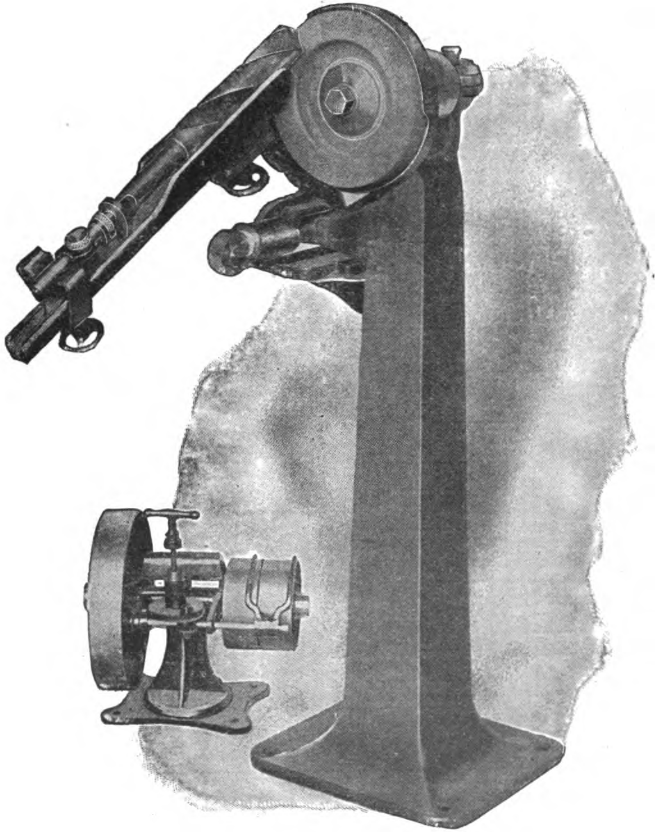


Fig. 32. New Yankee Twist Drill Grinder. Messrs Buck & Hickman.

of the "V" sides of its drill holder is said to bear the exact relation necessary to its journal of oscillation, the plane of its grinding wheel, and the longitudinal axis of the drill, that will give this perfect *ratio* of clearance between point and periphery to all sizes of drills; while the variation in the angle of clearance is secured by rocking the holder in its curved bearing, the circle of which is struck from the apex of the "V" holder itself.

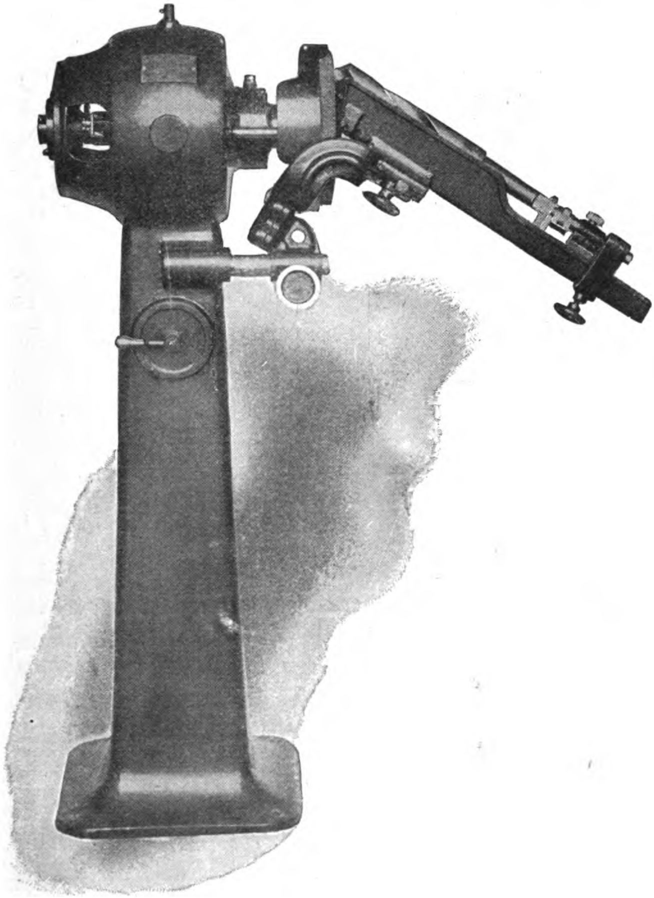


Fig. 33. New Yankee Twist Drill Grinder. Messrs Buck & Hickman.

The new Yankee drill grinder is shown in fig. 31, in what is known as style C. Fig. 32 illustrates the machine known as style B; in this design the machine has a separate overhead countershaft.

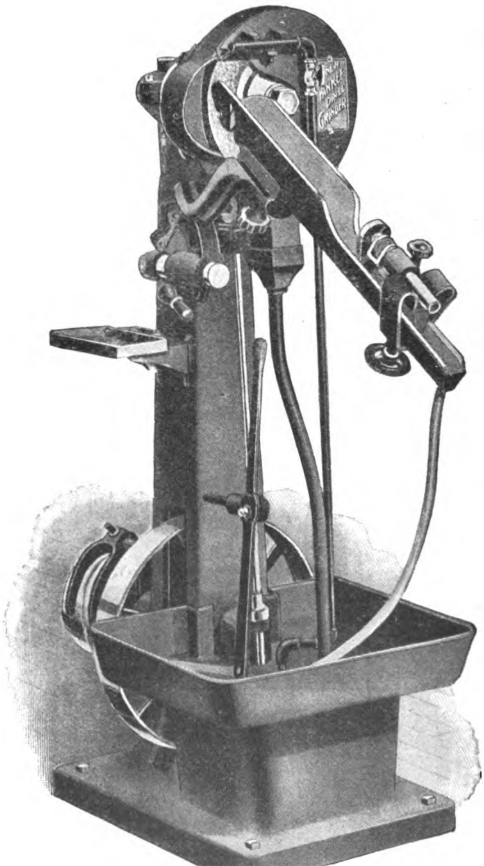


Fig. 34. New Yankee Twist Drill Grinder. Messrs Buck & Hickman.

Fig. 33 represents style D, which is electrically driven, the motor being entirely encased in a dust proof shell, to prevent the drill grindings and emery dust from reaching the working parts of the motor. Fig. 34, style F, is arranged with pump and tank for wet grinding; the water, which is delivered at the centre of the wheel, gives uniform distribution without splash or gush. The water is returned to the tank from the lower end of the holder by means of a flexible hose.

Returning to the question of drill clearance as dealt with in the description of figs. 29 and 30, it may be mentioned that, whilst the reasoning in favour of the perfect and regular ratio in the angle of clearance for the different sizes of drill appears to be well understood by most designers of specialities in drill grinding apparatus, there are evidently other points to be considered, equally interesting. An inquiry as to the views of Mr J. J. Guest, the designer and manufacturer of the "Guest Twist Drill Grinder," elicited the fact that the above reasoning is only a partial view of the question at issue. The author has permission to print the following letter bearing upon the subject which he has received from Mr Guest.

R. B. HODGSON, Esq.

February 14*th*, 1902.

DEAR SIR,—With reference to your questions as to the variation of clearance of drills from the circumference to centre, you may take it that all makers or designers of twist drill grinders are perfectly acquainted with the reasoning in its favour.

Supposing that an inch drill is fed at the rate of $\frac{1}{100}$ inch per revolution, at the outer part of the drill the angle to be added to the clearance to compensate for this would be $\frac{1}{100 . \pi}=(\frac{1}{314})$ circular measure, which bears to the ordinary clearance about the ratio of 1 to 45.

At $\frac{1}{4}$ inch from the axis the ratio would be half this, and so in proportion. At $\frac{1}{16}$ inch from the centre the ratio would be 1 to $5\frac{1}{2}$, and the point thickness of an inch drill is usually greater than $\frac{1}{8}$ inch. So you see that (as all clearance must be liberal to accommodate varying rates of feed) the matter is not of great relative importance.

On the other hand, this increase of clearance increases the length of the diagonal line at the point of the drill, which affects the cutting properties of the drill adversely, tending to make the hole irregular and necessitating a greater end force.

You will therefore see that the matter is not a one-sided affair; also it must be evident to you that a very slight displacement of the drill holder, either by slackness or bad fitting of its motion parts, or any spring, is fatal to the attainment of such refinement, and that to secure it, the overhang of the drill holder from its bearings must be small and its bearings readily adjustable.—Yours faithfully, JAMES J. GUEST.

We reproduce the "Guest" bench pattern twist drill grinder in fig. 35, and again in fig. 36, arranged or mounted on a stand for fixing upon the workshop floor; the stand type may or may not be cast in one piece. Fig. 36A shows the machine as arranged for wet grinding.

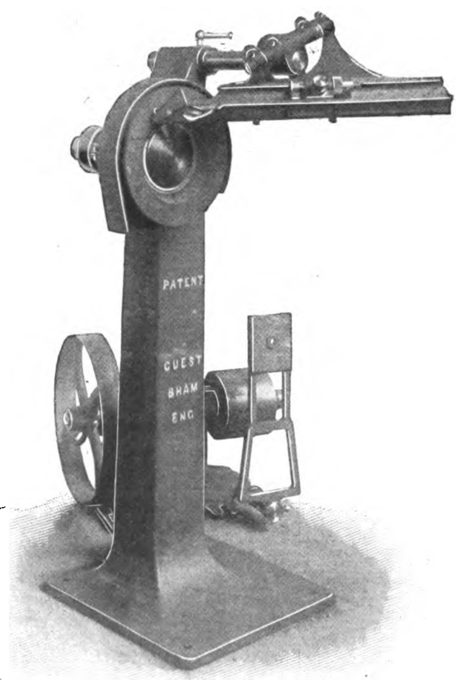


Fig. 35. Twist Drill Grinder.

The machine figs. 35, 36, 36A is for dealing with drills from $\frac{3}{16}$ inch to 2 inches in diameter. It is simple and compact, and fully conforms with the various points we have already described as essential to a good machine. It is without calipers or measuring devices, and there is no "setting" for various sized drills; in fact, the machine is always ready to grind any sized drills without adjustment for their various diameters. No mechanism for varying the clearance is provided in the standard type made, and the drill holder itself is made in one piece. As the machine possesses the above advantageous features,

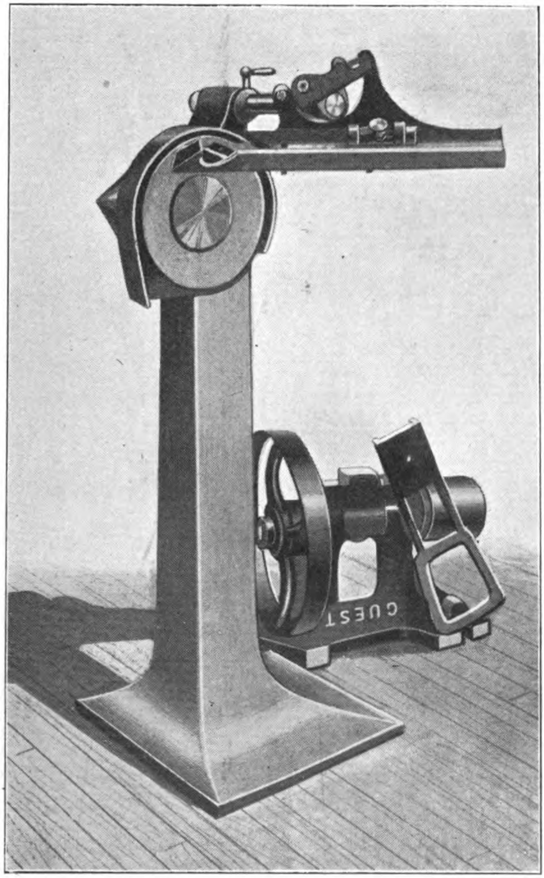


Fig. 36. "Guest" Twist Drill Grinder.

it would seem impossible for a drill ever to be ground incorrectly.

In the machine for wet grinding, the water is usually supplied from a tank by a centrifugal pump, so that, owing to the arrangement of the drill holder, it is not necessary to attach

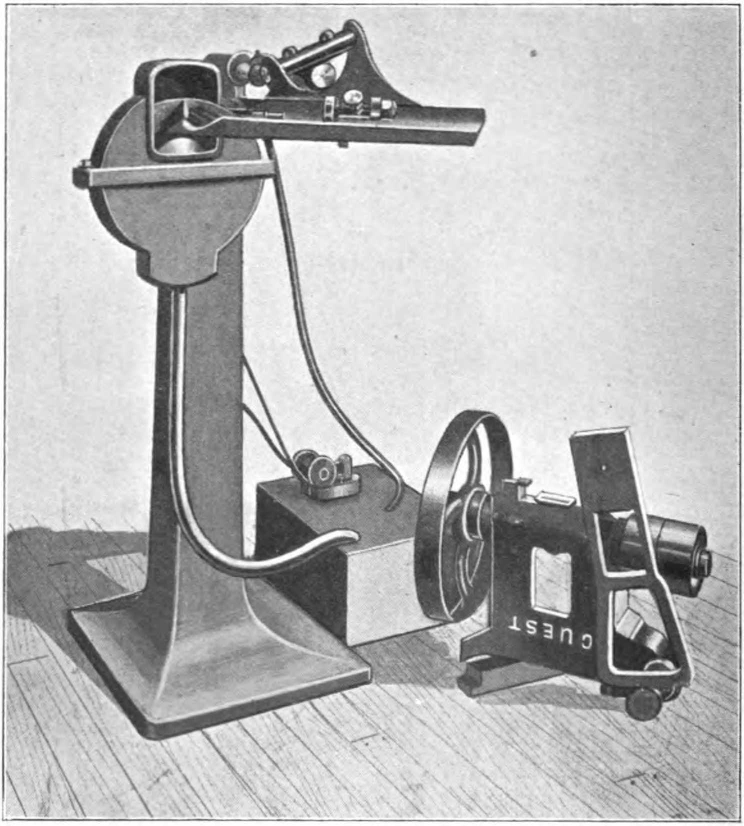


Fig. 36A. "Guest" Twist Drill Grinder.

a rubber pipe to the end of the drill holder. Hence the machine is as easily handled and as sensitive as the ordinary dry grinder.

In order to work it the following operations are required:—

(1) Unclamp the bar carrying the bracket, slightly rotate it, and then reclamp it; this causes the drill to be ground on a different part of the grinding wheel and prevents the surface from being worn into ruts.

(2) Place the drill in the holder and press it against the lip of the rest.

(3) Bring up the tail-stock and lock it in position.

(4) Swing the drill holder and feed up the drill until the edge is sharp.

(5) Turn the drill over and grind the other lip.

When a large number of drills of $\frac{3}{4}$ inch diameter and upwards are to be ground, Mr Guest recommends a special point-thinning attachment.

In addition to the special points mentioned at the beginning of this chapter in favour of a drill grinding machine over hand grinding, the following are also interesting:—(A) A machine ground drill very seldom breaks in working. (B) It can be ground very quickly and accurately by a boy, whilst it requires a skilled mechanic to make an equally good one by hand grinding. (C) The machine produces a far smaller waste of metal than the hand grinding does. (D) If the bearing of the machine is reasonably strong, the firmness of grip ensures the drill being ground perfectly true and equal on both lips.

CHAPTER VI.

DESCRIPTION OF THE LEADING TYPES OF MACHINE.

THE summary given in the present chapter of numerous types of special automatic machines now used in workshops suffices to indicate that by the aid of machinery any conceivable form of grinding tool likely to be required can be made with an accuracy and readiness quite unapproachable by any system of hand grinding.

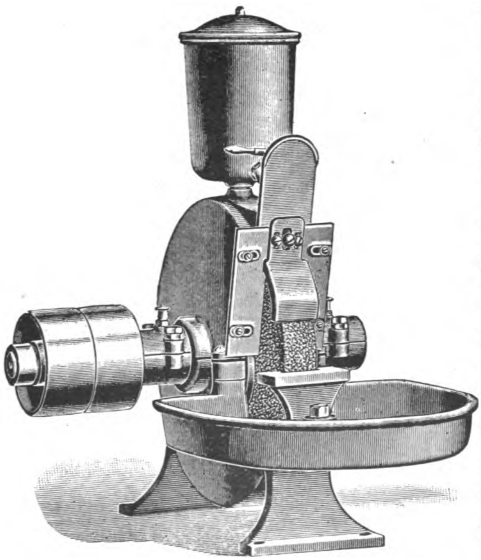


Fig. 37. Bench Tool Grinder.

By permission of The London Emery Works Co. and Messrs Buck & Hickman, we are able to reproduce a variety of illustrations taken from photographs; amongst these are figures of a number of automatic grinding machines designed for special purposes. These illustrations have been carefully selected with a view to covering as extensive a variety of work as possible without any needless repetition.

Fig. 37 represents a single wheel bench tool grinder, which is intended to be fixed upon the workman's bench in the place of the ordinary grindstone. Its advantages over the natural grindstone are, that it can be placed near the workman's vice, on the bench, or conveniently near his lathe for grinding his turning tools; it occupies less space, is much cleaner, does not give off an offensive smell, and, owing to its being small, there may be several in the same shop,

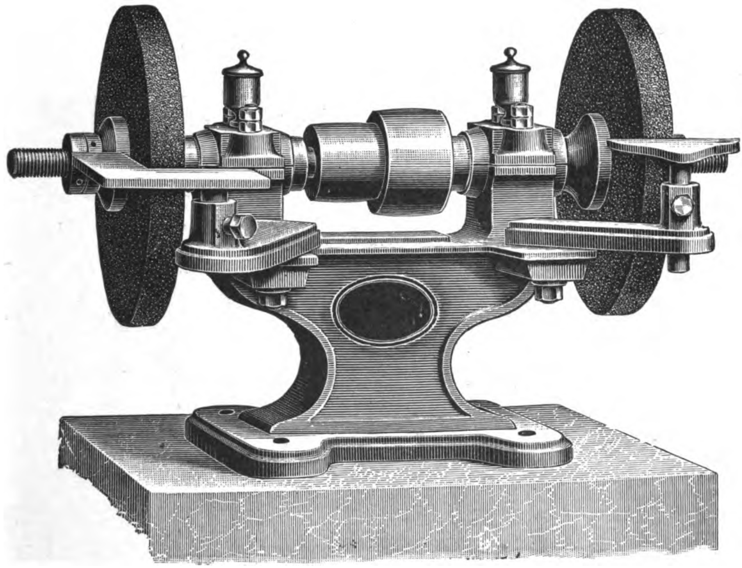


Fig. 38. Ordinary Double Grinding Head.

each being fixed at the spot where it will be most convenient for use, thereby avoiding the waste of time consequent on one large natural grindstone being used by all the workmen in the shop.

The machine is fitted with a watercan for wet grinding, and the emery wheel is protected by a hood which serves to prevent the water from flying over the operator.

The double emery wheel grinding machine, fig. 38, is used extensively in machine shops and foundries for light work, as also for the general work of white-smiths, bell-makers, gun-smiths, and brass or copper founders. The height from bench to centre of spindle is 11½ inches, the distance between the emery wheels is 17½ inches, and the machine takes emery wheels up

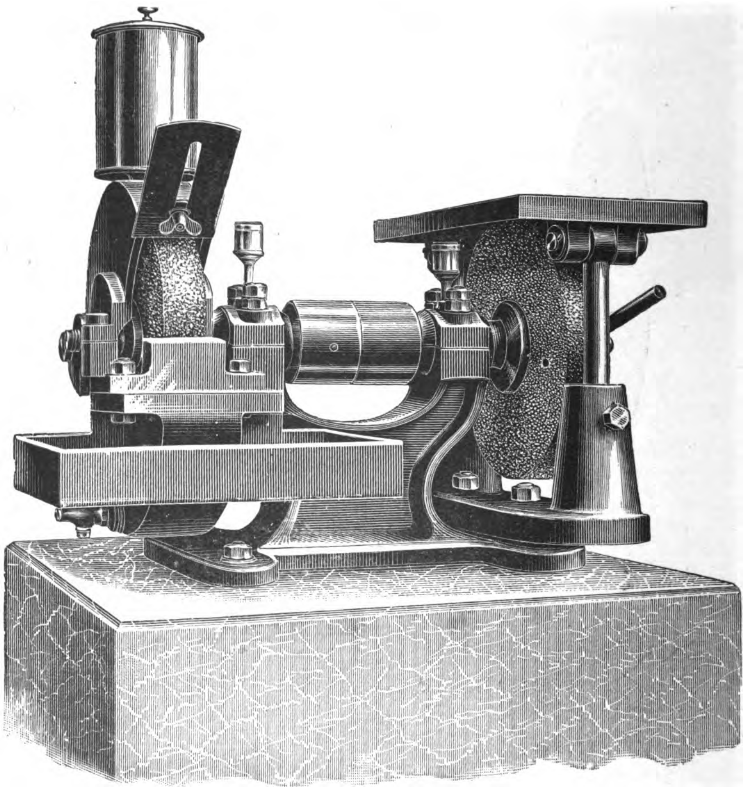


Fig. 39. Mechanic's Tool and General Grinder. London Emery Works Company.

to 14 inches diameter by 2 inches thick. The machine may be fitted with protection hoods and adjustable tables.

Fig. 39 is known as a mechanic's tool and general grinder. It is adapted for wet grinding small tools, such as are used by smiths and mechanics, iron and metal workers. The right-hand side of the machine is arranged for grinding straight surfaces on an adjustable table; this table can be thrown back when ordinary grinding is required to be done. The other end of

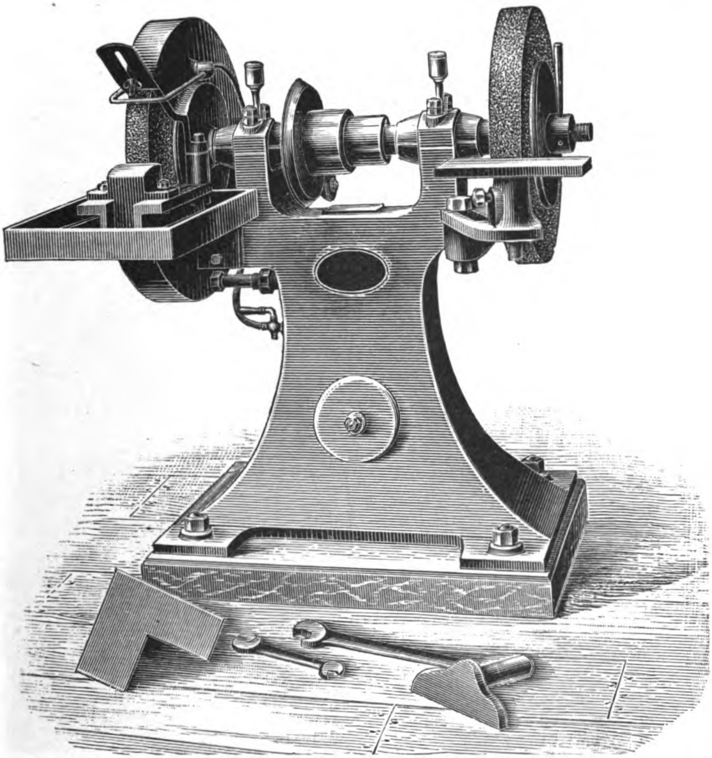


Fig. 40. Engineer's Emery Grinding Machine.

the machine has the tool rest, protector hood, watercan and trough, thus forming a complete wet hand grinding apparatus.

The engineer's emery grinding machine, fig. 40, is arranged, on one side, for grinding the machine tools used in turning, planing, shaping, etc.; and, on the other side, for the general requirements of engineers' shops, where this type of machine is fast supplanting the old-fashioned grindstone; the tool side of the machine is for wet grinding, a centrifugal pump ensuring a constant supply of water, while the cast iron standard of the

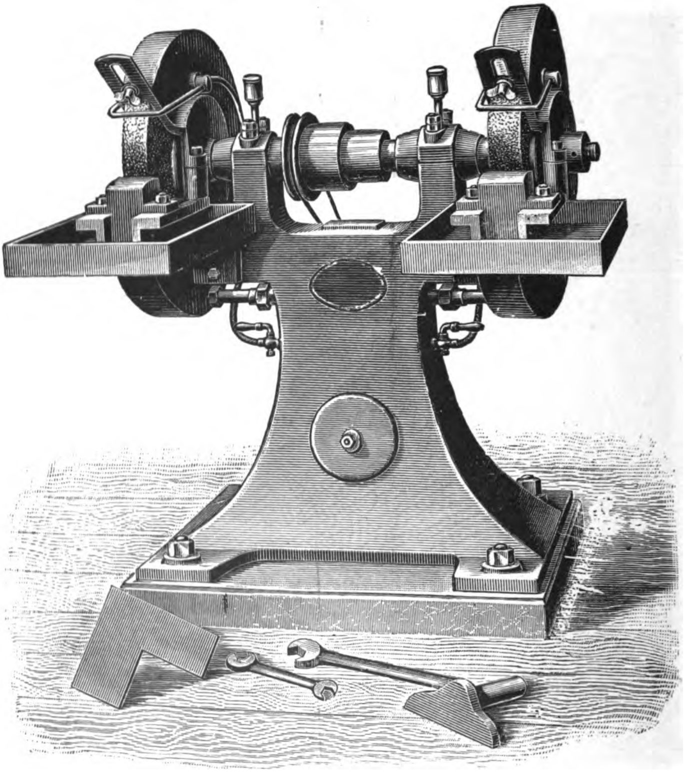


Fig. 41. Engineer's Tool Grinder.

machine serves as a trough for the overflow. The chief advantages of these machines over the old sandstone grindstones are, avoidance of dust in the workshops and much quicker grinding.

Fig. 41 shows the engineer's tool grinder with both wheels arranged for tool grinding and fitted with centrifugal pumps for supplying water to both wheels; the articles ground with machines of this kind make it necessary that the emery wheels be made of a grit specially suited for the work to be done.

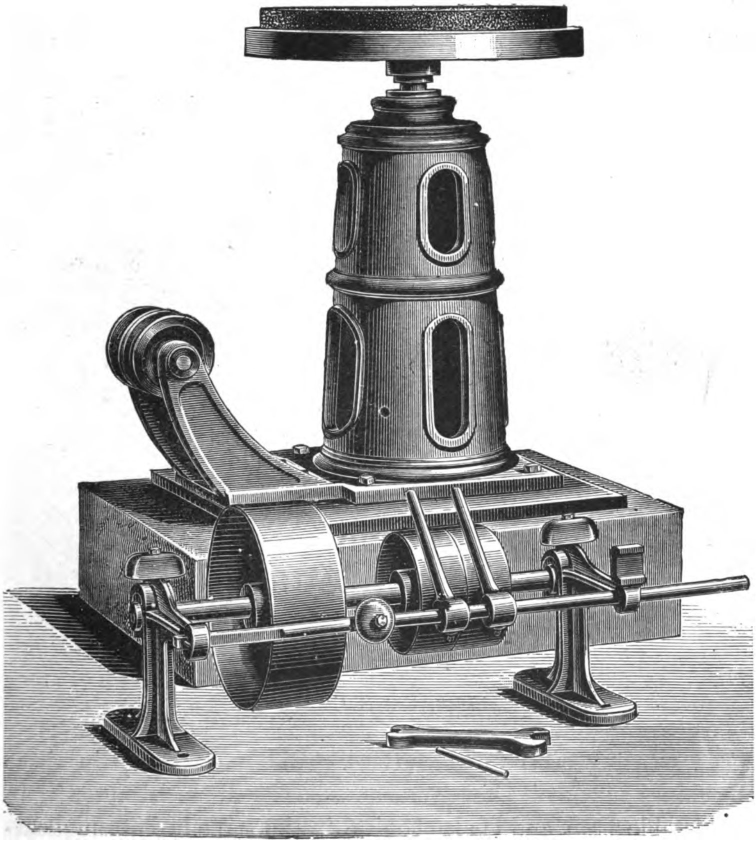


Fig. 42. Horizontal Emery Grinding Machine. London Emery Works Company.

The horizontal emery grinding machine, fig. 42, has an emery disc running horizontally for surface grinding. It will be found useful and effective for a variety of purposes where flat well as producing the cutting bevel. They are self-acting and automatic, even to feeding the knife on to the emery cylinders, thereby avoiding heating. They are fed with worm and worm-wheel to quickly adjust the bevel, and the emery cylinders are guarded with wrought iron rings, capable of adjustment as the

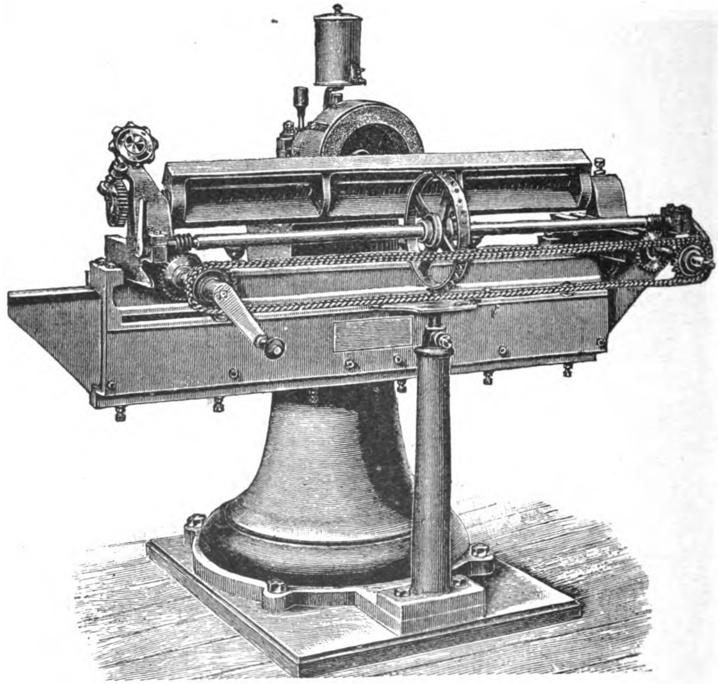


Fig. 45. Automatic Knife-grinding Machine.

emery cylinders wear. These machines grind the knives with a straight bevel, but when required they can be made to grind slightly hollow, so that they are very suitable for the knives of guillotine and other similar machines used by bookbinders, paper and millboard cutting, tobacco cutting, leather splitting machines, indiarubber-makers, cloth-finishers, wood planing and pulping machine knives. The machines can be arranged either for dry grinding, or with a dropcan for wet grinding, either with water from the town's main or with a centrifugal pump. The particular model figured (fig. 44) is, however, for dealing with knives 8 feet 3 inches in length by dry grinding only.

Fig. 45 shows another design of the improved automatic knife-grinding machine. This machine deals with knives up to 3 feet 3 inches in length; the mechanism for operating the machine is distinctly seen in the illustration, the handle with chain and chain-wheels, worm and worm-wheels for traversing the knife longitudinally, and the small hand wheel, and worm and worm-wheel for tilting the knife rest to the angle required to produce the bevel on the knife.

The automatic emery surfacing machine, fig. 46, is used for grinding the chilled dies and forms used in briquet or pressed coal works, also in engineering and in locomotive engine shops. It is successfully used for grinding and surfacing large hard or chilled pieces either of iron or steel, such as guide bars, cross heads, side bars and connecting rods for locomotive and other engines, heavy shear blades, parallel or taper strips, and many other parts of engines, railway carriages and waggons (see fig. 48). By removing the grinding head and inserting in its place the ordinary tool holder (fig. 47) it can be converted into a planing machine. The traverse of the table is automatic and is worked by a screw spindle; the feed of the tool or emery wheel rest may be effected either automatically or manually.

Fig. 46 shows the machine as adapted for being driven by electricity. The electro-motor is mounted on a plate which connects the two standards of the machine. In fig. 47 the machine is seen in front elevation; it is arranged with two driving belts for overhead motion—one for the machine, the other for the emery wheel. It will be observed from this illustration that the machine is actually a planing machine, having an emery wheel spindle and frame mounted upon the cross slide of the machine, and the additional belt for driving the emery wheel.

On the right and left of the machine are two views of the ordinary tool rest belonging to the planing machine.

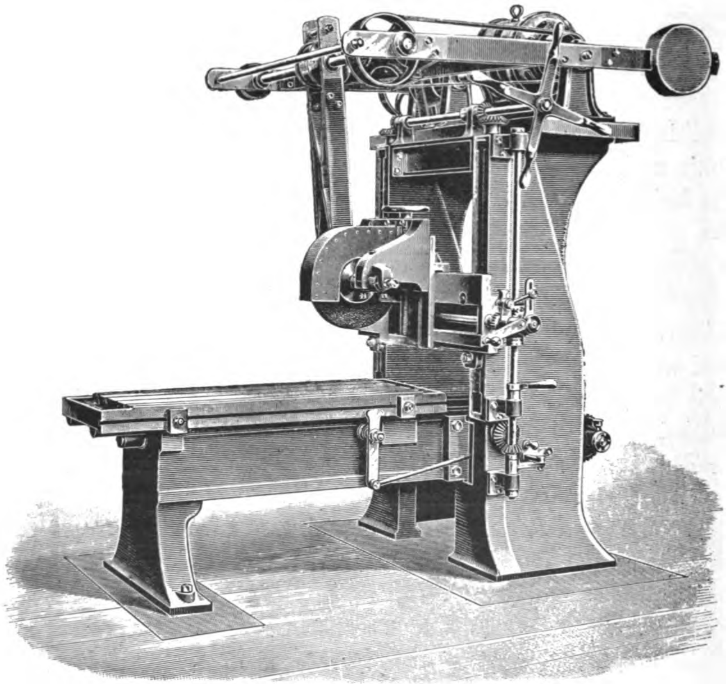


Fig. 46. Automatic Emery Surfacing Machine.
The London Emery Works Company.

Fig. 49 represents a machine for surfacing piston rings. It is used in engineering works and railway shops where steam-engine building is a speciality. In large shops where quantities of engines are made, such as marine engines, locomotive engines, traction engines, stationary steam-engines, or gas and oil engines, a machine of this description will make the slow

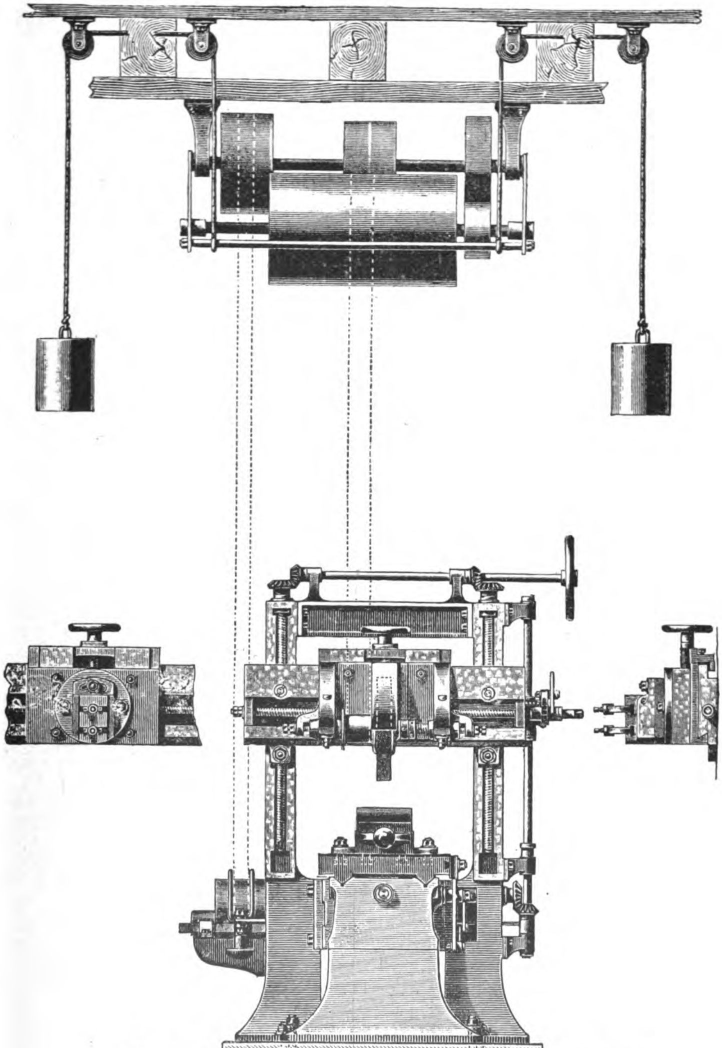


Fig. 47. Combined Planing and Surface Grinding Machine.
By the London Emery Works Company.

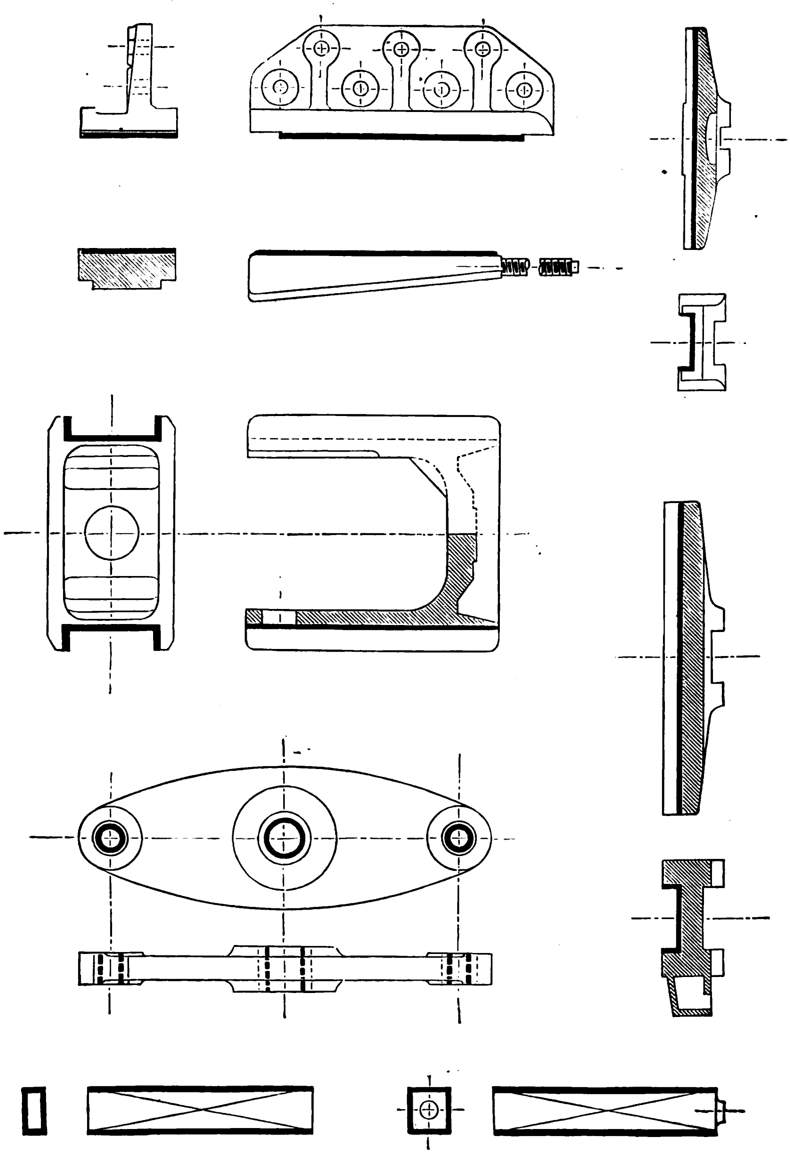


Fig. 48. Examples of work ground on Automatic Emery Surfacing Machine.

and expensive process of scraping the surfaces between the rings themselves and the piston body or plate and the rings obsolete, since the rings can be finished in this machine with

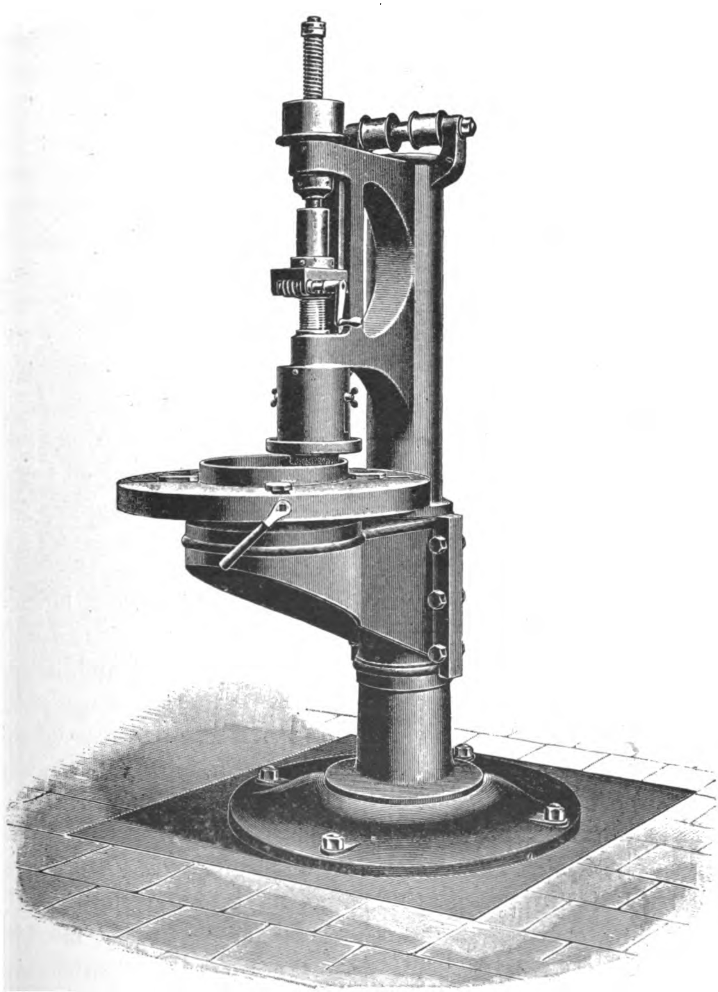


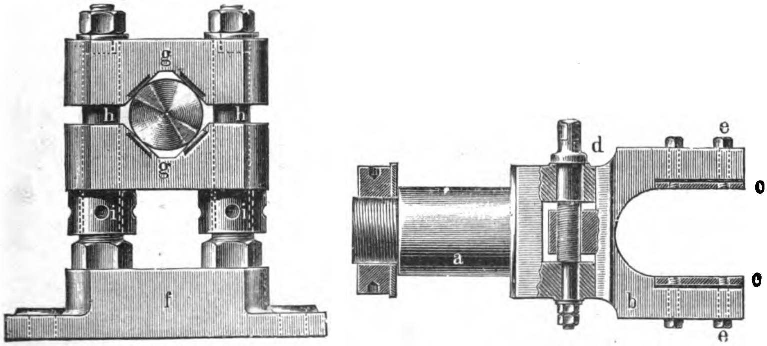
Fig. 49. Machine for Surfacing Piston Rings.

the greatest exactitude and at considerably less cost than formerly. The machine consists principally of a horizontal table or face plate, fitted with the necessary chucks, and so arranged as not only to be capable of revolving on its own centre, but also concentrically with the column of the machine; and of a grinding spindle mounted in a strong bracket fitted with very accurately adjusted carriages or bearings. The machine (fig. 49) takes in rings up to 29½ inches diameter; the rings are first roughly turned up, then placed upon the face plate and made fast by means of the clamps; the emery wheel is then brought down until it just touches the ring, and the face plate turned or rotated by hand, thereby producing a clean and even surface on one side of the ring; the ring is then turned over and the same process repeated, when the ring will be found to be both perfect in shape as well as of the desired thickness and degree of finish. It is interesting to observe that the emery wheel spindle is lubricated throughout from one hole only, and that the surplus oil or grease is carried off by a special arrangement, thereby preventing its getting upon the piston rings that are being ground.

We now come to an interesting machine known as the automatic chilled roller grinding and rifling machine (figs. 50 and 51). It is intended for the use of chilled roller manufacturers and roller millers, who are able therewith to grind and re-rifle their rollers. The machine has been designed and constructed with a minimum number of working parts, such as gear wheels and sliding surfaces; consequently the number of wearing surfaces has been reduced as low as possible. This is an important feature in machinery of this description, as the chief cause of inaccurate rifling is mainly due to the excessive friction brought about by the emery dust getting into and clogging the teeth of the gear wheels and other working parts of the machine when grinding is being done. Moreover, it makes it imperative that the individual working parts be simple and easily handled by workmen of the kind usually employed in operating these machines.

The machine shown in fig. 51 is arranged for grinding and rifling without shifting the roller. All that is necessary, after grinding out the old rifles, is to remove the grinding rest, and to substitute first the rifling rest and the apparatus for producing the feed and the curve of the rifles. When the machine is in action the grinding is continuous, as the traversing speed is the same in both directions; but when the rifling rest is at work the cut is in one direction only and the run back is three to four times quicker.

A



B

Adjustable Carriage. Fig. 50. Adjustable Guide Bar.

The adjustable carriages seen at A (fig. 50) will take any roller axle without alteration or any allowance being made for the wear of the axle, as the bottom bearings rest on strong nuts by means of which the roller and axle can be easily and quickly adjusted. Both bearings have hard steel plates to resist wear.

The grinding rest is so arranged that the emery wheel is placed between one pair of bearings, while the driving pulley is situated between another pair, thus preventing any deviation from the normal position through irregularities either on the pull of belt or in the pressure between emery wheel and roll. The adjustable guide bars B (fig. 50), between which a ball runs, are carried on an arm connected with the axle of the roller that is being rifled. These adjustable guide bars consist chiefly of two parallel hard steel bars, which are firmly connected by a number of steel forks; the latter can be adjusted in a vertical direction by means of screws, so that by changing the relative positions of these forks the steel bars can be given any desired curve, which curve is transferred by means of the revolving ball to the roller and cut by the rifling tool.

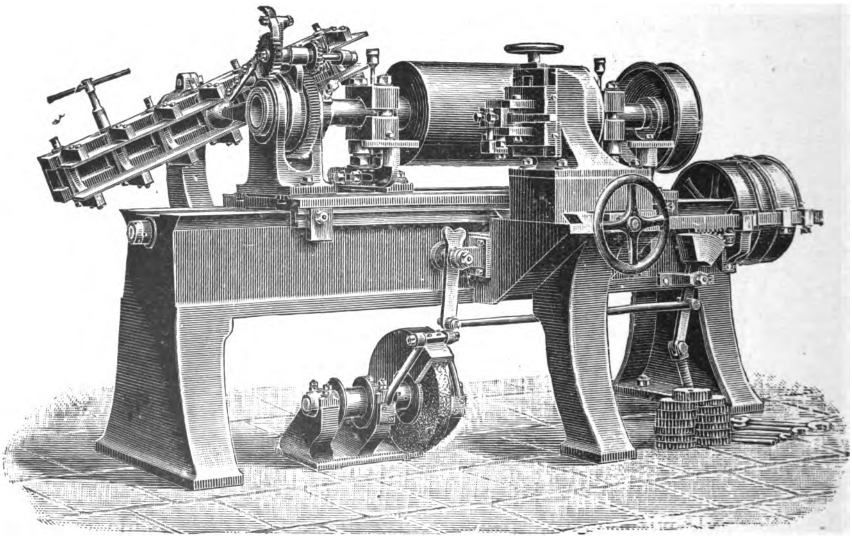


Fig. 51. Automatic Chilled Roller Grinding and Rifling Machine.
London Emery Works Company.

By means of this arrangement it is possible, when resharpening, to make use of the old grooves. It is therefore only necessary to grind the roller until it is perfectly true and then deepen the old furrows, which can be followed in every case by means of the foregoing improved arrangement. The result is a saving both in the emery wheel and in the roller itself, as the whole of the chilled surface is profitably used. The machine, when desired, can be furnished with a guide bar of simple construction, adjustable within certain limits for all inclines, but unalterable inside its own path.

When rollers with varying numbers of grooves have to be re-rifled, it is only necessary when commencing a new groove number to change one wheel in the self-acting feed arrangement; which wheel is to be changed is determined from a wheel table supplied with the machine. The machine is completely automatic, and the rifling tool is withdrawn at the end of each stroke.

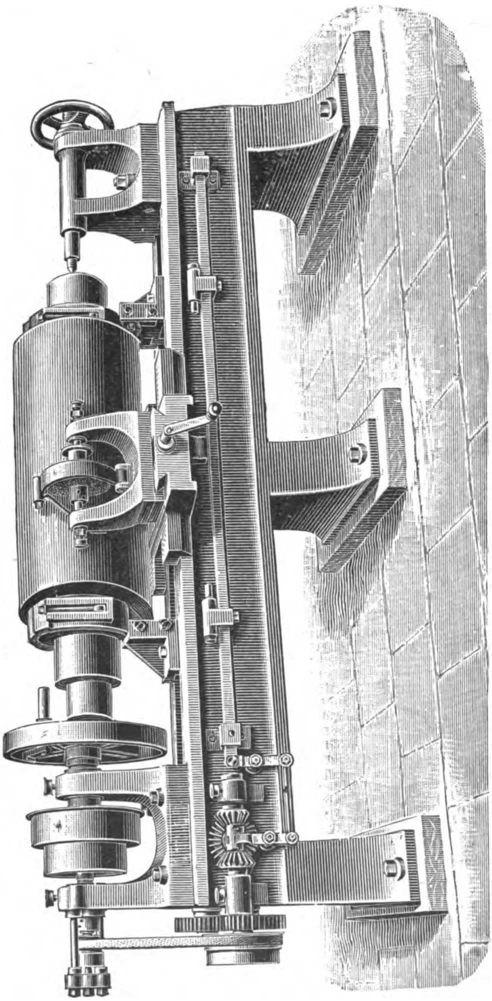


Fig. 52. Grinding Lathe for medium-sized Rolls. London Emery Works Company.

The grinding lathe for medium-sized rolls with self-acting reversing motion shown in fig. 52 is in some respects similar in construction to an ordinary self-acting turning lathe. It is fitted with head and side stocks (known by turners as head-stocks and poppet), to facilitate centring the rolls; but before commencing to grind these are withdrawn, and the rolls are carried by the adjustable bearings, as shown; this machine is for dealing with calenders, flour - mill rollers, etc.

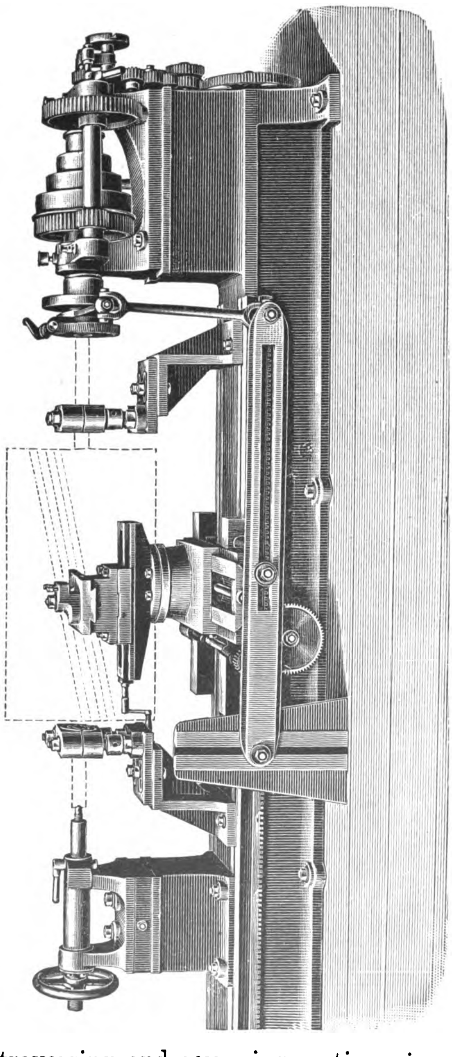


Fig. 53. Grinding and Rifling Flour Mill Rolls. London Emery Works Company.

The lathe shown in fig. 53 is a complete machine for turning, grinding, and rifling chilled cast iron or steel rolls. It is used in flour mills as well as for ordinary use as a lathe; in the latter case it would be provided with a set of change wheels for screw cutting. It differs from an ordinary lathe in having a self-acting traversing and reversing motion given to the slide rest.

The best plan for centring a roller, when the old centres remain in the necks, is to put the head and side stocks into

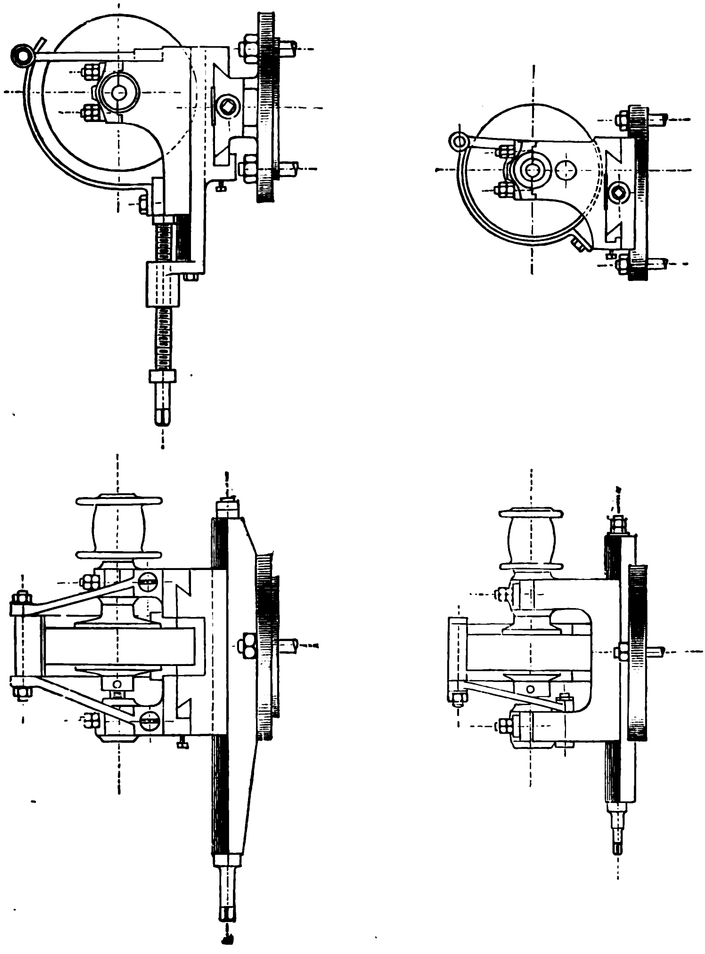


Fig. 54. Apparatus for Grinding Rolls. London Emery Works Company.

these old centres, and see if the necks require turning or truing-up; when these necks have been put right and are found to run dead true, put the adjustable carriages on to these necks, and withdraw the lathe centres before grinding either the roller itself or its grooves. Should there be no centres in the roller necks, then the carriages will have to be adjusted until the roller runs true. To cut the rifles or grooves in a roll, a dividing plate should be used on the neck of the head-stock, and be connected with the slotted guide bar at the back of the lathe (as shown in fig. 53); by altering the relative position of the joint bolt in the vertical slot to the actuating pin on the base of the slide-rest any degree of inclination can be given to the rolls. When the lathe is being used for grinding, a special form of tool holder carrying an emery wheel and spindle is substituted for the tool holder shown in fig. 53.

Four views of the apparatus forming this special tool holder are given in fig. 54, from which it will be seen that the emery wheel and spindle are mounted upon a compound slide rest suitable for attaching to any lathe.

CHAPTER VII.

CONCAVE AND CONVEX GRINDING.

THE apparatus shown in figs. 55, 56 and 57 is made by Messrs W. Muir & Co., Ltd., Manchester, for grinding concave and convex circular forms. It is designed to fit on the table of an ordinary grinding machine, the machine headstock being utilised for carrying the mandril on which the cutter is placed to be ground. Semicircular, concave or convex cutters, and forms of concave and convex section in either right- or left-handed combinations can be ground by the apparatus. By referring to figs. 55, 56, 57, its action may be thus explained. Fig. 55 shows the apparatus arranged for grinding a semicircular convex cutter. The emery wheel headstock spindle R^1 is fixed parallel with the length of the table F F; this spindle receives the mandril R, carrying the emery wheel N. The apparatus is placed with its bottom plate S on the table of the machine, the stud and bush T (which is the centre of vibration) being about the centre of the emery wheel N. Place the bottom slide U at an angle of about 45° to the axis of the spindle and mandril R; fix the headstock E of the machine at right angles to the axis of spindle and mandril R. Insert the mandril V (carrying the cutter W to be ground) in the spindle of the headstock E, and by means of the adjusting screws X X move the headstock slide Y, until the centre of the semicircle of the cutter to be ground is concentric with the centre of vibration T of the bottom slide U. Fix the stop B when in this position (as shown in fig. 55), and adjust the same until an arc of 180° is obtained; the stop B is used to give a positive stop to the circular motion, and to prevent the emery wheel from "*digging in.*" For arcs of less than 180° this stop is not absolutely necessary. The stop D is used to bring the cutter W back to the same position opposite the emery wheel N after being withdrawn to the left-hand side to examine the state of

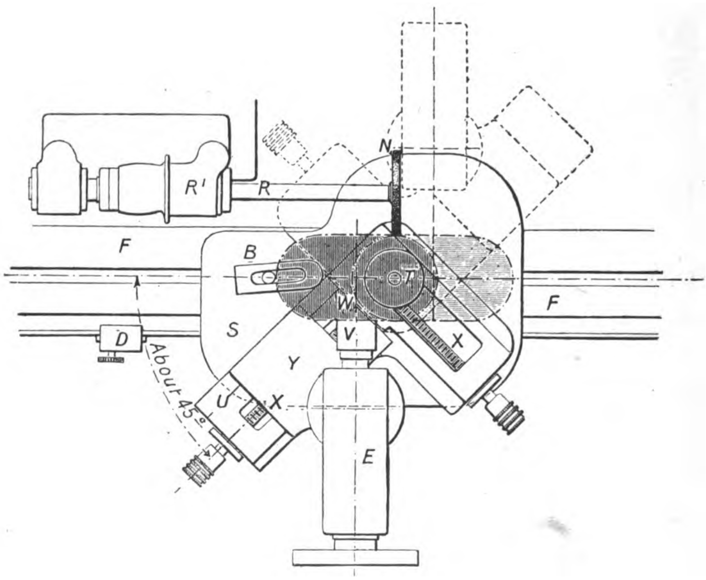


Fig. 55. Special Grinding Fixture. Wm. Muir & Co. Ltd.

the teeth when grinding. The emery wheel should lie flat on the periphery, and be quite free from ridges and grooves.

Fig. 56 shows the apparatus as arranged for grinding the concave part of a cutter which is concavo-convex in form. In this case the emery wheel headstock, carrying the mandril R and emery wheel N, is set at an angle of about 30° to the length of the table F F; the adjustment of the headstock E carrying the cutter to be ground is the same as in fig. 55. The emery wheel mandril R may vary in length according to the diameter of the cutter operated upon, and the emery wheel N may vary in diameter according to the radius and length of the arc of circle to be ground, but should be semicircular on the periphery, and as narrow as possible consistent with its wearing qualities.

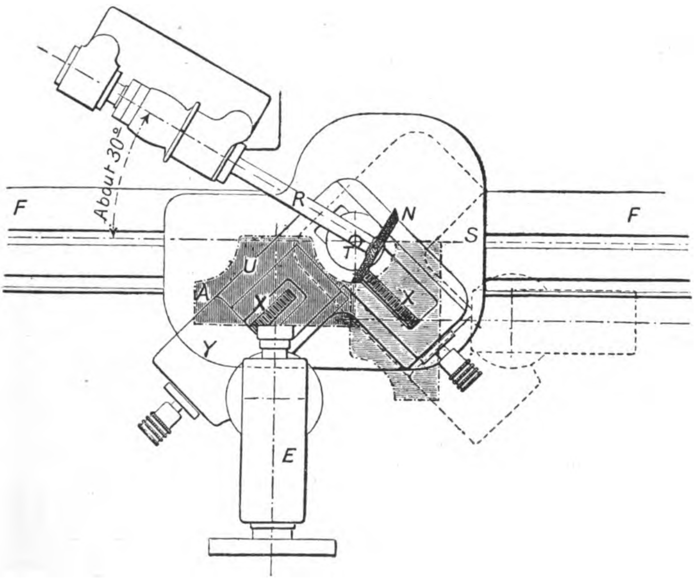


Fig. 56. Special Grinding Fixture. Wm. Muir & Co. Ltd.

Fig. 57 shows the apparatus as arranged for grinding the convex part of a cutter which is concavo-convex in form. The emery wheel headstock carrying the mandril R and emery wheel N is, in this case, set parallel with the length of the table F F, and the adjustment of the headstock E carrying the cutter is the same as described in fig. 55.

Fig. 58 represents the grinding *rest holder*, which requires readjustment for backing-off cutters as shown; the backing-off is to give a clearance behind the cutting edge of the teeth and the work when milling; it varies according to the quality and hardness of the material to be milled and the depth of cut. For ordinary work the clearance used is from 5° to 10°. The emery wheel should be of the greatest diameter possible in order that the "*backed-off*" surface may be as nearly a plane as possible, so as to give greater strength to the cutting edges of the teeth. After the circular grinding has been effected, it will be observed that the tops of the teeth form arcs of a circle.

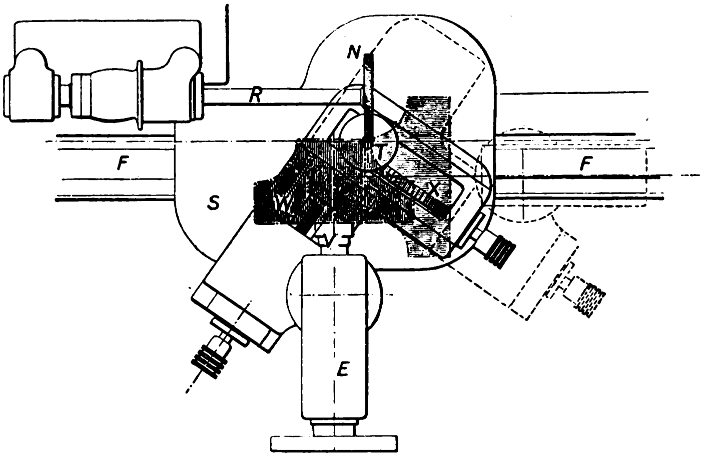


Fig. 57. Special Grinding Fixture. Wm. Muir & Co. Ltd.

These arcs serve as a guide in backing-off, and should never be ground completely away; the length of arc left after "backing-off" should be about the width of a fine line, and only just discernible. This will ensure a true cutting edge and perfect work. The *rest*, when readjusted, should just clear the emery wheel when supporting the teeth that are being ground, the left hand of the workman traversing the slide, and his right hand holding the work lightly upon the *rest*. Two passes for each tooth are sufficient for one revolution of the cutter.

The large grinding machine (fig. 59) was originally designed for grinding internally interchangeable chilled steel rolls 26 inches in diameter by 15 inches broad (fig. 60), the hole through the rolls being in the form of a double cone, the apexes of which are in the centre of the roll. These chilled rolls are used for quartz-crushing machinery. The machine represented in fig. 59 weighs about 98 cwts. It is suitable both for dealing with the chilled rolls and for grinding inside steel rings and cylindrical linings, but the external diameter must not

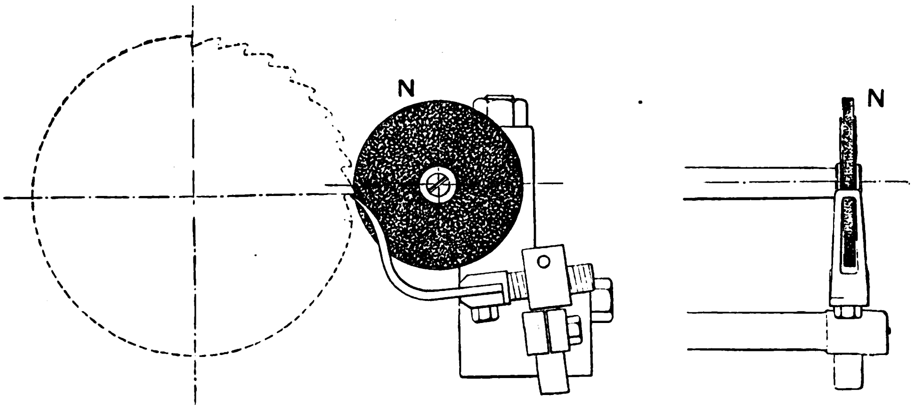


Fig. 58.

exceed 27 inches, as no article with a larger diameter can be "*chucked*," as indicated by fig. 59. The machine consists of one large casting, which forms right- and left-hand beds, with the driving headstock in the centre. The slides and traversing carriages are mounted upon the upper surfaces of the beds, and driven by an adjustable crank, connecting rod, compound worm and wheel gear, fast and loose pulleys; the carriages are coupled together by a strong tie rod, which can be disconnected so as to allow the left-hand carriage to be worked by hand if required. The self-acting traverse is alike for each carriage, so that they

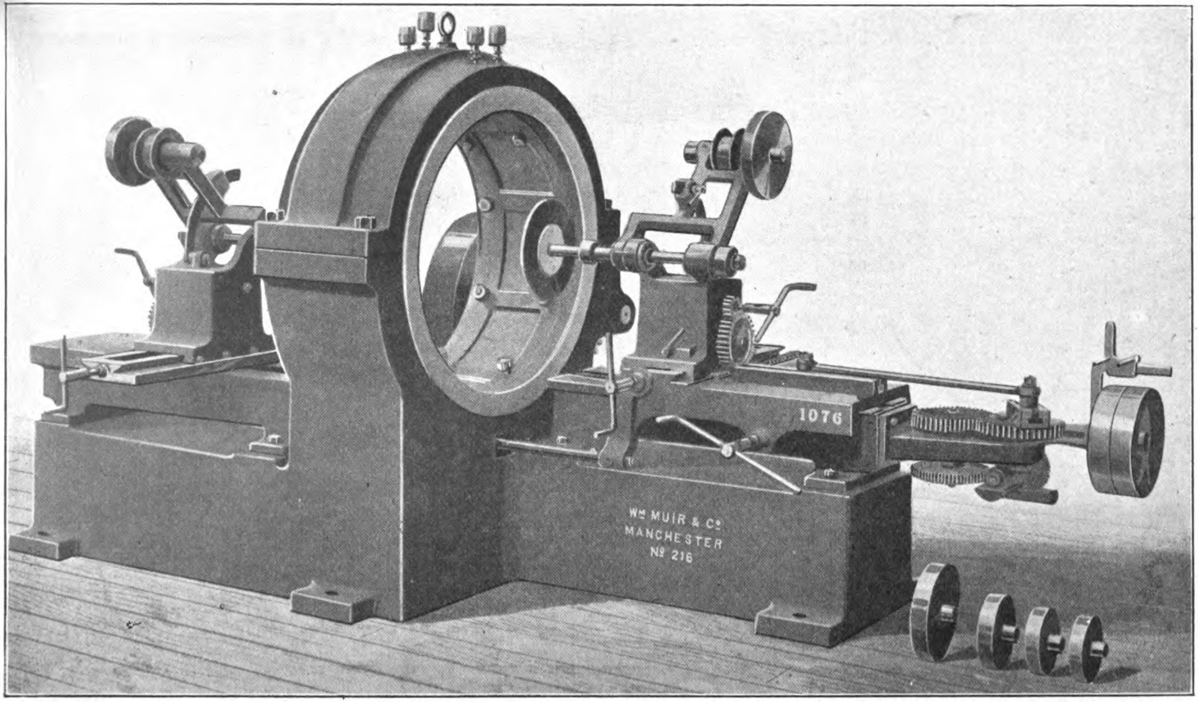


Fig. 59. Machine for Grinding internally Chilled Steel Rolls.

work simultaneously when coupled together, the amount of traverse being regulated from the crank. The position of the grinding wheel is obtained by the adjustment of the connecting rod in the T slot on the left-hand carriage, and a quick hand movement can be given to each carriage by handle, pinion and rack. A transverse grinding headstock is mounted upon each carriage and worked on opposite sides with an adjusting screw. A disengaging nut allows of the rapid movement of the headstock by rack and pinion, so as to clear the "*chuck*" when putting in or taking out the work. The driving is direct from countershafts, compensating frames being employed on each spindle head to keep the belts in tension. There are three changes of pulleys to suit the various diameters of emery wheels; these spare pulleys are seen in the right-hand bottom corner of fig. 59. The Alfred Muir's patent coupling used on the spindles readily secures and releases the mandrils of the emery wheels. The chuck seen in the centre of the machine bed is driven by single speed pulley, pinion and spur gearing, working in the shell cap, this driving mechanism being at the back of the machine. The work to be ground is fixed in the chuck by sixteen jack screws, eight on each side; some of these jack screws are clearly seen in the illustration.

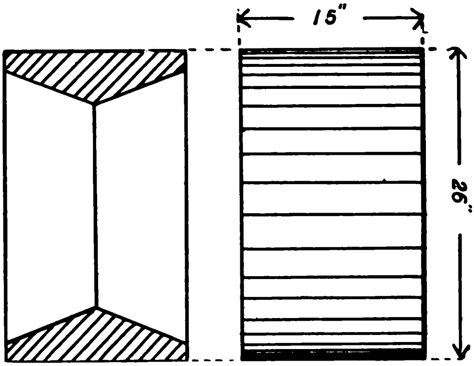


Fig. 60. Chilled Steel Rolls.

Long Cylindrical Work.—The production of a fine bright finish on a long cylindrical rod was a tedious operation prior to the introduction of suitable machinery for this purpose. Only a few years ago the usual practice was first, turning the rod; second, smooth-filing it, until it was as true or as near parallel as possible, testing it by the aid of the female Whitworth gauge; and finally, lapping it by means of a lead ring supplied with powdered emery and oil. How tedious and expensive this lapping operation was will become apparent by describing the process of lapping a steel mandril, like those used in the manufacture of German-silver tubes. Fig. 61 represents

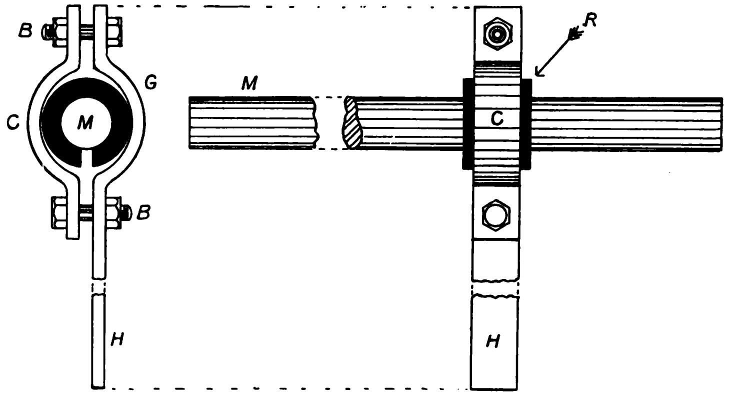


Fig. 61. Lapping Steel Mandril.

the arrangement. The mandril M is 8 feet long by 3 inches in diameter; it must be finished so that not a scratch or mark remains on the surface in the whole length, and it must be absolutely parallel.

A lead ring R, about 4 inches long and $\frac{3}{4}$ inch sectional thickness, is cast with a hole through it of the same diameter as the mandril. The ring is then cut through at any point in its circumference (as indicated in the figure), the ring being placed upon the mandril, and fastened between the two clamps C and G by the bolts B, B; one end of the clamp G terminates in the part H, which is used as a handle; this handle rests either upon some part of the lathe saddle or upon a block of wood, to prevent the lapping arrangement revolving with the mandril itself; the lathe is rotated, and the workman, having placed a liberal supply of powdered emery and oil upon the mandril, grasps the part H in his right hand while his left hand is near the lead ring, and slowly moves the whole up and down longitudinally along the mandril, occasionally screwing up the nuts of the bolts B, B. This process is repeated until the mandril M is perfectly parallel and of bright finish, a process which has been known to take as long as thirty hours.

It is interesting to compare the old lapping process (fig. 61) with the piston-rod grinding machine (fig. 62). This machine is one made by Messrs Geo. Richards & Co., Ltd., Broadheath, and was originally designed for grinding locomotive engine piston-rods; it is capable of producing a high degree of finish and exact parallelism on rods requiring precision. The machine is made in several sizes, the largest being capable of dealing with a piece 8 feet 3 inches long by 12 inches in diameter. A machine of this design would meet the requirements of the tube mandril shown in fig. 61. The cost of producing correct and highly finished pistons, spindles, and mandrils on such a machine is less than one-fourth what it would be when done by any method of hand grinding, such as working a slide rest by hand. Further, it must be clear that the cost of grinding a tube mandril (fig. 61) on this or similar machines, by reason of its being self-acting, is really too small for consideration, as compared with the lengthy and tedious old method of lapping with lead ring and emery dust. The emery head in (fig. 62) has a cross traverse by screw and handle at the back of the machine, and is so arranged on to a swivel that the emery wheel can be brought close up to the shoulder of a piston. The emery wheel head is traversed automatically in either direction with clutch interposed, and the bracket carrying the poppet head has a horizontal movement for different length of work. If a piston-rod or other circular piece of work produced by hand grinding methods be placed in the machine for correction, all irregularities of surface and deviations from parallelism are detected as the emery wheel automatically traverses along the rod; and this demonstrates the value of automatic grinding. The machine figured is built upon a foundation, but it is now made with a deeper base, or with suitable cast iron stands for

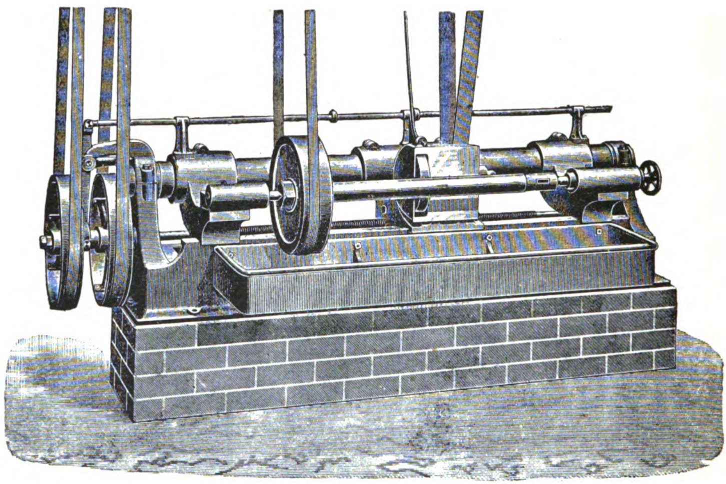


Fig. 62. Piston-rod being ground by Emery Wheel.

fixing it straight on the floor; in these cases no brickwork foundation is required.

The following example given by Mr H. F. L. Orcut will indicate the rapid action of a modern grinding machine. The machine used was capable of finishing parts up to 8 inches in diameter and 8 feet in length, the emery wheel was 24 inches in diameter and had a face 2 inches wide. A 4 inch shaft 3 feet long, which had previously been rough-turned with a 12 per inch feed and left 0·01 inch above size at the bottom of the tool marks, was finished in six minutes. (*Proc. Inst. Mech. Engineers*, January 1902.) Mr Orcut does not mention the make of machine; probably it was American.

Again, according to Mr Hans Renold (*Proc. Man. Ass. of Engineers*, November 1901), the Norton grinding machine will grind locomotive piston-rods 3½ inches in diameter by 50 inches in length at the rate of one rod every thirty minutes; these rods had been roughly turned and left $\frac{1}{32}$ inch above finished size. Mr Hans Renold saw this operation performed on the occasion of his visit to America.

CHAPTER VIII.

CUP AND CONE GRINDING MACHINES.

THESE machines are specially designed for grinding the ball-race of bicycle cups and cones, and the outside of cups. Various styles or combinations are made in building up the parts of the machine for dealing with straight and angular grinding, or for automatically grinding to a predetermined curve, the operation being performed either before or after the cups and cones are placed in the hub or on the axle.

The machines figured are manufactured by the Pratt & Whitney Co., Hartford, Connecticut. One of their special features is, that the collet or chuck for inside work is a step chuck, split in three places, and closed by means of springs in an ordinary spring barrel. For outside work an expansion chuck is used; at one end of the headstock is pivoted a lever which extends under the bed, and is there connected by a wire cord to a wooden treadle secured to the floor by a hinge and screws. A pressure on the treadle by the foot causes the drawback chuck to open for inserting or taking out the cups, the lever also acting as a brake for stopping the spindle immediately.

Removing the pressure from the treadle permits the chuck to close, thus clamping the cup to be ground. The belt for driving the machine is shifted by means of a connection with the same treadle that actuates the opening and closing chuck mechanism in the head. The countershaft for driving the machine is either attached to the ceiling or to the wall, according to circumstances. One combination of the machine (fig. 63) consists of bed, headstock and countershaft; it is fitted with an inside form grinding attachment for automatically grinding the inside of cups to any of the ordinary forms. The grinding attachment consists of an upper and a lower slide; the lower or cross slide is attached to the bed by means of two special clamps, and has an adjusting screw by which the diameter to be ground can be regulated. The hand lever on the upper slide is used to move the emery wheel from the work. The emery wheel travels in a predetermined path, and is controlled by a cam or form located under the wheel head; this form can be made for grinding surfaces at right angles almost to a sharp corner or a curve, and with its two tangential surfaces tangent of any radius up to one half inch.

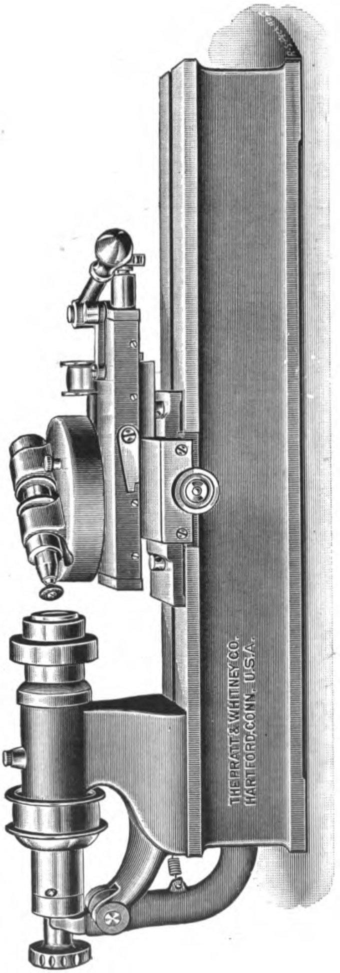


Fig. 63. Automatic Internal Cup Grinding.

The spindle of this attachment has a special form of bearing, consisting of separate balls running in suitable ground tracks;

a speed of 30,000 revolutions per minute can be maintained without heating.

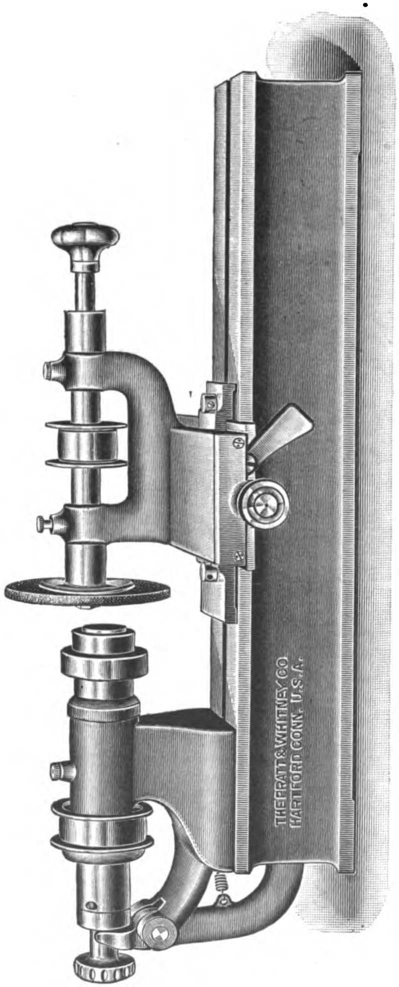


Fig. 64. Attachment for External Grinding.

Fig. 64 is another combination of the machine. It consists of bed, headstock and countershaft, as in the machine shown in fig. 63, but it is fitted with an outside grinding attachment for grinding the outside straight, and angular surfaces of cups and cones; it will not grind curves. This attachment is secured to the bed by means of suitable clamps, and has an adjusting screw by which the diameter to be ground can be regulated. The hardened tool-steel spindle $\frac{3}{4}$ inch diameter runs in hardened bearings, and carries an 8 inch emery wheel worked by hand.

In fig. 65 the combination consists of a bed, two inside-form grinding attachments similar to that described for fig. 63, one right-hand and one left-hand, and a countershaft. In this case, however, a special head is arranged for grinding cups automatically after their insertion in the hub, two cups being ground at the same time. The special head is placed in the centre of the bed, and has a quick chuck action, operated by a

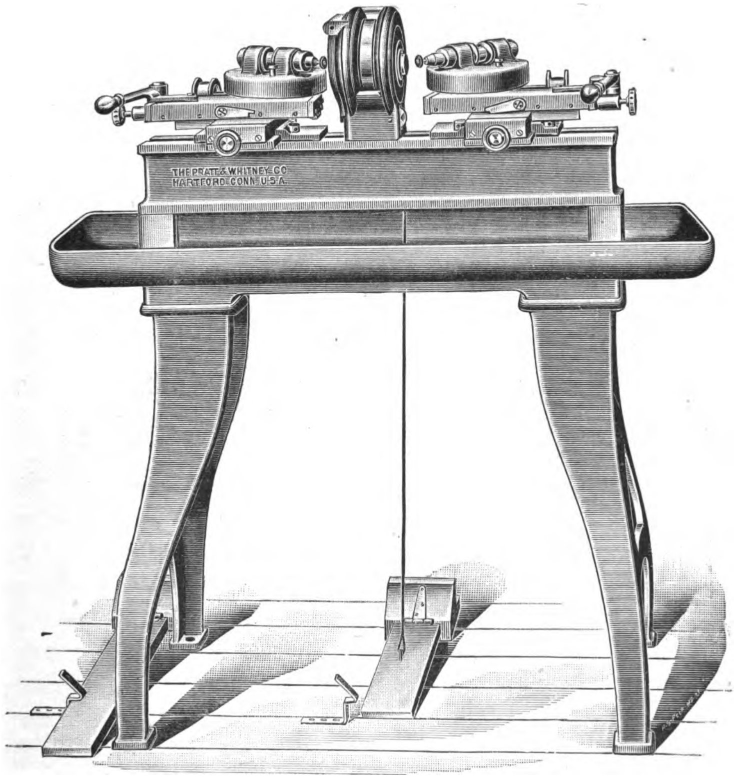


Fig. 65. Double Cup Grinder, after their insertion in the hub.

foot treadle, making the operation of inserting or removing hubs very simple.

Fig. 66 gives another combination. It consists of the bed, countershaft and inside-form grinding attachment, as in the machine first described (fig. 63), but in addition there is a special head, with an overhanging arm for grinding cones automatically after they are placed upon the axle, the axle being supported on dead centres, and driven by a pulley revolving on the front end of the fixed head spindle.

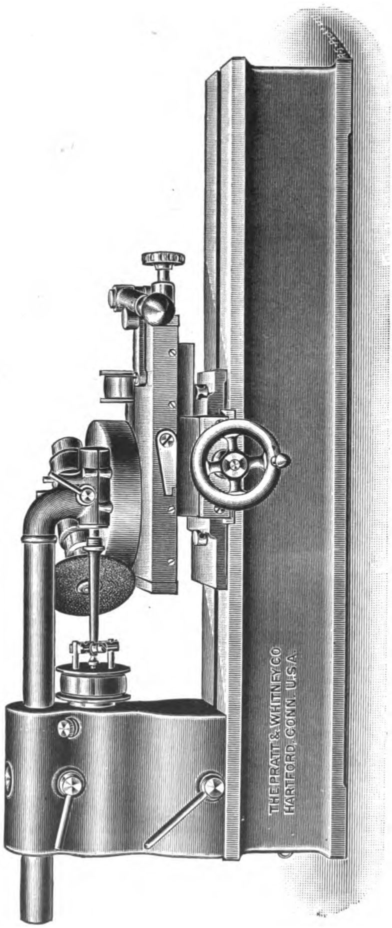


Fig. 66. Automatic Cone Grinding Attachment.

The samples of work (fig. 67) were done with the combination shown in fig. 63, and the samples of work shown in fig. 68 were ground by the machine combination shown in fig. 66.

Various Forms of Milling Cutters.—It is not within the scope of the present work to review either the processes of manufacturing milling cutters or the many purposes for which they are employed.

But the milling cutter is now used so extensively in operating upon the various metals, that the question of cutter grinding or cutter sharpening has become an important one. In fact, it is questionable if any other department is so important in a modern engineering or machine tool workshop as the *tool-room*, where the various cutting tools are made and kept

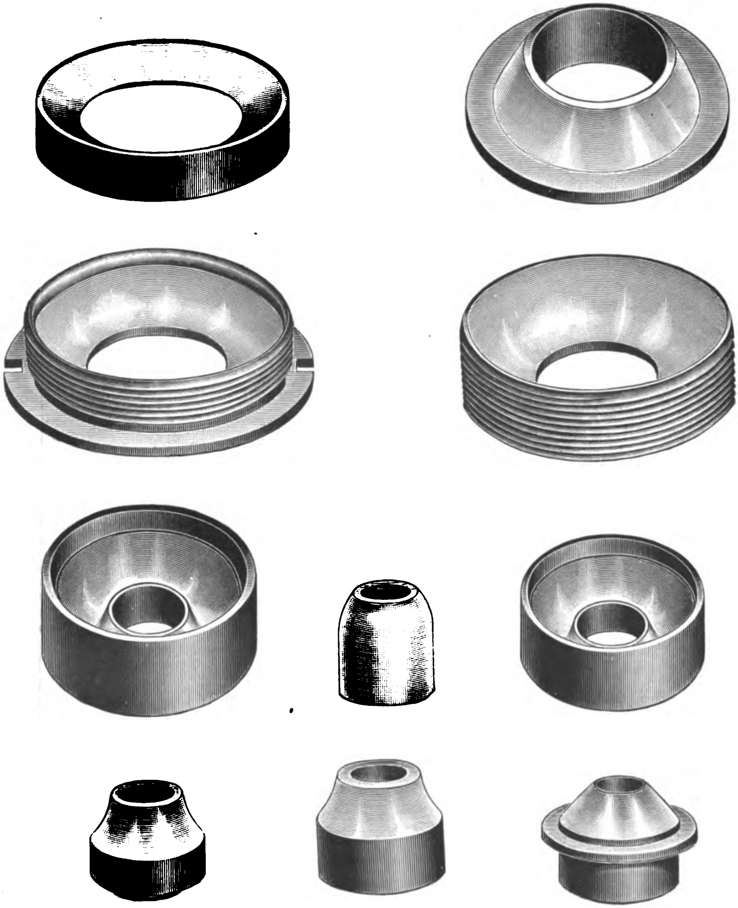


Fig. 67. Samples of Work ground on Machine, fig. 63.

in thoroughly good working order. It will therefore not be out of place here to give a number of illustrations (figs. 69 to

77) of the numerous forms of cutters used for these milling operations; for while, as they indicate the extensive variety of work on which the cutters are employed, they will also

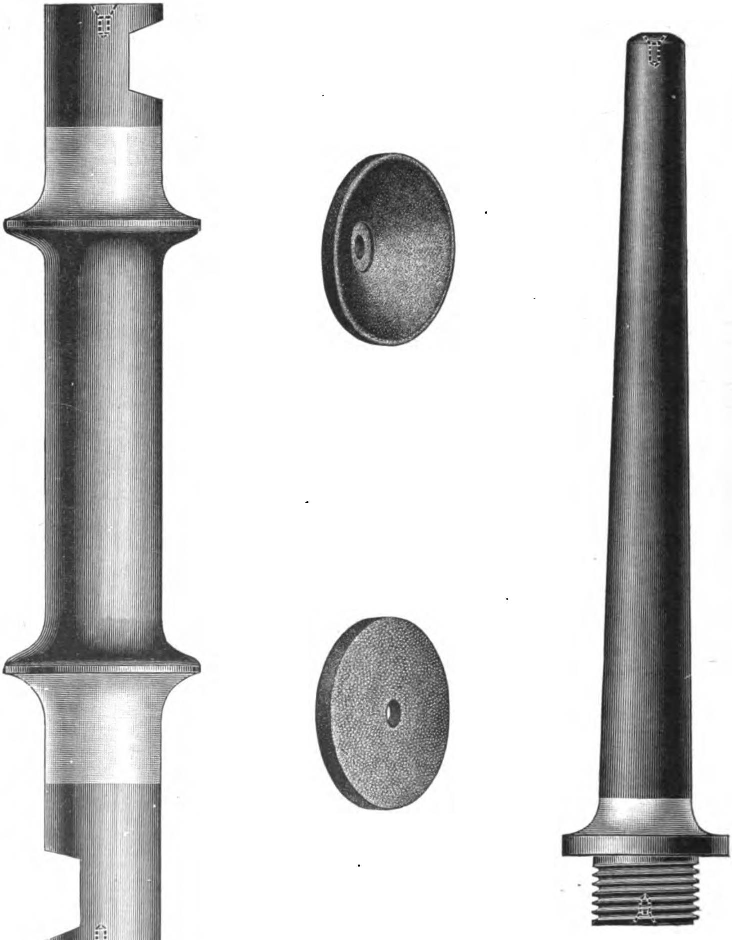


Fig. 68. Samples of Work ground on Machine, fig. 66.

illustrate the account given subsequently of the construction and manipulation of cutter grinding machines and cutter sharpening apparatus.

Fig. 69 represents an angular face cutter and a vee cutter; fig. 70, a side milling cutter; fig. 71, a circular cornering quarter circle cutter, single right-hand cutter, double right- and left-hand cutter, single left-hand cutter, convex and concave cutters for milling half circles; fig. 72, a shell reamer and rose shell reamer, left-hand T slot cutter with morse taper shank, and a solid reamer; fig. 73, a morse taper reamer, right-hand end mill

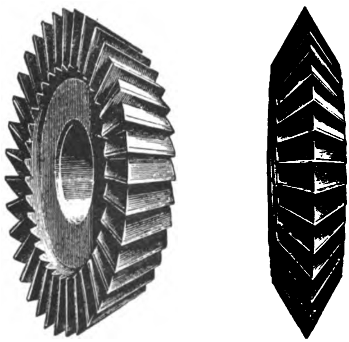


Fig. 69. Milling Cutters.

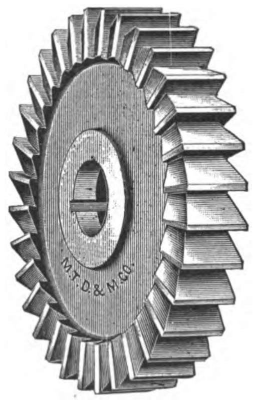
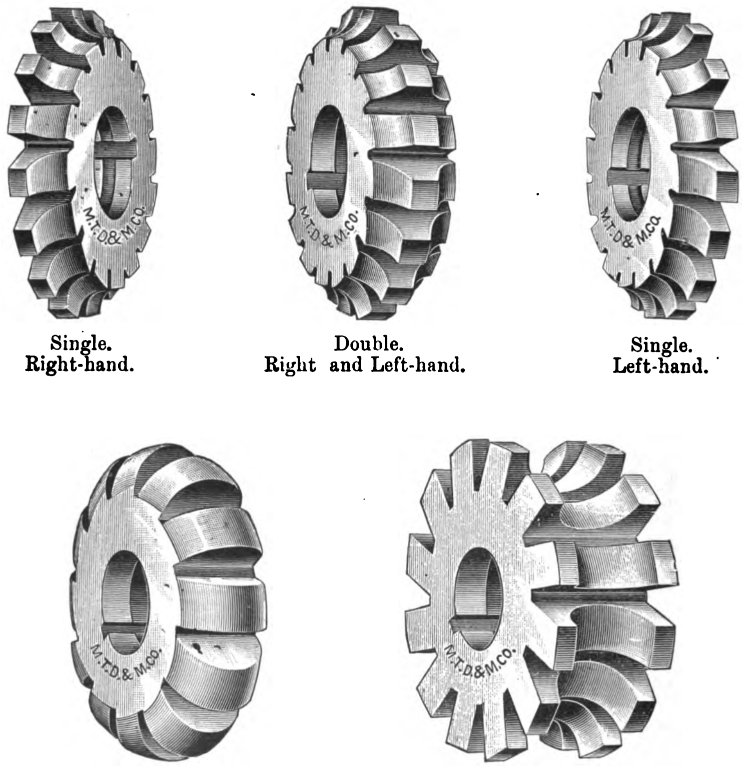


Fig. 70. Side Milling Cutter.

with morse taper shank, and an example of a hardened and ground steel mandril; fig. 74, a left-hand spiral shell end mill; fig. 75, a gang of formed milling cutters and side milling cutters, gang of milling cutters, one with radial grooves, gang of spiral mills and side milling cutters. In these examples (fig. 75) it will be noticed that the various cutters are mounted side by side upon the arbor, and that while individual cutters are of different shapes and diameters, yet when grouped together they take the peculiar shape or profile which it is desired to mill upon the work. Consequently, the shape or profile required upon the work *decides* the size and shape of the various cutters that are conjoined together to make up the complete gang of cutters. Figs. 76 and 77 are examples of

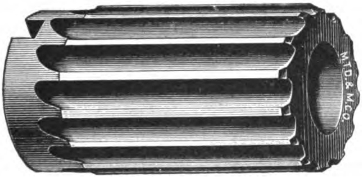


Single. Right-hand. — Double. Right and Left-hand. — Single. Left-hand.

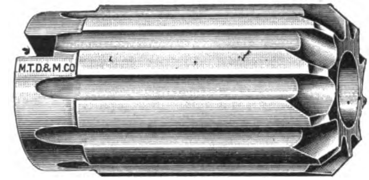
Convex. — Concave.

Fig. 71. Milling Cutters.

formed milling cutters; as in the case of gang cutters, the formed cutters produce a shape upon the metal by the operation of milling. The difference is that whereas the gang cutters consist of any number of cutters mounted together, *formed*

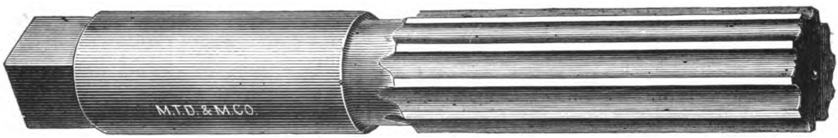


Shell Reamer.



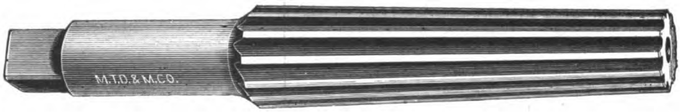
Rose Shell Reamer.

Left-hand T Slot Cutter.



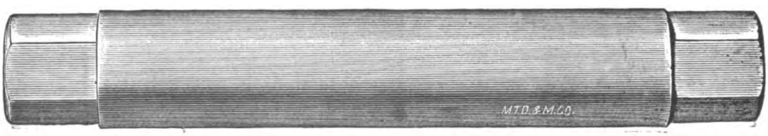
Solid Reamer.

Fig. 72.



Morse Taper Reamer.

Right-hand End Mill.



Hardened and Ground Steel Mandril.

Fig. 73.

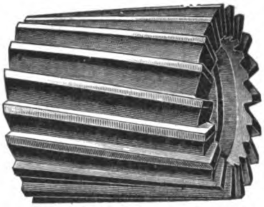
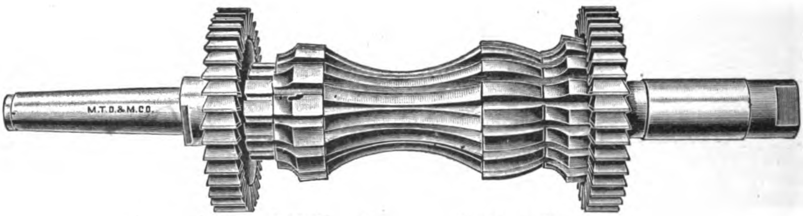
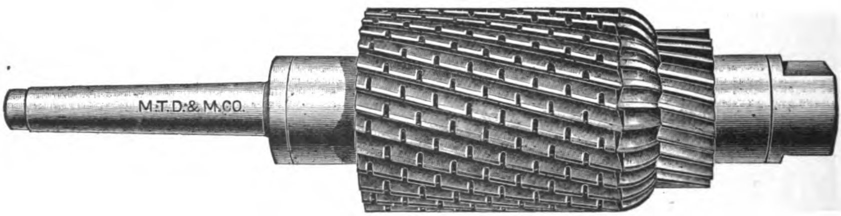


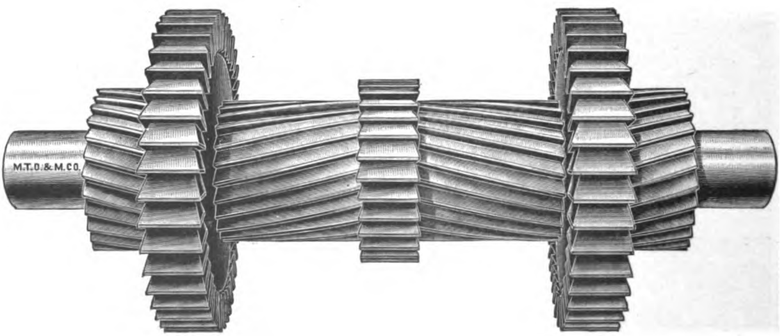
Fig. 74. Spiral Shell End Milling Cutter—Left-hand.



Gang of Formed Milling Cutters and Side Milling Cutters.



Gang of Milling Cutters, one with Radial Grooves.



Gang of Spiral Mills and Side Milling Cutters.

Fig. 75. Gang Cutters.

cutters (figs. 76 and 77) are made from one piece of steel; that is, the single formed cutter is so shaped that it will produce the desired profile when performing the operation of milling, by being of itself passed singly across the work. It must, how-

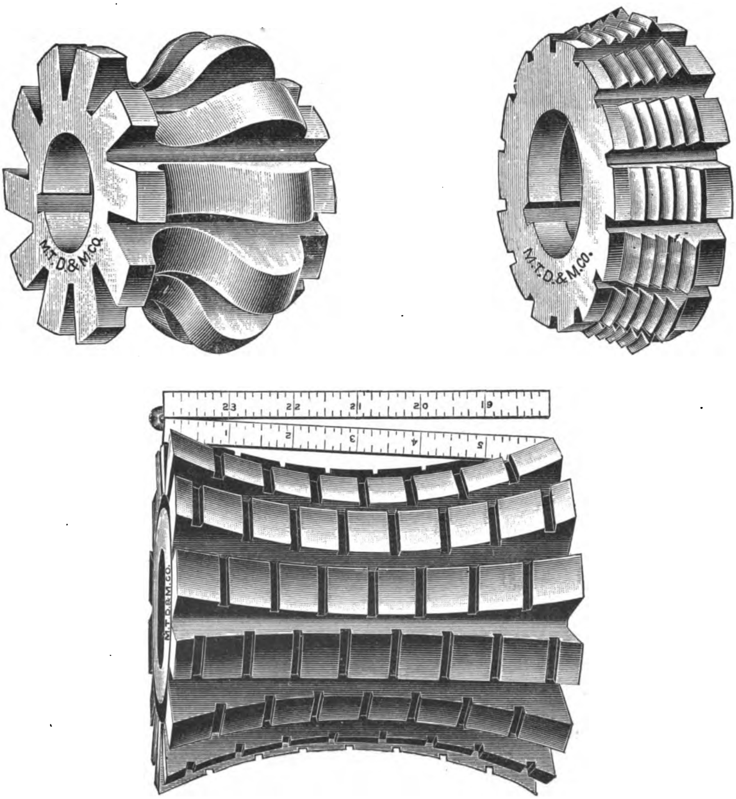


Fig. 76. Special Formed Milling Cutters.

ever, be remembered that a number of these single formed cutters are sometimes mounted along with plane cutters to form a gang of cutters for milling some new profile, probably upon a much wider piece of work than that dealt with by the single formed cutter. Each of the above mentioned cutters (figs. 69 to 77) may be correctly sharpened on a cutter grinding machine.

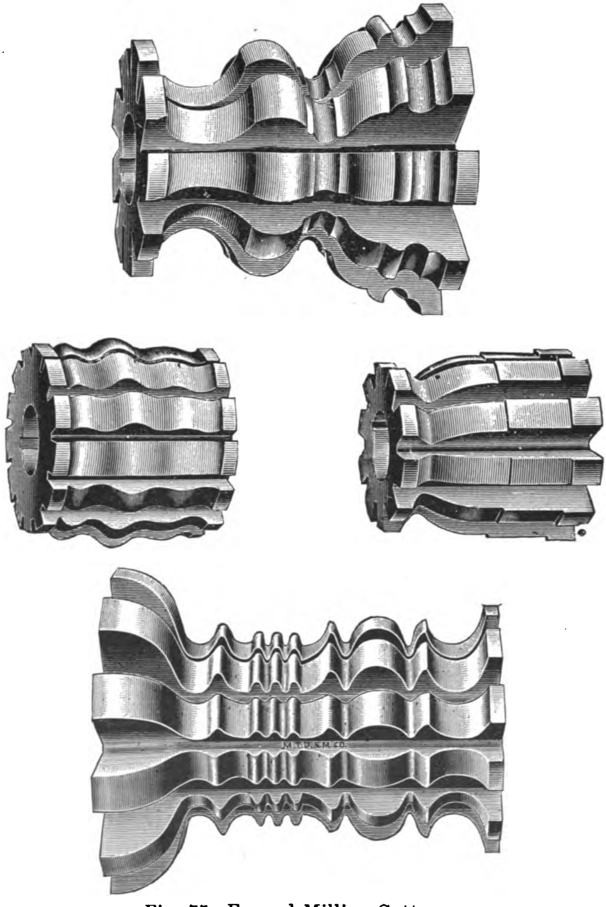


Fig. 77. Formed Milling Cutters.

An example of fine and accurate plane cylindrical grinding is given in fig. 78, which shows the standard plug and ring type of cylindrical gauges, as used in all modern machine tool and engineering workshops; these gauges are known as a pair of Whitworth male and female gauges. A number of examples, showing the application of the emery wheel for sharpening cutters and grinding cylindrical work, are seen in fig. 79, and the various operations are lettered from A to Q; some of these will be again referred to in another chapter.

Form of Teeth for Cutters.—As we have referred to the shapes or profiles of cutters and their application, it will be

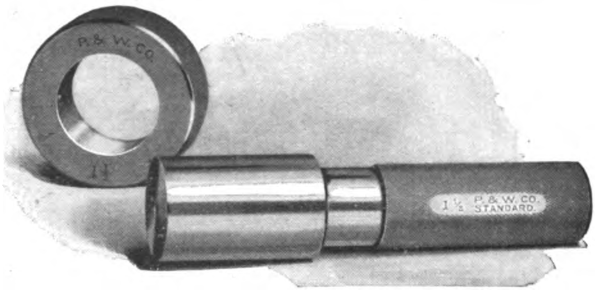


Fig. 78. Standard Plug and Ring. Cylindrical Gauges.

interesting to consider the shape of the cutter teeth. In the case of the formed cutters (figs. 76 and 77), the teeth must not be ground on the clearance side of their cutting angle, as that process would spoil the profile of the cutter itself.

The same reasoning applies to all cutters that are used for cutting the teeth of gear wheels; these and similar cutters have their teeth so shaped and specially backed off that they can be sharpened by grinding with an emery wheel without changing their form. The special backing-off forms the clearance of the tooth, and the teeth are sharpened by operating with the emery wheel upon the top-rake side of the cutting angle (see fig. 79, at M). Referring to fig. 75, the gang of spiral mills and side milling cutters are usually ground by applying the emery wheel to the "*clearance*" side of the cutting angle, known as the top of the tooth (see fig. 79, at O), so that every time the cutter is sharpened it becomes reduced in diameter.

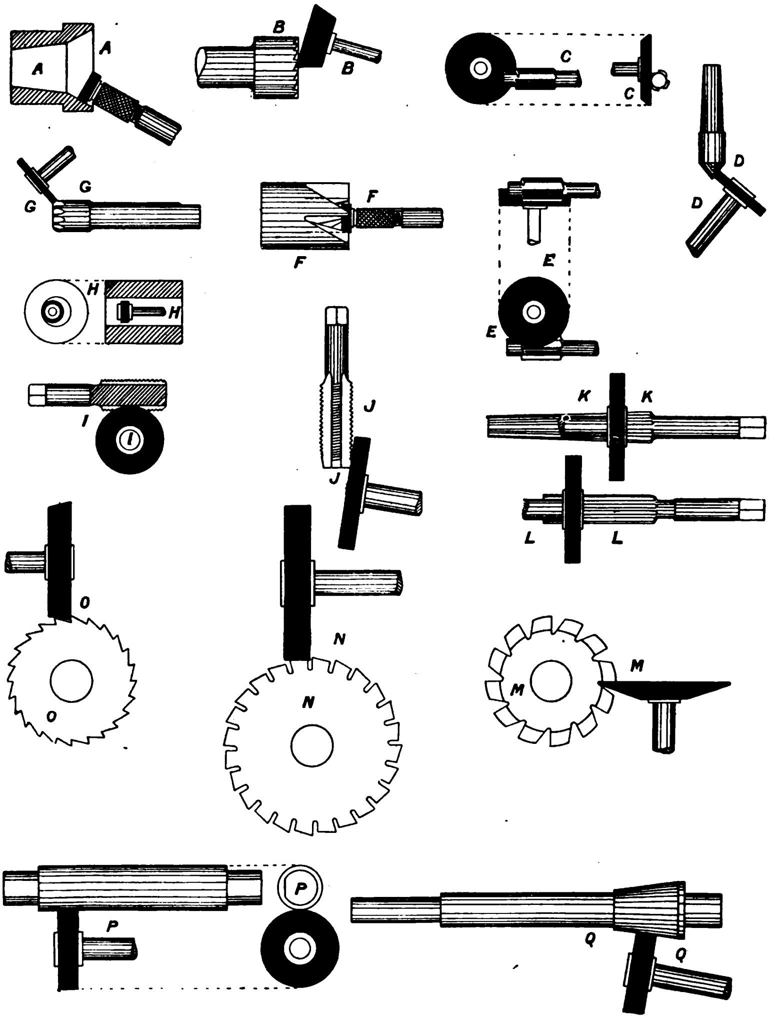


Fig. 79. Examples of Cutter Grinding.

In the case of any cutter, reamer, or tap, when it is necessary to keep their diameter correct to standard size, then the sharpening must be done by applying the emery wheel to the "*top-rake*" side (see fig. 79, at E and I), and on no account should the "*clearance*" side of the cutting angle be touched by the emery wheel.

In the designing of metal-slitting saws, which are really one form of cutter, there are two important points often overlooked by well known makers. The points are — No. 1, the cutting angle; No. 2, the clearance: these govern to a great extent the strength of the teeth, as will be readily seen by a study of figs. 80 and 81. The ordinary metal-slitting saw is seen at fig. 80, in which case it will be noticed that the "*top-rake*" side of the tooth is part of a line running nearly straight from the circumference of the cutter to the centre of the hole in the cutter. The cutting angle is then formed by a line running from the top of one tooth to the base of the next tooth; the tooth terminates in a sharp point like a turning-lathe tool; but though this form of tooth is used extensively for slitting metal, it is really more suitable for sawing wood. The author can instance a case where some hundreds of these metal-slitting saws were in daily operation. The special points of interest that were noted during the everyday working of these saws were as follows:—First, there being "*no top-rake*" and *too much* "*clearance*," it became necessary to apply a very slow rate of feed, because the teeth had a great tendency to rip or rag the metal instead of cutting freely. Second, the teeth having a

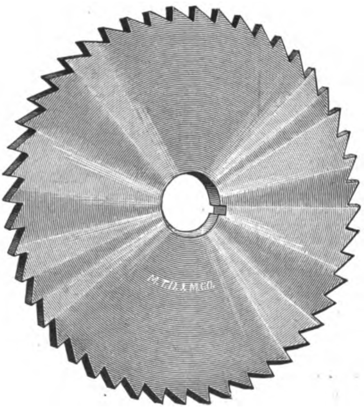


Fig. 80. Ordinary Slitting Saw.

cutting angle similar to a wood saw, they were not of sufficient strength for cutting or sawing metal, consequently the teeth often snapped off; this tendency to break was further increased by the ripping or ragging action in cutting. Hence it was a common experience to see a dozen or more saws thrown away during one day's working. Considering the heavy cost of these saws, the loss became a serious item. The saws were sharpened in the manner shown in fig. 79, at O. The continual losses in this respect led to the adoption of a special form of saw tooth (see fig. 79, at N). It is therefore surprising to see so many saws now in use having their teeth of similar shape to those in fig. 80. Let us compare the two shapes by considering them in the light of a metal lathe turning tool. To do this we will refer to fig. 81. S S is a steel shaft 2 inches in diameter; this shaft is being turned by an ordinary round-nosed turning tool, which has a suitable top-rake T R_3 of 10° and a clearance angle of 10°, thereby forming a cutting angle of 70°; this turning tool will be found to give good results when operating on steel.

A_2, fig. 81, is a portion of a saw having its teeth T_2 formed like those of the turning tool. C_2 is the clearance side of the tooth, and a dotted line a_2 b_2 runs through the tooth about $\frac{3}{16}$ inch from its top or cutting edge; this dotted line runs nearly through the whole width of the tooth. Another dotted line E_2 F_2 runs from the cutting edge of tooth through the centre of the saw, and crosses the centre line of the steel shaft where the tooth T_2 will be seen in the form of a turning tool having top-rake T R_2 and clearance C_2, which compares well with the actual turning tool T. These metal-slitting saws A_2 give splendid working results; they cut better than fig. 80, and being stronger teeth, they last much longer than the saw teeth (fig. 80).

The portion of a saw A, fig. 81, illustrates a part of the saw fig. 80; the dotted line a b is drawn through the tooth as in the case of A_2; from which it will be readily seen that the saw tooth in sketch A is very weak owing to the great clearance C; this clearance is seen in the black diagram at the bottom of the drawing, which diagram represents the tooth in the form of a turning tool. A top-rake of about 4° has here been shown, although they frequently have no top-rake at all. In fig. 81 at A_1 we see a portion of the saw fig. 80 after the teeth have been sharpened several times. The sharpening has

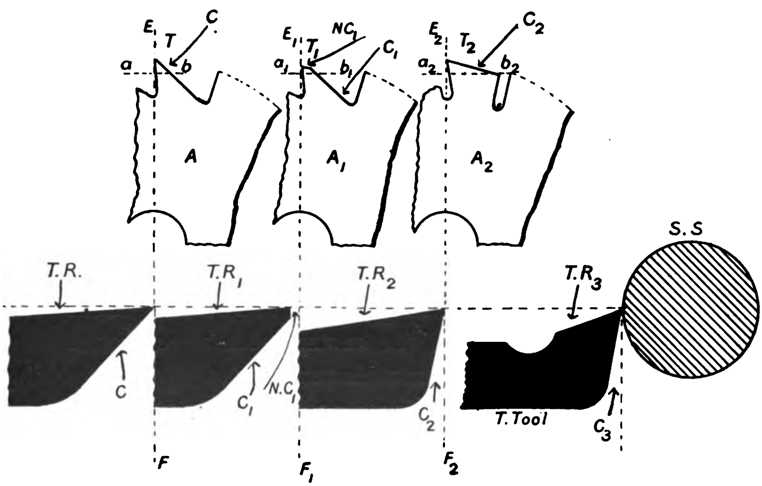


Fig. 81. Angle of Clearance on Metal Slitting Saws.

produced a new clearance angle, caused by the emery wheel having operated in the manner shown at O, fig. 79, while the old clearance is seen at C_1; but though we now have this new clearance N C_1, the strength of the tooth remains exactly the same. From the foregoing explanation it will be clear that the form of tooth given in fig. 80 is not serviceable.

To grind cutter teeth without waste.—When cutters are always ground to the same clearance, the least amount of metal is removed at each sharpening. Let us now see what happens if the clearance given to the tooth varies. Let the edge A B, fig. 82, become dull at A, and let it be ground to the line C D, which sharpens its edge and puts on more clearance; when the edge next becomes dull the tooth will possibly be ground to the line E F, just clearing up the whole surface which was left at the previous grinding, and bringing the tooth up to a sharp point once more at E. Now during these two sharpenings the tooth has been decreased by the amount A E, which is very considerably more than it would have been if sharpened to a constant clearance (see dotted lines *a b*, fig. 82). Hence cutters if sharpened to a constant clearance will last very much longer than otherwise. Taking the present example, fig. 82, if the cutter teeth were ground on a machine giving this constant clearance, the *first* sharpening would be as on the dotted line *a*, and the *second* sharpening as on the dotted line *b*, or even less than this, instead of the cutter teeth being ground off to the line E F.

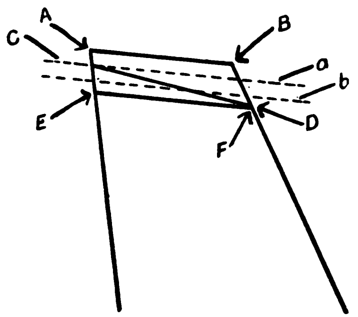


Fig. 82. Diagram of Grinding Clearance on Teeth of Cutters.

Effect of clearance on life of teeth.—The least possible clearance on the tooth of a cutter, which will enable the cutter teeth to cut freely, has been carefully investigated, and it is found to depend to a certain extent upon the kind of metal being cut. But the most suitable clearance varies within comparatively small limits, and is smaller than is given in most of the published tables for clearance. It seems likely, however, that these tables are compiled so as to allow a good margin to cover the inaccuracies of the workman grinding the clearance. The smaller the clearance, provided it is sufficient, the longer the edge of the cutter stands and the better the work. From this it follows that a properly designed cutter grinding machine should produce a clearance on the teeth of the cutter only just large enough to cut freely on all metals; and whilst the machine should be provided with means and be arranged in such a manner as to make it easy to obtain other clearances when desired, it is preferable that the clearance which the machine naturally produces on the cutter be adhered to. For if a cutter be sharpened first with one clearance and then with another, it wastes away far more rapidly than when a constant clearance is ground upon it. This was clearly indicated when noticing fig. 82, consequently the clearance has an important effect upon the life of a cutter.

CHAPTER IX.

MULTIPLE GRINDING.

In the sheet metal industries it is frequently necessary to grind and polish small articles on their edges, and in some instances these articles are produced in very large quantities. It is often essential that each of these small articles, after being ground and polished, should be so uniform with the others that no shop hazard collections will show any appreciable variation in shape or size. An example will demonstrate the immense advantage of the "multiple" method as regards both speed and economy, over one in which each article is ground singly.

Suppose we have several thousand gross of metal blanks in the form of *links*, like M in fig. 83, which, after having had the two small holes pierced, have to be ground all around the edge. By the single grinding method the link is placed upon the two pegs P P of the slide S, the slide S is brought up against the edge of the emery wheel E W, which has previously been carefully turned to a portion of the shape of one-half of the metal link, and by a slight pressure from the hand against the slide S the emery wheel is brought to bear upon the edge of the link as shown in fig. 83. The link is then reversed in position, replaced upon the pegs P P, and the edge of the other half of the link ground. The small portion of the edge at each end which still remains unground is finished by a plain semicircular emery wheel E W, running in front of a slide S in which is a single peg P, fig. 84, by grinding first one end and then the other, the link being quickly moved about in the various positions shown by the dotted lines, while slight hand pressure is exerted on the slide S. Although an expert operator may do the work fairly accurately, it is evident that the process is necessarily a very slow one.

The multiple method of grinding is illustrated in figs. 85, 86, 87 and 88. In figs. 86 and 88 thirty metal links M are shown threaded upon two wires, one of which is seen at L W. These

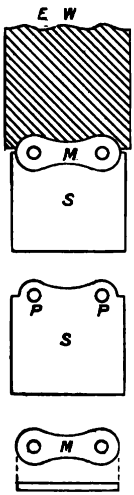


Fig. 83.

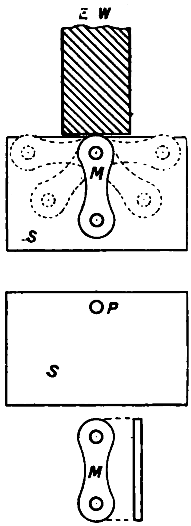


Fig. 84.

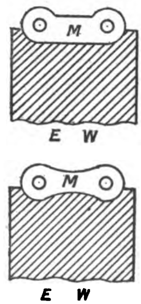


Fig. 85.

two wires are slipped into holes which have been drilled in the handles H at Y; when the ends Y Y are brought close up to the links M, the handles are gripped by the operator and the links are passed forwards and backwards over the top of the emery wheel E W. In fig. 88 the same operation is being performed on all the thirty links as was carried out in fig. 83, on one link only. Fig. 85, which corresponds with fig. 88, shows the section of two emery wheels E W, E W, one of which is shaped for a curved edged metal link, the other wheel for a link which has a portion of its edge flat. Fig. 86 shows the position of the multiple arrangement when grinding the ends of the links, and fig. 87 is the section of the emery wheel corresponding to the operation shown at fig. 86. Sometimes the links and wires are placed in suitable fixed chucks, the chucks being mounted upon slides, and the slides

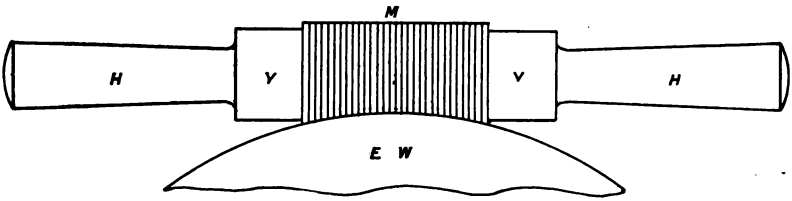


Fig. 86. Multiple Grinding on Ends of Links.

passed over the top of the emery wheel; this slide arrangement is necessary in some cases where absolute accuracy in grinding is required, but for general work an expert operator will produce rapid and excellent results by the multiple method and the two handles, provided the links are so accurately cut and pierced as to range quite evenly when threaded upon the two wires, for if the edges project unevenly, varying amounts of metal will be removed from each and the links will be of different sizes. Moreover, assuming that the links are of uniform size when threaded, it is necessary for the operator to keep his hands as steady as possible, for if there is any swaying up and down, the links will be unevenly ground, and the result will be great variation of size. Any convenient number of links can be threaded on the two wires. The chief difficulty in this method of grinding is the threading of the links on the wires, as extreme care is required to ensure the links fitting the wires easily without being in the slightest degree loose. This can only

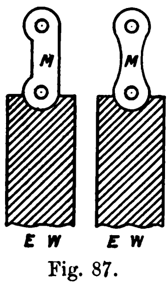


Fig. 87.

be done by piercing the holes accurately to within one-thousandth of an inch, and by carefully adjusting the distance between the centres of the two holes. If there is any departure from this standard of accuracy the links cannot be kept even, and cannot be steadily gripped, even by the aid of chucks. This difficulty is overcome by using special threading machines, one of which is shown in fig. 89, A B and D. In this figure are end views of iron castings, the under faces of which are so shaped as to allow of their being dropped on and fastened to a small machine bed, acting as a lathe bed. A is the threading head, B the head for guiding the wire, and D the drifting punch chuck. A and B are firmly fixed to the machine bed, while D is movable along the bed by means of the screw S S and nut N, actuated by the

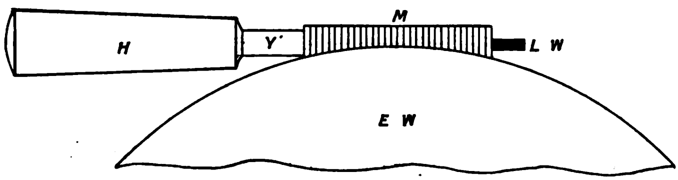


Fig. 88. Multiple Grinding on Backs of Links.

hand wheel W. As this machine is intended for threading links like those shown at M, a groove has been planed straight across in which these links can be mounted. V and E are two steel plates fastened to the end of A so as to prevent the links from falling out or from being pushed out of position. C is a hardened steel piece, planed to fit the head B, and drilled to freely pass the wires. The two pieces F are also of hardened steel, and are held in position in D by the top plate T P, so as to allow the shifting punches D P to be chucked. Z is a stop plate which receives the thrusts of the drift punches, and also garters the end of the screw S S to the drifting punch chuck. The upper portion of fig. 89 represents a plan of the machine when ready for mounting the links, but, in order to show the action, the machine bed does not appear in it.

The process of threading the links is effected in the following way. A number of wires (say two dozen) on which the links

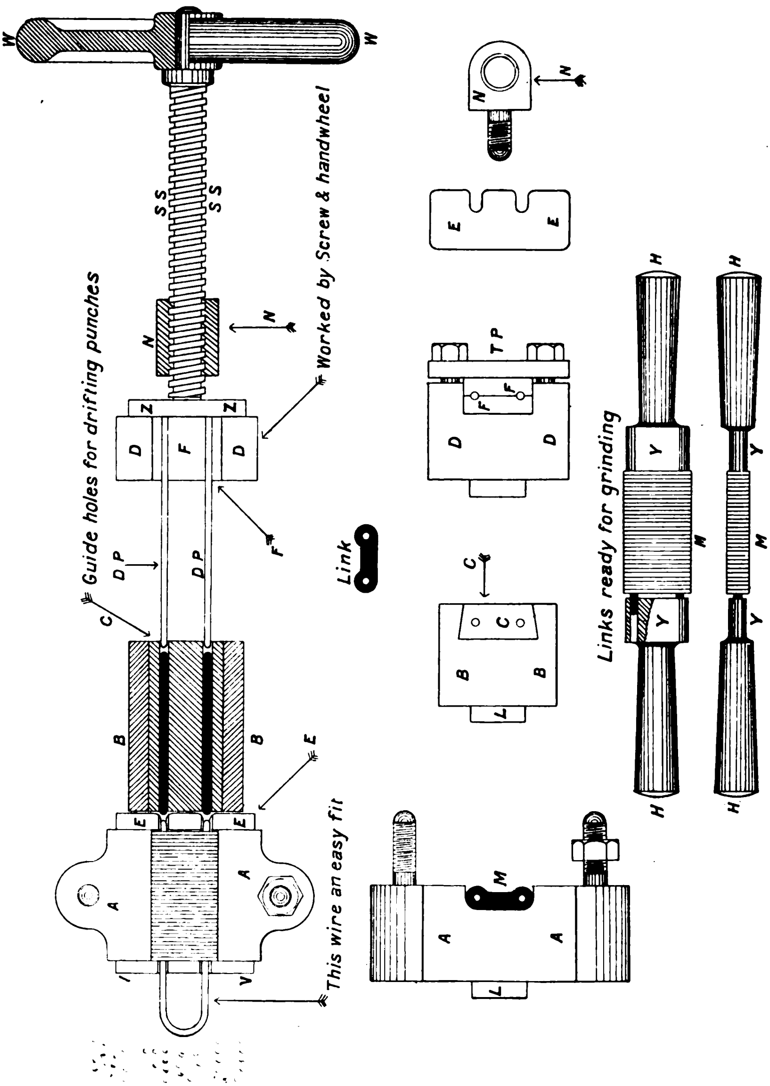


Fig. 89. Threading Machine for Multiple Grinding.

will fit easily are bent in the way shown in the casting A in the plan. Young operators rapidly thread a number of links (thirty or more) on each pair of bent wires by hand, and place them on the work bench near the threading machine. The machine operator has a number of other wires ready which have pointed ends and have been cut to a definite length. Their size is such that while the links cannot be put on them by hand, the wires can be forced into the link holes by the machines. Two of these large wires are shown black at C, as placed ready for being forced into the holes of the links. One of the bent wires, with its set of loosely fitting links, is dropped into the threading head between the steel plates V and E, and a top plate (not shown) fixed over the links by means of two studs and nuts (one of which is seen in the plan and end view) to prevent them from jumping up. On turning the hand wheel W the drifting punches D P advance and gradually force the pair of thick wires into the link holes, so as to displace the pair of the bent and thinner wires seen in the threading head A, until the latter drop into a box at the end of the machine. The pair of thick wires with the links are then slipped into the handles H H as seen at the bottom of fig. 89. By reversing the wheel W the drifting punches are withdrawn from the guide holes, and the operations repeated with another set of links. After a little practice this threading process is carried out with great rapidity. When the links have been ground and polished, they are unthreaded from the pair of wires by again placing these links in the threading head and pushing out the thick wires by means of longer and somewhat smaller gauged drifting punches than those used for threading.

CHAPTER X.

UNIVERSAL GRINDING MACHINES AND CUTTER GRINDING MACHINES.

A WORD or two is needed here as to the meaning of the term "Universal," as applied to grinding machines. As the previous chapters have shown, the number of grinding processes is very great, and the purposes for which they are applied exceedingly varied, so much so that no single machine could be devised for performing every kind of grinding operation. Hence, none can be entitled to the term "universal" without special qualifications. On February 27, 1877, the Browne & Sharpe Manufacturing Co. patented their Universal Grinding Machine. At that time grinding was almost entirely confined to cylindrical work, so that this machine, which is a cylindrical grinder, is universal only as regards this kind of work; after this date a demand arose for machines that would grind the teeth of cutters, and on November 3, 1885, the same firm patented a universal cutter and reamer grinder. Later, machines have been constructed which will grind an edge at any angle to a flat surface, but neither teeth nor cylinders.

The term is therefore only applicable to machines which can perform all the operations required for a special kind of grinding. It is misapplied in the case of what is called a "universal cutter and tool grinder," inasmuch as neither this machine nor any other can successfully deal with *every kind of tool.* Modern makers avoid the use of the word except for those machines which are universal for some special class of grinding work.

The result of the author's examination of the capabilities of numerous modern machines has led him to select the "Guest" and the "Ward" grinding machines as types illustrative of cutter and cylindrical grinding. In describing the "Guest" machine, attention is mainly given to the setting of the cutters, as exemplified in figs. 103 to 107, while in the case of the "Ward" machine the operations for grinding press tools are chiefly dwelt upon. Both machines are cutter grinders. But they are also convenient for external and internal cylindrical work. Many of the complex grinding machines, which are provided with attachments, may be employed for grinding cylindrical tools, as for instance sheet metal *press-tools.* But owing to the complicated adjustments on these complex machines, they have been little used for this purpose.

Messrs H. W. Ward & Co. have designed a set of useful and simple machines for dealing with tools. The machines are made in separate forms for special purposes, or in combinations as required; they include the universal cutter grinder, universal cylindrical grinder, cutter and tool grinder, general tool grinder, sheet metal tool grinder, and universal press tool grinder. The last mentioned machine is capable of successfully grinding cutting punches and dies, drawing punches and dies, and similar tools employed upon sheet metal; the working illustrations of it given in figs. 108 to 116 (Chapter XI.) show the machine specially arranged for grinding press tools in a simple manner.

The object of a cutter grinder is primarily to sharpen cutters when their edges have become dull. In most cases this is done by "*backing*" off their teeth, that is, by grinding the back of the teeth so as to give a certain amount of clearance to the cutting edge. The amount of this clearance is of the utmost importance, as is also the constancy with which it is secured (a subject fully discussed in this chapter). In large works, where numerous and varied expensive cutters are used, it becomes a matter of serious importance that the cutter teeth should be ground with such a suitable clearance that they not only cut well, but will perform the maximum amount of work before getting dull. Further, it is essential for the long life of the cutters that when their teeth are sharpened as little metal as possible be removed from the teeth themselves, since the future success of milling operations will mainly depend on increasing the weight of metal used up in actual cutting, and decreasing that wasted away by successive sharpenings.

The Guest Universal Cutter Grinder.—The combined universal cutter and grinding machine (fig. 90) is known as the "*Guest.*" It is especially suited to the requirements of general manufacturers, as, in addition to dealing with cylindrical internal and external work rapidly and accurately, it will conveniently grind cutters, reamers and similar tools. This machine is a great time-saver for the following reasons: (1) the style of grinding can be changed almost instantly; (2) as water can be freely used in ordinary grinding, the temperature is not raised sufficiently to interfere with the accuracy of the work; (3) the correct clearance of the cutters is automatically ensured, so that no time is spent in calculating and measuring.

General description.—The grinding spindle is carried in a head which revolves in a bearing in the body. It is so arranged that, whatever its position, the belt is always equally tight and the spindle therefore runs smoothly; it avoids the jar incidental to automatic tighteners, and the waste of time involved in hand adjusted tighteners. The tightener requires adjusting only a few times in a year, so that an endless belt can be used, which does not give the jar occasioned by the joint of a laced belt running at a high speed.

The wheel guards are designed for almost instantaneous removal and replacement (*when necessary*), the time required

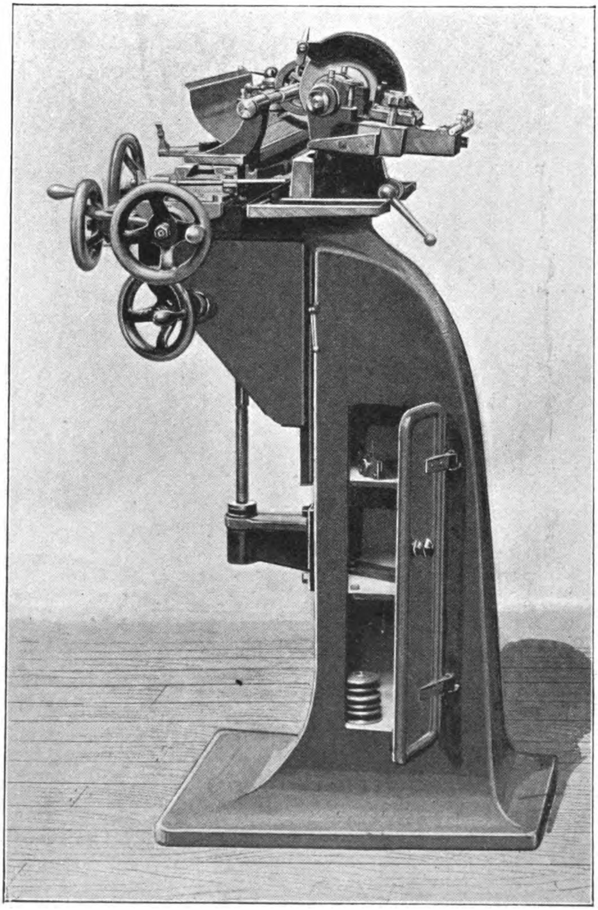


Fig. 90. "Guest" Emery Grinder. Position for Grinding Shafts and Tapers.

being so brief as to afford no excuse for an operator neglecting their use.

For ordinary grinding shafts, tapers and suchlike work, the head is used in the position shown in fig. 90. A quarter turn

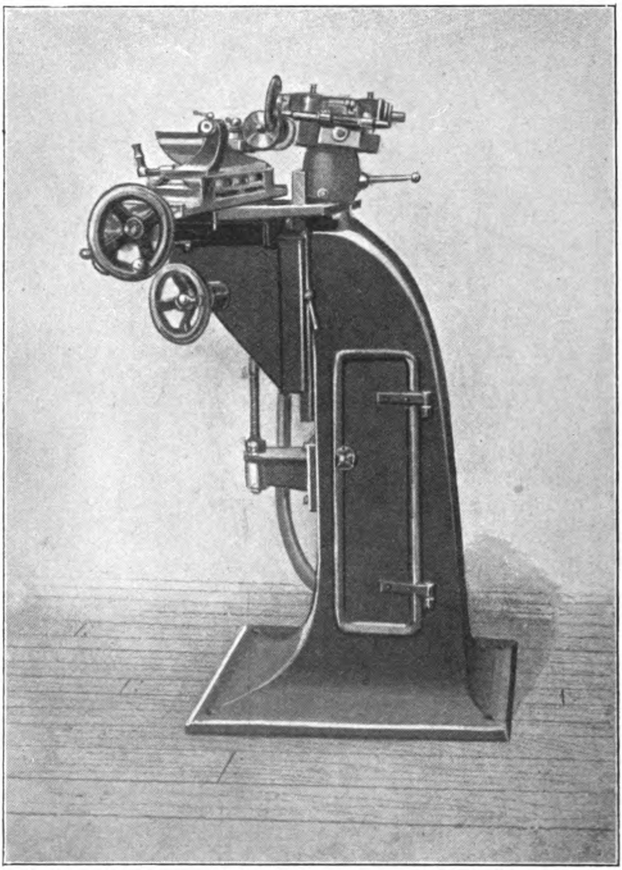


Fig. 91. "Guest" Emery Grinder. Position for Grinding Reamers and End Mills.

in either direction brings it into the position shown in fig. 91, used in grinding almost all cutters, reamers, end mills and taps. A further quarter turn brings the internal grinding spindle to the working position indicated in fig. 92. The internal spindle is driven from the ordinary grinding spindle by an open belt; this device of a revolving head instead of the knee enables the machine to be placed in line with others, and also allows of the operator always working from the same side, so that the

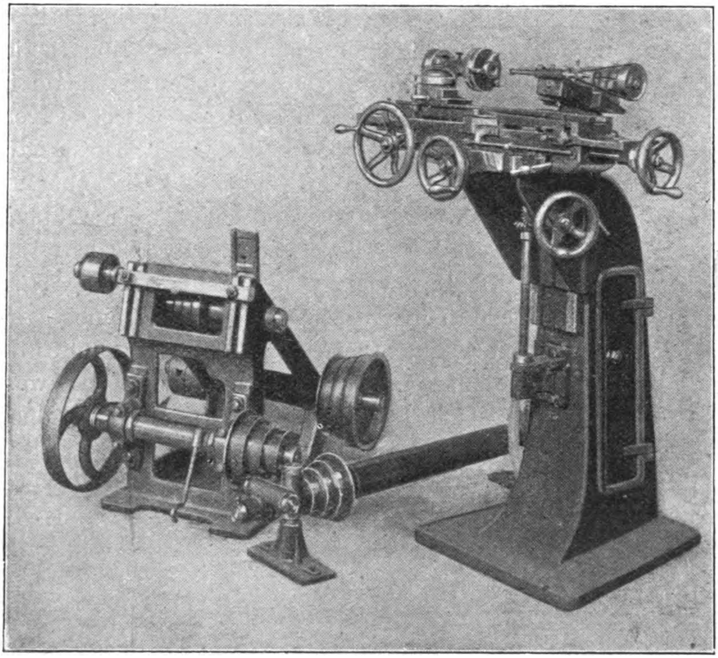


Fig. 92. "Guest" Emery Grinding Machine and Countershaft.

light always comes from the same direction, which, by proper arrangements, will be the most suitable one. This is a very important point when accurate grinding is needed.

The head can be quickly, easily and accurately set to any desired position; and owing to the stability of the machine, a deep stiff knee can be used, which renders it much easier to produce accurate work. On the other hand, it is very difficult to adjust the head to the right position in other machines when the knee with all its adjuncts—saddle, main slide, work-table, headstock, etc.—has to be moved round a column.

The use of water allows of highly finished work being done rapidly and accurately. Two shields of sheet metal, made to move with the headstocks so as always to be in position, effectually prevent any abrading material from being carried by water through the slides on to the top table; for should its surface be abraded, the true alignment of the headstocks is very soon interfered with. It will be noticed (fig. 93) that the overhang of the headstocks is very slight, and that the pull of the belt when grinding work of large diameter comes almost directly on to the saddle of the machine. By the half turn which brings the head into the position shown in fig. 92, it is automatically made to cross the belt of the machine, saving the operation which would otherwise be necessary, unless the work is held in a chuck on the left-hand side of the work headstock, a device seldom adopted owing to the awkwardness of gauging the work.

The new methods of cutter grinding adapted for the numerous and varied types are described in connection with the "Guest" machine on p. 116, but if necessary the clearance can be modified by the usual method of grinding at the back of the teeth. The uniform clearance automatically produced in the "Guest" machine has many advantages, such as (1) saving the time otherwise required for setting the machine and grinding each cutter, which may be considerable; (2) making the machine easy to use; (3) the clearance is practically flat, and just sufficient to allow of free cutting without heating, thereby giving the maximum efficiency to the cutting edges, as measured by the diminished cost of grinding, increased quantity of work done by a given weight of metal, decreased time required for repair, and longer duration of the cutters. In the ordinary way the operator makes excessive clearance, because if he make it too small his defective work is at once detected by the heating of the cutters, whereas the increased wear and tear consequent on the clearance being too large is credited to the presumed inferior quality of the steel.

The advantage of sharpening reamers on a machine which gives an unvarying clearance is obvious.

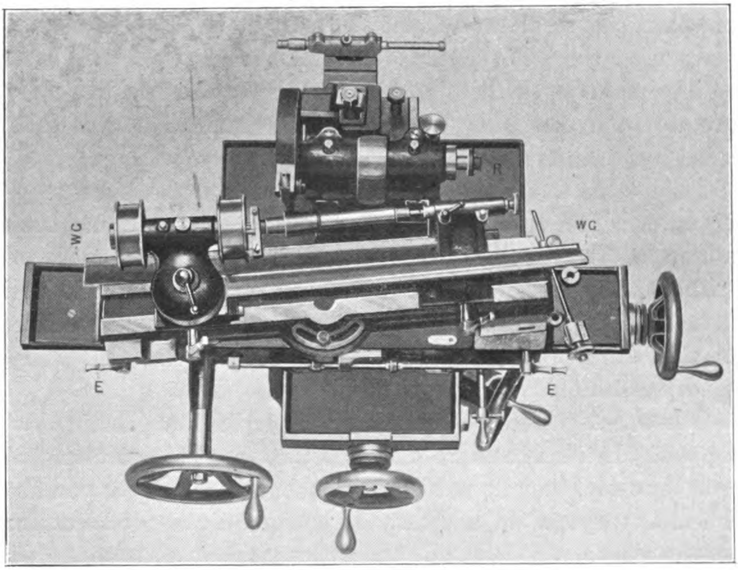


Fig. 93. Plan of "Guest" Grinder.

External Work.—For grinding shafts, arbors, tapers and other external work, the machine is used in the position shown in fig. 90, and the work, held between the centres or carried by one headstock, is driven from the overhead drum. The table should be set at the height indicated by the gauge, because, in quick work, the cross feed screw must size the work precisely. The grinding spindle need not be parallel with the main slide; indeed, when nearing a shoulder, it should be somewhat inclined. The emery wheel should be trued with a diamond tool when necessary, and the rod containing the diamond should be placed in a holder mounted upon the machine table and traversed by the rack feed. For large work the emery wheel should be on the right-hand side of the head, as at R, figs. 93 and 94, as the pull of the belt of the dead centre drive then always comes directly on to the saddle of the machine, the result of which is shown in the accuracy of the work produced. For light, small and slender work this is not so important, as the belt pull is less. Such work is frequently ground with the emery wheel on the left-hand side of the head, as seen at L in figs. 93 and 94.

The guards should always be used, as also a plentiful supply of water. The latter caries off the heat generated, and hence allows of the speed being increased beyond that practicable without the water. If the temperature rises too high, the work is liable to expand and to have the position of its axis shifted. Wet grinding produces a much better surface than is obtained by dry grinding.

The wheels should be run rather faster for dry grinding than for wet. If the wheels are not run up to speed they are wasted; that is to say, they do not remove as much metal per pound of wheel as they can do, and they do not produce so good a surface on the work.

If the wheels glaze, they should be rubbed with a piece of hand emery brick or old file, or re-turned with the diamond tool. If glazing still continues, the speed of the wheel should be lowered or a slightly softer wheel be substituted. Wheels that glaze are more liable to break than those which cut freely.

Fig. 90 represents the machine when grinding a parallel shaft. To grind tapers, the swivel table is set over so that it is not parallel to the main slide. It is usually required that

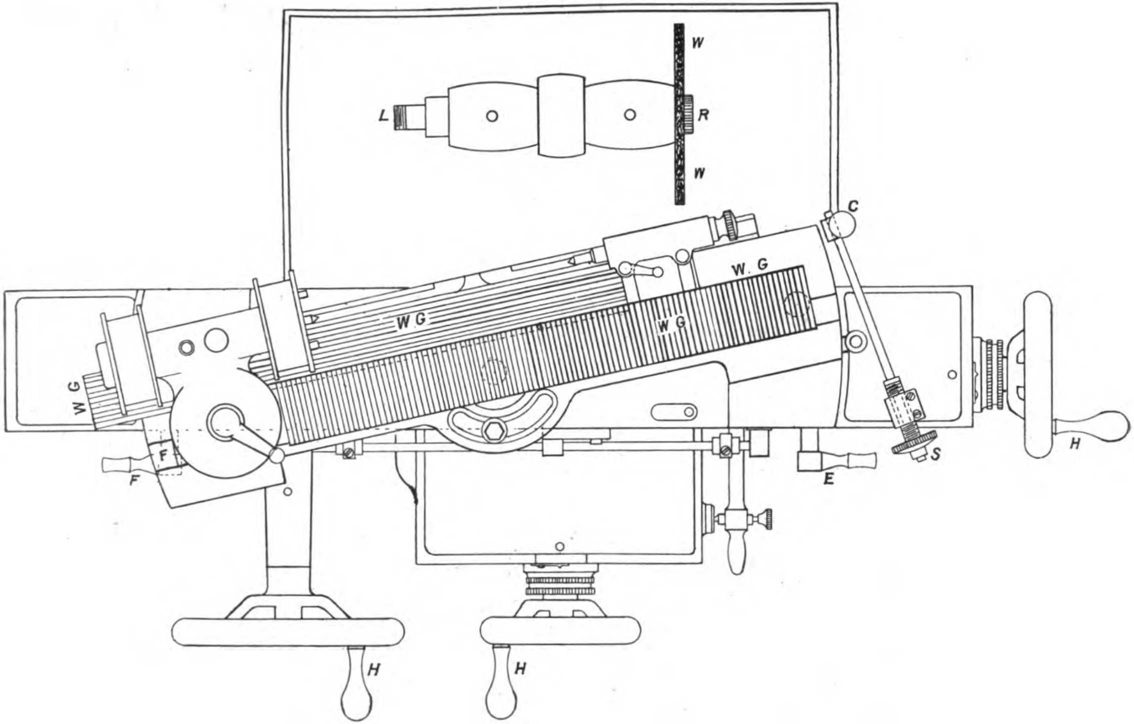


Fig. 94. "Guest" Cutter Grinder. Diagram showing position of Head.

some standard taper should be reproduced; the best procedure in this case is to place the copy between the centres (see figs. 93 and 94). The copy is then traversed in front of the indicator and the pointer watched, and the fine adjustment screws of the swivel table moved until the indicator pointer remains stationary whilst the copy is traversed. The swivel table is then clamped in position by the eccentric locks (which have not the tendency to turn the table that a bolt lock has). It is very important in taper work that the knee should be at the correct height, and that the swivel table should—*when set in any position*—be certain to remain there; this is the object of an eccentric lock. By this means all work, of whatever size or diameter, when ground on the machine, will have the same taper per foot or the same angular taper as the copy. These remarks apply to all taper work on any machine; for if the centre of the emery wheel is above or below the centre line of the article being ground, or should there be any tendency for the swivel table to rock about, it would be quite impossible to obtain a number of articles with identically the same taper.

Fig. 94 shows the position of the water guards W G of the work-table, *two* of which are shown shaded, and the figure indicates how they overlap and pass one another, and also how they clear the head and tail stocks. The water guards are clearly seen at W G in fig. 93. The change from one length of work to another is effected by simply adjusting the headstocks.

Figs. 93 and 94 show the method of setting the table to guide parallel on a desired taper. The clamp C is first unloosened and the table set by hand and eye nearly to the correct position. The clamp C is then tightened, and the fine adjustment screw S, fig. 94, used to obtain precision. The taper desired is then obtained quickly and accurately by changing the nut from one socket to the other; the arrangement works through an angle of 45 degrees, so that all tapers can be accurately set. The table, when adjusted, is clamped by the eccentric locks E F, fig. 94, which do not disturb the adjustment.

Internal Work.—For internal grinding the head is unclamped and a half turn made to the position shown in fig. 92. The pulley and belt for driving the small spindle is placed in position. As in external ordinary grinding, it is not necessary that the head should be set exactly square with the main slide, but the knee should be set at the correct height. The work is

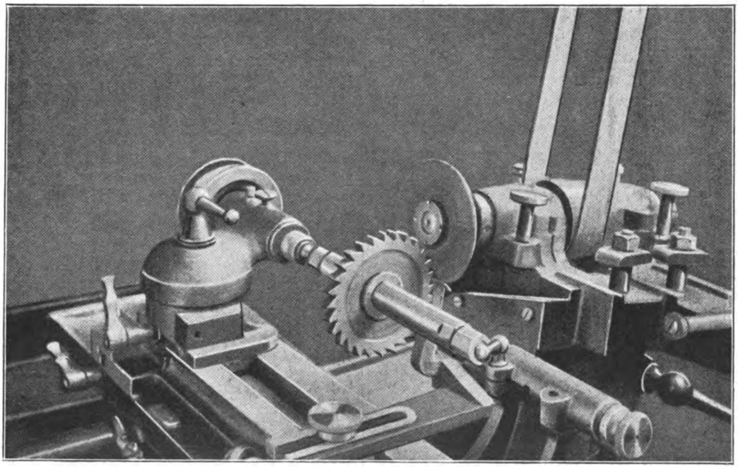


Fig. 95. "Guest" Cutter Grinder.

carried in the chuck on the headstock as shown in fig. 92. The guards should be kept in position. The emery wheel should be of softer grade than for external grinding.

Cutter Grinding on "Guest" Machine.—For grinding most cutters the grinding head of the machine is set in the position indicated in fig. 91; that is, the wheel shaft is inclined upwards at the needed angle of clearance, the top of the work-table is horizontal, and the axes about which the work-table and top of swivelling headstock rotate are vertical. Fig. 95 represents a cutter being ground. The tooth is located by a tooth rest, which acts as a pawl upon the tooth being ground, and fixes it at the same height as the centre. The tangent to the circle enveloping the cutter is then vertical, but the face of the wheel, which is of the cup or dish type, is concave. The edge of the tooth is inclined to this at the desired angle of clearance so as to put the correct clearance on the cutter. Hence, since

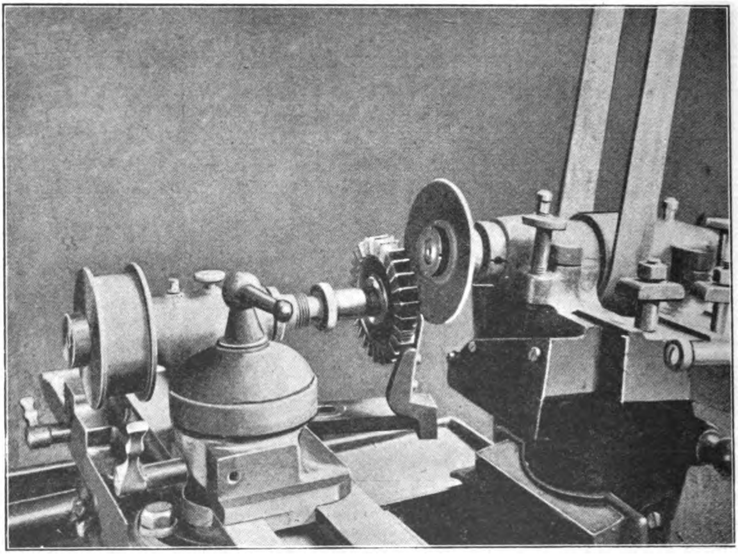


Fig. 96. "Guest" Grinder Sharpening a Face-Cutter.

the edge of the tooth rest is permanently fixed at the same height as the centres, the correct clearance is necessarily ground upon the cutter. It does not matter at what height the knee is set, but it is usually best to set it low and work towards the bottom of the wheel, nor does the diameter or angle of the cutter matter, for if the cutter has a uniformly varying diameter, that is, if it is an angular cutter, the clearance will still be the same. This will also be true when the angle of the cutter is so great that the cutter becomes a face cutter. Fig. 96 represents a cutter of this kind in the process of being ground.

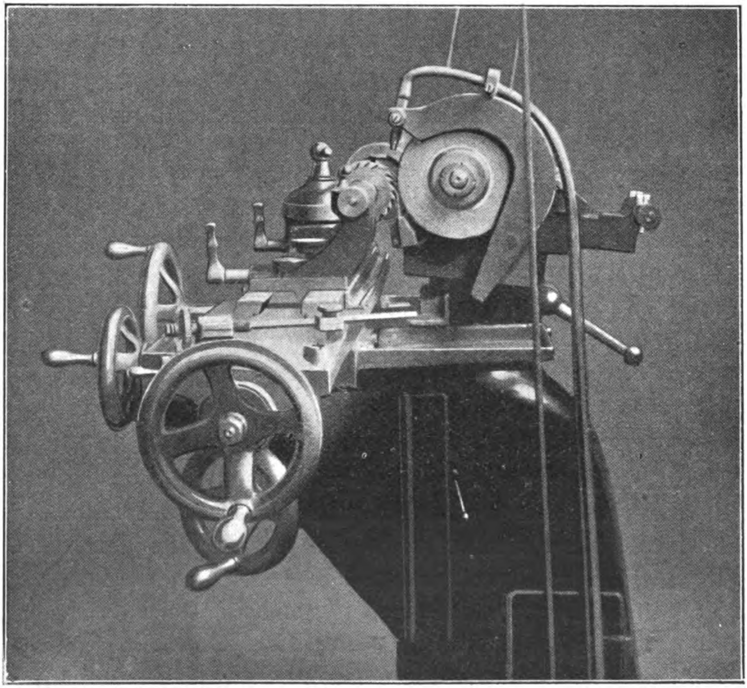
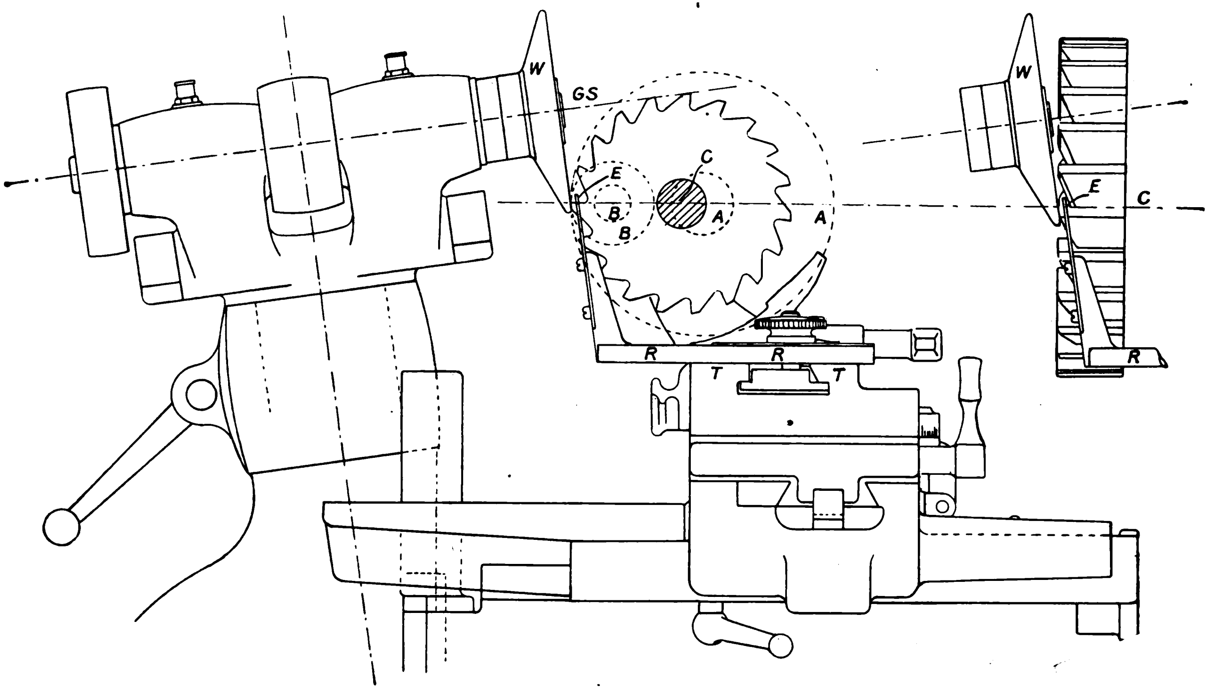


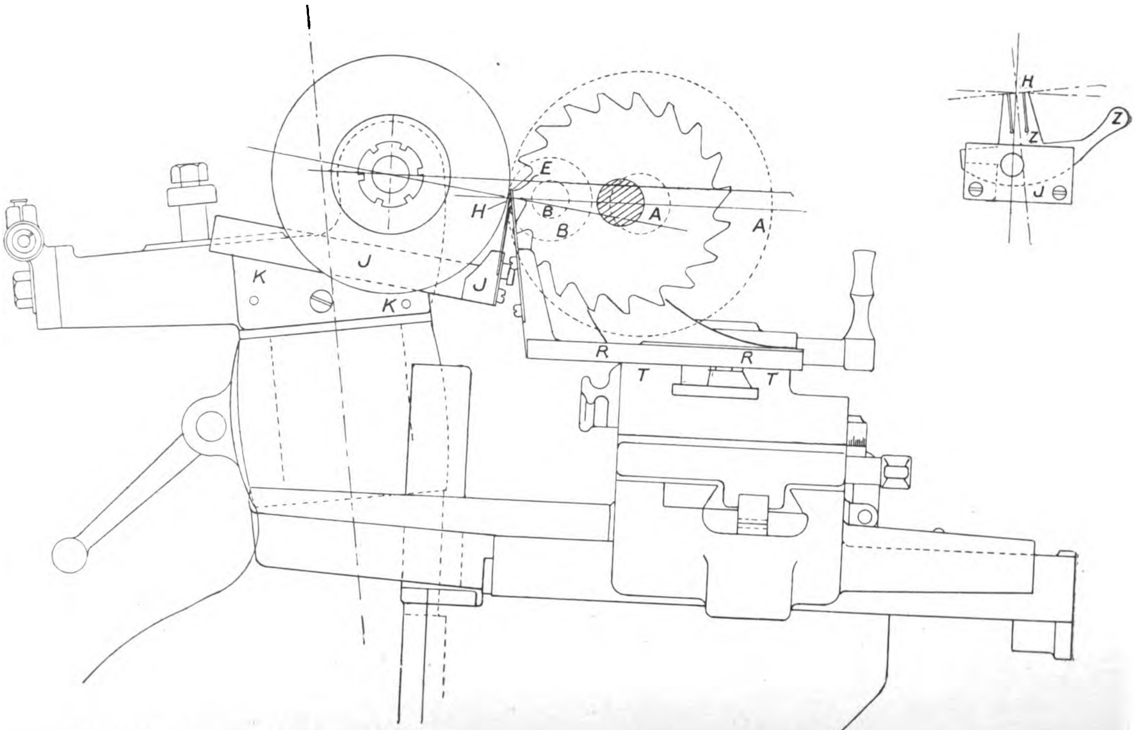
Fig. 97. "Guest" Grinder Sharpening on Edge of Wheel.

Sometimes, however, it is best to grind a cutter on the edge of the wheel, as is represented in fig. 97. To grind a cutter in this way, place the tooth rest on the inclined plane formed on the wheel headstock, and set it so that its edge is just outside the grinding wheel. Place the same tooth rest upon the table and adjust the knee until the edges meet. The table is then set for producing the correct clearance, the tooth rest removed, and the cutter set as shown in the figure. The manner in which the correct clearance is ground upon cutters may be traced by referring to figs. 98, 99, 100 and 101. Most cutters are ground by the method shown in fig. 98, from which it will be seen that the grinding spindle G S is canted upwards when in this position, and that the top of the work-table T is horizontal. The tooth of the cutter to be ground is located by the edge E of the tooth rest R, which works upon the surface T. This edge E is at the same height above T as the centre C of the work is, and consequently the tangent, at the point of the tooth being ground, to a circle enveloping the cutter, is vertical for all sizes and shapes of cutters, therefore the grinding wheel W, which is a cup or dish wheel, by being pitched over, puts on a clearance, which is the same for cutters of all diameters, as illustrated by the dotted circles A A and B B, which indicate cutters differing in diameter from that which is being sharpened. Fig. 99 shows a face cutter being ground by this method. It does not matter at what height on the wheel the cutter is ground, but it is usually considered best to set the table low, and to grind nearly at the bottom of the wheel. The clearance produced is flat and the edge smooth, both of which are advantages.

Sometimes, however, it is best to grind a cutter on the edge of the wheel as indicated in fig. 100. In this case the operation is as follows:—Place the tooth rest J on the inclined plane K, fixed to the wheel headstock, and clamp it so that its working edge H is just outside the wheel as in fig. 100. Place the tooth rest R (fig. 98) upon the table T as in fig. 100, and adjust the table until the edges H and E meet. The table is then correctly set, and any cutter is ground to the correct clearance, which, by arrangement, is to be the same as that obtained by the method given in the description of fig. 98. In fig. 100 the circles A A and B B, indicating cutters, are drawn



Figs. 98 and 99. "Guest" Cutter Grinder. Diagram of Face Cutter Sharpening.



Figs. 100 and 101. "Guest" Cutter Grinder. **Diagram of Sharpening Teeth on Edge of Emery Wheel.**

as before to show that this is so. The tooth rest J is of peculiar construction (see fig. 101); the blade Z is fitted to the body J by a circular arc, having its centre at the middle of the edge H. When a spiral cutter is to be ground, the blade is adjusted to fit the spiral of the cutter, but this adjustment does not move the centre of the blade, so that the same constant clearance is produced on spiral as on other cutters.

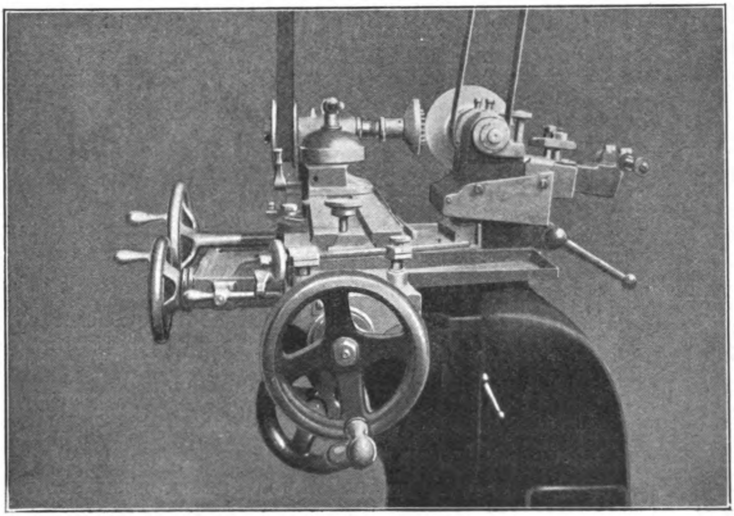


Fig. 102. "Guest" Cutter Grinder. Hollow-grinding a Slitting Saw.

Fig. 102 represents the operation of grinding the side of a slitting saw hollow; this slitting saw is one similar to fig. 80, as described in Chapter VIII. These saws, which are used extensively on metal work, are usually ground hollow after being hardened and tempered, but sometimes they are ground after hardening, but before tempering.

Typical American Grinders.—The author had an opportunity of inspecting a typical American universal cutter grinder, which may be called A, as it appears when set up for grinding a face-cutter. To set the machine for this operation, three distinct and important points of preparation were necessary:—

(1) Set the swivel head carrying the cutter round from its straight position through 90 degrees.

(2) Set the second swivel of the head to cant the cutter upwards through the desired angle of clearance.

(3) (After elevating the wheel head to the desired amount) set the tooth rest so as to hold the tooth to be ground exactly horizontal, the tooth rest being an adjustable one for this purpose.

In another type of American cutter grinder, which may be referred to as B, the machine was arranged for grinding a counter-bore (the same thing as a face cutter). In the case of machine B two important operations requiring both time and care were needed for setting, namely:—the No. 1 and No. 2 points as mentioned for machine A, and a third operation consisting in merely setting the tooth rest to the cutter by a method which need not be considered here. But the interesting point that could not be overlooked when viewing machine B was the occurrence of the *thin knees*, and the numerous right-angled elbows with adjustments, there being in this instance no less than eight. It may be mentioned that a good show of right-angled elbows is a characteristic of this type of American machinery. If good cutters are to be ground accurately it is necessary that a machine be steady, but the numerous joints and elbows, as also the weak knee in the case of machine B, would undoubtedly be very liable to yield in a way detrimental to accuracy in grinding. Probably this more than counter-balances the advantage gained (in example B) by abolishing one of the settings (necessary in A).

In the case of the "British" machine, fig. 90, another of these settings is abolished, so that only the first of the three settings mentioned for American machine A seems to be essential.

These setting operations that have to be performed for cutter work are comparatively easy compared with the trouble of bringing the second swivel of the head back *true again* when it is desired to return to circular work in the American machines. Any small error in restoring setting No. 1 (the only setting point which occurs in the "British" type of machine, fig. 90) is compensated for by the fine adjustment to the swivel table, but the second swivel of the head used in these "American" machines must be exceedingly accurately set back to zero, or else the machine would grind curved surfaces, because the centre will be vertically out of line. For instance, when machine B was set for internal grinding, unless the head was set back with a degree of exactness which in practice cannot be ascertained by the eye from the graduations, the axis of the running work spindle will be inclined to the line of travel of the main slide, which precludes the possibility of obtaining a perfectly true fit.

Further, when the American machine B was set up to be engaged on internal grinding, the workman is upon the horns of a dilemma: for when he attempts to gauge the hole to see how his grinding operations are proceeding, either he has to try the test gauge with his left hand, which few men can do successfully, or else he has to lean round the driving belt of the machine, which is a dangerous thing to do.

These troubles are owing to the inconvenient manner in which the machine is designed, and to its various attached parts. Another point concerning the machine B was the setting up of the machine for grinding gear cutters, as a special device was required to be used; in fact, a large number of special devices are necessary if many varieties of cutters are ground in some of the American types. The device for setting the teeth and holding them in position (in the case of machine B) consists of a centring gauge to which the tooth is set, and a tooth rest which is then set to the tooth. The centring gauge is removed after the tooth rest has been properly set, and the cutter is then ready for grinding.

In the "British" type of machine, fig. 90, the necessity for special attachments (when grinding gear cutter, reamers, etc.) is done away with; these and similar tools are simply held between the ordinary centres for grinding.

CHAPTER XI.

"WARD" UNIVERSAL CUTTER GRINDER.

THE Ward grinding machines are designed in several combinations, as was mentioned in the opening of Chapter IX. These combinations are arranged to meet the requirements of the various industries; for instance, in some workshops there are large quantities of cylindrical external and internal work to be ground, varying from $\frac{1}{2}$ inch to 10 inches in diameter, whilst there are no cutters whatever to be sharpened; in a case of this kind the machine must necessarily be a purely cylindrical grinder.

In another works where a large variety of cutters and reamers have to be sharpened, and where, possibly, an occasional cylindrical piece of work has to be ground, it would then naturally be essential that the machine be practically a complete cutter and reamer grinder, and yet be capable of dealing with an ordinary piece of cylindrical work when required, by the aid of certain attachments to the machine. It is in instances of this latter kind that the machine represented by fig. 103 comes in useful. The machine is arranged for sharpening cutters, reamers and drills; the slides are mounted on a round column which provides for bringing the work centres in line, at right angle or at any intermediate angle, with the emery wheel spindle. A fixture is provided for holding a twist drill grinding attachment. The knee bracket K B is attached to the column; M S is the middle slide upon which the swivel slide S is fixed ; T is the table or top slide whereon is placed the adjustable table T G to be used for taper grinding ; the former F is used for cutter grinding ; W D are the two heads

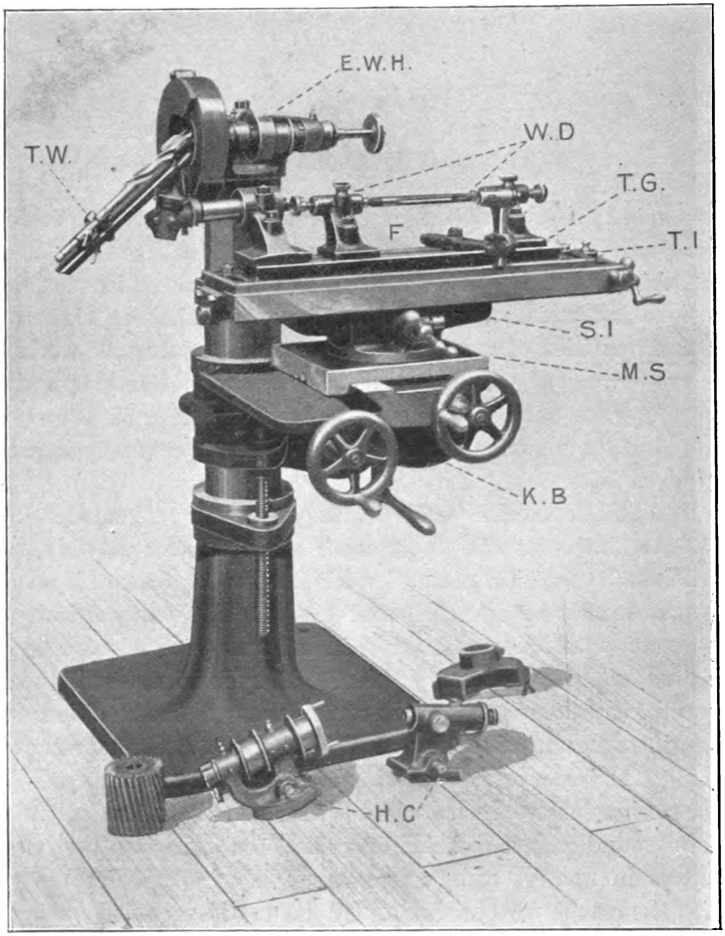


Fig. 103. "Ward" Combined Cutter Grinder and Twist Drill Grinder.

carrying centres for receiving the cutters to be ground; E W H is the emery wheel headstock, and the twist drill grinder is indicated by the letters T W. The two heads H C at the bottom of fig. 103 are separate heads provided for occasional cylindrical grinding.

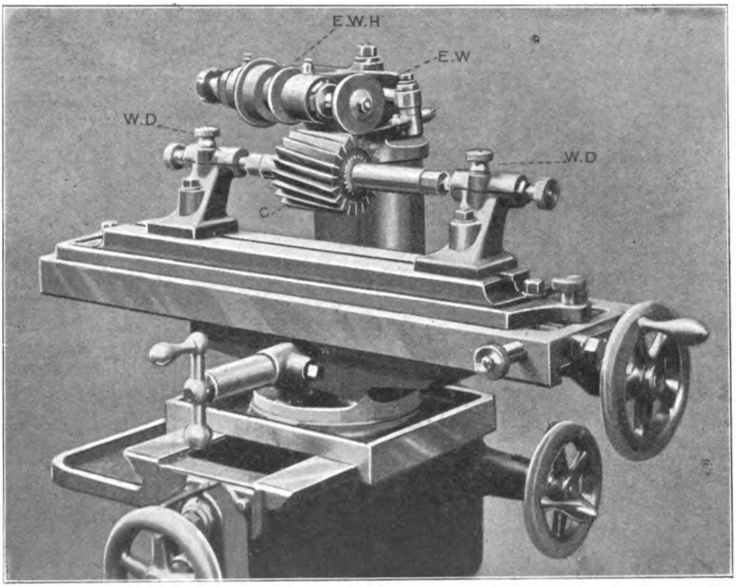


Fig. 104. "Ward" Cutter Grinder. Sharpening a Spiral Cutter.

Fig. 104 represents a machine as set up for grinding a spiral cutter. The emery wheel E W is operating upon the top of the cutter C; the cut is put on vertically by means of the lower hand wheel seen at the right-hand side of the machine. The point of the former being placed immediately at the back of the tooth that is being ground, the operator, with his right hand upon the hand wheel at the end of the table, winds backwards and forwards, whilst, with his left hand on the cutter, he keeps the cutter tooth bearing on the former, thereby giving the spiral movement necessary. The former consists of a piece of spring steel, so that after one tooth has been sharpened the cutter is moved backwards, and the spring steel former clicks into position on to the next tooth like a ratchet.

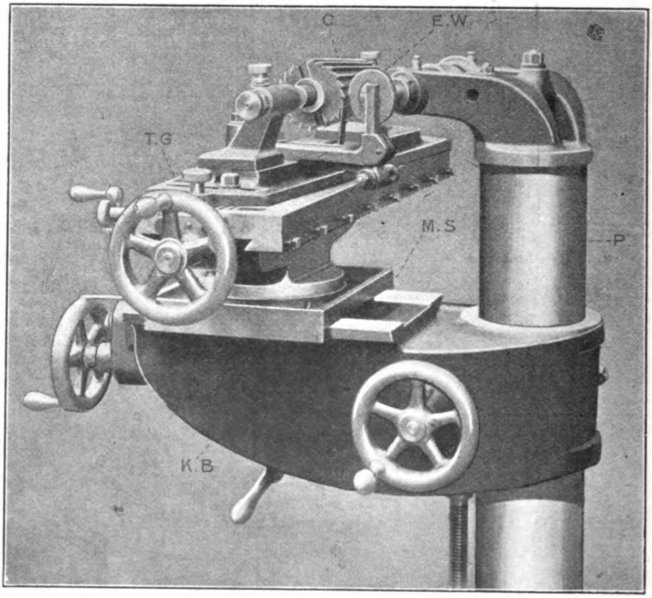


Fig. 105. "Ward" Cutter Grinder. Sharpening a Taper Milling Cutter.

Fig. 105 shows the machine sharpening a taper milling cutter, the teeth of which are straight. In this arrangement it will be noticed that the knee bracket K B has been raised higher up the column so as to bring the centre of the cutter level with the centre of the emery wheel, the reason for this being that the set-over of the table for taper grinding is in a horizontal direction. The table will swivel to the extent of 10° in either direction. It has a fine screw adjustment graduated to half degrees and to inches per foot. The cut is made in a horizontal direction by the hand wheel on the extreme left of the machine.

In fig. 105 the former is placed upon the table; in fig. 104 on the head.

Fig. 106 represents an involute milling cutter being ground with a dish or cup wheel E W, the face of the dish wheel

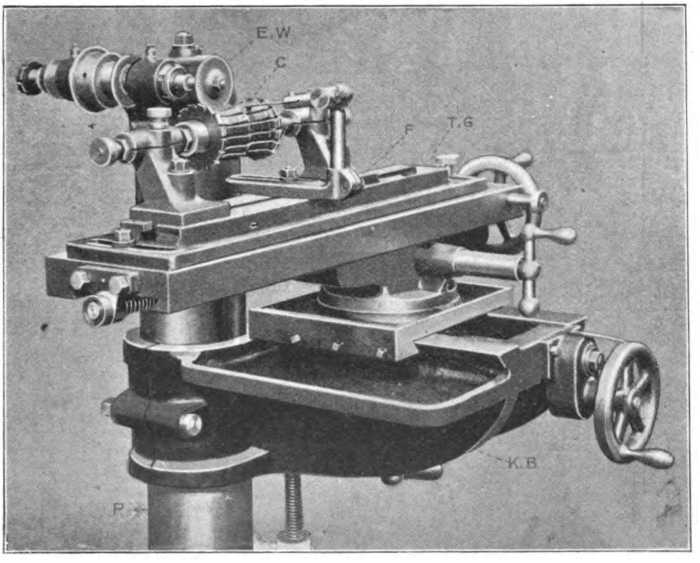


Fig. 106. "Ward" Cutter Grinder. Sharpening an Involute Cutter.

operating upon the face of the tooth instead of the top. This is a case where it is absolutely necessary that the emery wheel spindle should be at right angles to the axis of the cutter that is being ground. The former in this case is placed at the back of the tooth, it being impossible to place it on the same side as that on which the emery wheel is operating.

A plan of the cutter grinding head is shown at fig. 107, in which is seen the adjustable table and the headstocks holding

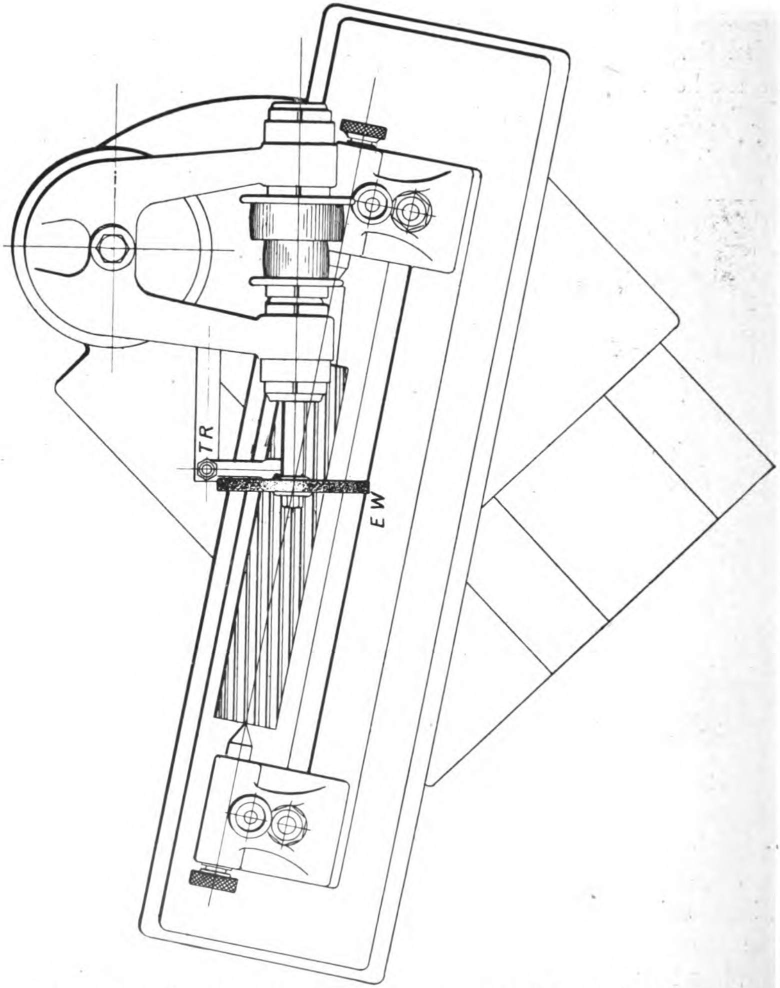


Fig. 107. "Ward" Cutter Grinder. A plan of fig. 104.

a long spiral cutter which is being operated upon by the emery wheel E W. The former T R places the tooth in position and keeps it there whilst the emery wheel does its work; this is really a plan of the work as seen in fig. 104, and explained when reviewing the action of that figure. It will also be noticed in the plan fig. 107 that the axis of the grinding spindle is set in line with the spiral.

Grinding Press Tools.—In reviewing the ancient and modern methods of tool grinding in Chapter I., several kinds of what are known as ordinary metal cutting press tools were mentioned, besides an indication of the extensive varieties of shapes, forms and classes of cutting tools that come under the classification of press tools; in fact, it is questionable if any other industry opens up so many inducements for speculative ideas, or creates so much inventive thought as do the various branches of sheet metal working. It will therefore be apparent that it has not been an easy matter for makers to design a grinding machine suitable for dealing with these very varied kinds of peculiarly shaped tools. The difficulties are not so much in performing the actual grinding operations, as in providing suitable means for holding the varieties of tools in proper position whilst the tool is being operated upon by the emery wheel. These difficulties, however, have been overcome in many instances, at comparatively small cost, by adding extra attachments, whilst in other cases they have been correspondingly expensive; some of these attachments are in the form of chucks and vices, and are illustrated herewith.

It may be noted here that the universal cylindrical grinding machine of the ordinary standard type, illustrated and described in the latter part of this chapter (figs. 117 to 119), can be used for grinding certain varieties of cylindrical press tools, both externally and internally; and in works where this type of machine is installed, it is often used for the purpose of grinding cylindrical cutting-out punches and beds. A machine of this kind would find constant employment in a small arms ammunition or similar works, where large quantities of cylindrical punching and drawing tools are used.

Again, a surface and angle grinding machine would perform many operations with convenience that would be difficult to manage upon a universal cylindrical grinder, so that in works where both these machines were installed, they could be jointly worked with a fair amount of success, the one doing cylindrical cutting and drawing tools, the other dealing with the surfaces and angles of flat-topped cutting beds and their bevelled edges, or grinding the cutting faces of square, rectangular or similar cutting punches. The same observation applies to many other machines illustrated in this work; that is to say, on many of the special machines a few kinds of press tools may be ground with a little scheming, but considering that it would be necessary to provide several machines, each of different design, to be able to manage all the tools in the press shop, their cost would more than counterbalance the advantages they would provide.

It will therefore be understood that one machine must be provided to meet the whole requirements of the shop. A grinding machine, to be thoroughly useful and successful on press tool work, must of necessity be capable of performing grinding operations in many directions, either vertically, horizontally, or at any intermediate angle. Hence it is advisable to construct the emery wheel headstock so that it will be capable of making a complete revolution in a horizontal plane. The table slides must be designed for giving motion both to and from the emery wheel headstock, and be capable of moving backwards and forwards in front of the emery wheel in a transverse direction. The table must also be provided with means by which it can be raised or lowered through a reasonable height in relation to the emery wheel head. A swivel table should also be provided. The machine illustrated in figs. 108 to 116 has been designed to give these movements. When such a machine is provided with the necessary fixtures or attachments, in the shape of work heads, chuck and vice for holding the tools, the varieties of tools, both punches and beds (within the limits of

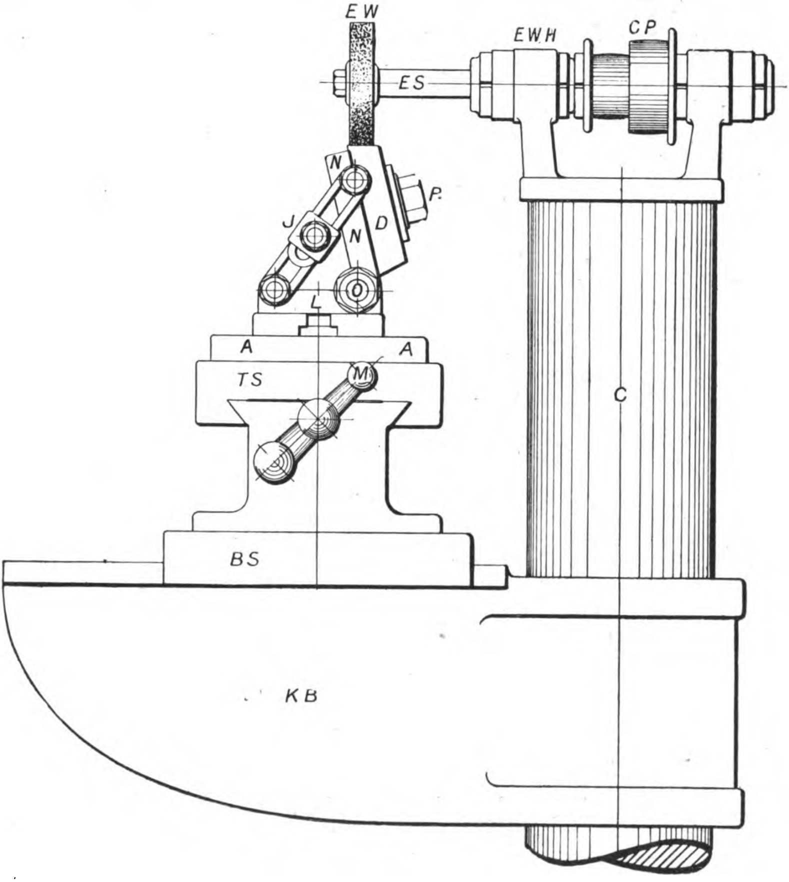


Fig. 108. "Ward" Machine operating on the edge of Press Die.

the machine), that can be ground thereon, are so numerous that it would seem to justify the name Universal Press Tool Grinder being given to the machine. It is true that there may be an occasional special tool requiring to be ground that might present some little difficulty, but seeing that this is likely to occur in any other department of grinding, it need not be taken into account.

Referring to fig. 108, which is an end view of the press tool grinder, the emery wheel head E W H carries the external grinding spindle E S and the two-speed cone pulley C P. The

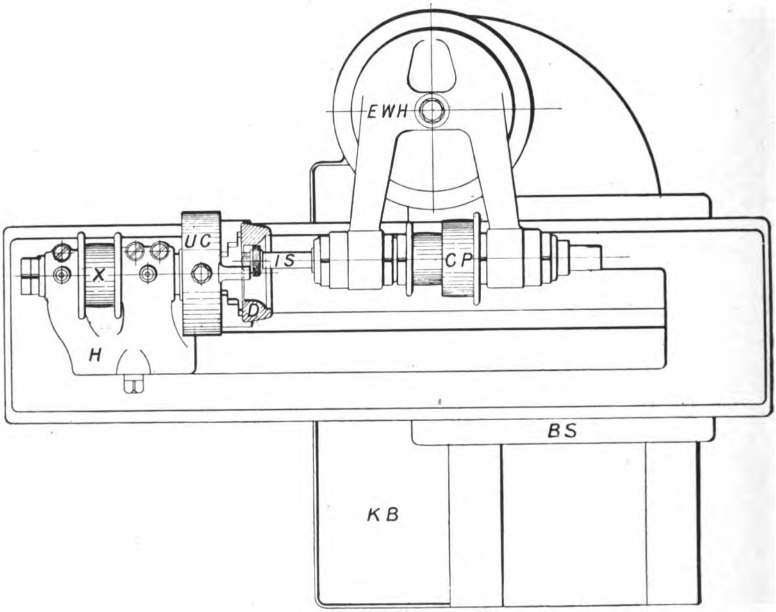


Fig. 109. "Ward" Machine grinding Press Drawing Die.

column C carries the knee bracket K B. The bottom slide B S can be traversed either towards or from the column as desired by means of screw and hand wheel (not shown in the figure). The top slide T S can be traversed in either direction at right angles to the motion of the bottom slide B S by means of the handle M. The swivel table A can be arranged to swivel 10 degrees or more as desired in either direction; it carries a special chucking device used for holding cutting-out beds whilst being ground upon their bevelled edges; this device consists of a base plate L and a receiving plate N N, these two plates being hinged at O. The cutting-out bed D is held in position on the receiving plate N by means of the pin R. A double set of slotted links are provided for moving the receiving

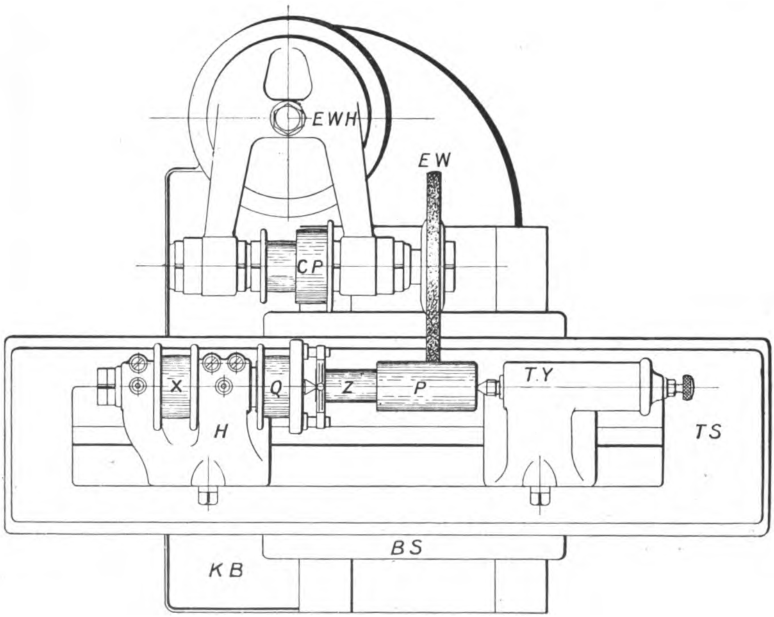


Fig. 110. "Ward" Machine grinding Punch.

plate N so as to place the edge of the bed D at any desired angle; this angle is obtained by loosening the pin J and telescoping the links. In the figure the emery wheel E W is grinding one angle of the bed. The machine is shown in plan at fig. 109, and is set up for grinding the hole of a cupping or drawing die D; the emery wheel head E W H has been moved through 90 degrees, so as to bring the small internal grinding spindle into proper position to grind the die; this die D is held by the universal chuck U C, the chuck being mounted upon the headstock H, and driven by the pulley X.

An example of grinding a drawing punch is seen in plan fig. 110. As this is an instance of external cylindrical grinding, it will be noticed that the universal chuck seen in fig. 109

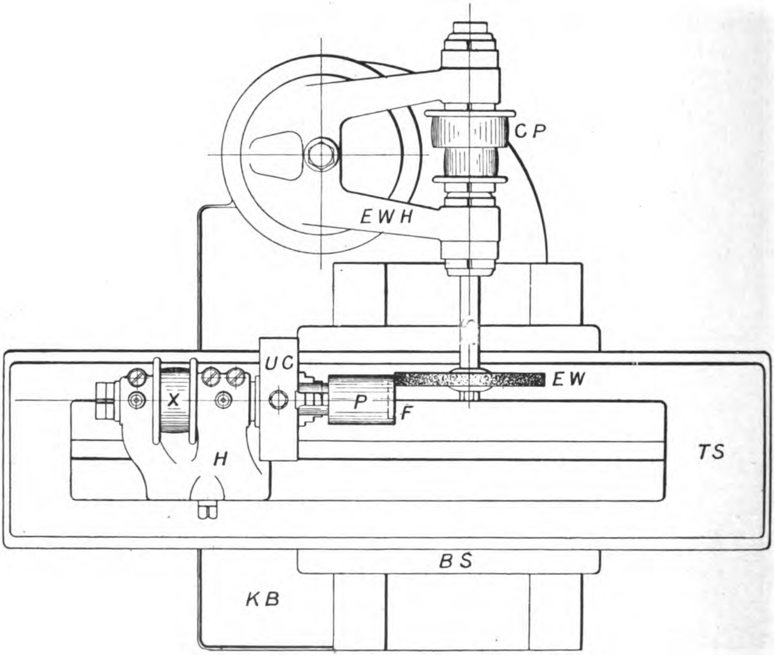


Fig. 111. "Ward" Machine grinding Face of Press Punch.

has been removed to allow of the special bronze bushed pulley Q being put into place, and the tailstock T Y has been fixed in a position for receiving the drawing punch P. In this example the spindle and pulley X remain stationary in the head H, whilst the pulley Q drives the punch P on dead centres by means of the studs and plates. These plates, which act as carriers or drivers, are shown fixed to the shank Z of the punch, while the emery wheel E W is grinding the punch P parallel to some definite diameter. These drawing dies and punches are usually bored or turned, as the case may be, to their exact finished size whilst they are in the soft state, and it is a frequent occurrence for

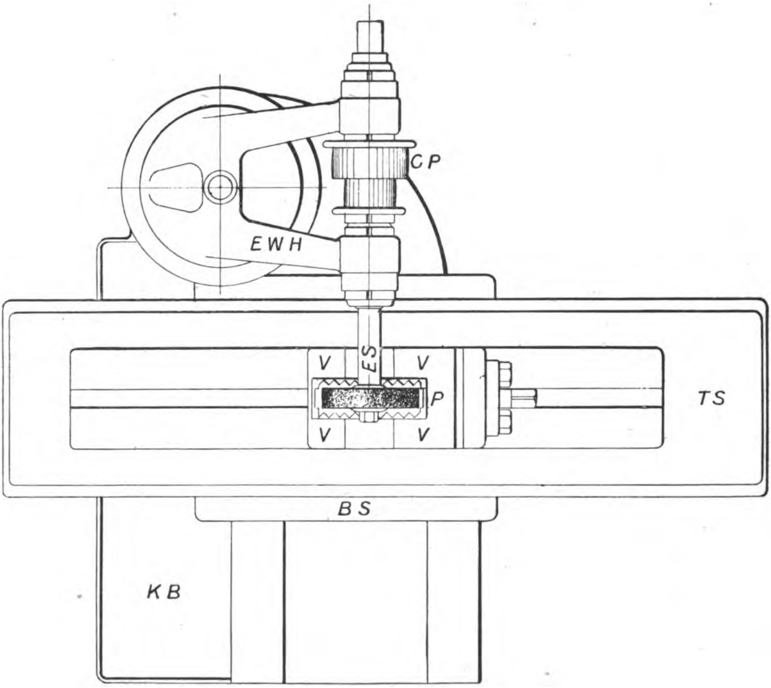


Fig. 112. "Ward" Machine. Plan showing Emery Wheel surfacing end of Press Cutting Punch.

them to warp slightly whilst undergoing the hardening and tempering process. It is on this account that the grinding machine is so valuable for dealing with drawing tools, because the hole in the die may be left slightly smaller in diameter when being bored, or the punch left larger when being turned, until they have been hardened and tempered. They can afterwards be ground perfectly smooth and to size by means of the emery wheel.

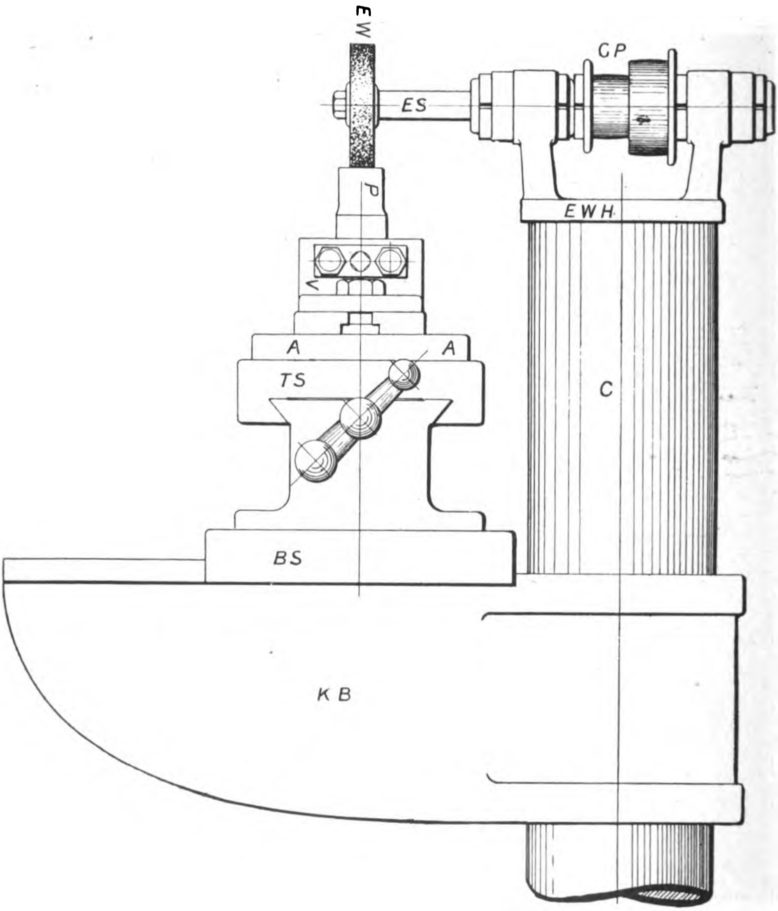


Fig. 113. End Elevation of "Ward" Machine operating as shown in fig. 112.

The plan fig. 111 shows the emery wheel head E W H in the same position as it was in fig. 108, but in fig. 111 the knee bracket K B has been raised higher up the column to bring the centre of the work head spindle level with the centre of the external grinding spindle; the cylindrical cutting punch P is chucked by its shank in the universal chuck U C, whilst the edge of the emery wheel operates upon the face F of the cutting-out punch.

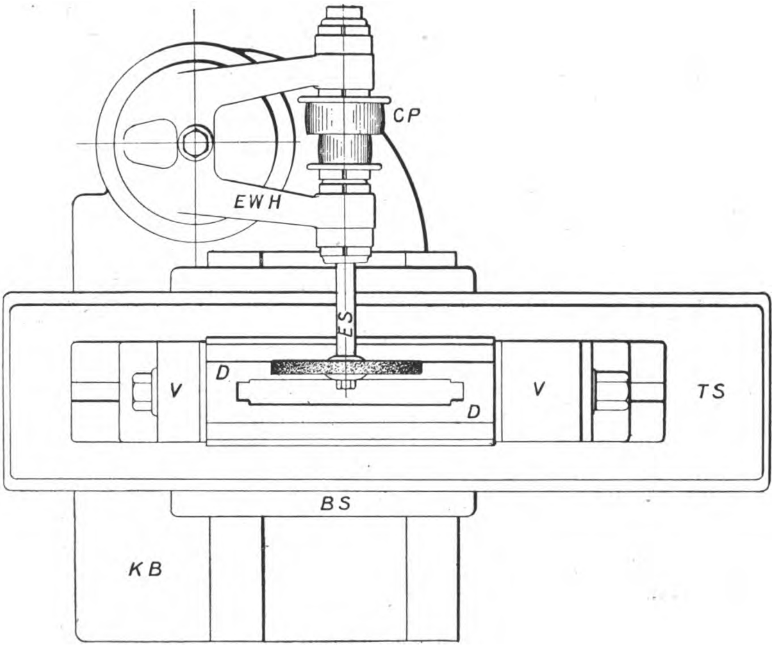


Fig. 114. "Ward" Machine grinding Press Die.

Another example of a machine for cutting-punch grinding is illustrated by the plan and elevation in figs. 112 and 113: the punch is for cutting out a portion of a cycle pedal; the knee bracket K B has been lowered down the column C sufficiently to permit of the punch face being brought directly under the emery wheel; the punch is held by its shank in the vice V, and the top slide T S is worked alternately backwards and forwards under the emery wheel, the bottom slide B S being moved from time to time so as to make the emery wheel operate upon another portion of the punch face. Many varieties of both large and small cutting punches and beds may be ground with the machine in this position.

Fig. 114 shows a large cutting bed held between the jaws of a screw vice whilst its top cutting edges are being sharpened

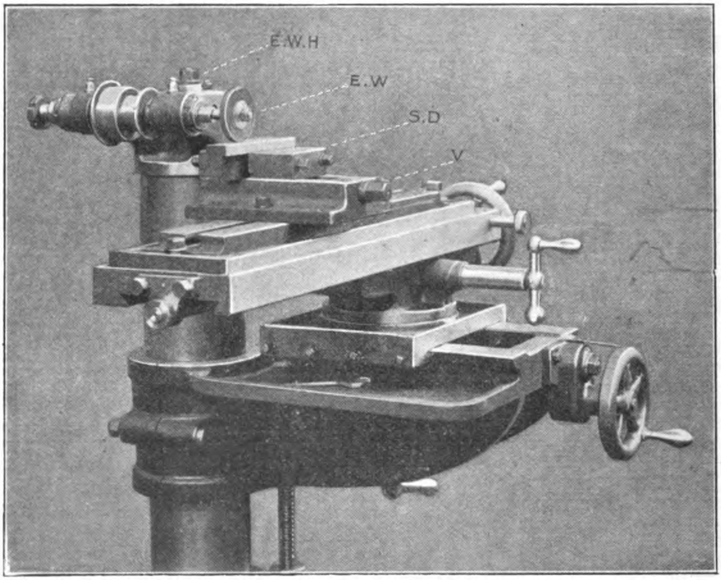


Fig. 115. "Ward" Machine surface grinding.

by the emery wheel operating upon its top face or surface; the machine is fixed in the same position as is indicated in figs. 112 and 113.

Two photographic views of the machine are seen in figs. 115 and 116. In the former case an emery wheel is grinding the top surface of a steel bed S D, and the bed is held in an ordinary machine vice.

In the latter case, fig. 116, a steel bush has been chucked in the universal chuck; the small emery wheel, mounted upon the internal grinding spindle I G S, is in the position it was when about to begin the operation of internal grinding.

"Ward" Universal Cylindrical Grinder.—The "Ward" universal cylindrical grinder, fig. 117, is a general purpose machine. It meets all the requirements of tool-room or cylindrical work within its capacity, such as

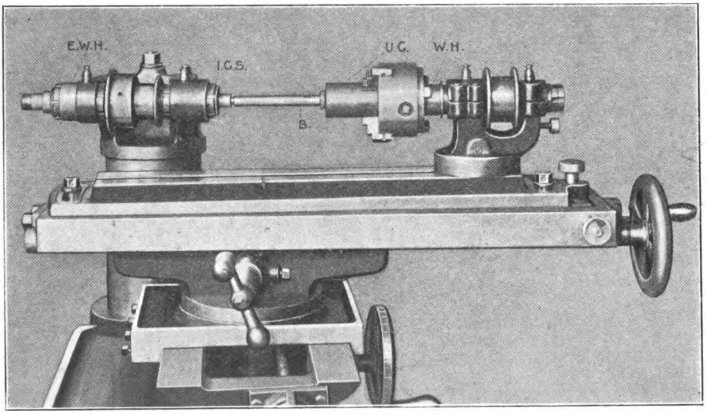


Fig. 116. "Ward" Machine grinding Steel Bush internally.

shafts, spindles, bearings, taper or parallel, external and internal work, gauges, collars, bushes, etc. The photograph fig. 117 gives a clear front view of the machine, and shows the various parts of the machine when ready for receiving a piece of work for external grinding. The photograph is lettered in conformity with the plan, front and end elevations, fig. 118, so as to enable the different parts of the machine to be traced. The machine is driven by three countershafts: the first receives its motion from the main shaft, and transmits motion by cone pulleys to the second and third countershafts, thus allowing a variation of speed both of the work being ground and of the emery wheel.

The headstock H W has a spindle running in adjustable bronze bearings, and can be swivelled for the purpose of grinding short sharp taper work in the chuck. A 4 inch

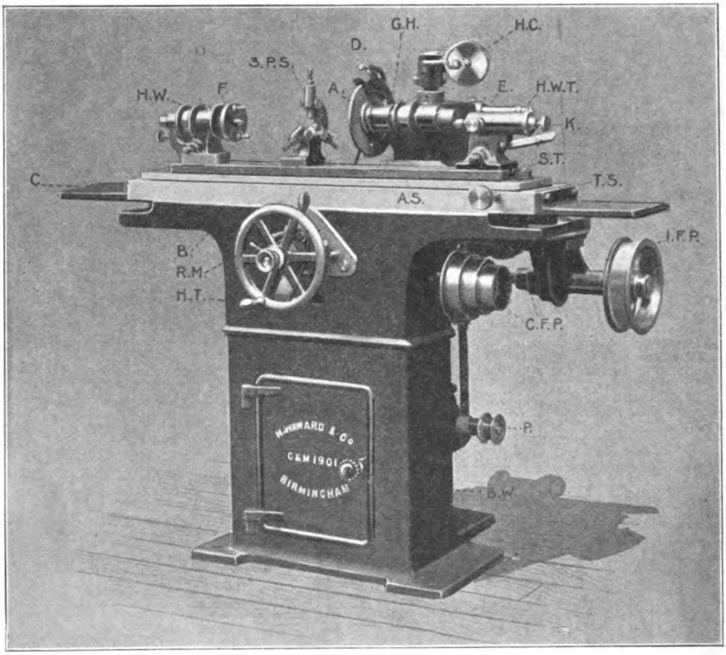


Fig. 117. "Ward" Universal Cylindrical Grinder.

universal chuck is used for work that has to be ground internally. For such work the spindle and chuck are driven by the pulley H W, which is seen in the centre between the spindle bearings. For external grinding the loose pulley F which runs on the front end of the spindle is used; this pulley is bushed with a bronze bush, so that whilst the rotating pulley moves the work, the spindle and centre remain stationary, and as the work therefore runs on dead centres it will be perfectly true. The tailstock H W T is arranged with a spring adjustment so as to allow of the removal of work for examination readily, and to provide room

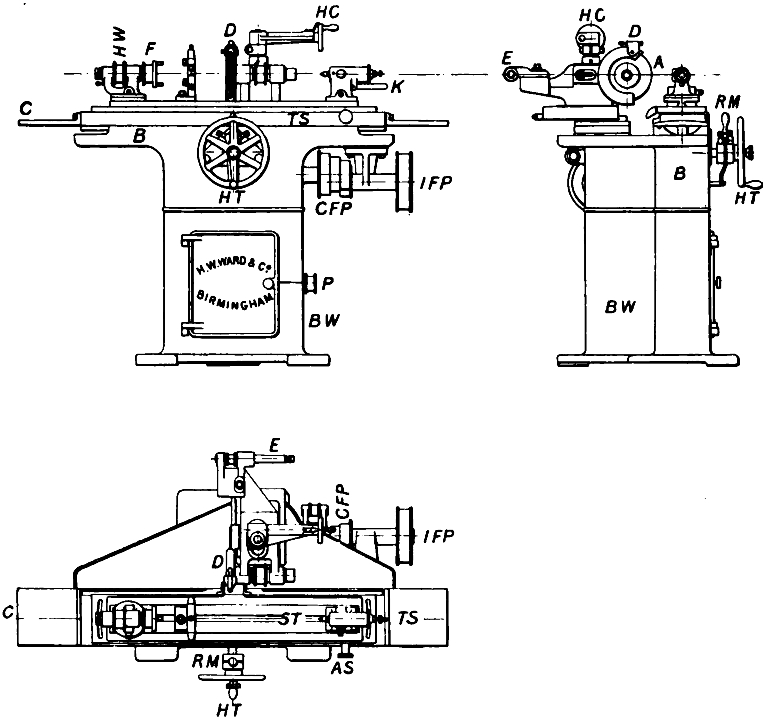


Fig. 118. "Ward" Universal Cylindrical Grinding Machine.

for any expansion due to heating that may occur, thereby ensuring a uniform pressure between the centres and the work. For instance, when the work has to be removed, examined and afterwards replaced for further grinding, it is released by pressing down the lever K giving motion to the barrel of the tailstock; then, having replaced the work, K is gently let back and the spring adjustment behind the tailstock centre comes into action, forcing the centre into its proper position by a pressure which is just sufficient to hold the centre up to the work.

The swivel table S T, with the work headstocks fixed to it, can be swivelled on a centre pin for 10 degrees in either direction, and by means of a graduated screw arrangement A S, reading to half degrees or inches per foot at the end of the slide, taper adjustments can be made with ease and accuracy.

The table slide T S, upon which the swivel table S T is mounted, runs in a vee groove on one side, and on a broad flat surface on the other. It travels automatically in either direction by means of a self-acting reversing motion, and the travel can be regulated to any distance within the limits of the machine; that is to say, for any length up to the full stroke of the table, which is 2 feet. There is also provided a fine adjustment by means of worms and wheels operated by small milled knobs, which can just be seen through the hand wheel on the front of the machine in the photograph fig. 117, but which are clearly seen in the front and end elevations, fig. 118. When it is required to make any considerable alteration in the length of travel, the worms may be thrown out of gear with the wheels, and the wormwheels may be rotated by hand; in this way a rapid adjustment can be obtained; after having set the travel quickly to something near what is required, the worms and wheels may now be thrown into gear again, so that any final accurate adjustments can be made by means of the milled knobs provided for the purpose. The reversing fork R M, by which the reversing action is transmitted to the motion itself for automatically reversing the table, will be seen in the plan and end elevation fig. 118; it is situated behind the hand wheel H T.

The emery wheel spindle is carried in the headstock G H, fig.

117, and is fitted to rotate in adjustable bronze bearings; this headstock is fixed to a swivelling slide to enable the headstock to be so set that the whole cutting face of the emery wheel can be brought into contact when taper work is being ground. The emery wheel A is provided with a water chute D, and as the headstock G H is placed behind the work and facing the operator, he is conveniently situated for seeing his work clearly, and for using his right hand in testing the work; this is exactly the opposite to what happens in the example of internal grinding on machine B, mentioned on page 121. On the machine figs. 117 and 118 the emery wheel is brought into contact with the work by means of the hand wheel H C on the top of the headstock; this hand wheel is graduated to thousandths of an inch, so that if three-thousandths of an inch have to be ground from the work, the hand wheel H C must be rotated through three degrees, thereby moving the emery wheel forward a sufficient distance to remove three-thousandths of an inch from the work to be ground.

For internal grinding the small special spindle E is brought into position by swivelling the headstock G H through half a revolution. The spindle E is driven by a small pulley fixed upon the end of the external grinding spindle.

The initial feed pulley I F P receives its motion from the counter shaft B, fig. 119, and this is transmitted through the change feed pulleys C F P and the gearing inside the bed B to the table slide S T by means of a rack and pinion, figs. 117 and 118.

The three countershafts are seen in plan fig. 119; the initial countershaft A receives its motion on the fast and loose pulleys D E from the main shaft. The cone pulley F drives on to the corresponding pulley E, thereby giving motion to the shaft B; on this shaft is the drum K which drives down on to the headstock H W, fig. 117; the length of the drum K is sufficient to allow for the whole traverse of the table. The cone pulley G is provided with a clutch, so that the work may be stopped for gauging or testing without the necessity for stopping the whole machine. The cone pulley H gives motion to cone pulley I, thereby rotating pulley J, which drives down to the pulley on the headstocks G H, fig. 117, thereby rotating the emery wheel spindle. The small flanged pulley O upon the middle counter-shaft B drives down to the initial feed pulley I F P, fig. 117. It is advisable to run the pump at a uniform

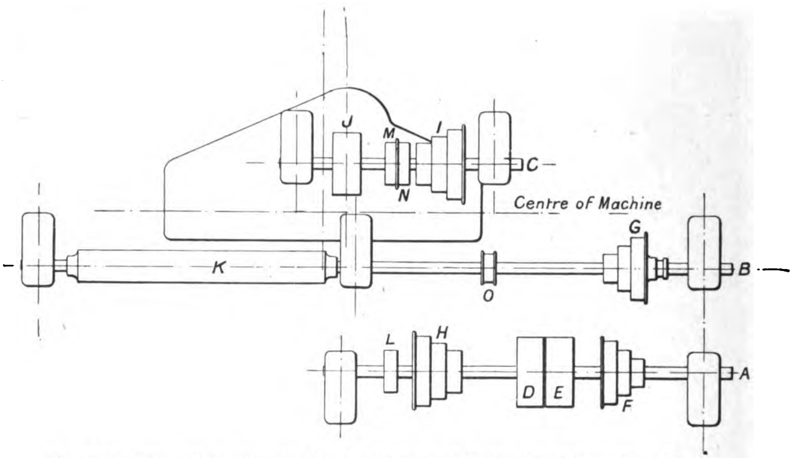


Fig. 119. Plan of Countershafts for Universal Cylindrical Grinding Machine.

speed, and this is accomplished in the following manner, namely: —The pulley L seen on the first countershaft A (which is always rotating at the same speed) drives over to the flanged pulley M on shaft C; this pulley M is bushed with a bronze bush, and runs loosely between two collars placed upon the shaft C; it will therefore be seen that whilst the countershaft C may have its speed varied, the flanged pulley M will always be rotating at one regular speed, as it is independent of the shaft C, running loose thereon. On the other side of the flanged pulley M is pulley N, which drives down to the pump pulley P, fig.

117, thus ensuring the speed of the pump, and yet allowing of the countershaft A being placed in any convenient position by means of the flanged double pulley M N.

The Steady Rest.—The steady rest is often useful as a support for special kinds of cylindrical work whilst being ground. For instance, if a long shaft or spindle has to be ground and finished perfectly parallel and true, it would necessarily be run on dead centres in the ordinary manner, but owing to its great length in proportion to its diameter, it may not of itself be sufficiently stiff to withstand the pressure due to the cutting action of the emery wheel without a certain amount of chattering or springing, but if it is supported by a steady rest it will be perfectly steady and will run true during the grinding. Again, suppose the machine is grinding the centre hole in the end of a lathe spindle, and the use of the tailstock centre is dispensed with, the usual plan is to chuck the tail end of the lathe spindle in a universal chuck and to place the end to be ground in a steady rest, so as to allow of the small emery wheel being in a position for grinding the hole. A steady rest may be stationary or sliding as required by circumstances. One form of steady rest (a three pin stationary one) is shown at 3 P S in fig. 117. The method of applying these steady rests is practically the same for grinding as for ordinary metal-turning operations.

In the first example given, that of a long shaft, the shaft is first threaded through the steady rest, next placed between the head and tail stock centres, and then the three pins are adjusted so as to support the shaft without giving rise to undue friction; in the second example, the tail end of the lathe spindle would naturally run true, as the universal chuck is a self-setting true chuck. The other end of the spindle is at first supported upon the grinding machine tailstock centre to keep that end of the lathe spindle true; then after the steady rest has been carefully set up to support that end, the tailstock centre is drawn back so as to allow of the internal grinding being effected.

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If an independent chuck is used for carrying the tail end of the spindle, its four jaws must be set to allow of the spindle running perfectly true previous to fixing and adjusting the steady rest; the universal chuck, however, is nearly always preferred, owing to its automatic action and the readiness with which the cylindrical work can be clinched.

CHAPTER XII.

LATHE CENTRE GRINDER.

THE old practice of correcting worn or damaged lathe centres by removing them from the headstock, softening, turning, and re-hardening them, was very tedious, expensive, and unsatisfactory, owing to their liability to be warped by insufficiently careful re-hardening. It has been superseded by using a grinding attachment which allows of the centre being reground without being removed. The handy portable arrangement by Messrs Luke & Spencer, Ltd., shown in fig. 120, consists of a conical spindle with gun-metal bush, a sapphire corundum wheel 6 inches in diameter by ½ inch thick, mounted between two iron washer plates, a grooved pulley, and a holder for fixing in the slide rest tool-box provided with an oil chamber to allow of constant automatic lubrication. A strong wrought iron tubular pillar (set in a suitable foot) with a spring adjustment carries a cross beam fitted with two double sets of guide pulleys. Attached to this lathe is a 12 inch grooved driving pulley, from which motion is transmitted by a twisted leather-banding rope which passes over the guide pulleys to the emery wheel spindle. The apparatus can be fixed in a few minutes. As the centres are ground true by it with a much smaller waste of material than by the old method there is great economy, especially if several lathes are made so as to allow of the application of the same driving pulley and pillar foot.

The utility and mode of using the apparatus will be evident from the following instructions.

Turn an annular groove in the lathe catch plate or face plate to fit the annular projection on the back of the grooved pulley

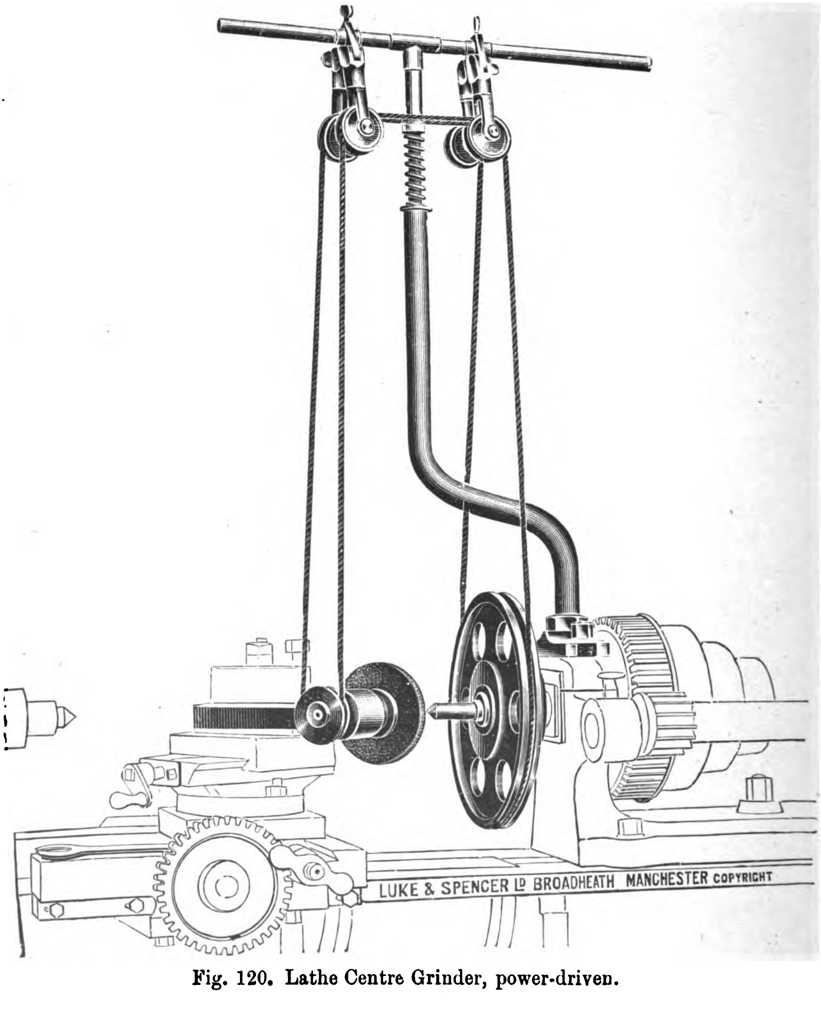


Fig. 120. Lathe Centre Grinder, power-driven.

supplied, then bolt the pulley against the face plate, having previously drilled corresponding bolt holes in the pulley and catch plate. Fix the pillar securely on the cap of front bearing of fast headstock.

Place the grinding attachment in the tool-box of the slide rest, and having brought the rest near to the centre to be ground, adjust it to the required angle; then put on the twisted leather driving band, and the apparatus will be ready for work. Take great care to keep oil from running on to the emery wheel, as this would prevent its grinding properly.

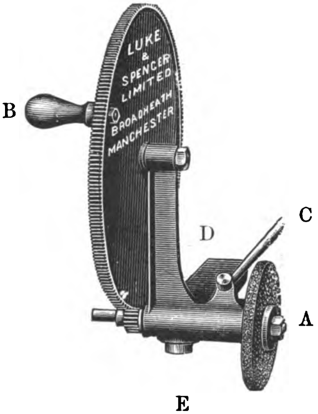


Fig. 121. Lathe Centre Grinder, hand-driven.

Description.—Fig. 121 represents a hand geared lathe centre grinder, while in fig. 122 it is seen fixed to the tool base of a lathe ready for use. It can be fixed in any lathe, no alteration thereon being required. It consists of a small sapphire corundum wheel A, mounted between plates upon a steel spindle, driven through a pinion by the handle B. When grinding, the corundum wheel is moved horizontally by means of the hand lever C.

Mode of operation.—The stalk D carrying the apparatus is clamped upon the slide rest in exactly the same manner as an ordinary turning tool would be, taking care that the centre of the corundum wheel A coincides with that of the lathe centre. The angle to which it is necessary the centre should be ground is then obtained by slackening the centre pin E. The grinding wheel is then revolved at a very high speed by turning the handle B, at the same time moving the spindle horizontally by means of the lever C.

Commutator grinding.—The heavy wear and tear that occurs between the commutator of an electrical dynamo machine and its brushes, due to the excessive friction that takes place between

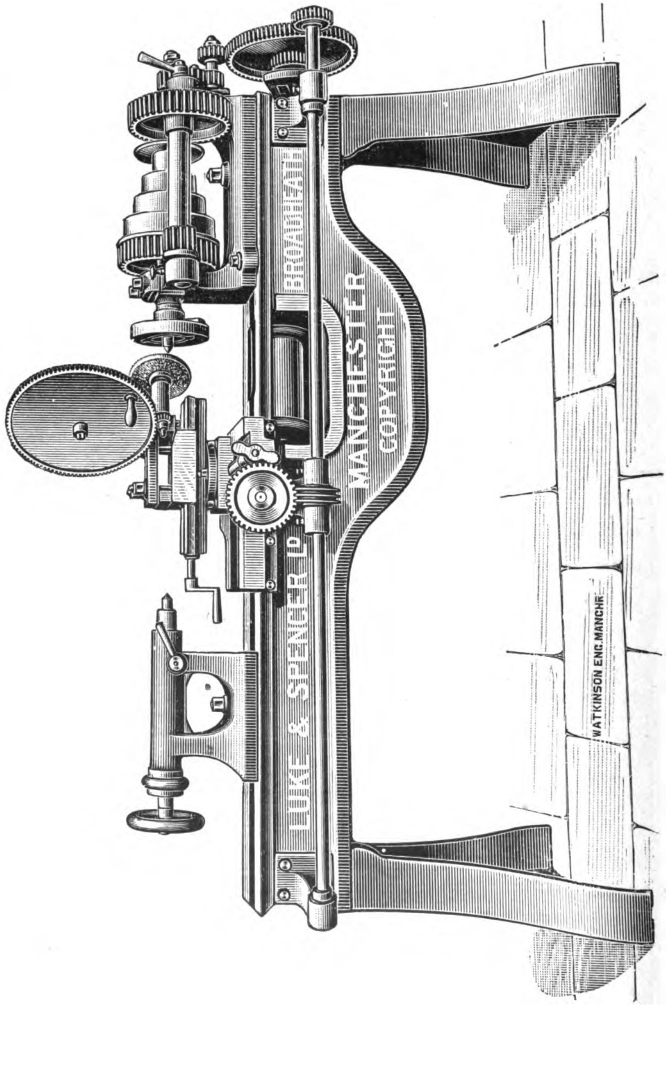


Fig. 122. Hand-driven Centre Grinder on Screw-cutting Lathe.

the two brushes and the commutator, frequently necessitates the removing of the whole armature of the dynamo machine to enable it to be fixed up in a lathe so that the grooves and unevenness of the commutator may be removed therefrom, leaving the commutator perfectly cylindrical and parallel. To obviate the neces-

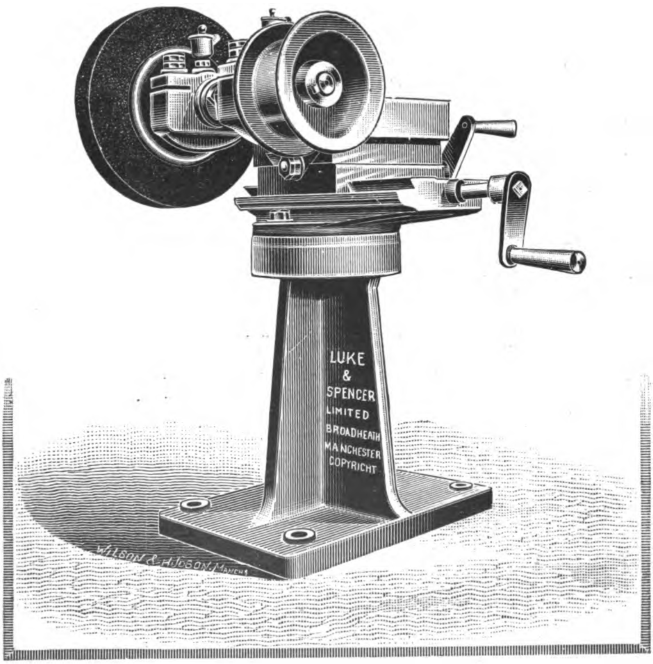


Fig. 123. Apparatus for grinding Dynamo Commutators.

sity of frequently disconnecting the dynamo for this purpose, the dynamo commutator grinding apparatus, fig. 123, has been designed. The arrangement, as will be seen from the illustration, is an exceedingly compact and useful tool to the electrical engineer. It consists of a strong cast iron pedestal for bolting on to the dynamo bed, and a compound slide rest with swivelling

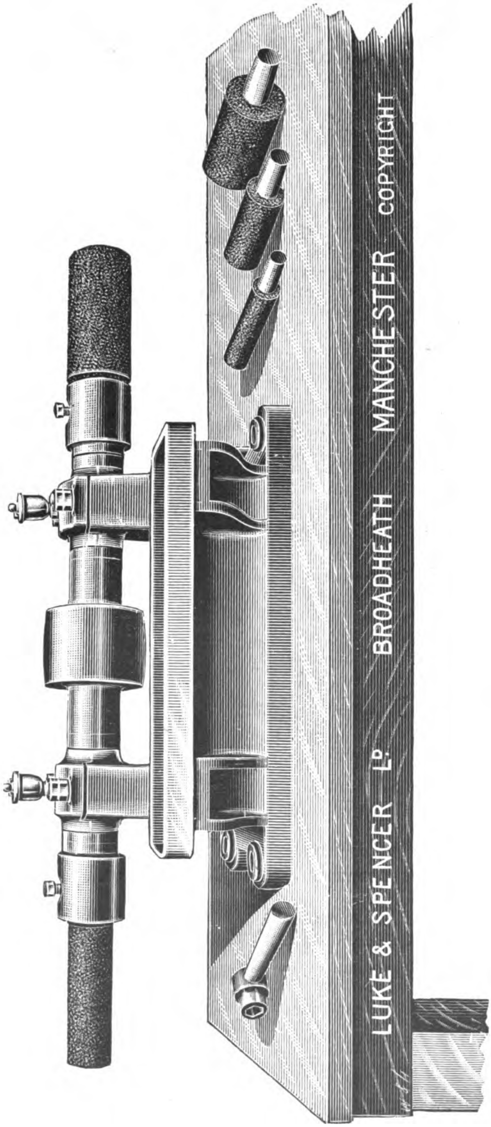


Fig. 124. Bench Emery Roller Machine.

arrangement for bringing the grinding wheel into position. The attachment carries an emery wheel 10 inches in diameter by $1\frac{1}{2}$ inch thick, carefully mounted and balanced between washer plates. The steel spindle is carried in an adjustable bearing, and the spindle is provided with lock nuts to take up any lateral wear. The fast pulley is $4\frac{1}{4}$ inches in diameter and $2\frac{5}{8}$ inches wide between the flanges.

Emery Roller Grinders. — The grinder (fig. 124) known as the Luke & Spencer Emery Roller Machine is capable of doing a variety of work, such as grinding out bushes, wagon brasses, bearings, hollowing shaft keys, dressing or fettling pulley arms, or other similar

Fig. 125. Emery Roller Machine.

irregular and curved work. The machine, as seen at fig. 124, is arranged for fixing upon a bench. Each end of the spindle

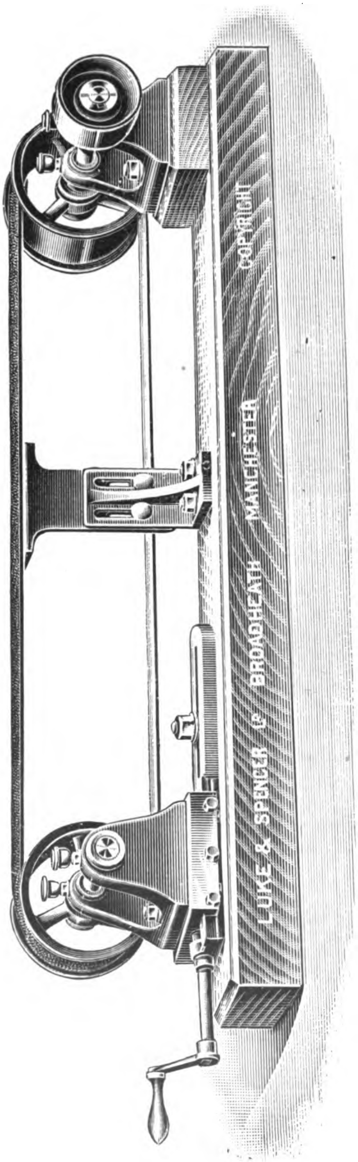


Fig. 126. Bench Emery Band Polishing Machine.

forms a chuck for receiving the emery rollers, which are mounted upon wrought iron mandrils turned to fit into the chucks. There are five rollers in a set, each 6 inches long, their respective diameters being 1 inch, 1½ inches, 2 inches, 2½ inches, and 3 inches. The box spanner seen lying upon the bench is for changing the rollers.

Fig. 125 represents another emery roller machine for doing exactly the same class of work, but adapted for fixing to the workshop floor by being mounted in a heavy casting.

Emery Band Machines. — These are used for polishing work of irregular form. The bands are dressed with powdered emery in the same manner as a buffing wheel (*see Chapter on Polishing*). Their flexibility allows of their application to the surface of the most irregularly shaped articles, such as spade and shovel straps, brass cocks, bends, mouldings, beads, hinges, latches, levers, straps, joints, connecting rods, catches and stove-grate fittings, while their rapid motion imparts a rigidity sufficient for the band to withstand a reasonable amount of pressure being brought to bear upon it, the workman pressing the article to be ground closely against the emery band. Many different forms and sizes of machine are made in order to meet the requirements of the varied surfaces, such as flats, corners, curves and bends to be dealt with. The Bench emery band polishing machine (fig. 126) consists of two cast iron headstocks, the centres of which are 3 feet 3 inches apart; each headstock is fitted with a steel spindle carrying a 7 inch by 4 inch double-flanged pulley over which the emery band passes; one of the headstocks has a cast iron planed bottom slide, with a screw and handle for regulating the tension on the band; and a $4\frac{1}{4}$ inch by $2\frac{1}{4}$ inch driving pulley is fitted to the other headstock; midway between them is an adjustable angle rest for supporting the band when extra pressure is brought to bear upon it.

A vertical type, provided with fast and loose pulleys, as also with guide pulleys at several points for supporting and guiding the emery band, is shown in fig. 127. On one side of the machine is a rest for supporting the work, whereas on the other side the article to be ground may be placed at any point between the top and bottom guide pulleys or rollers. Fig. 128 represents a double vertical machine for carrying two bands, the tension of which is regulated by the screw and spring arrangement at the top.

Self-acting Wheel Tooth Cleaning Machine.—This machine (fig. 128A) is constructed to clean teeth of spur wheels and pinions and the teeth of straight wormwheels by means of an emery wheel. It is a most important labour and file saving machine, as it cleans effectually from 1000 to 1500 teeth per hour without requiring skilled labour, the machine being self-acting; and the work is much better done than by hand filing, the teeth being left quite free from irregularities. The machine will take in wheels from $2\frac{1}{4}$ inches to 24 inches diameter, and up to 4 inches depth and $\frac{3}{4}$ pitch.

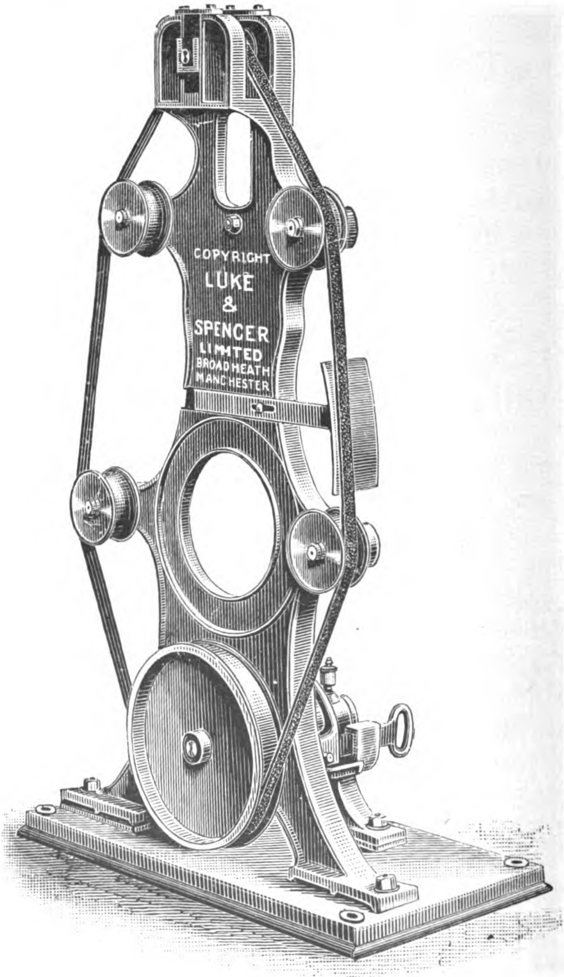


Fig. 127. Single Emery Band Polishing Machine.

The wheel to be cleaned rotates upon a stud at the top of the rising and falling ram, which works in long V slides; the

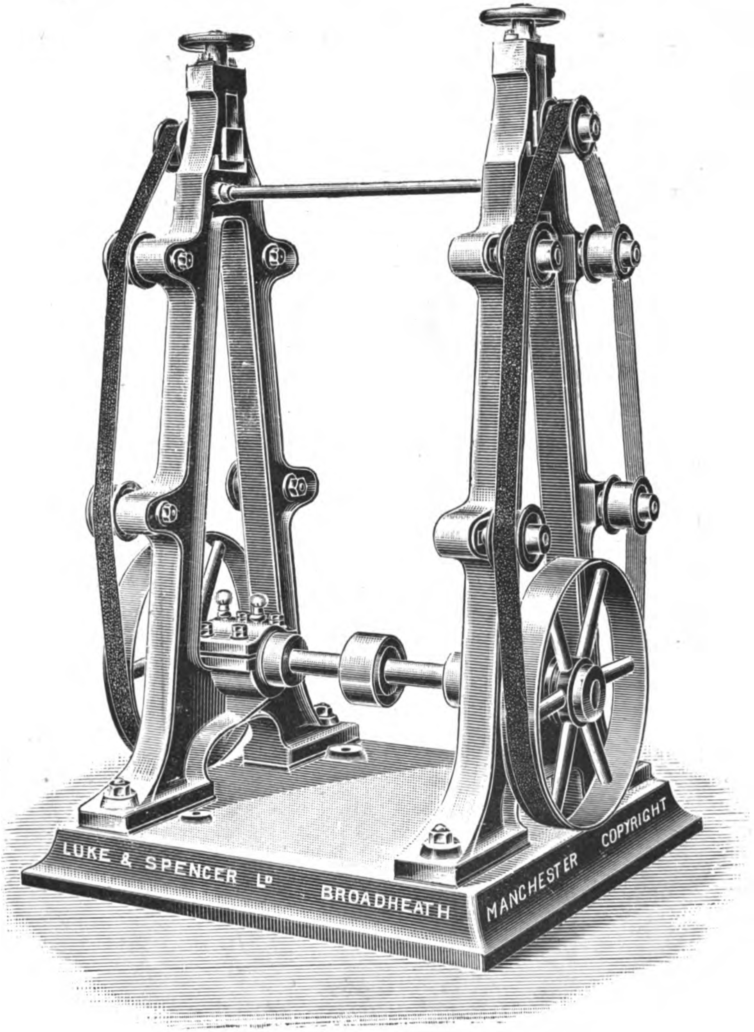


Fig. 128. Double Emery Band Polishing Machine.

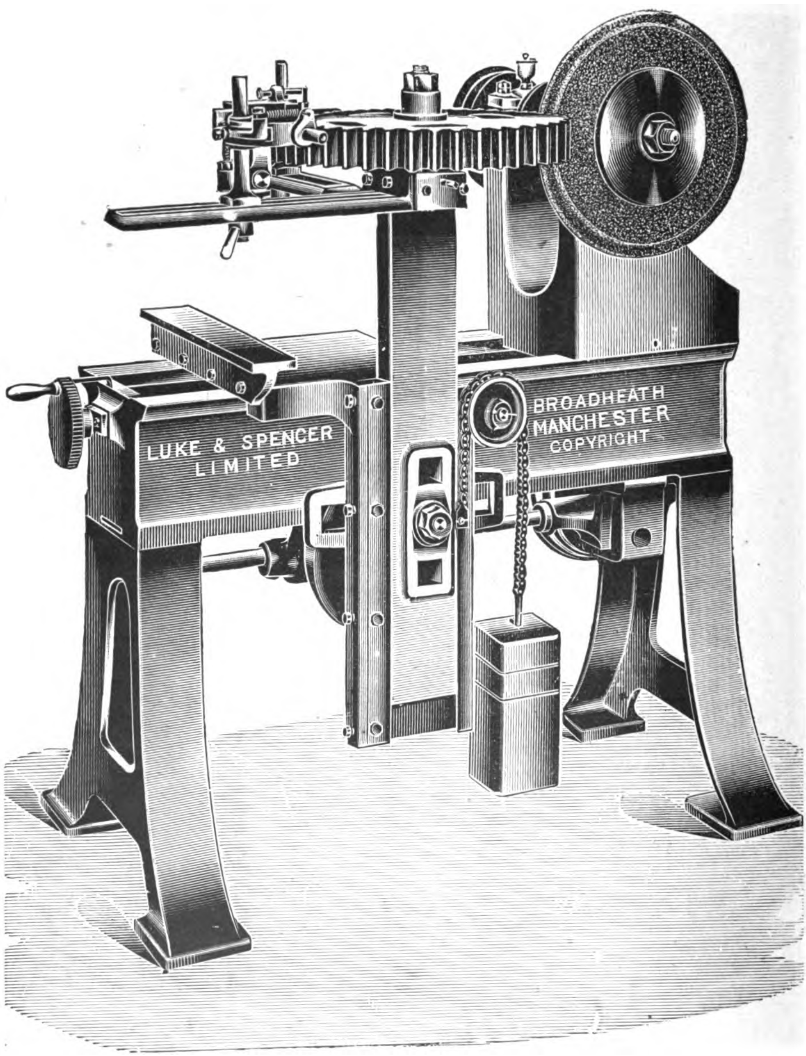


Fig. 128A. Self-Acting Wheel Tooth Cleaning Machine.

wheel is held in position during the grinding by means of a spring pawl, each tooth space being cleaned by the emery wheel in both the upward and downward movement, and the spur

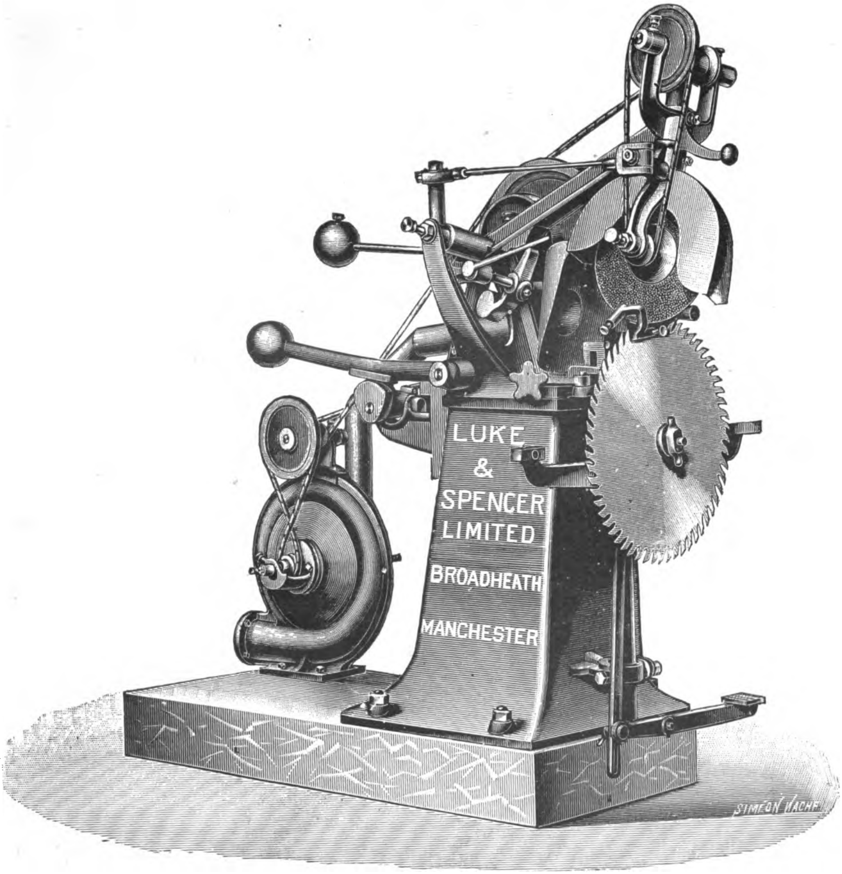


Fig. 129. Machine set for sharpening Circular Saw.

wheel is fed round tooth by tooth by means of a ratchet pawl. This feed can be adjusted to suit any pitch of tooth up to $\frac{3}{4}$ inch, and is obtained by merely adjusting a screw, which on the rising and falling of the ram comes in contact with the table beneath it and thereby operates the pawl. The balance weights are varied according to the weight of wheel being cleaned.

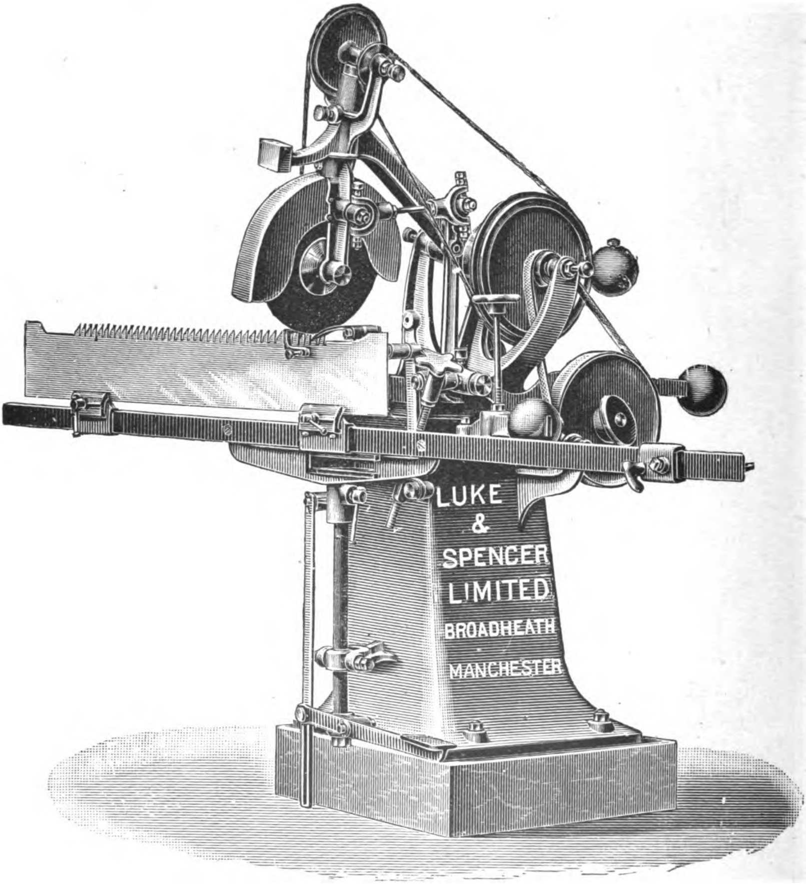


Fig. 130. Machine set for sharpening Frame Saws.

Automatic Saw sharpening.—The most evident advantages of the modern automatic saw sharpening machine over the old practice of hand filing are that the sawyer can always have a number of well-sharpened saws ready for use, so that he need never leave his saw frame idle while he is sharpening his saw;

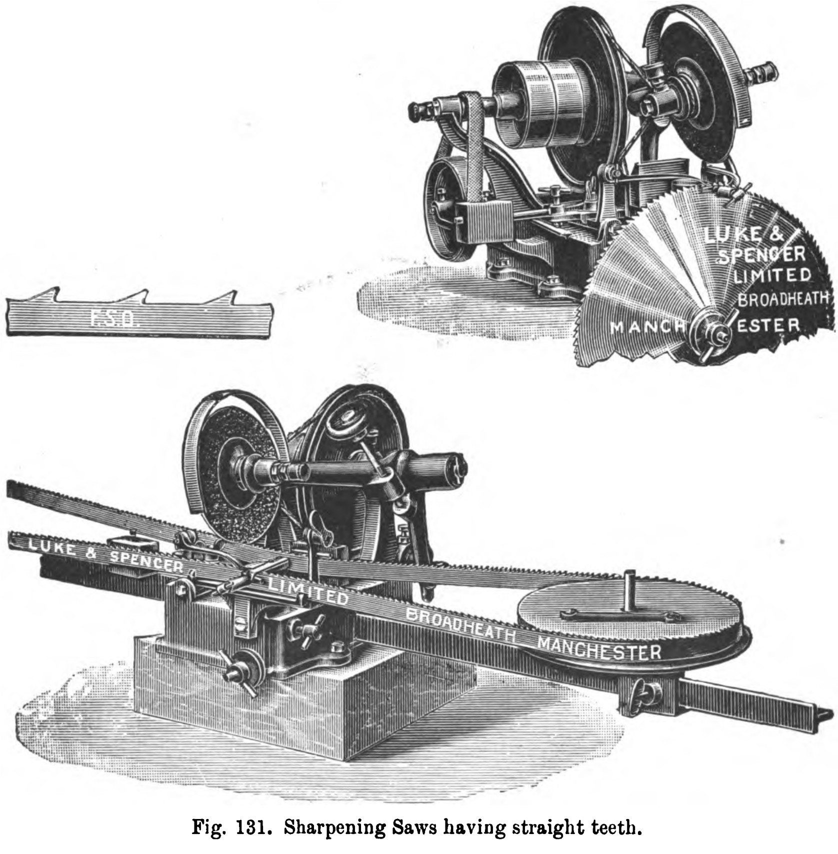


Fig. 131. Sharpening Saws having straight teeth.

the wear of the emery wheels is much less costly than that of files; and the teeth are always uniform in pitch and shape. The result is that for the same amount of power and of time much more work is produced, less timber is wasted, and the saws last longer. The saving thus effected in a large concern covers the cost of the saw sharpening machinery in a very short time.

The Schmaltz Patent Automatic Saw Sharpening Machines (figs. 129 to 134) have all these advantages, and can be readily worked by any intelligent workman after a little training. All the adjustments can be made whilst the saw is being sharpened.

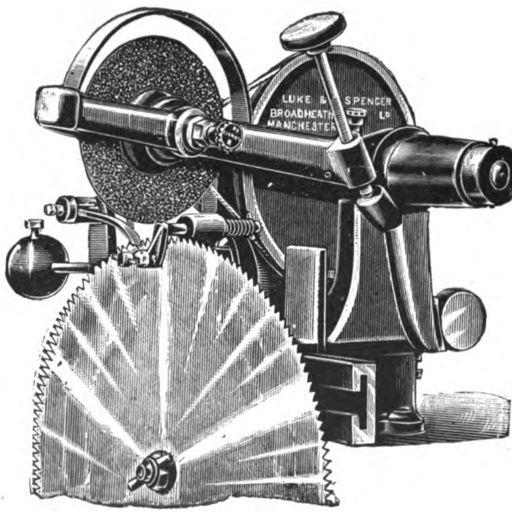


Fig. 132. Large Circular Saw for Hot or Cold Metal Work, being ground automatically.

Special provision has been made against the wearing out of the working parts by the emery dust, the motion being transmitted by hardened steel eccentrics working automatically in contact with steel rollers, while the dust is at once got rid of by a dust guard and an exhaust fan with air pipes.

The machines are specially adapted for automatically sharpening circular, frame, and band saws as used in saw-mills and by wood-workers generally, and any desired angle may be obtained so as to adapt the saws for cutting the particular kind of wood under treatment. The machine shown in fig. 129 sharpens circular saws; that in fig. 130 frame saws; that on fig. 131 wood-cutting saws with straight teeth, as also teeth like those seen in the small figure used on the American Log Band Saw Machine; they will accurately sharpen 80 to 100 teeth per minute.

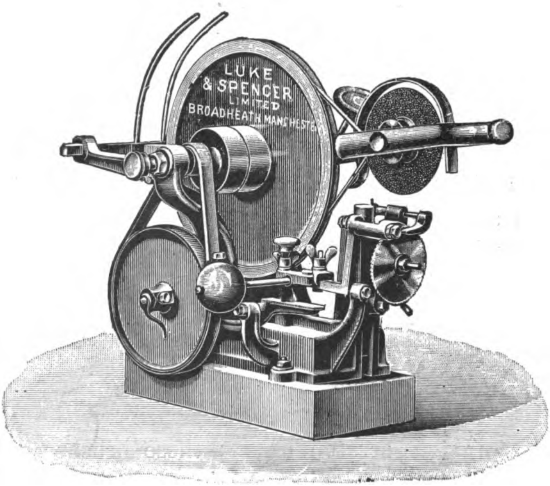


Fig. 133. Metal Slitting Saw being ground automatically.

Fig. 132 represents the Schmaltz machine for sharpening the straight teeth of a large metal-cutting circular saw used for cutting hot metals, and fig. 133 the machine for sharpening those in a small fine pitch circular saw similar to what would be used for cutting ivory, horn, or cold metals.

CHAPTER XIII.

POLISHING.

In the jewellery trades, where articles have to be cleaned, coppered, nickel-plated, silvered, gilded or bronzed, it is necessary to pass the articles through a series of polishing processes, both previous to and after they have received the deposit of copper, silver, gold or bronze, as the case may be. As these polishing operations are rather beyond the scope of the present work a very brief notice of them will suffice.

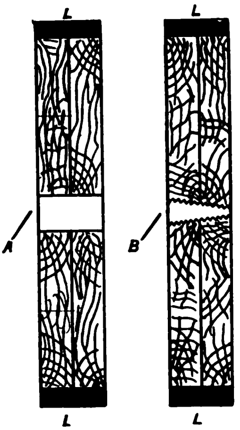


Fig. 134.

The metal articles of jewellery are cleaned by brushes, which range from the camel-hair brush to the steel-wire scratch brush; these brushes, which are made in a variety of shapes, are either used by hand or rotated upon a lathe. The articles are polished with what is known as a polishing bob, formed of a number of well-seasoned pine-wood segments glued and screwed together in cross grain section to prevent warping or splitting. When a hole has been bored in the centre, the bob is mounted upon a lathe spindle and turned circular. The hole in a bob 2 inches thick and 12 inches in diameter may have a uniform diameter of 1 inch, as in fig. 134, A; or it may be taper screwed, as in fig. 134, B, to allow of its being mounted upon the end of a taper-screwed polishing spindle like that in fig. 135, which represents one of Messrs Luke & Spencer's polishing lathes or machines. It consists of a cast iron headstock, carrying a steel spindle; the bottom half of the bearing forms part of the headstock, the upper half being fixed on by two bolts to hold the spindle down. The author has known instances where the bearings of polishing headstocks have worn away very rapidly; this cannot always be avoided, but in cases where

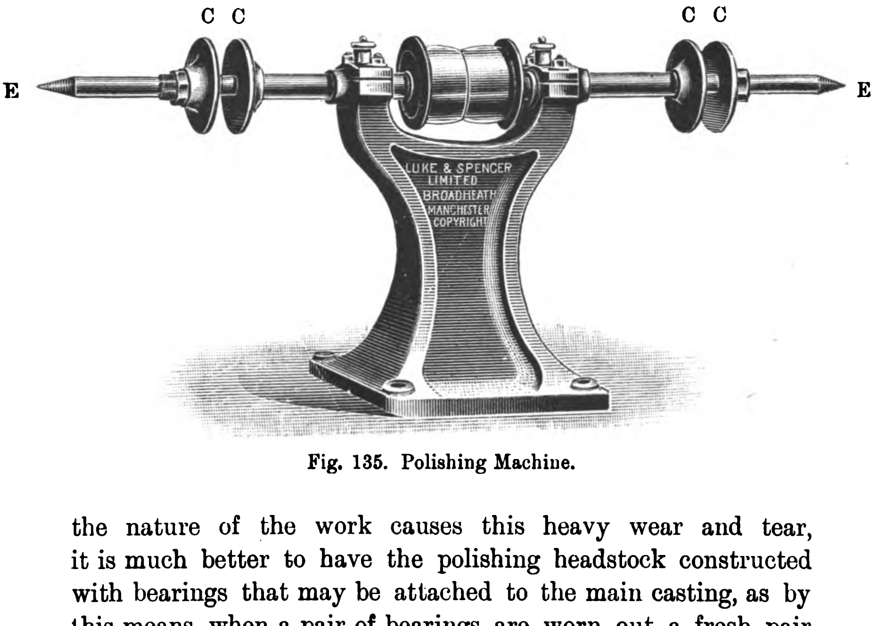


Fig. 135. Polishing Machine.

the nature of the work causes this heavy wear and tear, it is much better to have the polishing headstock constructed with bearings that may be attached to the main casting, as by this means, when a pair of bearings are worn out, a fresh pair may be introduced, thus avoiding the necessity of a new headstock, or of a new spindle of larger diameter. In the machine shown, the spindle projects well beyond the bearings, so as to allow of the work being clear of the head when operated upon.

The bob A, fig. 134, would be fixed between collars C C, fig. 135, and the bob B, fig. 134, would be screwed on ends E E of fig. 135. Around the wooden bob, fig. 136, is pegged a bull-neck leather or buff covering L. These coverings are laid on in strips, four of which are shown in the figure. They are glued and nailed into position by special bobbing nails. After the leather strips have become firmly fixed upon the wood the nails are withdrawn, and wooden pegs inserted and driven home. In fig. 136 it will be noticed that Nos. 1 and 2 leather strips have been pegged, No. 3 strip has been nailed, and the fourth strip is being glued and nailed upon the bob. When the glue has become thoroughly hard, the leather upon the bob is turned upon its outer surface, namely, upon the periphery C of the bob, fig. 137, and the bob is glued over and carefully rolled in corn or flour emery as the case may be.

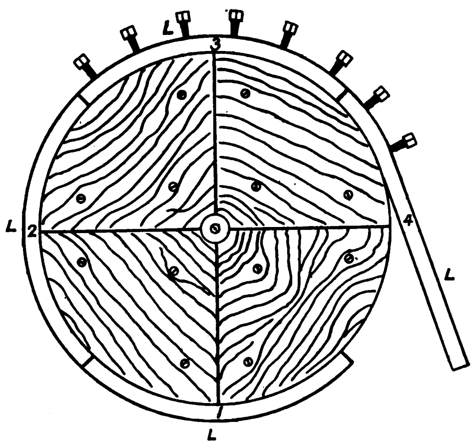
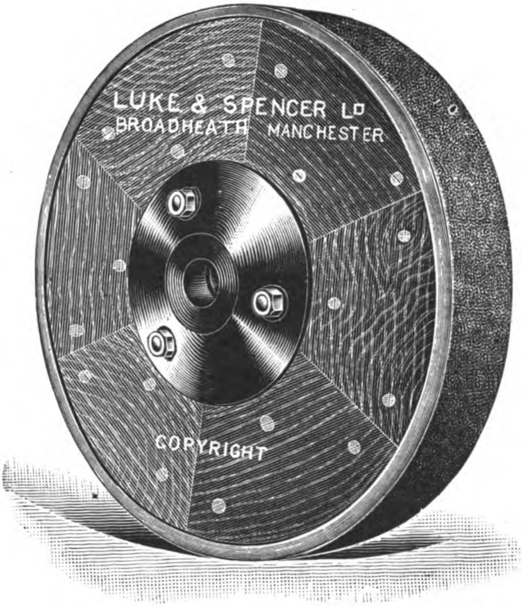


Fig. 136.

In order to obtain a highly polished surface on a metal article it is necessary that the article be first ground on an emery wheel, and afterwards be polished on buffing wheels dressed with emery of suitable grade for the desired finish. Polishing bobs may be made with various sized powdered emery, to suit any particular class of work.

In addition to the wood, leather, and buff combinations, there are felt bobs, basil leather mops, chamois leather mops, and calico mops; these mops are made by fixing any number of leather or calico discs together, according to the desired thickness of mop. The mops are nearly always fixed upon the ends E E of the spindle seen in fig. 135, in preference to placing them between the collars C C; but when mops or bobs (particularly the latter) are used between collars, it is much



C

Fig. 137. Buffing and Polishing Wheel.

better to provide a cast or wrought iron bush with flange for mounting upon the spindle, in preference to simply having a plain hole bored in the wood.

There are two important reasons for using mops upon the ends E E. First, it is more convenient to screw a mop upon the taper-ended spindle and ensure its running true each time it is changed, than it would be to do so if a plain hole was bored in the leather or calico; it should, however, be noticed that in nearly all cases a calico mop is provided with a leather centre-piece to take the thread of the screw on the polishing spindle.

Second, on many kinds of work it is necessary to change the mops very frequently, which is more quickly done on the screw than when the mop has to be placed between collars and a nut screwed up each time. In addition to using emery upon the bobs and mops, Tripoli compositions, rouge compositions, crocus compositions, and Sheffield lime are used.

The following instructions are taken from Messrs Luke & Spencer's catalogue for redressing their bobs and buffs. Clean off all the remains of the previous dressing, so that the periphery of the wheel has a perfectly level and true surface. The safest way to do this is to cover the old emery with wet grindstone swarf or similar material. Let it stand awhile until it has had time to soften the old dressing, then scrape all off together. The buff must not be soaked in water. Allow the leather to dry slowly before re-covering, and see that the periphery is perfectly clean and level. Dissolve 1 lb. of the glue (as supplied by the makers) in 2 lbs. of water. Make the solution very hot, and spread it on the periphery of the buff or leather as evenly as possible with a large brush; before the glue has time to cool, roll the buff or leather in a tray of emery until it has taken up sufficient to cover it; hang it up in a dry warm place, and allow it to dry slowly. Repeat this operation the next day, when the buff will be ready for use.

Note.—The author would remind the reader that although in the above instructions it is said that after the second glueing and emerying the buff will be ready for use, the operator should never use a freshly emeried bob or buff until it has become thoroughly dry. This is very important, as many cases have been known where an operator has not been supplied with a sufficient number of bobs or buffs to allow of their being left to become thoroughly set hard and dry, consequently the emery has peeled off very quickly during the working, thereby causing a great waste of emery, in addition to a loss of time in redressing bobs and buffs more often than would otherwise be necessary.

When covering a wheel with hard felt, slightly steam the felt, but on no account wet it, or the glue will not hold; use

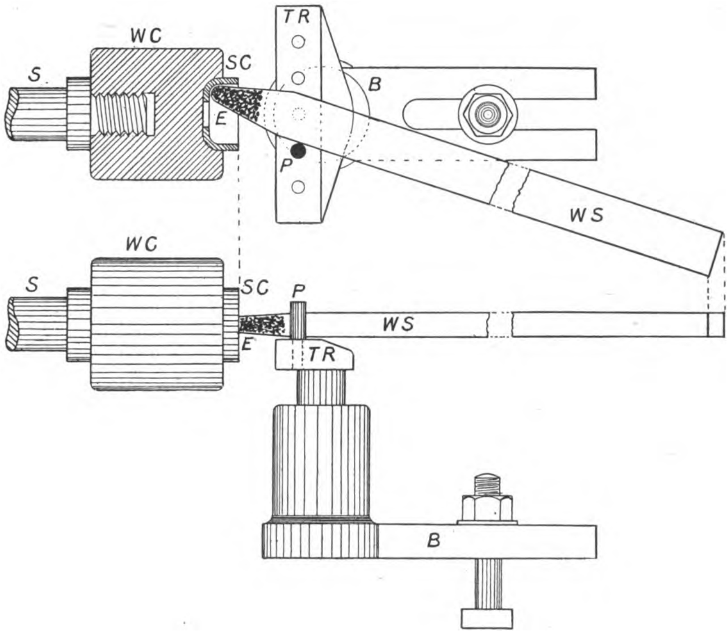


Fig. 138. Polishing with Emery, Oil, and Wood.

bobbing nails, and when taking out the nails, peg the holes straight away with wooden pegs.

In works where these polishing operations are carried out, the shaking barrel, made from either wood or iron, plays an important part. The articles, which may be of sheet brass or other metal, after being worked into shape by the variety of metal cutting and forming tools, are placed in the shaking barrel, mixed with a quantity of wood sawdust, and the barrel rotated. The action of the articles knocking one against another would remove any sharp fraze or edges from the corners, clean off all oil or dirt, rust, and produce a dull polish upon them, thereby preparing the articles for the final stages of bright polishing, which are necessarily done by the aid of the bobs, mops, and compositions.

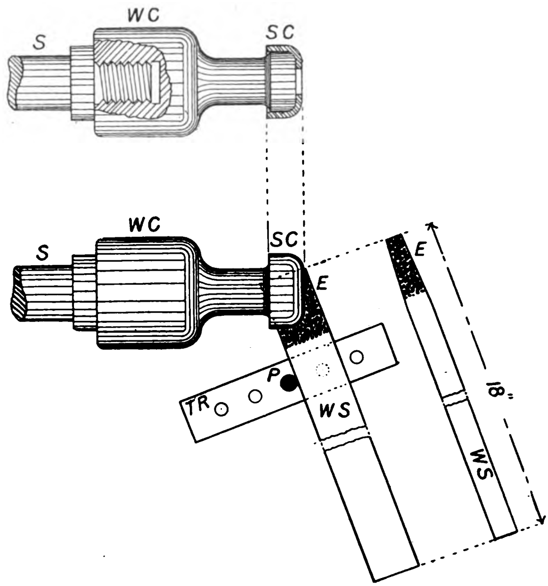


Fig. 139. Polishing with Emery, Oil, and Wood.

In the iron, steel, and cycle industries a large variety of work is polished with powdered emery and a stick of wood. The illustrations figs. 138 to 140 will show the method of application. In fig. 138, S is a lathe spindle, on which is mounted a box-wood chuck W C, into the outer end of which is let the sheet metal cup S C. A tool rest T R is fastened to a base casting B, and in T R five or more holes are drilled to receive the steel peg P.

The strip or stick of elm or ash-wood W S is about 18 inches long. Its pointed end E is dipped into a mixture of powdered emery and oil. The operator, grasping the stick with his hands, supports it against the rest and works the end round the inside of the steel cup (which has been case hardened) with considerable force by pressing against the peg P. In fig. 139 is represented the operation of polishing the outside of the cup. In this case the chuck W C is fitted with the inside of the cup, and the stick of wood used is flat.

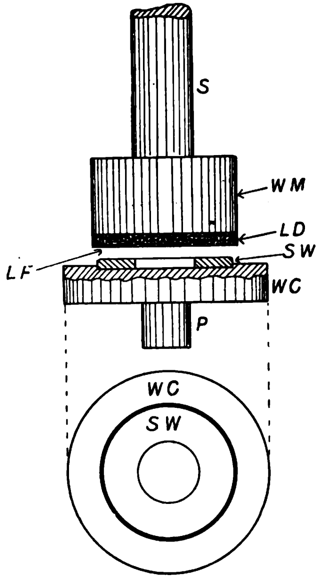


Fig. 140. Polishing Steel Washers.

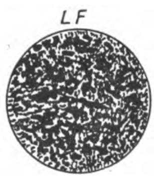


Fig. 141. Plan of L D seen in Fig. 140.

One example of the use of leather and emery to the engineer is seen in fig. 140. S is a spindle carrying a wooden mounting W M in the form of a chuck; on the face of W M is glued a leather disc L D. This leather disc is treated like a bob by being glued to receive powdered emery upon its face L F. Another wooden chuck W C has a peg P turned upon its bottom to fit the machine table of an upright or vertical polishing machine, W C being bored at the top to receive the engineer's steel washer S W. In the working of the machine like that shown in fig. 142, W C remains stationary and holds the steel washer, whilst W M rotates and is drawn down by a hand lever until L F comes in contact with the top face of S W, thereby producing a bright polish. Fig. 142 represents a vertical machine, suitable for fixing upon a wooden bench.

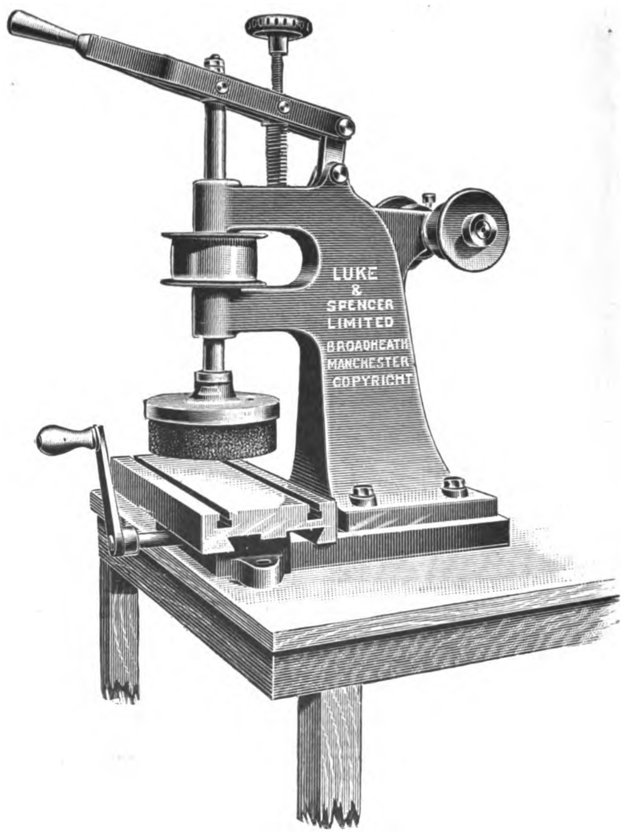


Fig. 142. Horizontal Surface Grinder.

Fig. 141 is an inverted plan of the leather disc L D, in which the powdered emery is clearly shown covering the leather face L F.

Scouring Rolls.—Another interesting application of the emery stick is for cleaning, lapping and polishing chilled iron and steel rolls. In rolling mills where gold, silver, german-silver, copper, brass and bright steel strips are rolled, it is essential that the rolls be kept perfectly cylindrical and parallel, since every defect in the rolls is reproduced on the strips, the thickness of which should in many cases not vary more than one-thousandth of an inch. When it is considered that the temper of the metal varies with each batch of strips, as well as during the process of rolling, and that the widths of the strips may vary from 2 inches to 6 inches in the course of an hour, it is manifestly no easy matter to keep

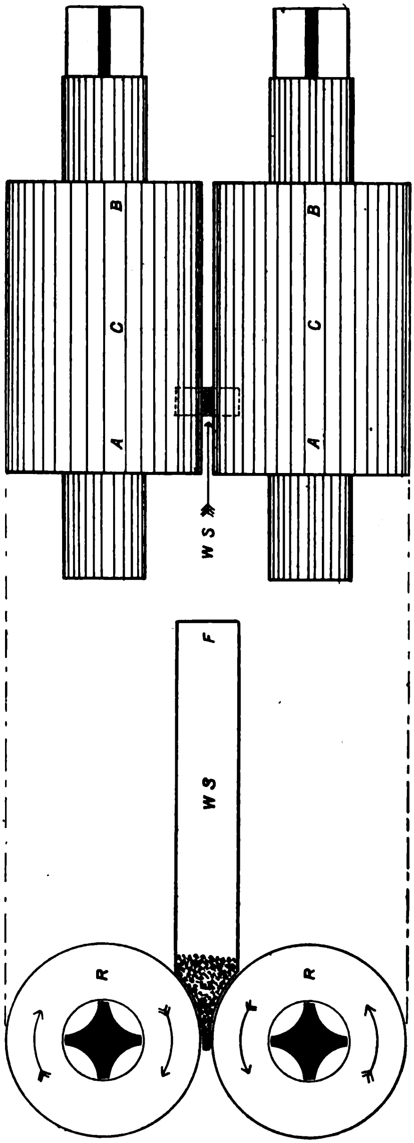


Fig. 143. Scouring Rolls with Emery and Wood.

the rolls in perfect condition, and yet competent workmen manage to do this for many months in succession. This is done by what is known in rolling mills as *scouring the rolls*, which is generally done at the end of each working week, but oftener if necessary.

In fig. 143, R R are two rolls, 12 inches in diameter and 18 inches long, used for rolling bright steel strips; W S is the wooden stick 4 inches by 2 inches, and about 2 feet long, one end of which, E, is curved to fit the periphery of the rolls, and tapered nearly to a point, thereby preventing its being pulled through the rolls during the operation of scouring. While the rolls are rotating in the direction of the arrows, the stick E with its coating of oil and suitable grade corn emery is grasped with right hand at the end F, and the left hand at about the middle, and applied to the more prominent parts of the rolls. In ordinary working of the rolls the strips of metal are passed through the rolls, first at one point, then at another, as at A A, B B, C C, so as to wear the rolls as evenly as possible. Sooner or later, notwithstanding every care being taken, the rolls become so uneven as to necessitate their being subjected to the process of scouring.

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