Construction and Use

of the

No. 13 Universal and Tool Grinding Machine

A Handbook for the Operator

Brown & Sharpe Mfg. Co.
Providence, R. I., U. S. A.
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CONTENTS

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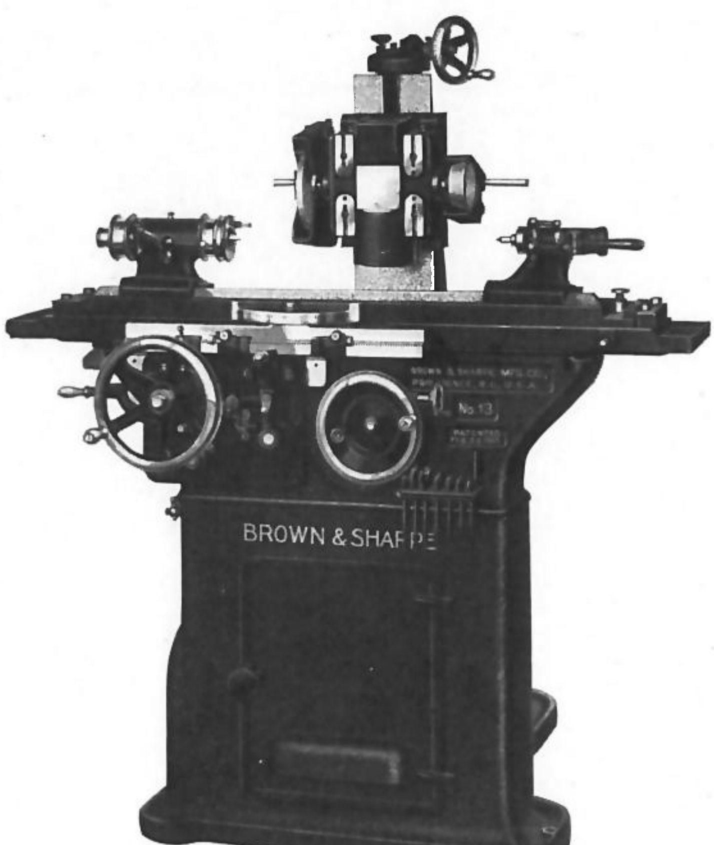
INTRODUCTION

In manufacturing, the sharpening of milling cutters and other tools is an important part of the work. When the cutters become dull they wear away rapidly, and, as only a relatively small amount is ground off each time, frequent sharpening prolongs the life of the cutters.

As cutters are made in so many varied forms and sizes, a machine for sharpening them must be more or less universal in its capacity, the Brown & Sharpe No. 13 Universal and Tool Grinding Machine is exceptionally suitable for grinding practically any type of cutter, taper, reamer, or other tool. This machine is designed to meet the most exacting requirements of the toolroom.

This book will point out the important principles in tool grinding practice that are easy enough to learn but which are often ignored or overlooked. Success in tool grinding depends on the application of common sense together with a close attention to the little things that may make or mar the success of a job.



No. 13 Universal and Tool Grinding Machine

CHAPTER I

The No. 13 Universal and Tool Grinding Machine

The No. 13 Universal and Tool Grinding Machine is adapted to sharpening milling cutters, formed cutters, straddle and face mills, beveled cutters of any angle, straight or tapered reamers, and cylindrical work. By the use of attachments (which can be furnished as extras), internal and surface grinding, and the sharpening of hobs and convex and concave cutters, the teeth of which are not formed but require grinding on the periphery, can be accomplished.

The machine is so readily adaptable to a variety of work that it is particularly efficient in shops where the amount of grinding does not seem to justify the cost of installing a different machine for each type of work.

In designing the machine, careful attention has been given to those parts that effect its efficiency. Durable accuracy is built into every operating part. It is exceptionally free from vibration because of the careful distribution of weight in the base and working parts. The frame is cast as one piece with a firm support beneath the wheel spindle slide. Substantial and properly placed braces cast into the structure of the supporting parts give the requisite stiffness without clumsiness.

A swivelling column is provided for the grinding wheel spindle. This makes the spindle slide adjustable on the column, and enables the operator to bring the spindle column toward the work. The table has longitudinal movement only.

The operating parts are located for the convenience of the operator and to insure ease of operation, compactness and simplicity. All the parts are very accessible and can be inspected and properly cared for without undue loss of time or effort.

The working parts are properly protected and the ways are covered. All the oil holes and parts that are subject to frequent adjustment are secured against grit and dirt.

The No. 13 Universal and Tool Grinding Machine is designed to be easily operated. Its operating parts are so conveniently located that the operator can give the greater part of his attention to the accuracy of his work rather than to the manipulation of the machine.

A wet grinding attachment as shown on page 30, is included with the machine as an extra when desired.

CHAPTER II

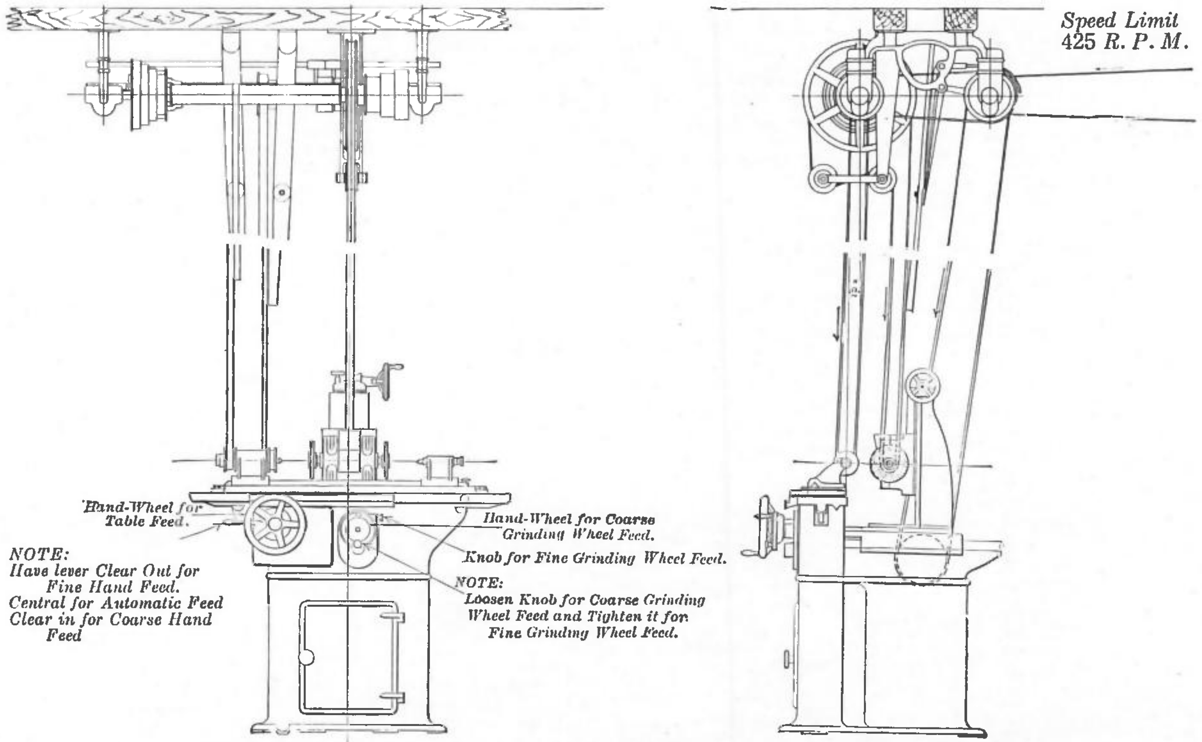
Erection, Adjustment, and Care

Erection. A machine should be placed upon a level, and, if possible, a solid floor or foundation. If the foundation is not firm, undue vibrations will exist and possibly impair its accuracy and durability. Either stone or concrete makes an excellent foundation. When placed on a wooden floor or used in the upper floors of a building the machine should be placed directly over a beam when possible; not in middle of bay.

Ordinary wooden shingles are commonly used in leveling a machine. When the exact position has been determined, the fastening screws or bolts should be screwed down until nearly tight. A spirit level should then be used to test the top of the table, both longitudinally and transversely. If the machine is too low at any corner, drive a shingle under the base at this point to bring it up. When the table is found to be level in every direction, the nuts, or bolts, should be brought up solidly. It is well, even after tightening the bolts, to test the surface of the table once more, as this tightening sometimes throws the machine out of level again.

Countershaft. Putting up the countershaft, when one is employed, is usually the first operation in installing a machine. It is generally placed directly over cone drive machines because of the interference of the driving belt with the upper part of the frame if it is located very far at either side. A blue print sent with each machine gives the proper installation instructions.

The countershaft should be level and accurately aligned parallel with the main, or driving, shaft. Where the beams are not uniform enough to bring the stringers to which the countershaft hangers are attached level, it will be necessary to shim between the feet of the hangers and the stringers to make the shaft level. The holes in the feet of the hangers are usually in the form of slots, which allow the hangers to be slightly adjusted when aligning the countershaft with the driving shaft. In leveling and aligning the countershaft, it is the practice to insert the bare shaft in its



Front Elevation
Fig. 1

Overhead Works

End Elevation
Fig. 2

boxes and take measurements from it. It is afterward removed, the pulleys put on and then replaced in its bearings. When the hangers are securely tightened, the shaft should revolve freely. About an eighth of an inch end play is desirable on a countershaft. This can be obtained when placing the hangers.

The shipper handles are most convenient when they come within easy reach from the left front side of the machine, as this is the position commonly taken by the workman to watch the operation.

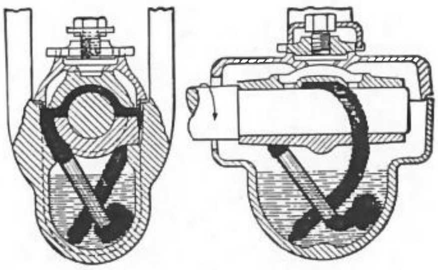


Fig. 3

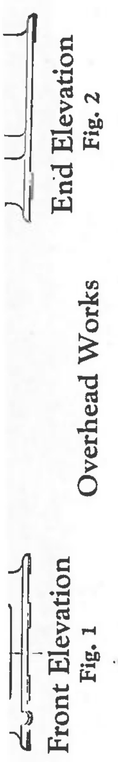
Countershaft bearings are lubricated in various ways. In our particular type the oil is raised from reservoirs in each hanger by means of rope wicks as shown in *Fig. 3.*

As a rule it is not necessary to draw off and replace the oil in countershaft reservoirs at very frequent intervals if a good machinery oil is used. If the reservoirs are thoroughly cleaned and filled with fresh oil once every year or so they rarely need much attention. It is good practice, however, to put in a little oil every three or four months in order to insure maintaining the proper level.

Importance of Keeping Machine Clean and Well Oiled. Many workmen fail to appreciate the importance of keeping a machine clean and well oiled, and we cannot emphasize this point too strongly. Proper attention to these details influences the accuracy and efficiency of a machine and prolongs its life, while neglect to attend to these matters has ruined many a good machine.

Working parts which are exposed to dust, dirt or chips, should be frequently cleaned and oiled.

Oil tubes and channels many times become clogged with a gummy substance, due to the accumulation of dirt in the oil, and also to decomposition of the lubricant itself. This can be effectively removed without injury to the bearing surfaces by flushing the tubes and channels with gasoline or naphtha. It is well to do this occasionally to insure free passage of oil to the



bearings, for if the bearing surfaces, especially cylindrical ones, run dry, they become roughed up, which necessitates taking them apart, and entails considerable work before they can be made to run satisfactorily again.

A machine that has been in active service for a period of a year or two should be thoroughly cleaned and inspected. To do this requires that it be taken apart to some extent, as it is impossible to ascertain the condition of some of the more important bearing surfaces in any other way. Also it is the only way in which one can make sure that some of the oil channels that are not easily accessible are not filled up.

Only good mechanics who thoroughly understand the construction of the different parts should be permitted to take apart and reassemble a machine. Because of the danger of parts being put together imperfectly and alignments not being made correctly, the work should be intrusted to responsible persons.

Spindles and boxes should be kept clean and care exercised that chips do not get in the spindle bearings.

Neatness about a machine is usually the mark of a good workman. By assigning definite places to tools and attachments and returning them immediately after using, he is able to know just where to look for any one whenever he wants it. The time required to replace tools in this way is more than offset by the advantage of being able to readily find them again; besides, the tidiness of a machine materially adds to the appearance of a shop.

It is well to remember when applying oil that ordinary bearings can hold only a few drops at a time and that this amount applied at regular and frequent intervals is far more beneficial than a flood of lubricant at irregular periods. It is a good practice to have one man attend to the oiling daily in shops where the machines are used by different workmen.

Kind of Oil. There are so many good machinery oils upon the market that it is hard to specify any one as the best to use for lubricating a grinding machine. Any good coal or mineral oil can be used. Never use an animal oil, as it will gum up the bearing surfaces, oil channels and tubes, and have a tendency to retard rather than render easy the movements of the different parts.

It might also be said that in buying machinery oil it is always safest to purchase a lubricant of reliable quality instead of experimenting with the less expensive brands. It is cheaper to buy good oil than to run the risk of damage to bearings from overheating or scoring.

Wheel Spindle and Boxes. The wheel spindle and boxes are shown in *Fig. 4.* The ends of the spindle are tapered to receive the wheel sleeves upon which the wheels are mounted, thus facilitating the changing of the wheels and insuring their running true when placed in position.

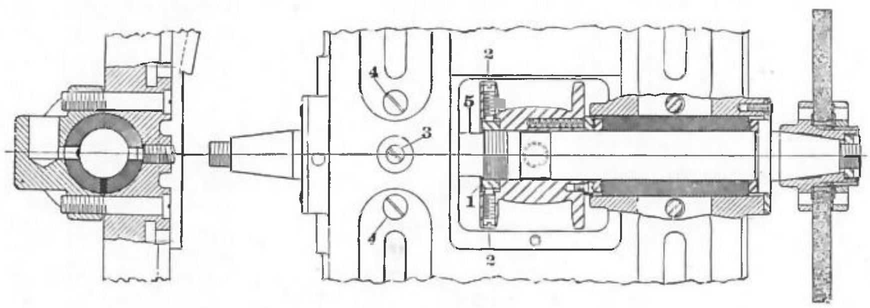


Fig. 4

Wheel Spindle

No. 1 Adjusting Nut for end play of Spindle.
No. 2 Locking Screws for Adjusting Nut.
No. 3 Screw to Locate Box Endwise.
No. 4 Screws for Adjusting Box.
No. 5 Recess in Spindle to receive Nut when backed off.

Adjustment of Spindle. To take up end play, loosen locking screws 2, *Fig. 4,* about one turn—they should not be taken out—then, by means of the spindle belt, hold the pulley from turning and turn the spindle toward the back of the machine until the end play is taken up by means of nut 1, which is recessed into the pulley and held by the locking screws; tighten screws 2 to clamp nut 1 to the spindle. The thrust is taken by the collar, shown on the right-hand end of the spindle, which bears against a hardened steel washer.

To remove the spindle without disturbing the adjustment of the boxes, loosen the locking screws 2, as mentioned above, and turn the spindle toward the front of the machine, the pulley being held in the same manner as for end play adjustment; this will turn the nut 1 off the thread, as that part of the spindle indicated at 5 is smaller to allow the nut to turn off and permit the spindle to be withdrawn. Nut 1 is made in halves so that it can be removed without the necessity of withdrawing the spindle.

Adjustment of Boxes. To adjust the boxes to compensate for wear, loosen screw 3, *Fig. 4,* about six turns and loosen screws 4, thus freeing the box which can be removed endwise. The brass-liners, inserted to keep the boxes from tightening up, can then be thinned down and the boxes replaced. By tightening screws 4 the boxes will close up.

The boxes are split, as shown in *Fig. 4,* and close concentrically when screws 4 are tightened, thus insuring a uniform bearing for the spindle at all times.

Wheel Slide. The wheel slide has a vertical adjustment of 8″ and is operated by the handwheel 18, *Fig. 5,* graduated to read to thousandths of an inch. The handwheel can be swiveled in a horizontal plane and adjusted to a convenient position to be reached from the front of the machine. The knob 1, *Fig. 5,* serves to clamp the wheel in position when it is satisfactorily adjusted.

The upright that carries the wheel slide is rigidly supported by a projection of the base of the machine that reaches to the floor. It swivels upon a large bearing that is protected from grinding grit and dust and is clamped evenly by four bolts that slide in a circular slot. The periphery of the base is graduated to degrees.

Aligning Centers of Wheel and Work. In grinding all varieties of cylindrical work, either straight or taper, the center of the wheel spindle should be in line with the head and foot-stock centers. To adjust the wheel spindle head to the proper height, place the center height gauge, furnished with the machine, on top of the table and move the head vertically until the top of the lug 11, *Fig. 5,* just touches the testing surface of the gauge.

The Internal Grinding Attachment is provided with a lug corresponding to that on the wheel spindle slide and is adjusted in the same manner. When using the gauge in connection with the Radial Grinding Attachment, the base should be placed on top of the work slide 3, *Fig. 10.*

Swivel Table. To make a quick adjustment of the swivel table, release clamp bolt 5, and the end table clamps, *Fig. 5*. Raise knob 6 and turn it a little to allow the latch to catch and hold the knob up. To set the swivel table to an angle greater than 3″ taper per foot, raise the knob 6 and use the graduations on the front. To obtain the fine adjustment, turn the knob 6 to allow it to engage the rack teeth cut in the adjusting nut. Use the thumb screw 7, *Fig. 5*, for making the adjustment. For slight adjustments, it is well to release the clamp bolt 5 and the end table clamps just enough to bind the table firmly—adjusting thumb screw 7 as required.

Setting the Table to Grind Straight. No amount of care in construction or in setting to a line can assure the elimination of error. There are many complications that arise to cause error, and over which there is no control. The adjusting screw should be used to adjust the table in order to grind accurately except where angles greater than 3″ taper per foot are required. A magnifying glass should not be used when setting to the zero line. It is sufficient that the zero lines practically coincide. If it is plain to the eye that they do, place the work on the centers and measure both ends, noting which is the larger, or whether they are alike. Then start the machine and move the wheel to take a very light cut. If one end of the work measures larger than the other, the cut should show deeper at that end. While the machine is running, adjust the screw 7, *Fig. 5*, carefully, allowing the sparks to indicate the correct position and amount of adjustment; the sparks will show with a reduction of diameter much less than .0001″. After the wheel has cut evenly over the entire length, measure the two ends and adjust as before until the required accuracy is obtained.

This method should also be employed in grinding tapers 3″ per foot and less; but in place of measuring the ends of the work, a suitable gauge or standard taper hole is preferable for determining the taper.

Headstock and Footstock. The spindles have No. 6 taper holes. The head-stock spindle has two pulleys, 12 and 13, *Fig. 5*, and the front end is 1½″ diameter, threaded 6 to the inch to receive a a chuck or face plate. Pulley 12 is for driving the spindle when it is desired to grind work held in a chuck, on a face plate or upon live centers. Pulley 13 is for driving work to be held upon dead centers; when this pulley is used, the spindle is clamped by the

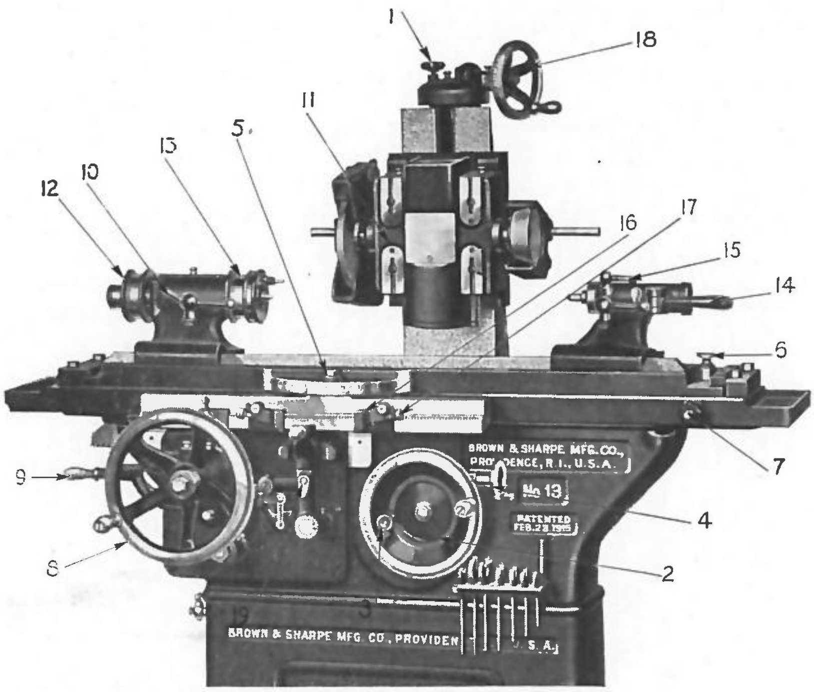


Fig. 5

Index to Parts of No. 13 Machine

1. Knob for Clamping Elevating Screw Handwheel Bearing after Setting.
2. Handwheel for Cross Feed.
3. Thumb Screw for Changing from Fine to Coarse Cross Feed.
4. Thumb Screw for Fine Cross Feed.
5. Bolt for Clamping Swivel Table.
6. Spring Knob for Engaging Fine Adjustment of Swivel Table.
7. Thumb Screw for Making Fine Adjustment of Swivel Table.
8. Handwheel for Traversing Table.
9. Lever for Controlling Hand and Automatic Table Feed.
10. Handle for Clamping Headstock Spindle.
11. Lug for Aligning Work Centers and Wheel.
12. Live Center Pulley.
13. Dead Center Pulley.
14. Lever for Operating Footstock Center.
15. Clamp for Footstock Spindle.
16. Adjustable Table Dog.
17. Screw for Fine Adjustment of Table Dog.
18. Handwheel for Vertical Adjustment of Wheel Slide.
19. Lever for Locking Hand and Automatic Table Feed.

handle 10, *Fig. 5*. The head-stock does not swivel. The foot-stock spindle can be adjusted longitudinally by means of a lever and is held in position by a spring and can be clamped by bolt 15, *Fig. 5*.

Automatic Table Feed. The automatic table feed is driven independently of the wheel spindle by a 4-stepped cone pulley. There are four changes of feed, varying from 12″ to 76″ per minute. The hand feed is operated by the handwheel 8. A coarse or fine feed can be obtained by the movement of the lever 9, *Fig. 5*, which controls both the hand and power feeds, as indicated by the note shown on page 12.

A safety mechanism prevents the operator from throwing on the table power feed while the reversing lever is locked and thus stripping the teeth of the table rack. Once the reversing lever is locked and the handwheel is employed for traversing the table, it is impossible to throw in the table power feed until the reversing lever is unlocked. The lever for locking the hand and automatic table feed is shown at 19, *Fig. 5*.

Cross Feed. The cross feed is operated by the handwheel 2, *Fig. 5*, that is graduated to read to thousandths of an inch on the diameter of the work. To obtain the coarse feed, loosen the thumb nut 3, *Fig. 5*, and to obtain the fine feed, tighten nut 3 and use knob 4 instead of the handwheel.

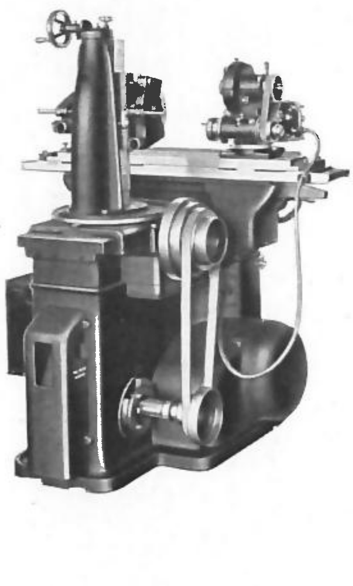
CHAPTER III

Motor Drive

The No. 13 Universal and Tool Grinding Machine (Motor Driven) is a very complete and compact grinding unit. It is recommended to those who desire the individual type of drive and also as a solution of installation problems where line-shaft belt drives are not available.

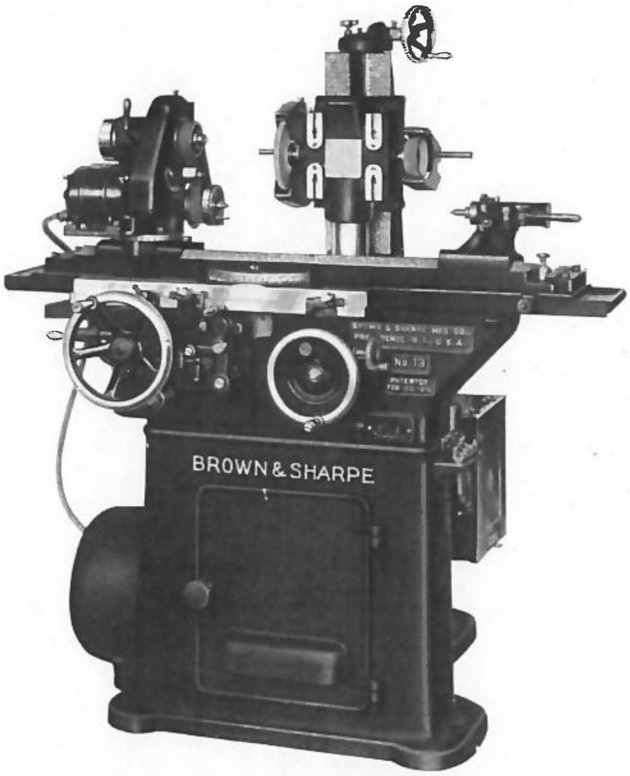
The main driving motor is securely mounted on a plate in the base of the machine and drives both wheel spindle and table. The drive to the wheel spindle is taken from the main motor by belt, an automatic belt tightener maintaining the correct tension in the belt regardless of the position of the wheel slide. Three wheel speeds are provided by change pulleys. The table is also driven by belt from the main driving motor through cone pulleys. Provision is made for maintaining the proper tension on this driving belt.

The compartment in which the motor is located is well ventilated to assure a cool-running motor. A shelf which divides the compartment provides space for the storage of tools and accessories. When a magnetic chuck is used, and there is no



Rear View
No. 13 Universal and Tool Grinding Machine Motor Driven

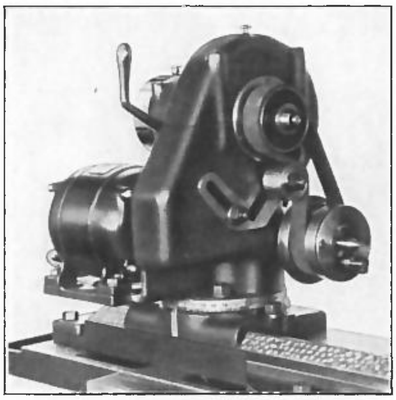
Note the cone pulleys used for table drive and the heavy wheel spindle slide upright shown in this view.



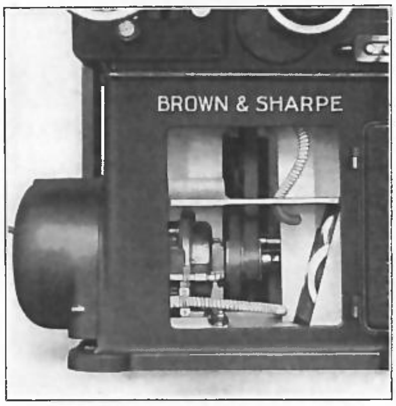
No. 13 Universal and Tool Grinding Machine
Motor Driven

source of direct current available, a third pulley, placed on the motor shaft, drives a generator which can be located behind the motor.

A second motor, mounted directly on the headstock, drives the work by belt on either live or dead centers, adjustable idlers assuring maximum belt-contact and power delivery. A quick acting clutch, operated by a convenient lever, starts and stops rotation of the work without stopping the motor.



Headstock



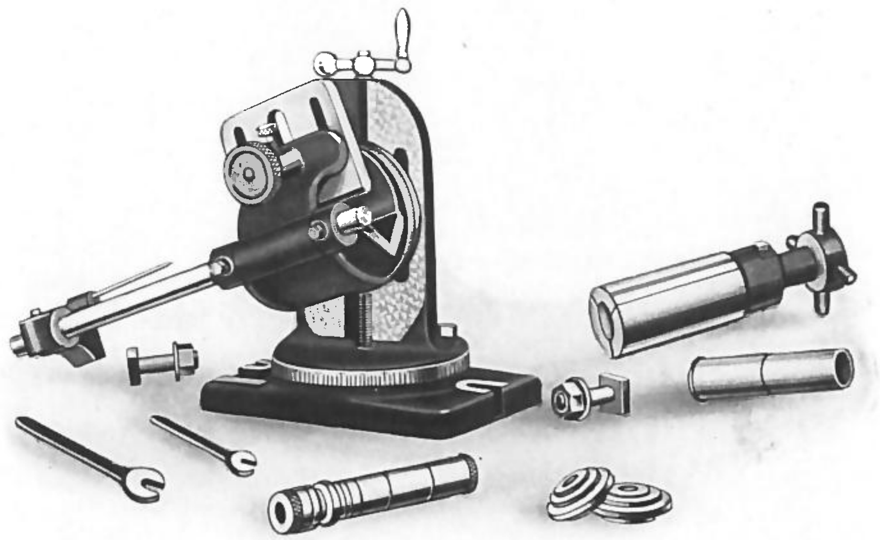
Motor Compartment

The headstock pivots on a central stud, a graduated scale and finger indicating the adjustment. The headstock may be easily detached from the machine as the electric cable is provided with a removable plug.

The electrical control of both motors is by a push button switch of the "start-stop" type, connected to a magnetic starting box. Each motor is protected from "burning out" by thermal cut-outs or fuses. The switch is conveniently located on the front of the machine while the magnetic starting box is attached to the base casting at the rear where it is readily accessible. Because of the fineness of motor balance required this machine is only furnished *fitted with* motors.

CHAPTER IV

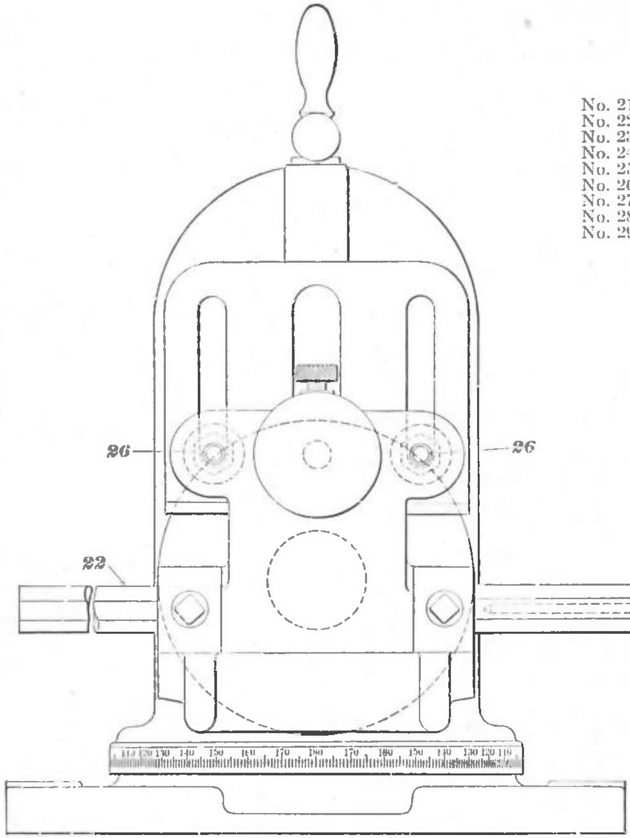
Attachments



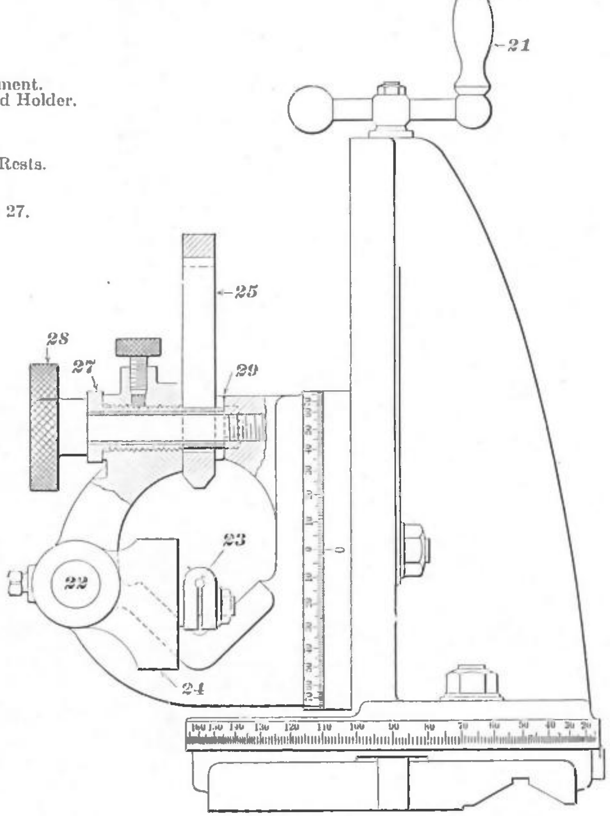
The Universal Head

The Universal Head is adapted to hold all forms of milling cutters directly by their shanks or on arbors, also for holding cutter bars to receive work mounted on sliding shells. The head-stock spindle sleeve and pulley of the machine can be removed and placed in the Universal Head for grinding tapered work similar to that shown in *Fig. 47* or work that is larger in diameter than the centers will swing. The base is graduated around the entire circumference in degrees. The tool head swivels to 90° either side of zero. They are each clamped by two bolts that slide in circular slots. The work head has a vertical adjustment of 4″ that is controlled by the ball crank 21, *Fig. 7*, at the top of the elevating screw. With the head at its extreme height, it will swing 16″ in diameter over the table.

No. 21. Screw for Vertical Adjustment.
No. 22. Bar for Carrying Stop Rod Holder.
No. 23. Stop Rod.
No. 24. Stop Rod Holder.
No. 25. Back Rests.
No. 26. Bolts for Clamping Back Rests.
No. 27. Adjusting Screw.
No. 28. Clamping Screw.
No. 29. Bearing Surface for Screw 27.



Front Elevation
Fig. 6



Side Elevation
Fig. 7

Universal Head

Side Elevation
Fig. 7

Universal Head

Front Elevation
Fig. 6

The cutter bar 22, *Fig. 6,* is provided for receiving sliding shells upon which cutters or other work can be mounted for grinding. It also supports the holder 24 that carries the rod 23. This rod is sufficiently flexible to adjust itself to the center of the work without the necessity of being accurately located and, at the same time, it is rigid enough to support the work endwise.

Setting Work in the Head. To set the arbor or cutter shank in the V of the head, adjust the stop rod 23, *Fig. 7,* approximately to the center of the work. Locate the holder 24 carried on bar 22, to allow the work to project a suitable distance beyond the V for convenient grinding.

The back rest 25 should be adjusted to rest freely upon the shank or arbor and the nuts 26, *Fig. 6,* tightened to clamp it in position. Adjust screw 27 so that when screw 28 is tightened it will bear against the surface 29, *Fig. 7,* and hold the work firmly seated in the V. The work, to be easily and quickly ground, should not be clamped tight enough to prevent its being readily turned by hand. After setting screw 27, it is clamped in position by the thumb screw shown at the top of boss, *Fig. 7.*

Taper Shank Mill Sleeve. This sleeve, shown at the right of the cut on page 23, and its application in *Fig. 31,* is for use in grinding end mills, etc., that are held by their shanks. Two bushings are furnished, one No. 7 and one No. 9 taper; other sizes are made to order when desired.

The outer shell or sleeve is held rigidly in the tool rest of the Universal Head. The tapered bushing that holds the work is free to turn in the sleeve and is held positively against the end of the sleeve by a spring. The handle, which is clamped to the end of the bushing, serves to hold the work against the tooth rest as well as a means for indexing.

Figs. 27 to 36 suggest uses of the Universal Head.

The Tooth Rest

The tooth rest should, wherever possible, bear against the face of the tooth being ground. The top of the tooth rest should be flat and true, and should be somewhat wider than the wheel, to allow the cutter to pass off before the tooth leaves the rest. If the top of the rest is narrower than the wheel, it will readily be seen that the teeth would not be correctly ground, because, during a part of the time, the tooth will not be supported while the wheel is grinding.

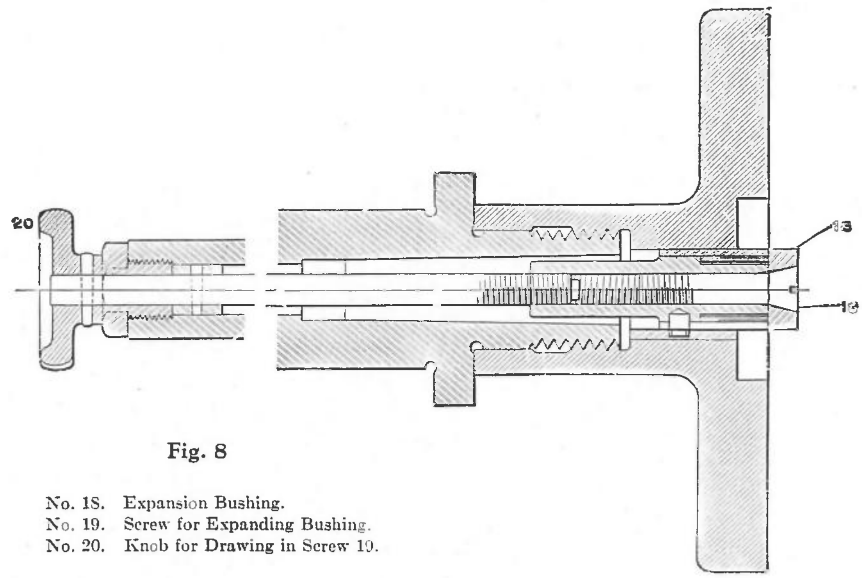
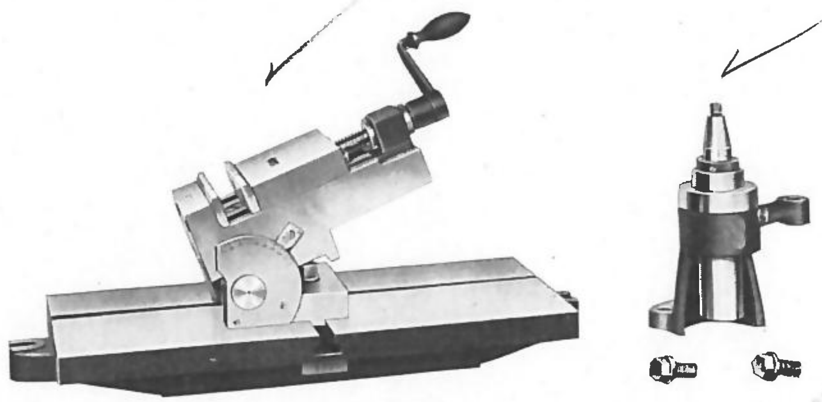


Fig. 8

No. 18. Expansion Bushing.
No. 19. Screw for Expanding Bushing.
No. 20. Knob for Drawing in Screw 19.

The Face Chuck

This chuck, shown in section *Fig. 8,* is for grinding the sides of thin milling cutters, saws, washers and work of a similar character. The work is held by the expansion bushing 18, which is expanded by the screw 19, and drawn against the face of the chuck by turning the knob 20. Different sizes of bushings are easily and quickly inserted to fit the various sizes of holes in the work. *Figs. 37 and 38* suggest uses of the Face Chuck.



Surface Grinding Attachment

This attachment, which is furnished when ordered, is convenient for all varieties of surface grinding within the capacity of the machine. It consists, as shown above, of an adjustable vise, a large table plate, and a wheel spindle extension.

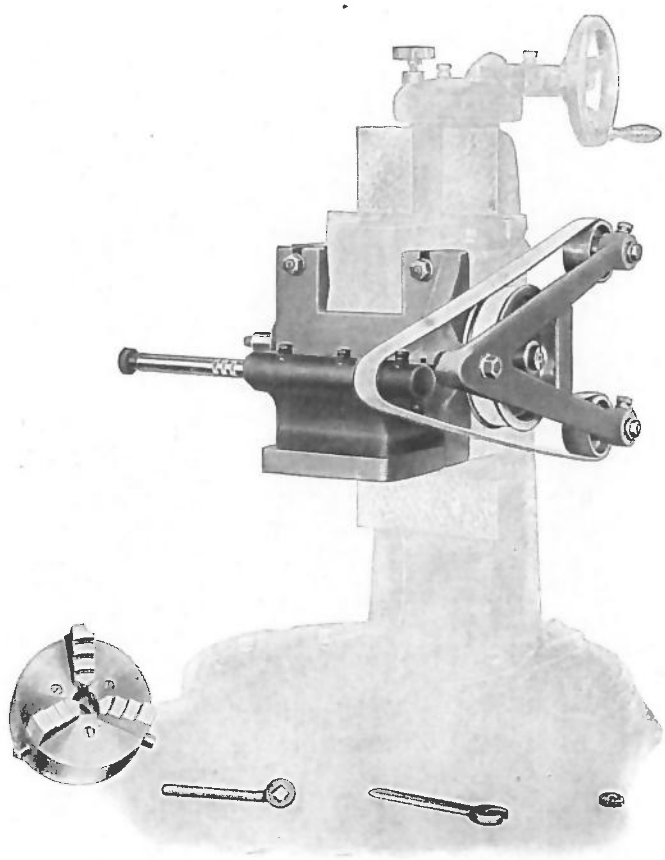
The Vise has hardened jaws, $4\frac{1}{8}''$ wide, $1\frac{1}{16}''$ deep and will open 2″. It is mounted upon a hinged base and can be set at any angle to 90° in a vertical plane. A dial on the hinged bolt, graduated to read to degrees, indicates the setting. The height of the vise is $4\frac{7}{16}''$.

The Table Plate has a working surface 17″ x $7\frac{3}{8}''$, is $1\frac{3}{4}''$ thick and has two T slots $\frac{1}{2}''$ wide at right angles. The plate is clamped to the table by two bolts that fit the T slot.

The Wheel Spindle Extension allows the wheel to be used over the entire surface of the table plate. It is screwed to the left-hand end of the wheel slide, and runs in a self-aligning box, which is supported by a bracket bolted to the wheel slide.

Weights. Net, about 68 lbs.; ready for shipment, about 80 lbs.

Dimensions for shipment, 24″ x 9″ x 9″. Space occupied, about 1 cubic foot. *Figs. 42 to 46* suggest uses of the Surface Grinding Attachment.



Internal Grinding Attachment

Internal Grinding Attachment

The Internal Grinding Attachment for this machine consists of a bracket or platen clamped to the machine, on which a regular Internal Grinding Fixture, as used on our Universal Grinding Machines, is mounted and driven from the wheel spindle.

A knee is provided which is clamped to the front of the wheel slide by four bolts, in T slots. The knee carries a belt tightener arm, and an internal grinding fixture, as shown on the opposite page.

A driving pulley, two grinding wheels, a 4″ 3-jawed universal chuck, and a belt, are furnished.

The grinding spindle is of comparatively small size, mounted in an adjustable bearing, and carried by telescopic tubes of sufficiently large diameter to give the required rigidity. These tubes are adjustable longitudinally relative to each other to take up wear in the bearing, and furnish a support for the spindle in close proximity to the grinding wheel. The small diameter of the spindle enables it to be run at the required high speeds. The pulley spindle is carried on ball bearings. Provision is made for excluding dust from the bearings.

No. 03 fixture is regularly furnished with the Attachment, but any other size can be substituted without extra charge. (See list below.)

The Attachment can be used to advantage on the machine in connection with the Radial Grinding Attachment for grinding cutters with fine teeth.

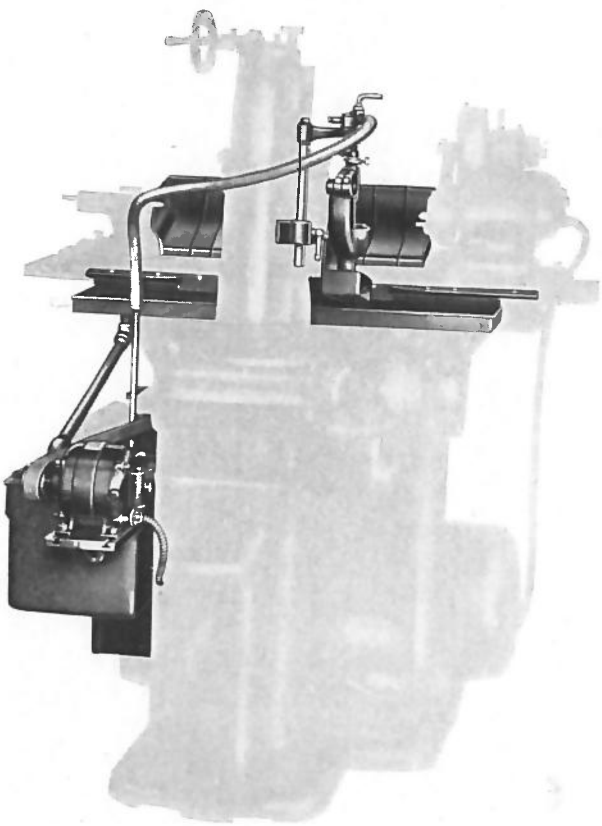
Weights. Net, about 55 lbs. Ready for shipment, about 72 lbs. Dimensions for shipment, 20″ x 12″ x 10″.

Figs. 48 to 51 suggest Uses of the Internal Grinding Attachment.

Internal Grinding Fixtures

No. of Fixture	Distance from Bottom of Stand to Center of Spindle	Length that can be Ground	Diameter of Hole that can be Ground	Diameter of Hole in Wheel	Speed, Revolutions per minute
*01	3″	1½″	¼″ to ½″	3/32″	22,500
02	3″	3¾″	½″ to ⅞″	¼″	18,000
03	3″	5¼″	¾″ to 1⅛″	¼″	15,700
04	3″	6″	1⅛″ upward	⅝″	15,000

*The No. 01 fixture differs in design from the one shown in the illustration and is provided with three arbors of varying lengths.



Wet Grinding Attachment on Motor Driven Machine

Wet Grinding Attachment

This attachment is particularly adaptable to cylindrical work. It consists of a No. 2 Centrifugal Pump that delivers an ample supply of water to the grinding wheel. The piping is designed to be adjustable to any necessary height and it can be swiveled in any direction. The special cast iron guard for the grinding wheel almost encloses the wheel although it does not interfere with the work. It furnishes adequate protection to the operator and confines the cooling fluid to its proper course. A set of telescopic water guards for the table gives the operator additional protection from the spray.

A trough is fastened to the rear of the sliding table and it catches the water as it leaves the work and conducts it back to the tank. In the water tank a settling pan is provided to collect the sediment and prevent the pump from becoming clogged. The pan can be easily removed and cleared. At the bottom of the tank a drain plug with a hexagon head furnishes a convenient means of draining the tank completely.

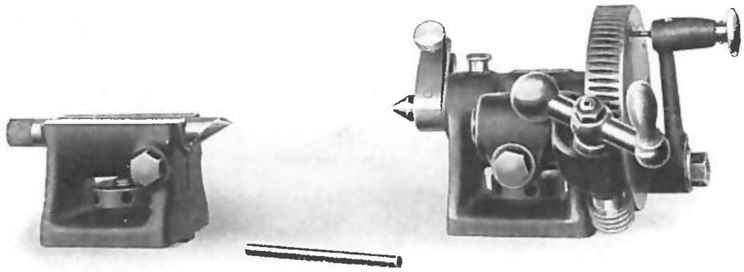
A bronze shut-off cock controls the flow of the water and a nozzle on the end of the pipe is designed to direct the water to the work without allowing it to spatter about.

Weights. Net, about 195 lbs. Ready for shipment, about 265 lbs. Dimensions for shipment, 46″ x 17″ x 17″. Space occupied, about 8 cubic feet.

The Wet Grinding Attachment, for use on the Motor Driven No. 13 Universal and Tool Grinding Machine, is shown on the opposite page and is essentially the same as the belt driven attachment except that the water tank is fastened to the opposite side of the machine and the pump is driven by a constant speed motor.

These attachments are not designed for surface grinding, or the grinding of splines or slots on centers as well as general cutter grinding.

Weights. Net, about 190 lbs. Ready for shipment, about 250 lbs. Dimensions for shipment, 46″ x 17″ x 17″. Space occupied, about 8 cubic feet.



Index Centers

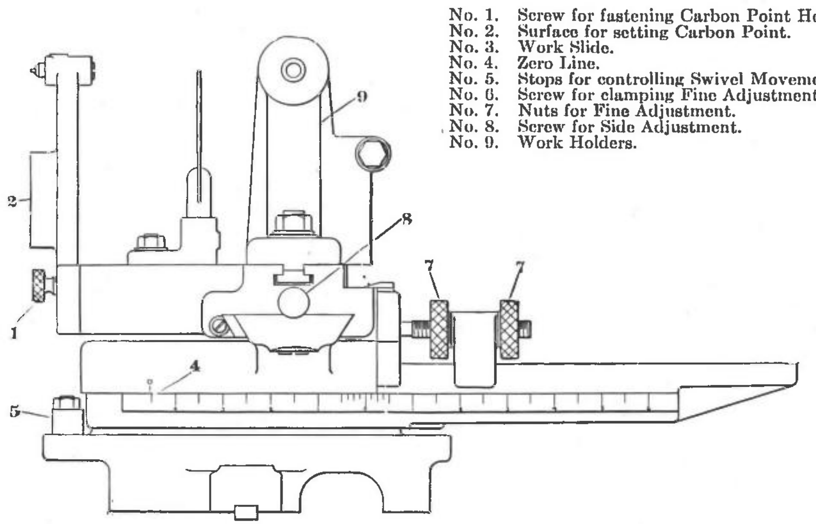
These Index Centers are our regular 4¾″ centers convenient for grinding formed cutters and work of a similar class as shown in *Fig. 17.* They are designed to be mounted with raising blocks on the machine table clamped to the table T slot. Raising blocks are required when used on this machine.

The index plate has 24 holes and can be turned by a worm or the worm can be disengaged and the plate turned by hand. The centers swing, with raising blocks, 8″ in diameter and take 30″ in length when used on No. 13 Universal and Tool Grinding Machine.

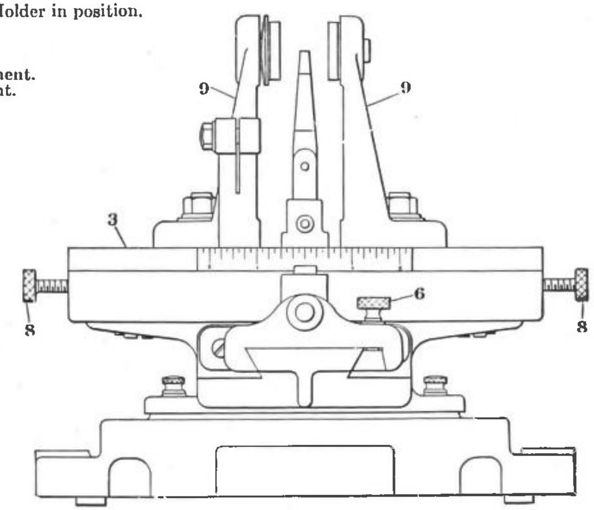
The combined length of the head and footstock is 8½″.

Weights. Net, about 12 lbs.; ready for shipment, about 16 lbs. Dimensions for shipment, 12″ x 8″ x 6″. Space occupied, about 1 cubic foot.

No. 1. Screw for fastening Carbon Point Holder in position.
No. 2. Surface for setting Carbon Point.
No. 3. Work Slide.
No. 4. Zero Line.
No. 5. Stops for controlling Swivel Movement.
No. 6. Screw for clamping Fine Adjustment.
No. 7. Nuts for Fine Adjustment.
No. 8. Screw for Side Adjustment.
No. 9. Work Holders.



Side Elevation
Fig. 9



Rear Elevation
Fig. 10

Radial Grinding Attachment

Cross Slide. A cross slide with fine adjustment is provided, and a graduated scale reading to 64ths of an inch which indicates the position of the slide up to 2″ either side of center.

Work Holders. The work holders 9, *Fig. 10,* take 5″ in length and swing 8″ in diameter, and provision is made for side adjustment. A spring washer is provided to hold the work against the positive holder; the washer can be depressed to allow the work to be indexed when it is half a circle and will not swing clear of the wheel.

The tapered shank holder has a bushing with a No. 10 tapered hole. A scale on the back of the slide, graduated to read to 64ths of an inch, indicates the transverse adjustment when it is required to grind a radius on the corners of cutter teeth or some similar operation.

Equipment. Eight bushings for $\frac{7}{8}$″, 1″, 1$\frac{1}{16}$″ and 1$\frac{1}{4}$″ holes, carbon point and holder.

Weights. Net, about 65 pounds. Ready for shipment, about 80 pounds. Dimensions for shipment, 20″ x 12″ x 7″. Space occupied, about 1 cubic foot.

Method of Adjustment

First: Set the wheel spindle to the same height as the center of work bushing, using the center height gauge, which should rest upon the work slide 3, *Fig. 10.*

Second: Place the carbon point holder in position and fasten securely with thumb screw 1, *Fig. 9.* It is important that the carbon point be on a line with the surface 2. A straight edge can be used in making this adjustment.

Third: Set the work slide 3 to the radius required. The most convenient method to employ in making this adjustment is as follows: Loosen clamp screw 6, *Fig. 10,* move the slide until the zero line is approximately correct; tighten screw 6 and adjust the nuts 7, *Fig. 9,* until the zero line 4 coincides with the reading on the scale for the required radius. To grind a convex cutter, the zero line 4 should be moved to the left of the zero on the scale, and to grind a concave cutter, it should be moved to the right.

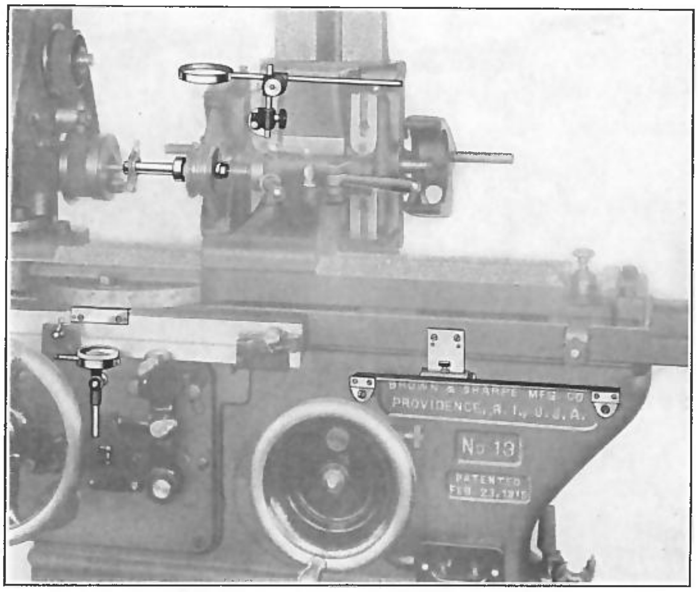
Fourth: Move the wheel transversely until it nearly touches the carbon point; lock the table of the machine by means of the table stop and adjustable dogs, to prevent longitudinal movement. Start the machine and move the wheel toward the carbon point until it begins to cut, then swivel the lower slide and feed the wheel to the cut until the wheel is properly trued to the radius to be ground. Another method of truing the wheel is shown in *Fig. 53.* In employing this method, the wheel spindle is set at right angles to the table and the carbon point held against the wheel by the table feed; the table should be locked after the wheel is trued, as explained above.

Fifth: Tighten screw 3, *Fig. 5,* to clamp the cross feed of the wheel. Do not change the vertical adjustment after truing, except as noted in paragraph 6. Release screw 6, *Fig. 10,* draw back the work slide, and remove the carbon point holder.

Sixth: Place the cutter in position and set the tooth rest as shown in *Fig. 54.* Feed the work slide forward until the cutter nearly touches the wheel. Raise or lower the wheel, as may be necessary, to obtain the proper clearance. It is important that the cutter be located on the work slide to bring the center of the radius to be ground directly over the center of the pivoting point of the lower slide. For example: To set the convex cutter, as shown in *Fig. 54,* swivel the attachment to bring first one side and then the other toward the wheel and move the cutter sideways until each side shows the same distance from the wheel, the side adjustment being used for this operation.

Seventh: Set the stops 5, *Fig. 9,* to control the swivel movement of the lower slide. Tighten screw 6, *Fig. 10,* and feed the cutter to the wheel by means of the nuts 7, *Fig. 9.* Should the radius obtained not be correct, move the wheel by means of the knob 4, *Fig. 5,* transversely, to compensate for the inaccuracy of setting the carbon point for truing off the wheel. To increase the radius to be ground on a convex cutter, the wheel should be moved away from the work, and for a concave cutter, toward the work.

To grind a radius on the corner of a cutter tooth, as shown in *Fig. 52,* the holder should be set off the center so that the reading of the scale on the back of the work slide will be equal to the distance from the radius center to the axis of the cutter. This is accomplished by manipulating screw 8, *Fig. 9.* *Figs. 52 to 57* suggest uses of the Radial Grinding Attachment.

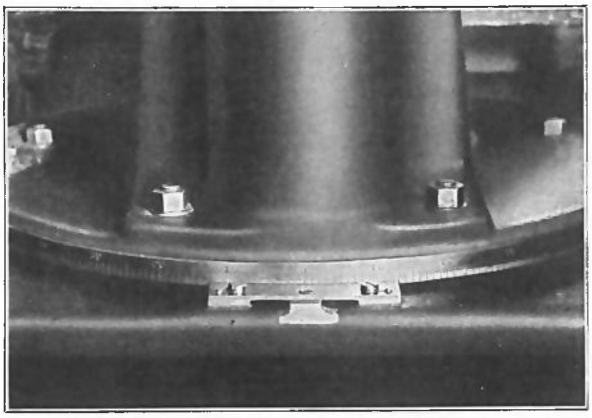


Circular Forming Tool Grinding Equipment

The contours of screw machine forming tools and similar work can be ground to advantage on the No. 13 Universal and Tool Grinding Machine by the use of the equipment shown above. The various parts can be readily applied to the machine and are furnished either as separate units or as a complete equipment.

The equipment is shown in place on the machine. All units may be seen except the vernier for angular setting of the upright. This is located at the rear of the machine on the graduated base of the vertical upright. The work arbor is shown held in position for grinding a radius on a forming tool. A dial indicator, mounted in a bracket secured to the bed, engages with a stop on the sliding table, permitting very accurate readings of the table movement.

The scale to the right of the cross feed handwheel is designed to give an accurate vernier reading on long work beyond the capacity of the dial indicator. The vernier is secured to the sliding table.



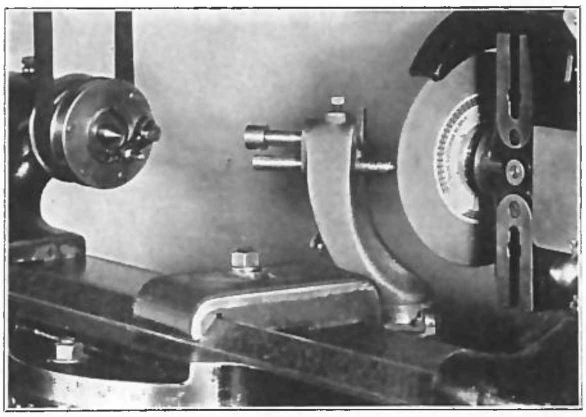
Graduated base of the vertical upright with the vernier scale secured to the rear of the cross feed carriage, enabling accurate angular setting of upright.

When the swivel table is set for grinding angles, the swivel table vernier facilitates accurate adjustment.

A separate booklet, "The Form Grinding of Circular Form Tools" can be obtained by writing us. This booklet is very valuable to the operator who does this work.

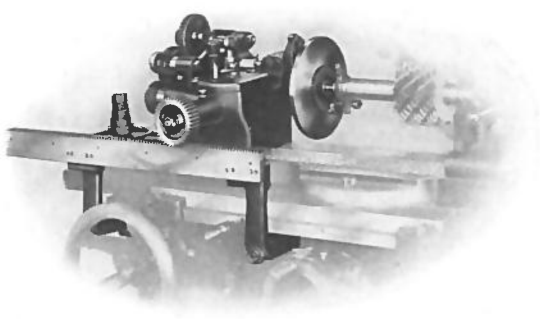
The following units can be furnished either separately or as a complete equipment:

Floating Arbor (For Nos. 2, 4 and 6 Auto. Screw Machine Tools). Table Travel Dial Indicator. Floating Arbor (For Nos. 00, 0 Auto. Screw Machine Tools). Table Travel Scale and Vernier. Radius Truing Device for Grinding Wheels. Upright Vernier. Diamond for Radius Truing Device for Grinding Wheels. Swivel Table Verniers. Reading Glass.



Radius Truing Device mounted on the swivel table in correct position to dress the grinding wheel to a radius.

Weights (complete) Net, about 29 lbs. Ready for shipment, about 36 lbs. Dimensions for shipment, 15"x13"x7". Space occupied, about 1 cubic foot.



The Hob Grinding Attachment on the Machine with Guards Removed

Hob Grinding Attachment

Any hob grooved on a Brown & Sharpe milling machine, either right or left-hand, can be quickly sharpened by using the No. 13 Universal and Tool Grinding Machine. In case of hobs having very short or long leads the gearing can be double compounded so that the correct rotary movement of the hob will be obtained. For grinding a straight grooved hob disconnect the gears and lock the headstock spindle. Hobs up to 8″ in diameter and 12″ in length can be ground with this attachment.

Construction. The attachment consists of a spindle which is driven, through a combination of change gears, by means of a small pinion the teeth of which mesh with those of a fixed rack located on the front of the machine. As the table is moved longitudinally, the driving pinion revolves, causing the spindle to turn in such a ratio to the table movement that the correct lead of the grooves is maintained and each tooth is ground an equal amount.

Reversing Mechanism. This consists of a pair of bevel gears keyed to the driving pinion shaft but free to move longitudinally. In this way, either gear may be made to mesh with a third bevel gear located between them. From this gear the drive to the spindle is positive; therefore by changing the direction of its rotation, that of the spindle is likewise changed.

A swinging lever on the top of the gear case controls the movements of the sliding bevel gears and, when brought into the correct position, automatically locks itself by means of a spring plunger which engages with holes in the top of the case.

Grinding Wheel. The wheel is mounted on a special spindle extension, which is furnished with the attachment, and after being set to grind the face of the teeth radially, its position is not changed, except to compensate for the wear of the wheel. All further adjustment, for depth of cut, is made by means of a fine screw that feeds the hob to the wheel.

Many operators have been bothered with the question as to which side of a beveled grinding wheel to use on a spiral grooved hob and which to use on a straight grooved hob. The beveled side should be used on the hob with the spiral groove and the straight side should be used on the hob with the straight groove.

Sharpening Hobs with Spiral Grooves. In sharpening hobs having spiral grooves, some difficulty is experienced in keeping the face of the tooth radial.

This is very noticeable on hobs having a short lead. On long lead hobs a bevel and concave or saucer shape wheel like Brown & Sharpe shape 27 is very satisfactory, using bevel side. But on shorter leads the wheel with the greater angle must be used to avoid the tooth striking the front and back edge as it rolls by the wheel.

On very short leads it is necessary to use a small wheel and shape it to a round back. As this must be done free hand it requires some skill and experience in dressing the wheel.

Index Plates. The index plate is free to revolve upon the spindle. A spring pin, carried upon an adjustable arm that is fastened directly to the spindle, fits into holes in the index plate and drives it in this manner. When changing the work from one groove to another, the pin is withdrawn and the plate turned until another hole is reached; the pin then automatically slides into place, locking the spindle and plate together. A work pin and an adjustable yoke, located on the opposite side of the index plate, provide for fastening the dog that drives the work in such a manner that there is no lost motion between the plate and the work.

Footstock. The regular footstock furnished with the machine is used in connection with this attachment.

Conveniences. All working parts are easily accessible and are furnished with ample and convenient means of lubrication. The change gears and rack and pinion are well guarded. The attachment is clamped to the table by means of a single lever located on the top of the case. Two index plates are furnished with the attachment, also the necessary change gears, and a table of gears and spirals, providing for indexing hobs of from 2 to 20 grooves.

Sharpening Hobs. The extreme leads found in the design of hobs make it usually necessary to employ the use of double compound gearing or the use of 6 change gears.

Double Compounding of Gearing. When grinding hobs, the table of leads that is used for ordinary work does not approximate closely enough the very long leads used in this class of grinding. Therefore, the table of gear ratios furnished with the attachment is used to supplement the ordinary Table of Leads and permit the quick selection of the other two gears.

The table of gear ratios is based upon the change gears furnished with the Hob Grinding Attachment for the No. 13 Universal and Tool Grinding Machine. The change gears furnished with this attachment are as follows: 24 (2), 28, 32, 40, 44, 48, 56, 64, 72, 86, 100. Occasionally in determining the most accurate lead, the proper change gears will necessitate the use of two gears of the same number of teeth. Inasmuch as there are no two gears with the same number of teeth furnished with each machine, (with the exception of two gears with 24 teeth), it will be necessary to employ the next nearest gear ratio, resulting in a lead very close to the one desired.

To Determine the Proper Lead Gears for use in Sharpening a Hob when Six Gears are necessary

Example: To find the proper change gears for sharpening the groove in a hob with a lead of 102.41″.

Referring to the Table of Leads we find that 107.14″ is the lead nearest 102.41″ that can be obtained with four regular gears. Assuming that a greater degree of accuracy is desired, divide the lead 102.41″ by the decimal equivalent 4.1667 given in the table and we have 24.5782. The decimal equivalent 4.1667 is taken as it corresponds to the first gear ratio (100:24) given for lead 107.14″ in Table of Leads. The nearest lead to

24.5782 (which was found above) listed in the Table of Leads is 24.57 and the change gears for this are 86:40 and 64:56.

Combining with these the gears which correspond to the decimal equivalent 4.1667 and also the factor 10, which is the constant of the lead of the No. 13 Universal and Tool Grinding Machine we have

$$\frac{86 \times 64 \times 100 \times 10}{40 \times 56 \times 24} = 102.3810''$$

Thus the six change gears 100, 24, 86, 40, 64 and 56 will give a lead of 102.3810″. The error of lead .0290″ or the difference between the lead desired and the lead obtained is practically negligible and is considered near enough for any practical grinding or sharpening of a hob.

When a lead greater than 149.31″ as listed in the Table of Leads is desired, it is necessary to find the proper gears by trying different values of the decimal equivalent.

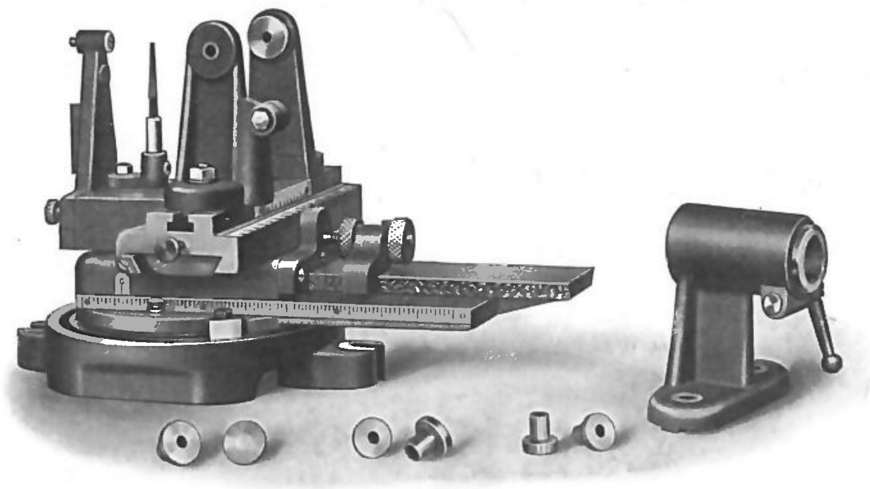
Tool Cupboard

This Cupboard is conveniently arranged for holding the various parts and attachments that are used on the machine.

It is substantially made and fitted with shelves, brackets, pins, etc., to accommodate the parts in as little space as practicable.

Dimensions. Height, 39″. Floor space, 16″ x 38″.

Weights. Net, about 100 lbs. Ready for shipment, about 200 lbs. Dimensions for shipment, 47″ x 39″ x 17″. Space occupied, about 18 cubic feet.



Radial Grinding Attachment

This attachment is for grinding convex and concave cutters and work of a similar character. It is clamped to the machine table by two bolts.

Lower Slide. The lower slide swivels on a central stud that is hardened and ground. Adjustable stops that slide in a circular slot control the arc of swing.

Work Slide. The work slide can be adjusted to grind any radius to 4½″, and a scale on the side, graduated to read to 64ths of an inch, indicates the setting. It has a fine adjustment for feeding the work to the wheel.

CHAPTER V

Grinding and Grinding Wheels

Considerable has been written upon the subject of grinding wheels and their selection for different classes of work. Opinions of writers differ somewhat, and this fact, together with the cataloging of dozens of varieties of wheels of numberless shapes by the different wheel manufacturers has seemed to confuse the inexperienced operator of grinding machines. He has, as a result, come to regard the selection of wheels as a mysterious process dependent upon good judgment coupled with long experience in the practice of grinding. In a measure, this is so, but there are many points about wheels with which the operator can acquaint himself that will enable him to soon become proficient in their selection.

As we have implied, no fixed set of rules can be laid down governing this matter and hence we give no absolute instructions in this book. Different characteristics of the materials to be ground and varying conditions that are to be fulfilled must be taken into consideration in selecting the proper grinding wheel to use.

Construction of Wheels

A grinding wheel consists of crushed abrasive, or cutting grit, held together by an adhesive substance known as the bond.

Abrasive. The first abrasives used in grinding wheels were emery and corundum, two natural abrasives found freely in nature. There were many disadvantages to these materials, chief among which was the lack of uniformity. These disadvantages led to much experimentation with the object of discovering an abrasive the quality of which would be uniform.

The results of these experiments was the discovery of carbide of silicon and oxide of aluminum, the two abrasives that are in general use today. They are both products of the electric furnace and their quality is constant.

Carbide of silicon was discovered in 1893. The first commercial use to which it was put was the polishing of precious stones. Its price at that time was in the same range as that of the materials on which it worked. With the development of hydro-electric power the cost of manufacture of silicon carbide has been decreased so that at the present time its cost is not prohibitive for general all round use.

Silicon carbide is composed of the elements silicon and carbon. The raw materials used in its production are the relatively cheap silica sand and coke which when subjected to high temperatures react to form the abrasive crystals.

The basic patents covering this material have expired and it is now manufactured by many companies under various trade names.

The crystals of silicon carbide are very hard and brittle. Because of this, wheels of silicon carbide are the best to use when grinding materials of low tensile strength such as cast and chilled iron, copper, aluminum, zinc and most non-metallic substances like rubber, celluloid, pearl and stone.

The second of the artificial abrasives, oxide of aluminum, was discovered in 1897 and produced in commercial quantities in 1901. The abrasive oxide of aluminum is produced commercially when bauxite, which is mined in many parts of the world, is exposed to intense heat. The abrasive qualities of oxide of aluminum are variable and can be controlled. The crystals of oxide of aluminum are not as hard as those of carbide of silicon but are much tougher, consequently wheels of oxide of aluminum are the best to use when grinding materials of high tensile strength such as alloy steels, wrought iron, tough bronzes and tungsten.

Bond. The second element of a grinding wheel is the bond which holds the abrasive particles together. Differences in bond impart distinct characteristics to grinding wheels.

The wheels most commonly used today are bonded by the vitrified process. The abrasive is mixed with the bonding clay, poured into molds and exposed to heat until the bonding material is vitrified.

These wheels have several important advantages. They are very pure, and are unaffected by heat or cold, water, oils, acids, etc. Their texture is porous but uniform and contains no hard or soft places. The porous texture is also advantageous as the grit is torn out more readily in the grinding process, and the wheel does not clog up easily with the material being worked upon.

The process has disadvantages, however, as well as advantages. Owing to its porous condition and to the character of the bond a vitrified wheel is not as strong as those of other processes and has practically no elasticity. Consequently thin wheels made in this way are not practical and it is not advisable to attempt very heavy side cuts with any vitrified wheel. The length of time required to make a vitrified wheel is also a disadvantage where a size is needed that is not carried in stock. It requires about a month to make a wheel, and with the larger sizes there is always danger of cracking in the kiln. In spite of these disadvantages about 80% of the wheels used are vitrified.

Silicate wheels derive their name from silicate of soda which constitutes the bond used. They are also spoken of as semi-vitrified wheels. Silicate wheels, as a rule, cut smoothly and with little heat and are especially adapted to work requiring a delicate edge. Their grade is dependable, for the process of manufacture can be easily controlled. Other points in their favor are that much larger wheels can be made by this method than by the vitrified process and that it takes only a short time to produce them. Vitrified wheels are rarely made larger than 36″ in diameter while silicate wheels can be produced up to 60″.

Shellac forms a strong bond and very thin wheels made with it are safe. These wheels also have considerable elasticity which is of advantage on certain types of work. Shellac wheels produce a very smooth finish and deep side cuts can be taken. These wheels are sometimes called elastic wheels. They are used in cutting off operations, for finishing chilled iron, cast iron and steel rolls.

Bakelite bonded wheels have proven to be very successful on certain cutting-off operations. The field of bakelite wheel cannot be definitely defined. They are very strong wheels and are usually run at higher speed than vitrified wheels.

Rubber forms a bond of great strength and wheels bonded with this material are used to cut grooves and for similar work. They are run at very high speeds.

Grain. All abrasives are screened through sieves and the fineness of the particles is designated as grain, according to the number of the finest mesh screen through which they pass. For instance, a 36 grain abrasive is one that will just pass through a 36 mesh screen, that is, a screen having 36 meshes or apertures per linear inch. This method of designation is likewise applied to wheels and hence a 36 grain wheel contains abrasive that will just pass a 36 mesh screen.

Several sizes of abrasive are often combined to produce a compact wheel, and when this is done the resultant wheel is known as a combination.

Grade. The bond of a grinding wheel does more than merely hold the particles of abrasive together. It also determines how strongly the particles are held. Wheels from which the grit is readily torn are known as soft bond or soft grade, and those that strongly retain the grit are called hard bond or hard grade.

These differences in tenacity of a bond are produced to some extent by varying the amounts of minor ingredients that enter into it. All wheels, however, are tested for grade by the makers and whatever degree of hardness they are shown to have, is recorded as their grade.

The grade of grinding wheels is designated in different ways by the various manufacturers. In some cases letters are used to indicate it, in others numbers are employed. It is to be regretted that all manufacturers have not adopted a uniform system of grading so that wheels of the same designated grade would be of an equal degree of hardness.

Grade and grain of grinding wheels should not be confused. Grade refers to the softness or hardness of the wheel, while grain is used to designate the size of the particles of the abrasive used in its construction. However, if two wheels of the same grade but different grains are compared it will be found that the finer grain wheel is the hardest due to the compactness of the grain. For example, a 100 grain, grade K wheel acts harder than a 60 grain, grade K wheel.

Selection of Wheels

The theory of action of a perfect grinding wheel is, that as the cutting points wear or become dulled they will be torn from the bond and drop away from the face of the wheel, allowing the sharp points underneath to be brought into action. This uniform wearing away of the wheel enables it to cut freely and with little heat. If the points are retained after they become dulled they prevent the sharp points beneath from coming in contact with the work and the wheel becomes glazed. In this condition the wheel must be forced into the work if it is to cut, and the result is springing of the piece, an undue generation of heat and an unwarranted consumption of power. It is apparent that accuracy cannot be obtained where such conditions exist.

Material To Be Ground. A most important consideration in the selection of wheels is the nature of the material to be ground. It has been found that wheels of oxide of aluminum are most efficient for hard and soft steels, and that those of carbide of silicon are most suitable for cast iron and chilled iron. In general wheels of oxide of aluminum are best for tough materials which offer the most resistance to penetration and wheels of carbide of silicon should be used when grinding hard, brittle materials and those which offer the least resistance to penetration such as rubber and leather.

The grade which should be used is also influenced by the material. As before explained the wheel should present sharp points to the work but not wear too fast. Materials that are very hard should be ground with a soft grade wheel as the cutting points become quickly dulled and in order to keep the wheel cutting freely they must be removed from its surface. A medium grade wheel should be used for grinding brass or bronze, for a hard one is apt to fuse the chips and heat the work and a soft wheel wears away too quickly. Hard grade wheels are best for the comparatively soft materials like annealed carbon steel and soft steel.

Type of Work. The kind of grinding to be done, whether external cylindrical, internal cylindrical, surface or tool grinding, has an influence on the selection of the proper wheel. Broadly speaking, for external cylindrical grinding wheels harder than grade M, vitrified (Norton or American Emery Wheel Works' Standard, or their equivalents in wheels of other makes) are seldom used. For surface grinding it is the practice to use a wheel softer than for external cylindrical work; grades G, H or I are commonly used. Internal grinding generally requires a wheel of grade J or K. Wheels of grades I and J are employed for sharpening cutters.

Wheel and Work Speeds. Wheel and work speeds are measured in surface feet per minute. Two rules for calculating the wheel and work speeds are given below.

To find the speed of wheel or work in surface feet per minute when the revolutions per minute and diameter are known.

Rule. Multiply 3.1416 by the diameter in inches, and by the revolutions per minute, then divide the result by 12.

To find the speed when the revolutions per minute and the circumference in feet are known.

Rule. Multiply the circumference by the revolutions per minute.

The speed of the wheel in relation to the speed of the work has an influence on wheel wear. It is good practice to run the wheel as near the speed recommended by the manufacturer as possible. In general, for cylindrical grinding, wheels should be run from 5000 to 6500 feet per minute, for surface grinding about 5000 feet per minute, and for cutter grinding from 4000 to 5000 feet per minute.

The slower the work speed the less work the wheel has to do in a given amount of time and therefore the wheel wear is less than when the work speed is high. From this it can be seen that a harder wheel is required when the work speed is low than when it is high if there is not to be a waste of abrasive.

Arc of Contact. Another factor that must be considered in the selection of wheels is the size of the work to be ground. The arc of contact between work of small diameter and the wheel is slight, while with work of large diameter the arc for the same depth of cut is much greater. In the first instance the cutting points of the wheel are in contact only a short period and have but little time to heat or wear but in case of the greater arc, the points remain in contact much longer and their tendency to heat and wear is accordingly greater. A small arc of contact also crumbles away the worn abrasive better than a greater arc. Hard wheels should therefore be used for small diameters and soft wheels for larger diameters if accuracy and the most economical results in wheel wear are to be obtained.

Skill of Operator. Grinding costs are varied considerably according to the skill of the operator. Whether the men are paid by the day or a piece rate is a factor in the selection of a wheel. Pieceworkers usually require a harder wheel than the day rate men.

Other details regarding the selection of wheels will come as a result of observation and experience. Manufacturers of grinding machines and of grinding wheels are in a position to give excellent advice as to the correct wheel to use where the material and conditions required are known and until an operator becomes proficient in selecting them, we believe that it is a good plan to rely upon the judgment of the manufacturer and study carefully the characteristics of the wheels recommended.

Suggestions for Ordering

It is the practice of most grinding wheel manufacturers to attach some kind of a tag to each wheel, giving complete specifications of it. It is a good plan to save this tag, for if a duplicate wheel is ever wanted the tag can be mailed to the manufacturer, thus facilitating quick delivery and insuring that the new wheel will be like the old one. If the tag is lost and it is possible to send a piece of the wheel it is wished to duplicate, this should be done.

The Grinding Wheel Manufacturers Association of the United States and Canada has adopted fourteen types of grinding wheels as standard. Of these, types 1, 7, 11 and 12 are used on Brown & Sharpe Grinding Machines.

In addition to the standard method many manufacturers further subdivide types of wheels and include the dimensions. Brown & Sharpe has a system of shape numbers that is very complete. To illustrate this system: a type 1 wheel, 12″ in diameter, 1″ thick, with a 5″ hole is the same as a Brown & Sharpe shape 77; a type 12 wheel, 6″ diameter, ½″ thick, with a 1¼″ hole is Brown & Sharpe shape 27.

Specifications that are necessary to the manufacturer in order to furnish any given wheel are:

Composition............(Whether Carbide of Silicon or Oxide of Aluminum.)

Process of Manufacture..........(Whether Vitrified, Silicate, or Elastic)

Outside Diameter.................Thickness................

Diameter of Arbor Hole.........Grain.........Grade.........

Shape............(If special shape is required the shape number given in catalogue should be specified or a sketch included with order. Otherwise a wheel with straight face and of uniform thickness will be furnished.)

When it is desired to leave the selection of the proper wheel to the wheel manufacturer, or to some other expert on grinding, a sample of the work it is proposed to grind, should be furnished if possible. When this cannot be done, the following information should be given.

Kind and size of machine..................................
(Whether cylindrical or surface grinding and maker's name.)
Material to be ground.....................................
Number of thousandths to be removed.......................
Description of piece..............(Also drawing, if possible.)
Production desired..
Quality of finish..............(Is work to be ground for accuracy or simply for finish, or both?)
Machine to be operated automatically or by hand? ....
Work to be ground wet or dry?.............................

Mounting Wheels. A wheel should fit easily upon the wheel sleeve, yet not loosely, for if loose it cannot be accurately centered and is consequently out of balance. Paper should not be wrapped around the sleeve to make a wheel fit when the hole is too large. On the other hand, a wheel that fits a trifle tightly may crack if forced on the sleeve. If the hole is only a slight amount under size it can be easily scraped out with an old file; or, if lead bushed, a jack-knife can be used to cut out enough metal to make the wheel fit easily on the sleeve.

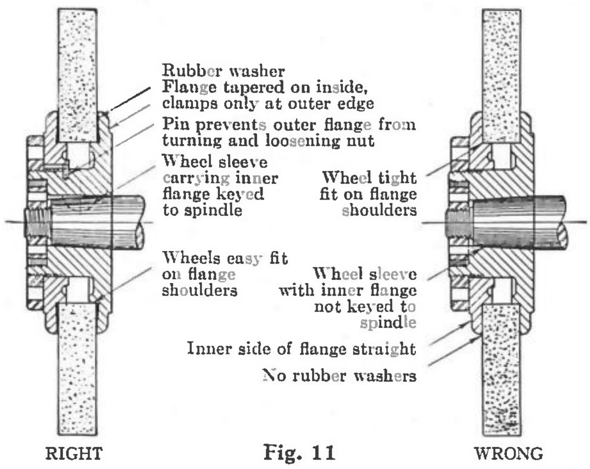


Fig. 11

The flanges between which the wheel is secured should be at least one-third of the diameter of the wheel; it is better to have them nearer one-half that diameter. They should be relieved on their inner sides so that they bear against the side of the wheel only at the outer edge. The inner flange should be keyed or otherwise fastened securely to the sleeve, and the outer flange should be keyed to the wheel sleeve to prevent it from turning and loosening the clamping nut. Flanges that are straight on their inner sides should never be used, for the tightening of the clamping nut will cause them to become slightly convex, bringing the pressure near the center instead of distributing it over the entire surface of that portion of the wheel enclosed between the flanges. Where the pressure is so concentrated there is danger of the wheel breaking.

Frequent inspection of the flanges and clamping nut is important. If flanges become out of true or out of balance, they should not be used. Careful inspection is also necessary when a wheel has been broken to guard against putting back flanges that have been damaged.

Washers of leather, pulp, or rubber should be placed between the bearing surfaces of the flanges and the wheel. Some makers attach a ring of heavy blotting paper to each side of their wheels for this purpose, but it is a good plan to use leather or rubber washers in addition.

The clamping nut should be tightened just enough to hold the wheel firmly in place, otherwise clamping strain may cause the wheel to crack.

Combination of Wheel and Work Speeds

It is an important and sometimes difficult task to adjust the wheel and work speeds so that the desired finish will be produced upon the work and the rate of production will be satisfactory. Hence it may not be out of place here to mention a few points in connection with this subject.

First, it must be remembered that *it is the surface speeds of both wheel and work that should be considered, not* their revolutions per minute. For example, if a piece 1″ diameter is being ground successfully with a given wheel and at given speeds, it does not follow that the same finish can be produced on a piece of this material 3″ in diameter using the same speeds. While the revolutions per minute of both pieces are equal, the difference in diameter makes the surface speed of the 3″ piece much greater than that of the 1″ piece. Consequently, if the surface speed of the 1″ piece is correct to enable the wheel to cut successfully, that of the 3″ piece is too fast; in other words if the work crowds the wheel the result will be unsatisfactory. If, however, the surface speed of the 3″ piece is reduced to about that of the 1″ piece, the finish obtained on both pieces will be the same.

The following facts apply in general to all ordinary grinding operations. Circumstances surrounding some special work, however, may alter these conditions.

If the work speed is correct and the wheel is running too fast, the wheel will glaze and heat the work.

If the work speed is correct and the wheel is running too slow, the work will cause the wheel to crumble, producing a rough finish. A wheel that wears away too rapidly or crumbles will not size work properly in response to the graduations of the automatic cross feed mechanism. Less stock will be removed than is indicated by the graduations.

If the wheel speed is correct and the work is running too fast, the result is apt to be somewhat similar to that just stated; or the wheel may have a tendency to glaze and chatter, consequently it will not cut as fast.

A wheel for machine grinding must cut without pressure, to effect which, it must always be *sharp*. This condition is maintained by the breaking away of the particles. Therefore a wheel of the proper grade to cut at a given work speed possesses "*sizing power*," or the ability to size uniformly without breaking away its own particles too rapidly.

If the wheel speed is correct and the work is running too slow, the tendency will be to drag and load up the wheel with particles of the material being ground and a rough finish will be produced.

Balance of Wheel. Care should be exercised to select a wheel that is properly balanced, as it is very essential that it run perfectly true and without vibration. It will not run true if out of balance either from the lead core or want of truing on the face. A wheel may also be out of balance from uneven density. In this last case it cannot be corrected and a new wheel should be substituted.

Truing Wheels. Great importance is attached by all makers to keeping grinding wheels true, for finish and production of work, for economy in wheel wear and for safety to the operator. The diamond is always to be preferred for this purpose rather than any other device as it will give the most satisfactory results and last longer.

The grade of a wheel and character of the work govern the frequency with which the surface of the wheel should be trued. Soft grade wheels are apt to become untrue more quickly than those of the harder grades; but, on the other hand, there is a tendency to glaze on the part of hard grade wheels and this can be corrected only by dressing off the surface.

A new wheel that runs out considerably should be trued up at a slow speed. Its speed can then be safely increased to that at which it is to run. Then the face should be trued again as it does not necessarily follow that it will run true at a high velocity even if it does at a slow one.

To obtain the best results, when truing grinding wheels of large diameter or wheels for cylindrical or surface grinding, the diamond must be held in a fixed-tool post or bracket, never held in the hand. There should be a constant flow of water or lubricant to keep the diamond cool and to avoid filling the air with dust. Wheels of small diameter or those used for small tool or reamer grinding, may be trued by holding the diamond in the hand.

Safety. There is always more or less liability of grinding wheels bursting because of flaws, too high speed, being thrust into the work too abruptly, faulty mounting on the spindle, etc. Brown & Sharpe Grinding Machines are fitted with a guard for covering the wheel to prevent injury to workmen and damage to the machine or surrounding objects in case of accident. When a wheel bursts beneath one of these guards there is comparatively little chance for it to do any damage. The pieces usually fall harmlessly to the machine or floor. Under no condition should a grinding wheel be operated without a guard, and in case of accident where this has been done there is absolutely no excuse.

Use of Water. Water is used in grinding principally to keep the work cool and to prevent distortion which results if the temperature of a piece is allowed to change while it is being ground. It also serves to wash the particles of metal and abrasive from the surface of the wheel, keeping it clean and free cutting.

A very slight change in temperature will sometimes cause serious inaccuracy in a finished piece of work; especially is this so in cylindrical work when a long slender piece is being ground. If water is not used here the heat generated is often sufficient to cause the piece to expand and bow toward the wheel, so that more stock will be removed than is intended, and the finished work will not be exactly round. Furthermore, its diameter will be smaller in the middle than at the ends. If cylindrical pieces of comparatively large diameter are ground dry they are apt to be under size when allowed to stand for a little while.

Water should be used whenever possible on cylindrical work. In surface grinding it should be used whenever there is much hardened work to be ground, although it can often be dispensed with in grinding cast iron. Internal grinding is usually done without water, owing to the liability of error in gauging holes from which all of the water cannot be easily removed.

To prevent rusting of the machine and work, just enough sal-soda (Sodium Carbonate) should be used in the water to show a slight deposit on the machine and finished work when dry.

For wet grinding we recommend a solution composed of one-half pound of sal-soda to every gallon of water.

Other details regarding wheels and their selection will come to an operator as the result of observation and experience. Manufacturers of grinding machines and of grinding wheels, however, are in a position to give excellent advice as to the correct wheel to use where the material and conditions required are known, and until an operator becomes proficient in selecting them, we believe it is a good plan to rely upon the judgment of the manufacturer and study carefully the characteristics of the wheels recommended.

Change of Axis of Work. Any change of axis of work and resultant errors is caused by poor centers, carelessness in cleaning the centers, or from changes of temperature produced by the action of the wheel.

Inaccurate and, sometimes, spoiled work is the result of poorly fitting centers and, as it costs as much to produce poor centers as it does good ones, there is apparently no excuse for poor work from this cause. Care should be taken to have all of the centers of the standard sixty degree angle and large enough to give good bearing surfaces. The centers of both lathes and grinding machines should accurately fit the centers of the work and should be kept clean and well oiled.

Change of axis of the work makes the wheel, after cutting uniformly around the entire circumference, cut more upon one side of the work than the other, which is something beyond the control of the machine operator. If the cut on one side is uniform from end to end it is caused by the wear of both centers to the same side or by some foreign substance on the same side in each center, but these cases will seldom, if ever, occur. The cutting on one side may occur at one end, and still be concentric at the other; this is caused either by the wear of one center or by the introduction of some foreign substance.

When the change of axis is caused by a change of temperature, the cut is always deepest at a point midway between the centers, but trouble from this cause will not arise until all of the turning marks are ground out, and the wheel has cut entirely around the piece.

Change in Temperature. One should not think that when there is a change in temperature the change is necessarily sufficient to be detected by the hand. It is probable that very few pieces of steel are so uniform in texture that they will not change their outline with a very slight change of temperature, even though it be the same throughout the piece. It is also well known that the slightest increase of temperature, unevenly distributed, of a piece of steel will cause a change in outline.

For example: If the finger is placed upon one side of a bar it will cause an elongation of the metal directly under it and the heat of the finger will be absorbed by the bar leaving as the warmest part that portion where the heat enters.

The amount of expansion is necessarily very small, but when one considers that a "clean-cutting" wheel shows sparks with a cut less than one one-hundredth part of one-thousandth of an inch, it is readily understood how a very slight change of outline can be detected by the grinding machine.

As a rule, the bar will not bend with perfect uniformity, owing to the tension within itself.

The wheel cuts more deeply in the side which is drawing toward it. This side becomes hotter as the wheel bites deeper and remains heated inasmuch as the bar does not equalize fast enough to cool between revolutions. The heat is increased at each succeeding revolution of the bar until the expansion on that side increases enough to noticeably bend it. The work is then ground only on one side of the circumference as the heating and consequent bending increases.

The heating being almost instantly equalized upon the removal of the wheel, the bar will return to its normal position and leave the other side of greater radius, so that on the next traverse of the table the wheel will cut on the opposite side, and cause the bar to bend this side toward the wheel, thus leaving it elliptical in form. If, as sometimes happens, these two bends have been exactly opposite, the next cut of the wheel will be on two points, and if the bar is of perfectly even tension on these two sides it will continue to cut both sides, but usually the bar will not bend exactly opposite at first. The successive cuts will, therefore, be somewhat as follows: 1st, completely around the circumference; 2nd, on one side; 3rd, the opposite side; 4th, at right angles; 5th, opposite again and so on.

In grinding tubing the change due to expansion is increased, as the hollowness of the piece does not permit of such a rapid conduction of the heat to the opposite side of the axis.

It has been stated in section headed "Change of Axis of Work" that a bar is not affected by change in temperature until the turning marks are ground out. One reason for this is that the ridges act as a file on the surface of the wheel, causing it to cut more freely. Furthermore, there is less stock to remove when cutting the ridges and less heat is generated, and, as the surface is not continuous, there is no longitudinal expansion of the warm side of the bar.

For example: A test bar was made similar to that shown in *Fig. 12.* It was found that dry grinding would cause the bar to grind first on one side and then on the other. A bar was then made similar to that shown in *Fig. 13.* Grinding dry on this showed that when grinding over the surface B no change of outline

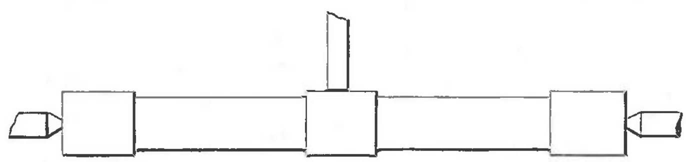


Fig. 12

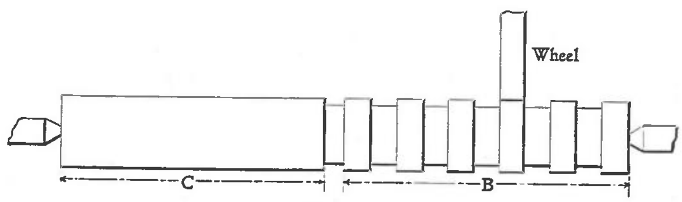


Fig. 13

occurred although the heat was sufficient to turn the surface blue, but the instant the wheel cut upon the surface C the piece changed its axis and ground upon one side only, cutting upon the opposite side on the return cut and grinding the whole circumference when again on the portion B.

By using a suitable wheel and plenty of water running directly upon the work at the grinding point this change of axis will never occur.

Amount of Error in Grinding. It is easy to be deceived as to the amount of error in roundness when judging by the sparks from the wheel. For example: A piece 36″ long and 3½″ in diameter was being ground showing sparks from one side only. Without correcting the error the piece was measured with a micrometer. Its error was so slight that it could not be detected and an indicator held against it while revolving showed no motion.

Another experiment was made with a hardened plug, 1″ in diameter. It was first ground round and straight, then carefully measured, replaced in the machine and the wheel advanced until sparks were just visible. When this amount was ground it was again measured and found to have been reduced about one one-hundredth part of one-thousandth of an inch.

Application of Wheel to Work. When the red-hot sparks of steel pour from the bar it is easily seen that there is considerable heat at the point of contact and, since the heat is necessarily greater at that point than elsewhere, the bar will constantly bend toward the wheel. In such cases the workman speaks of the wheel as "drawing in," when in reality it is the work that approaches the wheel by revolving with a greater expansion under the wheel than at any other point.

True Center Holes. To obtain good results when grinding on centers care should be taken that the center holes in the work are round and fit the centers accurately, that the centers are true, and that both are free from dirt.

True Face Plates. The face plates should be kept true. When necessary they can be readily ground in place on the machine.

Graduations. The graduations on a grinding machine are a great help to the operator, as they enable him to set the headstock swivel and the swivel table approximately correct, but it is seldom that the two lines can be made to exactly coincide even with the use of a magnifying glass. Accuracy therefore, must be secured by the use of the adjusting screw.

Error in Setting. The grinding machine is one of the most sensitive indicators of error known. A small error in the position of the headstock swivel zero will increase the error when setting the table. Any error in setting the machine is doubled on the work.

For example: An error of one-twentieth of one-thousandth in the setting of the headstock zero will give an error in the work of one-tenth of one-thousandth or more, as the point of the center is usually on a larger radius than the graduations. This alone would be sufficient to spoil the majority of work. If the point of the center is out one-twentieth of one-thousandth in the same direction as the headstock zero then something over two-tenths of one-thousandth is the error of the work, and when the same error is made in setting the swivel table the total error is still more. There is also the possibility that the footstock center is out.

Live and Dead Centers. Work to be ground can be mounted in various ways, as follows—on the live spindle of the headstock, on the two centers, being driven by the headstock pulley; or on two dead centers, the work in this case being revolved by the dead center pulley furnished with the machine.

The headstock pulley is frequently used for driving large work on centers. Most work, however, when ground on centers is driven by the dead center pulley. Pieces ground internally are generally driven by the headstock pulleys. The advantage of grinding on two dead centers is that any possible error that may be in the spindle bearing does not affect the work.

In grinding straight work both ends of the work should be calipered. If one end measures more than the other, the error may be corrected by swinging the table a trifle, using the adjusting screw of same.

Grinding Slight Tapers. When slight tapers are desired for either external or internal grinding the adjustment is obtained by setting the swivel table to the proper angle.

The graduations on the table scale for setting the table for grinding the taper to "degrees" indicate one-half of the included angle. The graduations for "taper per foot" and "per cent" indicate the included angle. "Per cent" of taper means 1 in 100 regardless of the unit of measurement used.

Grinding Abrupt Tapers. When more abrupt tapers are wanted for work ground on centers or for internal surfaces, the wheel slide is set to the proper angle. By placing the wheel slide and the swivel table at proper angles two tapers for either external or internal work may be obtained without changing the settings of the machine, the one automatically by the longitudinal movement of the table, the other by operating the cross feed by hand.

CHAPTER VI

Cutter Grinding

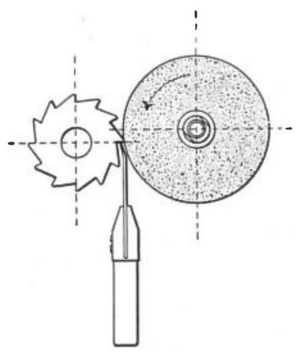
Sharpen Cutters Often. The importance of keeping all kinds of cutters well sharpened must not be overlooked. It might be supposed upon first thought that greater economy in cutter wear would be gained by regrinding no oftener than positively necessary. This is not the case, however, as experience has shown that a dull cutter wears more rapidly than a sharp one, and if a cutter is continued in use until its teeth are quite rounded, or burnt, it will be necessary to grind considerable stock off each tooth, to restore its correct cutting edge; consequently a cutter that is kept in good condition by frequent regrinding will invariably outlast one that is not so cared for. Besides, a dull cutter not only consumes more power, but cannot be operated as rapidly or take as heavy cuts as a sharp one, and the quality of the work is never so good. Too frequently in shops, the efficiency of machines is impaired by the use of dull cutters, and for no other reason than because of the carelessness and negligence of the operator. Cutters are ground so easily on our tool grinding machine that there is no reason for limiting the capabilities of a machine by using dull cutters. Grinding a cutter takes only a short time, and the greater efficiency that is obtained, together with the economy assured, more than compensates for the time spent in regrinding.

Drawing Cutter Temper. Although these machines are not complicated nor difficult to operate, the new operator should look up carefully the use and possibilities of the various parts in order to be sure he is doing each job in the most efficient way. It is a good plan at first to make a few movements of the cutter before starting the grinding wheel. Care should be taken in order not to draw the temper of the cutter teeth. This may happen in several ways due to carelessness. Do not attempt to grind off too much at one time, nor exert too much pressure on the cutter being ground. Use care in the selection of the wheel, which should be soft enough to wear freely. A wheel that is too hard will not fracture readily enough to expose its sharper points to the cutter tooth being ground, thus generating undue and excessive heat.

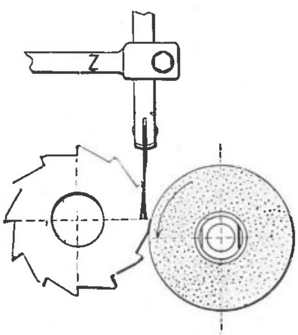
The wheel should be kept clean and true. A dirty or glazed wheel is frequent cause of drawing the temper of a cutter tooth. Another difficulty may arise because the cutter tooth is not held against the tooth rest and the wheel scores the cutter. If the teeth of a cutter or reamer are too thick, there is more likelihood of drawing the temper.

Direction to Revolve Wheel. The safest way is to run the wheel off the cutting edge, as shown in A, for by running in this direction there is no danger of the work being drawn away from the tooth rest by action of the wheel. A keener cutting edge can be obtained by running the wheel on to the cutting edge, as shown in B.

In the second method the cutter must be held against the tooth rest as the action of the grinding wheel tends to force the tooth away. This method requires a skillful operator.



A



B

Clearance. The clearance of the teeth back of the cutting edges is obtained, when the teeth face downward, by having the center of the work below the plane of the axis of the wheel, as at A, but when the teeth face upward, as at B, the center of the work should be above the center of the wheel. The dotted center lines illustrate this.

The angle of clearance depends upon the diameter of the cutters and must be greater for small cutters than for large ones. The clearance on the teeth of plain milling cutters should be from 4 to 5 degrees for cutters over 3 inches in diameter, and from 6 to 7 degrees for those under 3 inches. The land at the top of the teeth should be from .02″ to .04″ wide, before the clearance is cut or ground. The clearance of the end teeth of end mills should be about 2 degrees, and it is well to have the teeth a little hollowing, letting them be .001″ or .002″ lower near the center than at the outside, so that the inner ends of the teeth will not drag on the work. If the clearance of a cutter is too great, vibrations are likely to occur in operation, and this is something that should be prevented by all means. (See table, page 110.)

Center Holes in Work. The center holes should be round and smooth and the same angle, 60°, as the centers upon which the work is to revolve. Work should not be placed in the machine until both the center holes and centers are carefully cleaned.

Cutters may be divided into two classes: Those sharpened on the back of the cutting edge so that the clearance is produced by grinding, and those sharpened on the front face forming the edge to preserve the shape of the tooth. In the latter class the clearance has been produced by relieving in the process of manufacturing the cutter.

The first class may be subdivided into parallel cutters with straight or spiral teeth and angular cutters, face cutters, rose reamers, and end mills. In the second class are formed cutters, gear cutters, taps, and such reamers as are sharpened on the face of the tooth.

Either the periphery of a disc wheel or the face of a cup wheel may be used to sharpen cutters of the first class. The clearance is formed by the relation of the wheel, and the tooth with which it is in contact. It is important that the machine be so set that this relation will produce clearance of the correct angle.

CHAPTER VII

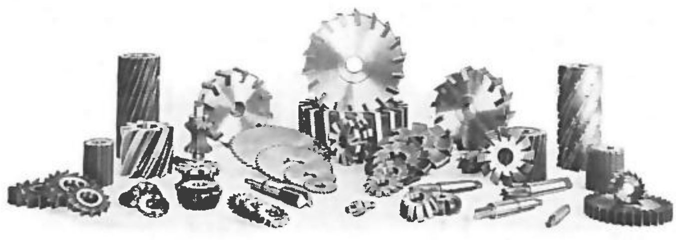
Operations

The No. 13 Universal and Tool Grinding Machine is capable of grinding a great variety of work, and in many cases the same job can be performed in several ways, each way having its particular advantage. To give a general idea of the methods of doing different, everyday shop operations, we have shown in the following pages a considerable number of illustrations, in connection with which attention has been called to the chief points of interest. In this way, the use of the several pieces of equipment and the attachments is shown, for the operator should become thoroughly familiar with them, in order to do his work in the most efficient manner.

The machine is not restricted to the kinds of work shown here, or to the methods of doing these operations as illustrated. Its greater possibilities will be brought out by continued use and familiarity gained from its operation.

Although all features of the set-up are not mentioned under each cut, a general reading of the suggestions should give a working understanding of the methods used.

The wheel guards shown are not recommended as they have been cut away to show the operations more clearly. Regular safety guards should be used.



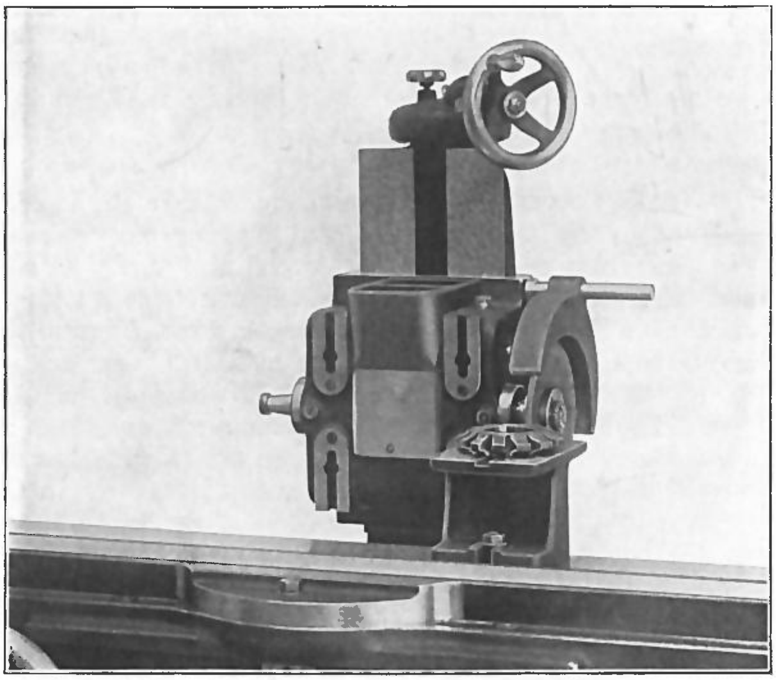


Fig. 14

Grinding a Formed Cutter

Formed cutters having comparatively narrow cutting faces, such as gear cutters, can be ground easily and quickly on the machine by the simple method shown above. A tool rest is furnished with the machine, which can be bolted to the table T slot. The cutter is then laid on the tool rest and fed against the wheel by hand. A bevel and concave wheel, shape 27 or 62, is used.

When grinding a formed cutter by this method, it is necessary to exercise considerable care, in order to keep the faces of the cutter teeth radial and of the same height. Hooking or dragging teeth do not cut the correct shape and do not do an equal share of work. This method of grinding the teeth has the advantage of quickness, but it can be done successfully only after some practice.

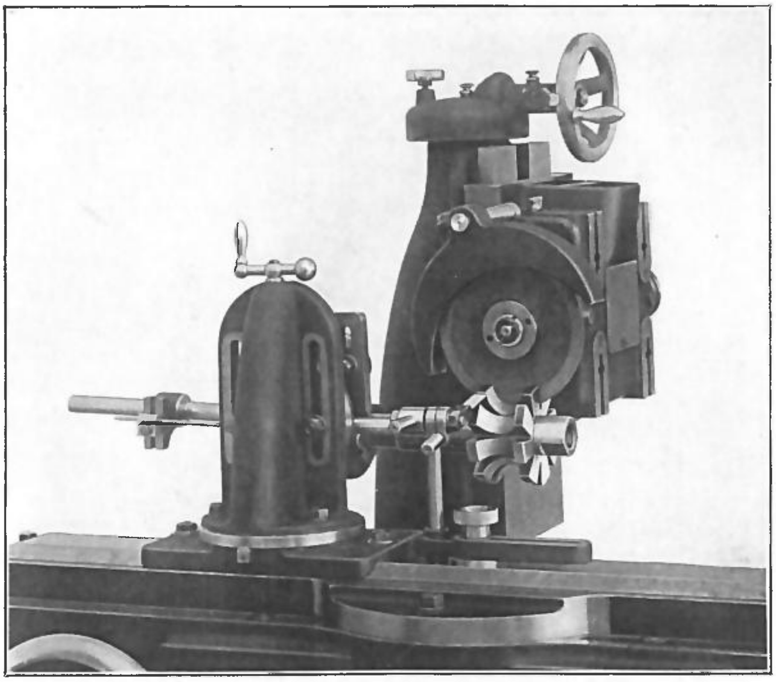


Fig. 15

Grinding a Wide-Faced Formed Cutter with the Universal Head

Another method of grinding formed cutters is illustrated above. This way is preferable to that shown in *Fig. 14*, as once the cutter and tooth rest are correctly set, all the teeth will be ground radially.

The cutter is shown on a gang arbor and is passed across the grinding wheel by traversing the table by hand. A bevel and concave wheel, shape 27 or 62, is used. The tooth rest is shown bearing on the backs of the cutter teeth. To insure correct spacing, this necessitates first grinding the backs of the teeth. This may be done on index centers, or the cutter may be mounted in the Universal Head, as shown above, but in the reverse position, using the tooth rest on the faces of the teeth while grinding the backs.

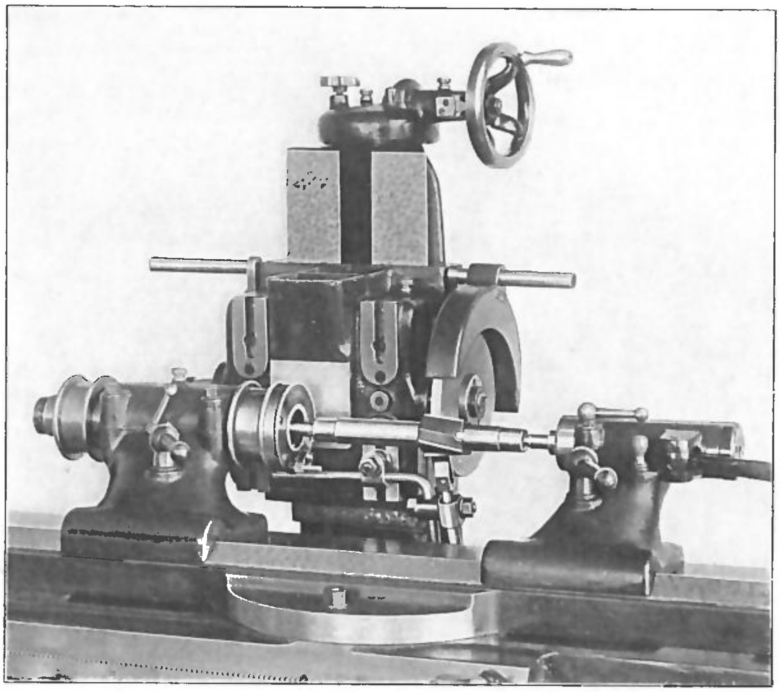


Fig. 16

Grinding a Four-Lipped Chucking Shell Reamer

The reamer is mounted between centers on an arbor and the table is traversed by hand. A straight wheel, shape 20 or 23, is used.

This job could also be handled on the Universal Head instead of between centers, if desired. In that case, the reamer would be mounted on the cutter bar and passed back and forth before the wheel by sliding it along the bar by hand. In the case shown above, the angle of clearance on the teeth is adjusted by raising or lowering the tooth rest, the work centers having first been brought to the same height as the center of the wheel. The tooth rest should be set so that the cutter will pass off the wheel on either end before it leaves the rest, to prevent the cutter from slipping and being ground incorrectly at the corners.

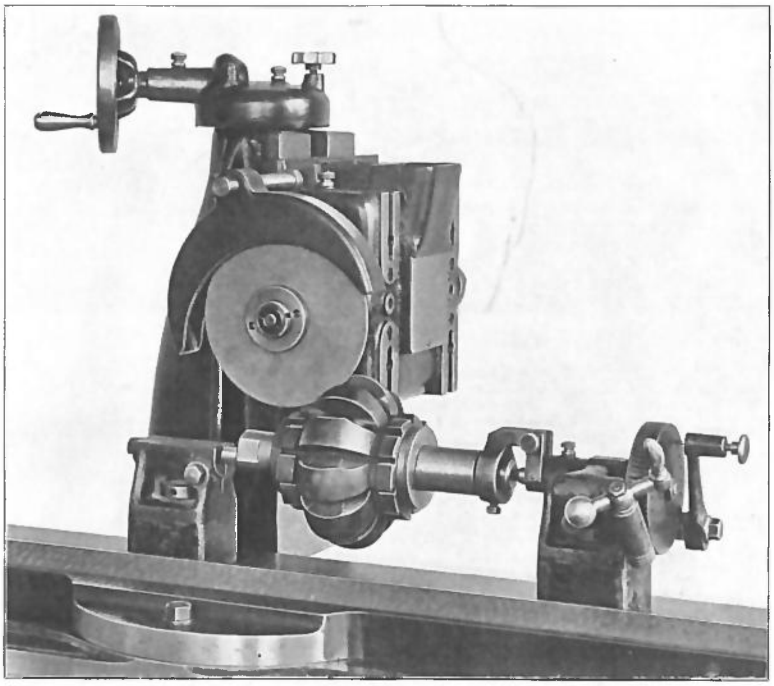


Fig. 17

Grinding a Wide-Faced Formed Cutter on the Index Centers

Still another method of handling wide-faced formed cutters is shown here, using the Index Centers illustrated on page 32. Large cutters can be ground on these centers by using raising blocks under the head and footstock.

A bevel and concave wheel, shape 27, is required for grinding. No tooth rest is used, and the cutter is rotated and held in position while grinding each tooth by means of the worm and wheel of the index. Take care to keep the cutter teeth the same height when grinding by this method, for while they will be ground radially without attention, some are liable to be ground further back than others, resulting in teeth of different heights. If this were the case, the longer teeth would do all the work.

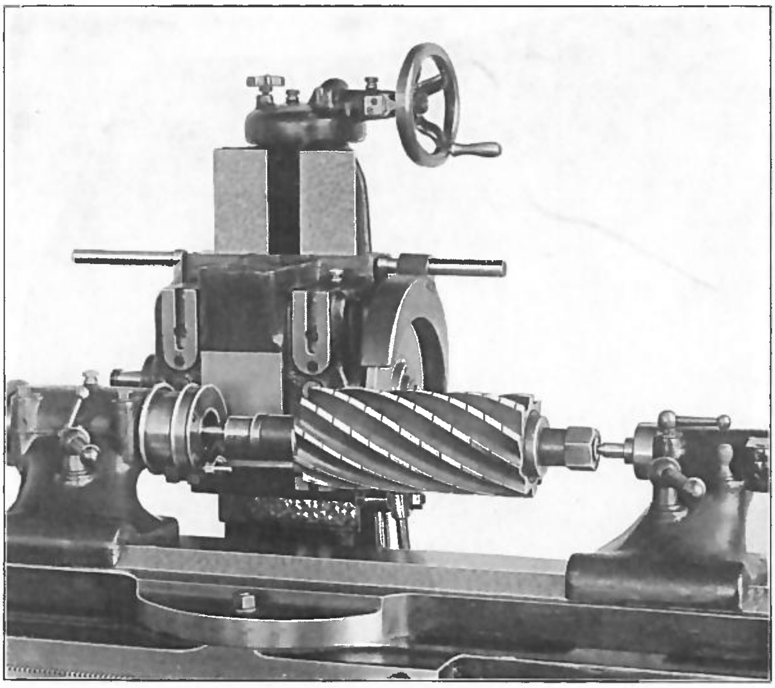
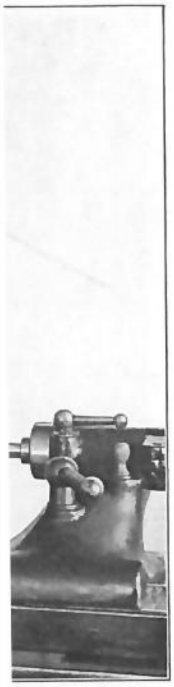


Fig. 18

Grinding a Coarse Tooth Milling Cutter Between Centers

The method illustrated above of handling long or very heavy cutters between centers on an arbor is preferred on work of this nature. Somewhat smaller work may be handled on the Universal Head by sliding the cutter along the cutter bar. In the case of heavy cutters or long cutters like the above, however, the weight of the cutter and the necessary overhang of the bar might result in springing the cutter bar. A straight wheel, shape 20 or 23, is used, and the table is traversed by hand. The cutter is held firmly against the tooth rest with the other hand. A cupped wheel may be used if desired, in which case the spindle is set at right angles to the position shown above. A straight wheel, such as the one used here, will give a slight concavity to the land of the tooth, whereas a cupped wheel will give a comparatively flat land.



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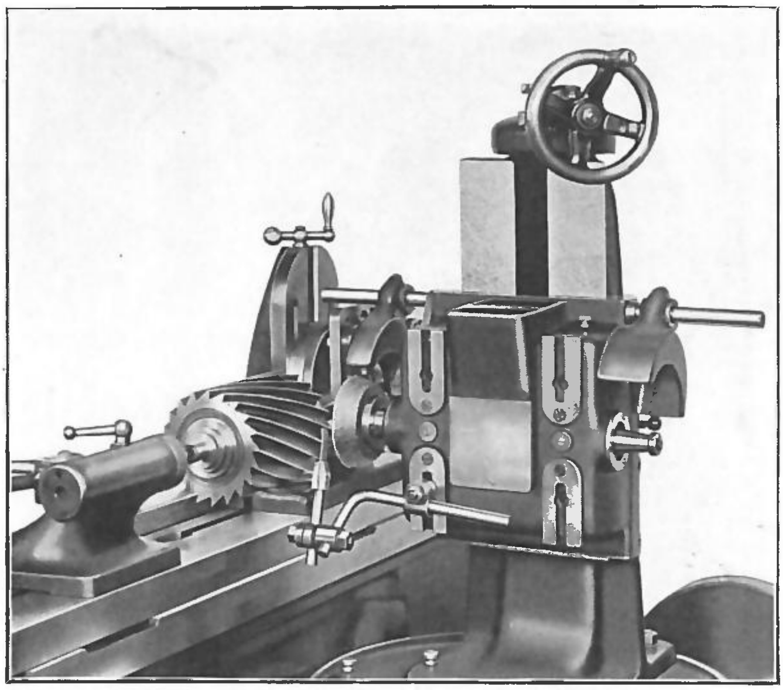


Fig. 19

Grinding a Milling Cutter with Spiral Teeth

When grinding a comparatively heavy cutter on the cutter bar of the Universal Head, as mentioned on preceding page, the end of the cutter bar can be supported by the footstock, as shown here, to prevent its springing. The table is traversed by hand.

A cupped wheel, shape 50, which is being used, gives practically a straight angle of clearance to the cutter teeth when set parallel with the cutter. The wheel spindle column is swivelled very slightly so that the back edge of the wheel will clear the cutter. A straight wheel can be used, as shown in *Fig. 18,* and it will give a concavity to the angle of clearance. The value of this concavity back of the cutting edge is a matter of opinion.

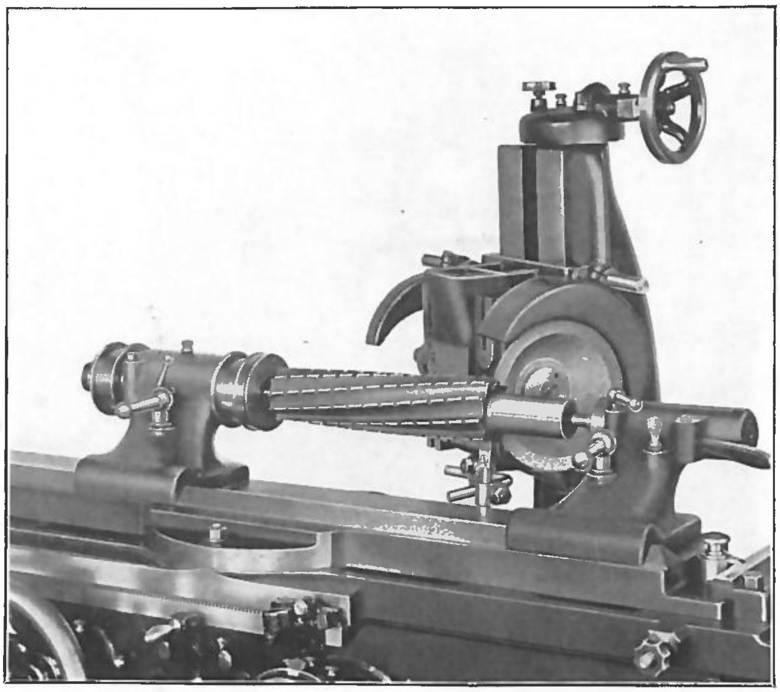


Fig. 20

Grinding a Taper Reamer with Spiral Teeth, Using a Cupped Wheel

On grinding operations similar to the above, the table of the machine is set at the angle of the taper of the work. The cupped wheel, shape 51, which is used, is swivelled so that the back edge will clear the work. A straight wheel can be used, if desired, as explained in connection with *Fig. 19*, if a concave angle of clearance is required. The cupped wheel can be made to give practically a straight angle of clearance by setting its face nearly parallel with edge of the teeth, or a varying amount of concavity can be obtained by swivelling the wheel spindle column, bringing the wheel to an angle with the work. The column is shown here swivelled to give a very slight amount of concavity.

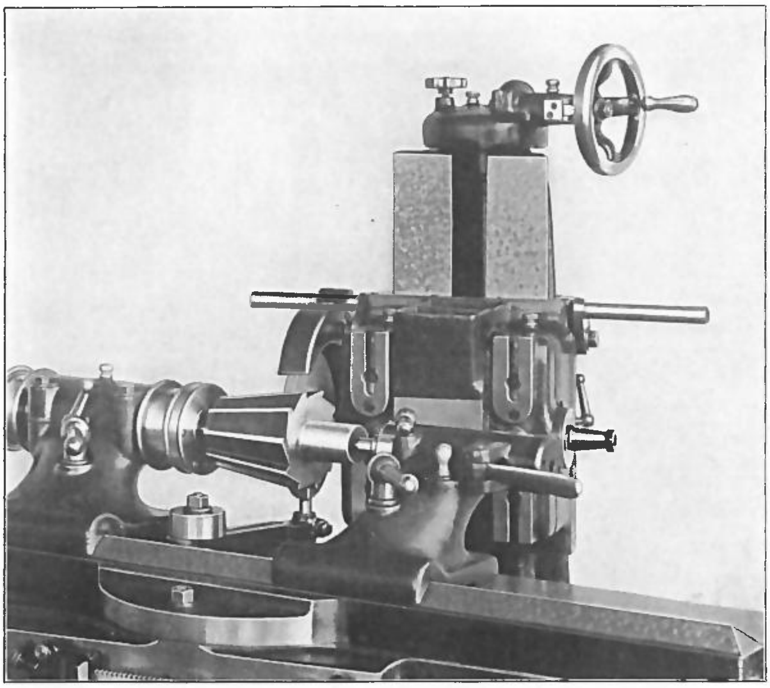


Fig. 21

Grinding a Straight Toothed Taper Reamer with a Straight Wheel

The cut above illustrates the method mentioned on page 70 in connection with *Fig. 20,* for obtaining a concave angle of clearance back of the cutting edges of the teeth. The table is set at the required angle corresponding to the angle of the reamer teeth. A straight wheel, shape 20 or 23, is used, and the table is traversed by hand. In this case, the tooth rest is placed on the table, as the reamer teeth must always remain parallel to the centers throughout their length. In cases like *Fig. 20,* where spiral teeth are ground, the rest must be attached to the wheel spindle, where it will rotate the cutter as it is traversed past the grinding wheel. The operator should keep the reamer in firm contact with the tooth rest by exerting a rotating pressure on its shank.

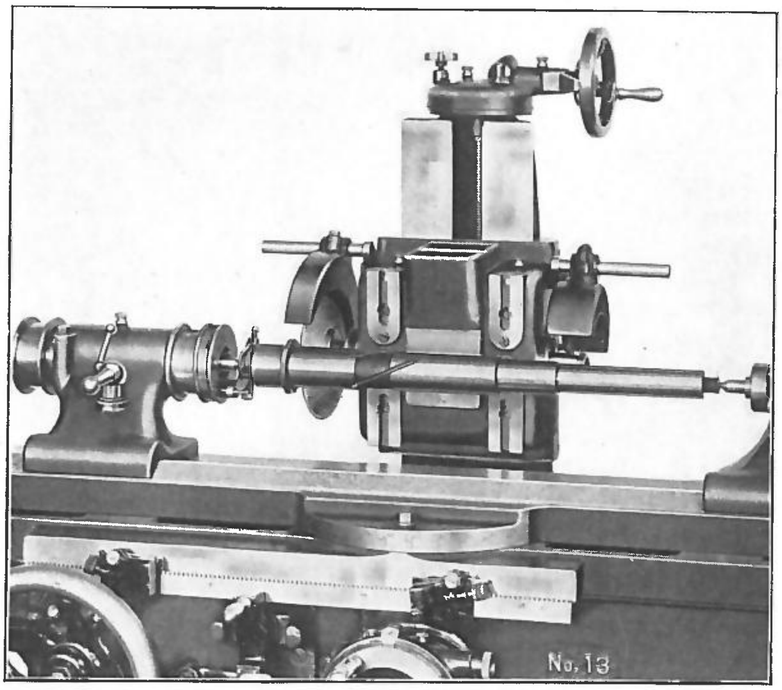
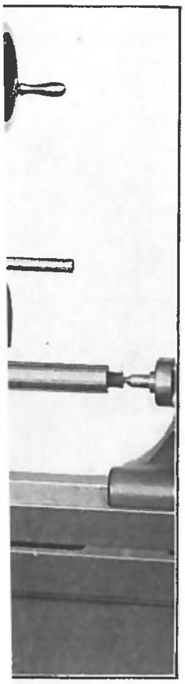


Fig. 22

Grinding a Shoulder on a Shaft

It may be necessary in some cases to grind the shoulder flat or slightly concave,—the latter method is usually employed so that the bearing will come at the extreme edge of the shoulder. For a straight shoulder, the wheel spindle column should be set parallel to the table. For a concave shoulder, it should be swivelled to a slight angle, (usually 3° or 4°), to give the required concavity. In case the shoulder is to be ground square, care should be taken that there is no end play in the wheel spindle to cause an incorrect angle in the finished work. The shaft is rotated on dead centers. The wheel is brought to the work with the cross feed and moved to the face of the shoulder with the longitudinal hand feed until the required finish is obtained. The wheel is withdrawn with the same feed. It should not be backed off the shoulder with the cross feed.



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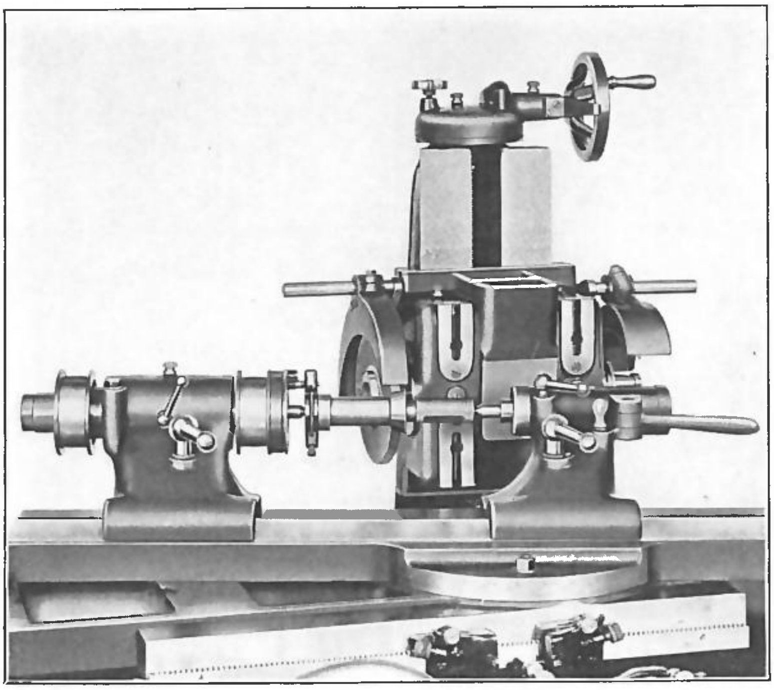

Fig. 23

Grinding a Steep Taper on a Chuck Sleeve Gauge

A plain wheel, shape 20 or 23, is employed and the gauge is revolved on dead centers. The machine table is swivelled to the angle of the taper and set approximately by means of the graduated arc on the front, (see page 17). For slighter tapers, the graduated scale on the end of the table can be used. The power table feed may be used for traversing the work. Care should be taken while setting up the machine for such jobs of cylindrical grinding to have the center of the wheel lined up with the head and footstock centers. Use the center height gauge, as explained on page 16. The graduated arc on the front of the table should only be used for approximate settings. In the case of accurate tapers, the final setting should be verified by trying the work in a taper gauge.

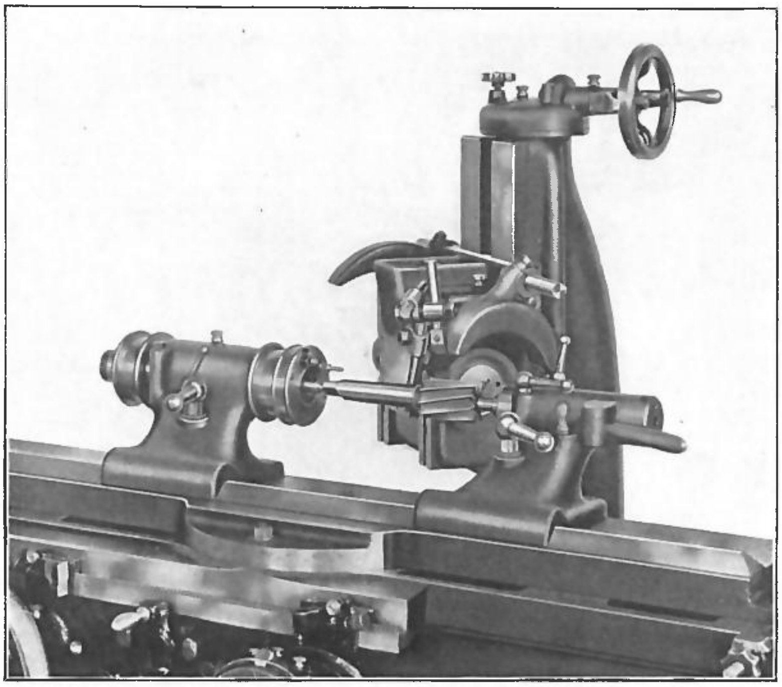

Fig. 24

Grinding the Face Teeth of a Spiral End Mill

End mills may be either mounted between centers as shown above or supported by the shank directly in the tool rest of the Universal Head. In the case of a spiral tooth mill, as shown here, where the mill must be rotated by hand while passing across the wheel, it is better to mount it between centers. In the case of a straight toothed mill, that is only rotated for indexing, it should be mounted in the Universal Head, with the tooth rest attached to the table or the Universal Head. A cupped wheel, shape 50 is used for a straight angle of clearance, and the wheel spindle column is swivelled just enough to allow the back edge of the wheel to clear the cutter. For a concave angle of clearance use a straight wheel.

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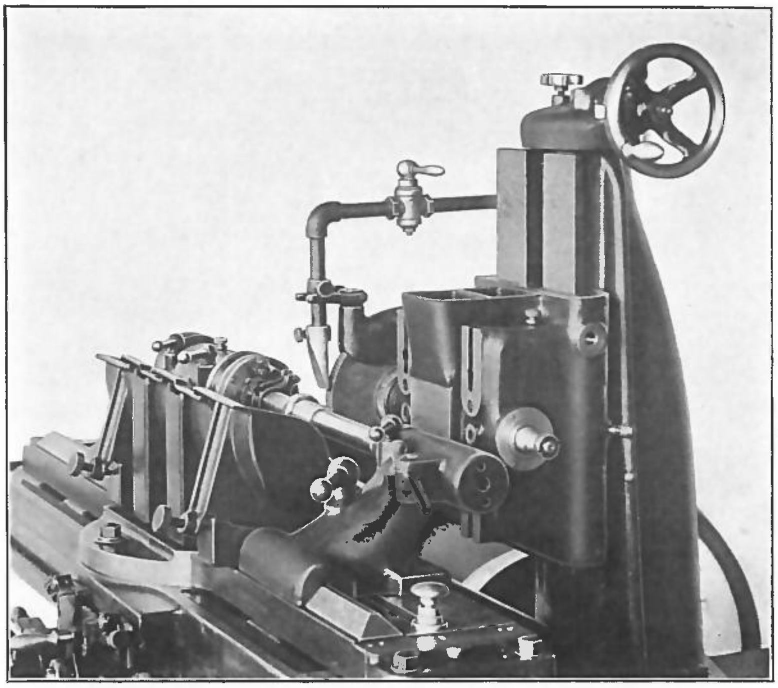

Fig. 25

Wet Grinding Arrangement on the Machine

This illustrates the arrangement for using water on the work. It is furnished as an extra for the machine. Water is pumped from a tank at the rear of the table on the left-hand side. A centrifugal pump is driven from the overhead works. Suitable table water guards keep the spray from the operator, and the water runs back to the tank through large channels and piping. *We recommend a solution composed of one-half pound of sal-soda (Sodium Carbonate) to every gallon of water to prevent the machine or work from rusting.* The piece of work in position on the machine is a plain bushing being ground on an arbor revolving on dead centers. The shoulder is squared up as explained under *Fig. 22.* Power table feed is used for traversing the work past the wheel.

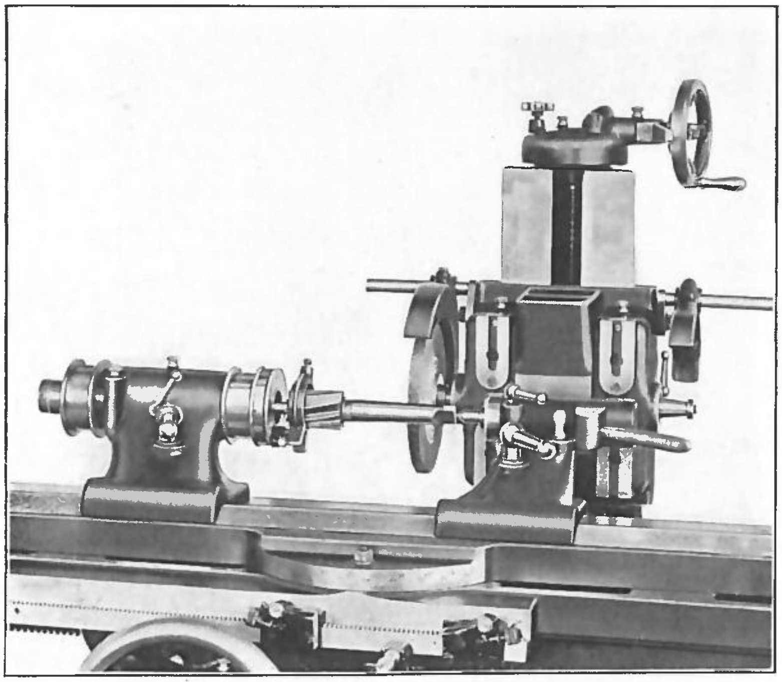

Fig. 26

Grinding the Shank of a Spiral End Mill

To true up an end mill shank, the end mill is revolved between dead centers and the power table feed is used for traversing the work.

The table is set to the required angle for the taper by means of the adjusting screw at the end of the table. To obtain the exact taper, a gauge should be used for testing the work, until the table is at the correct angle. When setting up cylindrical grinding, as in this case, take care that the work centers are aligned with the wheel center, as explained on page 16. When it is possible, use water on jobs where an appreciable amount of metal is to be removed.

A well-directed ample flow of water will always make a coarser feed practicable, and in the case of a job that includes numerous pieces, it will shorten the machine time on each piece.

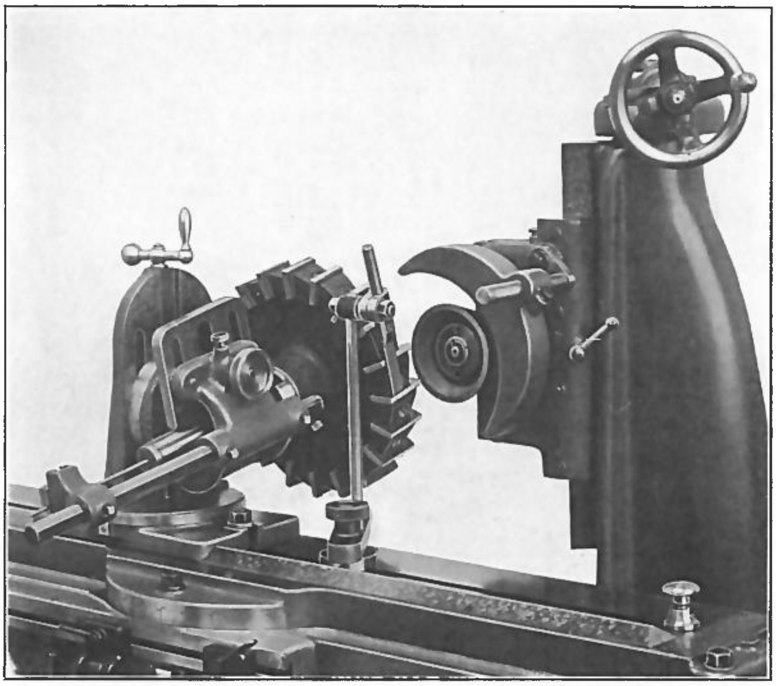

Fig. 27

Grinding the Teeth of a Side or Face Milling Cutter

Either solid or inserted tooth, side or face milling cutters can be ground by this method. The cutter is mounted on an arbor in the tool rest of the Universal Head. The tool rest is swivelled to the required angle of clearance and the cupped wheel, shape 50, is used.

A straight wheel, shape 20 or 23, can be used, in which case the cutter arbor would be in a horizontal position and the wheel or table would be raised or lowered to obtain the correct angle of clearance. In either case, the Universal Head or the machine table should be set at a slight angle to make the cutter teeth taper in a little toward the center of the cutter to prevent dragging. The cupped wheel gives a straight angle of clearance and the straight wheel gives a concave one.

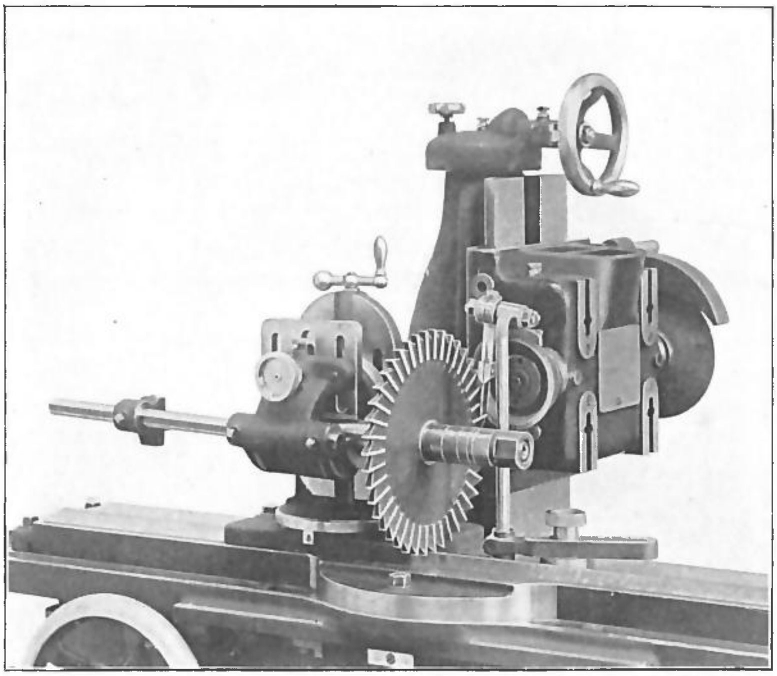

Fig. 28

Grinding the Face Teeth of a Side Milling Cutter

A side milling cutter, either the solid style, or one with inserted teeth, as shown in *Fig. 27*, can be ground to best advantage by mounting the cutter on an arbor supported in the tool rest of the Universal Head. On the job illustrated, the cutter is fastened on the arbor and the table traversed back and forth by hand. This is the best method when using a cupped wheel, shape 50, as shown.

If a straight wheel, shape 20 or 23, is used, the cutter can be mounted on sliding collars on the cutter bar and passed across the wheel by sliding it along the bar. The tooth rest is attached to the table as shown, or to the back rest of the Universal Head. The correct angle of clearance is obtained by raising or lowering the tooth rest.

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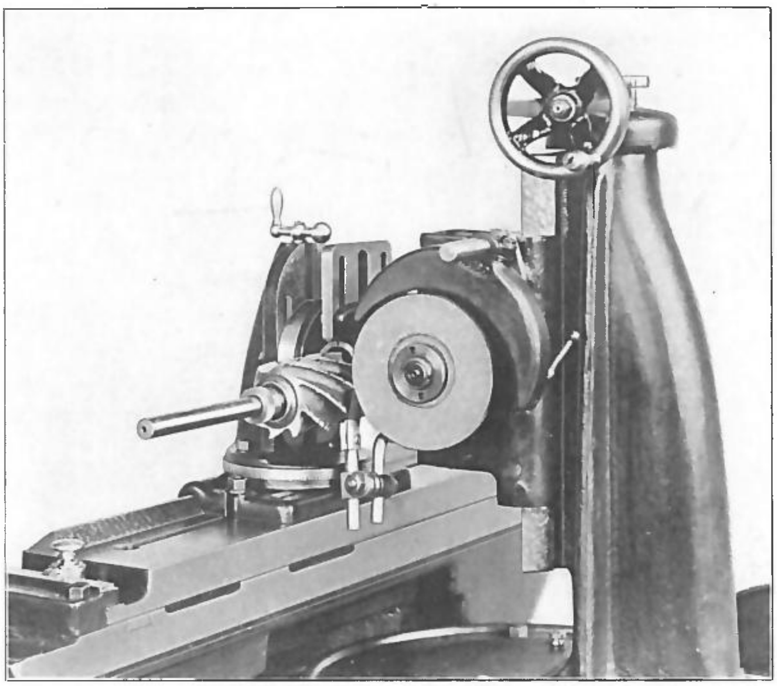


Fig. 29

Grinding a Coarse Tooth Milling Cutter in the Universal Head

This illustrates a method of grinding smaller sizes of milling cutters, as referred to in connection with *Fig. 18.* The cutter is mounted on a sliding shell on the cutter bar in the tool rest of the Universal Head. This method is employed when the weight of the cutter and the amount of overhang for the cutter bar is not sufficient to cause it to spring.

The straight wheel, shape 20 or 23, gives a slight concavity behind the cutting edge, whereas the use of a cupped wheel, as shown in *Fig. 19* on similar work, gives a straight angle.

Raising or lowering the wheel slide serves to change the angle of clearance. To insure correctly ground corners, the tooth rest must be placed so that the cutter passes off the wheel before it leaves the rest.

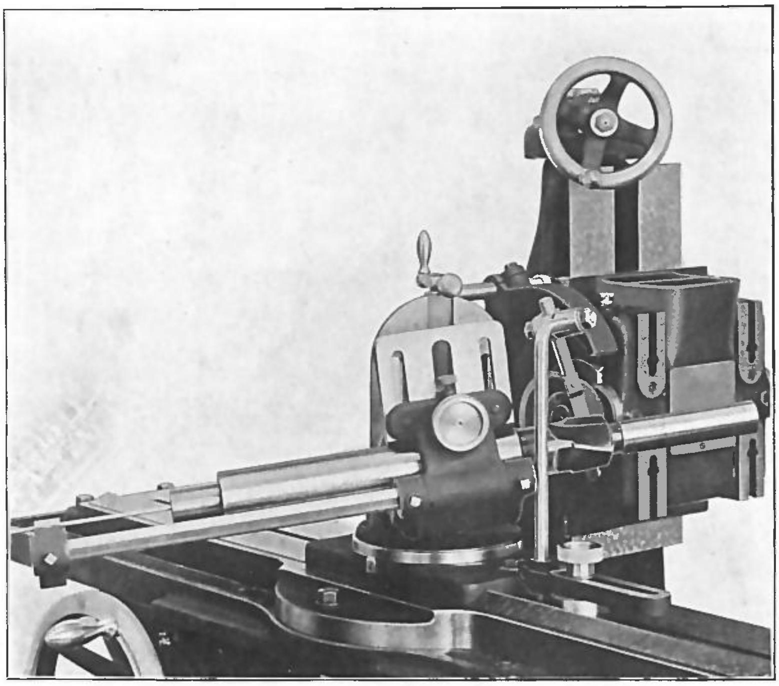
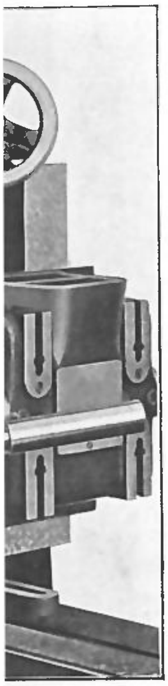


Fig. 30

Grinding the Ends of the Teeth of a Four-Lipped Reamer

The reamer is supported by its shank directly in the tool rest of the Universal Head. The use of the rod and center for supporting the work endwise in the Universal Head is well illustrated in this case. The required angle for the ends of the teeth is obtained by swivelling the head, and the table is traversed by hand. A straight wheel can be used instead of the cupped wheel shown here, if a concave surface is desired.

Raising or lowering the wheel slide will regulate the angle of clearance. The tooth rest may be placed on the table, as shown, or attached to the Universal Head. The latter arrangement is preferable, as in case the angle of the work is changed, the rest will move with the work and will not require adjustment.



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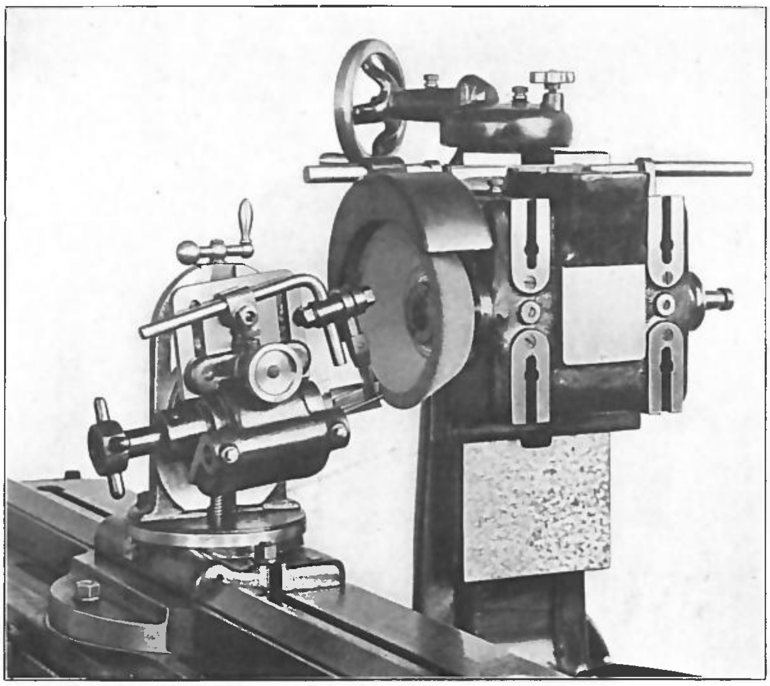


Fig. 31

Grinding the End Teeth of a Coarse Tooth End Mill

This illustrates the use of the taper shank mill sleeve and bushing with the Universal Head. This method of holding end mills is preferable where the shank is not larger than No. 9 taper. For larger end mills, the arrangement shown in *Fig. 24* is employed.

The edge of the tooth being ground, (that on which the tooth rest bears), is horizontal. The work head is swivelled vertically to obtain the required angle of clearance and the longitudinal feed is used for traversing the cutter. The Universal Head may be swivelled slightly to grind the teeth .001″ to .002″ low in the center of the cutter to prevent dragging. The tooth rest is mounted preferably on the head, as, when on the table, the angle of the cutter cannot be changed without readjusting the tooth rest.

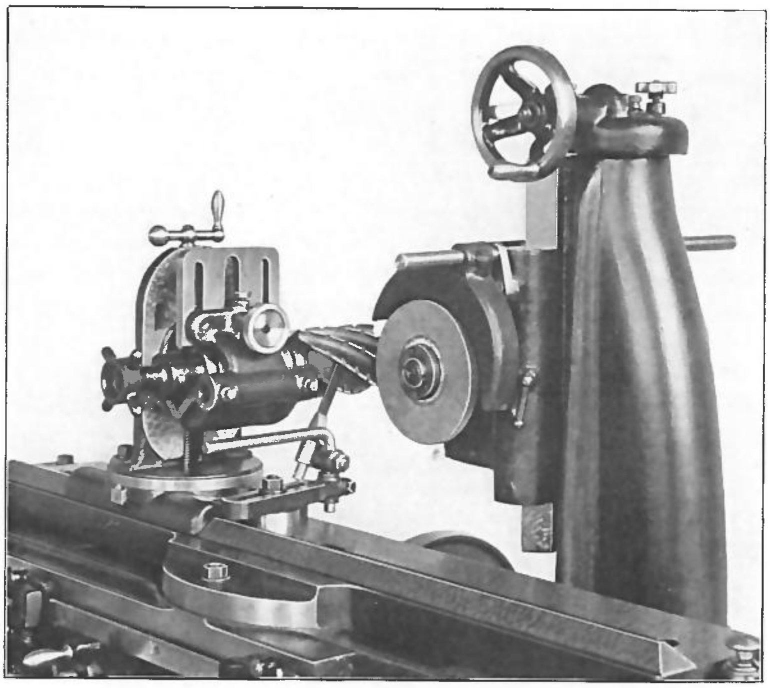
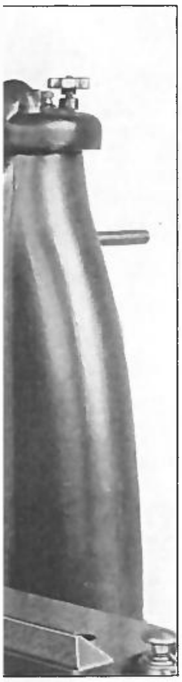


Fig. 32

Re-Nicking a Coarse Tooth Milling Cutter

The cutter in this case is set horizontally on an arbor in the taper shank mill bushing in the Universal Head. The wheel is formed to the required shape of the nick for the teeth,—that is, if a "V" nick is required, the edge of the wheel must be cut down to a "V" shape. Where no exact form is required for the nicks, merely a rounded or a "V" shape, a carborundum stick or a piece of a hard wheel is sufficient for shaping the grinding wheel. For an exact form, a forming tool is necessary. Care should be taken not to force the wheel and to draw the temper of the cutter, when cutting deep "V's." The clearance on the nicks is varied by raising or lowering the tooth rest.

This operation can be performed in the case of long or heavy cutters, with the cutter mounted between centers, as shown in *Fig. 18.*



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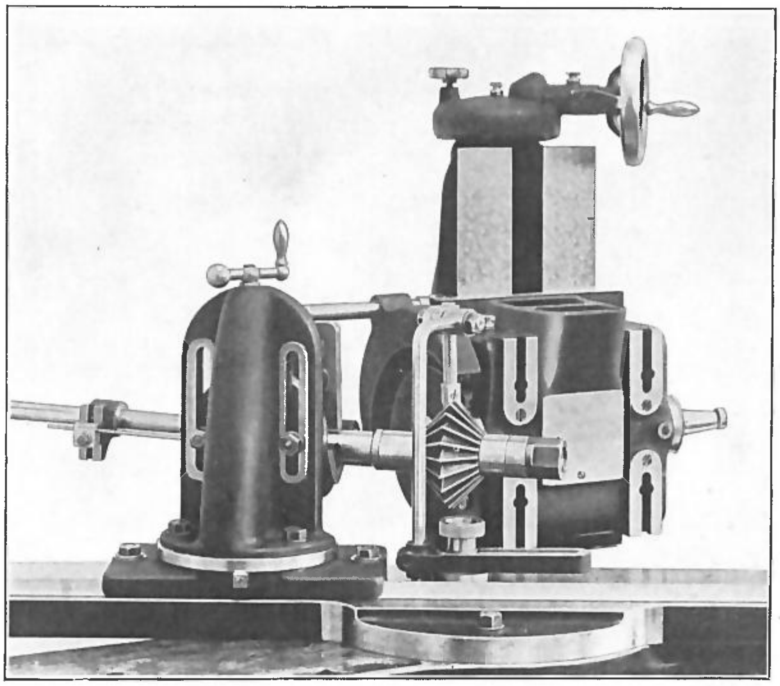

Fig. 33

Grinding a Double Angular Cutter

This method of grinding cutters of the double angular type is of particular advantage, for both edges can be ground without disturbing the work setting which insures a correct included angle. The table is shown swivelled to the required angle for one side of the cutter. The reading is taken from the graduations on the arc at the front. After one side is ground, the table is swivelled for the opposite side.

The Universal Head may be swivelled instead of the table for obtaining the angle. In that case the tooth rest should be clamped to the front of the head rather than to the table as shown here, so that it will shift with the work. This job could also be set up between centers in cases where the footstock would not interfere with the swivelling of the table for the required angle. A cupped wheel could be used, but a straight wheel is preferable.

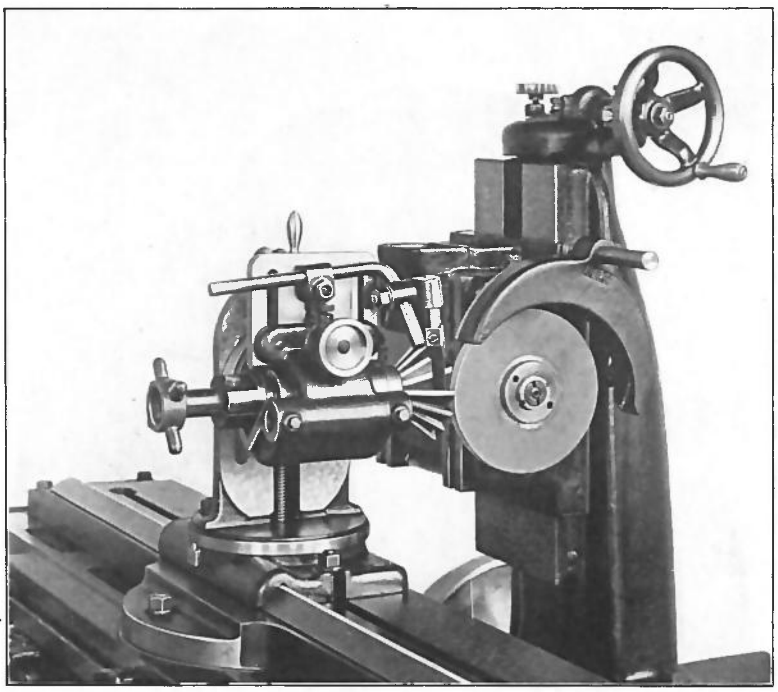

Fig. 34

Grinding the End Teeth of an Angular Cutter

The cutter is mounted on an arbor in the taper shank mill sleeve in the Universal Head. Either a straight or cupped wheel may be used for grinding, depending upon whether a straight or concave angle of clearance is desired.

It is often an advantage to grind the end teeth of cutters of this type slightly lower in the center, so that the teeth will not drag at the heel. In this case, the Universal Head should be swivelled very slightly. The tooth rest may be mounted on the table or on the face of the back rest as shown. The above arrangement is the best, because the rest does not have to be shifted if the cutter is moved, and can usually be set more rigidly in this position.

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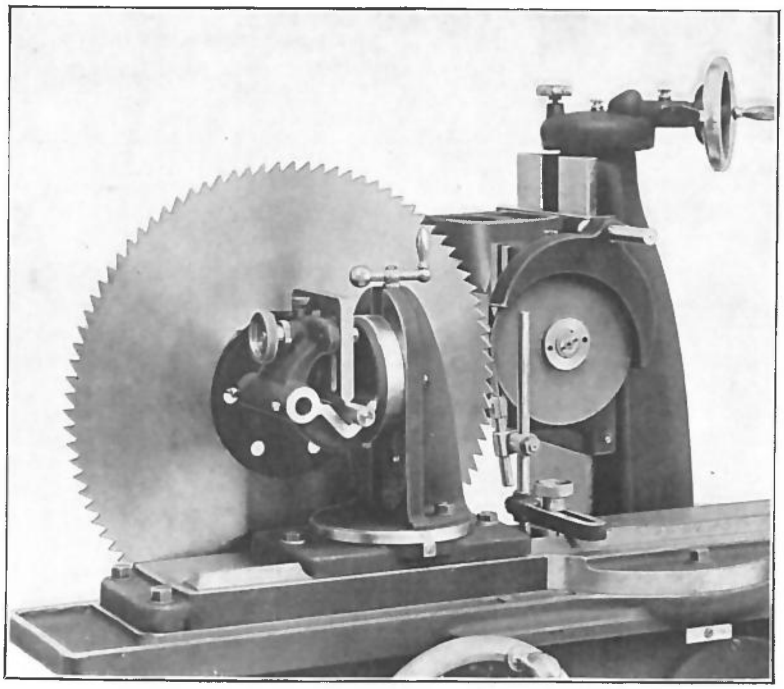

Fig. 35

Grinding the Teeth of a Large Saw

The method shown here of grinding a large saw over the side of the table should only be employed when the work is comparatively light, otherwise the cutter bar on which the work is mounted in the Universal Head, might sag, throwing the work out of line. With this arrangement, the operator stands behind the table and moves the saw across the face of the wheel by sliding it on the cutter bar. Saws up to 24″ in diameter can be ground on the machine by this method. The amount of clearance is regulated by adjusting the tooth rest.

Dexterity on the part of the operator makes this a fast operation; a tooth can be ground at each forward and backward stroke of the work.

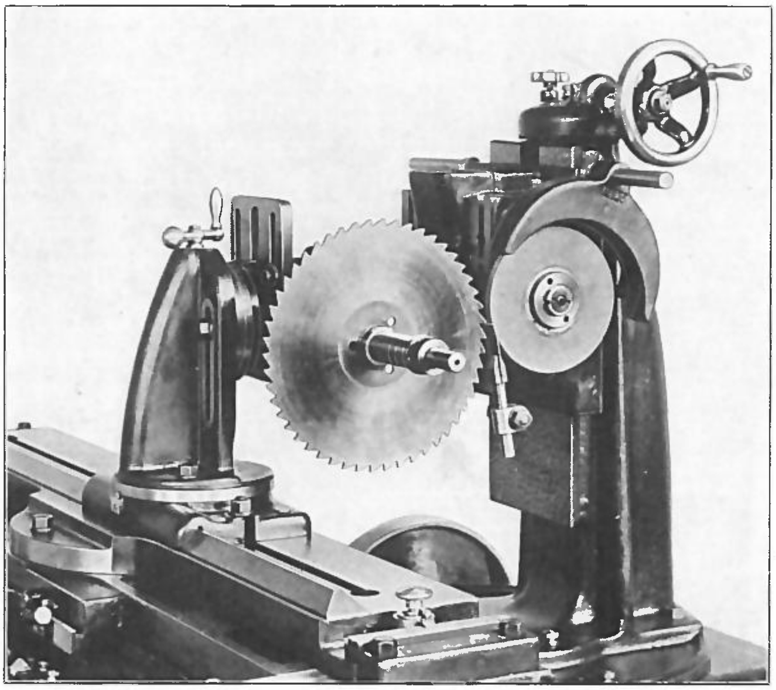

Fig. 36

Grinding the Teeth of a Small Saw

This illustration shows the method used in grinding saws up to the maximum swing of the Universal Head.

The saw is mounted on a sliding shell on the cutter bar and is moved across the face of the wheel by sliding it along the bar.

As the tooth rest is mounted on the wheel stand, the clearance is adjusted by raising or lowering the wheel slide.

The wheel guard in the picture is adjusted away from the wheel in order not to obstruct the view of the operation. In practice it should be well down over the wheel for protection.

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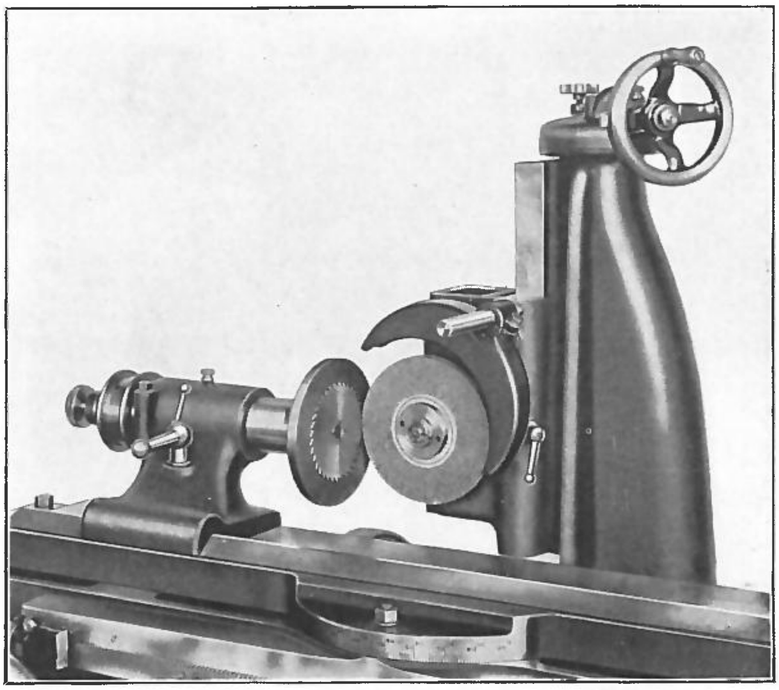


Fig. 37

Grinding the Side of a Saw with a Straight Wheel

In order to concave the sides of a saw for clearance, as shown here, the work is held in the face chuck, shown on page 26, and a straight wheel, shape 20 or 23 is used. The table is set at a slight angle to obtain the required concave surface. In case the saw is to be ground straight, the table should not be swivelled. The saw is rotated by power and the wheel is passed across the saw by means of the hand cross feed. Saws up to the diameter of the face chuck can be ground in this way.

Besides saws, this is a practicable method of grinding discs, thin milling cutters, washers, and collars. The work is easily removed from the chuck by a turn of the knob beyond the pulley.

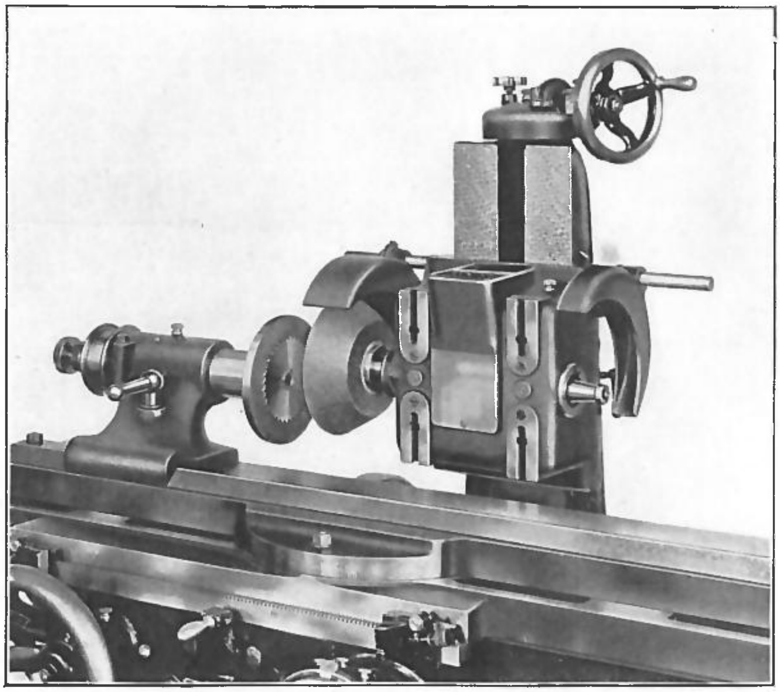


Fig. 38

Grinding the Side of a Saw with a Cupped Wheel

A cupped wheel, shape 50 or 51, can be used instead of a straight wheel for performing the same operation as in *Fig. 37*. The saw is mounted in the same manner, but in this case either the wheel stand or the table is swivelled to obtain the desired clearance on the side of the saw. The wheel is brought in as near to the center as it is desired to concave the surface and then fed against the saw by the table hand feed. This method allows the saw to be concaved for any part of the diameter required.

The concavity is produced by the curve caused by the intersection of the vertical plane of the saw with that of the face of the cupped wheel.

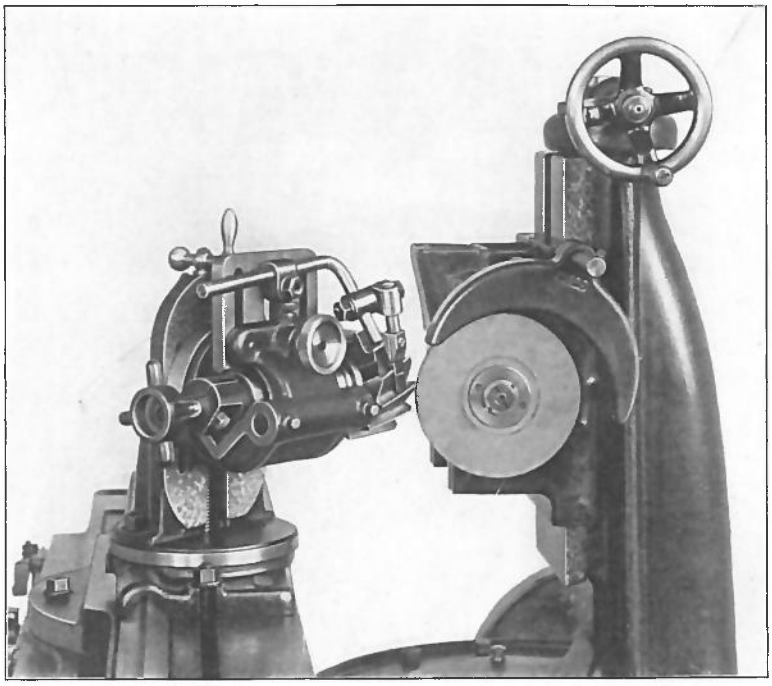


Fig. 39

Beveling the Corners of a Coarse Tooth Shell End Mill

It is often an advantage to bevel off the corners of the teeth of a large end mill at an angle of 45°. The shell end mill, shown here, is mounted on an arbor supported in the tool rest of the Universal Head. The Universal Head is swivelled to an angle of 45° and the table or wheel slide is moved up or down to obtain the required angle of clearance. Mounting the tooth rest on the Universal Head is preferable, because it allows the work holder to be adjusted without disturbing the tooth rest.

The work is rotated as the corner of each tooth is beveled by turning the four-pronged handle of the mill bushing sleeve. Even while the wheel is grinding, rotation pressure should be exerted here to maintain a firm contact between the tooth and the tooth rest.

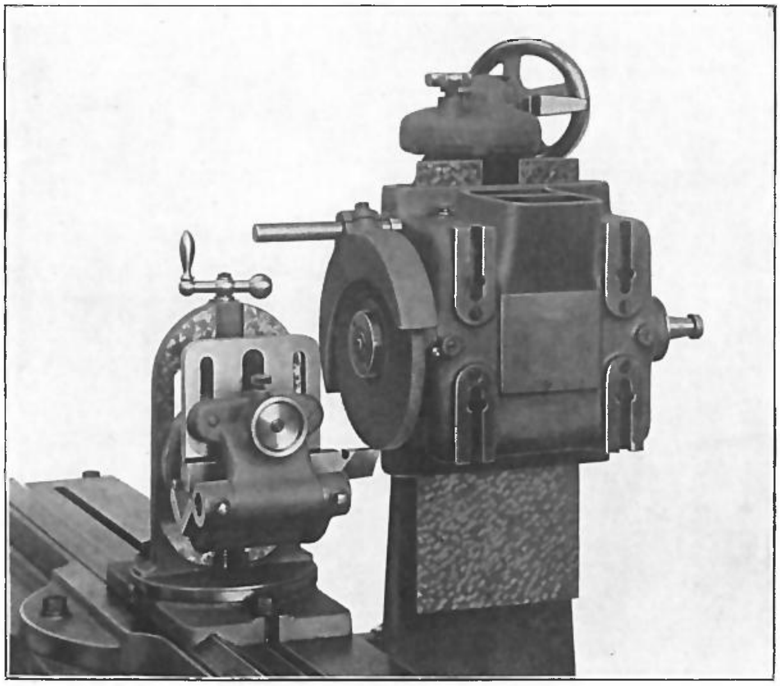
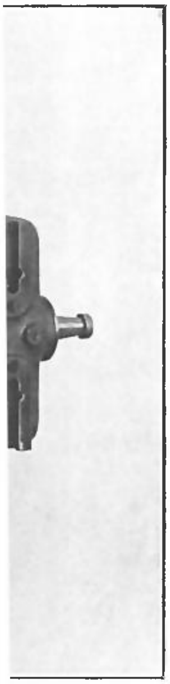


Fig. 40

Grinding a Lathe Tool in the Universal Head

In the case of accurate form cutting tools, like the worm thread tool for a lathe shown in place on the Universal Head, the above method of grinding is of particular advantage. The tool is clamped directly in the tool rest and the accurate adjustments that are possible with the Universal Head make it a comparatively easy operation to grind the correct angle of rake without making an incorrect cutting outline. The table is traversed by hand or power and the wheel is fed forward by means of the hand cross feed. A plain wheel, shape 20 or 23, is used.

This method of grinding lathe tools of all shapes and angles is to be recommended because it produces more accurate and uniform cutting edges than any sharpened by hand.



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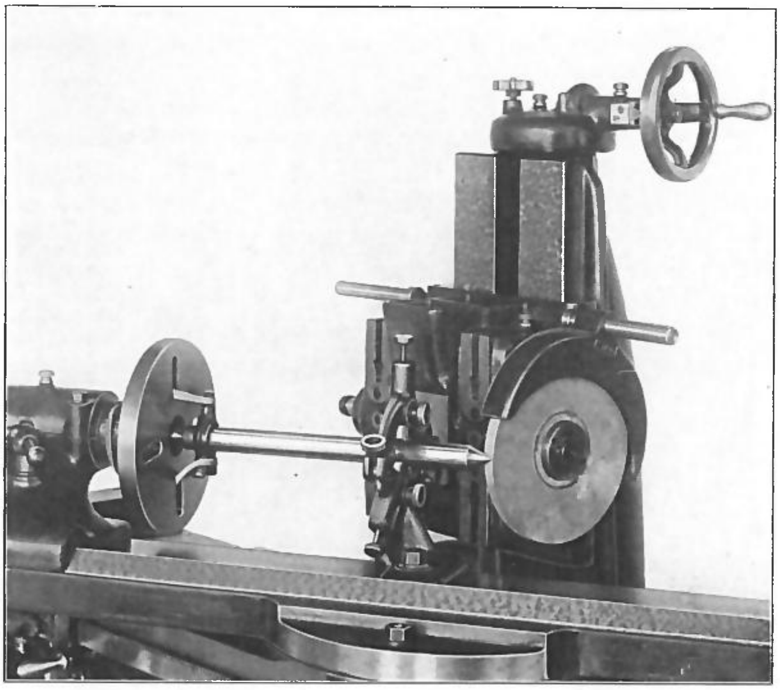


Fig. 41

Grinding a Work Center

The work center is held on the headstock center by means of a lacing passed around the driving dog and tied to the face plate. The outer end of the center is supported in the center rest, and the table is set at the required angle of 60°.

Power table feed or hand feed may be used for traversing the work, and, when convenient, the use of the Wet Grinding Arrangement will be found an advantage. The grinding wheel required is either shape 20 or 23. Work centers and wheel center should be carefully aligned by means of the center height gauge, that is furnished with the machine. Place the gauge on top of the table and move the wheel spindle head vertically until the top of the lug 11, (*See Fig. 5,*) barely touches the testing surface of the gauge.

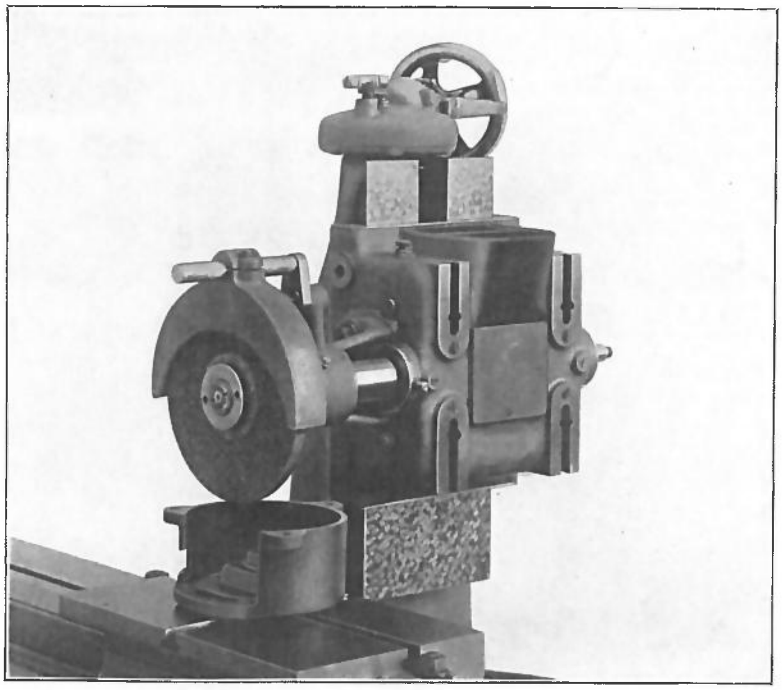


Fig. 42

Surface Grinding a Cast-Iron Guard

This illustration shows how plain surface grinding is done with the work clamped to the table plate. This table plate must be used on account of the "V" way on the table. The wheel spindle extension, shown in position, is necessary in order to bring the wheel a sufficient distance out over the table. Only light finishing surface cuts should be taken with this arrangement, because it is not intended for roughing out flat surfaces.

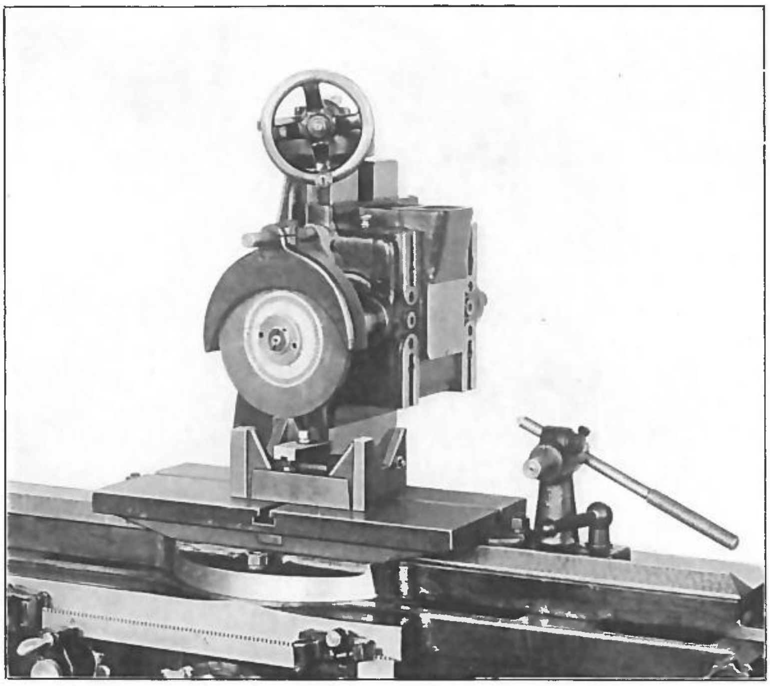


Fig. 43

Truing the Legs of a Jig

The diamond tool holder is shown in position with a diamond tool in place for truing the surface of the wheel. This may be done either in the above position or with the wheel spindle parallel to the table. The diamond tool should always be used in the holder, because it is very difficult to true the wheel by holding the tool in the hand.

A jig, ready to have the bottom of the legs trued, is shown clamped to the table plate T slot. The table hand feed is used for traversing the work.

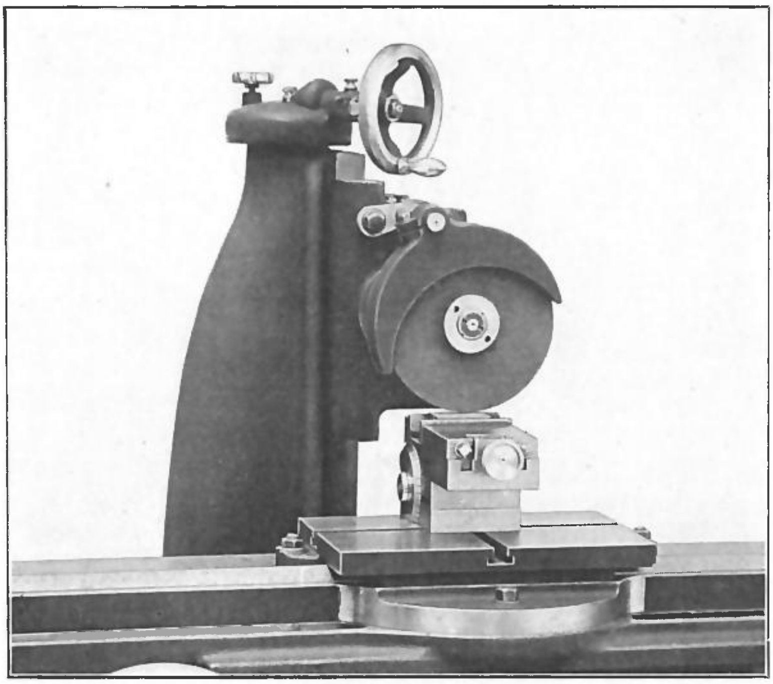


Fig. 44

Grinding the Sides of a Parallel Block

The vise furnished with our Surface Grinding Attachment is very useful in surface grinding small parts, such as the truing of blocks and plates distorted in hardening, finishing parallel blocks, etc. The vise is shown here clamped to the table plate. A plain wheel is used on flat work. The work is traversed by hand feed, and the grinding wheel by hand cross feed. The graduated hand wheel for the vertical adjustment can be used to advantage in finishing a piece to exact thickness.

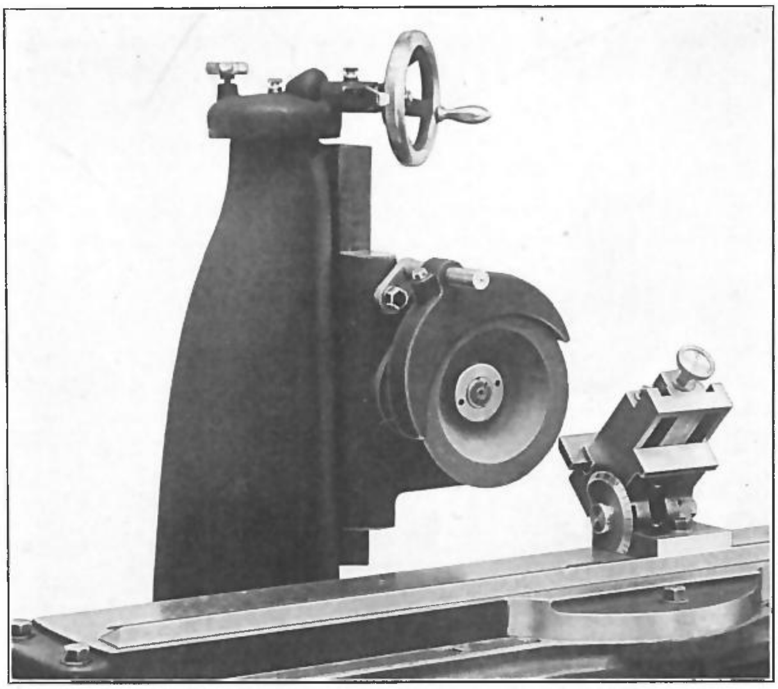


Fig. 45

Grinding an Angle on a Parallel Block

The vise furnished with the Surface Grinding Attachment is particularly useful for grinding exact angles on parallel blocks and tool parts, as illustrated above. The vise is elevated to the required angle, as indicated by the graduated dial on the pin. A cupped wheel, shape 50 or 51, is used and the work is traversed by hand. The table may be swivelled to an angle for grinding a taper on the work, if desired.

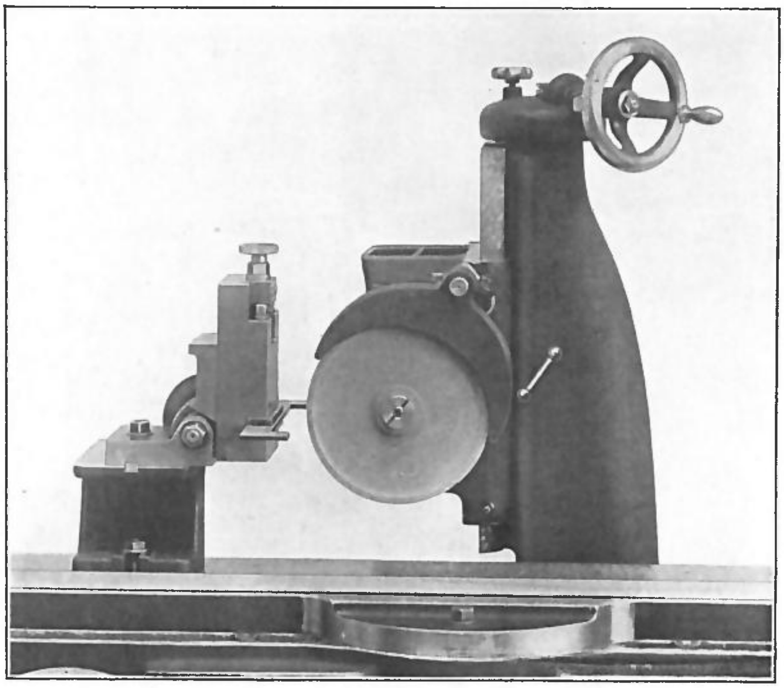
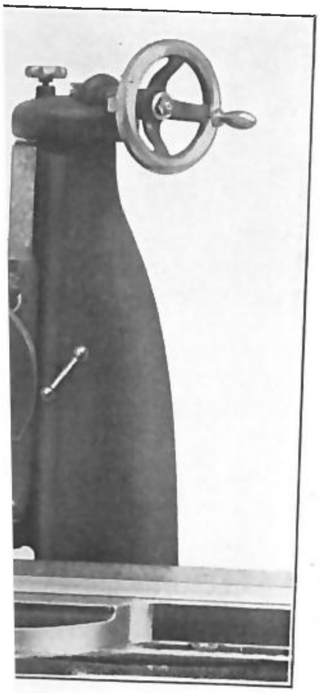


Fig. 46

Grinding Internal Parallel Surfaces

The operation shown in the illustration can be performed with the vise mounted on the tool rest. The vise is elevated to an angle of 90° and a special cupped wheel, shape 39, is used. The wheel is cupped on both sides. It is not furnished with the machine. The work may be ground internally on one side only, using cupped wheel, shape 51, which is furnished with the machine, or it can be ground on an angle by swivelling the table the desired amount.



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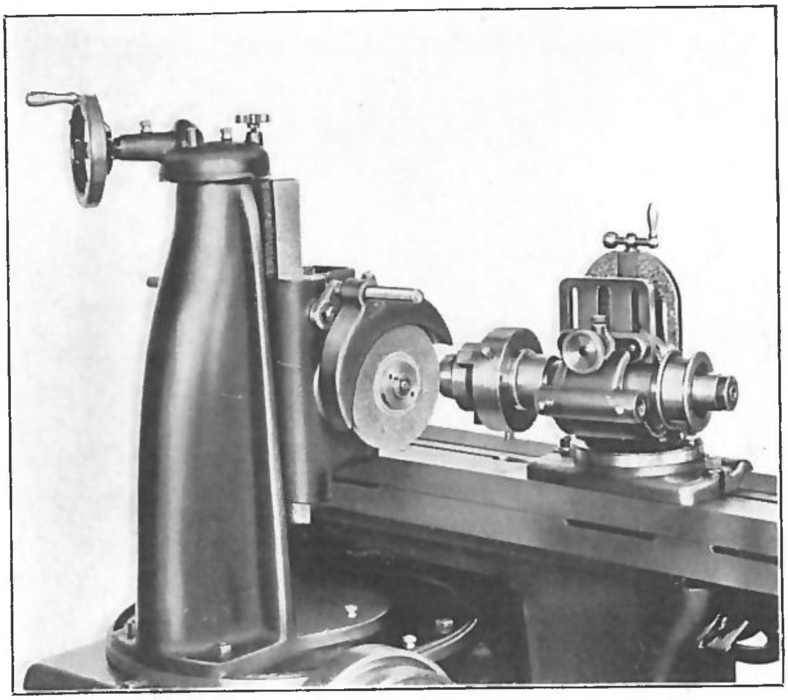

Fig. 47

Grinding an Outside Conical Surface

The work in this case is held in a universal chuck and the chuck is mounted on the headstock spindle, which is removed from the headstock and inserted in the tool rest of the Universal Head. In this way, the work is revolved by the live center pulley. The Universal Head is then set at the desired angle and the table is traversed by hand or power.

By this arrangement it is possible to grind at any angle.

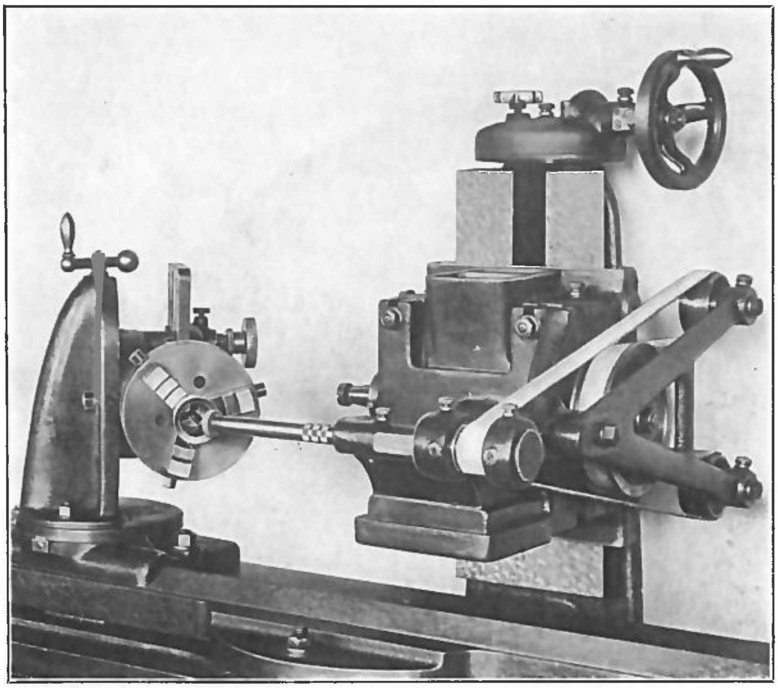

Fig. 48

Grinding an Inside Conical Surface

Steep internal tapers can be handled on the machine by using the Internal Grinding Attachment, as shown in the cut. The work is mounted, as in *Fig. 47,* in a universal chuck on the machine headstock spindle, placed in the Universal Head. The Universal Head is swivelled for the required angle and the work is rotated by the live center pulley.

For small angles the work can be mounted in a universal chuck on the headstock and the table swivelled for the angle, but this method is not commonly used.

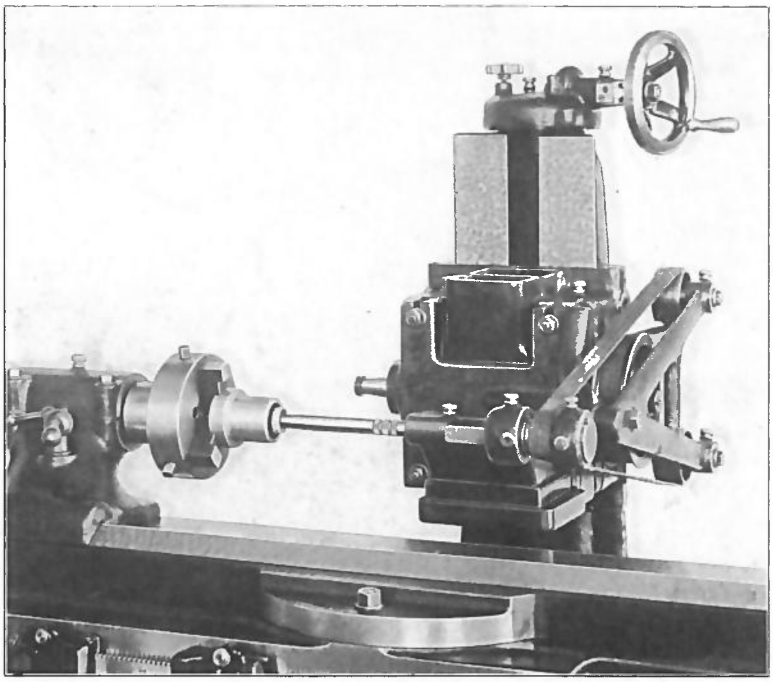

Fig. 49

Grinding a Hole in a Bushing

This straight internal grinding job serves to illustrate the simple method of applying the Internal Grinding Attachment to the machine.

The work that is to be ground, in this case a bushing with a straight hole, is mounted in the universal chuck and driven by the live center pulley. Hand table feed or power feed is used for traversing the work. If it is desired, the outside of the bushing can be ground true with the inside at the same setting by removing the attachment and using a plain wheel.

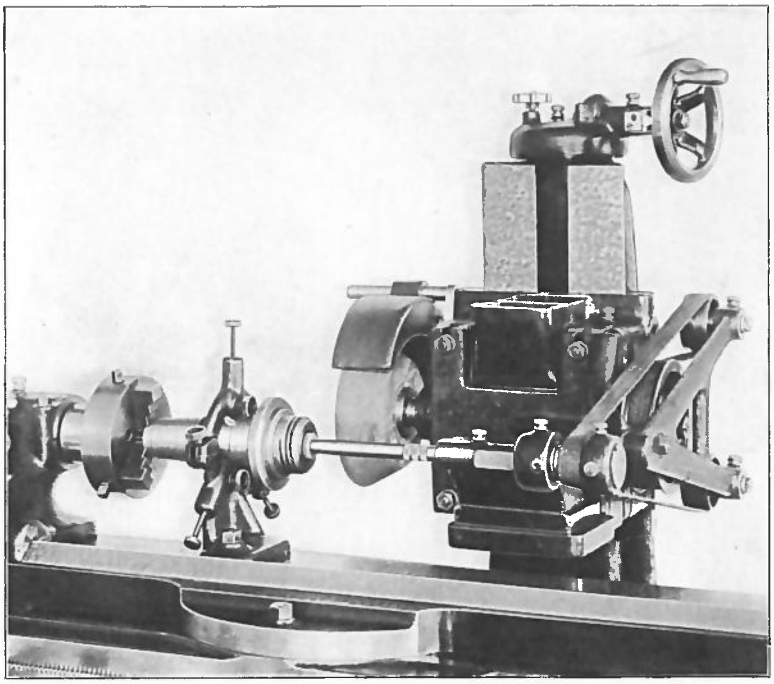

Fig. 50

Grinding a Taper Hole in a Spindle

The spindle is mounted in the chuck or driven by a dog lashed to the face plate. The outer end must be supported in a center rest and the spindle is revolved by the live center pulley.

The Internal Grinding Attachment is in position for grinding the taper hole inside, and the table is set for the required angle of taper by means of the graduated arc. The accuracy of the work should be tested with a taper gauge.

After grinding the taper hole, the shoulder can be ground in correct relation with the hole by means of a cupped wheel, shape 51.

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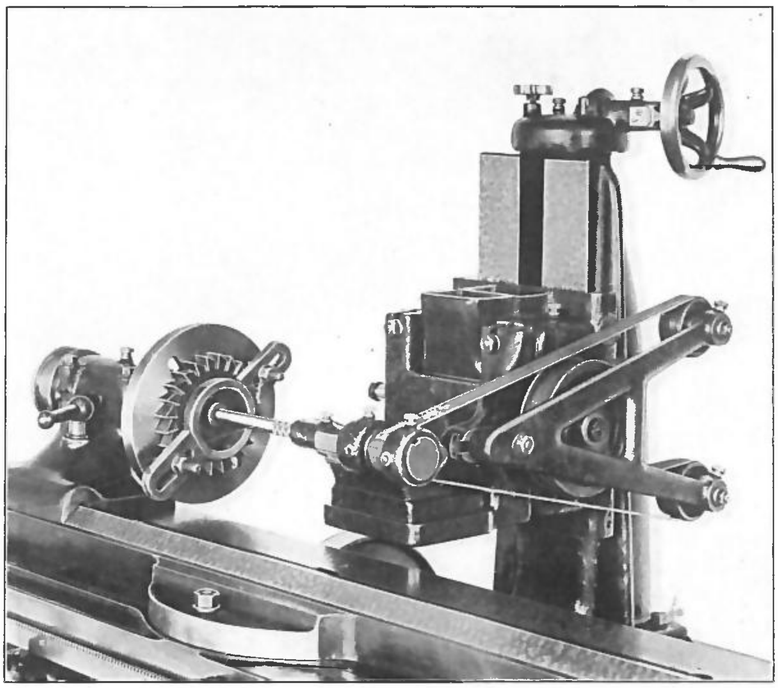


Fig. 51

Grinding the Hole in a Side Milling Cutter

To true up the hole in a thin cutter, the face plate is mounted on the headstock and the machine is set for live center grinding. The cutter must be centered on the face plate before the strap is bolted down. A bolt with nuts and washers on either end is passed through the spindle, the cutter clamped in place and centered, using an indicator on the edges of the teeth. A strap is then bolted to the face plate and the spindle bolt withdrawn. While truing the cutter, throw the belt off the headstock spindle pulley, so that the face plate can be rotated.

In the case of pieces that are too large for the headstock swing, but, which are under 16 inches in diameter, the headstock spindle may be mounted in the Universal Head, as shown in *Fig. 47*.

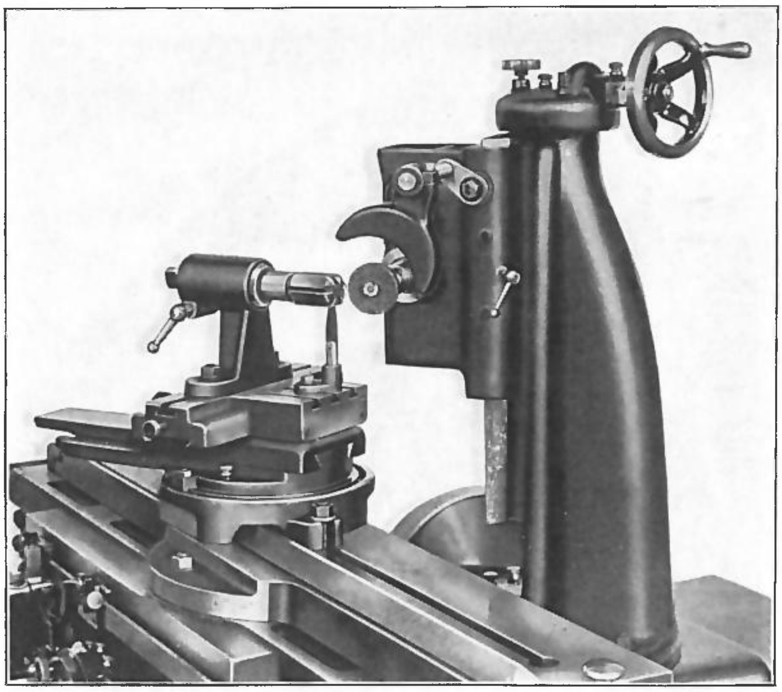
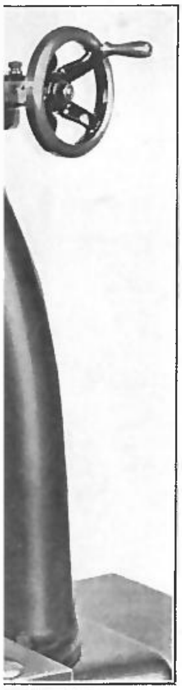


Fig. 52

Grinding a Radius on the Teeth of an End Mill

Rounded corners are sometimes required on end mills for milling formed grooves. They can be accurately produced by the Radial Grinding Attachment. A small grinding wheel, shape 95, is mounted on a 1/4" wheel arbor on the machine. The small wheel is necessary in order to prevent interference with the adjacent teeth. The cutter is set up in the taper shank work holder of the attachment and the wheel spindle is swivelled to an angle of 45° with the table. The wheel is then trued and the work adjusted as explained on pages 103 and 104. Detailed instructions for setting the cutter off center are given on page 36, in the last paragraph.



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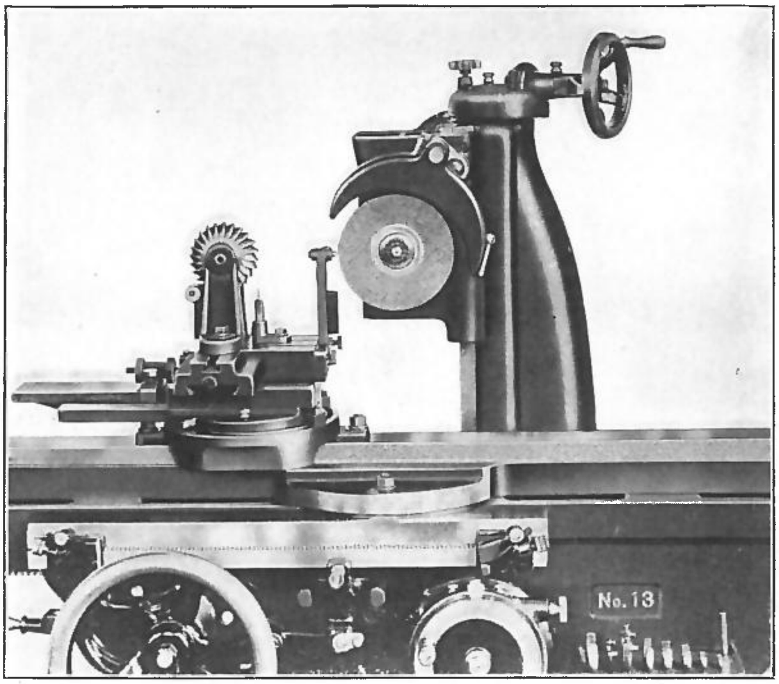


Fig. 53

Truing the Grinding Wheel for Radial Grinding

Before grinding a cutter with the Radial Grinding Attachment the wheel should be formed to the radius which is to be ground. The carbon point holder is placed in position as explained on page 35 and the slide is set for the required radius.

Two methods can then be used for truing; either the table may be locked longitudinally, with the wheel running at right angles, the carbon point swivelled and the wheel fed to it with the cross feed; or the wheel may be set parallel with the table as shown above, and the carbon point brought into line with it and fed forward with the longitudinal table feed while being swivelled. After the wheel is properly trued, the table should be locked. The attachment work slide should be drawn back and the carbon point removed. The wheel, after truing, should only be raised or lowered sufficiently to give the necessary clearance. The relation of the wheel to the attachment pivot should not be altered.

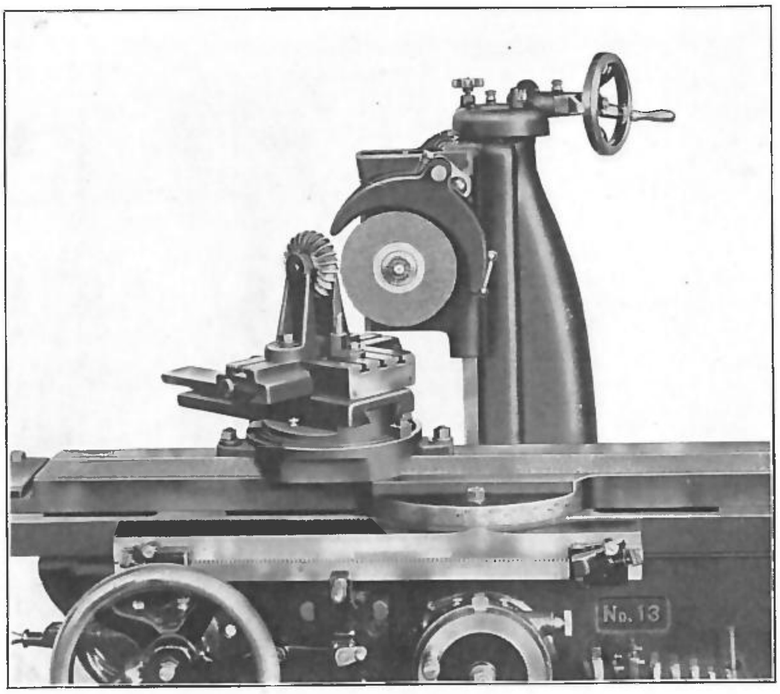
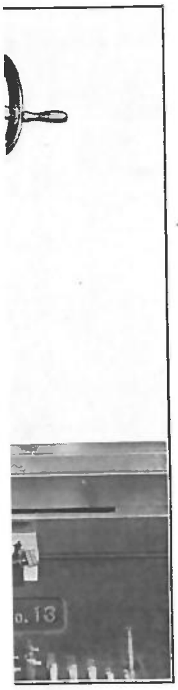


Fig. 54

Grinding the Teeth of a Convex Cutter

After the wheel has been formed for the required radius, as explained under *Fig. 53*, the tooth rest is set in position, at the same height as the center of the work holder. The work is brought forward to the wheel by moving the attachment work slide. In order to obtain the proper amount of clearance, the wheel slide should be raised or lowered.

Before beginning to grind, the work slide should be swivelled with the cutter near the wheel in order to see whether the cutter tooth remains equidistant from the wheel in all its positions. If it swings out on either side, it should be adjusted across the slide with the thumb screws. After the stops controlling the amount of swivel are set, the wheel is started and the cutter is fed forward with the thumb screws. Directions are given on page 36, paragraph 7, for compensating for any inaccuracy in the radius, due to incorrect setting of the carbon point.



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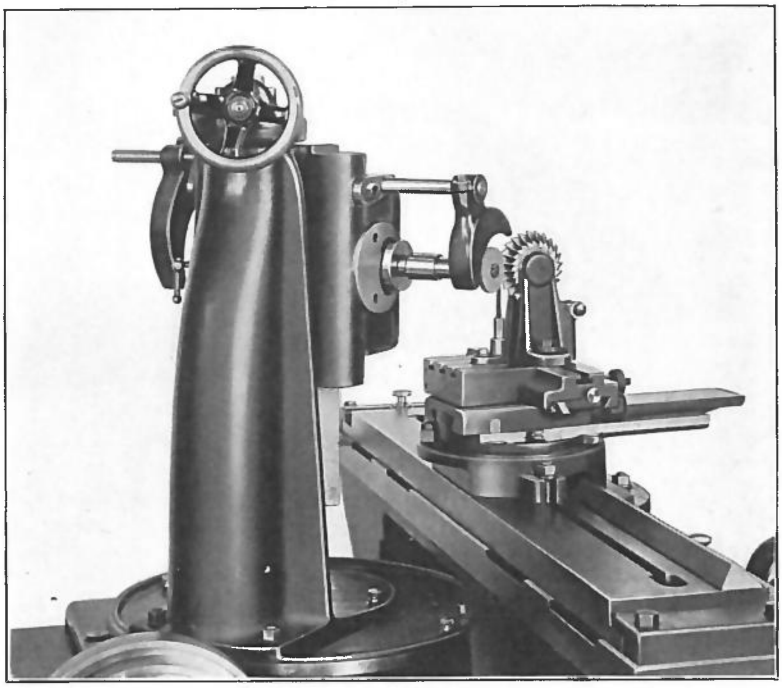

Fig. 55

Grinding One-half of an Interlocking Concave Cutter

For cutters with fine teeth, it is necessary that the wheel should be small enough in diameter to clear the tooth on each side of the one being ground. On this concave cutter a small wheel, shape 95, is used, mounted on a ¼″ wheel arbor. The wheel is trued and the work is adjusted as explained under *Figs. 53 and 54* and on pages 33 to 36. The wheel spindle is swivelled to 45° with the table, due to the position of the surface to be ground.

In the case of a small wheel running at a comparatively slow surface speed, the wheel will necessarily become worn in a short time. This should be anticipated and the wheel should be trued again to the correct form. This can usually be done without removing the work.

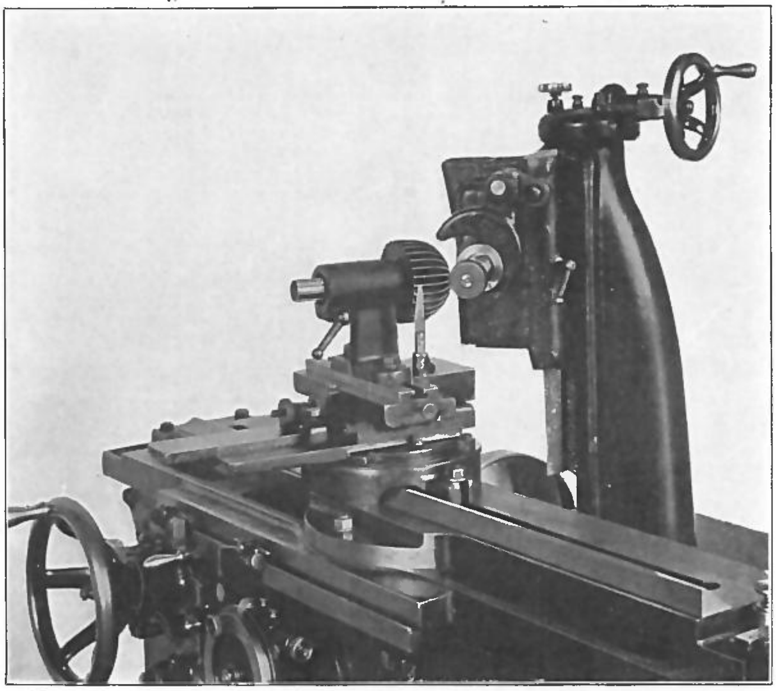

Fig. 56

Grinding a Spherical Cutter

A small wheel, shape 86, must be used on cutters like the one shown above, in order to clear the adjacent teeth. The wheel is mounted on a ¼″ wheel arbor and the wheel spindle is set at 45° with the table. The cutter is mounted on an arbor held in the taper shank work holder. The illustration shows how this part of the attachment is used. The wheel is trued and the work set up, as explained under *Figs. 53 and 54.*

For grinding a large number of cutters in this manner, the Internal Grinding Attachment is very economical, because the increased speed that is practicable enables the wheel to retain its form longer, and to do the work in less time.

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CHAPTER VIII

Specifications and Tables

	SPECIFICATIONS	Belt Driven	Motor Driven
CAPACITY	Centers swing, in diam. . . . . Inches	8	8
	Center of wheel spindle to		
	top of table, greatest distance. . Inches	12⅛	12⅛
	least distance. . . . . Inches	4⅛	4⅛
	Distance between centers. . . . . Inches	24	24
SPINDLE SLIDE UPRIGHT	Transverse movement. . . . . Inches	10½	10½
	Swivel base graduated to read		
	either side of zero. . . . . .Degrees	90	90
WHEEL SPINDLE SLIDE	Vertical adjustment. . . . . Inches	8	8
WHEEL SPINDLE	Belt width. Inches	1¼	1¼
	Number of changes of speed.	3	3
	Range. . . . . R.P.M.	2513 to 5656	2516 to 5688
	Takes wheels to diameter. . . . . Inches	1 to 7	1 to 7
	Takes wheels to thickness (straight wheels). Inches	¼ to ½	¼ to ½
	Takes wheels to width (cupped wheels). Inches	1½ and 2	1½ and 2
SWIVEL TABLE	One T slot width. . . . . Inches	½	½
	Swivels either side of zero . . . . Degrees	90	90
	Scale on end reads to taper per foot. . . . . Inches	3	3
CENTER REST	Diameter (max.) work taken . . . . . Inches	2	2
TABLE SPEEDS	Number of changes.	4	4
	Range. . . . . Inches per min	12 to 76	12 to 84
	Automatic table travel. . . . . Inches	17	15
HEADSTOCK	Front end threaded.	6 R. H. U.S.S.	6 R. H. U.S.S.
	Front end. . . . . diam. Inches	1½	1½
	Taper hole. . . . . .Number	6	6
	Base swivels (motor driven machine)		
	Scale graduated to.	. . . .	degrees
WORK SPEEDS	Number of changes.	4	3
	Range. . . . . R.P.M.	119 to 566	120 to 530
COUNTER-SHAFT	Tight and loose pulley. . . . . diam. Inches	6	. . . .
	Belt width. Inches	2½	. . . .
	Speed. . . . . R.P.M.	425	. . . .
UNIVERSAL HEAD	Vertical adjustment. . . . . Inches	4	4
	Set to any angle in vertical and horizontal planes to . . . . Degrees	90	90
	Work may be taken—Swing over table in diameter to. . . . . Inches	16	16
	Work may be taken with head at right angles to table, light work in diameter to. . . . . Inches	24	24
FLOOR SPACE	Parallel to spindle. . . . . Inches	79	71
	At right angles to spindle. . . . . Inches	45	47
WEIGHTS	Net. . . . . .Lbs.	2050	2450
	Shipping . . . . .Lbs.	3050	2950
EQUIPMENT	See Page 108.		

Grinding Wheels for the Machines

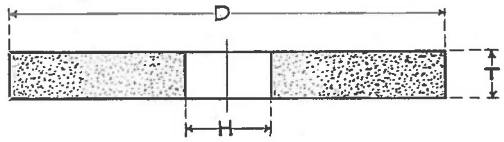
On the following pages is given a list of grinding wheels that we have found from experience to be suitable for the majority of work done on our machines. From the fact that the wheels of only a few manufacturers are mentioned it should not be assumed that other wheels cannot be successfully used. It is very probable that there are many other wheels that are just as well adapted for use on our machines as some of those that are listed, and the material of wheels is often a matter of choice. Any Oxide of Aluminum wheel can be used in place of Alundum or Aloxite and any Carbide of Silicon wheel can be used in place of Carborundum or Crystolon wherever they are referred to in the following list.

If it is desired to use wheels other than listed it is simply necessary to exercise care to select those that are equivalents in grain and grade of the ones given. All wheel manufacturers know the comparative grades of other makers and if a wheel to duplicate any particular maker's grade is ordered it can usually be readily supplied.

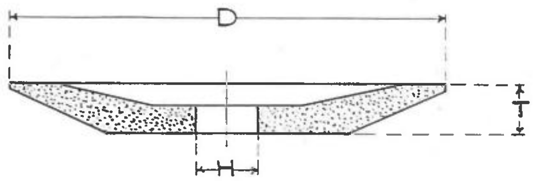
The assortment of wheels given or their equivalents in other wheels, together with a careful study of the matter relating to grinding wheels, will enable the operator to grind successfully all ordinary work for which the machines are adapted. Where special work demands other wheels these should be selected with a view to the requirements that must be fulfilled.

It should be understood that this list applies only when the same cones or pulleys that are furnished with the machines are in use. Any substitution of other cones or pulleys will require a different selection of wheels.

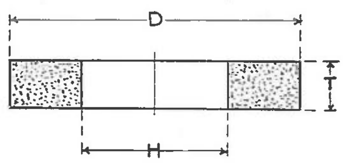
Dimensions of Wheels Furnished with the Machine



Shape 12	D-3"	T-1/4"	H- 3/4"
Shape 20	D-6"	T-3/8"	H-1 1/4"
Shape 23	D-7"	T-1/2"	H-1 1/4"



Shape 27	D-6"	T-1/2"	H-1 1/4"
Shape 62	D-3 1/2"	T-7/16"	H- 1/2"



Shape 86	D-1"	T-1/4"	H-1/4"
Shape 95	D-2"	T-1/4"	H-1/4"

Wheels Furnished with the Machine

*Shape 12	Grain 60	Grade J	Alundum
Shape 20	Grain 60	Grade I	Alundum
Shape 21	Grain 60	Grade I	Alundum
Shape 23	Grain 80	Grade L	Alundum
Shape 23	Grain 100	Grade I	Alundum
Shape 27	Grain 60	Grade J	Alundum
Shape 50	Grain 80	Grade J	Alundum
Shape 51	Grain 60	Grade J	Alundum
Shape 62	Grain 80	Grade J	Alundum
Shape 86	Grain 60	Grade K	Alundum
Shape 95	Grain 90	Grade K	Alundum

Internal Grinding Attachment

*Shape 85	Grain 19120	Grade J	Alundum
Shape 85	Grain 1946	Grade K	Alundum

*See preceding page for dimensions of wheel shapes.

Table of Grinding Wheel Speeds

Diameter of Wheel in Inches	Circumference of Wheel in Feet	R. P. M. for Surface Speed of 4000 Ft.	R. P. M. for Surface Speed of 5000 Ft.	R. P. M. for Surface Speed of 6000 Ft.	R. P. M. for Surface Speed of 7000 Ft.	R. P. M. for Surface Speed of 8000 Ft.
1	.262	15,279	19,099	22,918	26,738	30,558
2	.524	7,639	9,549	11,459	13,369	15,279
3	.785	5,093	6,366	7,639	8,913	10,186
4	1.047	3,820	4,775	5,730	6,684	7,639
5	1.309	3,056	3,820	4,584	5,348	6,112
6	1.571	2,546	3,183	3,820	4,456	5,093
7	1.833	2,183	2,728	3,274	3,820	4,365

Disk Wheel Clearance Table

Diam. of Cutter	For 5° Clearance	For 7° Clearance	Diam. of Cutter	For 5° Clearance	For 7° Clearance	Diam. of Cutter	For 5° Clearance	For 7° Clearance
1½″	3/64″	5/64″	2⅝″	1/16″	3/32″	4″	3/32″	⅛″
1⅝″	3/64″	5/64″	2¾″	5/64″	3/32″	4¼″	3/32″	⅛″
1¾″	3/64″	5/64″	2⅞″	5/64″	7/64″	4½″	3/32″	⅛″
1⅞″	1/16″	5/64″	3″	5/64″	7/64″	4¾″	1/32″	9/64″
2″	1/16″	5/64″	3⅛″	5/64″	7/64″	5″	3/32″	9/64″
2⅛″	1/16″	5/64″	3¼″	5/64″	7/64″	5¼″	3/32″	9/64″
2¼″	1/16″	3/32″	3⅜″	5/64″	7/64″	5½″	7/64″	9/64″
2⅜″	1/16″	3/32″	3½″	5/64″	⅛″	5¾″	7/64″	9/64″
2½″	1/16″	3/32″	3¾″	3/32″	⅛″	6″	7/64″	9/64″

TABLE OF DECIMAL EQUIVALENTS
OF
MILLIMETRES AND FRACTIONS OF MILLIMETRES.

mm. Inches.	mm. Inches.	mm. Inches.	mm. Inches.
$\frac{1}{100}$ = .00039	$\frac{33}{100}$ = .01299	$\frac{64}{100}$ = .02520	$\frac{95}{100}$ = .03740
$\frac{2}{100}$ = .00079	$\frac{34}{100}$ = .01339	$\frac{65}{100}$ = .02559	$\frac{96}{100}$ = .03780
$\frac{3}{100}$ = .00118	$\frac{35}{100}$ = .01378	$\frac{66}{100}$ = .02598	$\frac{97}{100}$ = .03819
$\frac{4}{100}$ = .00157	$\frac{36}{100}$ = .01417	$\frac{67}{100}$ = .02638	$\frac{98}{100}$ = .03858
$\frac{5}{100}$ = .00197	$\frac{37}{100}$ = .01457	$\frac{68}{100}$ = .02677	$\frac{99}{100}$ = .03898
$\frac{6}{100}$ = .00236	$\frac{38}{100}$ = .01496	$\frac{69}{100}$ = .02717	1 = .03937
$\frac{7}{100}$ = .00276	$\frac{39}{100}$ = .01535	$\frac{70}{100}$ = .02756	2 = .07874
$\frac{8}{100}$ = .00315	$\frac{40}{100}$ = .01575	$\frac{71}{100}$ = .02795	3 = .11811
$\frac{9}{100}$ = .00354	$\frac{41}{100}$ = .01614	$\frac{72}{100}$ = .02835	4 = .15748
$\frac{10}{100}$ = .00394	$\frac{42}{100}$ = .01654	$\frac{73}{100}$ = .02874	5 = .19685
$\frac{11}{100}$ = .00433	$\frac{43}{100}$ = .01693	$\frac{74}{100}$ = .02913	6 = .23622
$\frac{12}{100}$ = .00472	$\frac{44}{100}$ = .01732	$\frac{75}{100}$ = .02953	7 = .27559
$\frac{13}{100}$ = .00512	$\frac{45}{100}$ = .01772	$\frac{76}{100}$ = .02992	8 = .31496
$\frac{14}{100}$ = .00551	$\frac{46}{100}$ = .01811	$\frac{77}{100}$ = .03032	9 = .35433
$\frac{15}{100}$ = .00591	$\frac{47}{100}$ = .01850	$\frac{78}{100}$ = .03071	10 = .39370
$\frac{16}{100}$ = .00630	$\frac{48}{100}$ = .01890	$\frac{79}{100}$ = .03110	11 = .43307
$\frac{17}{100}$ = .00669	$\frac{49}{100}$ = .01929	$\frac{80}{100}$ = .03150	12 = .47244
$\frac{18}{100}$ = .00709	$\frac{50}{100}$ = .01969	$\frac{81}{100}$ = .03189	13 = .51181
$\frac{19}{100}$ = .00748	$\frac{51}{100}$ = .02008	$\frac{82}{100}$ = .03228	14 = .55118
$\frac{20}{100}$ = .00787	$\frac{52}{100}$ = .02047	$\frac{83}{100}$ = .03268	15 = .59055
$\frac{21}{100}$ = .00827	$\frac{53}{100}$ = .02087	$\frac{84}{100}$ = .03307	16 = .62992
$\frac{22}{100}$ = .00866	$\frac{54}{100}$ = .02126	$\frac{85}{100}$ = .03346	17 = .66929
$\frac{23}{100}$ = .00906	$\frac{55}{100}$ = .02165	$\frac{86}{100}$ = .03386	18 = .70866
$\frac{24}{100}$ = .00945	$\frac{56}{100}$ = .02205	$\frac{87}{100}$ = .03425	19 = .74803
$\frac{25}{100}$ = .00984	$\frac{57}{100}$ = .02244	$\frac{88}{100}$ = .03465	20 = .78740
$\frac{26}{100}$ = .01024	$\frac{58}{100}$ = .02283	$\frac{89}{100}$ = .03504	21 = .82677
$\frac{27}{100}$ = .01063	$\frac{59}{100}$ = .02323	$\frac{90}{100}$ = .03543	22 = .86614
$\frac{28}{100}$ = .01102	$\frac{60}{100}$ = .02362	$\frac{91}{100}$ = .03583	23 = .90551
$\frac{29}{100}$ = .01142	$\frac{61}{100}$ = .02402	$\frac{92}{100}$ = .03622	24 = .94488
$\frac{30}{100}$ = .01181	$\frac{62}{100}$ = .02441	$\frac{93}{100}$ = .03661	25 = .98425
$\frac{31}{100}$ = .01220	$\frac{63}{100}$ = .02480	$\frac{94}{100}$ = .03701	26 = 1.02362
$\frac{32}{100}$ = .01260			

10 mm. = 1 Centimeter = 0.3937 inches.
10 cm. = 1 Decimeter = 3.937 inches.
10 dm. = 1 Meter = 39.37 inches.
25.4 mm. = 1 English Inch.

DECIMAL EQUIVALENTS OF PARTS OF AN INCH

1/64	.01563	21/64	.32813	45/64	.70313
1/32	.03125	11/32	.34375	23/32	.71875
3/64	.04688	23/64	.35938	47/64	.73438
1-16	.0625	3-8	.375	3-4	75
5/64	.07813	25/64	.39063	49/64	.76563
3/32	.09375	13/32	.40625	25/32	.78125
7/64	.10938	27/64	.42188	51/64	.79688
1-8	.125	7-16	.4375	13-16	.8125
9/64	.14063	29/64	.45313	53/64	.82813
5/32	.15625	15/32	.46875	27/32	.84375
11/64	.17188	31/64	.48438	55/64	.85938
3-16	.1875	1-2	.5	7-8	.875
13/64	.20313	33/64	.51563	57/64	.89063
7/32	.21875	17/32	.53125	29/32	.90625
15/64	.23438	35/64	.54688	59/64	.92188
1-4	.25	9-16	.5625	15-16	.9375
17/64	.26563	37/64	.57813	61/64	.95313
9/32	.28125	19/32	.59375	31/32	.96875
19/64	.29688	39/64	.60938	63/64	.98438
5-16	.3125	5-8	.625	1	1.00000
		41/64	.64063		
		21/32	.65625		
		43/64	.67188		
		11-16	.6875		

F AN INCH

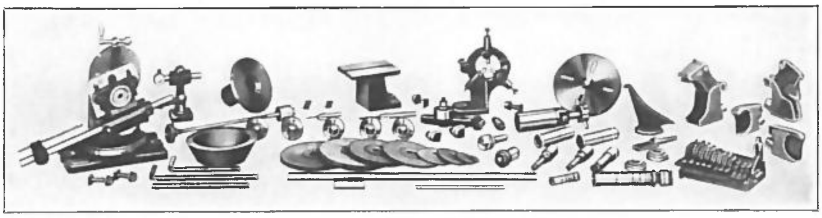
45/64 ...	.70313
......	.71875
47/64 ...	.73438
....	.75
49/64 ...	.76563
......	.78125
51/64 ...	.79688
6	.8125
53/64 ...	.82813
......	.84375
55/64 ...	.85938
....	.875
57/64 ...	.89063
......	.90625
59/64 ...	.92188
6	.9375
61/64 ...	.95313
......	.96875
63/64 ...	.98438
....	1.00000

EQUIPMENT

Furnished with the No. 13 Universal and Tool Grinding Machine

The parts listed below are furnished with the machine as part of its equipment together with everything else shown in illustration below.

Do not order separate parts by the numbers indicating the parts, as shown throughout this book. For ordering separate parts we have a special booklet which we would be pleased to send upon request. When ordering parts, specify style, size, and serial number of the machine for which they are intended.



Equipment. Universal head; face chuck; face plate; set of dogs; center height gauge; 3/4″ cutter bar with 7/8″ sliding shell and set of collars, including 4 stepped collars; 3/8″ cutter bar with bushing for universal head and 1/2″ sliding shell, with set of collars, including 2 stepped collars; arbor for straddle and face mills and 3 collars; 2 taper shank mill bushings; 4 tooth rests and holders; 3 centers, including reamer grinding center; center rest; tool rest; diamond tool bracket; 4 wheel arbors—1, 1/4″ R. H.; 1, 1/4″ L. H.; 1, 1/2″ R. H.; 1, 3/4″ R. H.; 7 wheel sleeves, 1 1/4″ diameter; 11 grinding wheels—1, 1″ diameter, 1/4″ thick, 1/4″ hole; 1, 2″ diameter, 1/4″ thick, 1/4″ hole; 1, 3″ diameter, 1/4″ thick, 3/4″ hole; 1, 6″ diameter, 3/8″ thick, 1 1/4″ hole; 2, 7″ diameter, 1/2″ thick, 1 1/4″ hole; 1 bevel and concave, 3 1/2″ diameter, 1/2″ thick, 1/2″ hole; 1 bevel and concave, 6″ diameter, 1/2″ thick, 1 1/4″ hole; 1 cupped, 4″ diameter, 1 1/2″ thick, 1 1/4″ hole; 1 cupped, 7″ diameter, 2″ thick, 1 1/4″ hole; 1 straight, 6″ diameter, 1/4″ thick, 1 1/4″ hole; 3 plain and 3 adjustable wheel guards, and everything else shown in cut on page 8 and in panel above, together with overhead works.

The equipment furnished with the No. 13 Universal and Tool Grinding Machine (Motor Driven) is in general the same as that listed above.