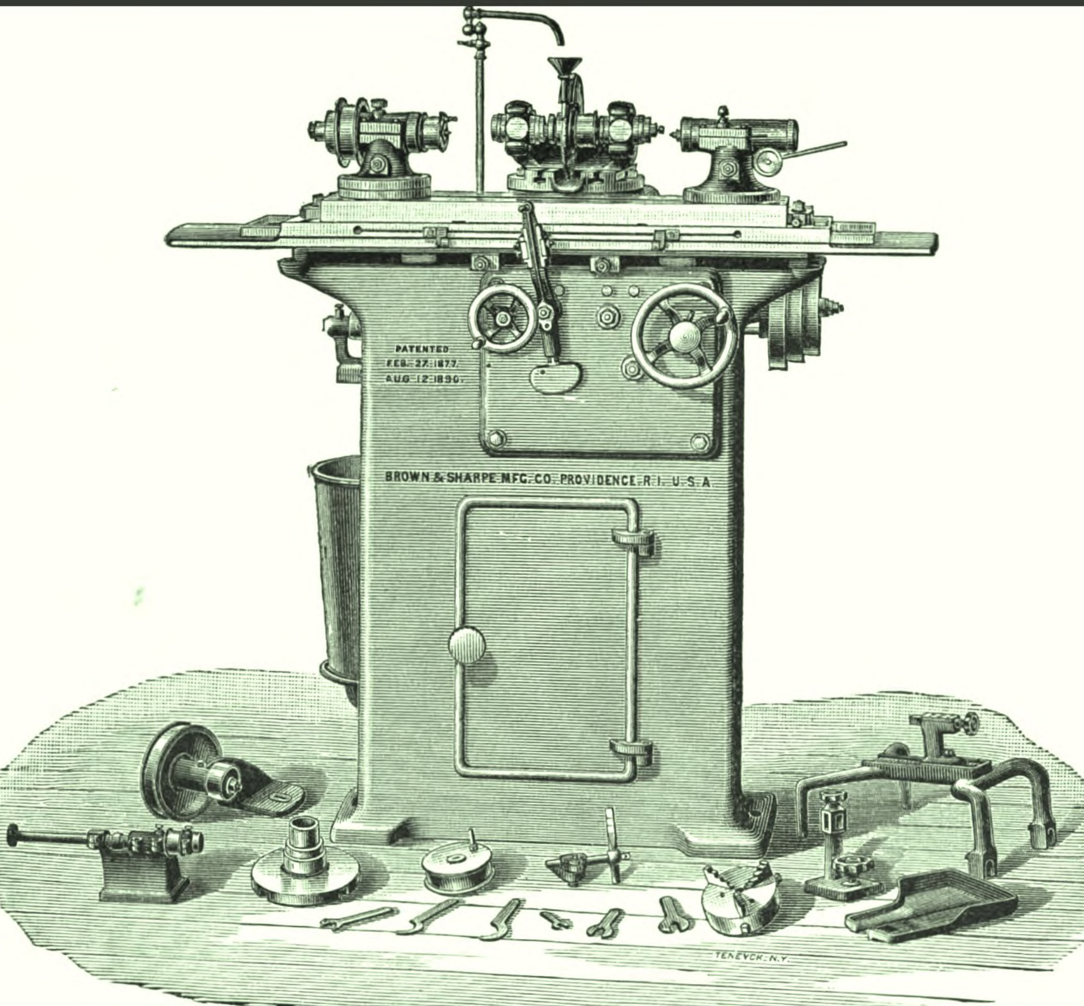

A treatise on the construction and use of universal and ...

Brown & Sharpe manufacturing co., Providence, R. I.

A TREATISE

ON THE

CONSTRUCTION AND USE

— OF —

UNIVERSAL AND PLAIN

GRINDING MACHINES,

— FOR —

CYLINDRICAL AND CONICAL SURFACES,

AS MADE BY

BROWN & SHARPE MFG. CO.,

PROVIDENCE, R. I. U. S. A.

MANUFACTURERS OF

FINE MACHINERY AND MACHINE TOOLS.

PROVIDENCE, R. I.
BROWN & SHARPE MAFUFACTURING COMPANY.

1891.

PREFACE.

Our chief desire in publishing this Treatise is to assist the novice in becoming familiar with the construction and use of Universal and Plain Grinding Machines. A complete description is given of each of the machines, although they have a number of features in common, for repetitions are here less objectionable than the annoyance and possibility of misunderstandings occasioned by frequent reference from one machine to another. To the descriptions we have added a number of suggestions in regard to the care and use of the machines and a number of examples showing their adaptation to different kinds of work. We also have included in the book a few pages on the measuring tools advantageously used by those operating Grinding Machines.

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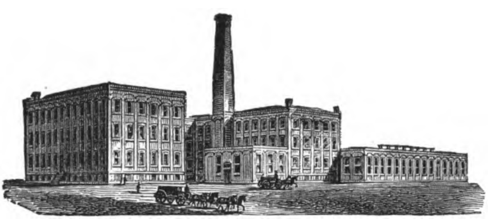

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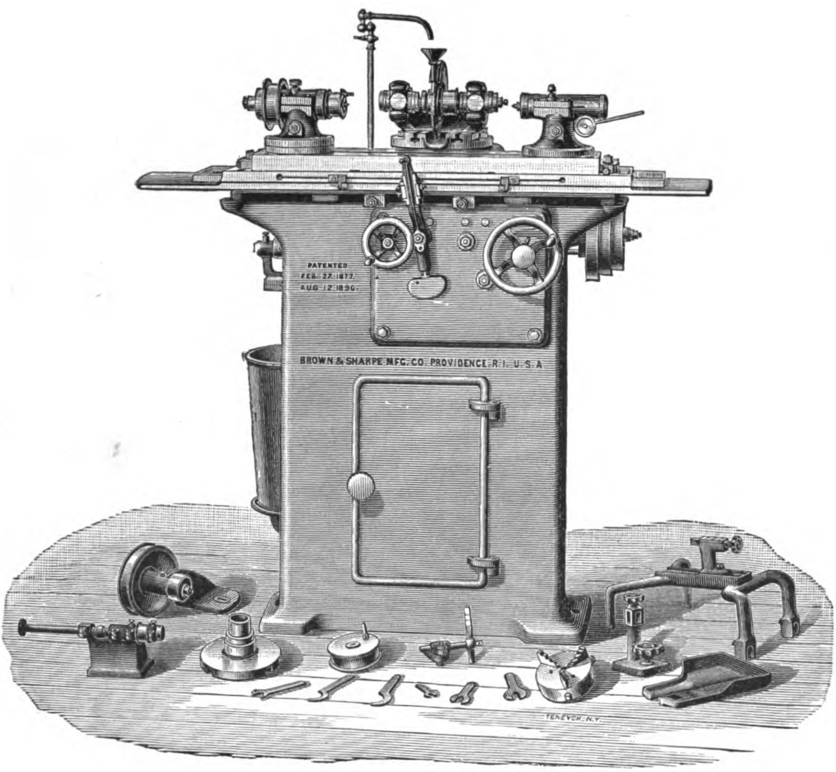


FIG. 1.

No. 1 Universal Grinding Machine.

INTRODUCTION.

The introduction of high-speed machinery, and the demand for increased accuracy in machine construction in general of to-day, call for machines which are better adapted to produce uniform surfaces and accurate work than the lathe and the planer of the past. It is well-known, to all engaged in the manufacture of machinery and tools of precision, that the lathe is incapable of producing accurate work, even in the softer metals, and in operating upon hardened surfaces it fails us altogether. It is very important to have journals and other wearing surfaces smooth and true when they are made. They cannot be depended upon to "wear to a fit" as formerly was sometimes erroneously supposed. If they are imperfectly made, the tendency is to become worse by wear. In high-speed machinery heating of journals is often caused by imperfect fitting. In fact, we may say that the success of high-speed machinery depends very largely upon our ability to do better work than we have been able to produce on the lathe. The only successful field which seems to be open to us, at the present time, to meet this want, is to use the lathe as a roughing tool, or machine to bring the work approximately to the desired size, then to finish by grinding with emery wheels on a suitably designed machine. To meet this want in our own works, a number of years ago, we designed and constructed grinding machines which have proved to be very useful, in fact indispensable, for the production of first-class work. They have become necessary and economical tools in the manufacture of special and general, as well as standard, machinery and tools. In duplicating parts of small machinery, manufactured on the interchangeable system, such as sewing machine shafts, needle bars, etc., they are unexcelled. They are especially useful, as they can be used to operate on hardened as well as soft work to produce the same degree of accuracy, excellence and economy. Without the use of suitable grinding machines the introduction of hardened spindles and boxes into lathes, milling machines, drilling machines, etc., etc., would be impossible, and the value and desirability of such improvements, in machine tools will not be disputed. By grinding such work as crank pins, valve rods, piston rods, etc., of locomotive and other steam engines, a vast improvement can be made in the quality and durability of the same, as well as a great saving in the cost of prodution.

The fact that it *costs less* to finish and fit work by grinding with emery wheels, than it does by the old way on the lathe, has been proved repeatedly by experience. The saving is in the cost of files, emery paper, etc., as well as in the *time* it takes to do the work. This is true for all kinds of work, whether the grinding is done for making accurate fits, or simply for the sake of finish or polish.

The fact that work can be done more *accurately* on a grinding machine than on a lathe, is also well sustained by experience. As an example of the *quality* of work that can be done on these machines, we may refer to the standard gauges which we manufacture, some of which are illustrated in the latter part of this Treatise.

In the want of something better than the lathe and the planer to produce accurate work, frequent attempts have been made in various shops to rig up an emery wheel attachment to lathes and planers, for the purpose of grinding such work as crank pins on the former, and cross-head guides on the latter, but, as might be expected, these would usually give unsatisfactory results, from the fact that these machines were not adapted to produce the quality of work wanted. The simple application of an emery wheel to an article will not improve its character unless the *grinding machine* is designed for, and adapted to, the kind and quality of work wanted. In doing fine work, defects will frequently appear which would never be noticed in a coarser class; hence it is that a planer, or a lathe, may be well adapted to a certain class of work, but when we demand something better from it than that for which it was designed, we shall invariably be disappointed.

The grinding machines, as built by us, are the outgrowth of our own experience in the business of manufacturing. We have, therefore, had ample opportunities, for a number of years, to study the needs and requirements which would adapt them to the use for which they are intended. We are now building them with all the improvements made during the past years of experience.

The Universal Grinding Machines were designed to do a general class and large variety of work, such as may be required in a general jobbing shop. For this kind of work they are well adapted, though they are equally applicable to ordinary manufacturing purposes. For manufacturing on a large scale, however, plain or special machines may be more desirable. Each of the regular machines indicates by its dimensions and capacity the class of work for which it should properly be used.

It may be but just to those into whose hands this Treatise may fall, as well as to ourselves, to state in this connection that the machines which we describe herewith and which we exhibit more in detail than is usually customary, are protected by letters patent issued in 1877, 1885 and 1890.

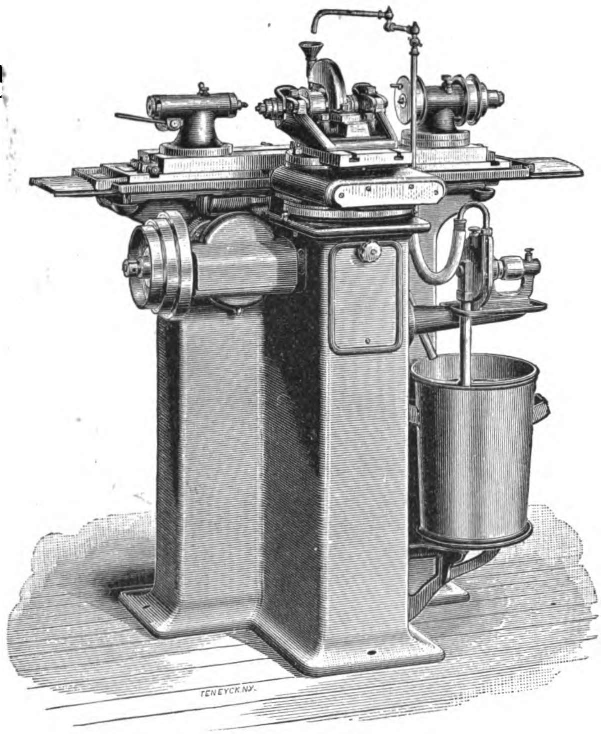


FIG. 2.

No. 1 Universal Grinding Machine.

REAR VIEW.

Description of No. 1 Universal Grinding Machine.

The perspective views, Figs. 1 and 2, give a general idea of the No. 1 Universal Grinding Machine. The design is well adapted to resist vibrations within the machine itself—an element essential to the durability of the machine and the accuracy of its work. **General Construction.**

The base rests upon three points or feet and is fitted as a closet for the tools and accessories used about the machine. **Base.**

The bed and base are cast in one piece and the sliding table moves upon the bed on one V and one flat slide, as shown in Fig. 3. The ways are lubricated by two rolls in each. Thus the oil is equally distributed over the bearings and the proper position of the sliding table is maintained, a feature of some consequence in accurate grinding. The waste oil from the mechanism in the bed can be drawn off through a pipe from the bottom of the bed. **Bed and Sliding Table.**

The shallow basins or pockets, one at each end of the sliding table, form convenient places for wrenches and other tools in frequent use about the machine, and the dust caps beyond the basins protect the slides when the table travels to its extreme movement. These caps are curved so that weights cannot conveniently be placed at the extreme ends of the platen.

The head and foot stocks are mounted upon a swivel table, which rests upon the sliding table and turns on a central stud. The line of centres accordingly can be set at any angle with the table slides, for the purpose of grinding tapers without throwing the head and foot stock spindles out of line—see Fig. 22. When **Swivel Table.**

set to any desired position, the swivel table is clamped for heavy work at each end to the sliding table. In ordinary work, however, the weight of the table gives sufficient stability, so that clamping is not required.

Adjusting Screw and Scale for Tapers. For setting the table accurately to grind any desired taper an adjusting screw is provided and a scale graduated to show the taper both in degrees and in inches per foot. The graduations marked "Taper in inches per foot," give the whole taper of the work, and those marked "Degrees," give the taper from the centre line of the work or one-half the whole taper, which is the angle the swivel table is set out of line. By this arrangement very exact settings can be easily obtained.

The T slot extends the whole length of the table and receives the heads of the clamp bolts, by which the head and foot stocks are secured. The slot is scraped to a straight edge and the tongues of the head and foot stocks are carefully scraped to fit the slot. The head and foot stocks may be set at any point on the platen, which is a convenience in using the machine for a variety of purposes.

Wheel Bed. The wheel bed is supported by the rear-ward projection of the base, shown in Fig. 2, which extends to the floor and stands directly upon one of the feet of the base. A semi-circumference at the lower edge of the wheel bed is graduated to degrees so that it may be set at any desired angle, in a horizontal plane, relative to the sliding table. When properly set it is clamped by a bolt on each side of the standard.

Wheel Slide. The wheel slide moves on wide, flat bearings and is held in place by a 45 degree gib. This and the forward projecting dust cover completely protect the slides from dust.

The wheel platen rests on a flat, circular bearing, the mean diameter of which is greater than the distance between the bearings of the wheel spindle. A steady support for the wheel stand is thus provided and rocking is prevented.

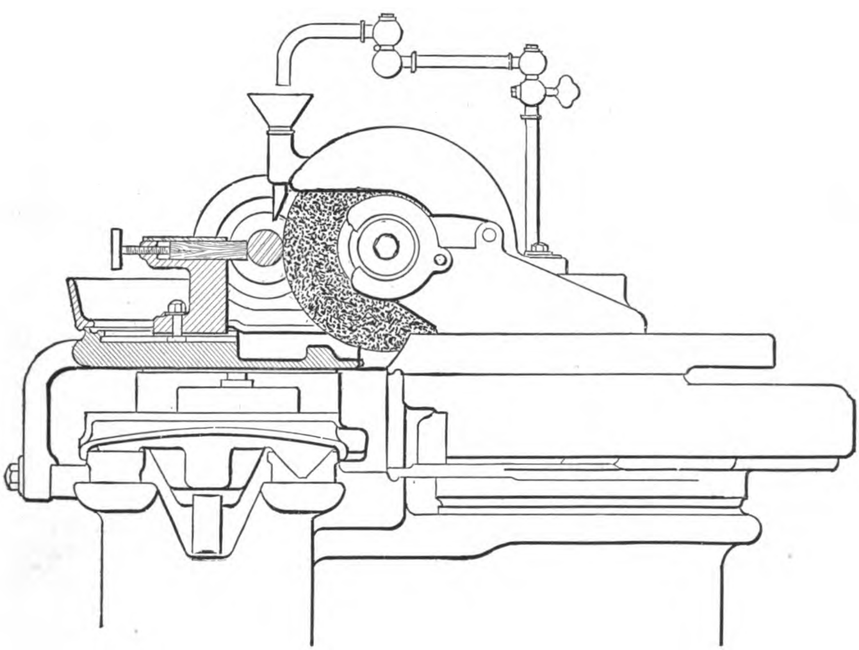


Fig. 3.

Wheel Platen. The wheel platen may be set in any position, and is held in place by a bolt on each side. The object in having the wheel platen swivel is to enable the operator to bring the face of the wheel parallel with the line of travel of the wheel slide as shown in Fig. 46.

In internal grinding the wheel platen is turned around, a speed counter is used in place of the wheel stand, and an internal grinding fixture is placed on the end projecting over the swivel table, as shown in Fig. 4.

Wheel Stand. The wheel stand is secured in any position on the wheel platen by two *T* bolts. These, with the two bolts in the wheel platen, and the two bolts in the wheel bed, form a rigid connection with the heavy rearward projection of the base.

Wheel Guard. The wheel guard is bolted to the wheel stand. It shields the operator from sparks, dust and water, and is sufficiently heavy to protect him in case of accidental breakage of the wheel.

Feed. The feed is engaged by pushing a knob in the centre of the hand wheel on the front of the machine. The connection is positive, and cannot become accidentally disengaged. When desired the table can be moved by the hand wheel.

Reversing. The motion of the table is automatically reversed by a lever, which is actuated by dogs that can be set at any position the same as the dogs on a planer. For very delicate adjustment of the length of stroke requisite in grinding up to a shoulder, etc., the lever carries a patented device. The lever and its adjoining parts are cushioned by a simple arrangement, so that the table is reversed without shock or jar—an important feature in accurate grinding. By raising the device on the lever the path is cleared for the reversing dogs when it is desirable to move the table beyond the reversing point for trying work. This convenient arrangement preserves the adjustment of the length of stroke, and at the same time allows any length of movement of the table by hand. By simply dropping the device down upon the lever, the machine will continue

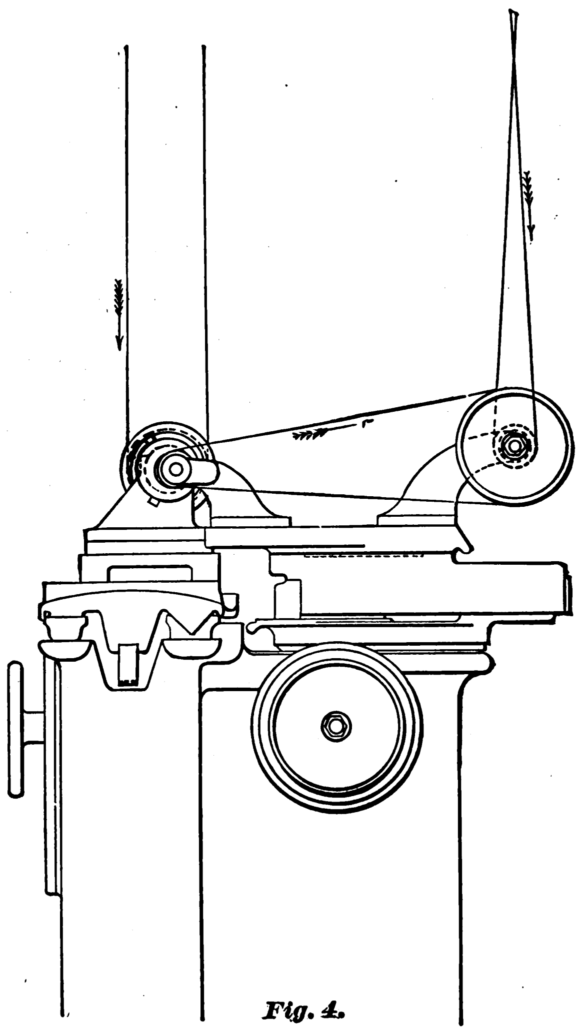


Fig. 4.

reversing as before. The wrench and nuts which secure the dogs in place are made in one piece, and are always in position.

Cross Feed. The cross feed by which the emery wheel is brought against the work to be ground, is operated from the front of the machine by a hand wheel graduated to read to thousandths of an inch.

The wheel is fed smoothly, whatever may be the position or angle of the wheel stand, wheel platen or wheel bed, and the universal features of these parts are extremely advantageous in grinding large tapers, either external or internal.

Head Stock. The head stock shown in Figs. 5 and 6 is fastened to the table by a clamp screw and swivels upon a central pin. Its whole circumference at the lower edge is graduated to degrees so it can be set at any desired position. The spindle is made of tool steel, and the bearings are hardened, ground and lapped. The boxes are phosphor bronze. Their material makes it possible to run the spindle when they are tightly clamped upon it, and this clamping is necessary to obtain perfect face and hole grinding. The clamping adjustment is simple and positive. Wear is taken up by screws *A*. The screws *B* limit the extent to which the box can be closed, and should be loosened before taking up the wear by the screws, *A*.

The end thrust is taken by a shoulder on the spindle, and adjustment for wear is made by a nut at the rear end of the spindle. The thread on the forward end is not cut up to the shoulder, but a bearing is left so that chucks and fixtures can be made to run true within a very small limit. This bearing and the taper hole are ground when the spindle is in place. The spindle is made fast for dead centre grinding by a thumb screw.

The head stock is provided with a pulley for driving the spindle and with small and large dead centre pulleys. Work may thus be ground in a chuck or fixture on the head stock spindle, or upon two dead centres, or upon

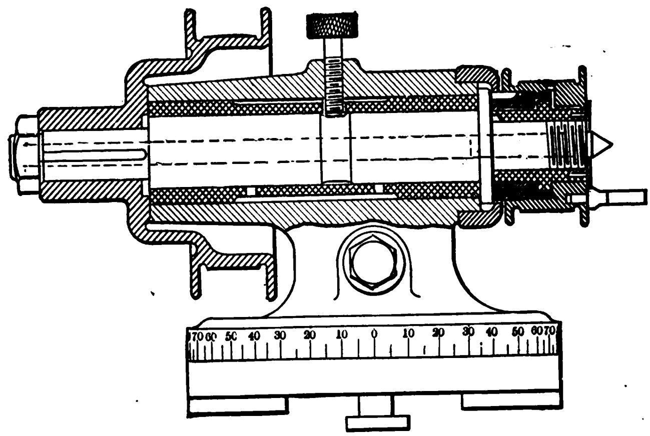


Fig. 5.

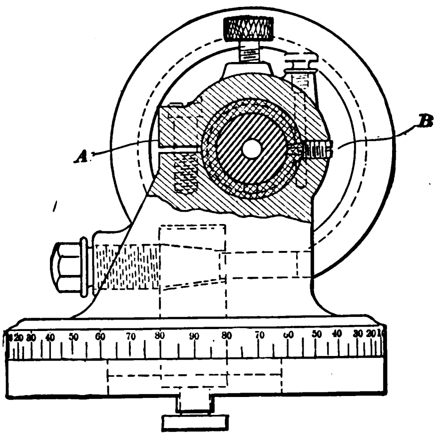


Fig. 6.

one dead and one live centre. The advantage of grinding work upon two dead centres is that any possible imperfection in the spindle bearings does not affect the accuracy of the grinding.

Foot Stock. The foot stock, shown in Figs. 7 and 8, is secured to the swivel table by a clamp screw. The spindle is quickly operated by a lever, and the work is held between the centers by a stiff spring. By this arrangement the spindle adjusts itself to the varying length of the work caused by expansion, and the pressure between the centres remains substantially constant. An oil reservoir is provided for oiling the centres. Both head and foot stock spindles are hollow.

Wheel Spindle and Boxes. A section of the wheel stand and spindle is shown in Fig. 9. The spindle is steel, hardened, ground and lapped. The end play is taken up with the nut *A*; *B* is the check screw. Provision is made for delicate adjustment. The boxes are 3 inches long, and 7/8 inches in diameter. They are made of phosphor bronze, are self-aligning, and may be adjusted by the nuts *C* and *D*. Both nuts are turned towards the back of the machine to take up the wear, and the boxes with the spindle can be removed from the wheel stand without disturbing the adjustment of the boxes.

An effort has been made to prevent vibration in the wheel. The bearings can be run metal to metal, and the wheel stand and adjoining parts are firmly connected with the rigid base of the machine.

Driving Pulley. The driving pulley and the flange are made in one piece, the pulley being 2¾ inches in diameter. It is fitted to the taper arbor at *I*, and held in place by the nut *J*.

Speed Counter. A special speed counter is furnished for internal grinding, as indicated in connection with Fig. 4. The belt from the overhead works to the speed counter should be crossed. Our patented Internal Grinding Fixture is used on this machine.

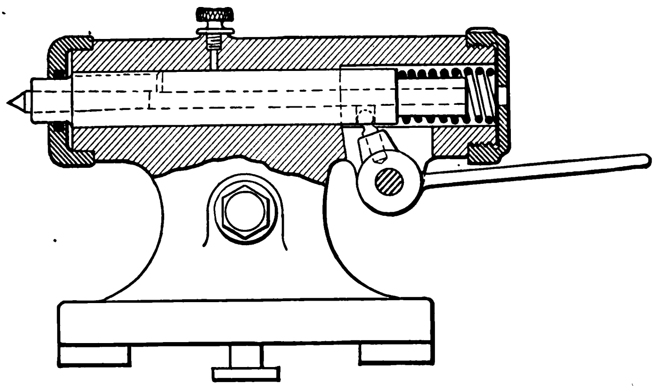


Fig. 7.

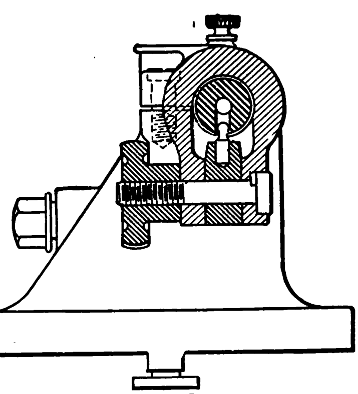


Fig. 8.

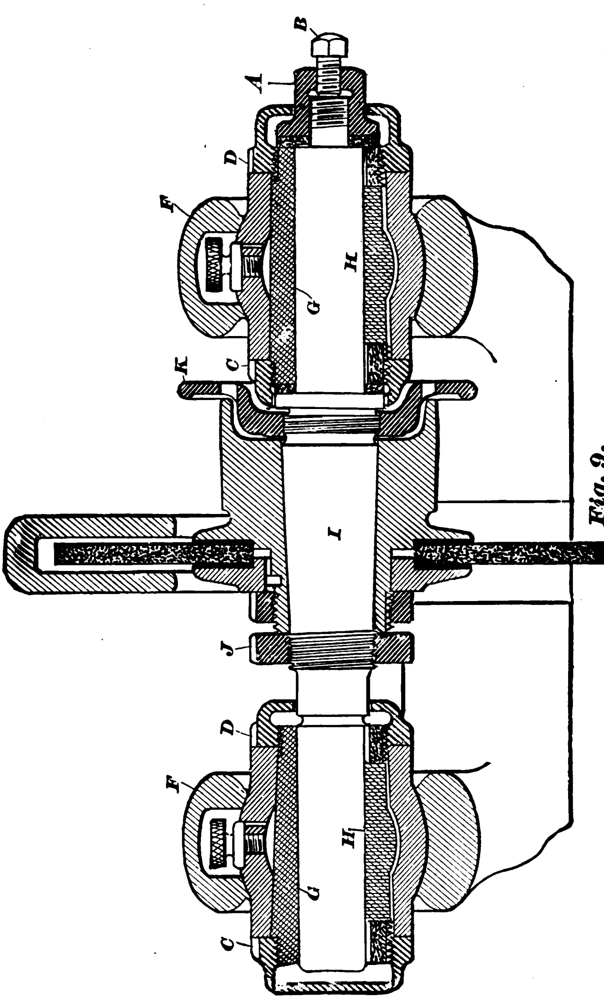


Fig. 9.

Wet Grinding. Provision is made for wet grinding. The pump is a simple fan revolving in a loose case, and has connections for distributing the water either upon the wheel or upon the work.

Overhead Works. The overhead works consist of three shafts with tight and loose pulleys 8-inch diameter for 3-inch belt. The shafts should run in the direction indicated by the arrows, Figs. 10 and 11, and are arranged for six speeds between 2,000 and 3,400 for the emery wheel, and for six speeds between 93 and 640 for the work. The drum shaft is driven by a 1½-inch belt, the emery wheel by a 1¼-inch belt, the feed cone by a 1-inch belt, the head stock spindle and dead center pulley by a 1-inch belt, and the pump by a 1-inch belt.

The motion of the emery wheel is controlled by the main belt shipper, while that of the work is controlled independently of the wheel. By this means work can be changed on the center or chuck without stopping the wheel. This saves time and allows the wheel to be in full motion when starting to grind.

Brake. That no time may be lost in waiting for the work to stop revolving after it is ready to be removed from the machine, a friction brake is connected with one of the shipper rods. When the clutch is released the brake is applied, and the work may be stopped almost instantly.

Location of Counter Shaft. The relation of the counter-shaft to the machine is shown in Figs. 10 and 11.

Drawing. A copy of a large scale drawing with figures giving the correct location of the most important parts of the counter-shaft is sent with every machine.

Speed. The speed of the counter-shaft should be about 280 revolutions per minute.

Hangers. The hangers are provided with self-adjusting and self-oiling boxes.

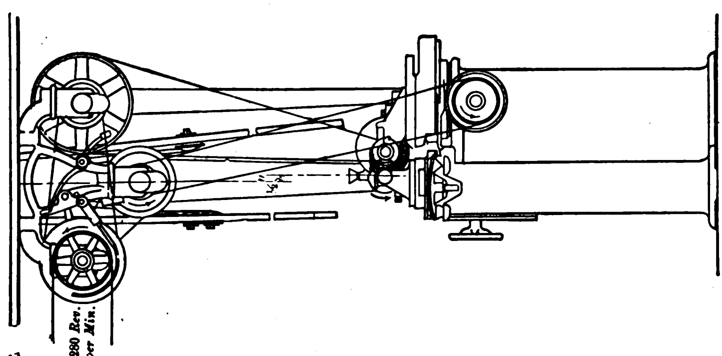


Fig. 11.

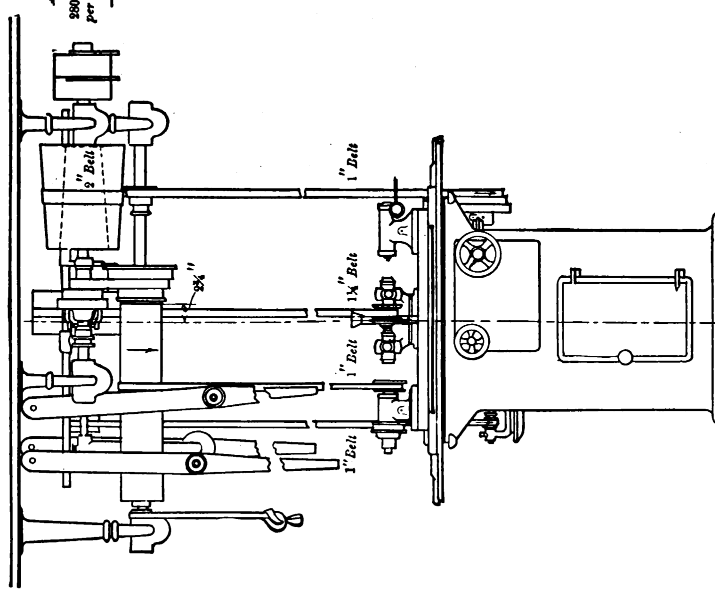


Fig. 10.

Capacity of the Machine.

The machine will swing work between centres 8 inches diameter and 16 inches long, while the table may be fed several inches beyond that length. The swivel table will swing to either side of its central position to grind tapers from zero to 1½ inches per foot, or from zero to 3½ degrees in angular measure. For grinding work on the face plate or chuck, the head stock can be set at any angle within the whole circle. The wheel slide has a movement of 4 inches, and may be fed at any angle from zero to 90 degrees on either side of a line at right angles with the slide bed. The wheel stand will take a wheel 7 inches diameter and ¼ thick with a 2-inch hole in centre.

The internal grinding fixture usually sent with this machine will grind holes 5 inches long, and ¾ inch and upwards in diameter. Wheels not larger than 1 inch in diameter are used with this fixture.

The weight of the machine boxed ready for shipment is about 2600 pounds.

The floor space measured over extreme projections and points of travel of the various parts is 36x69 inches.

Attachments and Accessories.

Each machine is provided with a drawing showing location of overhead works, copy of this treatise, an internal grinding fixture, a special speed counter for internal grinding, a 3-jawed chuck, special chuck for thin cutters, centre rest, back rest, wheel truing stand, tooth rest, large and small dead centre pulleys, centres, pump, wrenches, dogs and complete overhead works.

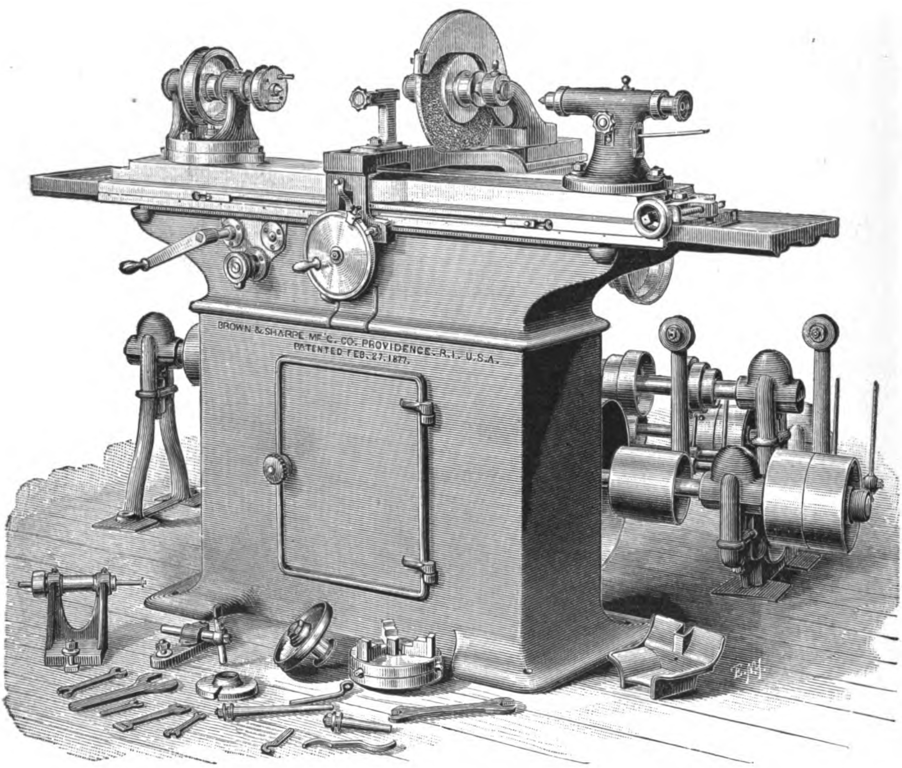


FIG. 12.

No. 2 Universal Grinding Machine.

No. 2 UNIVERSAL GRINDING MACHINE.

General Construction. The perspective view of the No. 2 Universal Grinding Machine, shown in Fig. 12, gives an idea of its general form and outward appearance. Figs. 13 and 14 give a general idea of its construction.

Stand. The stand is made in the form of a closet with shelves on each side of the door. These shelves are cast in the stand and serve to give stiffness as well as to form convenient receptacles for tools and accessories. The bracket, *E*, is designed to support a water pail to receive the waste water during the process of wet grinding.

Bed. The bed, *F*, is made in box form, and well braced by cross ribs.

Sliding Table. Upon the bed the sliding table, *G*, slides on one V and one flat slide, as shown in Fig. 14. At each end of the table is a shallow basin. These form convenient places to receive wrenches and other tools which are in frequent use about the machine. They also serve to protect the slides when the table travels to its extreme movement.

Swivel Table. The head and foot stocks are mounted upon a swivel table, *I*, which turns on a central stud. This allows the line of centers to be set at an angle with the table slides, for the purpose of grinding tapers, without throwing the head and foot stock spindles out of line—see Fig. 22. When set to any desired position, the swivel table is clamped by a bolt at each end to the sliding table. For the purpose of setting the swivel table to grind any desired taper, it is provided with an adjusting screw, and a scale accurately graduated to show the taper, both in degrees and in inches per foot. The scale marked, "TAPER IN INCHES PER FOOT, gives

Adjusting Screw and Scale for Tapers.

the whole taper of the work and the scale marked "DEGREES" gives the taper from the center line of the work, or one-half of the *whole taper*, which is the angle the swivel table is set out of line. The T slot extends the whole length of the table and receives the heads of the clamp bolts, *N*, *O*, Fig. 13, thus allowing the head and foot stocks to be set at any point in reference to its length.

The *T* slot is scraped to a straight edge, and the tongues of the head and foot stocks are scraped to fit the slot.

Wheel Bed. Upon the knee, *L*, Fig. 14, is mounted the wheel bed, *Q*, which may be turned in a horizontal plane, and a semi-circumference at the lower edge is graduated to degrees so it can be set at any desired angle relative to the sliding table. When properly set it may be clamped by bolts to opposite sides of the knee.

Wheel Slide. The wheel slide, *T*, slides on *V* gibs, one attached on each side to the wheel bed. One of these gibs is made adjustable for the purpose of taking up any play which may be caused by wear.

Wheel Platen. The wheel platen, *V*, is fastened to the wheel slide by a screw, which allows it to be set at any angle in reference to the table slides. The two *T* slots, *Y*, Fig. 13, receive the clamp bolts which secure the wheel stand, *Z*, to the platen, *V*.

Wheel Guard. The wheel guard is bolted to the wheel stand, and serves to protect the operator from sparks, dust and water, as well as from flying pieces of emery in case of accidental breakage of the wheel. It also forms a convenient terminus for the water tube which conducts the water to the work in wet grinding.

Feed. The general arrangement of the feed gearing will be seen in Fig. 14. The feed may be operated either automatically or by hand, and is engaged by tightening the nut, B_2. The motion of the table is regulated and automatically reversed at any desired point by the dogs which shift the reversing lever, Q_1. The table is moved by hand with the crank wrench.

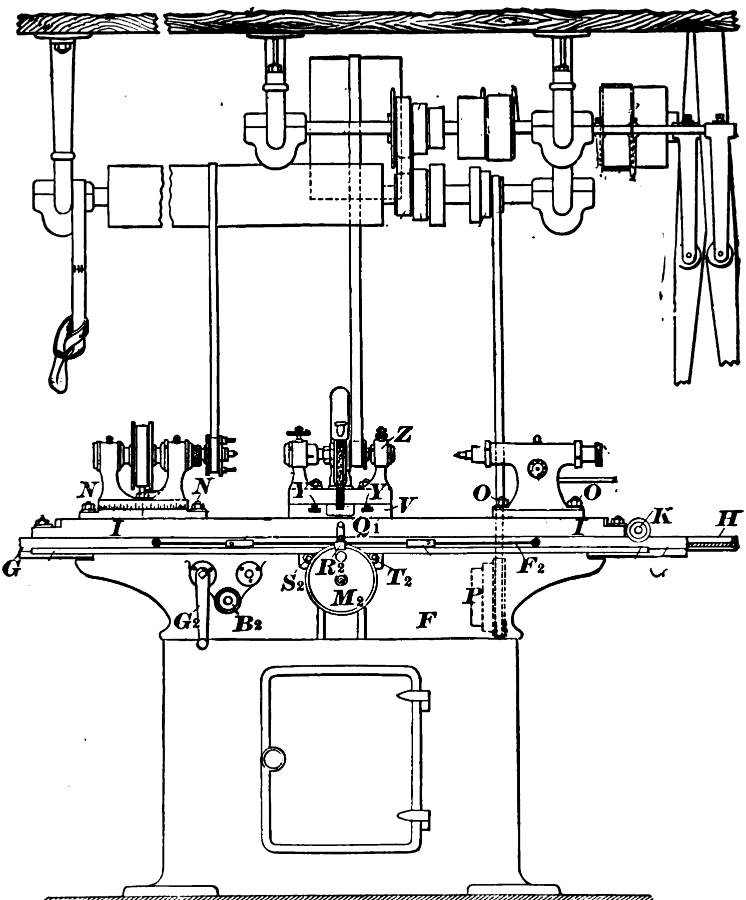


Fig. 13

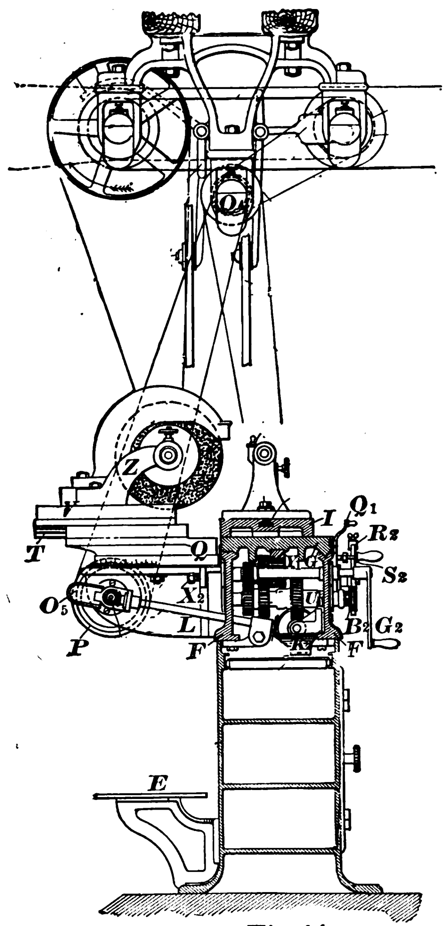


Fig. 14

The feed worm is provided with an oil cellar, K_2, from which oil is constantly supplied to it by a small disk wheel, revolved in the oil by the worm itself. The other gears are conveniently oiled from above by moving the table endwise out of the way. These do not require so much oil, as their motion is slow compared with that of the worm.

Cross Feed. The cross feed, by means of which the emery wheel is brought against the work to be ground, is operated by the crank wheel. As previously stated, the wheel bed, *Q*, swivels, and the feed will work smoothly whatever may be the position or angle to which the wheel slide, *T*, and the bed, *Q*, may be set. This universal feature of the cross feed is extremely advantageous in grinding large tapers, both external and internal. R_2 is an adjustable dog fitted to the periphery of the crank wheel. This, with the studs, S_2, T_2, forms a convenient stop to prevent accidentally forcing the wheel into the work being ground, and thus damaging one or the other, or both.

Head Stock. The head stock shown in Fig. 15 is attached to a base plate which is bolted to the swivel table of the machine. It is clamped to the base plate by two bolts, the heads of which are free to slide in a circular *T* slot. It is made to swivel about a central pin, and its whole circumference at the lower edge is graduated to degrees so it can be set at any desired angle.

The spindle is steel, and the bearings are hardened, ground and lapped. The driving pulley is placed between the uprights.

The boxes are phosphor bronze, and fitted to the bearings. Their material makes it possible to run the spindle when they are tightly clamped upon it, and this clamping is necessary to obtain perfect face and hole grinding. The clamping adjustment is simple and positive.

The end thrust of the spindle is taken entirely on the forward bearing, and is conveniently adjusted by check nuts with fine threads. The spindle projects

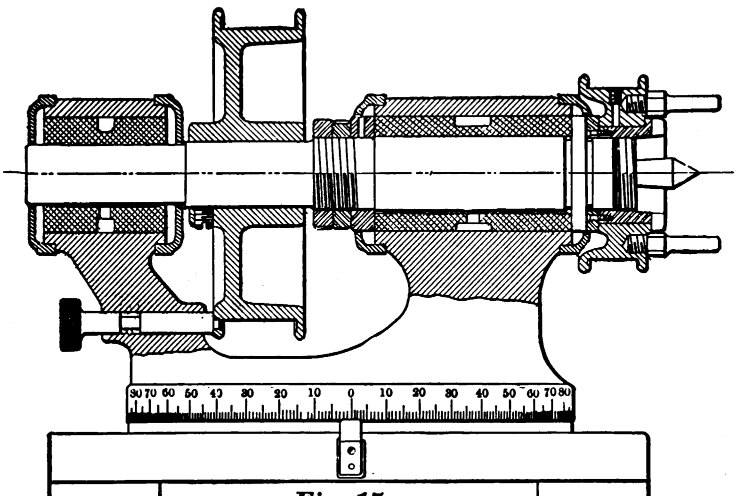


Fig. 15.

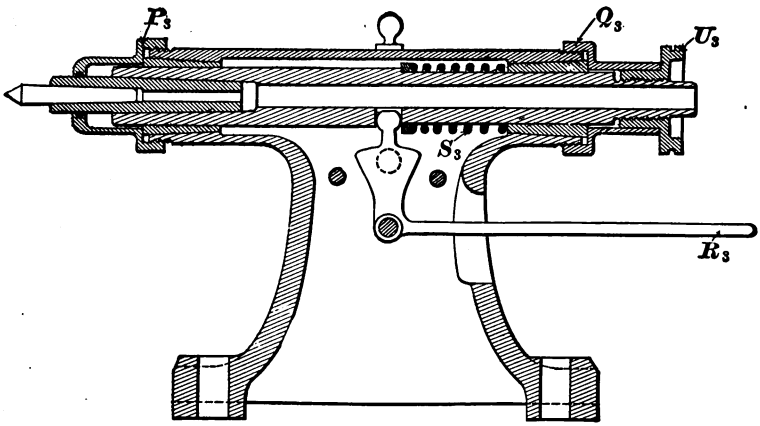


Fig. 16

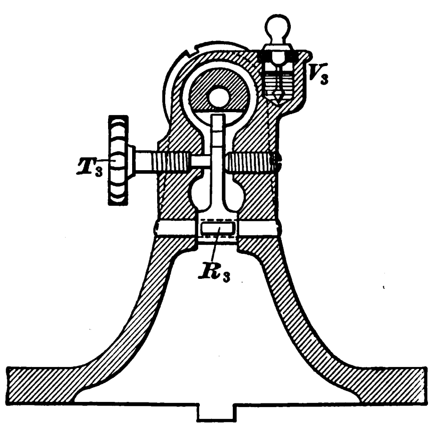


Fig. 17

through the rear dust cap to allow a bolt to be passed through its entire length to secure the work to the face plate when it is desired to true the periphery of a piece in which a hole is to be ground.

A stop is provided for holding the pulley between the uprights and preventing the spindle from turning when work is to be revolved upon centres.

The knurled nut serves to protect the thread on the spindle when the chuck or face plate is not in use. The caps inclose and protect the bearings from emery dust.

Foot Stock. The foot stock is clearly shown in sectional views in Figs. 16 and 17. The spindle is provided with taper boxes, which may be adjusted to compensate for wear, by turning the dust caps, P_8 and Q_8. The spindle is operated with a lever, R_8, instead of the usual screw, and the work held between the centres by a stiff spring. By this arrangement the spindle adjusts itself to the varying length of the work — due to the change of temperature caused by grinding—and the pressure between the centres remains substantially constant. It also possesses the advantage of being operated more quickly than a screw. Large work, which is not appreciably affected by the heat, may be held more securely, when necessary, by clamping the lever, R_8, with the screw, T_8. The movement of the spindle, as well as the tension of the spring, can be regulated with the *nut*, U_8. At V_8, is an oil *reservoir* for oiling the centres.

Both head and foot stock spindles are hollow, having a half-inch hole through them for the purpose of removing the centres.

Wheel Spindle and Boxes. A section of the wheel stand and spindle is shown in Fig. 18. The spindle is hardened, ground and lapped, and the end play is taken up with the nut, *A*, *B* being its check screw. This provides for the delicate adjustments necessary in accurate grinding. The journals are 3 inches long by ⅞ inches diameter, and run in bronze bearings which are self-aligning.

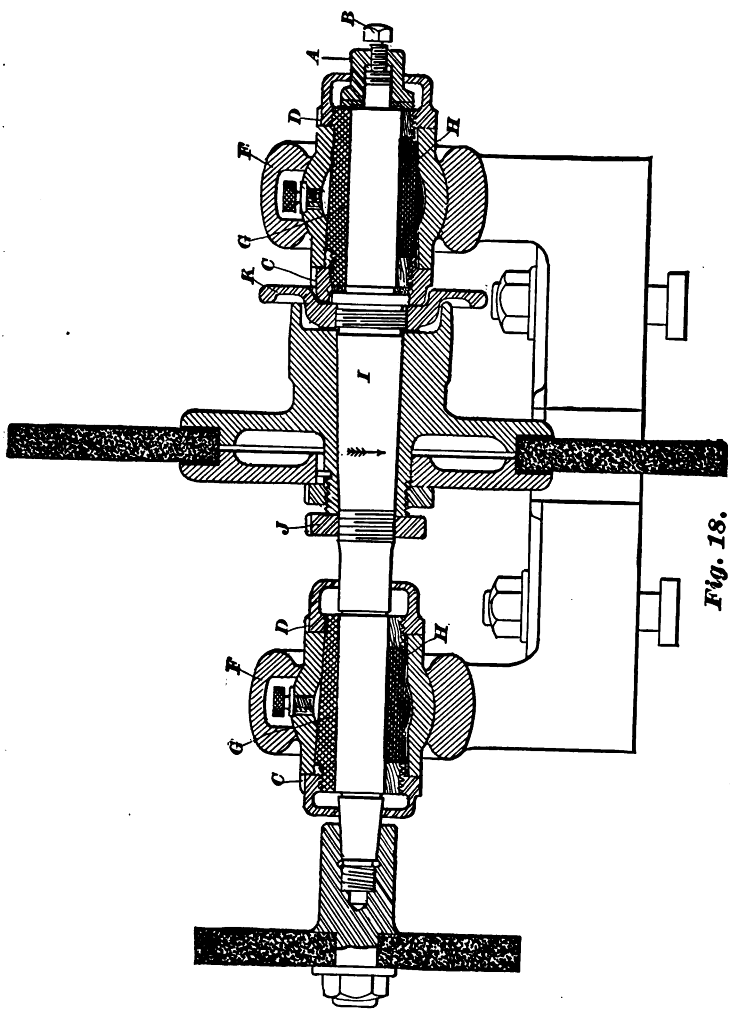


Fig. 18.

They are adjusted by the nuts, *C* and *D*, and turning both nuts towards the back of the machine takes up the wear. The spindle and boxes can be removed from the wheel stand without disturbing the alignment of the spindle, and the spindle with the boxes can be turned end for end.

Oil is supplied to the spindle by the felt, *H*, which is supported by a spring.

Driving Pulley. The driving pulley and flange are made in one piece. The pulley is 4½ inches in diameter. This pulley is fitted to the taper arbor at *I*, and is held in place by the nut, *J*.

Small Wheel. A smaller emery wheel is used for backing off cutters, reamers, etc., as in Fig. 60. The shank for this wheel is fitted on the left hand end of wheel spindle.

Pulleys for Internal Grinding. Two extra pulleys, *M* and *L*, shown in Fig. 24, are fitted to the spindle to take the place of the emery wheel, and its pulley, when it is desired to do internal grinding. Our patented Internal Grinding Fixture is used on this machine.

Wet Grinding. Provision is made for wet grinding.

Overhead Works. The overhead works consist of a compound counter-shaft as shown by Figs. 13 and 14, with a back shaft, a forward shaft, and a drum shaft, in combination with the hangers, pulleys and shippers, substantially as shown. The 3-inch main belt runs on 8-inch tight and loose pulleys on the back shaft, and is usually arranged as shown, Fig. 14. It may, however, be driven from back of the machine, as shown by the dotted line, in which case the belt fingers must be extended backwards and curved over the pulleys, as shown by dotted lines. In either case the shaft should revolve in the direction indicated by the arrow.

All the belts connecting the shafts and machine should usually be open.

The forward shaft is driven from the back shaft by a 2½-inch belt on tight and loose pulleys. The drum shaft is driven from the front shaft by a 1½-inch belt on the cone pulleys, with three changes of speed. The feed works receive motion from a three-step cone on the drum shaft through a belt ⅞ of an inch wide. The emery wheel is connected with the back shaft from the large pulley by a 1-inch belt. A ¾-inch belt from the drum drives the dead centre pulley in grinding small work, while for other kinds of work the pulley on the head stock spindle is driven from the same drum by a 1¼-inch belt.

The motion of the emery wheel is controlled with the main belt shipper, while that of the work is controlled, independently of the wheel, with the other shipper. By this means work can be changed on the centre or chuck without stopping the wheel. This saves time, and is productive of good work, as the wheel is always in full motion when starting to grind.

That no time may be lost in waiting for the work to stop revolving after it is ready to be removed from the machine, a friction brake is connected with the rod of the shipper, so that when the belt is shifted from the tight pulley to the loose one, the brake will be brought up against the flange of the cone pulley on the front shaft. By this means the drum, and consequently the work, may be stopped almost instantly. **Brake.**

The relation of the counter shaft to the machine should be such that, viewing the machine as in Fig. 13, a plumb line from the centre of the middle hanger should pass 6⅛ inches to the left of the centre of the machine. The other hangers can then be located by the length of the shafts. **Location of Counter Shaft.**

A copy of a large scale drawing, with figures, giving the correct location of the most important parts of the counter shaft, is sent with each machine. **Drawing.**

The speed of the counter shaft should be four hundred revolutions per minute. **Speed.**

The hangers are provided with self-adjusting and self-oiling boxes. **Hangers.**

Capacity of the Machine. The machine will swing work between centres 12 inches diameter and 28 inches long, while the table may be fed several inches beyond that length. The swivel table, *I*, Figs. 13 and 14, will swing to either side of its central position to grind tapers from zero to 2 inches per foot; or, from zero to 5 degrees in angular measure. For grinding work on the face plate or chuck, the head stock can be set to any angle within the whole circle. The wheel slide, *T*, has a movement of 5½ inches, and may be fed at any angle from zero to 90 degrees on either side of a line at right angles with the sliding table *G*.

The wheel stand will take in a wheel of 12 inches diameter, and ½-inch thick, with a 5-inch hole in centre.

The wheel shank, shown at H_4, Fig. 18, is adapted to 6-inch wheels, ⅜ of an inch thick, with a ¾-inch hole.

The internal grinding fixture usually sent with this machine will receive wheels up to 2 inches in diameter, and will grind 5¼ inches in length, and 1 inch and upwards in diameter.

The weight of the machine, boxed ready for shipment, is about 2,400 pounds.

The floor space, measured over projective and extreme points of travel of the various parts, is 38x114 inches.

Attachments and Accessories. Each machine is provided with a drawing showing location of overhead works, a copy of this treatise, an internal grinding fixture, a 3-jawed chuck, special chuck for thin cutters, tooth rest, centre rest, back rest, face plate, dead centre pulley, wheel shanks for small wheels, centres, wrenches, dogs, and complete overhead works.

No. 2 PLAIN GRINDING MACHINE.

General Construction.

The general appearance of this machine is in many respects the same as the No. 2 Universal Grinding Machine, Fig. 12.

Stand.

The stand is made in form of a closet with shelves on each side of the door. These shelves are cast in the stand and serve to give stiffness, as well as to form convenient receptacles for tools and accessories. Over the door suitable slides are provided to receive an oil pan, which catches the drippings from the mechanism above. A bracket supports a water pail to receive the waste water during the process of wet grinding.

Bed and Sliding Table.

The bed is made in box form, and is well braced by cross ribs. Upon the bed the sliding table rests and slides on one V and one flat slide. Shallow pockets or basins, one at each end of the table, form convenient places to receive wrenches and other tools which are in frequent use about the machine. They also serve to protect the slides when the table travels to its extreme movement.

The head and foot stocks are mounted upon the sliding table, and may be set at any point in reference to its length.

Wheel Slide and Bed.

The knee supports the wheel slide and stand, which are cast in one piece. This slides on V gibs, one of which is made adjustable for the purpose of taking up any looseness that may be caused by wear.

Wheel Guard.

The wheel guard is bolted to the wheel stand and serves to protect the operator from sparks, dust and water, as well as from flying pieces of emery in case of accidental breakage of the wheel. It also forms a convenient terminus for the water tube which conducts the water to the work in wet grinding.

Feed. The feed may be operated either automatically, or by hand, and is engaged by tightening a knurled nut on the front of the machine.

Reversing. The motion of the table is automatically reversed by the dogs, which shift the reversing lever. The travel of the table is also regulated by these dogs, as they can be set at any position, being fastened by bolts which are adjusted in a *T* slot the same as on a planer.

Cross Feed. The cross feed, by means of which the emery wheel is brought against the work to be ground, is operated by the crank wheel on the front of the machine. There is an adjustable stop fitted to the periphery of this wheel, which, with the adjoining studs, form a convenient arrangement to prevent accidentally jamming the wheel into the work and thus damaging one or the other, or both.

The wheel moves only at right angles with the sliding table.

Head Stock. The head stock is clamped to the table, and can be set at any point upon it. The upper part swivels upon the base, and may be firmly clamped to the same. The spindle is provided with a pulley, which can be used either for driving the spindle or for driving the work upon dead centres. When work is driven on dead centres the spindle is locked to prevent its turning. Means are provided to compensate for wear of the boxes and to take up the end play of the spindle. The head stock is marked for two positions, one to show when the spindle is in line with the foot stock spindle, and the other 30 degrees from this, to set the head stock for grinding centres. As it is difficult to set the spindle exactly in line by the graduations, means of adjustment are provided on opposite sides of the base plate.

Foot Stock. The foot stock is shown in Figs. 16 and 17. The spindle is provided with taper boxes, which may be adjusted to compensate for wear. It is operated by a lever, and the work held between centres by a stiff spring. By this arrangement the spindle adjusts itself to the varying length of the work, due to the change of temperature caused by grinding, and the pressure between the centres remains substantially constant. It also possesses the advantage of being operated more quickly than a screw. Large work, which is not appreciably affected by the heat, may be held more securely, when necessary, by clamping the lever. The movement of the spindle, as well as the tension of the spring, can be regulated by a nut. An oil reservoir is provided for oiling the centres. Both head and foot stock spindles are hollow.

Wheel Spindle and Boxes.

The wheel spindles and bearings are the same as shown in Fig. 18. The spindle is hardened, ground and lapped, and the end play is taken up by a nut, which is provided with a check screw. The boxes are 3 inches long and ⅞ inches diameter. They are self-aligning and made of bronze, and can be adjusted to compensate for wear. Oil is supplied to the spindle from the receptacle below by a piece of felt which is supported by a spring.

Overhead Works.

The overhead works consist of compound countershaft, with back shaft, front shaft and drum shaft, in combination with hangers, pulleys and shippers, substantially as shown in Fig. 14. The 3-inch main belt runs on 8-inch tight and loose pulleys, and is usually arranged as shown. It may, however, be driven from back of machine, as shown by the dotted line, in which case the belt fingers must be extended backwards and curved over the pulleys. In either case the shaft should be revolved in the direction indicated by the arrow. All belts connecting the shafts and machine should usually be open. The front shaft is driven from the back shaft by a 2½-inch belt on tight and loose pulleys. The drum shaft is driven from the front shaft by a 1½-inch belt on the cone pulley with three changes of speed, and the feed works receive motion from a three-step cone on the drum shaft through a ⅞-inch belt. The emery wheel is connected with the back shaft from the large pulley by a 1-inch belt. A ¾-inch belt from the drum drives the dead centre pulley in grinding small work, while for other kinds of work the pulley on the head stock spindle is driven from the same drum by a 1¼-inch belt.

The motion of the emery wheel is controlled with the main belt shipper, while that of the work is controlled independently of the wheel. By this means work can be changed on the centre, or chuck, without stopping the wheel. This saves time and is productive of good work, as the wheel is always in full motion when starting to grind.

Brake. That no time may be lost in waiting for the work to stop revolving after it is ready to be removed from the machine, a friction brake is connected with one of the shipper rods, so that when the belt is shifted from the tight pulley to the loose one, the brake will be brought up against the flange of the cone pulley on the front shaft. By this means the drum, and consequently the work, may be stopped almost instantly.

Location of Counter Shaft. The relation of the counter shaft to the machine should be such that a plumb line dropped from the centre, Fig. 14, of the drum, will intersect the line of centres of the machine. Viewing the machine, as in Fig. 13, a plumb line from the centre of the middle hanger should pass 5⅜ inches to the left of the centre of the machine. The other hangers can then be located by the length of the shafts.

Drawing. A copy of a large scale drawing, with figures, giving the correct location of the most important parts of the counter shaft, is sent with each machine.

Speed. The speed of the counter shafts should be about 400 revolutions per minute.

Hangers. The hangers are provided with self-adjusting and self-oiling boxes.

Capacity of the Machine. The machine will swing work between centres 12 inches diameter, and will grind pieces 6 inches diameter and 18 inches long, while the table may be fed several inches beyond that length.

The wheel stand has a movement of 5½ inches, and will take a wheel 12 inches diameter and ½ inch thick, with 5-inch hole in the centre.

The weight of the machine, boxed ready for shipment, is about 2,000 pounds. The floor space, measured over projections and extreme points of travel of the various parts, is 38x96 inches.

Attachments and Accessories.

Each machine is furnished with a drawing showing location of overhead works, a copy of this treatise, centre rest, back rest, centres, dogs, wrenches and complete overhead works.

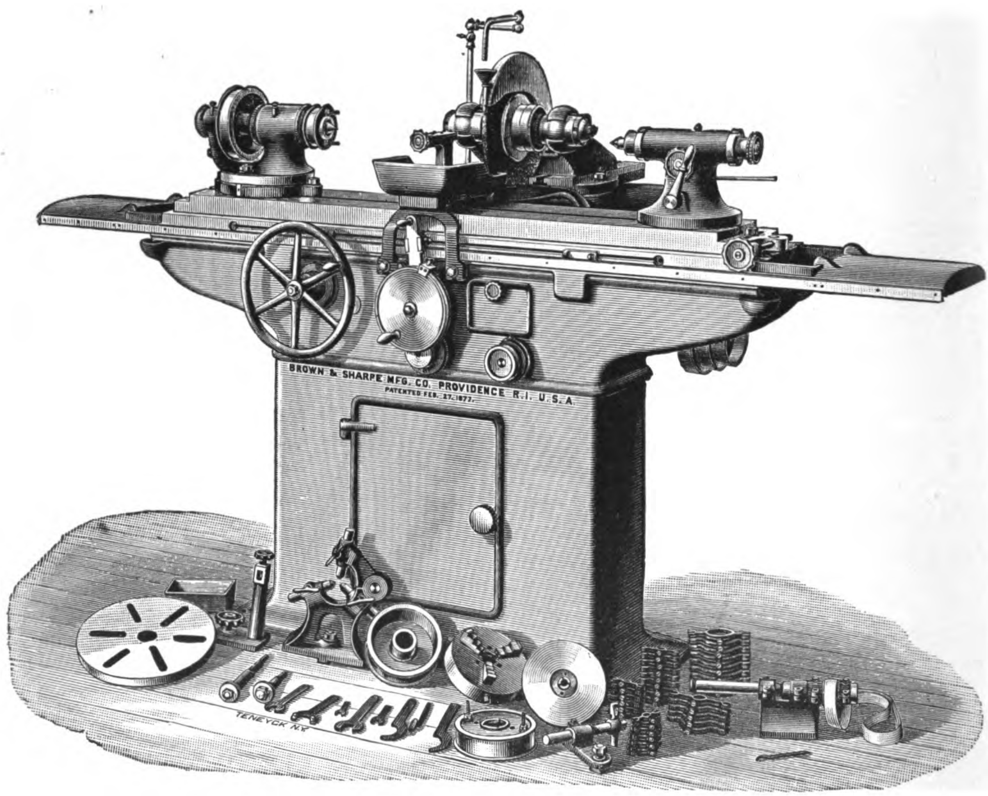


FIG. 19.

No. 2 Universal Grinding Machine,

IMPROVED.

No. 2 UNIVERSAL GRINDING MACHINE, IMPROVED.

General Construction. The perspective views, Figs. 19 and 20, give a general idea of the No. 2 Universal Grinding Machine Improved. The design is well adapted to resist vibrations within the machine itself, which is an indispensable element for the durability of the machine and for accuracy in the work produced.

Base. The base rests upon three feet, and has an internal web bracing. It is fitted as a closet, with shelves on each side of the door.

Bed. The bed is made in box form and well braced by cross ribs. From the bottom of the bed there is a descending pipe through which the waste oil can be drawn off.

Sliding Table. Upon the bed the sliding table moves on one V and one flat way, as shown in Fig. 21. These bearings are twice as large as in the No. 2 Universal Grinder, and are lubricated by two rolls in each, and the oil is thus equally distributed over the bearings, and the proper position of the sliding table is maintained,—a feature of consequence in accurate grinding.

The sliding table is heavier than that of the No. 2 Universal Grinding Machine, weighing, with swivel table and head and foot stocks, 225 pounds more than the corresponding parts of that machine. The shallow basins (one at each end of the table), form convenient places for wrenches and other tools in frequent use about the machine. The dust caps beyond the basins protect the slides when the table travels to its extreme movement, and, where accuracy is required, these basins should not be loaded with weights or heavy parts of machines. The caps are curved to prevent weights being placed at the extreme end of the platen.

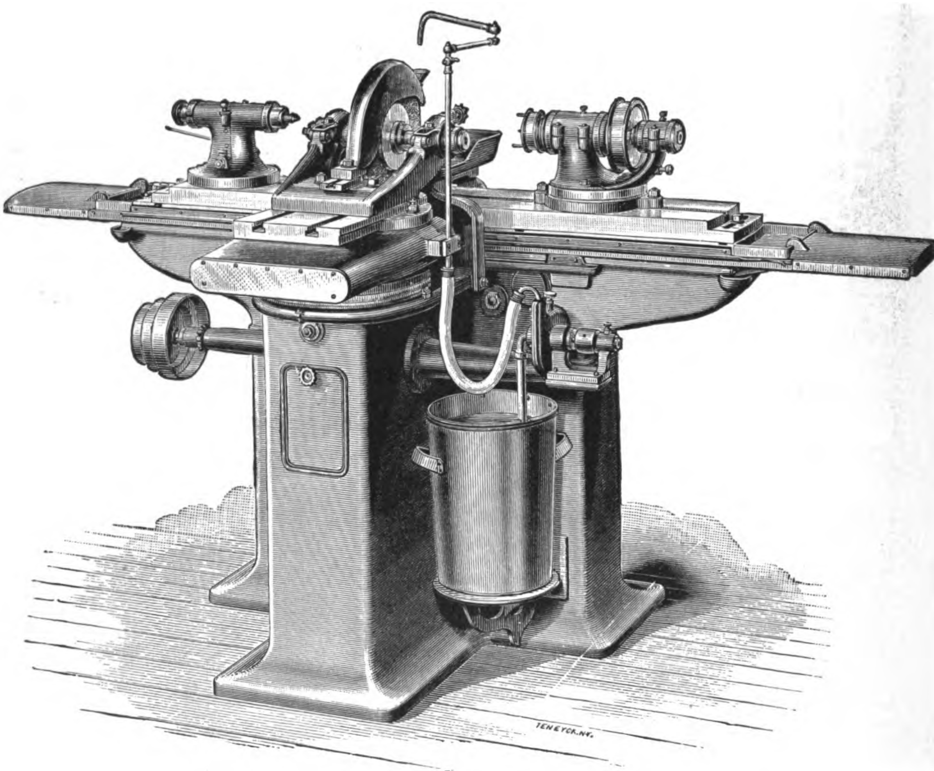


FIG. 20.

No. 2 Universal Grinding Machine, Improved.

REAR VIEW.

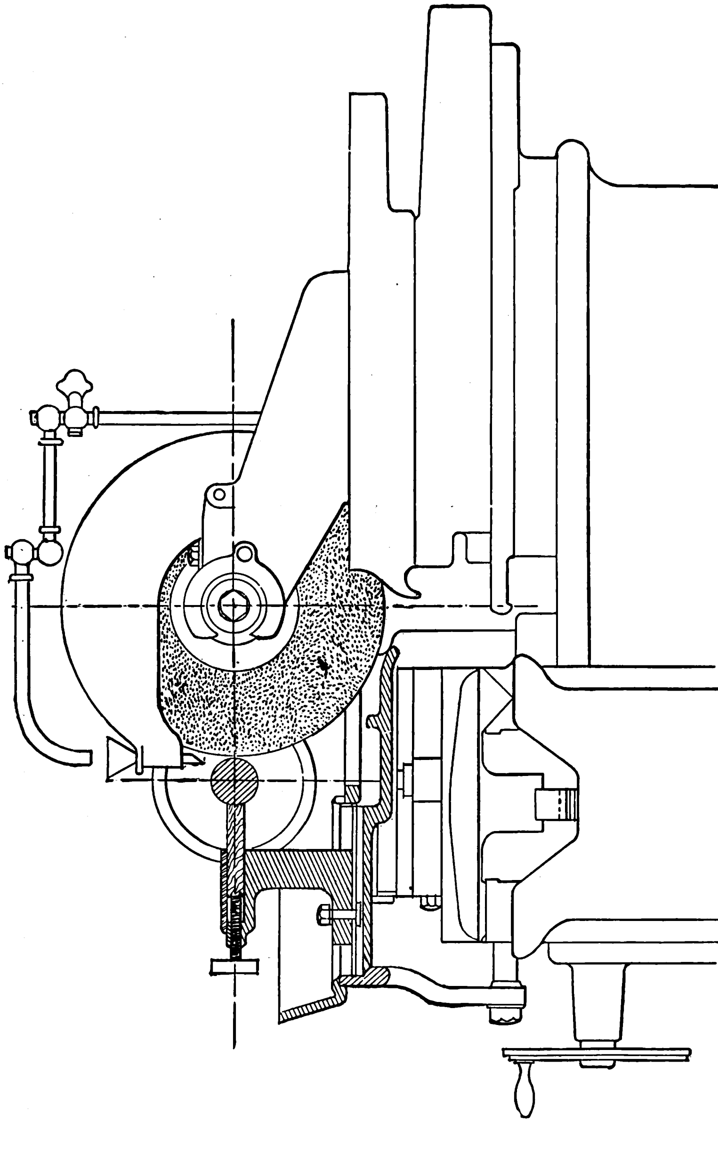


Fig. 21.

Swivel Table. The head and foot stocks are mounted upon a swivel table, which turns on a central stud, and thus allows the line of centres to be set at any angle with the table slides, for the purpose of grinding tapers, without throwing the head and foot stock spindles out of line—see Fig. 22. When set at any desired angle, the swivel table is clamped at each end of the sliding table for heavy work. For ordinary work the weight of the table gives sufficient stability, so that clamping is not required.

Adjusting Screw and Scale for Tapers For the purpose of setting the table accurately to grind any desired taper, it is provided with an adjusting screw and a scale graduated to show the taper both in degrees and in inches per foot. The scale marked "taper in inches per foot," gives the whole taper of the work, and the scale marked "degrees" gives the taper from the centre line of the work, or one-half of the whole taper, which is the angle the swivel table is set out of line. By this arrangement very exact settings can easily be obtained.

The T slot extends the whole length of the table and receives the heads of the clamp bolts, by which the head and foot stocks are secured. This slot is scraped to a straight edge, and the tongues of the head and foot stocks are scraped to fit the slot. The head and foot stocks may be set at any point on the platen, which is a convenience in using the machine for a variety of purposes.

Wheel Bed. The wheel bed is supported by a rearward projection of the base, shown in Fig. 20, which extends to the floor and rests upon one of the feet by which the base is supported. It may be turned in a horizontal plane, and a semi-circumference at the lower edge is graduated to degrees so that it may be set at any desired angle relative to the sliding table. When properly set it may be clamped by the bolts on opposite sides of the standard.

Wheel Slide. The wheel slide moves on wide, flat bearings, eight times as large as those of the No. 2 Universal Machine, and is held in place by a 45 degree angular gib, which, with the forward projecting dust cover, completely protects the slides from dust.

The weight of the wheel slide, with its platen and stand, is 365 pounds; corresponding parts on the other machine weigh 112 pounds.

Wheel Platen. The wheel platen rests on a flat circular bearing, the mean diameter of which is greater than the distance between the bearings of the wheel spindle. A steady support for the wheel stand is thus provided and rocking is prevented. The wheel platen is held in place by a bolt on each side.

The object in having the wheel platen arranged so that it will swivel, is to enable the operator to bring the face of the wheel parallel with the line of travel of the wheel slide as shown in Fig. 46.

In internal grinding the wheel platen is turned around and the wheel stand is used as a speed counter—see Figs. 23 and 24, while the internal grinding spindle is placed on the opposite end of the wheel platen, which in this position projects over the swivel table and brings the wheel spindle into the proper position for grinding holes.

Wheel Stand. The wheel stand is secured in any position on the wheel platen by two T bolts. These, with the two bolts in the wheel platen and the two bolts in the wheel bed, form a rigid connection with the heavy rearward projection of the base.

Wheel Guard. The wheel guard is heavy and is bolted to the wheel stand. It serves to protect the operator from sparks, dust and water, and is a safeguard in case of accidental breakage of the wheel.

Feed. The feed is engaged by turning the knurled knob at the right on the front of the machine. The connection is positive. When desired the table can be moved by the use of the hand wheel.

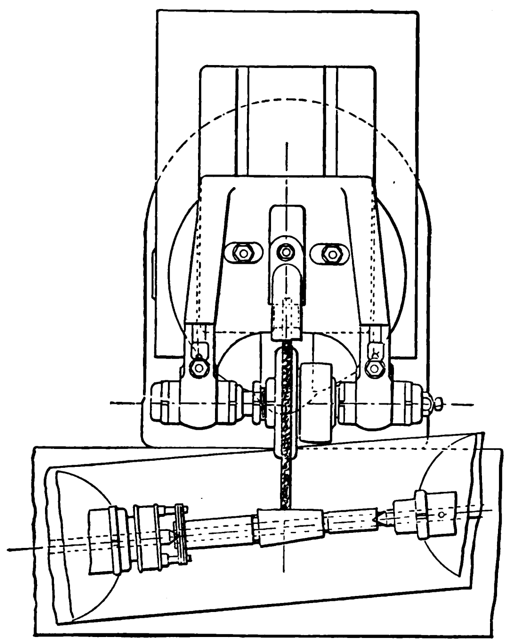


Fig. 22.

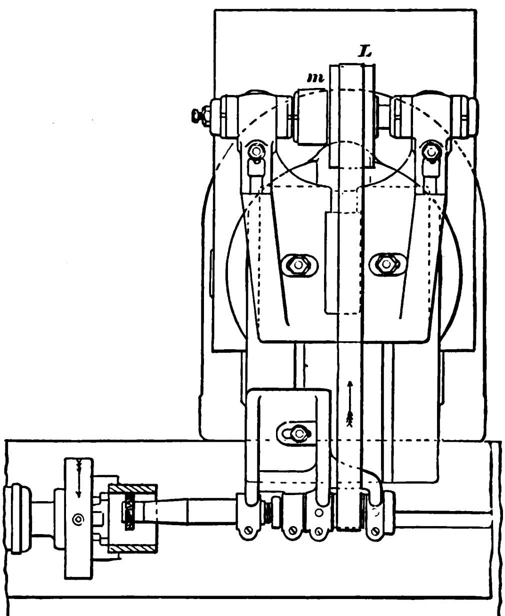


Fig. 23.

Reversing. The motion of the table is automatically reversed by a lever, which is actuated by the dogs on the front of the sliding table. For more delicate adjustment of the length of stroke requisite in grinding up to shoulders, etc., the reversing lever carries a patented device. This lever and its adjoining parts are cushioned by a simple arrangement, so that the table is reversed without shock or jar, a decided advantage, as any shock or jar in grinding machinery is detrimental to accurate work.

The dogs can be set at any position the same as the dogs on a planer.

By raising the device on the lever, the path is cleared for the dogs when it is desirable to move the table beyond the reversing point for trying work. This convenient arrangement preserves the adjustment of the length of stroke, and at the same time allows any length of movement of the table by hand. By simply dropping this device on the lever, the machine will continue reversing as before.

Cross Feed. The cross feed by which the emery wheel is brought against the work to be ground, is operated by a graduated hand wheel. These graduations read to .0005 of an inch.

By use of the stop top screw on rim of this wheel, the wheel slide can be moved as little as .00005, and .0001 of an inch can be ground from the diameter of the work. This screw forms a convenient stop to prevent accidental jamming of the wheel into the work and damage to one or the other, or both.

As previously stated, the wheel bed and wheel platen swivel, and the wheel is fed smoothly at whatever position or angle the wheel slide, platen or stand may be set.

These universal features of the cross feed are indispensable in grinding large tapers, either external or internal.

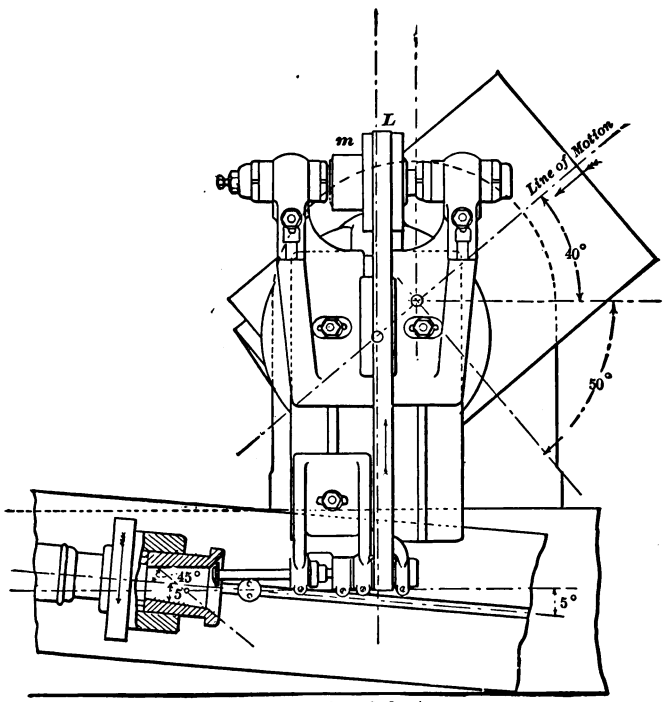


Fig. 24.

Head Stock. The base plate of the head stock, shown in Figs. 25 and 26, is bolted to the swivel table of the machine, as already explained. The head stock is clamped to the base plate with two bolts on opposite sides, and the heads of these bolts are free to slide in a circular T slot. The head stock swivels upon a central pin, and its whole circumference at the lower end is graduated to degrees, so that it can be set at any desired angle.

The upright supporting the forward bearing on the spindle is heavy to absorb all vibration, while the bearing itself is long and of unusual diameter. The spindle is made of crucible steel, and both the front and rear bearings are hardened, ground and lapped. These bearings are unusually far apart to secure rigidity and perfect alignment of the spindle while it is being used for hole and face grinding. The pulley which drives the spindle for this work is placed between the uprights.

The boxes are bronze, ground and fitted to the bearings. Their material makes it possible to run the spindle when they are tightly clamped upon it, and this clamping is necessary to obtain perfect face and hole grinding. The clamping adjustment is simple and positive. The end thrust of the spindle is taken entirely on the forward bearing, and lost motion is conveniently taken up by check nuts with fine threads.

The thread is not cut up to the shoulder, but a bearing is left on the forward end of the spindle so that chucks or fixtures can be made to run true within a very small limit. This bearing and the taper hole in the spindle are ground when the spindle is in place. The spindle projects through the rear dust cap to allow a bolt to be passed through its entire length to secure work to the face plate when it is desired to true the periphery of a piece in which a hole is to be ground.

A stop is provided for holding the pulley between the uprights and preventing the spindle from turning when work is to be revolved upon centres.

In addition to this driving pulley the head stock is provided with small and large dead centre pulleys

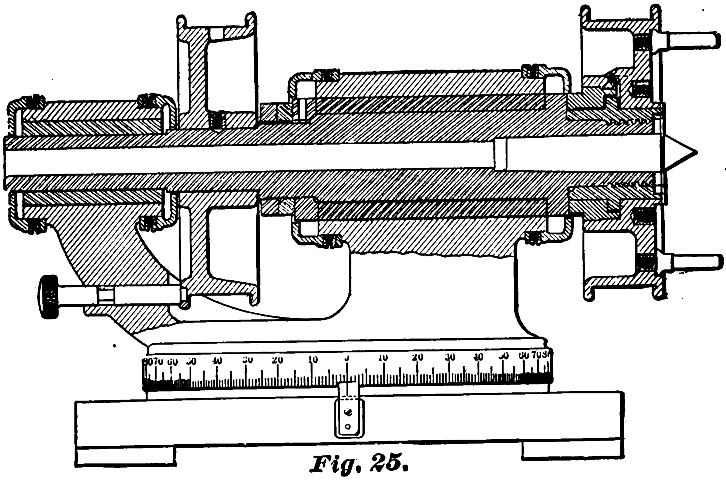


Fig. 25.

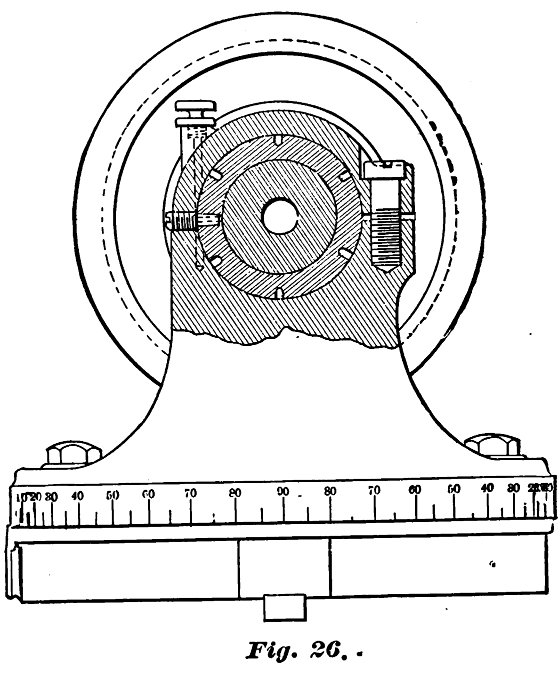


Fig. 26.

Work may thus be ground not only upon the live spindle but also upon two dead centres or upon one dead and one live centre. The advantage of grinding work upon two dead centres is that any possible imperfection in the spindle bearings does not effect the accuracy of the grinding.

Foot Stock. The foot stock is secured to the swivel table by a clamp lever and eccentric. The spindle is quickly operated by a lever, and the work is held between the centres by a stiff spring. By this arrangement the spindle adjusts itself to the varying length of the work caused by expansion, and the pressure between the centres remains substantially constant. The spindle may also be clamped when grinding large work or work not injuriously affected by the change of temperature caused by grinding. There is an oil reservoir for oiling the centres.

Both head and foot stock spindles are hollow, having a ½-inch hole through them for the purpose of removing the centres.

Wheel Spindle and Boxes. Sections of the wheel stand and spindle are shown in Figs. 27 and 28.

The spindle is steel hardened, ground and lapped. The end play is taken up with the nut, *A*, *B* being its check screw. This provides for the very delicate adjustment necessary in accurate grinding. The boxes are bronze, 4½ inches long and 1¼ inches in diameter. Turning the nuts, *C* and *D*, towards the back of the machine takes up the wear. The boxes are tapering outside, and are fitted to sleeves, which, at the centre of their length, have ball joints formed upon them, and rest in seats provided in the uprights, to which they are clamped by the caps *F F*, which are hinged and held down by bolts and nuts *E*, Fig. 28. By this arrangement, self-aligning boxes are secured, and the entire arrangement may be removed or replaced, or turned end for end, with the greatest facility, and without disturbing the adjustment of the boxes. Oil is supplied to the spindle through the felt, *H*, which is supported by a spring.

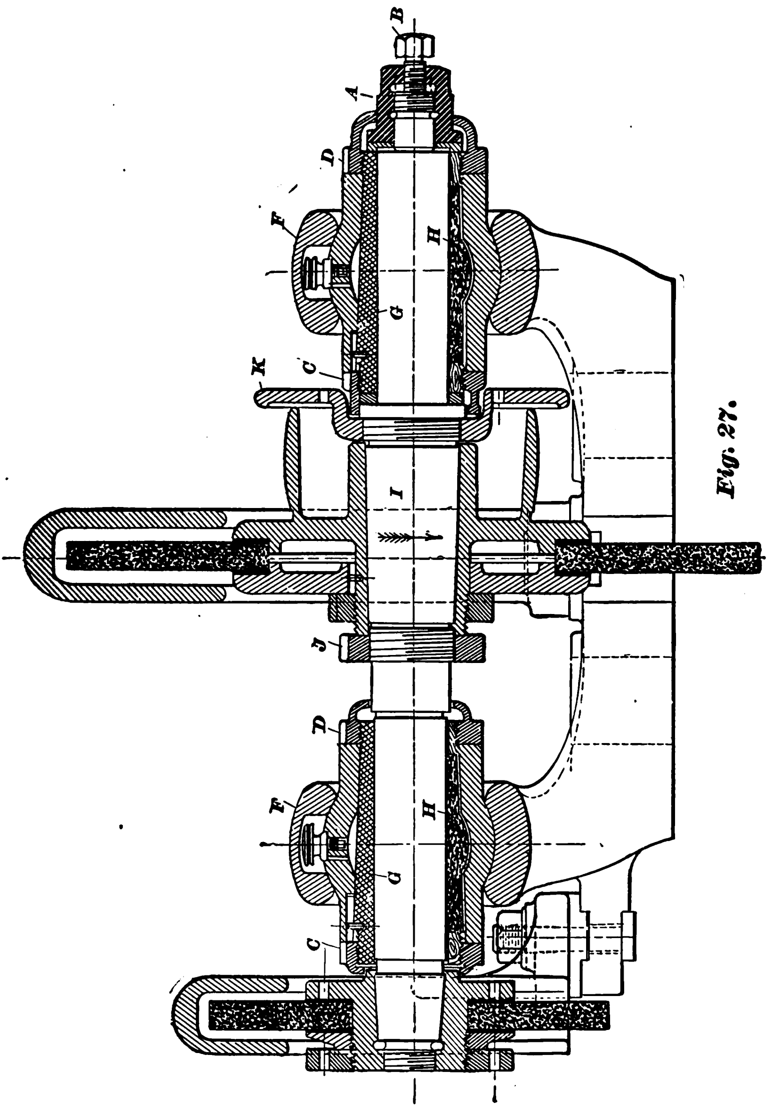


Fig. 27.

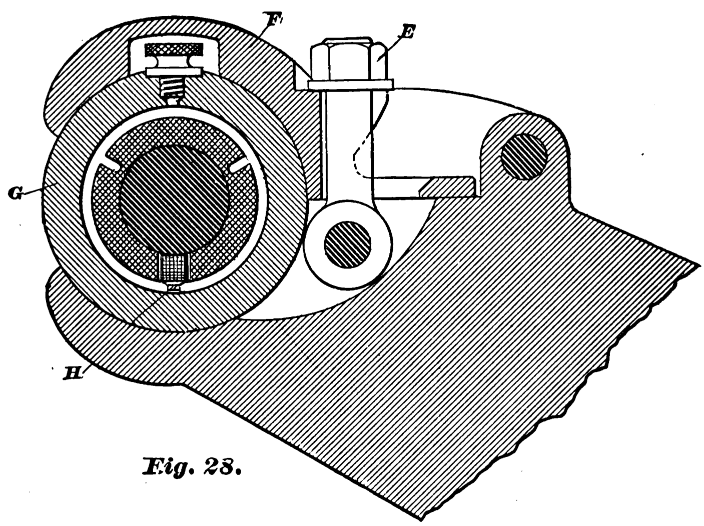


Fig. 28.

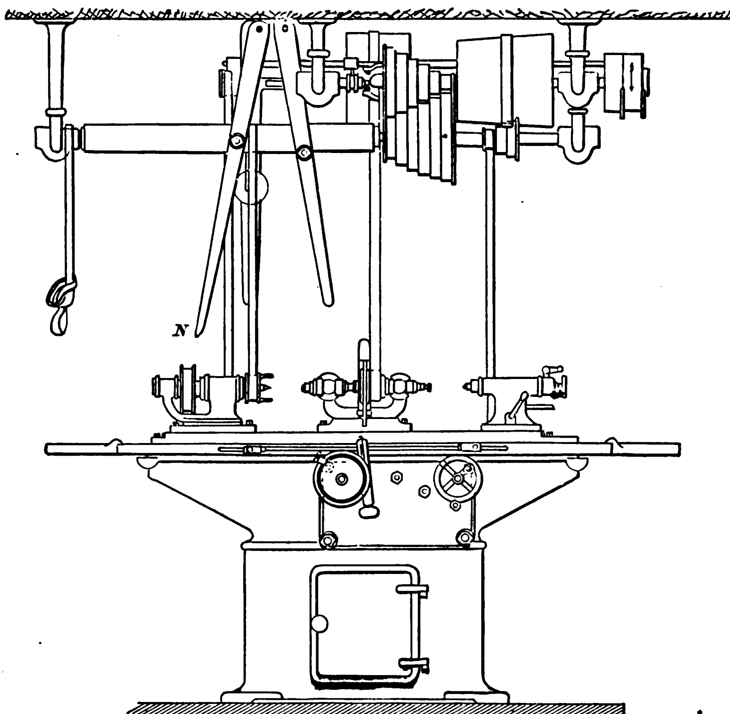


Fig. 29.

The effort has been made throughout to prevent vibration in the wheel. It is anchored to 500 pounds of iron in the wheel stand, platen, slide and bed, and these rest upon the base, which weighs 900 pounds.

Driving Pulley. The driving pulley and the flange are made in one piece. The pulley is 4½ inches in diameter, while the one on the No. 2 Universal Machine is 2½ inches in diameter. It is fitted to the taper arbor at *I*, and is held in place by the nut, *J*.

A smaller emery wheel is used on the end of the spindle for backing off cutters, reamers, etc.

For internal grinding, an extra spindle and boxes are furnished to take the place of the emery wheel spindle. This spindle has two pulleys, *L* and *m*, Figs. 23 and 24, and serves as a counter-shaft for driving the internal wheel spindle.

Overhead Works. The overhead works consist of three shafts with two drums, with tight and loose pulleys 10 inches diameter for 3-inch belt. The shafts should run in the direction indicated by the arrows, Figs. 29, 30 and 31, and are arranged for six speeds between 1,300 and 2,000 for the emery wheel, and for twelve speeds between 36 and 800 for the work. The drum shaft is driven by a 1½-inch belt, the emery wheel by a 1⅝-inch belt, the feed cone by a 1⅜-inch belt, the head stock spindle and dead centre pulley by a 1¼-inch belt, and the pump by a 1¼-inch belt.

The motion of the emery wheel is controlled by the main belt shipper, while that of the work is controlled, independently of the wheel, by the shipper, *N*, Fig. 29. By this means work can be changed on the centre, or chuck, without stopping the wheel. This saves time and allows the wheel to be in full motion when commencing to grind.

Brake. That no time may be lost in waiting for the work to stop revolving after it is ready to be removed from the machine, a friction brake is connected with the rod, *O*, Fig. 31. When the clutch is released the brake is applied, and the work may be stopped almost instantly.

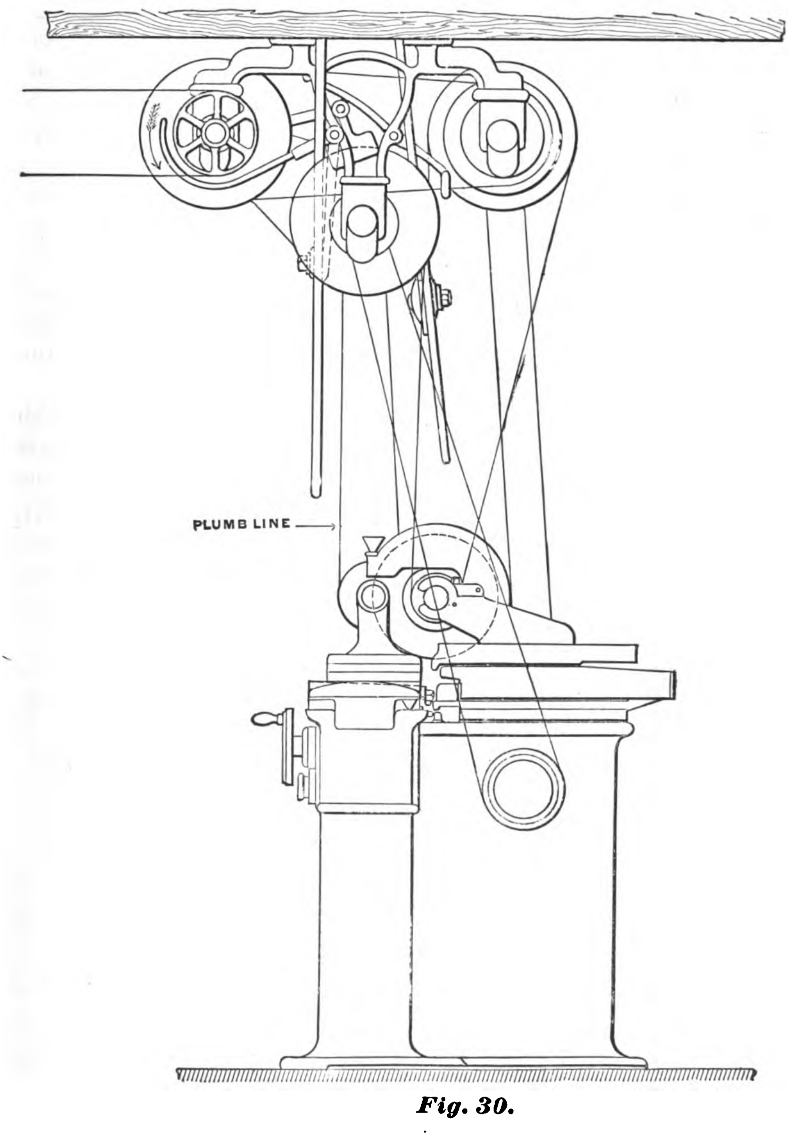


Fig. 30.

Location of the Machine. The relation of the counter shaft to the machine should be such that a plumb line, dropped from the front edge of the work drum will intersect the front face of the head stock pulley, as shown in Fig. 30. The distance from the centre of the machine to the end of the work drum is 2 inches, as shown by Fig. 29.

Drawing. A copy of a large scale drawing, with figures giving the correct location of the most important parts of the counter shaft, is sent with every machine.

Speed. The speed of the front counter shaft should be 325 revolutions per minute.

Hangers. The hangers are provided with self-adjusting and self-oiling boxes.

Wet Grinding. Provision is made for wet grinding by a centrifugal pump with connections for distributing the water either upon the wheel or work.

Capacity of the Machine. The machine will receive work between centres 12 inches diameter and 30 inches long, while the table may be fed several inches beyond that length. The swivel table may be set either side of its central position to grind tapers from zero to 2 inches per foot, or from zero to 5 degrees in angular measure. For grinding work on the face plate, or chuck, as shown in Figs. 46 and 47, the head stock may be set to any angle within the whole circle. The wheel slide has a movement of 6 inches, and may be fed at any angle from zero to 90 degrees on either side of a line at right angles with the sliding table.

The wheel stand will take a wheel 12 inches diameter and ½ inch thick, with 5-inch hole.

The internal grinding fixture usually sent with the machine will grind holes 5¼ inches long, 1 inch and upwards in diameter. Wheels up to 2 inches in diameter are used with this fixture.

The weight of the machine boxed ready for shipment is 4,000 pounds. The floor space, measured over extreme projections and points of travel of the various parts, is 47 × 122 inches.

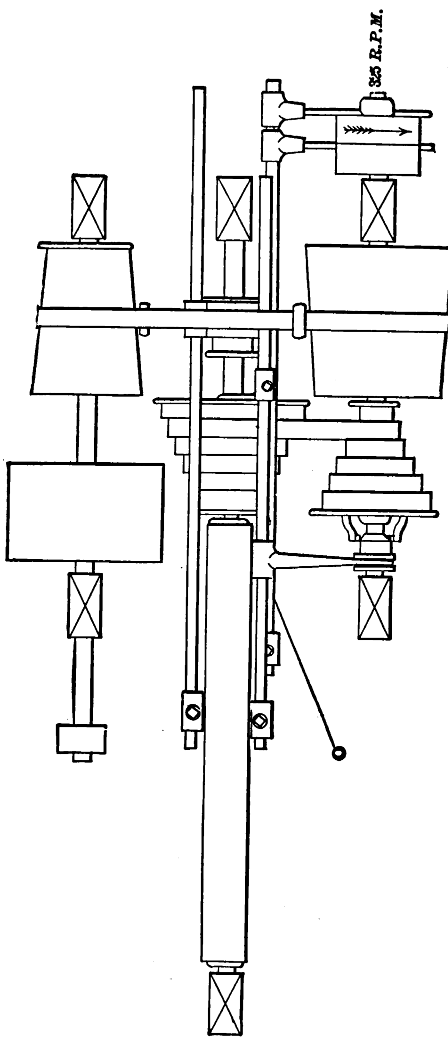
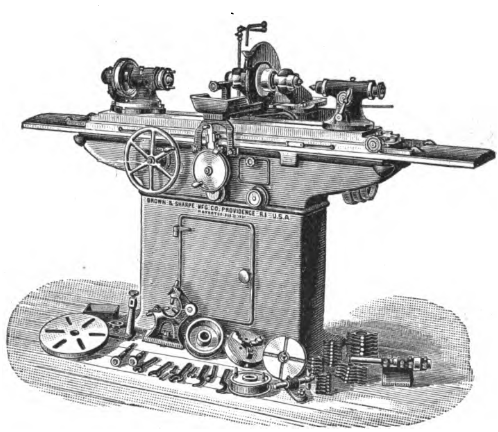


Fig. 31.

Machine to take 40″ between Centres. This machine is also made to take 40 inches between centres. Weight, 4,200 pounds; floor space, 47 × 152 inches.

Attachments and Accessories. The machine is provided with a drawing showing location of overhead works, a copy of this treatise, an internal grinding fixture, three-jawed chuck, special chuck for thin cutters, special spindle pulleys with bearings for internal grinding, face plate, wheel truing stand, centre rest, back rest, tooth rest, large and small dead centre pulleys, centres, arbors, pump, wrenches, dogs, and complete overhead works.


BROWN & SHARPE MFG. CO. PROVIDENCE R.I. U.S.A.

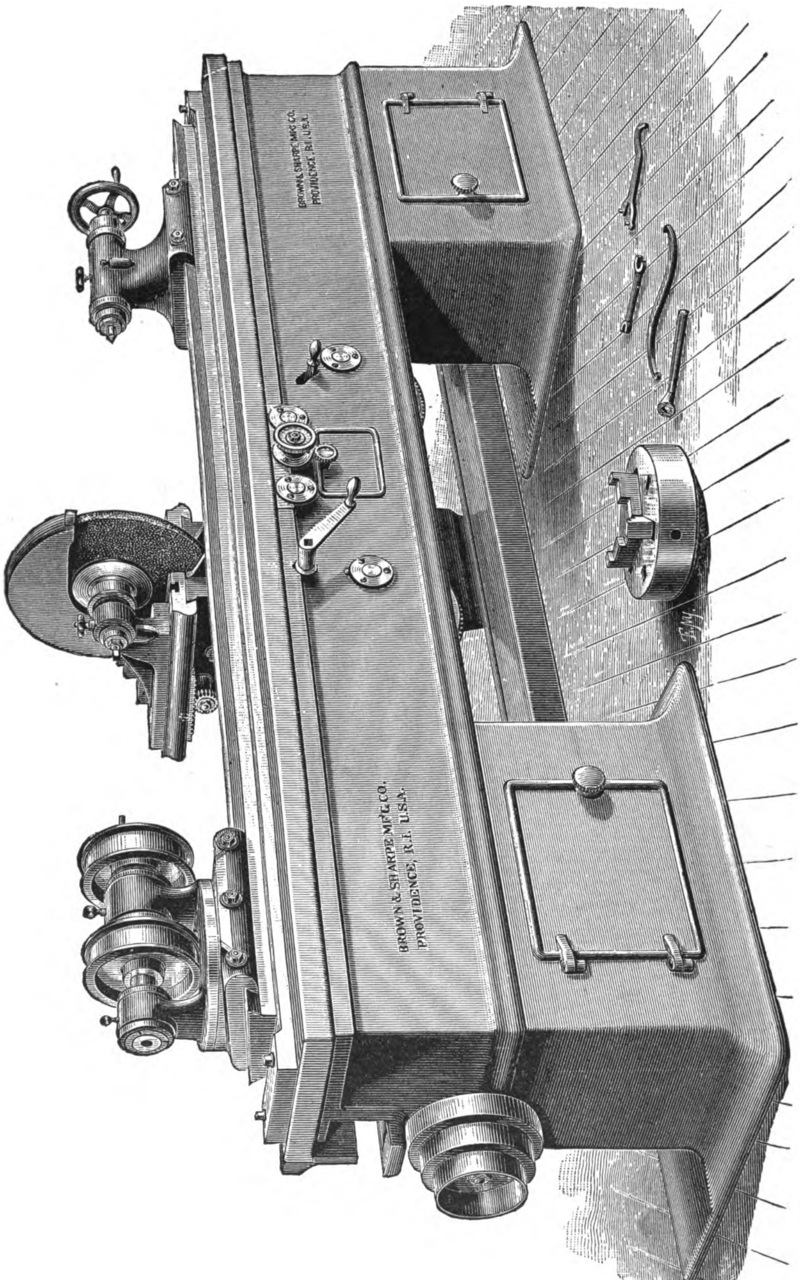


FIG. 32.

No. 3 UNIVERSAL GRINDING MACHINE.

General Construction. A general view of the machine is given in Fig. 32. The bed is supported by two hollow pedestals, which form closets for the reception of various articles that are frequently used about the machine.

Table. The head and foot stocks are mounted upon a swivel table, which rests directly upon the bed and turns on a central stud. This allows the line of centres to be set at any angle with the centre line of the machine, for the purpose of grinding tapers, without throwing the head and foot stock spindles out of line. When set to any desired position, the table may be clamped at each end to the bed.

Adjusting Screw Scale for Tapers. For the purpose of setting the table accurately to grind any desired taper, it is provided with an adjusting pinion and a scale graduated to show the taper both in degrees and inches per foot. The scale marked "taper in inches per foot," gives the whole taper of the work, and the scale marked "degrees," gives the taper from the centre line of the work, or one-half of the whole taper, which is the angle the swivel table is set out of line. By this arrangement very accurate settings can easily be obtained.

The head and foot stocks are gibbed to the table, and may be set at any point upon it, which is a convenience in using the machine for a variety of purposes.

The upper surface of the table is inclined backward, Fig. 33, for the purpose of conducting the water used in grinding toward a channel on the back side of the bed, from which it passes through a pipe at one end.

Wheel Bed. The wheel bed may be turned in a horizontal plane and a semi-circumference at its lower edge is graduated to degrees so that it may be set at any desired angle relative to the bed of the machine. When properly set it may be clamped by bolts on opposite sides of the carriage.

Wheel Slide. The wheel slide moves on wide, flat bearings, and is held in place by a 45 degree angular gib. The slides are completely protected from dust.

Wheel Platen. The wheel platen rests on a flat, circular bearing, the mean diameter of which is greater than the distance between the bearings of the wheel spindle. A steady support for the wheel stand is thus provided and rocking is prevented. The wheel platen is held in place by a bolt on each side.

The object in thus arranging the wheel platen so that it may swivel is to enable the operator to bring the face of the wheel parallel with the line of travel of the wheel slide, as shown in Fig. 46.

In internal grinding this wheel platen is turned around and the wheel stand proper is used as a speed counter, while the internal grinding fixture is placed on the opposite end of the wheel platen, which in this position projects over the wheel slide and brings the wheel spindle into the proper position for grinding holes.

Wheel Stand. The wheel stand is secured in any position on the wheel platen by two T bolts.

Wheel Guard. The wheel guard is heavy, and is bolted to the wheel stand. It serves to protect the operator from sparks, dust and water, and is a safeguard in case of accidental breakage of the wheel.

Feed. The carriage which supports the wheel bed and adjoining parts is fed longitudinally, either automatically or by hand. The feed is engaged by turning a knob in the centre of the front of the machine.

Reversing. The motion of the wheel carriage is automatically reversed by a lever which is actuated by the sliding collars on the rod at the back of the bed, and the

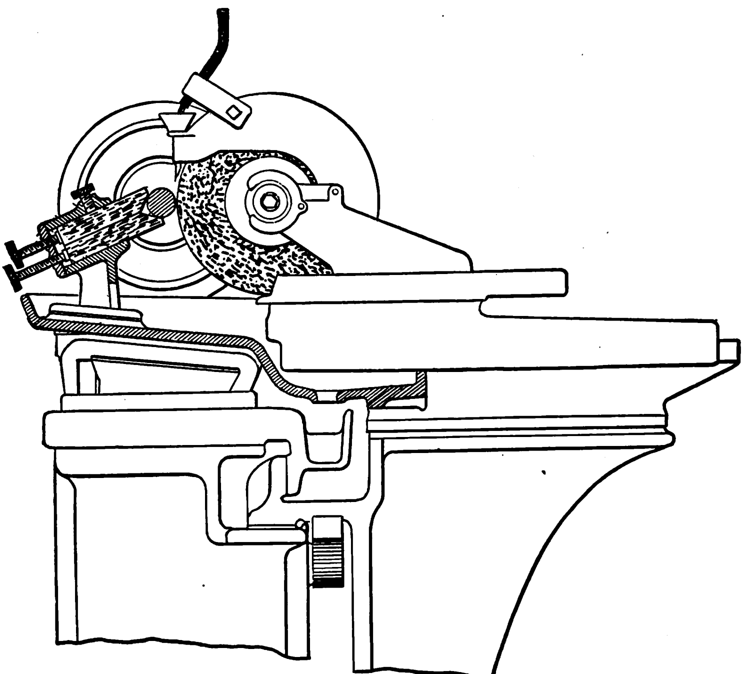


Fig. 33.

carriage is reversed without shock or jar. The collars can be set at any position the same as the dogs on a planer. The machine may also be reversed by using the lever at the front of the machine.

Cross Feed. The wheel slide is moved and the emery wheel brought against the work to be ground, by a hand wheel at the right of the emery wheel. Twenty revolutions of this wheel advance the emery wheel 1 inch. Below this hand wheel there is a second wheel by which the wheel slide may be quickly moved. The connection for the quick movement is readily made by turning the milled knob.

As previously stated, the wheel bed swivels and the wheel may be fed smoothly at whatever position or angle the wheel slide may be set.

Head Stock. The head stock shown in Fig. 34 is made to swivel about a central pin, and its whole circumference at the lower edge is graduated to degrees, so that it can be set at any desired angle.

The uprights supporting the spindle are heavy, to absorb all vibration, while the bearings are long and of unusual diameter. The pulley which drives the spindle is placed between the uprights.

The boxes are bronze, ground and fitted to the bearings. Their material makes it possible to run the spindle when they are tightly clamped upon it, and this clamping is necessary to obtain perfect face and hole grinding. The clamping adjustment is simple and positive.

The end thrust of the spindle is taken entirely on the forward end of the front bearing, and is conveniently adjusted by the thrust and check nuts. The spindle has a portion of its forward end ground perfectly true with its bearings, which insures the accurate running of the chuck and fixtures. This bearing and the taper hole in the spindle are ground when the spindle is in place. The spindle projects through the rear dust cap to allow a bolt to be passed through its entire length, to secure work to the face plate when it is desired to true the periphery of a piece in which a hole is to be ground.

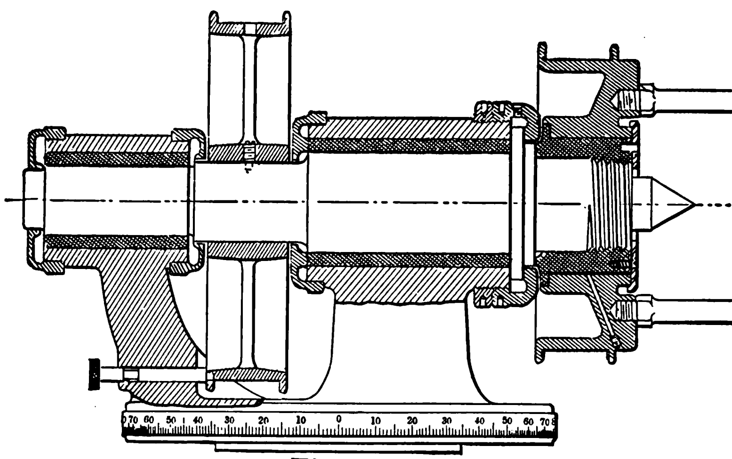


Fig. 34.

A stop is provided for holding the pulley between the uprights and preventing the spindle from turning when work is revolved upon centres.

The head stock is provided with a small and large dead centre pulley. The small dead centre pulley runs upon a stem fitting in the taper hole of the spindle, and the thread on the end of this stem and dead centre pulley is the same as thread on end of spindle and dead centre pulley of No. 2 Improved. Work may be ground upon two dead centres and upon one dead and one live centre, as well as upon the live centre alone. The advantage of grinding work upon two dead centres is that any possible imperfection in the spindle bearings does not affect the accuracy of grinding.

Foot Stock. The foot stock spindle is large and is operated by a hand wheel and screw, and the work is held between the centres by a stiff spring. By this arrangement the spindle adjusts itself to the varying length of the work caused by expansion, and the pressure between the centres remains substantially constant.

By the use of the hand wheel and screw the tension of the spring may be varied, and by tightening the set screw the spindle can be made fast. There is an oil reservoir for oiling the centres, and when the spindle is drawn back the centre is thrown out.

Wheel Spindle and Boxes. A section of the wheel spindle and boxes is shown in Fig. 35.

The spindle is hardened, ground and lapped. The end play is taken up with the nut, *A*, *B* being its check screw. This provides for the very delicate adjustment, necessary in accurate grinding. The boxes are 4½ inches long and 1¼ inches in diameter. They are self-aligning and made of bronze. They are adjusted by the nuts, *C* and *D*, and turning both nuts towards the back of the machine takes up the wear. The spindle and boxes can be removed from the wheel stand without disturbing the adjustment of the boxes, and the spindle with the boxes may be turned end for end by turning the cap nuts and raising the caps.

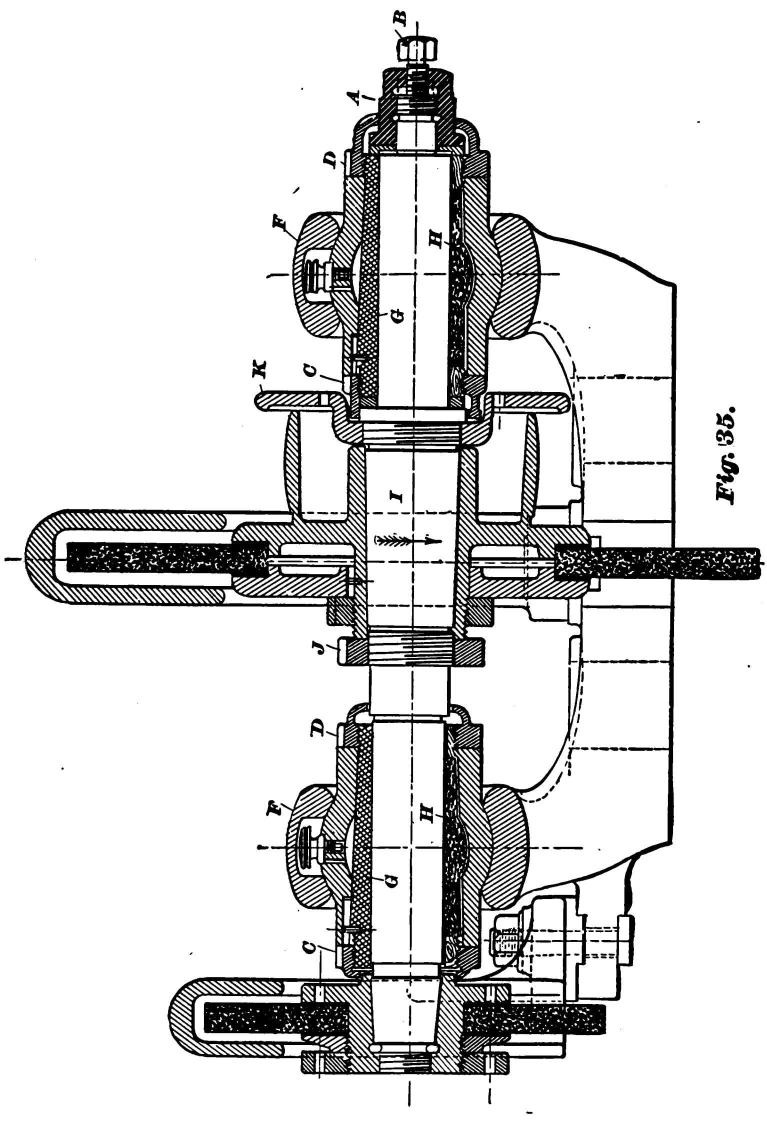


Fig. 35.

Oil is supplied to the spindle through the felt, *H*, which is supported by a spring.

Driving Pulley. The driving pulley and the flange are made in one piece, and the pulley is 4½ inches in diameter. It is fitted to the taper arbor at *I*, and is held in place by the nut, *J*.

A smaller emery wheel is used on the end of the spindle for backing off large cutters, reamers, etc., and a large wheel may here be used for grinding up to shoulders, collars, etc., as shown in Fig. 36.

For internal grinding, an extra spindle and boxes are furnished. This spindle has two pulleys, *L* and *m*, Figs. 23 and 24, and serves as a counter-shaft for driving the internal wheel spindle.

Wet Grinding. Provision is made for wet grinding by a centrifugal pump with connections for distributing the water either upon the wheel or upon the work.

Overhead Works. The overhead works consist of a compound counter-shaft, Figs. 37, 38 and 39, with a back shaft, forward shaft, and drum shaft, in combination with the hangers, pulleys and shippers substantially as shown. The 4¼-inch main belt runs on 12-inch tight and loose pulleys on the back shaft, and the shaft should revolve in the direction indicated by the arrow. All the belts connecting the shafts and machine should usually be open.

The forward shaft is driven from the back shaft by a 2-inch belt on cone pulleys, with five changes of speed, and the drum shaft is driven from the back shaft by a 2½-inch belt on cone pulleys, with two changes of speed. The feed work receives motion from a four-step cone on the front shaft through a 1¼-inch belt. The emery wheel is connected with the drum by a 1¾-inch belt. A 2-inch belt from the drum on the front shaft drives the dead centre pulley. In grinding small work the small dead centre pulley is used. It is driven by a 1¼-inch belt. For other kinds of work the pulley on the head stock spindle is driven from the same drum by a 2¼-inch belt. For convenience in changing these belts, the larger one should have its ends connected with belt hooks so it can be unhooked when put on the pulley.

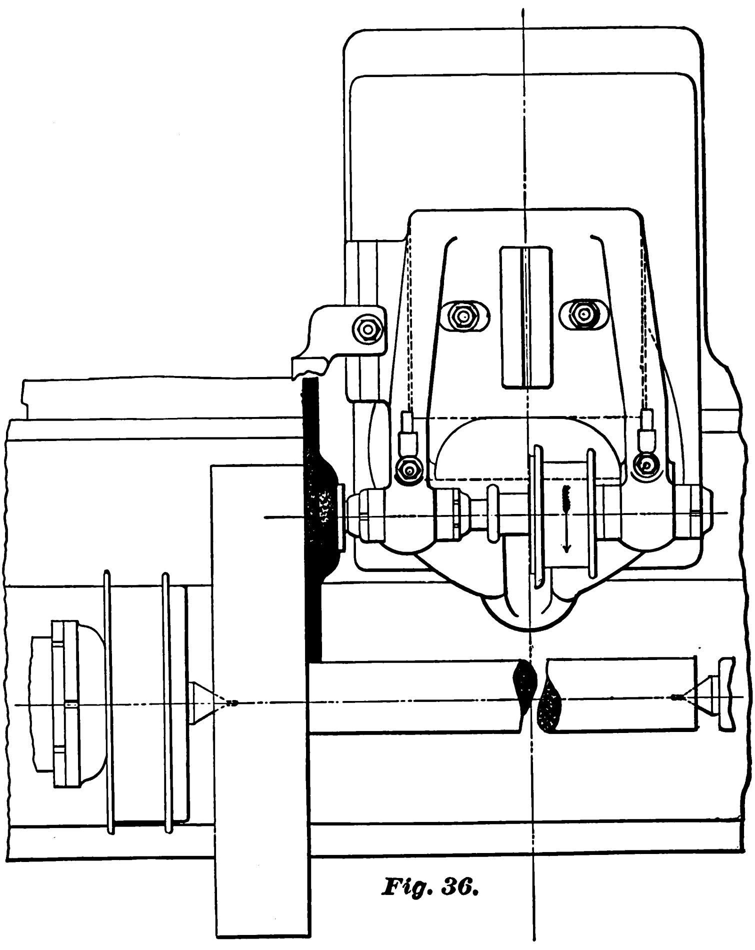


Fig. 36.

The motion of the emery wheel is controlled by the main belt shipper, while that of the work is controlled independently of the wheel by the shipper connected with the front shaft. By this arrangement the work can be changed on the centre, or chuck, without stopping the wheel. Time is thus saved as the wheel is always in motion when brought against the work.

Brake. That no time may be lost in waiting for the work to stop revolving after it is ready to be removed from the machine, a friction brake is connected with the shipper on the front shaft. By this means the drum, and consequently the work, may be stopped almost instantly.

Location of Counter Shaft The relation of the counter shaft to the machine should be such that a plumb line dropped from the centre of the drum, Fig. 38, will intersect the line of centres of the machine. The front shaft is placed by the cone from which the feed cone is driven, and the positions of the other shafts are determined by the cone pulleys.

Drawing. A copy of a large scale drawing, with figures giving the correct location of the most important parts of the counter shaft, is sent with each machine.

Speed. The speed of the back counter shafts should be about 250 revolutions per minute.

Hangers. The hangers are provided with self-adjusting and self-oiling boxes.

Capacity of the Machine. The machine will receive work between centres 20 inches diameter and 6 feet long, and the swivel table will swing to either side of its central position to grind tapers from zero to 2 inches per foot, or from zero to 5 degrees in angular measurement. The head stock can be set to any angle within the whole circle, and the wheel slide has a movement of 12 inches, and can be fed at any angle from zero to 90 degrees on either side of a line at right angles with the ways of the machine.

The wheel stand will take a wheel 12 inches diameter and ½-inch thick, with a 5-inch hole in centre.

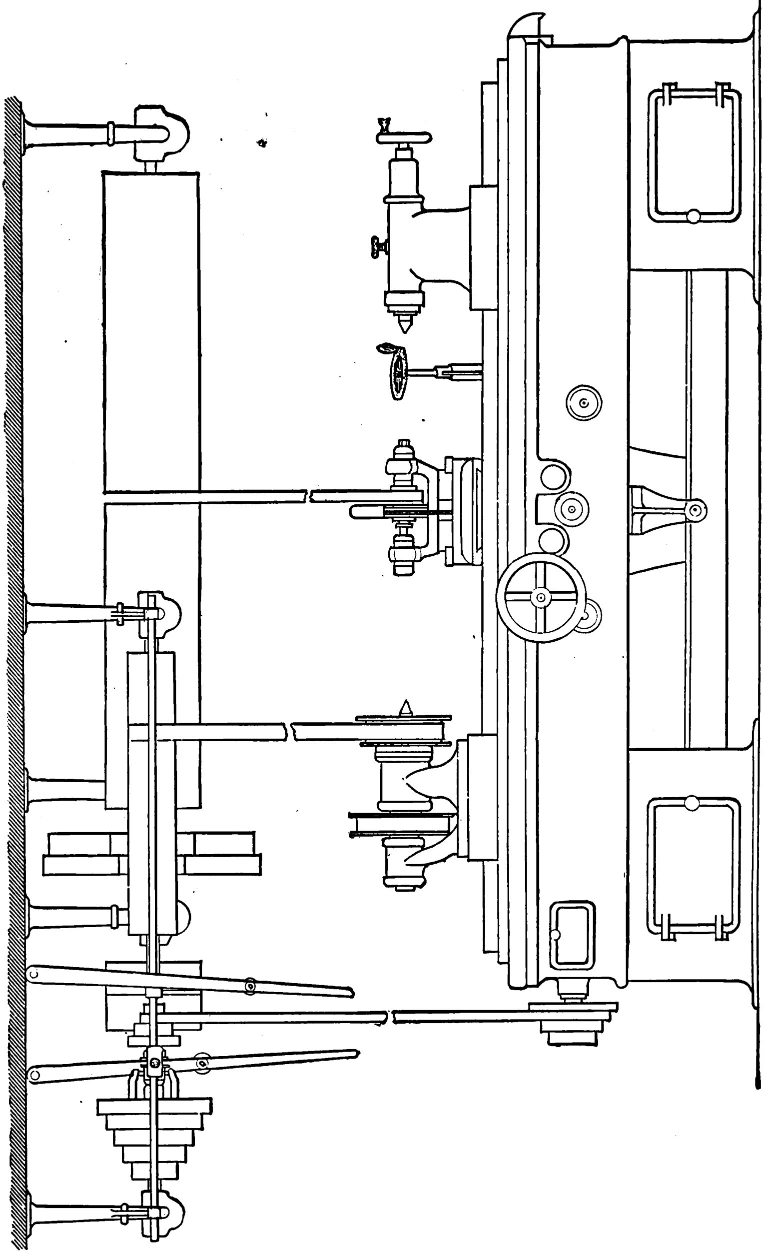


Fig. 37.

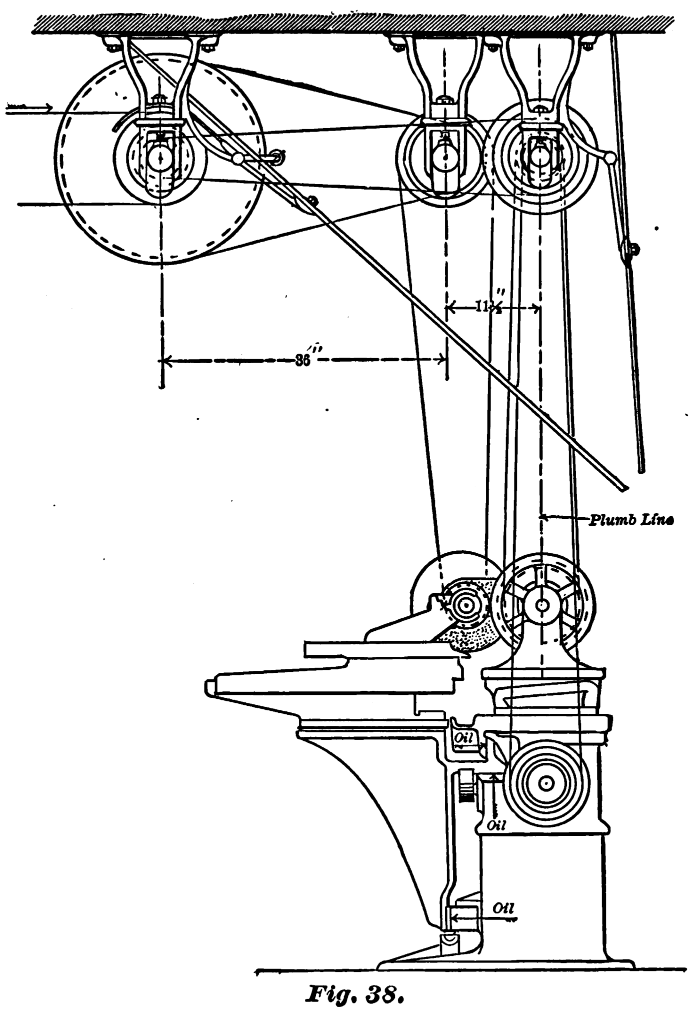


Fig. 38.

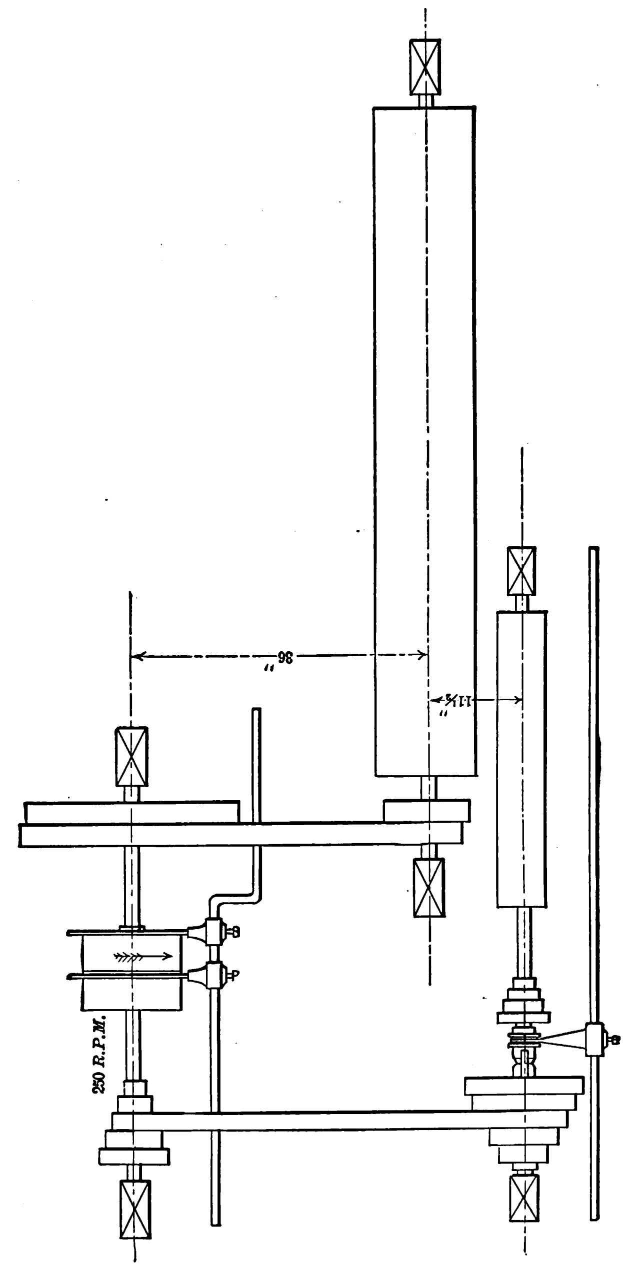


Fig. 39.

The internal grinding fixture usually sent with the machine will grind holes $5\frac{1}{4}$ inches long, 2 inches and upwards in diameter. Wheels up to 3 inches in diameter are used with this fixture.

When a large wheel is used on the end of the spindle, a piston rod, for example, may be ground up to a piston 20 inches in diameter.

The weight of the machine boxed ready for shipment is about 8,400 pounds.

The floor space, measured over extreme projections and points of travel of the various parts, is 63 inches by 12 feet.

Attachments and Accessories. Each machine is furnished with a drawing showing location of overhead works, a copy of this treatise, an internal grinding fixture, a special speed pulley with spindle and bearings for internal grinding, a three-jawed chuck and centre rest, two back rests, wheel arbor for small wheels, large and small dead centre pulley, centres, dogs, pump, wrenches and complete overhead works.

INTERNAL GRINDING FIXTURE.

The Internal Grinding Fixture, recently patented, is a decided improvement upon earlier fixtures. Formerly it was customary to employ a solid spindle or shaft, with a driving pulley at one end and a small wheel at the other end. To grind holes of any considerable depth the end of the spindle necessarily projected a corresponding distance beyond the bearing, and any motion or play in the bearing was multiplied at the end of the spindle so that even a slight motion or play in the bearing caused a considerable movement at the end of the spindle and necessarily produced imperfect work. In order to give it sufficient rigidity the spindle was made of a considerable diameter, but this large diameter rendered impossible the attainment of the high speed requisite for thoroughly efficient work. Also, when pressure was brought upon the end of the spindle by the action of the wheel upon the work, this pressure tended to force the spindle against its bearing with considerable power, owing to the leverage, due to the distance between the grinding wheel and the bearing, and this necessarily produced a great amount of friction between the spindle and the bearing and tended to prevent the attainment of high speeds.

The present fixture overcomes these difficulties, and is thoroughly efficient. It consists, primarily, of a grinding spindle of comparatively small size, mounted in a bearing of telescopic tubes of sufficiently large diameter, to give the required rigidity. These tubes are adjustable, longitudinally relatively to each other, and furnish a support or bearing for the spindle in close

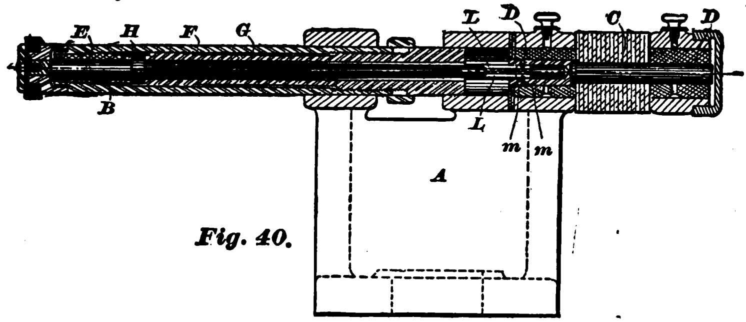


Fig. 40.

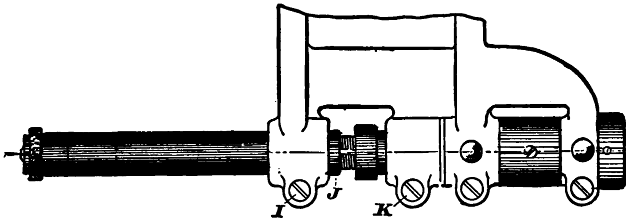


Fig. 41.

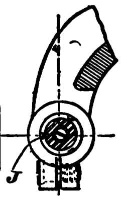


Fig. 42

proximity to the grinding wheel. The small diameter of the spindle enables it to be revolved at the necessary high speeds.

Figs. 40, 41 and 42 show the construction. *A*, is the stand; *B*, the wheel spindle bearing; *C*, the pulley spindle; *D D*, the pulley spindle bearings. The bronze box, *E*, is tapered on the outside to fit in the tapered end of the external tube, *F*, and this tube is made to screw on to the internal tube, *G*. It follows, that when the external is turned upon the internal tube, the box, *E*, will be moved toward or from the internal tube, decreasing or increasing the end play of the wheel spindle collar, *H*.

When the external tube has been screwed on to the internal tube far enough to take out all end play of the collar, *H*, still further movement will force the box, *E*, into the taper end of the external tube and close the box to compensate for wear. After the box has been forced far enough into the taper, the external tube is unscrewed sufficiently to relieve the pressure on the collar, *H*, and make a running fit. In adjusting as above the screw, *I*, should be loosened and the spanner wrench used in the notches, *J J*.

The projection of the wheel from the stand has a limited adjustment, which is made by loosening the screws, *I* and *K*. The wheel spindle, with its connecting tubes, can be removed from the stand without disturbing the pulley and spindle, as connection is made by the spindles, *L L*, and pins, *m m*.

Provision is made for excluding dust from the bearings.

Four sizes of the fixtures may be used on the No. 1 Universal Grinding Machine, and five sizes may be used on the No. 2 Universal Grinding Machine, No. 2 Universal Grinding Machine Improved, and No. 3 Universal Grinding Machine.

In ordering these fixtures it should be stated whether or not they are to be used on the No. 1 Universal

Grinding Machine, as the fixtures sent for this machine have lower standards than those used on the other machines.

No. 1 will grind holes	1½″	long,	¼″	to	½″	diameter.
" 2 " " "	3¼″	"	7/16″	"	⅞″	"
" 3 " " "	5¼″	"	¾″	"	1⅛″	"
" 4 " " "	5¼″	"	1″	and upwards		"
" 5 " " "	5¼″	"	2″	"	"	"

Wheels up to 2 inches diameter may be used on the No. 4 Fixture. Wheels as large as 3 inches in diameter may be used on the No. 5 Fixture.

Diameter of hole in wheels used on No.	1	Fixture,	3/32″
" " " " " " " "	2	"	¼″
" " " " " " " "	3	"	¼″
" " " " " " " "	4	"	⅝″
" " " " " " " "	5	"	¾″

Speed of No.	1	Fixture,	16,800	revolutions	per minute.
" " "	2	"	13,400	"	" "
" " "	3	"	12,200	"	" "
" " "	4	"	11,200	"	" "
" " "	5	"	8,050	"	" "

Fixture No. 3 is usually sent with the No. 1 Universal Grinding Machine.

Fixture No. 4 is usually sent with the No. 2 Universal Grinding Machine.

Fixture No. 4 is usually sent with the No. 2 Universal Grinding Machine, Improved.

Fixture No. 5 is usually sent with the No. 3 Universal Grinding Machine, Improved.

If any other size is preferred it will be forwarded at the expense of the customer, the fixture sent with the machine being returned without expense to us.

MATERIAL, WORKMANSHIP, ETC.

Throughout the construction of the machines we aim to employ first-class material and workmanship, and obtain the highest degree of durability as well as accuracy. All plane surfaces requiring fitting are scraped to surface plates, while all round surfaces, such as shaft bearings, etc., are fitted by grinding. All screws, bolts and nuts requiring frequent adjustment, are hardened. **Material and Workmanship.**

Special attention has been given to the protection of all wearing surfaces from the emery dust, which unavoidably accumulates about the machine. This dust would, of course, ruin a machine in a very short time if it were admitted to the bearings. The feed gearing is completely enclosed. The dust caps, which protect the spindle bearings of the head and foot stocks and wheel stand have been referred to. All oil holes are provided with plugs or screws.

CARE AND USE OF THE MACHINES.

SELECTION OF WHEELS—EXAMPLES OF GRINDINGS.

Oil and Oiling. As the durability of a machine depends very largely upon the care of the operator, however well a machine may be constructed, if it is not properly cared for it will soon become unreliable. The wearing surfaces should be especially guarded and kept well oiled. In all cases we recommend the use of a good quality of oil in preference to one of low grade. Sperm oil should be used on the Internal Grinding Fixtures. Those holes which are closed with screws have the words "oil hole" stamped around them, and all oil holes should be well guarded. Among the least prominent oiling places in the No. 2 Universal Grinding Machine, may be mentioned the bearing of the cross feed worm which has an oil hole in the centre, on the upper end, and may be oiled after running the wheel slide back out of the way. The oil hole to the bearing of the feed cone, *P*, in this machine, Fig. 14, is covered by a sleeve encircling the bracket. This sleeve, when turned a quarter of a turn, will expose the hole. The operator should make himself familiar with all oiling places, so none will be overlooked. The counter-shaft hangers should be cleaned out about once a year and re-filled with clean oil. If the oil wicks are found to be badly worn where they come in contact with the shaft journals, they should be replaced by new ones of sufficient length to have the ends well immersed in the oil.

Cleaning. The machines should be kept as clean as possible, and in no case should the bearings be allowed to "gum up." When bearings are opened and exposed for any purpose whatever, they should be carefully wiped off, before they are closed again, to free them from any grit that may have found its way upon the surfaces.

The spindle boxes should be perfectly clean when put together. Before tightening the cap the oil space *G*, Figs. 9, 18, 27 and 35, should be filled with good oil, never lard oil, and the wheel turned slowly while first one cap and then the other is screwed until quite tight. The felt by which oil is supplied to the spindle should be kept clean where it rubs on the spindle. **Adjusting Spindle Boxes.**

A loose fit between the wheel spindle and its boxes will produce imperfect work, and when very fine work is required the bearings should run nearly, if not quite metal to metal. This necessarily will cause the boxes to heat, but in this case the heat is not injurious, for, as the bearings are hard and the boxes bronze, the belt will slip, unless it is exceedingly tight, before abrasion can occur.

All end motion should be taken out of the wheel spindle before the wheel is used on the work. **End Motion of Spindle.**

The pump is a simple fan revolving in a loose case and the shaft should be kept packed air tight and the driving belt should be open. **Pump.**

A satisfactory Emery Wheel is an important factor in the production of good work. Too much, however, must not be expected of one wheel. A variety of shapes, sizes and grades of wheels are necessary to bring out all the possibilities of the Grinding Machine, the same as a variety of shapes and sizes of tools are necessary to obtain the best results from the Lathe or Milling Machine. **Emery Wheels.**

Our aim in grinding is usually to obtain an accurate or true surface, but as a true surface is almost always a good surface it should be remembered that generally the same methods are employed, whether an exact size or a fine finish is the object desired.

Our suggestions are not offered as positive rules but as the embodiment of our experience and as representing the methods which our shop practice has indicated are desirable.

In selecting and using a wheel, we are governed by the character of the metal to be operated upon, the shape and size of the work and the degree of accuracy desired. We have to consider the size of the particles of emery in the wheel, the hardness of the wheel and its width. We also have to determine the speed at which it is to be revolved, the speed at which the work is to travel or be revolved, and whether or not water is to be used.

For the sake of clearness we refer separately to the various characteristics of wheels, but it should be borne in mind that a wheel should not be selected for a single characteristic but that each of the essential elements is importantly affected by the others, and that all should be considered in choosing or using a wheel for any desired work.

Coarseness or Fineness of Wheels. Wheels are numbered from coarse to fine; that is, a wheel made of No. 60 emery is coarser than one made of No. 100. Within certain limits, and other things being equal, a coarse wheel is less liable to change the temperature of the work and less liable to glaze than a fine wheel. As a rule, the harder the stock the coarser the wheel required to produce a given finish. For example, coarser wheels are required to produce a given surface upon hardened steel than upon soft steel, while finer wheels are required to produce this surface upon brass or copper than upon either hardened or soft steel.

Softness or Hardness of Wheels. Wheels are graded from soft to hard and the grade is denoted by the letters of the alphabet, A denoting the softest grade. A wheel is soft or hard chiefly on account of the amount and character of the material combined in its manufacture with emery or corundum. But other characteristics being equal, a wheel that is composed of fine emery is more compact and harder than one made of coarser emery. For instance, a wheel of No. 100 emery, grade B, will be harder than one of No. 60 emery, same grade.

The softness of a wheel is generally its most important characteristic. A soft wheel is less apt to cause a change of temperature in the work, or to become glazed than a harder one. It is best for grinding hardened steel, cast iron, brass, copper and rubber, while a harder or more compact wheel is better for grinding soft steel and wrought iron. As a rule, other things being equal, the harder the stock the softer the wheel required to produce a given finish.

Generally speaking, a wheel should be softer as the surface in contact with the work is increased. For example, a wheel $\frac{1}{16}$ inch face should be harder than one $\frac{1}{2}$ inch face. If a wheel is hard and heats or chatters, it can often be made somewhat more effective by turning off a part of its cutting surface; but it should be clearly understood that while this will sometimes prevent a hard wheel from heating or chattering the work, such a wheel will not prove as economical as one of the full width and proper grade, for it should be borne in mind that the grade should always bear the proper relation to the width.

Width of Face of Wheel.

The width should be in proportion to the amount of material to be removed with each revolution, and as a wheel cuts in proportion to the number of particles in contact with the work, less stock will ordinarily be removed by a narrow wheel than by one that is of full width. The feed will also have to be finer if a narrow wheel is used.

The quality of the work as a rule is improved by using a wheel of full width if the wheel is soft in proportion. Judgment should be exercised in deciding upon the width of wheel to be used, as sometimes the work is of such size and shape as to make it necessary to use a wheel with a narrow face. Where this is the case the wheel should, where strength will admit, be only that width throughout, and care should be taken that the grade is kept in the proper relation to the width.

Speed of Wheel.

A wheel is most efficient in grinding just at the point before it ceases to crumble. The faster it is run up to this point the more stock will be removed and the more economically the work will be produced. Occasionally, however, it is necessary to run a wheel rather slowly, as the more slowly it runs the coarser it cuts and the less likely it is to change the temperature of the work. As a general rule, on any given stock, the softer the wheel the faster it should be run.

Should a wheel heat or glaze it can often be made somewhat more effective by being run more slowly. On the other hand if it be too soft, it can often be made to somewhat better hold its size and grind straight by being run more rapidly.

Speed of Work. The surface speed of the work should be proportionate to the speed of the wheel, that is, other things being equal, if the speed of the wheel is reduced the speed of the work should be reduced also. The desire is to have the work revolve at such a speed as to allow time for the wheel to cut away the high points on the work. If the work is run so fast that there is no time given for the wheel to cut, but the work is simply crowded against the wheel, the tendency is for the wheel to follow the inequalities in the form of the work and straight or round surfaces are not obtained. When the wheel is not free cutting and the pressure of the wheel against the work is sufficient to cause the work itself to spring or to cause a slight movement of the oil upon the centres the accuracy of the result is impaired.

The coarser or softer and more free cutting the wheel the greater can be the speed of the wheel, and consequently of the work. It is, however, not necessary to graduate the speed of the work as closely as the speed of the wheel. The character of the wheel being influenced so readily by a change of speed it is sometimes essential and often very convenient on Universal Grinding Machines to be able to slightly increase or decrease the speed of the wheel.

Accurate Grinding. The desire in accurate grinding is to have a free cutting wheel and to obtain the proper speeds so that the stock may be removed with the least possible amount of pressure, thus preventing a change of temperature in the work and allowing the high parts to be most speedily reduced.

Requirements in Grinding Large or Long Pieces.

Thus far we have had in mind the selection and use of wheels for the comparatively small or medium sized work ordinarily ground on our machines. The requirements in grinding extremely large or long pieces are somewhat different. For example, in grinding a piece of steel three inches long, one inch diameter, on a Universal Grinding Machine we have indicated that the most absolutely accurate work would be accomplished by selecting a wheel only just hard enough to retain its size while passing six or eight times over the surface of the piece, and we have suggested that such a wheel should be run at a high rate of speed. We have considered rapidity of production as more important than economy of emery. If, however, we should attempt to use such a wheel to grind a piece of steel one inch diameter and three feet long, it is clear that before the wheel had passed over two of the three feet it would have ceased to cut.

The problem now is to maintain the diameter of the wheel so as to take a uniform cut over a large area. Each particle of emery must be used as long as possible before being thrown away. A wheel full width and full diameter should be used, and the face should be true so that as many particles as possible may be brought in contact with the work, and each particle be dulled as little as possible while the wheel is passing over the work. The particles may be used a longer time and are not so rapidly thrown away in a hard as in a soft wheel. Accordingly one expedient in grinding large areas is to increase the grade of the wheel as the area increases, the speed of the wheel being reduced as the grade is increased.

The loss of fine particles will not decrease the diameter of the wheel as rapidly as the loss of coarser or larger particles. Thus another expedient is to use a finer wheel. A fine wheel can be relatively softer than a coarser wheel, and so with a fine one there need be less pressure between the wheel and the work and there is more certainty of obtaining an accurate surface.

If a wheel is run rapidly the particles of emery soon become dull and have to be thrown away, To retard this loss it is well to run the wheel more slowly as the length or area of the work increases. If the speed of the wheel is reduced the speed of the work should be reduced accordingly.

As the length or area of the work increases the feed should be coarser, so that the wheel may travel the entire length or area of the piece while its diameter is practically unchanged.

Water. Water should be used on such classes of work as are injuriously affected by a change in temperature caused by grinding. It should be used upon work revolved upon centres, as in this work a slight change of temperature will cause the wheel to cut on one side of the piece, after it has been ground apparently round.

In very accurate grinding water is especially useful, for it should be remembered that the exactness of the work will be affected by a change in temperature which is not perceptible to the touch.

In very accurate grinding it is also well to use the water over and over again, as by so doing there is less difference between the temperature of the water and that of the work than if fresh water is used. For many purposes soda water is the most satisfactory, as it has less tendency to rust the work or the machine.

Internal Grinding. For internal grinding it is especially important that a wheel should be free cutting and the work revolved so slowly as to enable the wheel to readily do its work. The wheels should generally be softer than for external grinding, as a much larger portion of the periphery is in contact with the work. Their small diameters make it impossible for the proper periphery speed to be obtained, and this must be considered in regulating the speed of the work.

Summary. To repeat some of the more important suggestions offered above, the numbers given on the labels denote the coarseness, and the letters indicate the grades of the wheels.

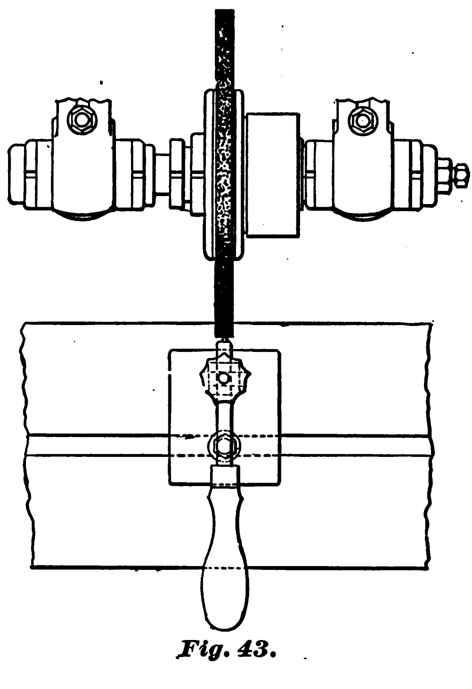


Fig. 43.

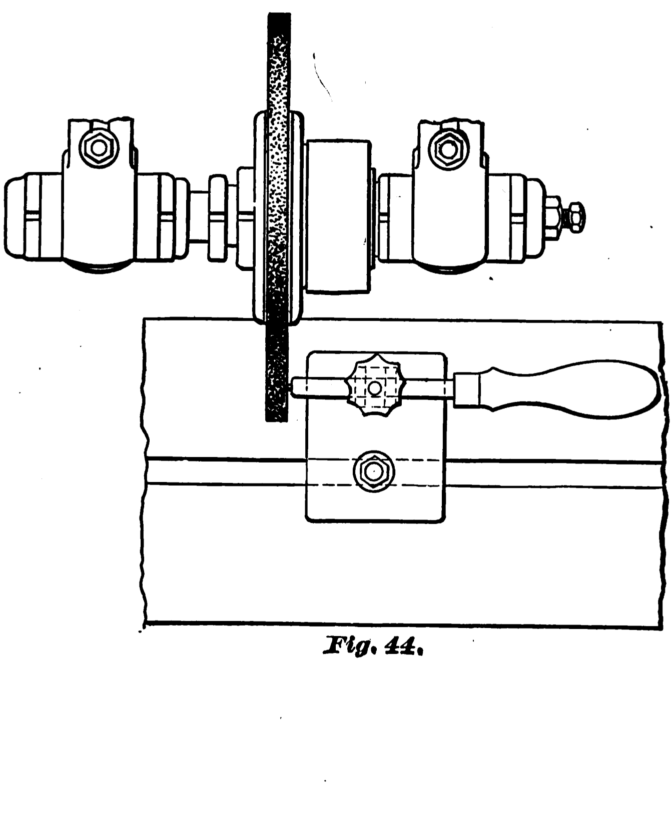


Fig. 44.

Soft free cutting wheels such as are made by a number of the companies using the vitrified process are the best for most purposes. The ideal wheel is the one composed entirely of cutting materials. The width of the wheel should be in proportion to the amount of stock to be removed at each revolution. The wheel should be soft in proportion to the surface in contact with the work. The speed of the wheel should be in proportion to its softness, and the speed of the work should be in proportion to the speed of the wheel.

List of Wheels. The wheels listed at the end of this book are those which our experience has shown to be suitable for the various purposes specified. Special cases may demand changes in the grade letter, but under ordinary circumstances the list should be accepted as a guide.

The speed, diameter and width of wheels, and the number of the emery cannot be changed without changing the grade and cutting qualities of the wheels.

Truing Wheels. Wheels should always be kept true. They can be easily kept so by truing them off with a diamond tool, known as the black diamond or carbon point, held by hand or in the fixture sent with several of the machines. A new wheel should be started slowly and trued gradually. Fig. 43 shows the method of truing the face, Fig. 44 the side of a wheel.

Mounting Wheels. In mounting emery wheels there should always be elastic washers placed between the wheel and the flanges. Sheet rubber is best for this purpose, but soft leather will answer very well. In some cases manufacturers of emery wheels attach a thick, soft paper washer to each side of the wheel for this purpose, in which case no further attention is required in this direction.

Removing Wheel from Spindle. The wheel with its pulley can be removed from the spindle at any time by unscrewing the nut *J*, and screwing up the nut *K*, Figs. 9, 18, 27 and 35. In no case should a hammer be used for removing the wheel.

Direction in which Work should Run. In all kinds of grinding the work should move in a direction opposite to that of the wheel at the cutting point, as shown by the arrows in Fig. 21.

Lapping. Where a high finish is desired on hardened work, such as jewelers' rolls, standard gauges, etc., the final finish is usually given by lapping.

True Centre Holes. To obtain good results when the grinding is done on the centres it must be remembered that true centre holes in the work, as well as true centres, are absolutely necessary.

True Face Plates. The face plates should be kept true. They can be readily ground in place on the machines.

Different Methods of Grinding. From the description of the machines it may be noticed that work can be ground on the live spindle in the head stock, or that it may be ground on one dead and one live centre, being driven by the pulley between the uprights on the head stock, or upon two dead centres, the work in this case being driven by the large or small dead centre pulley furnished with each machine. Also from their construction it is clear that for plain grinding, the various parts of the universals are set practically the same as corresponding parts of the plain grinding machine.

Grinding Slight Tapers. When slight tapers are desired for either external or internal grinding, the swivel table is set to the proper angle.

Grinding Abrupt Tapers. When more abrupt tapers are wanted for work ground on centres or for internal surfaces, the wheel slide is set to the proper angle. By placing the wheel slide and the swivel table at the 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.

When an abrupt taper is required on work held on the head stock spindle, independent of the foot stock, the taper is obtained more conveniently by swiveling the head stock than by setting the wheel slide. In this case the work is driven by the pulley between the uprights on the head stock.

Driving Work on Centres.

This pulley is frequently used for driving large work ground on centres, when it is desirable to run slowly. Most work, however, when ground on centres is driven by the large or small dead centre pulley. Most pieces, whose internal surfaces are ground, are driven by the pulley between the uprights on the head stock.

Advantage of Grinding on Dead Centres.

The advantage of grinding on two dead centres is that any possible play in the spindle bearing does not affect the character of the work.

Grinding Straight Work.

In grinding straight work both ends should be calipered. If one end measures a little more than the other, the defect may be corrected by swinging the table *I* a trifle by means of the adjusting screw *K*, Fig. 13. Sometimes it is more convenient to correct this defect by taking a slightly heavier cut at the large end. By very great care the wear of the wheel can be practically offset by feeding up the wheel, but the best method, in most instances, to straighten work is to take a number of very light cuts.

Examples of Operations

Passing from these general suggestions, the reader will gain a clearer idea of the manipulation, use and arrangement of the machines by studying the descriptions and illustrations of special operations.

Plain External Grinding.

In Figs. 3, 10, 11, 13, 14, 21, 29, 30, 33, 37 and 38 the machines are shown properly arranged for parallel or plain external grinding. The work, in Figs. 3, 21 and 33, is shown supported by a back rest.

Use of Back Rest.

It is used to absorb vibration caused by the emery wheel in slender pieces, and should be so placed that only the high points of the work will touch as the work is revolved. When it is thus placed and a light cut is taken by the wheel the back rest assists in the production of round or approximately round work, and the cut of the wheel and the pressure on the rest may be increased as the work approaches to a perfectly cylindrical form. In other words when work is first commenced on a piece the back rest should be considered more as an absorbent of the vibration than as a support. After the work has become quite round the rest can be used to regulate the size at different points. This method of using the rest is particularly advantageous in grinding pieces that are apt to be large midway from the ends. Slender work, until it becomes approximately cylindrical, as a rule, requires a very coarse feed when the back rest is used.

The back rest is stationary when used for straight grinding on the No. 1 and No. 2 Universal, No. 2 Universal Improved and No. 2 Plain Grinding Machines. On the No. 3 Universal Machine one of the rests is arranged to travel with the wheel and the other is stationary. In Fig. 45 the use of a back rest is shown in taper grinding on the No. 1 Machine. The rest here is fastened to the table by means of a special block and travels with the work.

Figs. 21 and 33 illustrate two kinds of back rests, that in Fig. 33 being usually preferred when grinding slender work or very long pieces. Sometimes the wooden point of the back rest is replaced by soft metal, which conforms, by wear, to the shape of the piece to be ground. The exact way in which a back rest must be used depends upon the various conditions existing in each individual case.

Plain Grinding with Wheel on End of Spindle.

Fig. 36 shows an example of plain grinding which may be done on the No. 3 Universal Grinding Machine. In this, as in the previous cases, the automatic longitudinal feed is used; the wheel is brought up against the work by means of the cross feed, and the work is on centres and driven by the large dead centre pulley. The wheel, however, in this example is not on the centre of the wheel spindle, but on the end, the object being to grind up to a shoulder, collar or piston as shown. The wheel is driven by the small pulleys on the centre of the spindle the same as in internal grinding, and the length of the stroke is regulated by the collars on the rod at the back of the bed. For very many operations a small wheel is convenient on the end of the spindle, and

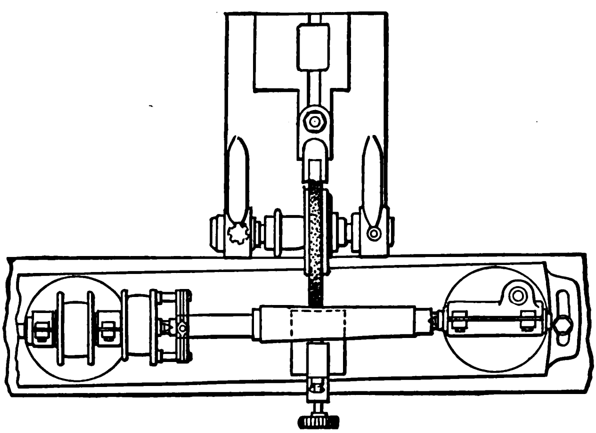


FIG. 45.

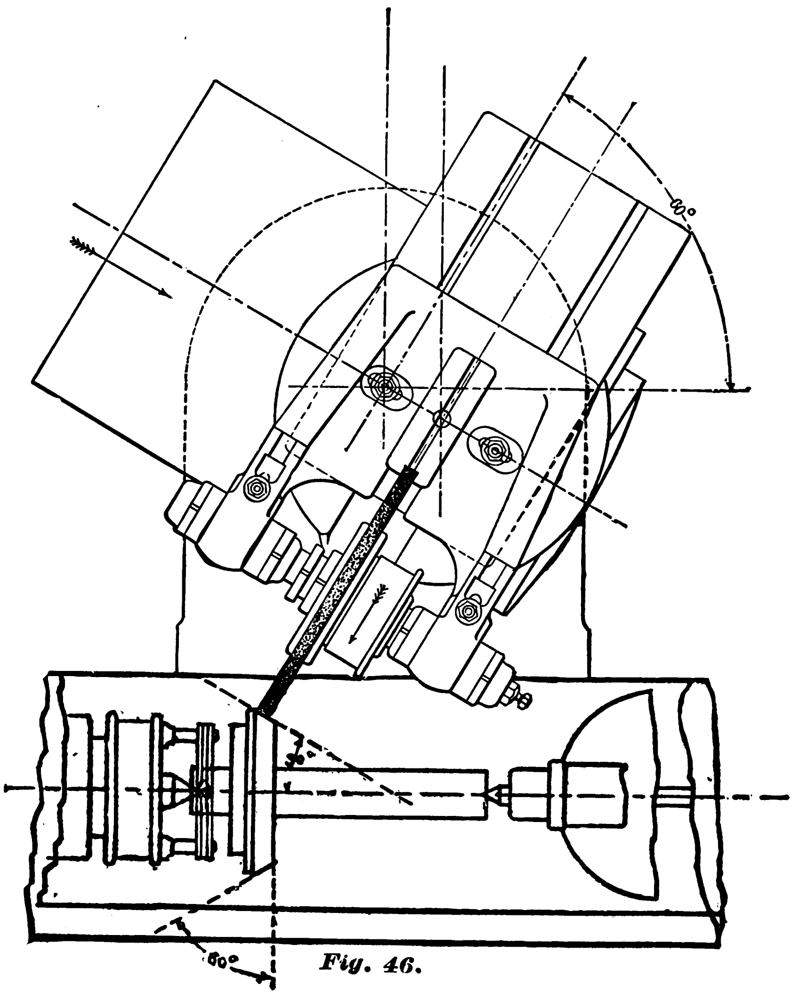


Fig. 46.

may be so used on either Universal Machine. A large wheel is thus used only on the No. 3.

Plain Internal Grinding. The adjustment of the machines for plain internal grinding is shown by Fig. 23. The wheel platen and the wheel stand are turned about the central stud 180 degrees from the position usually occupied in plain external grinding and shown in Fig. 21. The internal grinding fixture is bolted to the forward end of the wheel platen, and the spindle of this fixture is driven from a small pulley which is substituted for the emery wheel on the centre of the spindle of the large wheel stand. In internal grinding the belt from the overhead works to pulley *m* must be crossed and the emery wheel run backwards or opposite to the direction shown in Fig. 36. The work is held in the chuck and run forward in the usual way as indicated by the arrow. Here, as in external grinding, the emery wheel is brought against the work by means of the cross feed, while the automatic table feed may be used for feeding longitudinally and the length of stroke is regulated by the dogs on the front of the table. The piece might be strapped to the face plate instead of held in the chuck as shown.

Grinding External Tapers. The arrangement of the machines for grinding external tapers, not over 1½ or 2 inches per foot, is shown by Figs. 22 and 45. It is the same in all respects as for plain grinding except that the swivel table is set at the proper angle. The reading on the scale marked degrees, it should be remembered, is one-half the whole taper.

Where the work is to be ground to a fit, it is usually placed in the machine in the manner shown, the smallest end of the taper being toward the foot stock. The wheel and the table are operated, the work is driven, and the length of the stroke regulated the same as in plain grinding.

When an abrupt taper similar to that shown in Fig. 46 is to be ground, the swivel table remains parallel to the ways of the bed as in plain grinding, but the wheel bed is set to the angle which brings the line of motion of the wheel slide when operated by the cross feed, parallel with the taper to be obtained. The wheel platen is set at right angles with the line of movement of the wheel slide, indicated by the arrow, and the face of the wheel is thus brought parallel with the line of the desired taper. The work is revolved by the dead centre pulley, as shown in cut, and the wheel is moved over the surface of the work by the cross-feed.

Two Tapers with One Setting. The method of grinding two tapers with one setting of the machine when one of the tapers is not more than 10 degrees is shown in Fig. 47.

For grinding the slight taper the swivel table is set as in Fig. 22, and for grinding the more abrupt taper tne wheel bed is set as in Fig. 46.

But the wheel platen is here set to bring the face of the wheel parallel with the longest surface to be ground. Were the abrupt taper longer than the slight taper it would be well to set the wheel platen as in Fig. 46, so that the face of thewheel would be parallel with the line of taper. In obtaining the angle at which the wheel bed is to be set when the swivel table has been set over, it should be remembered that the angle must equal the sum of the two tapers. The abrupt taper is ground by feeding the wheel across the work by hand. The slight taper is ground while the table is fed automatically.

Grinding Spindle and Box. When, as suggested by the cut, a spindle and box are both to be ground, the box is ground first and the spindle is fitted to it. For convenience in fitting the work, the box may be placed as shown by the dotted lines and supported so that it will not touch the spindle as the latter revolves. The spindle thus need not be removed from the centres when it is necessary to try it in the box.

Grinding Internal Tapers. In grinding the box the machine is set as shown in Fig. 24. Provision is made for grinding the slight taper by setting the swivel table and for grinding the abrupt taper by swiveling the wheel bed. As in external grinding, the bed is set so that the line of motion of

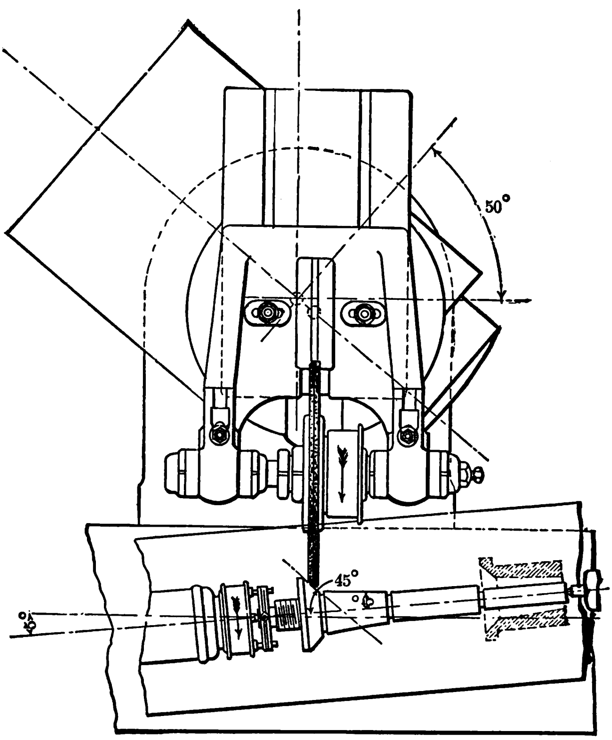


Fig. 47.

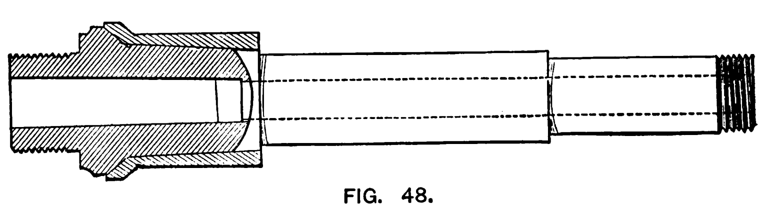


FIG. 48.

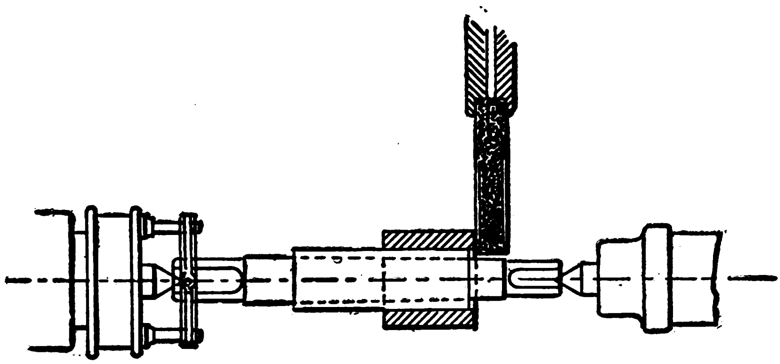


Fig. 49.

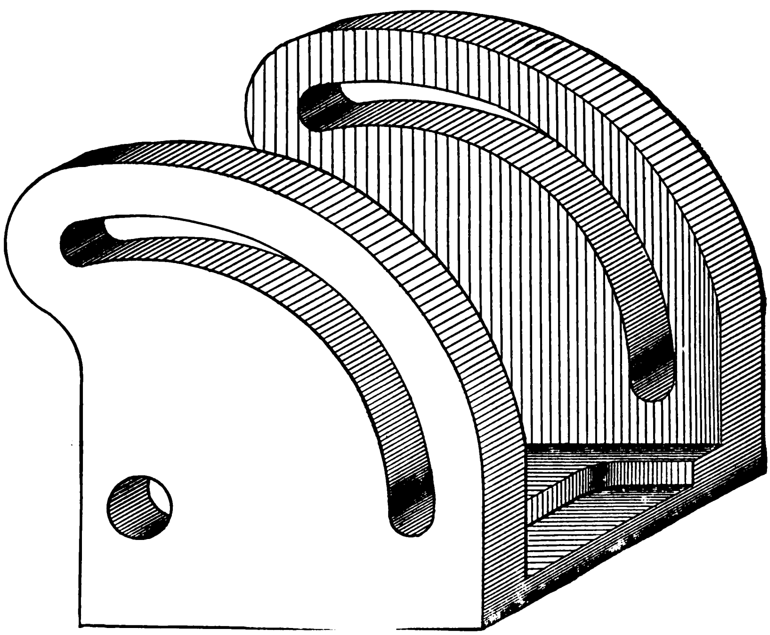


FIG. 50.

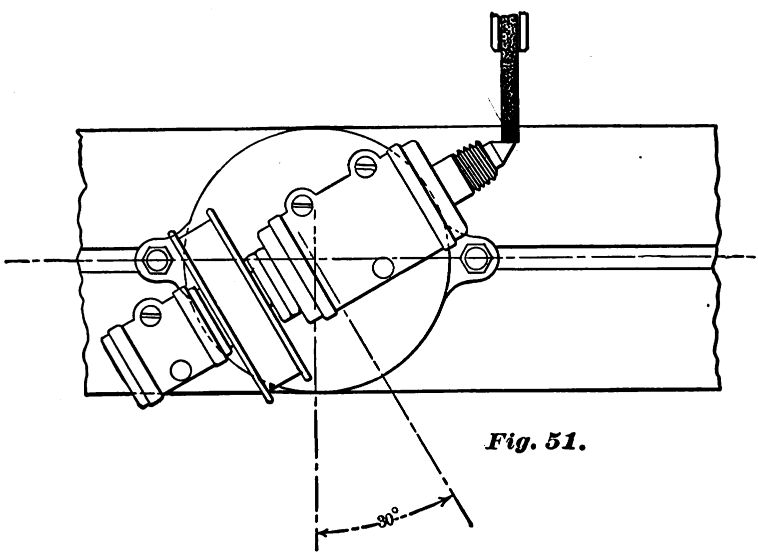


Fig. 51.

the wheel slide will be parallel with the line of the taper to be ground. The angle with the ways of the machine in this case, the swivel table having been set over, is equal to the difference in the angles of the tapers. As in external grinding, the abrupt taper is ground by feeding the wheel across the work by hand and the slight taper is ground while the table is fed automatically.

Fig. 48 illustrates work ground on the No. 3 Universal Machine.

Squaring Ends of Bushings.

Fig. 49 shows a method of squaring the end of steel bushings. The wheel is turned away on the side, leaving a narrow cutting corner, and should be very soft. If the axis of the arbor and the axis of the wheel spindle are exactly parallel the surface will be perfectly flat and at right angles with the axes. A concave or convex surface can be obtained by varying the relation of the axes.

Work Swung by Hand on Centres.

A great deal of odd work in manufacturing machinery may be done on the machines; for example the spiral box of the milling machines, Fig. 50, may be swung on centres by hand and the curved surfaces, shown at the right in the cut, may be satisfactorily ground.

Grinding Work on Headstock. Truing Centres.

The accuracy of all work ground on centres is so dependent upon the centres being true that the operation shown in Fig. 51 is very frequently seen. To grind or true a centre it is only necessary to set the head stock to the proper angle, and this can be done on the plain as on the universal grinding machines.

Grinding Collars, etc.

Fig. 52 shows another illustration of the class of work ground by swiveling the head stock in which may be included grinding the sides of collars, washers, milling cutters, etc. The plate or disk shown is held in the chuck, and the head stock is turned at right angles to the sliding table. The wheel is brought against the work by the cross-feed and the automatic table feed can be used for passing the work in front of the wheel. It is evident that the surfaces ground in this manner may be plain, concave or convex, according to the setting of the head stock.

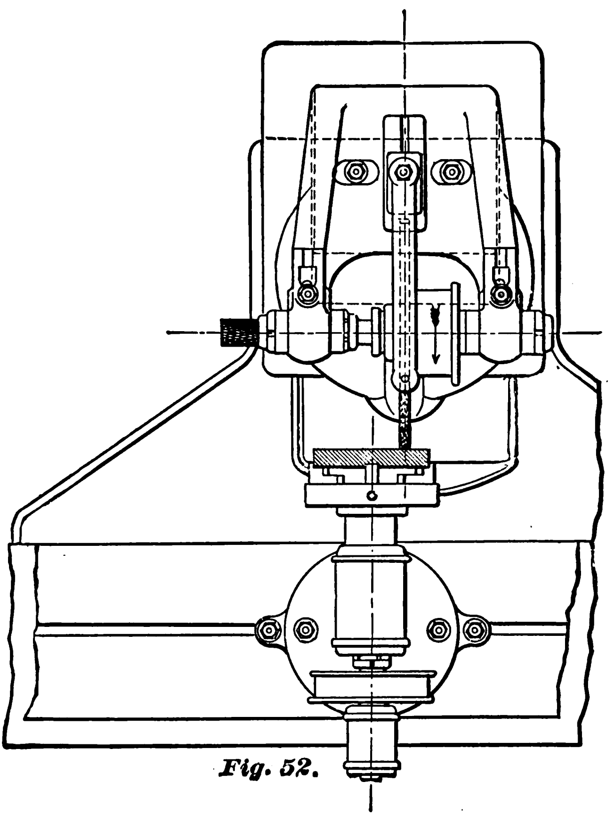


Fig. 52.

Two surfaces may be ground on pieces held in the head stock with only one setting of the machine. For example, if the portion of the work ground in Fig. 46 were detached from the shaft or arbor and it were desired to grind the flat and bevel surfaces, the head stock would be turned at right angles to the table as in Fig. 52, and the wheel bed would be set to such an angle that the line of motion would be parallel with the taper. The general position of the wheel and wheel platen in this case is suggested by Fig. 24.

Fig. 53 shows an operation similar to Fig. 52, but the piece is here ground by a small wheel on the end of the spindle.

Use of Centre Rest. Fig. 54 illustrates the use of the centre rest in connection with work held in the chuck on the head stock, the work being driven as in Fig. 23 and the swivel table set to produce the desired taper. The cut also illustrates the use of an indicator to determine that the work runs absolutely true.

Use of Special Chuck. Thin washers and cutters are conveniently mounted on a special chuck furnished with the machine. This chuck, as indicated by Fig. 55, holds the cutters by the hole in the centre and should be used in all disk grinding where both sides of the pieces must be parallel. For most disk grinding it is also more convenient than a common chuck and more accurate results are generally attained by its use. Thin saws, Fig. 56, are held this way and are ground concave or thinner at the centre than at the teeth, to give the proper clearance.

Grinding Cutters and Reamers. The machines are used for grinding the holes in milling, form and gear cutters, Figs. 57, 58 and 59, as well as for grinding their sides or ends They also are suitable for grinding the teeth or cutting edges of a large variety of cutters and reamers, and for use on this work are provided with a tooth rest which may be bolted to the wheel platen at one of its *T* slots. The ordinary place for the tooth rest, when in use, is directly in front of the wheel as in Fig. 60, where the face of a side milling cutter, Fig. 61, is being ground,

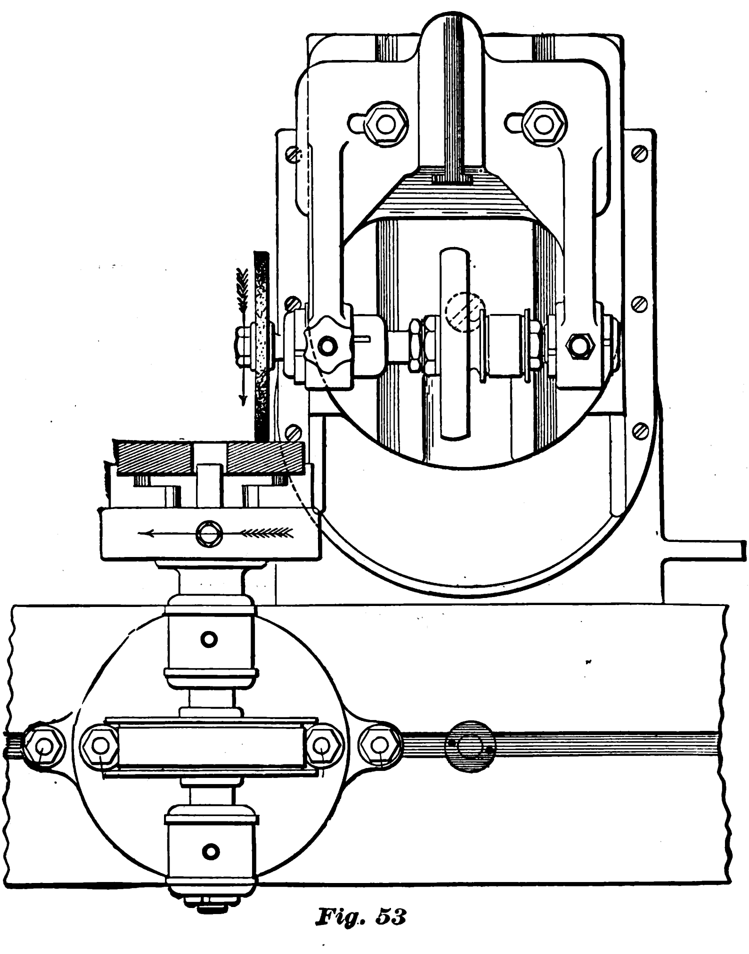


Fig. 53

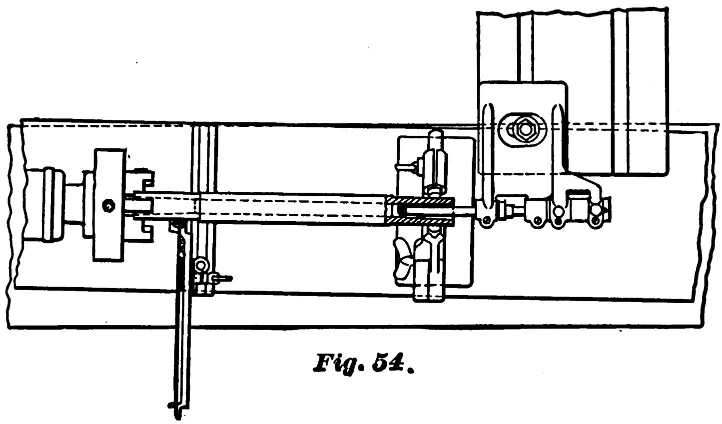


Fig. 54.

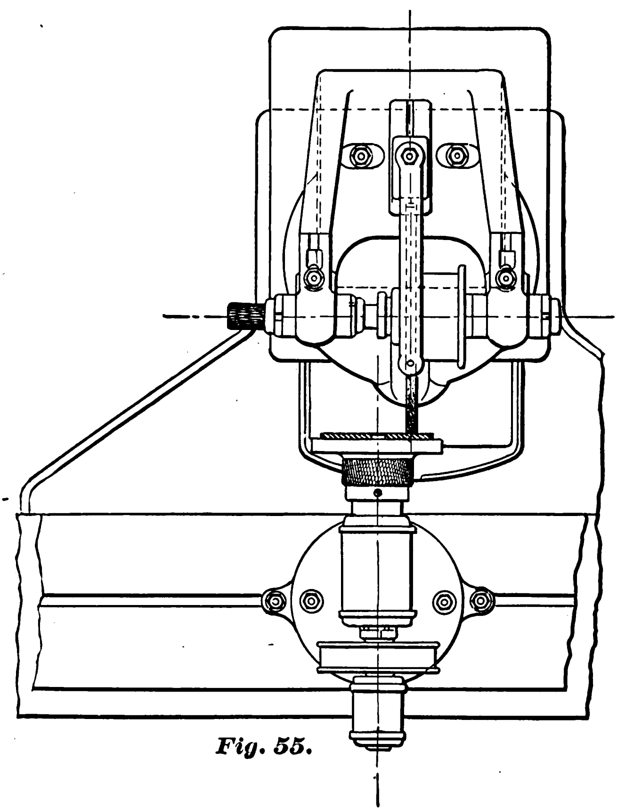


Fig. 55.

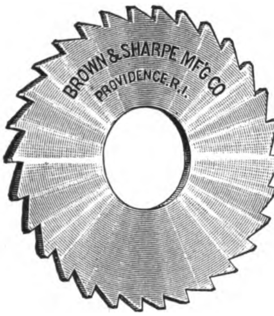


FIG. 56.

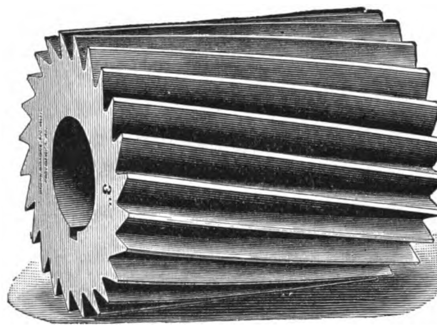


FIG. 57.

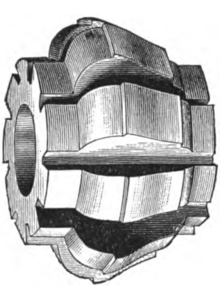


FIG. 58.

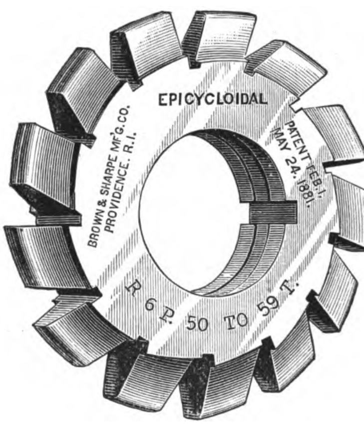


FIG. 59.

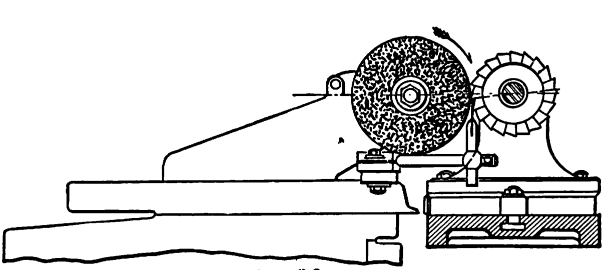


Fig. 60.

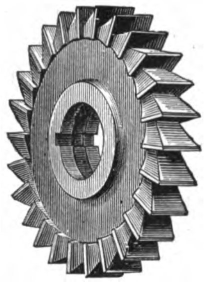


FIG. 61.

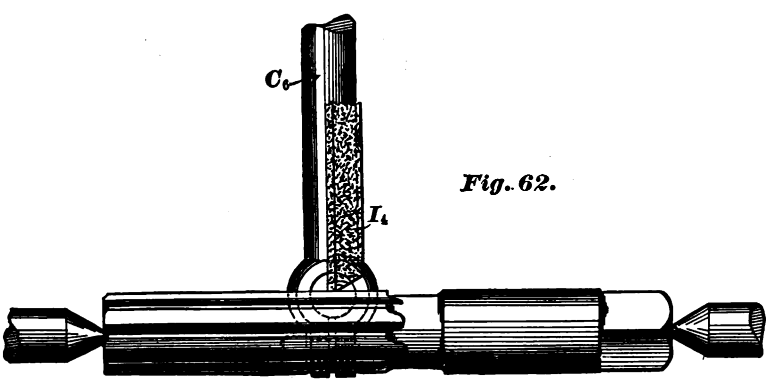


Fig. 62.

the cutter being held on a mandrel. To get the necessary amount of clearance or backing off to the tooth the end of the rest which supports the tooth must be set a little lower than the centre of the wheel, so that the ground surface will have the proper clearance angle. For this kind of work the wheel must, of course, be small enough to clear the tooth next above the one being ground. Fig. 62 is a top view, showing a reamer on centres. The machine is very quickly and conveniently operated by grasping with one hand the shank of the reamer, or the mandrel as the case may be, and holding the tooth firmly upon the tooth rest, while the other hand is engaged in feeding the reamer, or cutter, across the face of the wheel with the crank wrench, or hand wheel. When a tooth has been run by the wheel and off the tooth-rest the reamer, or cutter, may be turned to bring the next tooth upon the rest, and the table moved in the opposite direction while it is being ground. Thus a tooth can be ground at every stroke of the table when the grinding is done simply for the purpose of sharpening; but when it is necessary to grind a cutter to a certain diameter, it must, of course, be ground repeatedly until the required size is obtained. As the tooth slides over the tooth rest, in feeding it by the wheel, it is obvious that the clearance will always be the same whether the teeth are straight or spiral, since the relation of the tooth to the wheel is always the same at the grinding point. The wheel should be run in the direction indicated by the arrow; then the action of the wheel will tend to hold the tooth upon the rest.

Angular or taper cutters, such as shown in Figs. 63 and 64, may be ground by holding them on a mandrel, as in Fig. 60, but the swivel table must be set over for the proper taper. When the taper of the cutter is greater than two inches per foot, the feeding may be done with the cross-feed, and the wheel set as shown in and explained in connection with Fig. 46.

The side teeth of a cutter, Fig. 61 for example, may be ground on a Universal Grinding Machine, but the

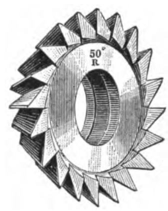


FIG. 63.

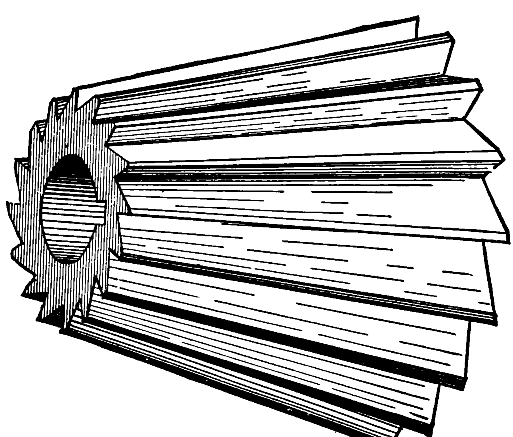


Fig. 64

machine is not recommended for such a purpose, as, in order to obtain the proper clearance, the wheel stand must be elevated so that the centre of the wheel will be above the tooth rest; the tooth rest, in this case, having to be set as high as the centre of the head stock spindle. Where many cutters of this class have to be ground, or in fact for manufacturing establishments having a great deal of tool grinding we would recommend our special tool and cutter grinding machines as more convenient and economical.

Special Cutter Grinding Machinery

Our Nos. 1 and 2 Tool Grinders and No. 3 Cutter and Reamer Grinder are illustrated and described in our catalogue, and the No. 3 Universal Cutter and Reamer Grinder is more completely described and a number of its operations are shown in a special pamphlet, which is mailed, with the catalogue, to any address on application.

GAUGES AND CALIPERS.

Next in importance to a machine, which is directly used to produce true and accurate work, come the supplementary tools used in testing and determining the dimensions of the work. It is evident that unless these are accurate and trustworthy, there can be no certainty as to the true quality of the work which is tested by them. In the following pages we illustrate some of the measuring tools, manufactured at our works, which are well adapted to a large variety of work in connection with our grinding machines, as well as for general machine shop use.

Standaad Caliper Gauges.

Fig. 65 illustrates our Standard Caliper Gauges which are hardened and ground to the sizes marked on the side of the gauge. One end is adapted to outside and the other to inside calipering. The use of these gauges has the effect of eliminating, in a large degree, the personal differences in measuring work with ordinary calipers, and therefore results in a greater uniformity in the production of machine parts. These gauges are made in sizes from one-quarter to two and a half inches, varying by sixteenths up to two inches, and above that by eighths. Every full set is neatly arranged in a suitable box. Special sizes are usually made to order.

Standard Cylindrical Gauges.

Standard Cylindrical Gauges shown in Fig. 66, are arranged in sets, ranging in size from three-sixteenths to two inches diameter, varying by sixteenths. Other sizes are usually made to order. They are very convenient for ordinary machine work, as calipers can be

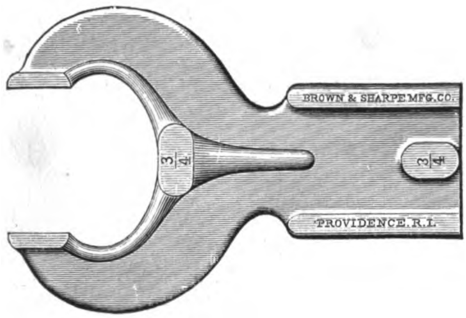


FIG. 65.

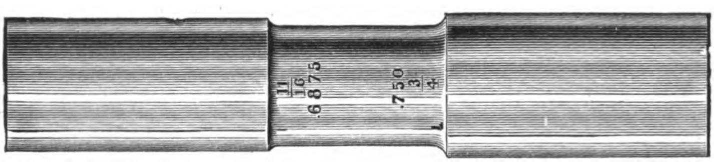


FIG. 66.

FIG. 67.

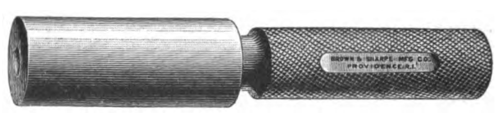


FIG. 68.

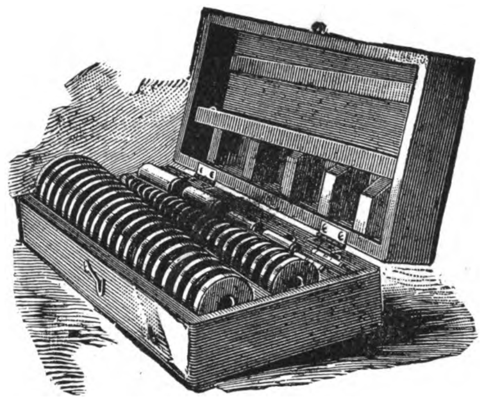


FIG. 69.

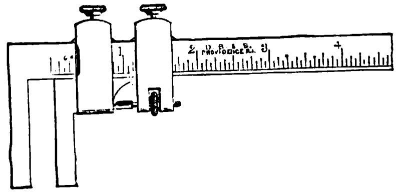


FIG. 70.

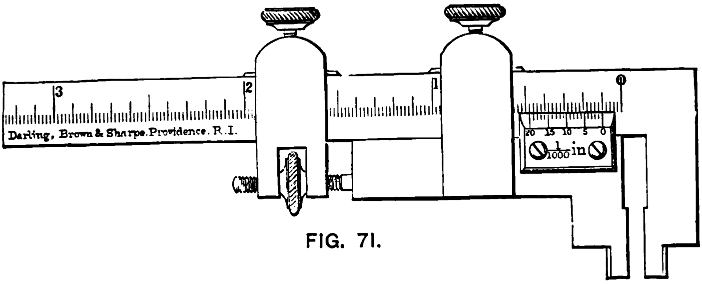


FIG. 71.

set and diameters transferred from them much more accurately than from a rule. For measuring work internally these gauges can be used directly, without the use of calipers.

Standard Internal and External Cylindrical Gauges. The more costly Standard Internal and External Cylindrical Gauges are illustrated in Figs. 67 and 68. They are arranged in boxes in sets ranging in size from one-quarter to two inches in diameter, and varying by sixteenths. The sizes are stamped on the handles as shown, both in common and decimal fractions.

Standard Reference Disks. The Standard Reference Disks, Fig. 69, are used, generally without handles, for setting calipers, testing measuring tools, and reference for sizes in shop practice. With handles, they are used in place of Standard Cylindrical Gauges, but are not recommended for constant use as substitutes for these. They are designed to serve principally as reference, not as working gauges. A complete set consists of 45 disks, varying by 16ths of an inch, from ¼ inch to 3 inches diameter, and six handles. A suitable box is furnished with each complete set of disks and handles.

Caliper Squares. The Caliper Square shown in Fig. 70 is a convenient tool for ordinary use. It is graduated on one side, to sixty-fourths, and on the other to hundredths. There are different sizes of these tools, varying from two to nine inches in length, either with or without the adjusting screw.

Vernier Calipers. For accurate measurements, the Vernier Calipers, illustrated in Figs. 71, 72 and 73, are very convenient, as they can be readily set to any desired distance, and the jaws are adapted to both outside and inside measurements. They are divided to read to the thousandth part of an inch on one side, and on the other to sixty-fourths, or to the one-fiftieth part of a millimeter ($\frac{1}{50}$ m. m. = .0007874 inch), as may be desired. The one shown in Fig. 71 is about three and five-eighths inches long and will measure, between the jaws, when fully open, one inch and eleven-sixteenths. This makes a convenient size to carry in the pocket. The caliper,

FRONT SIDE.

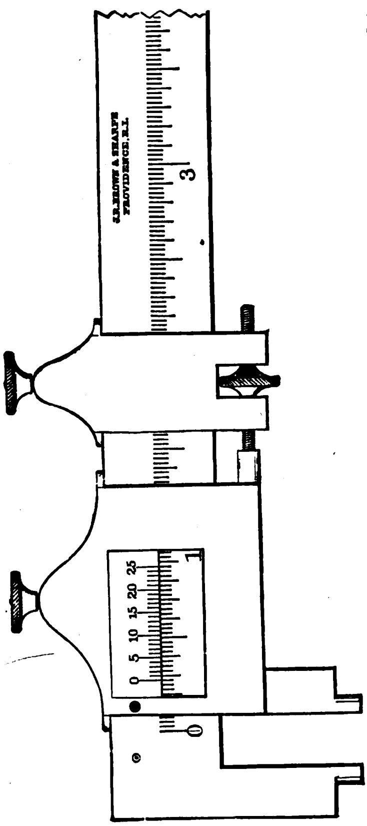


Fig. 72

Fig. 26 is a fac-simile of one side of the Vernier Caliper, which reads to thousandths of inches. On the other side (Fig. 27) are 64ths or 50ths of inches, to read without a Vernier. This instrument is furnished with both inside and outside calipers and points to transfer the distance with dividers. An explanation of the Vernier accompanies each instrument. These instruments are made of steel, and have the points tempered and jaws ground.

Price, in Morocco Case—6 in. $20; 12 in. $25; 24 in. $30.

BACK SIDE.

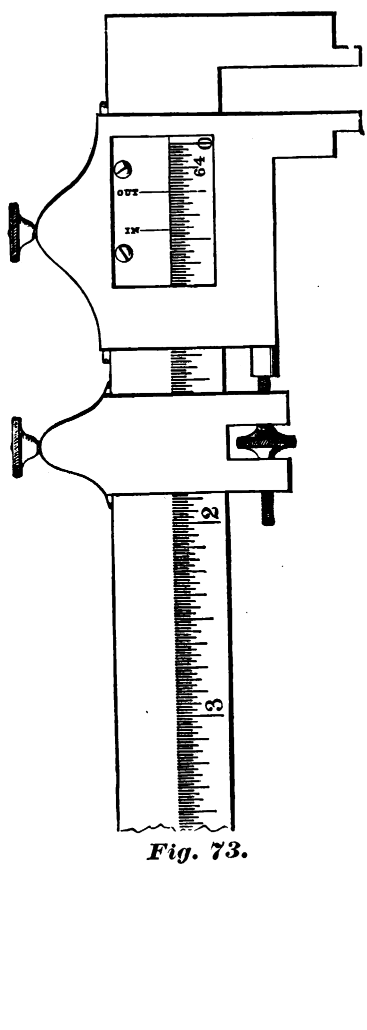


Fig. 73.

shown in Figs. 72 and 73 is a larger size and is made of different lengths, from six to twenty-four inches. Fig. 72 shows the side which reads to thousandths, and Fig. 73 the other side, which is divided to sixty-fourths, or French measure, if desired. Directions for reading and setting the caliper by the vernier accompany every instrument.

Micrometer Calipers. Perhaps the most convenient and accurate instruments for small external measurements are the Micrometer Calipers shown, full size, in Figs. 74 to 83. The smallest measures all sizes up to one-half inch and the largest, all sizes up to two inches. They are graduatde to read to thousandths of an. inch, but one-half and one-quarter thousandths are readily estimated. Some of the calipers have verniers by which sizes can be obtained to ten-thousandths. We also graduate some of these instruments to read to hundredths of a millimeter instead of to thousandths of an inch. When they are so graduated the tables of decimal equivalents are omitted.

The gauge screws are encased, and protected from dirt and liability to injury. The parts most subject to wear are hardened, and means of adjustment are provided to compensate for wear of the screw or nut. The decimal equivalents stamped on the frame are very convenient, and render possible the immediate expression of readings in eighths, sixteenths, thirty-seconds and sixty-fourths.

The chief mechanical principle embodied in the construction is that of a screw free to move in a fixed nut. An opening, to receive the work to be measured, is afforded by the backward movement of the screw, and the size of the opening is indicated by the graduations.

The pitch of the screw is forty to the inch. The graduation of the hub, in a line parallel to the axis of the screw, is forty to the inch, and is figured, 0, 1, 2, etc., every fourth division. As the graduation conforms to the pitch of the screw, each division equals the

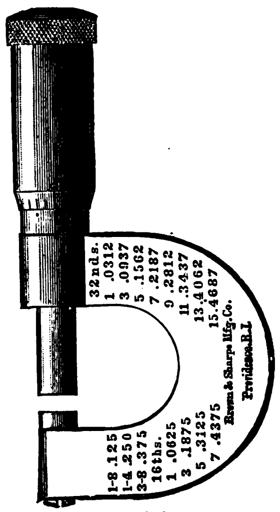


FIG. 74.

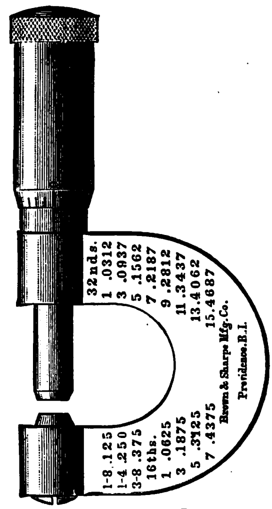


FIG. 75.

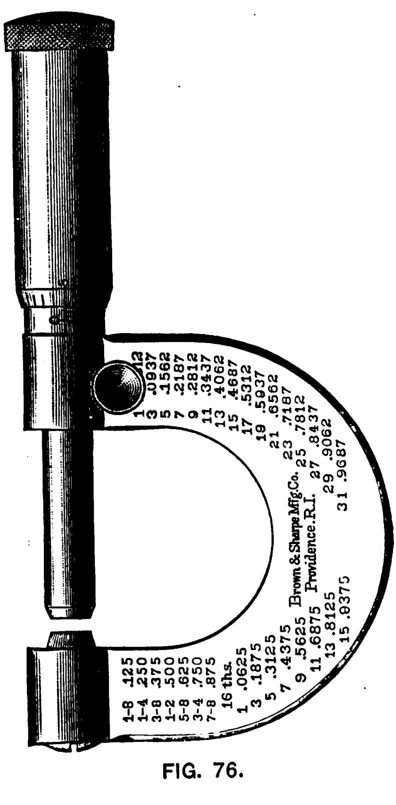


FIG. 76.

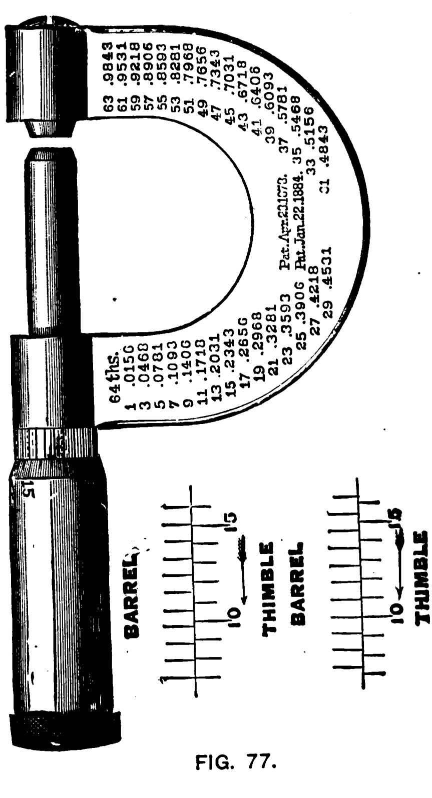


FIG. 77.

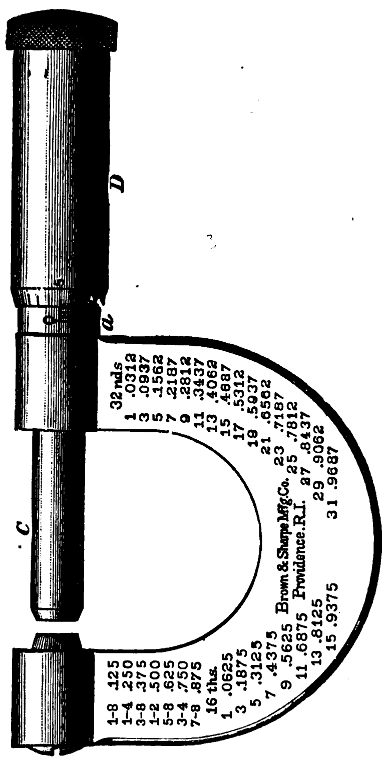

D
a
C
32 nds
1 .0312
3 .0937
5 .1562
7 .2187
9 .2812
11 .3437
13 .4062
15 .4687
17 .5312
19 .5937
21 .6562
23 .7187
25 .7812
27 .8437
29 .9062
31 .9687
1-8 .125
1-4 .250
3-8 .375
1-2 .500
5-8 .625
3-4 .750
7-8 .875
16 ths.
1 .0625
3 .1875
5 .3125
7 .4375
9 .5625
11 .6875
13 .8125
15 .9375
Brown & Sharpe Mfg. Co.
Providence. R.I.

FIG. 78.

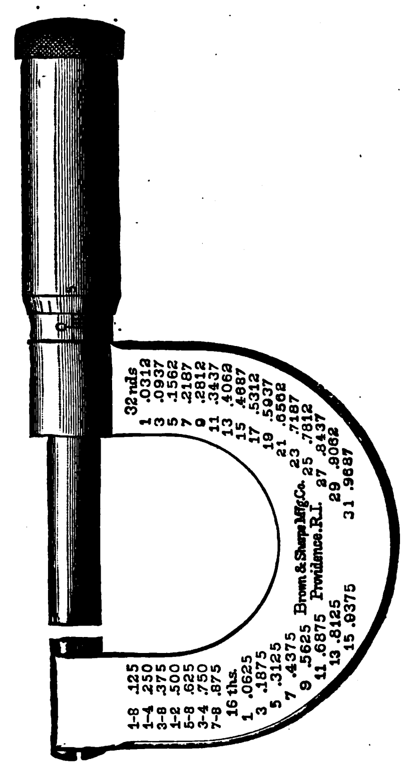

32 nds
1 .0312
3 .0937
5 .1562
7 .2187
9 .2812
11 .3437
13 .4062
15 .4687
17 .5312
19 .5937
21 .6562
23 .7187
25 .7812
27 .8437
29 .9062
31 .9687
1-8 .125
1-4 .250
3-8 .375
1-2 .500
5-8 .625
3-4 .750
7-8 .875
16 ths.
1 .0625
3 .1875
5 .3125
7 .4375
9 .5625
11 .6875
13 .8125
15 .9375
Brown & Sharpe Mfg. Co.
Providence. R.I.

FIG. 79.

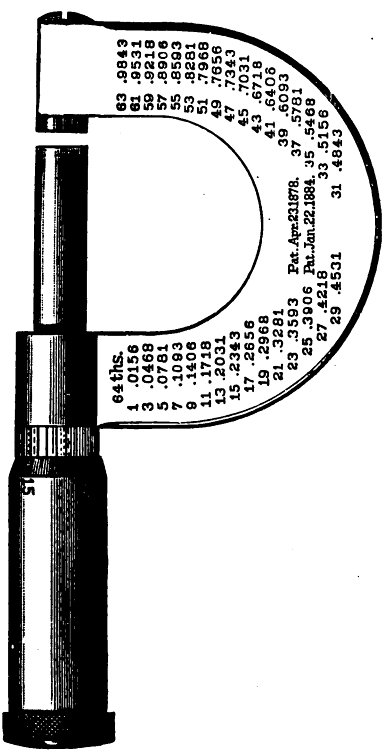

64ths.
1 .0156
3 .0468
5 .0781
7 .1093
9 .1406
11 .1718
13 .2031
15 .2343
17 .2656
19 .2968
21 .3281
23 .3593
25 .3906
27 .4218
29 .4531
31 .4843
33 .5156
35 .5468
37 .5781
39 .6093
41 .6406
43 .6718
45 .7031
47 .7343
49 .7656
51 .7968
53 .8281
55 .8593
57 .8906
59 .9218
61 .9531
63 .9843
Pat. Apr. 23 1878.
Pat. Jan. 22. 1884.
15

FIG. 80.

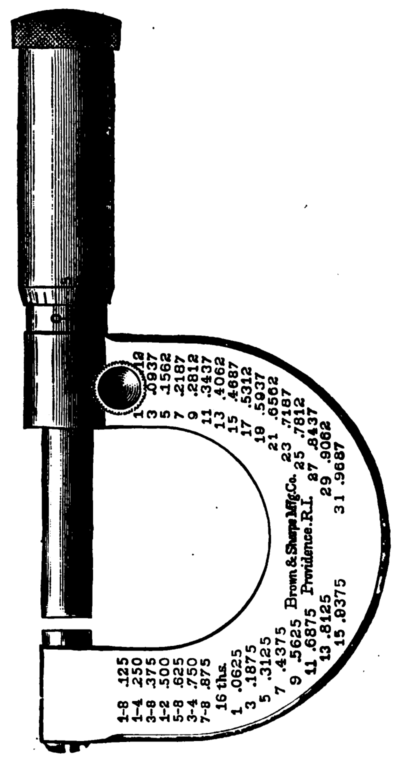

1-8 .125
1-4 .250
3-8 .375
1-2 .500
5-8 .625
3-4 .750
7-8 .875
16 ths.
1 .0625
3 .1875
5 .3125
7 .4375
9 .5625
11 .6875
13 .8125
15 .9375
Brown & Sharpe Mfg. Co.
Providence, R.I.
3 .0937
5 .1562
7 .2187
9 .2812
11 .3437
13 .4062
15 .4687
17 .5312
19 .5937
21 .6562
23 .7187
25 .7812
27 .8437
29 .9062
31 .9687

FIG. 81.

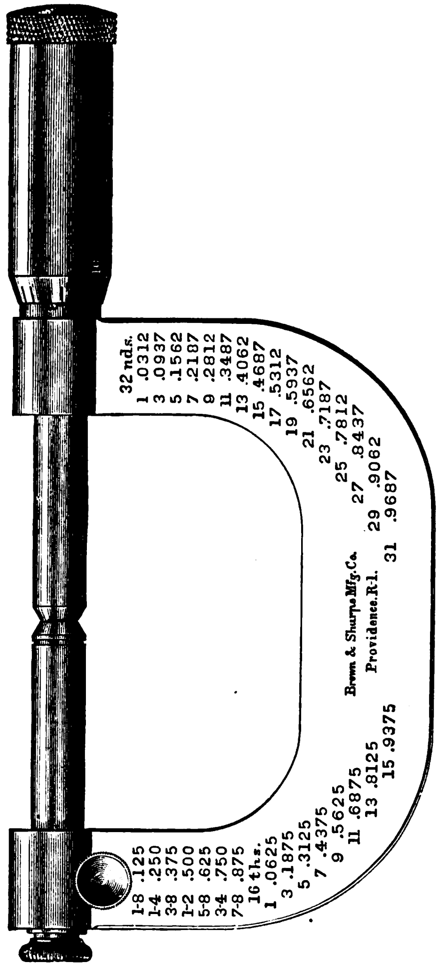


FIG. 82.

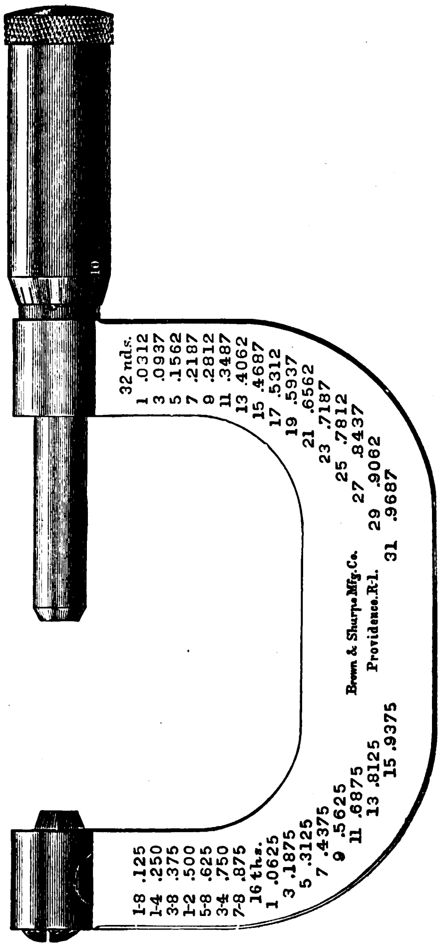


FIG. 83.

longitudinal distance traversed by the screw in one complete rotation, and shows that the caliper has been opened one-fortieth or .025 of an inch. The beveled edge of the thimble is graduated into twenty-five parts, and figured every fifth division, 0, 5, 10, 15, 20. Each division, when passing the line of graduations on the hub, indicates that the screw has made one twenty-fifth of a turn, and the opening of the caliper increased one twenty-fifth of one-fortieth, or a thousandth of an inch.

Method of Reading a Micrometer Caliper.

Hence, to read the caliper, multiply the number of divisions visible on the scale of the hub by twenty-five, and add the number of divisions on the scale of the thimble, from zero to the line coincident with the line of graduations on hub. For example :—As the caliper, Fig. 78, is set in the cut, there are three whole divisions visible on the hub. Multiplying this number by twenty-five and adding five, the number of divisions registered on the scale of the thimble, the result is eighty-thousandths of an inch. ($3 \times 25 = 75 + 5 = 80$.) These calculations are readily made mentally.

Limit Gauge.

In the manufacture of machinery where interchangeability is an essential feature, the gauging system is an important factor in the cost of production. For instance, if it be desired to have a lot of five-eighths inch (=.625) shafts made, all of which should fit the same size bearing, it would be a very expensive process to grind all these shafts exactly to .625 of an inch in diameter, as the care required and the time consumed in gauging and testing them would amount to a large portion of the time of production. But the time required to grind these shafts can be reduced considerably, if we can tell the workman that we will allow him a variation of .002 of an inch in the diameter; that is, we will reject all shafts which are gronnd less than .624 and more than .626 of an inch in diameter. To work conveniently between these limits the workman should be provided with *limit gauges*, or *snap gauges* as they are commonly called, which are made in various forms.

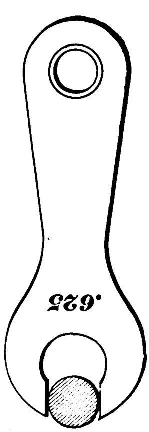


Fig. 84

Fig. 85

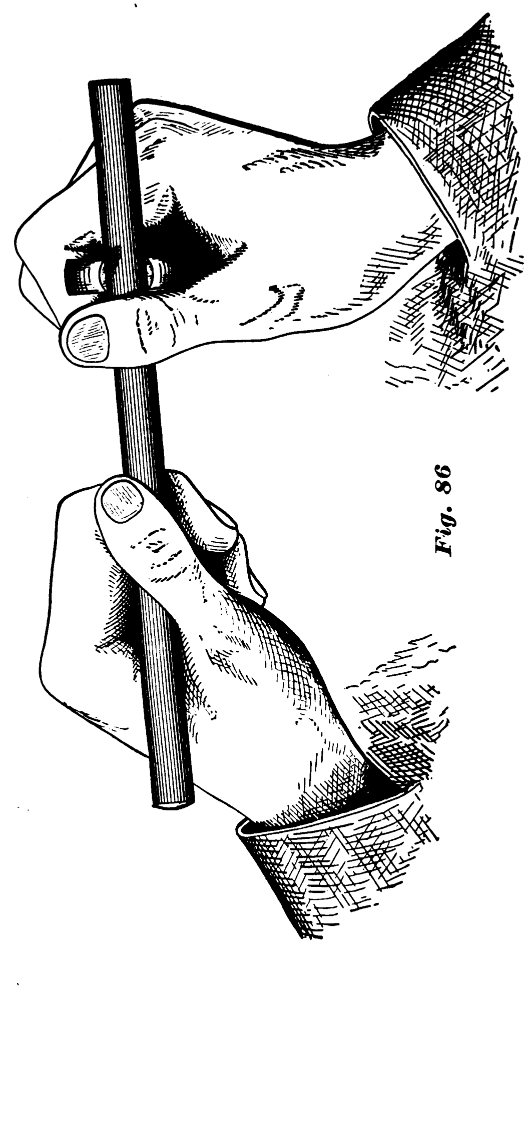


Fig. 86

Sometimes two gauges are made as shown in Fig. 84, one of which is ground to .624 and the other to .626 of an inch between the jaws, or whatever the limits may be. Instead of making two gauges they are sometimes made double-ended, i. e., one of the sizes at each end of one gauge. Another, and very convenient form is shown in Fig. 85, where both sizes are made between the same jaws at one end of the gauge. The larger size is at *A* and the smaller limit at *B*. The shaft, then, to be accepted, must enter freely at *A*, but not enter at *B*. When these gauges are made of good steel and properly hardened they wear very slowly. When they become worn the jaws can be frequently closed to the proper size again by careful peening. To reduce the wear to a minimum the shaft should be passed through the jaws but once in testing. A convenient way of applying the gauge is shown in Fig. 86. The gauge is held in the right hand while the shaft is passed between the jaws by pressing it with the thumb, then, instead of returning it through the jaws, it is withdrawn endwise.

Internal limit gauges are usually made in the form of the cylindrical gauges, Fig. 66, one end being ground to the small size and the other to the larger limit.

Limits Allowed.

In the example above, the limit of variation was assumed to be .002 inches. This, however, must necessarily vary with the nature of the work and must be determined for every particular piece. A limit of .0005 to .001 inches is usually adopted for close fits, such as sewing machine shafts and similar work, while for coarser work from .004 to .008 inches may be advantageously adopted. It is evident that the larger the limit the easier it will be to work within it, and the less the time consumed in measuring and testing the work. By the use of such a set of gauges for any particular work, the time consumed in measuring it can be reduced to a minimum.

Catalogue.

Special and Limit Gauges are made to order. Catalogue showing a full line of stock gauges and calipers is sent to any address upon application.

TABLE OF DECIMAL EQUIVALENTS.

8ths, 16ths, 32nds and 64ths of an inch.

8ths.

$\frac{1}{8}=.125$
$\frac{1}{4}=.250$
$\frac{3}{8}=.375$
$\frac{1}{2}=.500$
$\frac{5}{8}=.625$
$\frac{3}{4}=.750$
$\frac{7}{8}=.875$

16ths.

$\frac{1}{16}=.0625$
$\frac{3}{16}=.1875$
$\frac{5}{16}=.3125$
$\frac{7}{16}=.4375$
$\frac{9}{16}=.5625$
$\frac{11}{16}=.6875$
$\frac{13}{16}=.8125$
$\frac{15}{16}=.9375$

32nds.

$\frac{1}{32}=.03125$
$\frac{3}{32}=.09375$
$\frac{5}{32}=.15625$
$\frac{7}{32}=.21875$
$\frac{9}{32}=.28125$
$\frac{11}{32}=.34375$
$\frac{13}{32}=.40625$
$\frac{15}{32}=.46875$
$\frac{17}{32}=.53125$
$\frac{19}{32}=.59375$
$\frac{21}{32}=.65625$
$\frac{23}{32}=.71875$
$\frac{25}{32}=.78125$
$\frac{27}{32}=.84375$
$\frac{29}{32}=.90625$
$\frac{31}{32}=.96875$

64ths.

$\frac{1}{64}=.015625$
$\frac{3}{64}=.046875$
$\frac{5}{64}=.078125$
$\frac{7}{64}=.109375$
$\frac{9}{64}=.140625$
$\frac{11}{64}=.171875$
$\frac{13}{64}=.203125$
$\frac{15}{64}=.234375$
$\frac{17}{64}=.265625$
$\frac{19}{64}=.296875$
$\frac{21}{64}=.328125$
$\frac{23}{64}=.359375$
$\frac{25}{64}=.390625$
$\frac{27}{64}=.421875$
$\frac{29}{64}=.453125$
$\frac{31}{64}=.484375$
$\frac{33}{64}=.515625$
$\frac{35}{64}=.546875$
$\frac{37}{64}=.578125$
$\frac{39}{64}=.609375$
$\frac{41}{64}=.640625$
$\frac{43}{64}=.671875$
$\frac{45}{64}=.703125$
$\frac{47}{64}=.734375$
$\frac{49}{64}=.765625$
$\frac{51}{64}=.796875$
$\frac{53}{64}=.828125$
$\frac{55}{64}=.859375$
$\frac{57}{64}=.890625$
$\frac{59}{64}=.921875$
$\frac{61}{64}=.953125$
$\frac{63}{64}=.984375$

TABLE OF DECIMAL

Equivalents of Millimetres and Fraction of Millimetres.

mm.	*Inches.*	*mm.*	*Inches.*	*mm.*	*Inches.*
$\frac{1}{50}$	.00079	$\frac{26}{50}$	.02047	2	.07874
$\frac{2}{50}$	.00157	$\frac{27}{50}$	.02126	3	.11811
$\frac{3}{50}$	.00236	$\frac{28}{50}$	.02205	4	.15748
$\frac{4}{50}$	.00315	$\frac{29}{50}$	.02283	5	.19685
$\frac{5}{50}$	.00394	$\frac{30}{50}$	.02362	6	.23622
$\frac{6}{50}$	.00472	$\frac{31}{50}$	.02441	7	.27559
$\frac{7}{50}$	.00551	$\frac{32}{50}$	.02520	8	.31496
$\frac{8}{50}$	.00630	$\frac{33}{50}$	.02598	9	.35433
$\frac{9}{50}$	.00709	$\frac{34}{50}$	.02677	10	.39370
$\frac{10}{50}$	.00787	$\frac{35}{50}$	.02756	11	.43307
$\frac{11}{50}$	.00866	$\frac{36}{50}$	.02835	12	.47244
$\frac{12}{50}$	.00945	$\frac{37}{50}$	.02913	13	.51181
$\frac{13}{50}$	.01024	$\frac{38}{50}$	.02992	14	.55118
$\frac{14}{50}$	.01102	$\frac{39}{50}$	.03071	15	.59055
$\frac{15}{50}$	.01181	$\frac{40}{50}$	.03150	16	.62992
$\frac{16}{50}$	.01260	$\frac{41}{50}$	.03228	17	.66929
$\frac{17}{50}$	.01339	$\frac{42}{50}$	.03307	18	.70866
$\frac{18}{50}$	.01417	$\frac{43}{50}$	.03386	19	.74803
$\frac{19}{50}$	.01496	$\frac{44}{50}$	.03465	20	.78740
$\frac{20}{50}$	.01575	$\frac{45}{50}$	.03543	21	.82677
$\frac{21}{50}$	.01654	$\frac{46}{50}$	.03622	22	.86614
$\frac{22}{50}$	.01732	$\frac{47}{50}$	.03701	23	.90551
$\frac{23}{50}$	.01811	$\frac{48}{50}$	.03780	24	.94488
$\frac{24}{50}$	.01890	$\frac{49}{50}$	.03858	25	.98425
$\frac{25}{50}$	.01969	1	.03937	26	1.02362

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

TESTIMONIALS.

WM. B. BEMENT & SON,

MANUFACTURERS OF MACHINE TOOLS, STEAM HAMMERS, ETC.

Callowhill and 21st Streets, PHILADELPHIA, Feb. 13, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—Having used one of your smaller Universal Grinding Machines for four years and another of the larger size for nearly two years; it gives us pleasure to say that they produce economically and well all the kinds of work for which they are intended, and we could not dispense with them.

Yours truly,

WM. B. BEMENT & SON.

WM. SELLERS & CO.

PHILADELPHIA, Feb. 7, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—In reply to your inquiry of the 6th inst., we have to say that we have been using your "Universal Grinding Machine" almost constantly since June, 1880, with very satisfactory results. We hope to add more to our plant as business increases.

Yours truly,

WM. SELLERS & CO.

THE MACHINE TOOL WORKS, (FORMERLY FERRIS & MILES).

Twenty-fourth and Wood Streets, PHILADELPHIA, Pa., Feb. 7, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—We take pleasure in informing you that the Universal Grinding Machine of your make, which we have had in use since April, 1881, has given us very great satisfaction. In the first place, such a neatly designed and finished machine is an ornament to any machine shop, and in addition to this, is of the utmost utility in very many operations, which without it would have to be done in a slower and more clumsy way. By means of this machine we are enabled to grind up all our lighter spindles, reamers and mandrels, whether straight or taper—also our milling cutters. Besides these tools, etc., we find it extremely useful in grinding up many articles of our manufacture, for which it is peculiarly adapted by its facility and accuracy of adjustment, and the convenience with which it can be operated. When times improve we expect to order of you one of the larger size, for we think no well regulated machine shop can afford to be without two or more of these useful machines.

Yours very truly,

FRED'K. B. MILES.

BALDWIN LOCOMOTIVE WORKS, BURNHAM, PARRY, WILLIAMS & CO.

PHILADELPHIA, Feb. 11, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN :—Probably the best way of answering your inquiry of 7th inst., with reference to the Universal Grinding Machine of your manufacture that are now in service in our works, is to say that they give "Universal" satisfaction. We find them well adapted to the work to which we apply them, and have no unfavorable comment to make. Very truly yours,

BURNHAM, PARRY, WILLIAMS & CO.

PITTSBURG LOCOMOTIVE AND CAR WORKS.

PITTSBURG, PA., Feb. 14, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN :—Replying to yours of the 6th inst., we have been using one of your "Universal Grinding Machines" for about three years. It more than merits our expectations and covers such a large range of work, that in our opinion no locomotive or railway shop can afford to be without one of them.

Yours truly,

D. H. WIGHTMAN, SUPT.

PRATT & WHITNEY CO.,

MANUFACTURERS OF MACHINISTS TOOLS.

HARTFORD, CONN., U. S. A., Feb. 7, 1885.

BROWN & SHARPE MFG. CO.

GENTLEMEN :—We have had in use since August, 1882, one of your Universal Grinding Machines, and since then have bought two more. We find them indispensable in our shop. It has become with us, pretty well understood, that there is no way to make a good journal bearing and other cylindrical surfaces, except by grinding. Such a machine must be perfect in its construction to answer the purpose. We find that these machines respond to all the requirements. Very truly yours,

THE PRATT & WHITNEY CO.,

F. A. PRATT, PREST.

R. HOE & CO.,

PRINTING PRESS, MACHINE AND SAW MANUFACTURERS.

29 and 31 Gold Street, NEW YORK, March 4, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN :—We have used one of your Universal Grinding Machines for the last four or five years and regard it as one of our most serviceable tools. Indeed for grinding mandrels, reamers, circular cutters, etc., it has become indispensab'e.

It is a strong, well made machine, convenient to work, and in every respect well adapted to its purposes. Very truly yours,

R. HOE & CO.

WESTINGHOUSE AIR BRAKE CO.

PITTSBURG, PA., Feb. 9, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN :—We have had in use for some years one of your Universal Grinding Machines in our works at Pittsburg, one in the works of the Westinghouse Brake Co., Limited, in London, and one in their works at Paris. These machines have given entire satisfaction to our people in Europe so far as we know. I can only speak positively of the machine that we are using in the Brake Company's works here, which I can say has proven entirely satisfactory to us in every respect,—in fact so much so that we do not see how we could get along without it.

We will very gladly give parties desiring to purchase such machines any information we can in regard to it.

Yours truly,

THE WESTINGHOUSE AIR BRAKE CO.,

T. W. WELSH, SUPERINTENDENT.

POND MACHINE TOOL CO., SUCCESSORS TO DAVID W. POND, MANUFACTURER OF IRON WORKING MACHINERY.

WORCESTER, MASS., Feb. 10, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN :—We have used constantly since October, 1881, one of your Universal Grinding Machines and find it to be invaluable for tool room and special work, and find uses for the machine that we did not anticipate when ordered. Yours very truly,

POND MACHINE TOOL CO.,

DAVID W. POND, PRES.

MORSE TWIST DRILL AND MACHINE CO.

NEW BEDFORD, Mass., Feb. 12, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

DEAR SIRS :—We are duly in receipt of yours of the 6th and will comply with pleasure to your wish, in adding a favorable testimony to the value of your Grinding Machines as in use in our works. We have one Universal Grinding Machine and two of the Plain. All have given us satisfaction. The Universal Machine we find applicable to a large variety of purposes. It is thoroughly well made and conveniently constructed, readily and accurately adjusted, an effective, very handy machine.

Yours respectfully,

EDWARD S. TABER, TREAS.

THE SINGER MACHINE CO., AMERICAN FACTORY.

ELIZABETHPORT, N. J., Feb. 13, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—Replying to your letter of inquiry would say: We have used one of your Universal Grinding Machines in our Gauge department for about a year and a half, and another in our Tool department for more than one year. We have found them very valuable tools in both departments. We consider the machine admirably adapted to do the work for which it was designed.

Yours very truly,

THE SINGER MFG. CO.

L. B. MILLER, SUPT.

THE NEW HOME SEWING MACHINE CO.

ORANGE, Mass., Feb. 9, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—Replying to your letter of 7th inst., would say, we purchased one of your Universal Grinding Machines, March, 1878. The best recommendation we can give you is, since then we have purchased two others from you. The three have been constantly at work in our works giving perfect satisfaction. Faithfully yours,

NEW HOME SEWING MACHINE CO.

W. L. GROUT, SUPT.

WHITE SEWING MACHINE CO.

CLEVELAND, Ohio, Feb. 20, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—We take pleasure in stating that after a practical test of your "Universal Grinding Machine" since June, 1880, we are highly pleased with results. We do not hesitate to recommend it as a convenient, economical and practical machine. Very respectfully,

WHITE SEWING MACHINE CO.

SETH THOMAS CLOCK CO.

THOMANSTON, Conn., Feb. 21, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—Your favor of 7th came duly to hand. In reply we give you the reply of our foreman, Mr. Bowen. He says: I consider the Universal Grinder very valuable for finishing cast iron and soft steel, for sizing reamers and hardened arbors, and for all work requiring accurate and smooth fitting.

Yours respectfully,

SETH THOMAS CLOCK CO.

SETH THOMAS, SECY.

HOPEDALE MACHINE CO.

HOPEDALE, Mass., Feb. 11. 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—We have had in our shops for the past two or three years two of your Grinding Machines. One "Universal" Grinder, and one "Special" Grinder. We use the "Universal" in finishing all our better class of work which is cylindrical, and also in finishing holes. The work we finish on it runs as a rule from one and a half inches to fifteen inches in length and from half an inch to an inch and a quarter in diameter. Very rarely indeed do we have to lap any of the work which has been done on your machines. The machines are entirely satisfactory to us. Yours truly,

HOPEDALE MACHINE CO.

GEO. DRAPER, AGT.

GLOBE WORKS.

ACCRINGTON, ENGLAND, Feb. 25, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—We have pleasure in saying that we are well satisfied with the "Universal Grinding Machine" we had from you in May, 1882. We consider it well adapted for the purpose for which it is used.

We remain, yours truly,

HOWARD & BULLOUGH.

SALFORD IRON WORKS.

MANCHESTER, ENGLAND, March 12, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

DEAR SIRS:—We thank you for the copy of your book on the "Universal Grinding Machine," which is just to hand. We take this opportunity of informing you that the machine we had in 1883 has been of much service to us. We find it specially suitable in correcting any irregularities in work after leaving the lathe or other tools. For truing up surfaces after hardening, the "Universal Grinding Machine" is by far the best that we have seen.

We are, yours truly,

MATHER & PLATT.

THE WESTINGHOUSE BRAKE CO., LIMITED.

Canal Road, York Road, King's Cross, LONDON, ENGLAND, March 12, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

DEAR SIRS:—We have much pleasure in informing you that we have had one of your small "Universal Grinding Machines" in use in our London works since 1880, and one in our Paris works since 1881. We find these machines exceptionally well made, requiring little or no repairs, and well protected, at the wearing parts, from the emery. They have given entire satisfaction, and we find them to be one of the most useful tools we have, and indispensable for doing our work economically. I take great pleasure in recommending these to any one in want of such tools. Your emery wheels for these machines are superior to any others we can obtain.

Yours truly,

G. W. SIMONDS,

Mechanical Superintendent.

J. E. REINECKER, WERKZEUGFABRIK.

CHEMNITZ, SAXONY, GERMANY, March 3, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—It affords me pleasure to say that I am unusually well satisfied with the "Universal Grinding Machine" bought of you in February, 1880. This machine has been of very great advantage to me in the manufacture of my special tools, and has placed me in condition to execute a class of work which it would not have been possible to do in the most desirable manner without it. Every large machine shop should have one of these machines, especially those devoted to the manufacture of sewing machines, fire-arms and small tools. I would also say that you have left nothing to be desired in the construction and accuracy in workmanship of this machine. Should opportunities offer to recommend the character of the above mentioned machine to those interested, I shall take great pleasure in so doing.

I am very respectfully yours,

J. E. REINECKER.

E. CORNLEY, SEWING MACHINE MANUFACTURER.

82 Boulevard de Sebastopol, PARIS, FRANCE, March 18, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

GENTLEMEN:—I have had in use since July, 1876, one of your "Universal Grinding Machines," and I find it of the greatest utility for making cylindrical parts, such as shafts, arbors, and needle bars for sewing machines, etc., which can be made thereon with the greatest facility and accuracy and without the employment of skilled labor, thus producing them at a low price, in a most perfect state. I consider the machine as indispensable in any machine shop for the manufactnre of the above parts. Yours very truly,

E. CORNELY.

ATELIERS DUCOMMUN—HEILMANN-DUCOMMUN & STEINLEN.

MULHOUSE (ALSACE), March 5, 1885.

TESTIMONIAL—

We bought in 1876, at the Exposition in Philadelphia, a "Universal Grinding Machine" of the Brown & Sharpe Mfg. Co. We use this machine for correcting hardened steel pieces, such as cylindrical gauges, both internal and external, reamers, twist drills, cylindrical cutters, lathe arbors with tempered collets, collars, etc., the ingenious arrangements of the machine permitting its use for a great variety of work. It takes the place of a grinding device we had arranged to use on our lathes, and saves the time required to attach it for each operation. In 1879 we ordered another of these machines for one of our patrons, and are now about to purchase a third. In our opinion, all workshops of importance should be provided with a Universal Grinding Machine.

HEILMANN-DUCOMMUN & STEINLEN.

MAISON DES MACHINES A BOUDRE DE WILLCOX & GIBBS. ET DU BOUSO BEODEUR UNIVERSAL.

E. CORNLEY, 82 Boulevard de Sebastopol, PARIS, FRANCE, April 28, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I., ETATS UNIS.

Depuis le mois de Juillet, 1876, je me sers de vos machines à meuler automatiques et je trouve qu'elles sont de la plus grande utilité et même de première nécessité pour la fabrication de toutes les pièces cylindriques, d'une certaine longueur, comme les arbres et les porte aiguilles, des machines à coudre ou autres. Ces pièces pouvant être terminées et finies sur votre machine avec la plus grande précision par n'importe quel mécanicien leur prix de revient et beaucoup diminué. Je considère vos machines absolument indispensables, dans toute fabrique ou on vent produire industriellement les pièces mentionnées ci-dessus avec une parfaite précision et à bon marché.

Agreez Messieurs mes salutations empressées. E. CORNLEY.

ATELIERS DUCOMMUN—HEILMANN-DUCOMMUN & STEINLEN.

MULHOUSE (ALSACE), March 5, 1885.

ATPESTATION.

Nous avons acheté en 1876 à l'Expositiod de Philadelphie une machine à rôder universelle de la Brown & Sharpe Mfg. Co. Nous nous servons de cette machine pour la rectification des pièces trempées, telles que jauges cylindriques, arbres de tours à collets trempés, manchons, etc., ses dispositions ingénieuses permettent de l'utiliser aux travaux de rôdage les plus variés. Elle remplace avantageusement l'appareil à rôder que nous montions sur nos tours et qui nécessitait une installation préalable pour chaque opération. En 1879 nous avóus été chargés de procurer une machine analogue à un de nos clients et nous sommes sur le point d'en placer une nouvelle. A notre avis, chaquc atelier de construction d'une certaine importance devrait être pourvu d'une machine à rectifier universelle du type en question.

HEILMANN-DUCOMMUN & STEINLEN.

J. E. REINECKER, WERKZEUGFABRIK, CHETNITZ, I S.,

CHEMNITZ, den 3 Marz, 1885.

BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

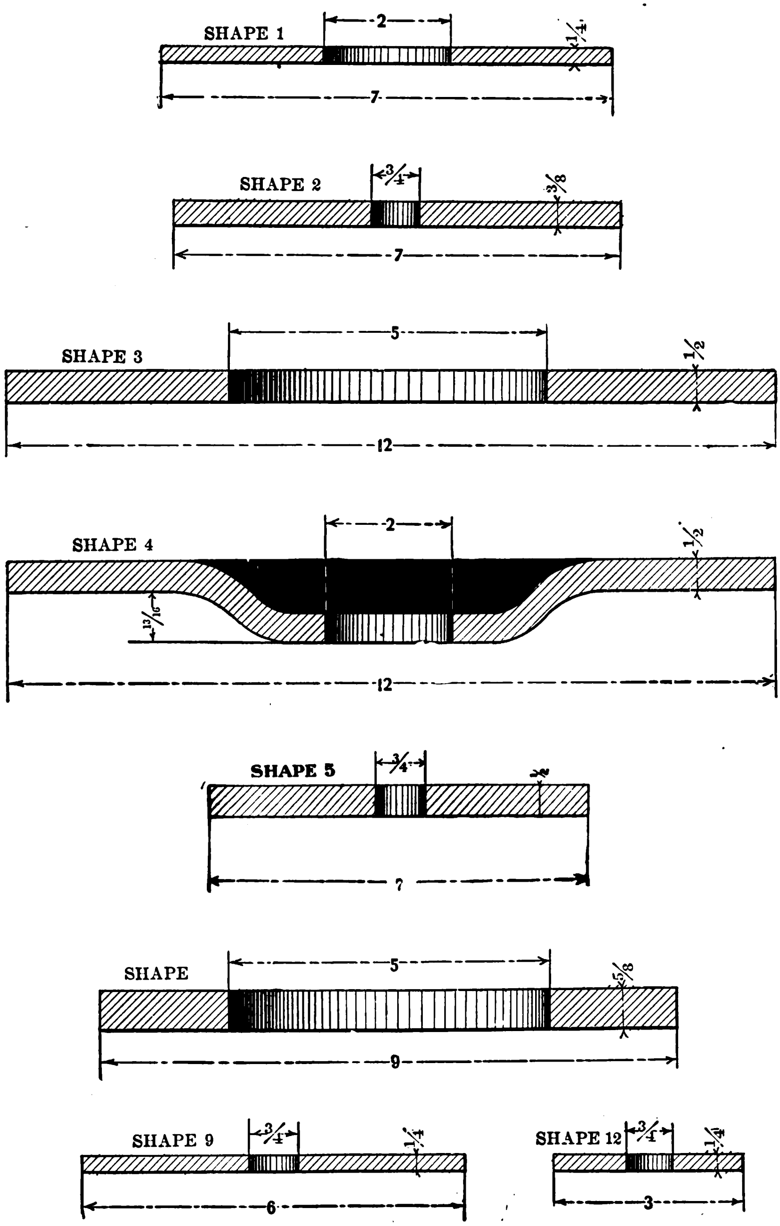
Mit meinem heutigen Ergebenen, habe ich das Vergnügen Ihnen mittheilen zu können, dass ich mit der im Februar, 1880, von Ihnen bezogenen "Universal Grinding Machine" ganz ausserordentlich zufrieden bin. Diese Maschine hat mir in meiner Special Fabrikation von Werkzeugen, sehr grosse Vortheile gewährt; und mich in den Stand gesetzt Arbeiten auszuführen, die ich ohne dieselbe in der gewünschten Weise, nicht hätte fertig stellen können. Derartige Maschinen sollten in keiner grösseren Maschienfabrik, noch weniger aber in Nähmaschinen, Werkezeug, und Gewehr Fabrihen fehlen. Ausserdem, muss ich noch erwähnen, dass auch die Ausführung betreffender. Maschine in ihren einzelnen. Theilen in Bezug auf Accurrtesse, nichts zu wünschen übrig lässt. Solite sich mir die Gelegenheit bieten, über die Eigenschaften dieser Maschine sich dafür Interessirenden berichten zu können, so soll mir dieses nur Vergnügen machen.

Mich Ihneu ergebenst empfohlen haltend, zeichnet,

Mit vorzüglichster Hochachtung,

J. E. REINECKER.

CUTS ⅓ SIZE



SHAPE 1
2
¼
7
SHAPE 2
¾
⅜
7
SHAPE 3
5
½
12
SHAPE 4
2
½
13/16
12
SHAPE 5
¾
7
SHAPE
5
⅝
9
SHAPE 9
¾
¼
6
SHAPE 12
¾
¼
3

LIST OF EMERY WHEELS.

The wheels listed below are those which our experience has shown to be suitable for the various purposes specified. Special cases may demand changes in the grade letter, but under ordinary circumstances the list should be accepted as a guide.

The speed, diameter and width of wheels, and the number of the emery cannot be changed without changing the grade and cutting qualities of the wheels.

Water need not be used on work held in the head-stock spindle on Universal Grinding Machines, such as saws, collars, boxes, etc., with wheels given in the list.

Cast Iron plates are an exception to this rule. They require a large supply of water with slow wheel speed when ground with the wheels specified in the list.

While there are many makers of good vitrified wheels we obtain those given in this list from the Norton Emery Wheel Co., of Worcester, Mass., for this company up to the present time has most carefully graded these wheels and most nearly met our requirements. This list may be used in ordering from the Norton Emery Wheel Co.

No. 1 UNIVERSAL GRINDING MACHINE.

To grind hardened steel bushings, spindles, etc.—Shape 1, Emery 100, Grade I, Mixture 14–½–A, Speed 2,800 to 3,300.

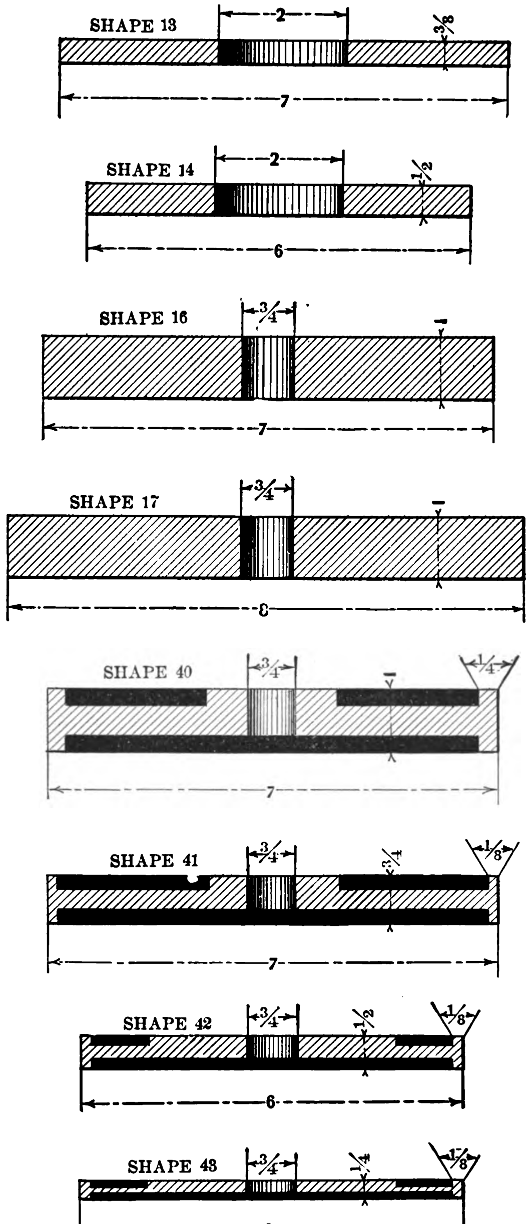
To grind soft steel—Shape 1, Emery 100, Grade M, Mixture 13–A, also Emery 150, Grade K, Mixture 14–A, Speed 3,000 to 3,300.

To grind cast iron—Shape 1, Emery 60, Grade F, Mixture 15–A, Speed 2,100 to 2,800.

To grind the sides of thin disks or hardened work, such as saws, collars, sides of cutters, etc.—Shape 1, Georgia Corundum No. 36, Grade J, Mixture X–17–C, Speed 3,000.

To grind holes see below.

CUTS ⅓ SIZE



SHAPE 13
2
3/8
7
SHAPE 14
2
1/2
6
SHAPE 16
3/4
1
7
SHAPE 17
3/4
1
8
SHAPE 40
3/4
1
1/4
7
SHAPE 41
3/4
3/4
1/8
7
SHAPE 42
3/4
1/2
1/8
6
SHAPE 43
3/4
1/4
1/8
6

No. 2 UNIVERSAL GRINDING MACHINE.

To grind hardened steel, spindles, etc.—Shape 3, Emery 60, Grade H, Mixture 15–A. Emery 60. Grade M. Mixture 13–A, Speed 2,000.

To grind soft steel—Shape 3. Emery 100. Grade L, Mixture 14–A, Speed 2,000.

To grind sides of disks, etc.—Shape 5. Emery 60. Grade J, Mixture 14½–A. Speed 2,800.

To grind long or large soft steel pieces—Shape 3. Emery 100, Grade N, Mixture 5–A, also Emery 100. Grade O, Mixture 6–A.

To grind thin saws, etc.—Shape 2. Corundum 36, Grade J, Mixture X–17–C, Speed 2,800.

To grind holes see below.

No. 2 UNIVERSAL GRINDING MACHINE, IMPROVED.

To grind hardened steel, spindles, etc.—Shape 3. Emery 60, Grade H. Mixture 15–A, also Emery 60. Grade M. Mixture 13–A, Speed 1,300 to 2,000.

To grind soft steel—Shape 3. Emery 100. Grade L, Mixture 14–A, Speed 2,000.

To grind long or large soft steel pieces—Shape 3. Emery 100, Grade N, Mixture 5–A, also Emery 100, Grade O. Mixture 6–A.

To grind collars, disks, saws, etc.—Shapes 1, 13 or 14, Georgia Corundum 36. Grade J. Mixture X–15–C. Speed 3,000.

To grind cast iron plates—Shape 8. Emery 60, Grade F, Mixture 15–A, Speed 1,300 to 2,000.

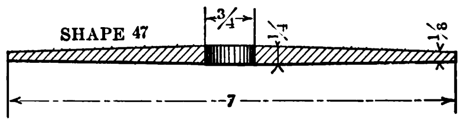
To grind cast iron spindles (solid)—Shape 3. Emery 60, Grade M, Mixture 13–A, Speed 1,300 to 2,000.

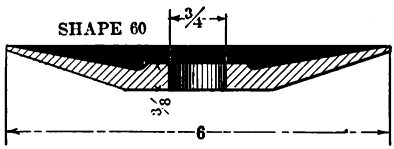
To grind hollow cast iron rolls—Shape 3. Emery 60, Grade F, Mixture 15–A. Speed 1,300 to 2,000.

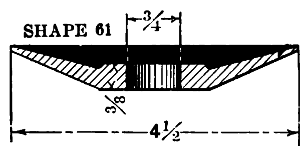
Any wheel listed for use on the No. 1 Universal Grinding Machine can be used on the No. 2 Universal Grinding Machine Improved.

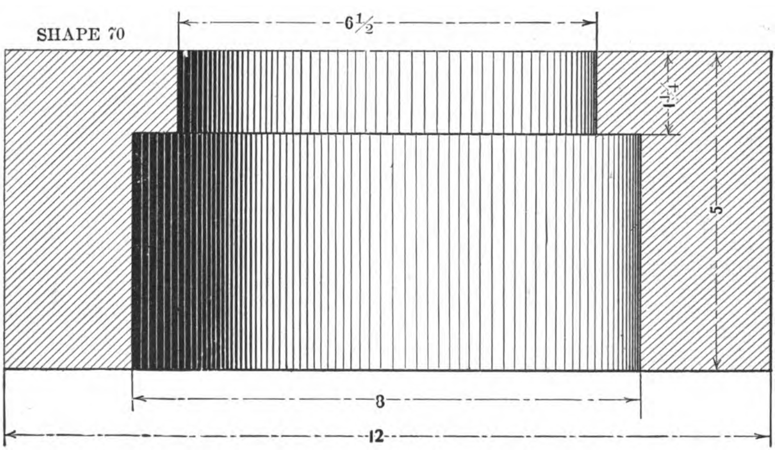
To grind holes see below.

CUTS ⅓ SIZE



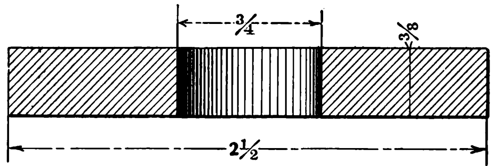






FOR INTERNAL GRINDING
CUTS FULL SIZE

SHAPES 80 TO 91



SHAPE	81	3/8 × 1/4 × 3/32	HOLE	SHAPE	86	1 × 1/4 × 1/4	HOLE
"	82	1/2 × 1/4 × 1/4	"	"	87	1 × 3/8 × 1/4	"
"	83	5/8 × 1/4 × 1/4	"	"	88	1 1/4 × 3/8 × 5/8	"
"	84	3/4 × 1/4 × 1/4	"	"	89	1 1/2 × 3/8 × 5/8	"
"	85	7/8 × 1/4 × 1/4	"	"	90	2 × 3/8 × 3/4	"

No. 3 UNIVERSAL GRINDING MACHINE.

Any wheel listed for use on the No. 2 Universal Grinding Machine Improved can be used on the No. 3 Universal Grinding Machine.

To grind close up to gear, collar or piston head of large radius—For hardened steel, Shape 4, Emery 60, Grade H, Mixture 15–A, also Emery 60, Grade M, Mixture 13–A, Speed 1,300 or 2,000.

For soft steel—Emery 100, Grade L, Mixture 14–A, also Emery 100, Grade N, Mixture 5–A, Speed 2,000.

WHEELS FOR INTERNAL GRINDING.

TO ROUGH OUT FOR ACCURATE WORK, BUT CANNOT BE CROWDED, FOR HARD AND SOFT STEEL AND CAST IRON.

Shapes 82, 83 and 84, Emery 46, Grade G, Mixture X–12–A, Speed 13,400, Fixture No. 2.

Shapes 84, 85 and 86, Emery 46, Grade G, Mixture X–12–A, Speed 12,200, Fixture No. 3.

Shapes 87, 88 and 89, Emery 46, Grade G, Mixture X–12–A, Speed 11,200, Fixture No. 4.

Shapes 90 and 91, Emery 46, Grade G, Mixture X–12–A, Speed 8,050, Fixture No. 5.

TO GRIND QUICKLY.

Shape 81, Emery 46, Grade J, Mixture X–10–A, Speed 16,800, Fixture No. 1.

Shapes 82, 83 and 84, Emery 46, Grade J, Mixture X–10–A, Speed 13,400, Fixture No. 2.

Shapes 84, 85 and 86, Emery 46, Grade J, Mixture X–10–A, Speed 12,200, Fixture No. 3.

Shapes 87, 88 and 89, Emery 46, Grade J, Mixture X–10–A, Speed 11,200, Fixture No. 4.

Shapes 90 and 91, Emery 46, Grade J, Mixture X–10–A, Speed 8,050, Fixture No. 5.

TO GRIND FOR FINISHING AFTER ROUGHING WHEELS HAVE BEEN USED.

Shapes 82, 83 and 84, Emery 120, Grade F, Mixture X–10–A, Speed 13,400, Fixture No. 2.
Shapes 84, 85 and 86, Emery 120, Grade F, Mixture X–10–A, Speed 12,200, Fixture No. 3.
Shapes 87, 88 and 89, Emery 120, Grade F, Mixture X–10–A, Speed 11,200, Fixture No. 4.
Shapes 90 and 91, Emery 120, Grade F, Mixture X–10–A, Speed 8,050, Fixture No. 5.

TO GRIND FOR NICE FINISH IN BRASS HOLES.

Shapes 82, 83 and 84, Emery Flour, Grade E, Mixture X–10–E, Speed 13,400, Fixture No. 2.
Shapes 84, 85 and 86, Emery Flour, Grade E, Mixture X–10–E, Speed 12,200, Fixture No. 3.
Shapes 87, 88 and 89, Emery Flour, Grade E, Mixture X–10–E, Speed 11,200, Fixture No. 4.
Shapes 90 and 91, Emery Flour, Grade E, Mixture X–10–E, Speed 8,050, Fixture No. 5.

The fixtures referred to above are the patented Internal Grinding Fixtures, made for use on our Universal Grinding Machines.