

March 26, 1940.

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2,195,050

METHOD AND MEANS FOR GRINDING

Filed Dec. 28, 1936

3 Sheets-Sheet 1

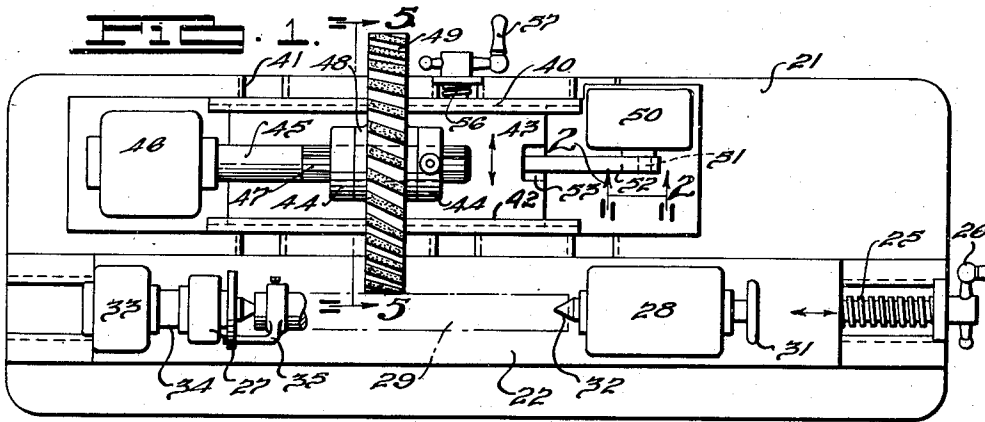
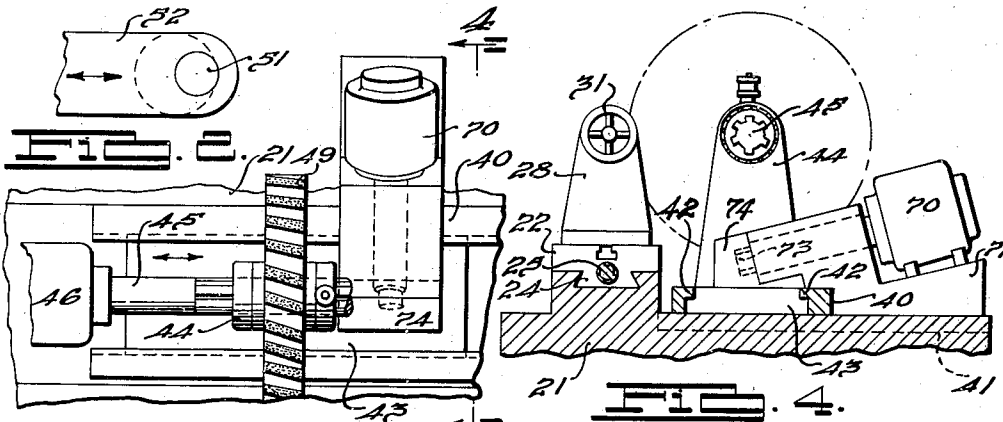
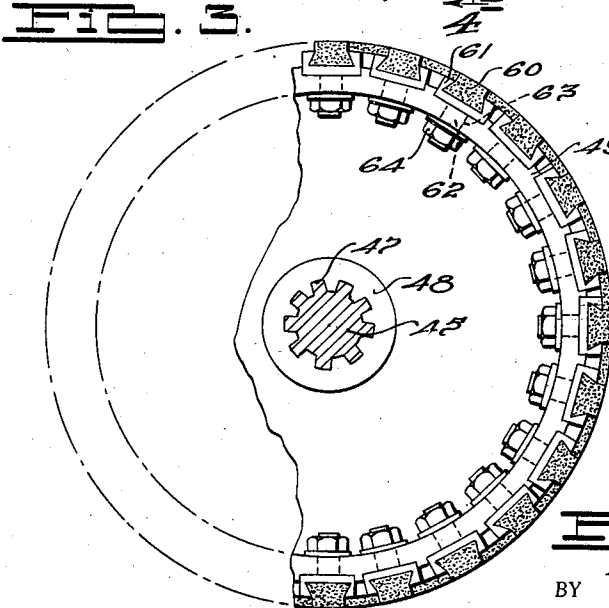
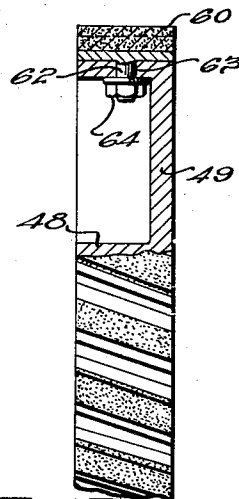


FIG. 5.

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3 Sheets-Sheet 2

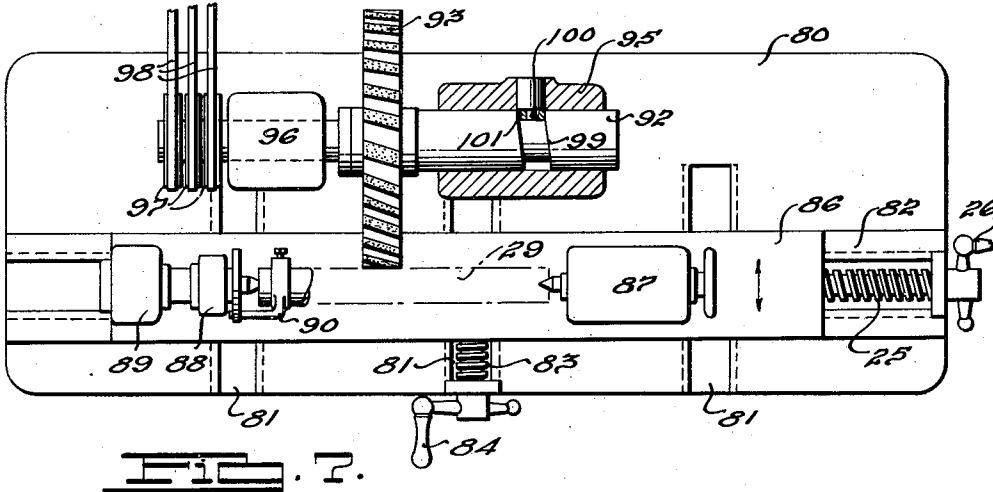


FIG. 8.

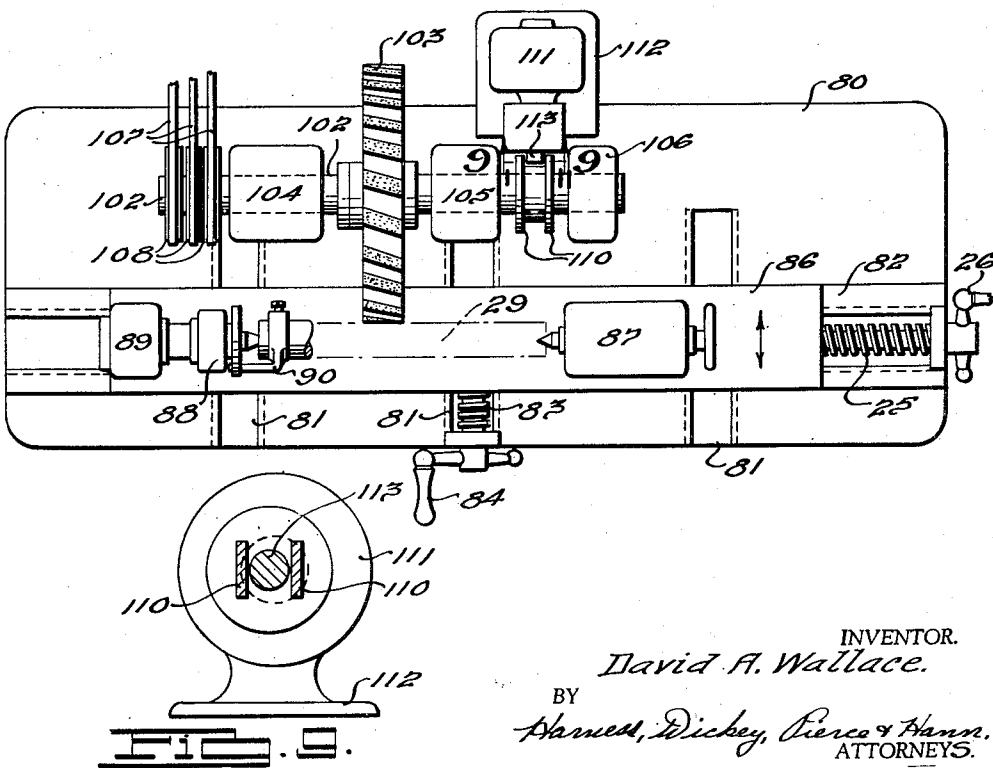


FIG. 9.

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3 Sheets-Sheet 3

FIG. 10.

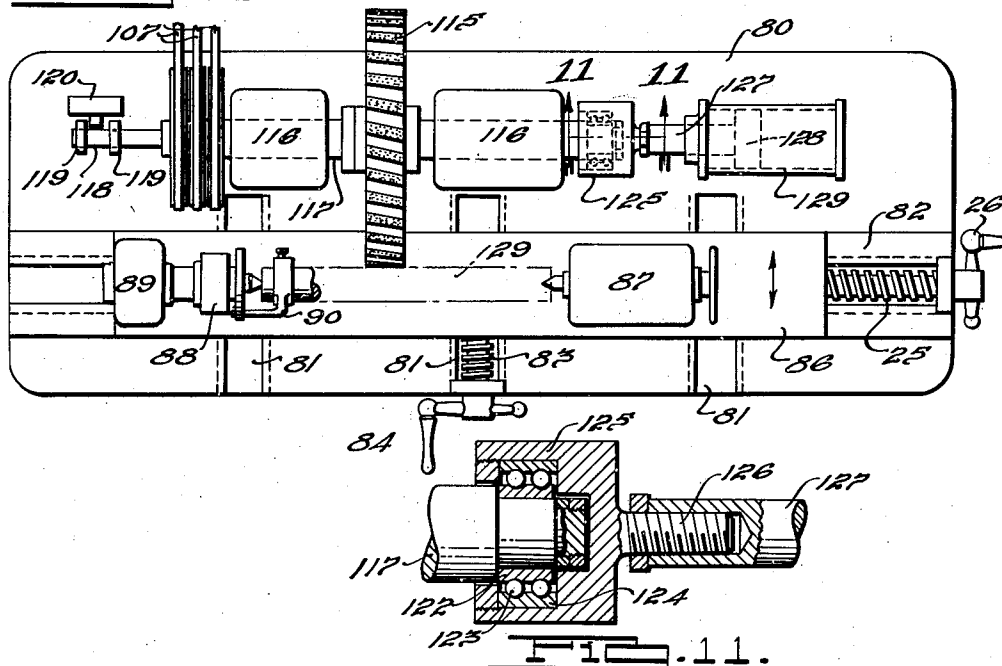


FIG. 11.

FIG. 12.

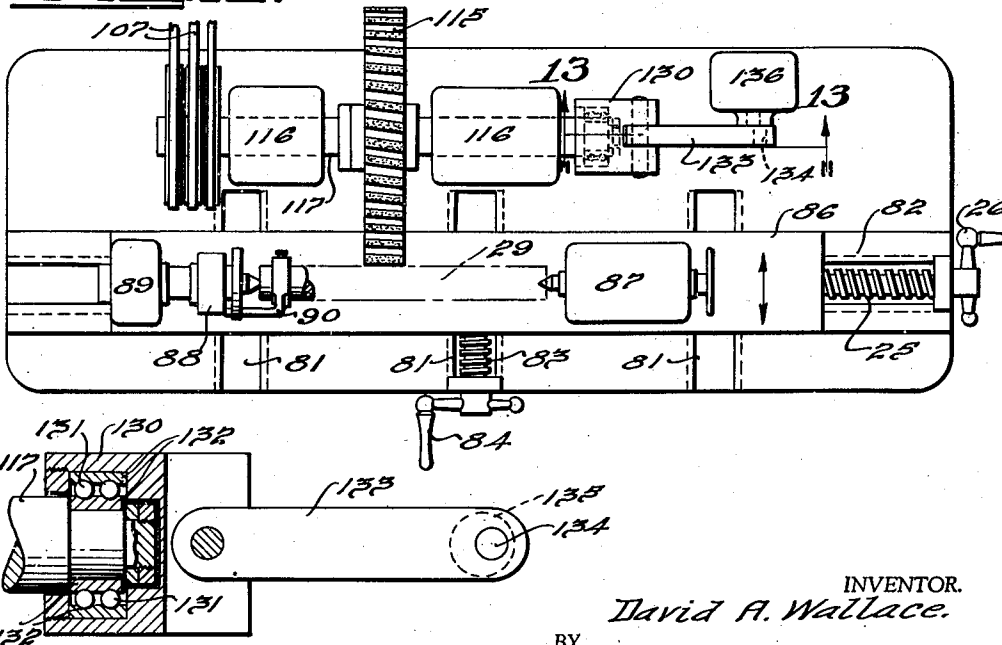


FIG. 13.

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UNITED STATES PATENT OFFICE

2,195,050

METHOD AND MEANS FOR GRINDING

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Application December 28, 1936, Serial No. 117,752

3 Claims. (Cl. 51—45)

This invention relates to a method of grinding and to a novel form of machine particularly adapted to the performance of the improved method. More particularly it relates to novel method and machine for grinding articles which is of highly efficient, novel and improved design.

Heretofore grinding operations on work elements have been effected by use of a grinding stone or wheel usually formed of some bonded abrasive material, such for example as silicon carbide, which is rotated at a relatively high speed in engagement with the work to be ground. The speed must of necessity be controlled within the safety factor of the stone or disintegration will result from the centrifugal forces encountered. In stones of conventional construction, irrespective of size, the peripheral speeds obtainable consistent with safety cannot now exceed 6000 to 7000 peripheral feet per minute.

It is a primary object of the present invention to provide an apparatus for and method of grinding articles in which the abrasive wheel is of such a character that it may be rotated at extremely high speed in order to greatly accelerate the rate of cut thereof as well as to obtain the inherently higher degrees of finish resulting from high speed grinding operations.

It is a still further object of the present invention to provide a method of grinding in which the abrasive wheel is bodily shifted axially and oscillated in an axial path as it is rotated in order that the lines cut upon the article being ground will lie along lines inclined to the plane of rotation of the wheel and consequently as the wheel is bodily reciprocated and the work moved or rotated as the case may be, the lines of cut of one revolution will cross those of another revolution.

The invention further contemplates the provision of a grinding wheel which is preferably of the built-up type having a metal body portion to which individual grinding elements are secured around the periphery thereof. The surfaces of these elements are preferably adjacent each other and are substantially continuous so as to form the periphery of the grinding wheel. Each element is preferably bonded under pressure to a holder which is mounted on the periphery of the metal body portion. In order to obtain a more complete understanding of preferable forms of wheels for use in the apparatus of the present invention and to obtain a detailed understanding of the manner in which the wheels may be most satisfactorily formed reference may be had to applicant's co-pending application, Serial No. 117,751 filed De-

cember 28, 1936, in which certain types of wheels are disclosed which have been found particularly adaptable for operation with the apparatus and method of the present invention.

It is an object of the present invention to provide a mounting for such improved grinding wheels which mounting not only makes possible a relatively high speed rotation of the grinding wheel but also inherently results in an axial reciprocation of the grinding wheel relative to the work in order that the surface of the work will be traversed with cross hatched lines of cut resulting from the combined axial reciprocation and rotation of the wheel with respect to the work.

It is another object of the present invention to construct the wheel and reciprocating parts of the device from light material to reduce the mass of the reciprocating parts. The combined rotary and reciprocatory movements at high speed has the faculty of preventing the loading of the wheel surface. The material cut by the abrasive elements as it is rotated and moved laterally in one direction, will be freed as the wheel is moved in the opposite direction and will be washed from the wheel surface by the coolant. The "sharpening" operations which were found necessary to eliminate the loaded surface are materially reduced and the life of the wheel proportionately increased. Such movements in rotation and reciprocation in the presence of the interrupted wheel face provides extremely rapid machining.

Because of the combined movements of the wheel, the interrupted wheel face and the unloaded condition of the abrading material, the grain size of the abrasive material may be larger and the stone may be softer, features which are very desirable.

Still further, the present invention contemplates the provision of structure in which extremely high speed ranges above 10,000 peripheral feet per minute may be obtained. The soft wheels with the larger grained material not only produce rapid cutting but provide a very high polish to the surface of the work piece when operated at such speeds. Especially is this true in the presence of the rapid reciprocatory movement imparted to the wheel.

It is a still further object of the invention to provide an apparatus in which the speed of axial reciprocation of the grinding wheel may be carefully co-related with the peripheral speed thereof in order that the angle of crossing of the lines of cut produced upon the work piece may be accurately regulated within relatively wide limits.

Many other and further objects, advantages and features of the present invention will become clearly apparent from the following specification when considered in connection with the accompanying drawings forming a part thereof.

In the drawings:

Fig. 1 is a plan view of a grinding machine embodying the improvements of the present invention illustrating more or less diagrammatically the operating mechanism thereof.

Fig. 2 is an enlarged fragmentary elevational view taken substantially on the line 2—2 of Fig. 1 illustrating in detail the eccentric and pitman utilized for producing the necessary axial oscillation of the grinding element.

Fig. 3 is a fragmentary plan view of a grinding machine embodying the features of a modified form of the present invention.

Fig. 4 is a fragmentary vertical sectional view taken substantially on the line 4—4 of Fig. 3 illustrating in detail the construction and arrangement of the parts in the machine illustrated therein.

Fig. 5 is an enlarged fragmentary axial end view of an abrasive wheel embodying the improvements of the present invention and particularly adaptable for utilization in connection with the grinding machine disclosed herein.

Fig. 6 is a fragmentary elevational view with parts broken away illustrating the construction of the improved composite grinding wheel and the manner in which the abrasive elements are secured thereon.

Fig. 7 is a plan view of a grinding machine illustrating a still further modified form of the present invention and showing a different means for producing the desired axial oscillation of the grinding element.

Fig. 8 is a plan view similar to Fig. 7 illustrating a still further modified form of the present invention.

Fig. 9 is an enlarged fragmentary sectional view taken substantially on the line 9—9 of Fig. 8 illustrating in detail the construction and arrangement of the eccentric mechanism.

Fig. 10 is a plan view of a grinding machine embodying a still further modified form of the present invention.

Fig. 11 is an enlarged fragmentary sectional view taken substantially on the line 11—11 of Fig. 10 illustrating in detail the mounting of one end of the drive shaft and the novel means for effecting oscillation of this shaft.

Fig. 12 is a plan view of a grinding machine embodying a still further modified form of the present invention.

Fig. 13 is an enlarged fragmentary sectional view taken substantially on the line 13—13 of Fig. 12 illustrating in detail the mechanism utilized for producing the desired axial oscillation of the grinding element.

With more particular reference to the drawings specifically to the form of the invention illustrated in Figure 1 thereof a grinding machine is shown which embodies the novel teachings of the present invention and is adapted to perform extremely satisfactory grinding operations at relatively high speeds. The specific form of the apparatus shown in Fig. 1 includes a bed or base 21 on which is mounted a work supporting table 22. The table 22 as is clearly seen is mounted for longitudinal movement with respect to the base member 21 in a pair of longitudinally extending trackways. This, as is conventional, is accomplished by means of an interlocking dovetail 24

which serves to slidably interconnect these members in order to permit relative longitudinal movement of one with respect to the other. In the specific form of the invention shown this relative longitudinal movement of the work supporting table 22 with respect to the base 21 is effected by means of a feed screw 25 actuated by a conventional operating handle 26.

The work supporting table 22 has mounted thereon a head stock 27 and a tail stock 28 for supporting a work piece 29 between the centers thereof. The tail stock 28 is provided with a conventional actuating handle 31 by which a center 32 of this tail stock is moved to and from engagement with the work to be ground. As is conventional in constructions of this general character, the tail stock 28 is adjustable longitudinally upon the work supporting table 22 so that it may be bodily moved relatively to the head stock in order to accommodate work pieces of relatively widely varying size. The head stock 27 is driven by means of a suitable source of power, such for example as an individual electric motor 33 which is carried upon and rigidly secured to a suitable support formed upon the work supporting table 22. A driving connection is provided between a work piece 29 and a shaft 34 of the head stock by means of a conventional dog 35.

The grinding unit of the present invention is mounted upon a table 40 which has a dovetail or slidable connection 41 with the base or bed 21 in order that this table 40 may be moved with respect to the bed 21 in a direction at substantially right angles to the direction of movement of the work supporting table. The grinding table 40 has preferably integrally formed thereon a pair of substantially parallel trackway elements 42 in which is mounted a base 43 of a member utilized to produce axial reciprocation of the grinding wheel. Integrally formed with the base member 43 are a pair of upwardly extending bearing supports 44 which are provided with co-axial apertures in their upper ends and which serve to provide a bearing for the outer end of a shaft 45. The shaft 45 is directly connected at its opposite end to a suitable electric motor 46 which serves to rotate the same.

The portion of the shaft 45 which extends through the uprights 44 is provided with a plurality of axially extending splines 47 which are adapted to interengage with suitable internal splines formed within a hub 48 of a grinding wheel 49. The hub 48 of the grinding wheel 49 has an axial length sufficient to fit snugly between the bearing support members 44 in order that axial movement of the supports with respect to the shaft 45 will cause a corresponding axial movement of the grinding wheel along the shaft 45 and it will be readily appreciated that the splineways 47 permit such axial movement without in any way interfering with the driving engagement between the shaft 45 and the grinding wheel 49.

As is clearly seen in Fig. 1 a suitable motor 50 is rigidly mounted upon the base or bed 21 of the apparatus and that the shaft projecting from this motor is provided with an eccentric 51 on which is journaled one end of a pitman 52 the opposite end of which is pivotally connected to a suitable bracket 53 integrally formed upon the base 43 of the oscillating member. It will therefore be readily appreciated that as the motor 50 is run the eccentric 51 and pitman 52 will effect a longitudinal oscillation of the base member 43 in the guideways 42 and will consequently effect an axial

movement of the bearing supports axially with respect to the shaft 45 which they surround. Inasmuch as the hub of the grinding wheel 49 is mounted directly and snugly between these up-
 5 rights it will be readily apparent that as the motor 50 is driven an axial movement of the grinding wheel will take place along the shaft 45. In the event that the motors 46 and 50 are driven simultaneously it will be apparent that the
 10 grinding wheel will be not only oscillated axially but will be rotated at the same time. The entire supporting base for the grinding apparatus which, as has been described above, is mounted for transverse movement with respect to the table
 15 21, may be advanced towards the work piece 29 by means of a feed screw 56 actuated by suitable operating cranks 57 clearly seen in the upper portion of Fig. 1.

The apparatus described above will operate a
 20 great deal more satisfactorily if a specific form of grinding wheel particularly adaptable to the high peripheral speeds obtainable with this apparatus is utilized. One form of such wheel particularly
 25 adaptable for this type of work and for use in connection with the apparatus shown in Fig. 1 is illustrated in detail in Figs. 5 and 6. This wheel preferably comprises a body portion 49
 30 which is preferably formed of a single integral casting and it has been found preferable to form the casting from some suitable relatively light
 35 exceedingly strong material, such, for example, as aluminum and its alloys. As has been explained above, the hub portion 48 of the grinding wheel is provided with internal splines adapted to
 40 engage the splines on the shaft 45 in order to effect a positive driving engagement with the wheel with respect to this shaft and yet at the same time permit relatively free axial reciprocation of the wheel on the shaft. The periphery of
 45 the wheel is preferably made up of a plurality of individual stones 60, each firmly seated and bonded within an individual receiving cup or mounting member 61. The cup or mounting
 50 member 61 for each of these stones is preferably deformed after the stones are placed therein in order to firmly grip the enlarged dovetailed base portion of the stone and retain the same firmly seated in the cup.

The cups 61 each preferably has secured thereto a projecting stud 62, which stud is adapted to project through a suitable aperture 63 in the periphery of the wheel and these studs are each externally threaded and adapted to receive nuts
 55 64 which securely retain the same in predetermined position upon the periphery of the wheel. In the form of the wheel shown, the exposed surfaces of each of the stones are shaped generally like parallelograms in order that the axial edges of the stones will be helically disposed with respect to the periphery of the wheel, consequently
 60 providing substantial spaces between each of the individual stones making up the peripheral grinding surface of the wheel as a whole.

The helical disposition of the individual stones making up the grinding surface of the wheel has been found particularly important inasmuch as the square corners of each of the stones serve to provide a greatly increased cutting action and it will be readily understood that in the event the
 70 wheel as a whole is utilized for grinding an area substantially parallel to the axis of rotation of the wheel the helical disposition of the stones serve to prevent the entire cutting edge of any of the individual stones coming into contact with
 75 the work piece throughout its entire length at

the same time, but rather results in a shearing action greatly increasing the rate of cut. The spacing of the individual stones upon the periphery wheel has been found to be particularly advantageous inasmuch as it provides adequate
 5 surface area to effect the cooling of the individual stones and provides a construction in which the individually mounted stones may conveniently be replaced as may be necessary.

In the modified form of the invention shown in
 10 Figs. 3 and 4 of the drawings substantially the same fundamental basic principles are utilized except that a modified means of obtaining axial oscillation of the grinding element during rota-
 15 tion is used. In this form of the invention an electric motor 70 is mounted upon a rigid support 71 permanently secured to the grinding table 40. This electric motor preferably has the support 71 facing in such a manner that it will serve
 20 as a bearing for the shaft of the motor. The shaft of the motor is provided with an eccentric portion 73 at its outer end which cooperates with a slot or recess formed in an upstanding block 74 secured to the oscillating bed 40. It will consequently be apparent that in this form of the
 25 invention rotation of the electric motor 70 serves to effect an oscillation of the bed 40 substantially of the same order as the oscillations obtained as a result of the pitman connection shown in Figure 1 of the drawings.

In Figure 7 is illustrated a still further modified form of the invention which is substantially different from the forms described above, but which, at the same time, retains the inherent advantages of the apparatus described. In this
 35 form of the invention the grinding machine comprises a bed or base frame 80 which is recessed and adapted to provide a pair of ways in which are mounted slides 81 serving to mount a work supporting table 82. It will be readily appreciated that the slides 81 serve to provide means
 40 by which the entire work supporting table may be shifted as a unit transversely of the bed 80 in order to feed the work piece toward the grinding apparatus. This feed is accomplished by a conventional feed screw 83 operated by a crank
 45 handle 84. The work supporting table 82 includes a pair of trackways or guides which serve to support a plate 86 which carries a tail stock 87 and a head stock 88 between the centers of which the work to be ground is mounted. As has been described above in connection with the preferred embodiment of the invention the work to be operated upon may be rotated by means of an electric motor 89 which serves to drive the work,
 50 the driving connection being established by a conventional dog 90.

A shaft 92 is provided for driving the grinding wheel 93 which wheel may be of substantially the construction shown in Figures 5 and 6 of the drawings. This shaft is mounted for rotation in bearings 95 and 96, which are preferably rigidly supported upon the bed 80 of the apparatus. The shaft 92 has secured adjacent one end thereof a plurality of pulleys 97 which serve to receive V
 65 belts 98 which may be driven from any convenient source of power. The grinding wheel 92 is locked in engagement with the shaft and consequently will be rotated thereby. In this form of the invention novel means are provided for effecting axial reciprocation of the shaft as rotation thereof takes place.

In this form of the invention this lateral or axial oscillation of the shaft is effected by means of a cam trackway 99 cut into the peripheral sur-
 75

face of the shaft interiorly of the bearing 95. A projecting stud 100 carries a roller 101 journaled on the end thereof which roller is adapted to co-operate with the cam trackway to effect axial reciprocation of the shaft and consequently the grinding wheel secured thereto as rotation of the shaft takes place. The cam trackway 99 may be of any suitable form and, as shown, is designed to produce an axial oscillation of the wheel about half its axial length for each complete revolution of the shaft. In this form of the invention it will be readily apparent that the axial oscillation of the grinding wheel is synchronously controlled by the rotation thereof and the length of stroke of this oscillation may be conveniently controlled by the particular type of cam trackway which is provided in the surface of the shaft.

In Figs. 8 and 9 is illustrated a still further modified form of the present invention in which the mounting of the work supporting members is substantially the same as has been described in connection with the modified form of the invention illustrated in Fig. 7. Consequently, like reference characters have been utilized for designating identical parts. In this form of the invention a shaft 102 is utilized for the purpose of supporting the grinding wheel 103 which grinding wheel is permanently secured to the shaft to rotate therewith and is locked to the shaft in such a manner that relative axial movement between the wheel and the shaft is precluded. The shaft 102 is supported in the bearings 104, 105 and 106 which bearings serve to provide a rigid mounting for the shaft and which are supported upon the bed 80 of the apparatus. As has been described above, the shaft may be driven by a plurality of V belts 107 passing over suitable pulleys 108 secured to the shaft 102. The shaft 102 has a pair of radially extending substantially parallel flanges 110 thereon which flanges are disposed in slightly spaced relation and preferably located between the bearing supports 105 and 106.

An electric motor 111 is mounted upon a suitable support 112 secured to the bed of the apparatus and is provided at its outer end with an eccentric shaft 113 which is cylindrical in exterior configuration but the axis of which is offset from the axis of the shaft of the motor. The shaft 113 is of a diameter sufficiently large to snugly fit between the annular flanges 110 and consequently it will be seen that as the motor 111 is rotated, axial reciprocation of the shaft 102 and of the grinding wheel carried thereby will take place.

In the modified form of the invention shown in Figs. 10 and 11 still different means are utilized for effecting axial reciprocation of the grinding element during rotation thereof.

In this form of the invention hydraulic or pneumatic means are utilized for effecting reciprocation of the grinding element axially with respect to its work. The mounting of the work to be operated upon in this form of the invention is substantially identical to that described in connection with the forms of the invention illustrated in Figs. 8, 9 and 10 and consequently the same reference characters are utilized to designate like parts. In this form of the invention a grinding wheel 115 is supported in suitable bearing supports 116 which bearing supports are mounted directly upon the bed 80 of the apparatus. The shaft 117 on which the grinding wheel 115 is mounted has an axial extension 118 at its outer end which axial extension has a pair of spaced radial flanges 119 which serve to engage a lever

120 which serves to control a fluid valve, the purpose and function of which will hereinafter become clear.

The opposite end of the shaft 117 is of slightly reduced diameter and has permanently secured thereto a raceway element 122 which serves to form the inner raceway for a pair of series ball bearings 123. The outer raceway 124 for these ball bearings is secured internally of a cylindrical cup-like member 125 which is provided with an axial externally threaded projection 126. The projection 126 has secured thereto a rod 127, the opposite end of which is connected to a piston 128 operating with a cylinder 129 which is preferably permanently mounted upon the bed of the apparatus 80. Supply of fluid to either of the ends of the cylinder is controlled by the fluid valve which, as has been explained, is controlled by lever 120. Consequently, it will be seen that the axial reciprocation of the shaft will serve to open and close the valve alternately supplying the fluid to opposite ends of the cylinder and effecting an axial oscillation of the shaft 117 and grinding wheel 115 secured thereto.

In Figures 12 and 13 a still further modified form of the invention is illustrated in which mechanical means are provided for reciprocating the shaft. In this form of the invention a cup-like member 130 is secured to the end of the shaft by means of the ball bearing 131 and raceways 132. The cup-like member 130 serves to provide a pivotal connection for a pitman 133, the opposite end of which is journaled upon an eccentric shaft 134 integrally formed on the shaft 135 of a motor 136. Consequently, it will be readily appreciated that as motor 136 is operated, axial oscillation of the shaft 117 will take place, causing an axial movement of the grinding wheel with respect to the work on which it operates.

It will be readily understood that in all forms of the invention illustrated in the drawings and described above as well as in various other modifications of the invention presented, that in the event the grinding wheel is simultaneously rotated and oscillated axially, the lines of cut formed on the work piece by the abrasive elements of the wheel will cross each other. The angle at which these lines cross each other has been found to be particularly important in producing a highly polished surface as the result of the grinding operation. It will be readily understood that if a wheel eight inches in diameter is utilized to perform the grinding operation, the peripheral travel of this wheel will be approximately two feet for each revolution thereof. Consequently, it will be readily appreciated that in the event an axial reciprocation of the wheel throughout a travel of one-half inch is used, this reciprocation or oscillation if produced only once for each revolution of the wheel will of necessity cause an intersection of the crossing lines of cut at an extremely acute angle. This angle, of course, may be varied by slowing down the rate of rotation of the wheel with respect to the rate at which it is axially oscillated until an angle of intersection of the lines of cut is obtained which results in the polish desired. In as much as variable speed motors are utilized for the purpose of individually actuating the rotation and oscillation of the grinding wheel, this angle may be varied throughout an extremely wide range by varying the relative speed of the motors, and angles of the intersection of the lines of cut as high as 45 or 60 degrees may be obtained to produce the type of polish surface desired.

Many other and further modified forms of the invention falling within the scope thereof as defined in the subjoined claims will become clearly apparent to those skilled in the art.

What is claimed is:

- 5 1. A grinding machine including, in combination, a bed, means upon said bed for mounting a work piece, a grinding wheel, a shaft for supporting said grinding wheel, means for effecting rotation of said shaft at relatively high speed, splines
10 interconnecting said grinding wheel and shaft whereby the former will be driven by the latter, a pair of collars engaging opposite sides of said grinding wheel and means for effecting relatively rapid reciprocation of said collars to produce axial
15 oscillation of said grinding wheel while the same is rotated.
2. The method of grinding an article which consists in moving said article into engagement with a grinding wheel while the same is rotating
20 at relatively high speed and effecting relative

oscillation between said workpiece and grinding wheel in a direction parallel to the wheel axis, a number of oscillations for each said rotation, relatively feeding said wheel and workpiece parallel to the surface to be ground, and relatively feeding the axis of the wheel and workpiece toward and away from each other. 5

3. A grinding machine including, in combination, a bed, means on said bed for supporting a workpiece to be ground, means for rotatably mounting a wheel on said bed, means for driving
10 said wheel, means independent of said driving means for oscillating said wheel at high speed with a short stroke in the nature of a vibratory movement, a number of times for each revolution of said wheel, means for positively rotating said
15 workpiece while the same is being acted upon by said grinding wheel, and means for relatively feeding the workpiece and wheel parallel to the wheel axis during said rotation and vibration.

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