June 7, 1960 J. H. GREENING 2,939,251

HIGH FREQUENCY HONING

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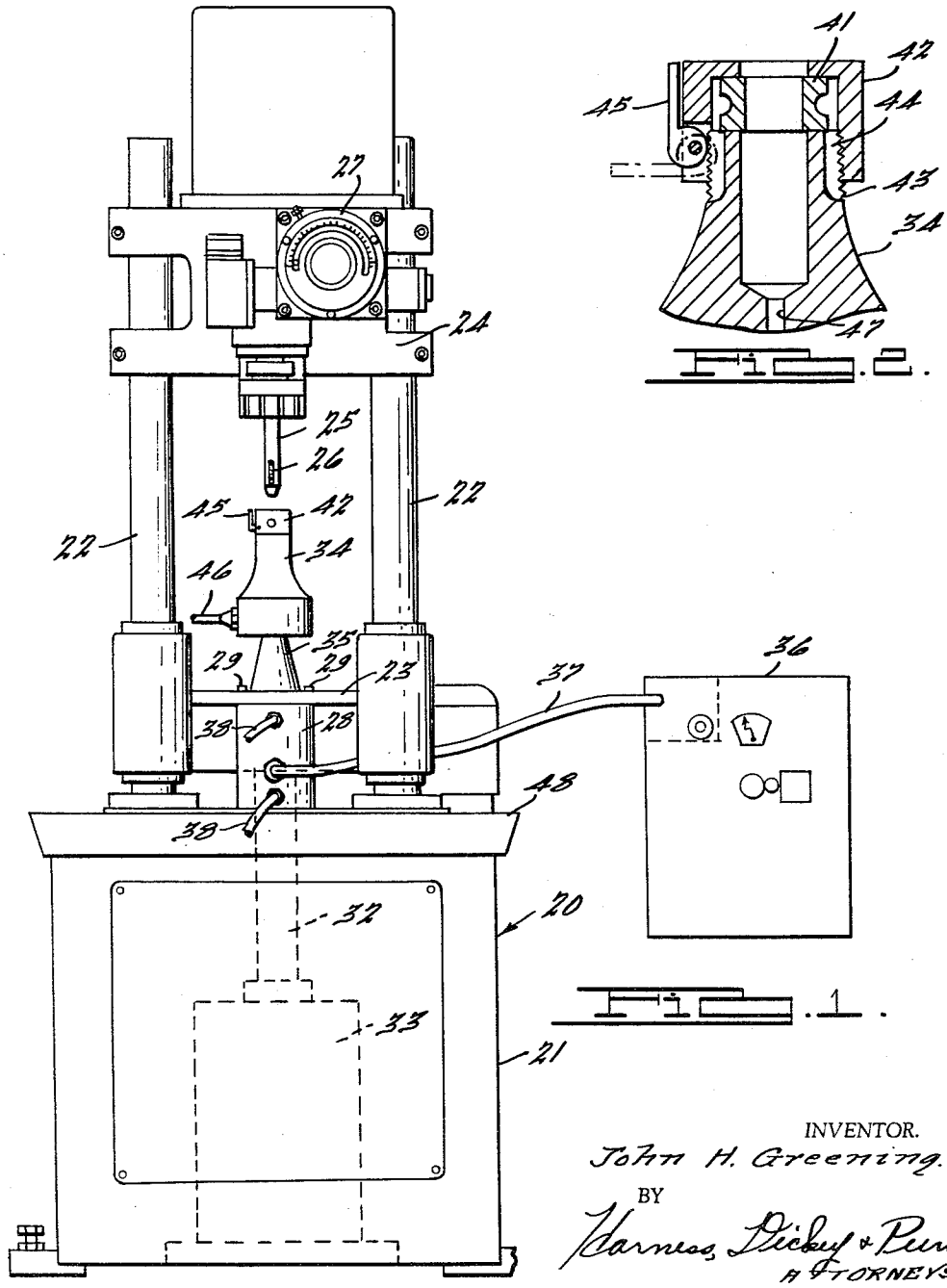


Fig. 2.

Fig. 1.

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FIG. 3.

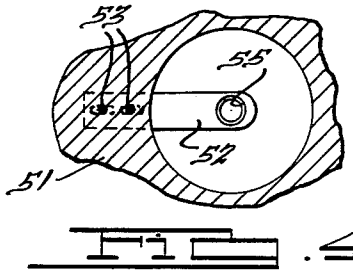
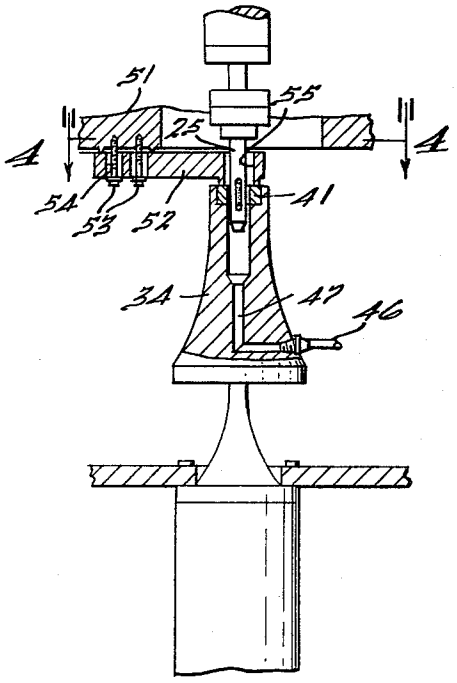
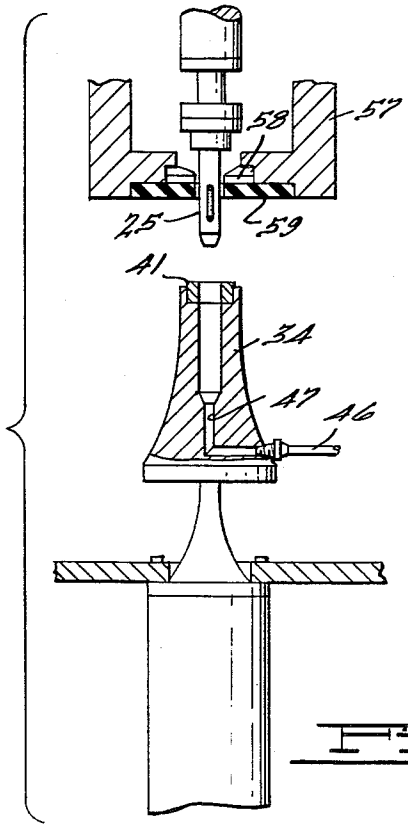


FIG. 4.





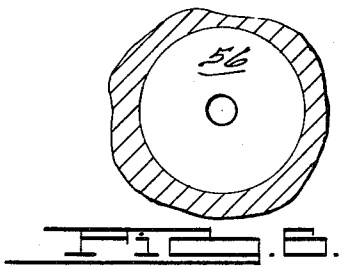


FIG. 5.

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HIGH FREQUENCY HONING

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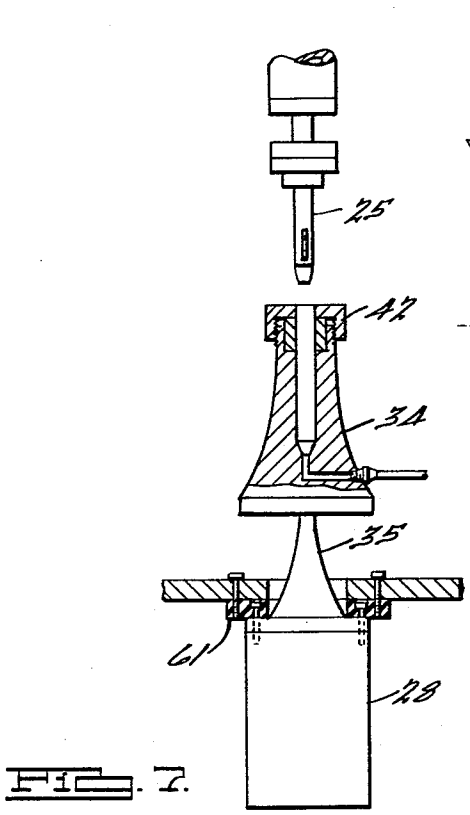


FIG. 7.

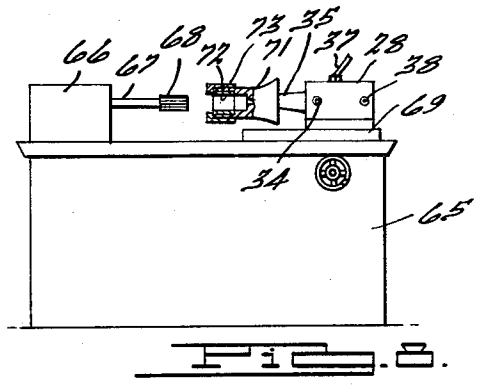


FIG. 8.

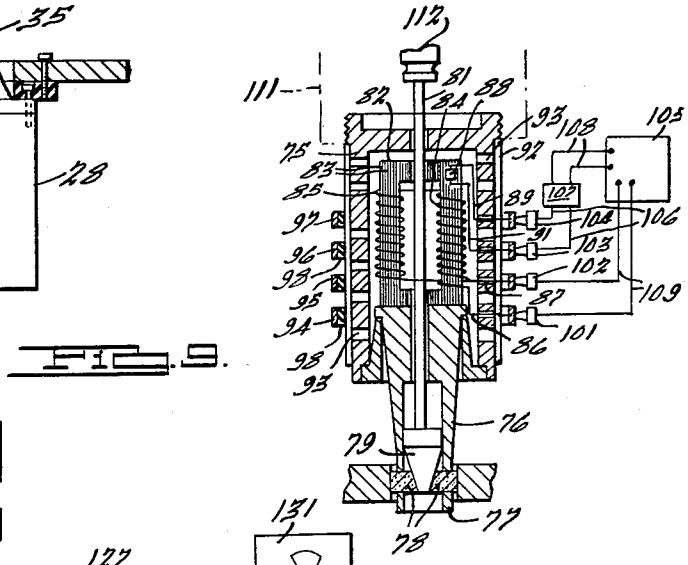


FIG. 9.

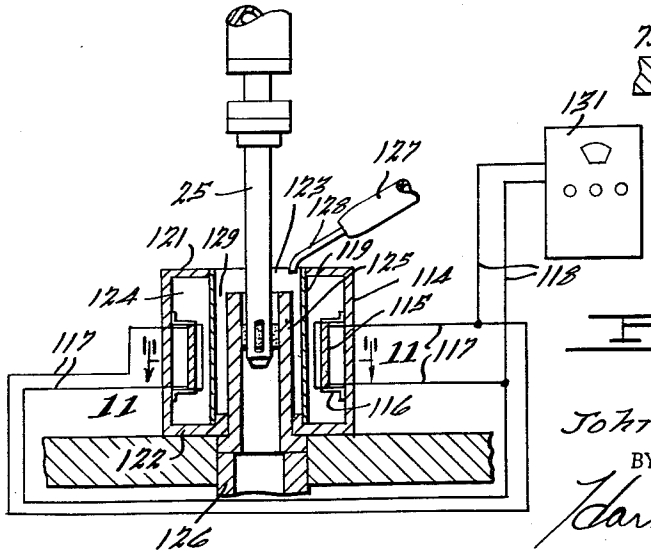


FIG. 10.

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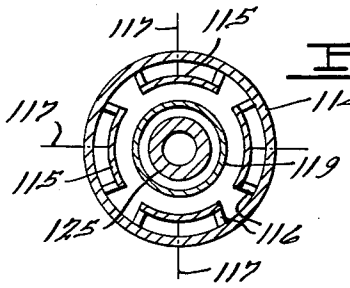


FIG. 11.

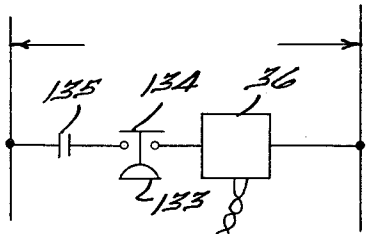


FIG. 12.

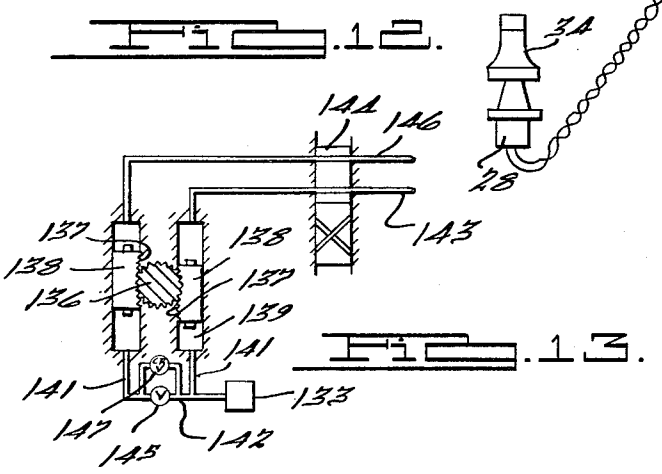


FIG. 13.

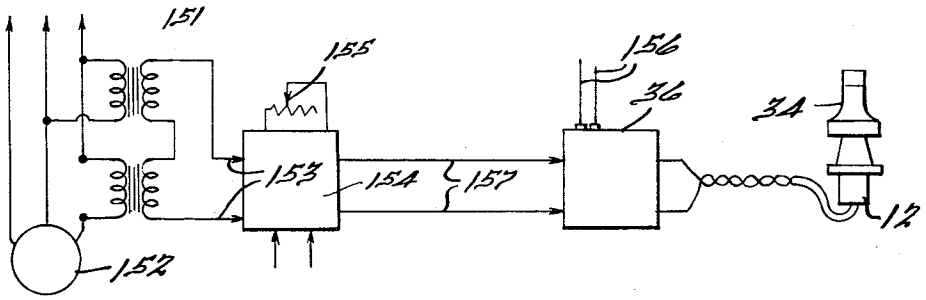


FIG. 14.

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United States Patent Office

2,939,251

Patented June 7, 1960

2,939,251

HIGH FREQUENCY HONING

John Hurley Greening, Oak Park, Mich., assignor to Micromatic Hone Corporation, Detroit, Mich., a corporation of Michigan

Filed Feb. 18, 1957, Ser. No. 640,645

12 Claims. (Cl. 51—34)

This invention relates to honing devices, and particularly to a honing device which dresses the working faces of the abrasive stones of a honing tool.

Difficulty has been experienced in the past when performing a honing operation due to the working faces of the stone becoming dulled and glazed while operating on the wall of the bore being honed. The stones were selected to have a proper hardness of grit and a proper bonding material which anchored the grits together to form a solid mass. The size of the grits was selected to conform to the honing operation which may be either of a roughing nature for stock removal or a finishing nature to provide a fine finish to the bore surface. Two operations were usually performed on a bore, the one for removing stock followed by one for producing finish. A rapid rate of honing was maintained so long as the grits were retained sharp by the breaking down of the face of the stones when the grits became dulled. Unfortunately, as was pointed out above, the breaking off of the sharp grit points with the resulting plateaus and glazing substantially reduced the abrading action and increased the load on the driving spindle which continued to increase as the glazing of the stone faces increased. This deleterious action continued until an actual crushing of the grits and the bonding material on the working faces of the stones relieved the condition and permitted the honing operation to continue with the newly provided sharp pointed grits. As a result of the repeated loading and breakdown of the stone faces, substantial stone life was lost and increased honing time required.

The present invention pertains to a device which produces the continuous breakdown of the working faces of the stones which prevents the glazing thereof. Such operation may be performed only at times when breakdown is desirable before the grits become dulled and the stone faces become glazed to any substantial degree. The device embodies a transducer which has a range of oscillation from 20 to 100,000 cycles per second and preferably above the audible sonic range to eliminate annoying sounds and damage to the ears of the operator. An oscillating core or armature such as a sonic cone is mounted on the transducer having clamping means thereon for the workpiece which is rapidly vibrated as the tool is reciprocated and rotated within the workpiece bore while the stones are moved outwardly under a predetermined pressure. A minute dressing operation is constantly occurring to the stone faces during the high order of vibration of the workpiece which prevents the glazing of the stones by breaking off the dulled points of the grits so that a rapid honing operation is continuously being performed without the periodic destructive crushing of the grits and bonding material at the stone faces.

The tool may have the high cycle of vibration applied directly to it instead of the workpiece and in some instances the tool may have the transducer built directly therein. The rapid vibratory movement of the stones relative to the stationary expanding cone of the tool will change the pressure on the stones and produce a breakdown of the dulled points of the grits on the faces of the stones so long as the stones are in the field of vibration. Controls may be provided to have the workpiece or the tool continuously vibrated during the entire honing operation. Near the end of the honing operation, the transducer is deenergized and the honing tool is continued in operation for a few strokes to produce a finish on the honed surface to the high degree desired. The rapid removal of stock and the production of a desired finish occurs in a single operation, which has been materially shortened in time. The energization of the transducer for producing the high order of vibration may be so controlled as to occur only when the points of the grit particles become dulled and before any substantial glazing occurs to the working face. This control may occur from the change in pressure on the feed mechanism for the stones which operates a pressure switch to energize and de-energize the transducer, the energization occurring when breakdown is desired and the de-energization occurring as soon as the breakdown has occurred. Another control may result from the change in load on the motor when driving the spindle. As pointed out hereinabove, upon the dulling of the points of the grits and the glazing of the stone faces, greater power is required by the motor to rotate the spindle, and this increase of power requirement may be utilized as a signal means for energizing the transducer and producing the vibration between the stone faces and the wall being honed to provide sharp points on the grit particles. This removes the load from the motor and an indication is thereby had for interrupting the energization of the transducer. Since the voltage and current in the supply line varies from time to time, the control is preferably by power employing an indication by the power factor of the three-phase line to the motor of the time when the motor is loaded. The stone life of the honing tool has been substantially increased by the use of the vibrating devices and the time for producing the honing operation has been shortened to a large degree, not only because of the rapid rough honing but because the finishing operation is performed in the same honing operation.

Accordingly, the main objects of the invention are: to provide a device which dresses the stone faces of a honing tool during a honing operation; to provide a device which prevents the glazing of the working faces of the stones during the honing operation, to thereby decrease the honing time; to provide a device which dresses the faces of the stones so that rapid stock removal occurs and a desired finish is produced in a single honing operation; to provide a dressing device for the face of a honing stone and a control therefor which is energized only during the time that a dressing operation is indicated, and, in general, to provide a dressing device for the faces of the abrading stones of the honing tool which is simple in construction, positive in operation, and economical of manufacture.

Other objects and features of novelty of the invention will be specifically pointed out or will become apparent when referring, for a better understanding of the invention, to the following description taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a view in elevation of a honing machine having a stone dressing device thereon which embodies features of the present invention;

Fig. 2 is an enlarged, broken sectional view of the structure illustrated in Fig. 1, showing the clamping means for the workpiece being honed;

Fig. 3 is an enlarged, broken sectional view of the structure, similar to that illustrated in Fig. 1, showing another form thereof;

Fig. 4 is a sectional view of the structure illustrated in Fig. 3, taken on the line 4—4 thereof;

Fig. 5 is a view of structure, similar to that illustrated in Fig. 3, showing another form of the invention;

Fig. 6 is a view of structure which could be employed in combination with the structure illustrated in Figs. 3, 4 and 5;

Fig. 7 is a view of structure, similar to that illustrated in Fig. 5, showing still another form which the invention may assume;

Fig. 8 is a view in elevation of a machine, similar to that illustrated in Fig. 1 but of the horizontal type, having the device of the present invention mounted thereon;

Fig. 9 is a sectional view of a honing tool having the device for dressing the face of the stone incorporated therein;

Fig. 10 is a view of structure showing another form which the invention may assume;

Fig. 11 is a sectional view of the structure illustrated in Fig. 10, taken on the line **11—11** thereof;

Fig. 12 is a view of structure for dressing the stones, shown in combination with a circuit which controls the operation thereof when required;

Fig. 13 is a schematic view of a feed mechanism for the abrading stones of the honing tool which produces indications which operate the circuit illustrated in Fig. 12, and

Fig. 14 is a view of structure, similar to that illustrated in Fig. 12, showing another form of control produced from the loading of the spindle while being driven by a motor.

Referring to Figs. 1 and 2, a honing machine **20** is illustrated of conventional form having a base **21** supporting a pair of columns **22** on which a pair of cross heads **23** and **24** are adjustably mounted. The cross head **24** supports a honing tool **25** and the mechanism required for driving it in rotation and reciprocation and also for feeding the abrading stones **26** of the tool outwardly and retracting the stones at the end of the honing operation. A control device **27** for the feed mechanism operates a push rod within the tool which has a conical end in engagement with a sloping surface on the stones for forcing them outwardly. Positive means are employed embodying a fluid actuated rack for rotating a screw which applies a downward movement to the push rod.

A magnetostriction transducer **28** is mounted on the head **23** by screws **29** and is moved upwardly and downwardly therewith by a piston rod **32** within a cylinder **33** in the base **21** to which a suitable fluid conduit (not shown) is connected. An armature **34** is supported on a cone portion **35** of the transducer **28**. Energy is supplied to the transducer from a suitable power source **36** through a conducting cable **37**. A cooling fluid is also conducted to and from the transducer **28** by conduits **38**. The power source **36** delivers a pulsating D.C. current to the transducer, the frequency of which may be varied over a large range from 20 cycles per second to 100,000 cycles per second. The actual frequency employed in tests was above that which produces annoying vibrations to the eardrums in the order of 15,000 cycles per second or more, which is above the audible range. The power source **36** and the transducer **28** are similar to those procurable in the trade from different sources, including the Raytheon Corporation.

A workpiece **41**, which is herein illustrated as an inner ball race, is mounted on the armature **34** by suitable means, herein illustrated as by an internally threaded cap **42** which is screwed upon threads **43** on the small end of the armature **34**. The thread may be intersected by slots **44** to permit a clamping cam **45** to extend therein and prevent the cap from becoming loose on the threads due to the intensive vibration of the cone. A coolant conduit **46** is mounted on the base portion of the armature at a nodal point of the vibration wave produced in the transducer **28** and the armature **34**. The coolant conduit is joined to a passageway **47** in the

armature and produces a flow of coolant through the workpiece **41** and out over the cap **42** which will flow downwardly over the armature and into the top of the bed **21**. The coolant is confined within the trough formed by the upwardly projecting edge flange **48** of the base from which it will flow into a reservoir therewithin to provide a supply which is pumped back into the conduit **46**. While cutting oils were heretofore required for the honing operation, it was found that by employing the present sonic method of honing a water base coolant may also be employed.

In a normal honing operation, the size of grit employed in the stones was selected to meet the requirements of producing the final finish on the honed surface. The bond for the grit was selected to control the rate of breakdown of the dulled grit particles so that sharp particles are always present to maintain a proper rate of cutting conforming to the type of material being worked on. Difficulty was experienced, due to the glazing of the faces of the stones, as the expected breakdown of the dulled grit particles was delayed. When the grit becomes dull and the breakdown of the bond does not occur between the stone faces and the surface being honed, friction increases, producing heat and the further dulling and glazing of the grit particles, which reduces cutting by the stones. As this occurs, the force to drive the stone substantially increases until such time as the surface of the stones will be crushed and crumbled by the build-up of pressure to produce the sharp grit particles.

The present invention pertains to a method of honing which superimposes a vibration of a high order between the face of the stone and the surface to be honed for the purpose of substantially preventing the dulling of the stones and the requirement for bond breakdown to maintain sharp cutting grit particles. This permits the use of stones having exceedingly hard bonding materials as the necessity for constantly breaking down the bond is materially reduced, with a result that the life of the stone is substantially increased and the rate of cutting is materially enhanced. Thus, where it required more than a minute to hone a bore by prior known methods, the present method is capable of honing the bore in ten seconds, with a material increase in abrasive economy in view of the lack of necessity of constantly breaking down the bond between the grit particles. By selecting the proper size of grit particles, a fine finish may be obtained after the superimposed vibration is removed at the end of the honing operation. Thus, in a single machine, a high rate of stock removal occurs while producing a finish of approximately thirty micro inches, which finish, within half a second after the sonic vibration is removed, will become substantially finer, in the order of eight or ten micro inches. Thus, in a single machine where heretofore two operations were required, an extremely rapid and accurate honing operation will be performed in an extremely short time with a desired fine finish provided to the honed surface. By this method of honing, no glazing occurs to the surface being honed and heat is substantially eliminated when a water base solvent is employed as the coolant. While in Figs. 1 and 2, the armature **34** is shown as supporting the workpiece, it is to be understood that the reverse could be true, that is to say, the armature could be employed to support the tool to provide the vibrations between the stone faces and the workpiece surface.

In Figs. 3 and 4, a fixture is illustrated for retaining a workpiece in position within the small end of the sonic cone which permits the rapid loading and unloading of the workpieces. A bracket **51** is mounted on the head **24** about the honing tool **25**. A clamping bar **52** is extended in cantilever from one side of the bracket **51**, being supported thereon by a pair of screws **53** which extend in slots **54**, permitting the bar to be adjusted to produce proper tuning with relation to the armature **34**. An aperture **55** at the end of the bar is made large enough

to permit such adjustment. The length of the bar **52** will correspond to the frequency at which the armature vibrates so as to have the end engaging the workpiece **41** in resonance therewith. When the bar **52** is properly tuned, the armature **34**, the workpiece **41** and bar will move in unison and retain a workpiece in clamped position. In place of the bar **32**, a disk **56**, similar to that illustrated in Fig. 6, having a proper variation in thickness, could be bolted or otherwise secured to the bracket **51** to produce the same resonance and unison movement.

In Figs. 5 and 6 a further form of clamp is illustrated, that wherein a bracket **57** is supported on the cross head **24** having a rotatable ring **58** for gauging the size of the diameter of the workpiece being honed. A washer **59** of nylon or like material is supported by the bracket to be engaged by the workpiece **41** when the cross head **23** is raised to advance the workpiece over the honing tool **25**. The nylon or like washer moves in resonance with the armature **34** and firmly locks the workpiece wihin the recess in the end thereof. When the diameter of the bore of the workpiece reaches size, the gauge ring **58** is rotated when engaged by tabs on the ends of the honing stones. The rotation actuates a switch which sets up a cycle that terminates the honing operation. This may be accomplished by terminating the energization of the transducer **28** and permitting the honing tool to continue to reciprocate and rotate within the workpiece for a short period of time before the honing stones are collapsed and the tool retracted from the bore to thereby produce a desired fine finish on the honed surface. After the retraction of the stones, the cross head **23** is moved down to permit the workpiece **41** to be released so that a new workpiece may be placed within the recess in the end of the armature. It is to be understood that other types of gauging elements may be employed, such as plug, caliper, air and the like, mounted on the tool or the bracket **57** and employed to gauge the bore diameter and control the termination of the honing operation. In Fig. 7 the honing device is similar to that illustrated in Fig. 1, with the exception that an insulating ring **61** of nylon or like material is employed to insulate the transducer **28** from the machine.

In Fig. 8, a machine **65** is illustrated which is similar to an internal grinding machine, having drive means **66** for an arbor **67** for rotating a honing tool **68**. A reciprocating bed **69** supports the transducer **28** with a cone portion **35** having an armature **71** thereon which supports a workpiece **72** for reciprocation over the honing tool **68**. The transducer **28**, armature **71**, and the workpiece **72** retained thereon by a cap **73**, are vibrated and reciprocated over the tool **68** as the tool is driven in rotation, preferably at speeds higher than those normally employed in honing. This was found to further reduce the time required to perform the honing operation which produced a substantial saving in the cost and life of the stones. The transducer is preferably de-energized substantially at the end of the operation so that a few additional honing strokes will occur by the reciprocation of the bed **69** to produce the fine finish on the surface of the bore after the rapid removal of the metal therefrom by the same honing stones. It is to be understood that suitable gauging means may be employed on the arbor **67** within the armature **71** to accurately gauge the termination of the honing operation.

In Fig. 9 a honing tool is illustrated having the transducer built directly therein and automatically controlled to be in resonance, producing automatic frequency control between the stones and the surface of the bore. In this arrangement, the tool is constructed from a cylindrical housing **75** having an armature **76** supported therein which is somewhat similar to armature **34**. A cylindrical extension **77** on the armature **76** forms a support for the honing stones **78** which are forced outwardly by a cone **79** actuated downwardly in the usual manner by a rod **81** which passes through the center of the cylindrical housing **75**. The transducer **82** within the cylindrical housing is made up of nickel laminations **83** in rectangular shape, having a central rectangular opening and end apertures for the rod **81**. The bottom ends of the laminations are brazed or otherwise secured to the armature **76**. Coils of wire **84** and **85** are wound on opposite legs of the laminations and connected in series relation to each other, having conductors **86** and **87** leading therefrom. A strain gauge **88** is mounted on the nickel laminations, having conductors **89** and **91** extending therefrom. Any expansion or contraction of the laminations strains the gauge and causes a change in the flow of current in the conductors **89** and **91**.

The cylindrical housing **75** is provided with a plurality of vanes **92** on the outer surface, between which vanes a plurality of apertures **93** are provided for cooling purposes. The flow of air will be produced about the laminations as the cylindrical body **75** is rotated and heat will be conducted from the vanes to cool the body housing **75** and the laminations which became heated during operation. A plurality of slip rings **94**, **95**, **96** and **97**, having insulating rings **98** on the inside, are supported on the vanes **92** and are joined, respectively, to the conductors **86**, **87**, **91** and **89**. Brushes **101**, **102**, **103** and **104** are mounted in conducting relation to the slip rings. A power source **105** is employed to energize the tool which is similar to the power source **36** of Fig. 6, with the exception that the internal source of oscillation is eliminated. The oscillation produced by the vibration of the laminations also activates strain gauge **88** which functions as an oscillator pulsing current in circuit **106** from the slip rings **96** and **97** and through a phase-shifting device **107** and an input circuit **108** to the power amplifier **105**. The phase of the input signal from the strain gauge **88** is shifted by the phase-shifting device **107** to reinforce the output signal in a circuit **109** to the slip rings **94** and **95**. This phase synchronized signal reinforces the current delivered to the coils **84** and **85** which increases the oscillation of the laminations, further straining the strain gauge **88**, which superimposes a greater current on the output current from the amplifier **105** and thereby builds up the current until saturation is reached and a maximum amount of energy is being supplied to the hone body **77**. While specifically a strain gauge **88** is illustrated as the siganlling device, this was shown by way of example, as other elements such as a piezo electric crystal, a differential transformer, a coil about one branch of the laminations, or other means known in the art to be suitable may be employed to change the current flow in the circuits **89** and **91**. This automatic frequency control as herein described can be employed upon the transducer of any of the construction herein illustrated and described to provide self control which produces maximum efficiency. When applied directly to the tool, as herein illustrated, the vibration of the body **77** actually causes the stones **78** to move relative to the cone **79** which is not vibrated, changing the pressure on the stones relative to the workpiece, which thereby assists in producing grit breakdown and the maintaining of sharp points thereon. It is to be understood that the cylindrical body **75** is supported on a reciprocable arbor **111** of a standard type of honing machine and that the end **112** of the rod fits within the stone-adjusting device of the machine. All of the beneficial effects of the stone-adjusting device and the timing of the retraction of the stone after the interruption of the vibration of the laminations can be advantageously employed when vibrating the tool instead of the work.

In Figs. 10 and 11 a further form of construction is illustrated for obtaining the rapid vibration between the surface of the stones and the surface of the workpiece being honed. In this relationship, a cylindrical housing **114** has four arcuate-shaped barium titanite transducers

115 mounted therein on a plurality of brackets 116. Pairs of conductors 117 are connected to the central portion of the transducers 115 and are connected in parallel in a circuit 118. A thin cylindrical-shaped, stainless steel closure element 119 is sealed to the top and bottom flanges 121 and 122 of the cylindrical housing 114, leaving a central aperture 123 therethrough. A liquid 124 fills the area about the transducers within the housing and may be water or any other fluid which will conduct the vibration from the transducers to the interior cylindrical element 119. A workpiece 125 is clamped to the bottom wall 122 of the housing by a sleeve 126 to be in alignment with the honing tool 25. A coolant conductor 127 directs a coolant from the nozzle 128 to within the aperture 123 to fill the area between the wall of the workpiece and the cylindrical element 119 from which it will flow over the top of the workpiece and the surface being honed. The vibration set up within the liquid 124 is transferred through the cylindrical element 119 to the coolant 129, to thereby vibrate the workpiece 125 relative to the honing tool 25. This vibration is in the order above mentioned and may be of a substantially higher order. The conductors 118 are connected to a power source 131 which energizes the transducers to produce the high order of vibration. The current is of the A.C. type and the device 131 is similar to those employed on high frequency induction welders.

In Fig. 12 a circuit is illustrated embodying a power source 36 for energizing a transducer 28 in a manner as described hereinabove for oscillating a workpiece relative to the honing tool. A pressure operated switch 133 has contacts 134 in series with the supply current to the power source 36. Contacts 135 of a relay are also disposed in series in the circuit and the contacts are closed upon the advancement of the work and tool into honing relationship. When pressure on the stone adjusting cone 79 (see Fig. 9) is varied in a manner to have the pressure transferred to the pressure operated switch 133, the contacts 134 are closed and will open and close in accordance with a decrease or increase in pressure, respectively. In this manner, the supply source to the transducer is cut off or encircuited in accordance with the condition of the stone faces. If the increase in glazing causes a reduction in pressure, the power source delivers current to the transducer to cause vibration to occur between the workpiece and stones, to thereby relieve the stones from the loaded condition. When this occurs, the pressure will immediately increase, thereby cutting off the power source and eliminating the vibration which is not required.

One manner of controlling the fluid pressure is illustrated in Fig. 13. A gear 136 is rotated to operate a screw to move a rod, similar to the rod 81, to advance or retract the cone 79 to change the pressure on the stones 78. The teeth of the gear 136 mesh with rack teeth 137 on a pair of pistons 138. Hydraulic fluid 139 on one side of the pistons is connected to the pressure switch 133 by passageways 141 and 142. An air supply passageway 143 through an air valve 144 produces a pressure on the top end of the right-hand cylinder 138 which applies a pressure to the hydraulic fluid on the lower side thereof. The fluid passes to the pressure switch 133 and also through a needle valve 145 to control the feed movement. The air above the left-hand piston 138 is exhausted through a passageway 146. When the valve 144 is shifted, air is admitted under pressure through the passageway 146 to the left-hand piston 138, permitting the hydraulic fluid to rapidly pass to the right-hand piston through the ball check valve 147 which bypasses the needle valve 145. The air above the right-hand piston 138 then exhausts through the passageway 143 and in this manner a rapid retraction on the cone 79 and stones 78 occurs at the end of the honing operation.

During the honing operation, when the faces of the stones become glazed, the pressure on the hydraulic fluid 139 beneath the right-hand piston 138 is reduced, which thereby operates the pressure switch 133 to close the contacts 134 and thereby energize the transducer 28 to relieve the loaded condition of the stones. Thereafter, the pressure of the hydraulic fluid 139 on the right-hand piston 138 substantially increases to cause the pressure switch 133 to be actuated to open the contacts 134 to thereby de-energize the transducer 28. In this manner, the superimposing of high frequency oscillation between the workpiece and hone may be controlled so that such high frequency action only occurs when needed.

In addition to the "off" and "on" cycles of operation of the transducer 28, it is also within the purview of this invention to modulate the amount of energy supplied by the transducers 28. One manner of doing this would be by the indication of a change of torque in the driving spindle in the power requirement of the driving motor. In Fig. 14 a standard current transformer 151 in placed in series with one phase of a motor 152 which drives a spindle of the honing machine in rotation, reciprocation, or both. A voltage transformer 151 is placed in parallel with the phase and in series in a circuit 153 with the current transformer 151. Any resistance to movement either in rotation or reciprocation on the spindle will increase the current requirement of the motor and the increase of current flow through the primary of the current transformer 150 increases the output voltage which adds to the output voltage of the transformer 151 which is a function of line voltage and power factor. The circuit 153 is connected to the rectifier-amplifier 154 where the voltage signal is rectified and amplified and used to increase the output of the power supply 36. When, for example, the stone faces become glazed and an increased effort is required to move the spindle in reciprocation or rotation, or both, this will cause an increase in the difference of potential in the circuit 153, which thereby causes an increase in the current supply to the transducer, which thereby increases the amplitude of vibration to relieve the loaded condition. When the condition is relieved, less effort is required to move the spindle and the difference in potential in the circuit 153 is lowered, to thereby reduce the supply of energy to the transducer which decreases the amplitude of vibration. The rectifier-amplifier 154, to which the conductors 153 are connected, has the current supply controlled by a suitable device 155, which current is carried by the conductors 157 to the power supply 36. The power supply is energized from a circuit 156 and is connected to the transducer 28. The amount of control for a given amount of change in the spindle current of the motor can be regulated by the device 155. In this manner, only a small amount of change in the spindle motor current can be amplified to produce a substantial change in the amplitude of vibration on the transducer. It is desirable that the control be rectified by a flow of power by wattage of current times voltage rather than by current or voltage alone as these may fluctuate substantially, depending upon the overall load on the main circuit and would produce false indications rather than accurate spindle conditions of operation.

What is claimed is:

1. In a honing device, a honing tool having an abrading stone and means within the tool for moving the stone outwardly to increase the tool diameter, means for operating said tool in rotation, a support for a workpiece, means for relatively advancing a workpiece and the stone of the tool into working relationship to each other, means for relatively reciprocating said tool and workpiece, an electrically operated transducer for producing a high cyclical vibration between the stone face and the wall of the workpiece, and indicating means actuated by a change in pressure on the honing stones for energizing the transducer upon the increase of pressure and de-energizing the transducer upon the reduction in pressure.

2. In a honing device, a honing tool having abrading stones and means within the tool for moving the stones outwardly to increase the tool diameter, means for operating said tool in rotation, a support for a workpiece, means for relatively advancing a workpiece and stones of the tool into working relationship to each other, means for relatively reciprocating said tool and workpiece, an electrically operated transducer for producing a high cyclical vibration between the stone faces and the wall of the workpiece, and means actuated by the change of load on the driving spindle for energizing the transducer upon the increase of load and for de-energizing the transducer upon the reduction in load.

3. The combination with a honing machine, a honing tool, a spindle for driving said honing tool in rotation, a transducer, an armature on said transducer, means on said armature for supporting a workpiece, means for relatively reciprocating the workpiece and said honing tool, power means for energizing said transducer to produce vibrations to the armature and workpiece, and means controlled by the change of pressure on the stones for energizing and de-energizing said transducer.

4. The combination with a honing machine, a honing tool, a spindle for driving said honing tool in rotation, a transducer, an armature on said transducer, means on said armature for supporting a workpiece, drive means for relatively reciprocating the workpiece and said honing tool, power means for energizing said transducer to produce vibrations to the armature and workpiece, and means controlled by the change in power requirement for the drive means for energizing and deenergizing said transducer.

5. The combination with a honing machine, a honing tool, a spindle for driving said honing tool in rotation, a transducer, an armature on said transducer, means on said armature for supporting a workpiece, means for relatively reciprocating the workpiece and said honing tool, and power means for energizing said transducer to produce vibrations to the armature and workpiece, said supporting means for the workpiece embodying a device on said machine on the nodal point of the vibration wave which abuts the workpiece to retain it in position and resonated to vibrate therewith.

6. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a homing tool body, abrasive stones in said body, means in said body for moving the stones raidially of the body, and a coil having conductors disposed about said laminations for vibrating said armature and said stones.

7. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a honing tool body, abrasive stones in said body, means in said body for moving the stones radially of the body, a coil having conductors disposed about said laminations for vibrating said armature and said stones, and slip rings on said housing to which the conductors of said coil are encircuited.

8. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a honing tool body, abrasive stones in said body, means in said body for moving the stones radially of the body, a coil having conductors disposed about said laminations for vibrating said armature and said stones, slip rings on said housing to which the conductors of said coil are encircuited, separate circuit means on said laminations to provide a signal, and slip rings on said housing to which said circuit of said signaling means is connected.

9. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a honing tool body, abrasive stones in said body, means in said body for moving the stones radially of the body, a coil having conductors disposed about said laminations for vibrating said armature and said stones, slip rings on said housing to which the conductors of said coil are encircuited, separate circuit means on said laminations to provide a signal, slip rings on said housing to which said circuit of said signaling means is connected, and power means connected to said slip rings which are encircuited to said coil for delivering a high cycle of alternating current thereto.

10. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a honing tool body, abrasive stones in said body, means in said body for moving the stones radially of the body, a coil having conductors disposed about said laminations for vibrating said armature and said stones, slip rings on said housing to which the conductors of said coil are encircuited, separate circuit means on said laminations to provide a signal, slip rings on said housing to which said circuit of said signaling means is connected, power means connected to said slip rings which are encircuited to said coil for delivering a high cycle of alternating current thereto, and means applying the signal circuit from the slip rings to said power means for superimposing a current to the output thereof for building up the output power corresponding to increases in the signal means until full power is delivered to produce saturation of said laminations.

11. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a honing tool body, abrasive stones in said body, means in said body for moving the stones radially of the body, and a coil having conductors disposed about said laminations for vibrating said armature and said stones, said housing having a plurality of apertures therethrough for producing the cooling of said coil and laminations.

12. In a honing tool, a cylinder, a housing, a core in said housing made up of a plurality of laminations, an armature to which one end of said laminations is secured, the opposite end of the armature forming a honing tool body, abrasive stones in said body, means in said body for moving the stones radially of the body, a coil having conductors disposed about said laminations for vibrating said armature and said stones, said housing having a plurality of apertures therethrough for producing the cooling of said coil and laminations, vanes on the exterior of said housing, and slip rings on said vanes for further cooling of said housing.

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