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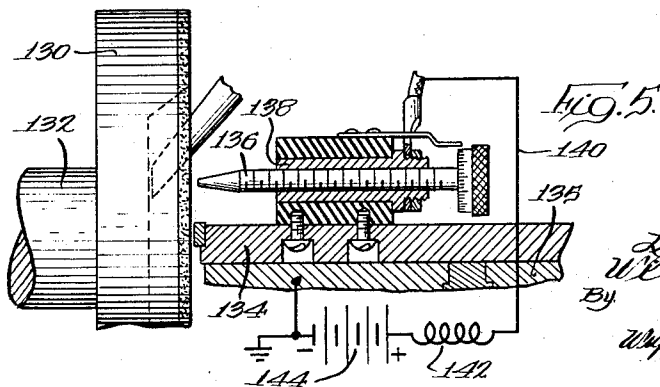
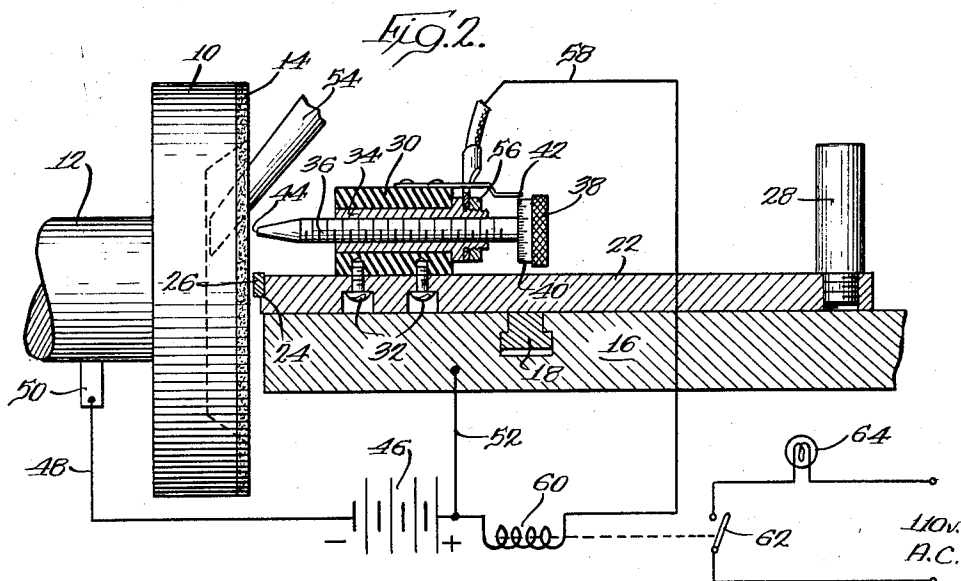
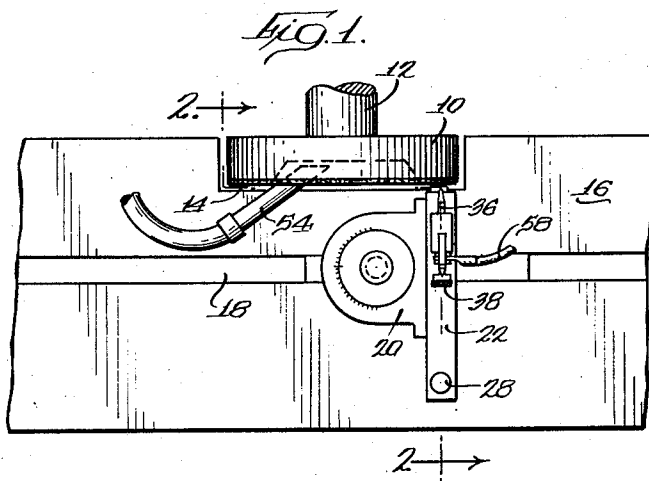
L. A. WILLIAMS ET AL

2,961,394

GRINDING APPARATUS

Filed Dec. 16, 1958

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3

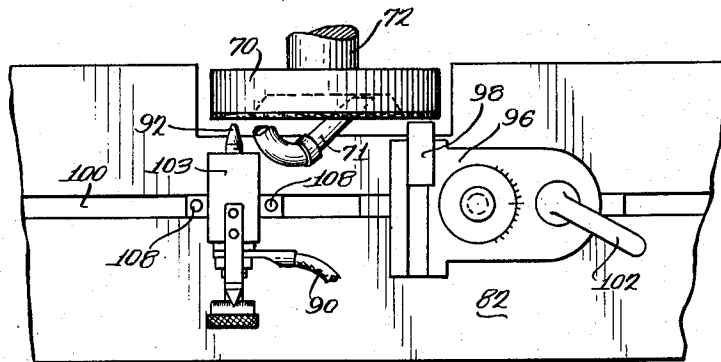
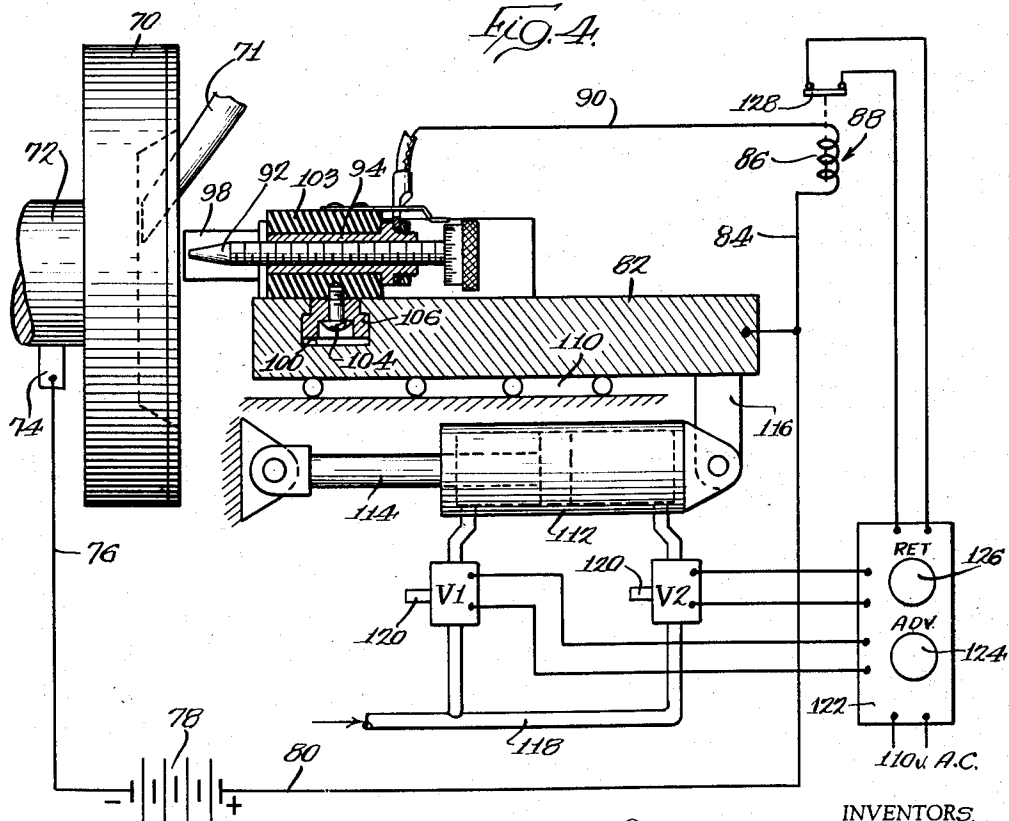


FIG. 4



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2,961,394

GRINDING APPARATUS

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Filed Dec. 16, 1958, Ser. No. 780,748

9 Claims. (Cl. 204—218)

This invention relates to grinding apparatus and, particularly, to means for gauging and, if desired, for controlling automatically the amount of material to be removed from a workpiece.

One object of the invention is to provide novel mechanism and a method for the gauging of a workpiece while it is being ground in such a way that accuracy is not affected by wear of the wheel.

Another object is to accomplish the gauging by a probe which indicates the desired thickness of the workpiece while it is being ground by gauging from the back side of the workpiece to the working face of the wheel.

Another object is to sense the locus of the workface of a grinding wheel by a probe which does not touch the wheel.

Another object is to provide novel automatic means for withdrawing a workpiece from a grinding wheel when the workpiece has been ground to a predetermined thickness.

Yet another object is to provide a method and mechanism for accomplishing the above upon grinding equipment of either the electrolytic or non-electrolytic type.

Still another object is to accomplish all of the above at low cost and with a minimum of complexity.

Other objects and advantages will appear from the following description of a preferred embodiment of the invention which is illustrated in the accompanying drawings.

In the drawings, in which similar characters of reference refer to similar parts throughout the several views,

Fig. 1 is a diagrammatic top view of the pertinent portion of a manually operated grinding machine showing the features of the present invention applied thereto;

Fig. 2 may be considered as an end view of the mechanism of Fig. 1, drawn to somewhat larger scale and with portions of the apparatus being broken away so as to illustrate the structure in section as indicated by the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1, but showing the features of the invention as applied to one type of automatic grinder;

Fig. 4 is a diagrammatic representation of the machine of Fig. 3 shown partly in end elevation and partly in section, as indicated by the line 4—4 of Fig. 3; and

Fig. 5 is a view similar to the principal portion of Fig. 2, but showing an alternative manner of applying the features of the present invention to a grinder.

It is often desired to grind a considerable number of parts to the same dimension. If, however, the attempt is made to accomplish this by moving the part toward the grinding wheel to a predetermined stop point, then, apart from the many problems which arise in establishing an accurate stop, unaffected by dirt, etc., there is always the problem that as the wheel face wears away, the stop position will no longer be correct and the critical dimension of the pieces will change (increase).

If a stop member in a fixed position with respect to the workpiece could ride into contact with the wheel face as a gauging surface, this problem would be overcome, but this has always been regarded as impractical because

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of the fact that almost any plausible stop member would be worn by contact with the grinding wheel so as to lose dimension.

By using the features of the present invention, the result of using the wheel face as the gauging surface can be accomplished by using a probe member which receives an electric charge (or which completes an electric circuit) by way of a constant thickness film of conductive liquid which is maintained upon the wheel face. The electric charge received by the probe (or the circuit completed by the probe) may be used to operate a signal or to actuate automatic mechanism for withdrawing the work from further grinding contact with the wheel. By the use of this invention very simple low-cost, rugged, mechanical and electrical means may be used to accomplish extremely accurate results.

There are currently in use two general types of grinding equipment and, in applying the invention to these different types, variations in the arrangement are advisable. One type of grinding equipment may be referred to, for the present purpose, as abrasive grinding, in which all of the material removed from the workpiece is accomplished by mechanical action by bringing the rapidly moving abrasive particles against the workpiece in the presence of some coolant.

In the other type of grinding—which is well explained in United States Patent No. 2,826,540 issued to George F. Keeler for "Method and Apparatus for Electrolytic Cutting, Shaping, and Grinding"—a heavy, direct current is caused to flow through an electrolyte between a metal bonded conductive grinding wheel and the workpiece so that the major portion of the material removed from the workpiece is removed and placed into solution by electrolytic action, the rapidly moving abrasive surface of the grinding wheel being used primarily for the purpose of spacing the workpiece from the conductive metal bonding material of the wheel. In this arrangement, the wheel and the workpiece are connected into an electric circuit such that the workpiece is an anode and the wheel is the cathode, and the electrolyte which replaces the normal coolant has a high current-carrying capacity and a high degree of electrochemical activity.

Figs. 1, 2, 3, and 4 primarily show application of the present invention to electrolytic grinding equipment, whereas Fig. 5 is directed more specifically to an application of the invention to abrasive grinding where the grinding wheel may or may not be metal bonded or otherwise conductive. With minor variations, the equipment illustrated in Figs. 1 to 4, inclusive, may be used for mechanical grinding with grinding wheels having a conductive matrix or coating, such as metal bonded wheels for instance, whereas the arrangement of Fig. 5 may also be used with grinding wheels of the ordinary vitrified type which customarily are not conductive unless specially treated.

Referring to Figs. 1 and 2, a metal bonded grinding wheel 10 is illustrated as being mounted upon a spindle 12 so that its grinding face 14 is positioned in front of a table 16. This table has a T slot 18 which serves to guide a protractor 20. The protractor is thus enabled to move parallel and at a fixed distance from the grinding wheel working face, such that a work holder 22 may be held against the face of the protractor and moved toward or away from the grinding wheel work face so as to accomplish the grinding operation.

As shown in Fig. 2, the work holder 22 is provided with a notch forming a ledge 24 at its forward end upon which a small workpiece 26 of tungsten carbide, for instance, may be rested so that its outward face will be brought against the grinding wheel as the tool carrier 22 is moved forwardly by means of the handle 28.

In this embodiment of the invention the work carrying

slide 22 is provided with an insulating block 30 attached by means of screws 32, and this block in turn carries a press-fitted metal bushing 34 which is internally threaded to receive a threaded probe 36. The rearward end of this probe is equipped with a knurled knob 38, and preferably carries a dial 40 which may be used in conjunction with a pointer 42 to determine the position of the probe relative to the work carrier 22.

The forward end of the probe, indicated at 44, is frusto-conical, and preferably should be plated with rhodium which resists corrosion or electrolytic decomposition and projects well ahead of the block 30 so that, by turning the knob 38, the probe free end may be brought approximately into contact with the face of the grinding wheel when the workpiece 26 is ground to appropriate thickness. Ordinarily, of course, it will be convenient to provide a range of adjustment which will far exceed that set forth above, since it will commonly be desired to use the same probe with workpieces 26 of different sizes.

In the arrangement shown in Figs. 1 and 2, which includes the essential characteristics of an electrolytic grinder, the electrolyzing power source is exemplified by the battery at 46, although a practical embodiment of an electrolytic grinder will usually use a high capacity, well regulated, direct current supply obtained by the rectification of alternating current, as explained in the previously referred to Keeler patent. In any event, the negative terminal of the power source 46 is connected by a lead 48 to a spring loaded brush 50 in contact with the grinding wheel spindle 12 or, more properly, a slip ring thereon. This spindle 12 and its bearings are insulated from the remaining portion of the machine. The positive terminal of the power supply is connected to the workpiece by way of a connection to the work table 16 represented by lead 52, and electrolyte is supplied to the center of the grinding wheel in any suitable manner as by a soft rubber tube type electrolyte or coolant applicator 54. A preferred form of applicator for use when the working surface is at the periphery of the wheel is illustrated in the copending application of Lynn A. Williams, filed May 10, 1957, Serial No. 658,264, now Patent No. 2,899,781, and entitled "Coolant Applicator."

In operation, as the slide 22 is advanced toward the grinding wheel so as to bring the workpiece 26 against the wheel surface, electrolytic action will cause a rapid removal of the work material with the abrasive grains of the grinding wheel acting as a spacing means to prevent arcing and the development of irregularities in the surface of the workpiece.

The bushing 34, which carries the probe 36—44, is connected by a nut 56 to a lead 58 connected through a relay coil 60 to the line 52 at the positive side of the power supply 46. Relay coil 60, when energized, closes a set of contacts 62 in a series circuit with a power source and an electrically responsive signaling device such as an indicator lamp 64 so that illumination of the lamp 64 will signal the presence of an electric current in the relay coil 60.

Since the probe 36—44 is mounted upon the work carrier 22, its tip 44 will advance along with the workpiece 24 as the slide 22 is pushed forwardly. The amount of extension of the probe free end 44 is so adjusted by turning the knob 38 that when the workpiece 26 has been ground to the precisely correct thickness, the probe tip 44 will just touch the film of electrolyte covering the working face 14 of the grinding wheel.

Contrary to what might be expected, for any particular work setup the thickness of this film of electrolyte upon the grinding wheel is extremely constant even though the rate of supply of electrolyte to the grinding wheel is varied widely, provided the film is measured some distance away from the inner edge of the wheel. Thus it appears that with any particular grinding wheel operating at a particular speed and with any particular electrolyte, the electrolyte film thickness will be found to be nearly constant.

As the electrolytic grinding operation proceeds, there

will be no substantial current in the relay coil 60 until the tip end 44 of the probe just touches the electrolyte film upon the wheel. As soon as this happens, a circuit will be completed from the positive side of the power supply 46 by way of the lead 52 and relay coil 60 to the probe end 44, and thence by way of the electrolyte film upon the grinding wheel to the grinding wheel metal matrix, the spindle 12, brush 50, and lead 48 to the negative side of the power supply 46. This circuit, therefore, produces a current in the coil 60 which closes contacts 62, thereby energizing the signal light 64. Relay coil 60 should respond at about 2–4 volts, but should not be of the ultra-sensitive type which might be affected by stray currents through splatter of electrolyte.

As an example of the precision of grinding and gauging with this simple apparatus used in conjunction with an ordinary inexpensive grinder rotating a 6" wheel at 3400 r.p.m., about 5000 surface feet per minute, 150 small pieces of tungsten carbide to be used as thread guides in a loom were ground in this manner by hand feeding, care being taken merely to withdraw the work holder slide 22 and remove the workpiece 24 as soon as the signal light 64 was illuminated. After grinding, these 150 pieces were carefully gauged, and it was found that the maximum variation which existed was no greater than four ten-thousandths of an inch, and the great preponderance of the pieces varied one from another much less than this. To hold such close tolerances would ordinarily be thought quite impossible without very heavy rigid and costly machinery and fixtures. Here, if the wheel and spindle yield slightly away from the work under pressure (as is common particularly with a spindle which is not new), this makes no difference, for the holder and workpiece simply advance further to offset the retreat of the wheel, but no signal is given until the probe end 44 engages the liquid film on the wheel face.

Surprisingly, the signal provided to the relay by the probe is sharp and determinate. This appears to be because the liquid film has a determinate thickness, and therefore, has a fixed outer surface relative to the wheel itself. Splatter and mist around the wheel area do not cause erroneous signals, apparently because the current level which can be passed by random drops is far below that which can be passed by a continuous electrolyte layer, and is apparently far below that required to operate any ordinary relay. In addition is the fact that the relay and voltage need not be precisely adjusted. It has been found, for instance, that a variation in the voltage between the wheel and the probe of the order of 5 to 10 volts causes no significant change in the gauging; that is, it causes no change in the distance of the probe from the wheel face at which the relay contacts shift position.

As mentioned previously, it was surprising to find that the gauging was not affected in any significant degree by the volume of electrolyte applied to the wheel through the nozzle 54, as it might have been supposed that the thickness of the liquid film would vary with the volume applied. It is possible that this might be so if the variation were carried from the extreme of a tiny trickle to a heavy flood, but inasmuch as neither extreme is desirable in grinding, these extremes were not explored as being unimportant in industrial application. Apparently when the fluid is applied at a constant distance away from the probe (reckoned radially or in the direction of wheel rotation), then the liquid film as it passes the probe, has a quite constant thickness determined by the surface of the wheel, the nature of the liquid, and the speed of the wheel.

This discovery of the comparative constancy of liquid film thickness despite normal variations in liquid flow rate is of considerable importance and forms the basis of the experiments upon which this invention rests. The exact thickness of the film is difficult to measure, for while it is easy to find the locus of the outer surface of the film electrically, it is quite difficult to find the locus

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of the wheel surface. If this is attempted by slowly advancing the probe through the film toward the wheel, it is hard to know, except by sound, just when contact is made, and with the noise of the machine the sound test is not reliable. If the wheel is stopped, then irregularities in its surface cause erratic measurements. As nearly as could be determined, however, the film thickness under the conditions described, was of the order of a few thousandths of an inch.

In any event, this thickness is great enough to permit taking a signal from the outer surface of the film without the risk of contact between the probe tip 44 and the wheel face 14, which would almost instantly grind away some of the probe, thereby shortening it and changing the gauging point. But even in manual operation as described above, there is no difficulty on this account so long as the workpiece is in the holder and so long as reasonable care is observed in retracting the slide 22 as soon as the light signal appears.

Inasmuch as the probe tip 44 is subjected to electrolytic action only momentarily during each cycle, its useful life will be long even though no special precautions are taken for its protection. If desired, however, its life may be almost indefinitely extended by plating it with a hard electrochemically inert metal such as rhodium.

Now, turning to Figs. 3 and 4, the same principle is shown as applied to an automatic work feed system. The machine illustrated represents a Model SCE-6 carbide grinder manufactured for electrolytic grinding by Hammond Machinery Builders, Inc. of Kalamazoo, Michigan, modified in some details for the practice of this invention.

A metallic grinding wheel 70 is mounted on a grinding spindle 72, journaled and driven in the usual way. It is supplied with electrolyte near its center by an applicator 71. A brush system 74 (illustrated schematically) provides an electrical path to the spindle through conductor 76 from the negative pole of a power source 78 which, in practice, may be a Model 103 Automatic, Electronically Controlled Power Supply Unit manufactured and sold by Anocut Engineering Company of Chicago, Illinois. This unit provides direct current for electrolytic grinding at a potential between 2 and 18 volts, which is adjusted to the work requirements. The positive terminal is connected by conductor 80 to the work table 82 and by conductor 84 to one terminal of the coil 86 of relay 88. The other terminal of the coil is connected by conductor 90 to the probe 92 through bushing 94.

In the Hammond SCE-6 grinder, a protractor vise 96 is provided by which the workpiece 98 is firmly clamped. The vise is arranged for adjustment and clamping in T slot 10, and is also adjustable for angular position. The work is locked by tightening cam lever 102. The details of the vise are no part of this invention, and such vises are well known, the one shown constituting standard equipment provided by the Hammond SCE-6 machine.

The probe device is essentially similar to the one described previously except only that its insulated support block 103 is mounted by screws 104 to a T slot bar 106. The probe then may be adjusted to a convenient position on the work table and locked with locking screws 108. Such adjustment may be necessary because of the need sometimes to shift the vise 96 from one side of the wheel 70 to the other to accommodate different shapes of workpieces or the convenience of the operator. Thus the vise here shown at the right side of the wheel (Fig. 3) might be shifted to the left side, the probe device then being shifted to the right side.

In the Hammond machine, the entire work table is mounted on ball ways 110 for motion toward and away from the grinding wheel. A double-acting air cylinder 112 with a piston and piston rod assembly 114 is mounted beneath the table with the piston rod fixed to the body of the machine and the cylinder to a solid lug 116 depend-

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ing from the table. Thus, the table may be actuated by air toward or away from the grinding wheel.

Control of the table motion is obtained by solenoid valves V1 and V2, connected by tubing as shown. Each is capable of taking two positions, one to admit air under pressure from an air line 118 to the cylinder, the other to shut off the air and open an exhaust vent 120 to the end of the cylinder to which the valve is connected. It will be readily understood that when valve V1 is in position to admit compressed air to the left hand end of the cylinder, valve V2 is in position to vent the right hand end of the cylinder, and vice versa.

These valves are electrically actuated from a control panel 122 such that when an advance button 124 is depressed, valve V1 will admit air under pressure to its end of the cylinder to advance the table 82 toward the wheel 70, air in the other end of the cylinder being exhausted through valve V2. Conversely, when the retract button 126 is depressed, valve V2 will admit pressure air to the rearward end of the cylinder to retract the work table and valve V1 will vent its end of the cylinder. Relay coil 88, previously mentioned, operates, when energized, to open a set of contacts 128 connected into the control system at 122 in such manner that separating of these contacts has the same effect upon the valves V1 and V2 as depressing the retract control button 126.

This machine may conveniently be set for grinding a number of pieces to identical dimensions by clamping one of the pieces 98 in the vise 96, with its rearward end against some sort of stop. The probe is then adjusted so that it will come into contact with the film of electrolyte over the face of the grinding wheel slightly before the piece 98 is ground to the appropriate dimension. The advance button 124 is then depressed so as to cause the work table 82 to move toward the grinding wheel.

As the workpiece comes against the grinding wheel and the electrolyte moves across the face thereof, the electrolytic grinding action will proceed with the work continuing its advance slowly as metal is removed therefrom until the probe 92 touches the electrolyte film upon the face of the wheel 70. This, in the manner previously described, energizes the relay coil 86 and separates contacts 128. This causes the valves V1 and V2 to shift their positions so that the work table is retracted. The workpiece is then gauged, and the amount of metal yet to be removed determined. The probe 92 is then backed off this amount and the advance button 124 is again depressed. The work is therefore returned to the grinding position and this time, when the probe 92 touches the electrolyte film upon the grinding wheel so as to energize relay coil 88 and cause the work table 82 to be retracted, the dimension of the workpiece should fit that specified.

Thereafter it is necessary merely to clamp the piece to be ground in the vise 96 and depress the advance button 124. This causes the work automatically to be fed into the grinding wheel until the probe 92 touches the electrolyte film, thereby causing the table to be retracted. The workpiece is then replaced with another workpiece and the cycle repeated.

The arrangement shown in Figs. 1 to 4 may be used in conjunction with a non-electrolytic grinding operation, providing that the coolant is one which is electrically conductive, or is made so by addition of ionizing salts. As a conductive coolant I prefer to use a solution of five to ten parts potassium nitrate in water, together with a rust inhibiting material such as sodium nitrite (3 to 6%), or sodium nitrite may be used alone.

In a non-electrolytic grinding operation the power source, indicated at 46 and 78, need not be capable of supplying the current necessary for electrolytic grinding, since it is necessary merely that there be sufficient current in the relay circuit when the probe 44 or 92 touches the coolant film upon the wheel to cause the relay to shift its contacts.

The arrangement is otherwise similar to that described above in connection with electrolytic grinding if an electrically conductive metal bonded grinding wheel is used. If the grinding wheel is of the vitrified type which is not appreciably conductive in its ordinary state, such a wheel may be rendered suitably conductive in any of several manners. As an example, the faces of the wheel may be metalized—such as by metal spraying—by depositing metal from a carbonyl salt such as nickel carbonyl, or by dipping the side of the wheel in a shallow molten bath of copper or solder within a hydrogen furnace. Alternatively, the wheel may be fed with the conductive coolant in such a manner that the coolant engages the wheel spindle and then is centrifuged outwardly to the working face, thereby establishing a conductive path from the spindle to the working face of the wheel.

If the grinding machine is of the ordinary type which is not specifically adapted for electrolytic grinding, a simple solution to the problem is illustrated in Fig. 5. Here the grinding wheel 130 may be optionally of the non-conductive vitrified type, or of the conductive metal bonded type. The spindle 132 carrying this wheel is of the ordinary type and is not insulated from the remaining portion of the machine. The work at 134 may be clamped in a vise such as that shown at 96 in Fig. 3, or it may be supported in a manually supported slide, such as that at 22 in Figs. 1 and 2. In any event, it is grounded to the machine table 136 and adapted to be moved toward and away from the face of the grinding wheel 130. As in the previous examples, the probe 136 is supported in an insulating block 138 and is so arranged that it moves forwardly and backwardly along with the workpiece 134.

In this application, the probe 136 is simply connected by a lead 140 to one end of a relay coil 142, the other end of which is connected to one side of an electric power source 144, the other side of the power source being grounded to the frame or table of the machine. The power source at 144 may be of low capacity and capable of supplying a potential of a few volts. If desired, an alternating current source may be used if the relay coil 142 is of the alternating current type. The relay coil 142 may operate a set of contacts, as at 62, for energizing a signal, such as the lamp 64, whenever the relay coil is energized, or, if desired, this coil may actuate contacts such as those at 128 in an automatic control circuit.

In any event, as the work 134 is fed against the grinding wheel with the conductive coolant flowing over the face of the wheel, the conductive workpiece will, of course, establish contact with the coolant while the probe 136 is still spaced some distance therefrom. As the grinding proceeds, the end of the probe 136 will touch the film of conductive coolant upon the grinding wheel when the workpiece 134 has been ground to appropriate size. As soon as this occurs, a circuit is established from the power source 144 through the relay coil 142 to the probe 136, thence from the probe to the conductive liquid film upon the face of the grinding wheel and, by way of the film, to the work 134, and thence from the work to the machine frame which is connected to the other side of the power source 144. As in the previous examples, energization of the relay coil 142 will actuate a signal lamp or other signal device so as to notify the operator that the work has been ground to finished size, or it may actuate an automatic control circuit for retracting the work table, as illustrated in Fig. 4 for instance.

This application of the invention to an ordinary grinder has the advantage that it is not necessary to insulate the grinder spindle, nor is it necessary that the grinding wheel be conductive. Furthermore, since the entire machine (excepting the probe) is of one polarity and may be grounded, no electrolytic action takes place between the machine elements which might otherwise affect parts of

a grinder not specifically conditioned for electrolytic grinding.

Although the invention has been illustrated in conjunction with grinding wheels of the face grinding type, it is also equally applicable to use with grinders of the peripheral or other type, it being necessary merely that the probe be arranged to advance toward the grinding wheel along with the work in such fashion that when the work has been ground to its finished dimension the probe will just contact the film of conductive coolant or electrolyte upon the grinding wheel at any place where the film thickness remains constant during the grinding operation.

From the above description of the invention as incorporated in different types of grinding machines for different types of grinding operations, it will be apparent that changes may be made in the equipment without departing from the scope or spirit of the invention, and the scope of the invention therefore is to be measured by the scope of the following claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. Grinding apparatus comprising means providing the elements of a grinding machine including a rotatable spindle having a grinding wheel thereon and a work holder movable toward and away from said grinding wheel for carrying a workpiece thereon into engagement with the grinding face of said grinding wheel, means for continuously supplying a liquid coolant to the grinding face of said grinding wheel, said coolant including a substance for rendering said coolant electrically conductive, means for rotating said grinding wheel to form said coolant into a film of constant thickness over at least a portion of said face, a probe mounted to move toward and away from said face along with said work holder, said probe being so positioned that it just touches the constant thickness film of coolant on said face when said work holder is spaced a predetermined distance from said face, and said probe and conductive coolant forming the elements of an electric switch which is closed when said probe touches said film and is open when said probe is spaced from said film.

2. Grinding apparatus comprising means providing the elements of a grinding machine including a rotatable spindle having a grinding wheel thereon and a work holder movable toward and away from said grinding wheel for carrying a workpiece thereon into engagement with the grinding face of said grinding wheel, means for continuously supplying a liquid coolant to the grinding face of said grinding wheel, said coolant including a substance for rendering said coolant electrically conductive, means for rotating said grinding wheel to form said coolant into a film of constant thickness over at least a portion of said face, a probe mounted to move toward and away from said face along with said work holder, said probe being so positioned that it just touches the constant thickness film of coolant on said face when said work holder is spaced a predetermined distance from said face, and electric circuit means including a source of electrical energy, said probe and said coolant; said circuit being actuated when said probe establishes electrical contact with said film.

3. Grinding apparatus comprising means providing the elements of a grinding machine including a rotatable spindle having a grinding wheel thereon and a work holder movable toward and away from said grinding wheel for carrying a workpiece thereon into engagement with the grinding face of said grinding wheel, means for continuously supplying a liquid coolant to the grinding face of said grinding wheel, means for rotating said grinding wheel to form said coolant into a film of constant thickness over at least a portion of said face, a probe mounted to move toward and away from said face along with said work holder, said probe being so positioned that it just touches the constant thickness film of coolant on said face when said work holder is spaced a predetermined

distance from said face, and a signal device operated by said probe when said probe touches said film.

4. In grinding apparatus, means for gauging during a grinding operation in which a workpiece and a grinding wheel are relatively moved toward each other which comprises means for continuously supplying the grinding wheel with a liquid coolant, means for rotating the grinding wheel at grinding speed to cause the liquid coolant to flow in a film of constant thickness over at least a portion of the surface of the grinding wheel, means for determining the position of the workpiece relative to the grinding wheel by sensing the locus of the surface of the constant thickness film with reference to the position of the workpiece, said determining means comprising a probe element, means for relatively moving said probe element and said grinding wheel toward each other as said workpiece and said grinding wheel are relatively moved toward each other, and a signal device operated by said probe when said probe touches said film.

5. An apparatus for gauging during an electrolytic grinding operation in which a workpiece is brought against an electrically cathodic grinding wheel coated with an electrolyte which comprises, means for rotating the grinding wheel at grinding speed to cause the electrolyte to flow in a film of constant thickness over at least a portion of the surface of the grinding wheel, a probe movable toward and away from said film as the workpiece moves toward and away from said grinding wheel, normally dormant electric circuit means including said probe operable to provide a signal, said signal circuit means being operated when said probe is electrically connected to said cathodic wheel by said electrolyte film.

6. Electrolytic grinding apparatus comprising means providing the elements of an electrolytic grinding machine including an insulated rotatable spindle having a conductive grinding wheel thereon and a work holder movable toward and away from said grinding wheel for carrying a workpiece thereon into engagement with the grinding face of the grinding wheel, means for continuously supplying a liquid electrolyte to the grinding face of said grinding wheel, means for rotating said grinding wheel to form said electrolyte into a film of constant thickness over at least a portion of said face, a probe mounted to move toward and away from said face along with said work holder, said probe being so positioned that it just touches the constant thickness film of electrolyte on said face when said work holder is spaced a predetermined distance from said face, electric circuit means including a power source and connections for maintaining said wheel at a negative potential relative to said workpiece and said probe, and a normally dormant electrically energized signaling circuit connected to be energized when said probe is electrically connected to said wheel by said constant thickness film.

7. Grinding apparatus comprising means providing the elements of a grinding machine including a rotatable spindle having a grinding wheel thereon and a work holder movable toward and away from said grinding wheel for carrying a workpiece thereon into engagement with the grinding face of said grinding wheel, means for continuously supplying a liquid coolant to the grinding face of said grinding wheel, said coolant including a substance for rendering said coolant electrically conductive, means

for rotating said grinding wheel to form said coolant into a film of constant thickness over at least a portion of said face, a probe mounted to move toward and away from said face along with said work holder, said probe being so positioned that it just touches the constant thickness film of coolant on said face when said work holder is spaced a predetermined distance from said face, and electric circuit means including a source of electrical energy, a device responsive thereto, said probe and said work holder and being so connected that said device is energized when said probe and a workpiece on said work holder are both in contact with said constant thickness film.

8. Grinding apparatus comprising means providing the elements of a grinding machine including a rotatable spindle having a grinding wheel thereon and a work holder movable toward and away from said grinding wheel for carrying a workpiece thereon into engagement with the grinding face of said grinding wheel, power means for advancing and retracting said work holder with respect to said wheel, means for continuously supplying an electrically conductive liquid coolant to the grinding face of said grinding wheel, means for rotating said grinding wheel to form said coolant into a film of constant thickness over at least a portion of said face, a probe mounted to move toward and away from said face along with said work holder, said probe being so positioned that it just touches the constant thickness film of coolant on said face when said work holder is spaced a predetermined distance from said face, and electric circuit means adapted when energized for actuating said power means for retracting said work holder, said electric circuit means including said probe and said electrically conductive coolant and said circuit being energized when said probe establishes electrical contact with said film.

9. Grinding apparatus comprising means providing the elements of a grinding machine including a rotatable spindle having a grinding wheel of insulating material thereon and a grounded work holder movable toward and away from said grinding wheel for grounding a workpiece thereon and for carrying said workpiece into engagement with the grinding face of said grinding wheel, means for continuously supplying a liquid coolant to the grinding face of said grinding wheel, said coolant including a substance for rendering said coolant electrically conductive, means for rotating said grinding wheel to form said coolant into a film of constant thickness over at least a portion of said face, a probe mounted to move toward said face as said work holder moves a workpiece thereon toward said face, said probe being insulated from ground and so positioned that it just touches the constant thickness film of coolant on said face when said work holder is spaced a predetermined distance from said face with the workpiece thereon against said face, a source of electrical energy grounded at one side, and a device responsive thereto electrically connected between the ungrounded side of said energy source and said insulated probe.

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