

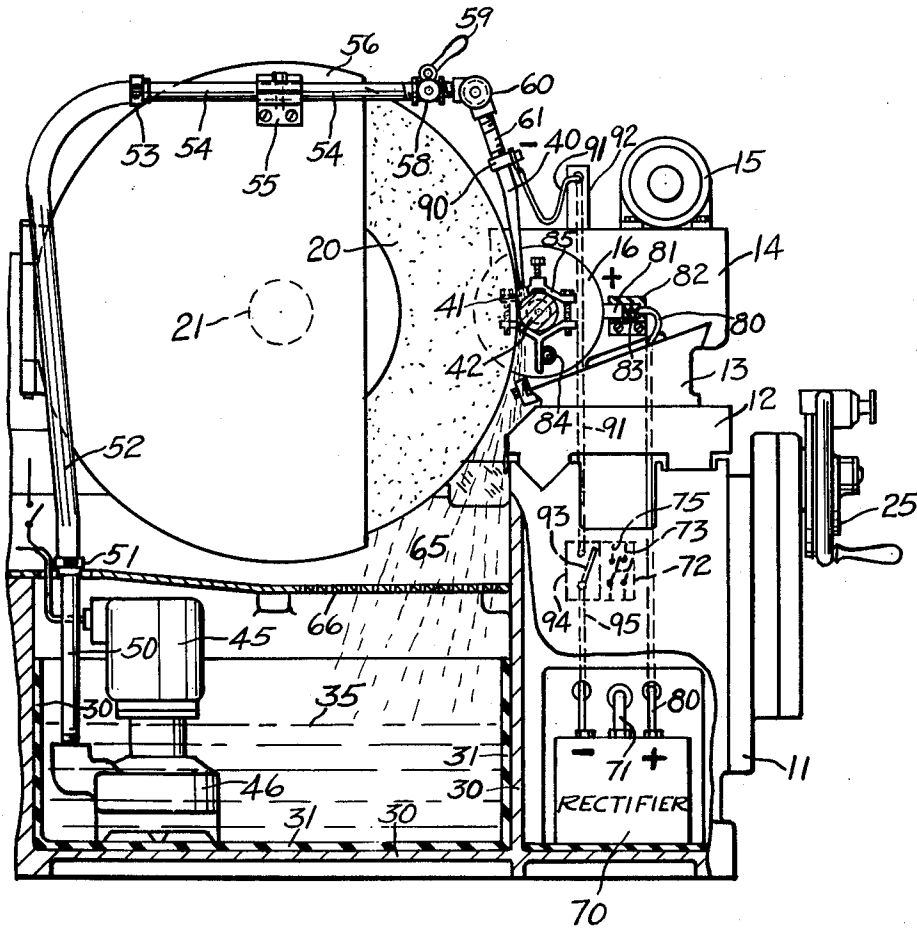
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ELECTROLYTIC GRINDER AND METHOD OF GRINDING

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3,061,529 ELECTROLYTIC GRINDER AND METHOD OF GRINDING

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The invention relates to electrolytic grinders and methods of grinding.

One object is to provide an electrolytic grinder capable of operating with a non-conductive grinding wheel. Precision grinding is now usually done using vitrified grinding wheels which are non-conductive. Some precision grinding is done with organic bonded grinding wheels usually phenolic resin bonded grinding wheels and these are non-conductive. Other kinds of grinding are done with various organic bonded grinding wheels including phenolic resin bonded grinding wheels, also rubber bonded grinding wheels and some others. In most grinding operations the grinding wheel is non-conductive. For certain grinding operations such as the grinding of the hard cemented carbides, metal bonded diamond wheels are used. These are conductive. But in most grinding operations, covering by far the greater part of all grinding, conductive grinding wheels cannot be efficiently used. Another object is to provide a method of grinding which can be performed with a non-conductive grinding wheel.

Another object of the invention is to provide an electrolytic grinder of simple construction. Another object is to provide a method of electrolytic grinding which can be carried out with simple apparatus. Another object of the invention is to achieve efficient electrolytic grinding of steels, cast iron, non-ferrous metals and to multiply the stock removal rate as much as several fold in a given time. Another object is to achieve the foregoing object without causing any greater wheel wear and in some cases less wheel wear. Another object is, by means of a very simple circuit involving no electronic apparatus and with no mechanical complexities and with an ordinary grinding wheel, completely to avoid all arcing and sparking, the former being in all cases and the latter when it is strong, detrimental in electrolytic grinding. The foregoing is actually six objects which are achieved in this invention.

Other objects will be in part obvious or in part pointed out hereinafter.

The accompanying drawing illustrating one of many possible embodiments of the invention is a view of a cylindrical grinder partly in end elevation and partly in vertical section.

As conducive to a clearer understanding of the present invention, it is noted that electrolytic grinding of the hard cemented carbides is now an industrial fact. Industrially the grinding wheels have always been metal bonded wheels, mostly metal bonded diamond wheels but occasionally metal bonded silicon carbide wheels. It has been found that the saving in diamonds by electrolytic grinding of the hard cemented carbides runs as high as 90%, meaning that for a given amount of stock removal only one tenth as much wheel wear is incurred as in the same grinding operation without the assistance of the electrolytic work erosion. Of course in many cases the saving isn't this great.

Although this invention is illustrated as applied to a cylindrical grinder, it has no such limitation as it can be embodied in any other kind of a precision grinder, such as a surface grinder, a centerless grinder and any other type and also in non-precision grinders of various kinds wherever liquid coolant based on water can be used.

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Referring to the drawing, the machine has a base 11 having ways supporting a carriage 12 which supports a work table 13 having ways which supports a headstock 14 supporting a motor 15 which through driving mechanism rotates a face plate 16.

A grinding wheel 20 is supported and rotated by a spindle 21 which is journaled in a wheel head not shown on a cross slide not shown, the spindle being driven by a motor not shown through pulleys and belts. All this is conventional and does not have to be illustrated. The cross slide will usually be given an infeed and withdrawal movement by hydraulic mechanism and also can be operated by a hand wheel 25.

The grinding wheel 20 can be any kind of an electrically non-conductive grinding wheel in accordance with the foregoing discussion. It could even be a metal bonded grinding wheel so far as operability is concerned but there is no present apparent advantage therein, in fact this would cancel one of the objects of the invention. Still, for the grinding of hard carbide with metal bonded diamond wheels the present method of producing electrolytic work erosion may be preferred.

In the base 11 is formed a tank 30 lined with rubber 31 or other non-conductive material. This contains water having dissolved therein some non-corrosive salt to make it electrically conducting. Alkaline salts can be used for ferrous metal grinding. Very good examples are sodium carbonate Na_2CO_3 , sodium phosphates and sodium borate, $\text{Na}_2\text{B}_4\text{O}_7$. Neutral salts can be used in some cases, the common example being sodium chloride. Even acids can be used for certain grinding operations where discoloration of the work is not important and where erosion of machine parts can be tolerated in view of the further disintegration of the metal being ground by the acid. Bases such as sodium hydroxide can be used. In any case where sodium is a part of the compound other alkali metals such as potassium can be substituted, also alkaline earth metals, where soluble salt results. In fact there is no limit to the materials which can be used provided they are readily soluble in water ionizing therein. But for most practical grinding operations, the salt should be alkaline. The three specifically mentioned are rust inhibitors which is an advantage and they are also non-corrosive to the hands. Broadly speaking, therefore, the electrolyte used in accordance with this invention is any water based electrolyte having ionized material therein therefore being a conductor of electricity. All kinds of mixtures can be used.

The electrolyte 35 is pumped through insulated piping to a metal nozzle 40 whence it emerges in a stream 41 to contact the work piece 42 acting both as a coolant, a grinding swarf remover and an electrolyte to convey the positive electricity from the work piece thus producing electrolytic work erosion at the same time that the grinding wheel 20 is abrasively grinding the work piece 42. I will first describe the coolant-electrolyte circuit and then the electric circuit.

In the tank 30 is an electric motor 45 driving a pump unit 46 having a self-contained strainer to remove the abrasive swarf. This pump 46 pumps electrolyte 35, which will be called water from now on because it is mostly water, through a metal pipe 50 which is connected by a clamp 51 to a rubber hose 52 which is connected by a clamp 53 to a plastic pipe 54 which is supported by a bracket 55 which is secured to the wheel guard 56. The plastic pipe 54 is connected to a valve 58 having an operating handle 59 which is connected to a swivel joint 60 which is hollow for the passage of the water which is connected to a pipe 61 which is connected to the metal nozzle 40.

The grinding wheel 20 is usually not as wide as the work piece 42 and even if it is, the water can go down-

ward on either side of the wheel 20 where it flows into a chamber 65 formed by various walls of the machine base and having a perforated bottom 66 over the tank 30, so therefore the water returns to the tank 30 to be repumped around the circuit again.

Any source of electric current can be used but there is shown a rectifier 70 energized by a cable 71 supplying electricity from the regular factory single phase system. Usually this will be a 60 cycle 440 volt supply. This cable is connected to a switch box 72 having a double pole switch 73 operable on the outside of the machine and diagrammatically shown in the drawing which is connected to the 440 volt line 75.

From the positive side of the output of the rectifier 70 goes a cable 80 to an insulated brush 81 in an insulating holder 82 secured to the headstock 14 which holder has a spring 83 pressing the brush 81 against the periphery of the face plate 16 which is of course made of metal. Thus the direct current reaches the face plate 16 and then passes into a work driving dog 84 which drives a clamp 85 which grips the work piece 42 to drive it. This clamp 85 is broken away in the upper left quadrant to show the stream 41.

The electric current now flows up the stream 41 to the nozzle 40 and due to the greater conductivity of the nozzle most of the electricity goes into it at the very opening of the nozzle. If this nozzle is made of brass or copper, its resistance from a practical point of view is zero.

Clamped by clamp 90 to the nozzle 40 is a cable 91 which is flexible to allow for movement of the wheel slide and this cable 91 is secured to a standard 92 secured to the far end of the wheel base 11. The cable 91 extends to an exteriorly operated switch 93 in a switch box 94 which is connected to a cable 95 connected to the negative side of the rectifier 70. Thus from the nozzle 40 electricity flows through the cable 91 to the switch 93 through the cable 95 to the negative side of the rectifier 70. All cables mentioned herein are of course suitably insulated.

In the supplement to the report on "Electrolytic Process for Shaping Metals and Metal Carbides" published in or about December 1951, by George F. Keeler of United Drill and Tool Corp., Howard T. Francis of Armour Research Foundation and Charles L. Faust of Battelle Memorial Institute, a table of electrolytic grinding is given wherein the highest current used was 38 amperes.

As progress has been made since then I assume that it will be desirable to provide at least 40 amperes of current. In a practical grinding operation the stream 41 of water may be 5 centimeters long. It should be in the form of a ribbon which in a given grinding operation might be 4 centimeters wide and one centimeter thick. The resistivity of water containing 15 grams of sodium carbonate for 100 grams of water at 18° C., 64° F., is 12 ohms cm. The cross section at the orifice of the nozzle 40 is therefore 4 square centimeters and it can be assumed not to change although it increases somewhat. The resistance of the stream is therefore $12 \times \frac{5}{4} = 15$ ohms. The rest of the circuit can be disregarded especially as, since the stream 41 widens, the resistance will be a little less than 15 ohms. Using the equation $C = E/R$ we have $40 = E/15$ and $E = 600$ volts.

This might seem to be prohibitively dangerous but it is not for the following reasons. The positive side of the output of the rectifier 70 is grounded because the face plate 16 is grounded to the machine except for an oil film in the spindle bearings and this kind of a grinder must have a tail center and a tail stock which tail center contacts the work piece and sometimes there is no oil film between them. Even if the oil on the ways of the base supporting the carriage 12 is an insulator, the operator working on the machine will at one time or another touch the headstock 14 or the tail stock or the table 13.

But he cannot receive a shock unless he also touches the negative side of the line somewhere.

The nozzle 40 should be given a coating of Rokide (trademark) by means of the Rokide process patented to Wheeldon #2,707,691. This coating is actually a porous coating of oxide commercially one of either aluminum oxide or zirconium oxide or in a few cases zircon, all of which are good insulators. This is done after the clamp is applied and the clamp also is given a Rokide coating. The pipe 61 is made of some non-conductive material, for example a strong plastic. Over the Rokide coating to fill the pores it is desirable to apply any penetrating organic material which will stay when the solvent dries such as shellac and alcohol. A thin solution should be used to obtain good penetration. After the cable 91 is connected to the clamp 90 the connection should be Rokided and this can be done because the Rokide apparatus is portable. Then the connection should be shellaced.

No appreciable current will run to the gate valve 58 through the water because the regular path of the current is a far, far better conductor than the water. Since the work piece 42 is so much better a conductor than the human body it is probable that a finger could be put into the stream 41 without a serious burn but of course it shouldn't be tried. Water mist and drops of water cannot carry any electricity hence are harmless. For this reason also practically no electricity is carried downward beyond the work piece 42 by the water because before it touches metal parts of the machine below the work piece it is in the form of separate drops.

It will be seen that yielding 40 amperes current, the rectifier must have an output of 24 kilowatts and an input of a little more say 25 kilowatts. At 440 volts, to get 25 kilowatts the current will be 56.82 amperes. Good sized cable is therefore needed both for the input and the output of the rectifier and in that respect the drawing must be considered merely diagrammatic. Rectifiers having an input of 25 kilowatts and even larger are readily available. In fact rectifiers having an output of 30 kilowatts are now being used for some purposes and probably there are even larger ones. To make the machine still more efficient as an electrolytic grinder since it is relatively safe as shown, the current used could be increased as much as five fold by reducing the length of the stream 41 to one centimeter.

The rectifier box should also have in it a transformer to transform the input from 440 volts to, for example, 600 volts or any other desired E.M.F. plus suitable breaker switches for overload and an operating switch for the input or this can be in the cable 71 as shown. It may have an ammeter and a voltmeter for the input and the output.

A special feature of the invention is that using the stream 41 for what can be called the electrode in electrolytic grinding, there can be neither arcing nor sparking with any reasonable current density so far as I am aware. This is because the electrode stream 41 is in actual contact with the other electrode, work piece 42. The stream would quench any arc that started and there is no gap for a spark. Furthermore the current cannot channel; it is evenly distributed. This offers a considerable improvement in electrolytic grinding and for some purposes gives better finishes.

By providing two swivel joints instead of the single swivel joint 60, the nozzle 40 can be pressed into contact with the grinding wheel 20 and the work piece 42. The grinding wheel will immediately grind it on one side until contact is broken and when the current is turned on an arc will be formed which will make a small gap on the other side. This arcing will be harmless as the work piece will be ground later.

The circuit breakers may work several times but after a while a very fine gap is formed. If this is only as small as one millimeter, and it might be less, the resistance is reduced to one-tenth of what it was at the last calculation

which was one-fifth of what it was at the first calculation, that is the resistance is reduced to three-tenths of an ohm. Thus with a voltage of 600 and a resistance of three-tenths of an ohm, the current is 2,000 amperes.

While grinding keeps the work piece round or flat or some other shape to accuracy and a grinding machine brings the work piece to precision size, the electrolytic method of eroding metal herein described may have advantages in certain cases where there is no grinding involved. The charged stream 41 erodes the metal and also carries away dislodged metal particles which are filtered out by the filter or strainer in the pump unit 46.

It will thus be seen that there has been provided by this invention electrolytic grinders and methods of grinding in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiments above set forth, it is to be understood that all matter hereinbefore set forth, or shown in the accompanying drawing, is to be interpreted as illustrative and not in a limiting sense.

For the best mode of the invention so far as the electrolyte is concerned, I pick alkaline salts and of those, since I know its resistivity but do not know that of the others, I pick sodium carbonate. The invention can be applied to many different kinds of grinders each one being the best for some grinding operations so the best mode cannot be picked but to comply with the statute I pick the mechanism described.

I claim:

1. An electrolytic grinder comprising a base, a grinding wheel, means to rotate said grinding wheel supported by said base, a work piece holder supported by said base and positioned to hold an electrically conductive work piece in contact with said grinding wheel, a fluid circulating system electrically insulated from said base including circulating means operable to continuously circulate an electrically conductive fluid and an electrically conductive nozzle from which a continuous stream of electrically conductive fluid is discharged for impingement upon a work piece at its point of contact with said grinding wheel, and an electrical circuit electrically insulated from said base including a source of direct current, an electrical conduit interconnecting the positive side of said source and said work piece holder so as to render said work piece holder and an electrically conductive work piece supported thereby positive, and an electrical conduit interconnecting the negative side of said source and said nozzle so as to render said nozzle and a stream of electrically conductive fluid in contact with and discharged therefrom negative.

2. An electrolytic grinder comprising a base, a grinding wheel, means to rotate said grinding wheel, an electrically conductive work piece holder supported by said base and positioned to hold an electrically conductive work piece in contact with said grinding wheel, a fluid circulating system supported by and electrically insulated from said base having circulating means incorporated therein for circulating an electrolytic fluid therethrough, said fluid circulating system including an electrically conductive nozzle arranged to be continuously supplied with a circulating electrolytic fluid by said circulating means and positioned to direct a jet of electrolytic fluid substantially tangentially of the grinding wheel at its point of contact with a work piece, a source of direct current, an electrical conduit interconnecting said source and said work piece holder so as to render said work piece holder

positive, and an electrical conduit interconnecting said source of direct current and said nozzle to render said nozzle negative, whereby an electrical circuit for electrolytically assisted grinding is established and maintained by the impingement upon an electrically conductive work piece of a continuous stream of electrolyte discharged from an electrically conductive nozzle independent of the electrical properties of the grinding wheel.

3. An electrolytic grinder comprising a base, a grinding wheel, means to rotate said grinding wheel supported by said base, an electrically conductive work piece holder supported by said base and positioned to support an electrically conductive work piece in engagement with said grinding wheel, a fluid circulating system for an electrolytic-coolant fluid supported by and insulated from said base including means for circulating electrolytic-coolant fluid within said system and an electrically conductive nozzle for discharging a continuous stream of electrolytic-coolant fluid so that the continuous stream discharged impinges on the portion of the surface of a work piece supported by said work piece holder contiguous to said grinding wheel, and means together comprising an electrical circuit including a source of direct electric current provided with positive and negative terminals, an electrical conduit interconnecting the positive terminal of said source and said work piece holder to render said work piece holder and thence an electrically conductive work piece supported thereby positive, and an electrical conduit interconnecting the negative terminal of said source and said nozzle to render said nozzle and thence a continuous stream of electrolytic-coolant fluid discharged therefrom negative.

4. The method of combined grinding and electrolytic erosion which comprises providing a water based electrolyte having ionized material therein which is a conductor of electricity, causing said electrolyte to flow through an electrically conductive nozzle as a continuous stream from an external source against the contiguous surfaces of a grinding wheel and an electrically conductive work piece engaged thereby, energizing a work piece so disposed positively electrically, energizing said nozzle and thence the continuous stream of electrolyte discharged therefrom negatively electrically, and coincidentally grinding a work piece so disposed with a grinding wheel, thereby electrolytically eroding the work piece and also abrasively grinding it.

5. An electrolytic grinder according to claim 1 in which the grinding wheel is an electrically non-conductive wheel.

6. Method of grinding according to claim 4 in which the ionized material is an alkaline salt.

References Cited in the file of this patent

UNITED STATES PATENTS

1,416,929	Bailey	May 22, 1922
1,473,060	Taylor	Nov. 6, 1923
2,061,554	Billiter	Nov. 24, 1936
2,385,198	Engle	Sept. 18, 1945
2,741,594	Bowersett	Apr. 10, 1956
2,793,992	Heuser	May 28, 1957
2,798,846	Comstock	July 9, 1957
2,826,540	Keeleric	Mar. 11, 1958
2,873,232	Zimmerman	Feb. 10, 1959
2,961,394	Williams	Nov. 22, 1960

FOREIGN PATENTS

748,485	Great Britain	May 2, 1956
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