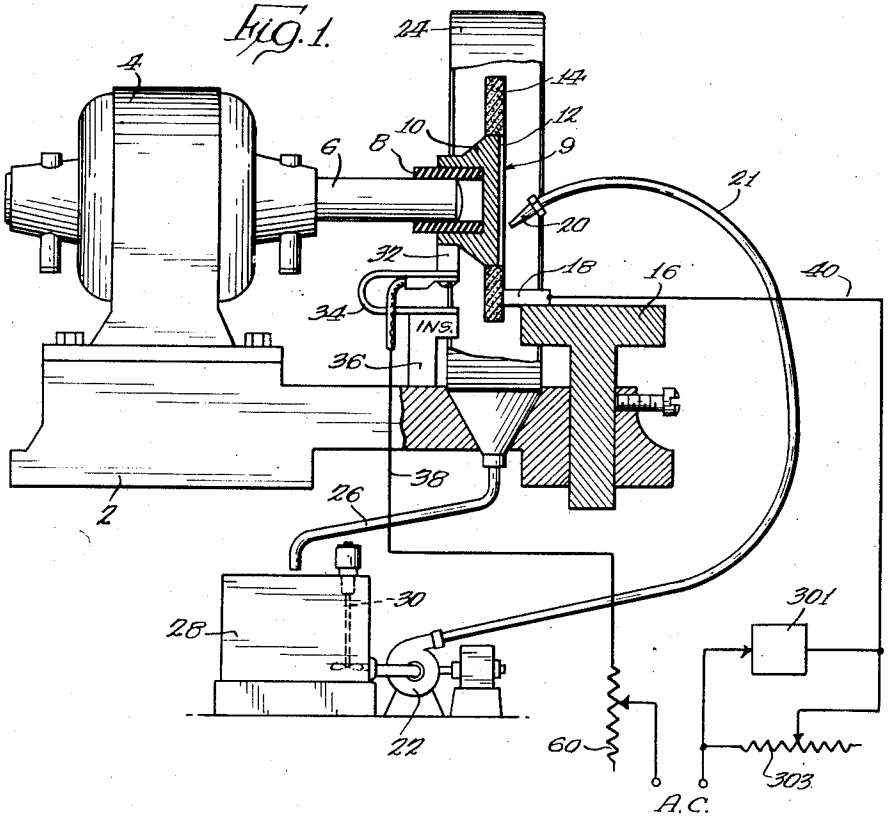
Sept. 22, 1959 G. F. KEELERIC ET AL 2,905,605

DRESSING OF ABRASIVE TOOLS

Original Filed May 19, 1953 2 Sheets-Sheet 1

Fig. 1.



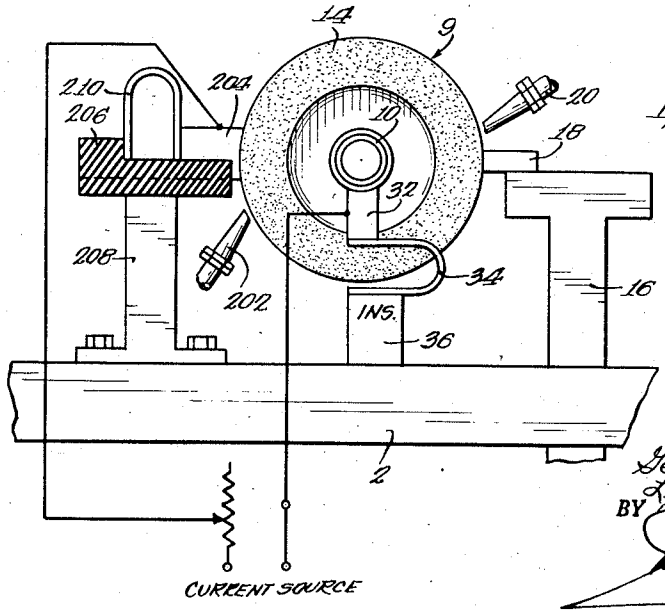


Fig. 2.

INVENTORS.
George F. Keeleric
Lynn A. Williams, Jr.
BY
Atty

Sept. 22, 1959 G. F. KEELERIC ET AL 2,905,605

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Fig. 3.

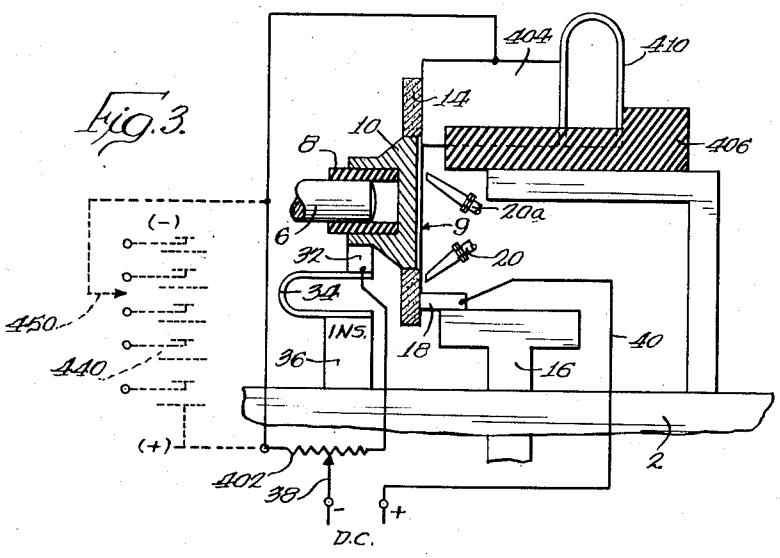
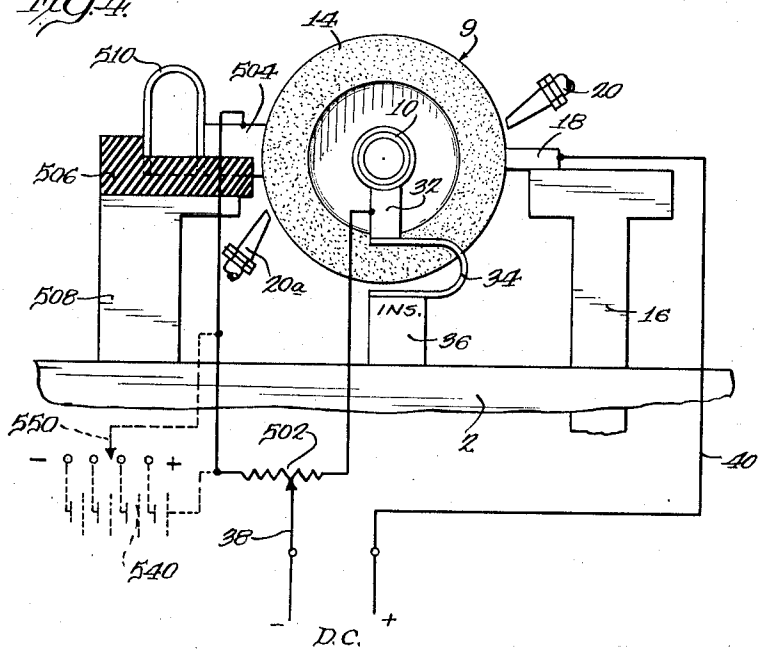


Fig. 4.



INVENTORS.
George F. Keeleric
Lynn A. Williams, Jr.
BY
Atty

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2,905,605

DRESSING OF ABRASIVE TOOLS

George F. Keeleric, Dundee, and Lynn A. Williams, Jr., Winnetka, Ill.; said Williams assignor to said Keeleric

Original application May 19, 1953, Serial No. 355,932. Divided and this application August 7, 1956, Serial No. 602,558

1 Claim. (Cl. 204—143)

This invention relates to apparatus and methods for dressing and conditioning abrasive tools by electric means. The present application is a division of our copending application, Serial No. 355,932, filed May 19, 1953.

In a copending application of George F. Keeleric (one of the co-inventors herein), Serial No. 310,244, filed September 18, 1952, for "Method and Apparatus for Electrolytic Cutting, Shaping and Grinding," and issued as Patent No. 2,826,540, dated March 11, 1958, there is disclosed a method of shaping materials by concurrent electrolytic and abrasive action. In another copending application of George F. Keeleric, Serial No. 310,243, filed September 18, 1952, and now abandoned, for "Electric Cutting, Shaping and Grinding," there is disclosed the idea of using insulating spacers (which may be abrasive particles) to maintain proper spacing between a workpiece and a moving electrode in electric material-shaping techniques. The present invention includes, among other things, improvements in the use of the methods and apparatus of those applications.

When electric shaping techniques are employed, the spacing distance between the workpiece and the electrode will often be of great importance. This will be so whether the electric shaping method is of the arc or spark type or of the electrolytic type. In the electrolytic method the spacers tend to be abraded by contact with the workpiece, and this tends to alter the spacing distance between the electrode abrasive tool and the workpiece. The same is true when the spark or arc method is used but to a lesser extent because, in this method, metal is removed from the electrode by the spark or arc, thus tending to offset wear on the abrasive particles.

One of the general objects of this invention is to provide means for maintaining a predetermined spacing distance between an electrode and a workpiece in electric shaping procedures.

A related problem arises in the preparation and use of some kinds of abrasive tools as electrodes in electric shaping operations. It is possible, and frequently desirable, to use as electrodes, abrasive tools, usually in the form of grinding wheels in which particles of insulating abrasive are held in a metal bond commonly produced by powdered-metal techniques. For example, finely divided metal powder may be mixed with abrasive particles, then pressed in a mold, and then sintered to bond the mass together. One of the reasons for use of such techniques is to achieve a desired degree of brittleness or frailty in the metal bond so as to facilitate self-dressing of the tool. By this invention, other metal bonds of much stronger characteristics and easier manufacturability may be used. When a metal-bonded grinding wheel is made in any of these ways, the metal bond and the abrasive particles will be substantially flush at the working surface. Before such a tool can be used effectively for electric shaping, it is necessary to establish a spacing distance between the metal of the tool and

the workpiece, which will be determined by the amount of protrusion of the insulating abrasive particles above the metal. To do this the metal may be cut away by using a dressing tool or by etching back the metal. While the etching may produce greater uniformity than ordinary dressing techniques, still there is no certainty that some parts of the metal will not come much closer to the working surfaces established by the abrasive particles than others. Here it should be understood that the spacing distance used may be quite small, so that even small variations in height of the metal of the tool will represent proportionately large variations in the spacing distance.

This will be deleterious, particularly in electrolytic shaping where the workpiece to be shaped is made an anode in an electrolytic circuit in which the abrasive tool is a cathode, and in which an electrolyte is flowed in the space between the workpiece and the tool. The reason for the harmful effect is that in this electrolytic process it is desirable to operate at the maximum current level which can be reached without inducing heavy sparking or arcing, as explained in the copending Keeleric application, Serial No. 310,244, mentioned above. But if any part of the metal of the electrode tool comes closer than another to the workpiece, sparking and arcing may be initiated at that point at a current level well below that which could be safely sustained over the rest of the electrode tool. This makes it necessary to cut back the current level and reduces the speed of operation as compared with that achieved when the metal surface of the electrode tool is uniformly at the optimum spacing distance from the workpiece with maximum current being carried.

Thus, another object of this invention is to provide a simple means for conditioning abrasive tool electrodes to bring about uniform depth of metal below the surface established by the abrasive particles.

Another aspect of the problem arises in the use of abrasive tool electrodes in electrolytic grinding. As work proceeds, material removed from the workpiece may become lodged between the abrasive insulating particles on the metal of the electrode. If this is carried far enough, the wheel becomes "loaded," in the parlance of the art. But even prior to this, the presence of conductive material from the workpiece may disturb the spacing relationship, and an object of this invention is to get rid of any such accumulations as they occur.

Another aspect of this invention is to broaden the use of non-diamond abrasives, such as silicon carbide and aluminum oxide, in shaping hard materials, such as sintered tungsten carbide. When the attempt is made to use such abrasive materials by conventional grinding in this application, the rate of wear is so great as to be quite unsatisfactory. When the attempt is made to use these materials in electrolytic grinding as abrasive spacers, then, unless very light grinding pressure is used, the rapid rate of wear leads to loss of spacing distance, and brings about undesirable direct contact between the workpiece and the electrode or metal portion of the grinding wheel or other tool. An object of this invention is to provide continuous electrolytic dressing of such tools at a rapid enough rate to assure maintenance of adequate protrusion distance of grains of such abrasive materials as silicon carbide and aluminum oxide to permit their use in shaping of very hard materials.

Other objects of the invention will appear in the description of the invention which follows.

In the drawings:

Fig. 1 is an elevation, partly in section and partly schematic, showing one form of apparatus for the conditioning of abrasive tool electrodes for electric shaping of materials.

Fig. 2 is a schematic view of apparatus for electrolytic dressing of metal-bonded abrasive tools for conventional grinding.

Fig. 3 is a schematic view of another form of apparatus.

Fig. 4 is a schematic view of the apparatus of Fig. 3 as applied to an abrasive tool wheel electrode in which the working face is around the periphery.

The gist of the invention is the use of electric action for the dressing of abrasive tools and, particularly, for the dressing of abrasive tool electrodes to maintain proper spacing distance between the metal surface of a metal-bonded abrasive tool and a surface generated by the protrusion of abrasive particles beyond the metal surface.

In Fig. 1 this is accomplished by an arrangement to permit making the grinding-wheel tool electrode an anode periodically, so that the metal of the tool is removed electrolytically to condition it for optimum use in the system. This we refer to as electrolytic tool dressing.

Referring to Fig. 1, the bulk of the apparatus consists of any conventional grinding machine adapted for electrolytic grinding, and is, in many respects, similar to the apparatus shown in the above-mentioned Keeleric application, Serial No. 310,244. It may consist of a bed **2** carrying a motor **4** having a spindle **6**, on which is fixedly mounted through insulating sleeve or bushing **8** an abrasive tool electrode **9**, here taking the form of a grinding wheel. This consists of a central portion having a metal hub **10** and flange **12**, around which is mounted an abrasive-bearing ring **14**, shown here as made of sintered powdered metal in which particles of insulating abrasive are imbedded at random so that some of them are always exposed at the working face. The particles may be of any of several kinds of insulating abrasive, such as diamond bort, silicon carbide or aluminum oxide. Boron carbide may also be used, although it is somewhat conductive. This is so because, relative to the electrolytic path which has very low resistance, the boron carbide may be considered as a partial insulator. If desired, the grinding-wheel tool electrode may be of another type, such as that shown in United States patent to Keeleric, No. 2,368,473, issued January 30, 1945, for "Method of Making Abrasive Articles."

A tool rest or pedestal **16** is provided in the conventional manner, so that a workpiece **18** may be rested on it while being held against the abrasive-bearing ring **14**.

To supply electrolyte to the work area, there is provided a nozzle **20** fed by conduit **21** leading from pump **22**. Around the grinding-wheel tool electrode **9** is a shroud **24**, shown partly cut away, which collects the splatter of electrolyte and returns it through conduit **26** to sump tank **28**, from which it is picked up by pump **22**. The sump tank may be fitted with an agitator **30**.

The electrical system includes a source capable of supplying direct current in the range between 2 and 30 volts. This source may be a storage battery or a motor generator or, more frequently, a rectifier system fed by alternating current. It may be of the automatically-controlled type, as shown in the above-mentioned Keeleric application, Serial No. 310,244.

To make connection to the electrolytic circuit between the tool electrode **9** and the workpiece **18**, a brush **32** is provided and is urged against hub **10** by spring **34**, which is supported by insulating block **36** from bed **2**. A conductor **38** leads to the brush **32**. Another conductor **40** leads to the workpiece **18** and may also be grounded to the tool rest **16** or bed **2** in order to minimize unwanted electrolytic action between components of the machine arising from stray currents.

The system shown in Fig. 1 is especially applicable to abrasive tool electrodes in which the abrasive particles are not diamonds but are some other material, such as silicon carbide or aluminum oxide. In shaping tungsten carbide parts with such an electrode, the ordinary operator will use grinding pressures such that the abrasive

particle spacers will be rapidly worn down. The spacing distance will soon be lost unless some means is provided to remove metal from the tool electrode at a rate sufficient to keep pace with the wear of the spacing particles.

This is accomplished by a novel electrical supply system. The source is alternating current, and a partial rectifier system is so arranged that an adjustment can be made to control the extent to which the reverse-current cycle (i.e., that in which the abrasive tool electrode is the anode) is applied.

The conductor **38** leads to brush **32** from the alternating-current source and a rheostat **60** is included in this part of the circuit.

In the lead **40** to the workpiece **18**, a rectifier **301** is provided and connected in the sense to pass the positive cycle so that the workpiece **18** is the anode. Connected across rectifier **301** is a rheostat **303**, which in its maximum position has several times the resistance of rectifier **301**.

When the rheostat is in its maximum-resistance position, it passes very little current and, thus, the workpiece receives substantial current to make it an anode and almost none to make it a cathode. But when it is desired to cause deplating or electrolytic dressing of tool electrode **9**, rheostat **303** is adjusted to pass a substantial amount of current on the reverse cycle. This will cause removal of metal from tool electrode **9**. The rate of removal will, of course, be determined by the adjustment of the rheostat—the lower the resistance, the higher the removal rate. In practice, as the metal is removed so that the spacing distance increases, the amount of current carried between the workpiece **18** and the tool electrode **9** decreases, thus reducing the removal rate. Therefore, the adjustment of rheostat **303** more or less determines the spacing distance at which the system comes toward equilibrium and, for any given operation, it is not necessary to make frequent adjustments.

Before starting to use an abrasive tool electrode in which the abrasive particles are substantially flush with the metal, or in which the spacing distance from the workpiece is non-uniform due to unevenness in the metal surface, the rheostats **60** and **303** will be moved to such positions as to pass substantial current on the cycle where the abrasive tool electrode is positive and the workpiece is negative. The apparatus will then be operated for a brief period under this condition with the workpiece **18** held against the abrasive-bearing ring **14** of the abrasive tool electrode **9**, and moved back and forth across it.

The result of doing this is to cause electrolytic removal of metal from the abrasive tool electrode **9**. If the metal surface is irregular, the high points will be subject to higher current and greater removal rate, thus bringing about uniformity in the spacing distance.

If, initially, the abrasive particles are flush with the metal of the tool electrode it will be desirable to use something other than a workpiece for dressing purposes, as otherwise direct, metal-to-metal contact may accidentally occur. While this may be partially overcome by backing a workpiece away slightly or by relying on an initial period of arcing and sparking for metal removal, a more easily controlled procedure is to use, in place of a standard workpiece, a special tool, itself having its working surface formed with insulating-particle spacers, thus assuring some spacing so that electrolytic action is assured from the outset.

While this operation may be carried out as an initial conditioning operation, it may also be used as a reconditioning method. Thus, if the tool electrode **9** becomes loaded or partially loaded, a brief period of reverse-current operation will clean it. If the abrasive particles wear down so as to narrow the spacing distance, then a brief period of reverse-current operation will restore it by removing metal equal in depth to the amount of wear in depth of the abrasive particles.

For this purpose, another method is to operate for a

brief period in such a way as to produce sparking or arcing between the workpiece **18** and the tool electrode **9**. While for normal operation such sparking and arcing must be held to a low level, for the conditioning or reconditioning operation a substantial amount is permitted for a long enough time to cause metal from the tool electrode **9** to be removed by the spark and arc action. The spark and arc will be most intense at any high points on the electrode and, thus, will produce an equalizing effect similar to that of electrolytic dressing. For this spark and arc dressing a dummy workpiece may be substituted, as sparking and arcing produces a rough finish on the workpiece. If, however, instead of waiting until the tool electrode needs substantial reconditioning it is dressed from time to time by brief periods of moderate arcing and sparking, then production workpieces may be used without seriously harming them.

Sometimes spark and arc dressing will be used for rough dressing followed by electrolytic dressing for finishing.

When spark and arc dressing is to be used, the rheostat **60** will be adjusted for higher current flow. If the current source consists of the automatically regulated system shown in co-pending Keeleric application, Serial No. 310,244, then the adjustment of that apparatus will be set so that the voltage is not reduced until a substantial amount of arcing and sparking occurs.

In electric dressing of the tool electrode the workpiece will be moved back and forth so as to obtain uniform spacing distance across the entire working surface. This may be checked adequately by noting the extent of electric sparking at the workpiece. Wherever the greatest amount of sparking occurs, the spacing distance is smallest, and, thus, continued application of the workpiece will be made at such areas until the sparking is uniform throughout. For this check, the current level should be such as just barely to produce sparking, as this will enable closed discrimination. Care must be taken not to be confused by the normal abrasive sparking which appears predominantly at the trailing edge of the workpiece.

Fig. 2 shows schematically apparatus for electrolytic dressing of an abrasive tool for use in conventional grinding operations. It may be used for the improvement of any conventional grinding operation in which a metal-bonded grinding wheel or any other electrolytically susceptible grinding wheel is used, but it will be of particular value where the workpiece or material being ground is of a non-conductive type such as glass, ceramic, etc. Thus, the dressing arrangement of Fig. 2 is applicable not only to electric material shaping methods, which require that the workpiece be conductive, but also to the many grinding and shaping applications in which the workpiece is non-conductive.

The reference numerals common to Fig. 1 in this figure, and in other figures herein, designate identical or similar parts operating in the same way except as otherwise indicated.

The abrasive tool **9**, as shown in Fig. 2, is formed with an abrasive-bearing ring **14**, which is of the metal-bonded type; that is, it consists of a metal bond in which abrasive particles, such as diamond bort, silicon carbide or aluminum oxide, are imbedded. A conventional tool rest **16** is provided in the usual way and on it is shown a workpiece **18**. It should be noted, however, that no electrical connection is made to the workpiece **18**, which is here being ground in the conventional manner.

With abrasive tools of this kind, however, one of the difficulties is that the abrasive particles tend to be worn down flush with the metal bond, and when this occurs the cutting action is slowed down. The common practice is to apply a dressing tool from time to time so as to restore the effectiveness of the working surface. When an abrasive tool of this kind is freshly dressed, its cutting speed is considerably greater than it is after a period of use. However, the application of a dressing tool necessarily removes a considerable part of the abrasive tool, and, thus, shortens its life. This difficulty is accentuated by the fact that many operators carry out the dressing operation more vigorously and for a longer time than is necessary.

The arrangement of Fig. 2 provides for a different method of dressing the abrasive tool. The brush **32** is provided to run against hub **10** of the abrasive wheel. It is urged against the hub by spring **34**, which in turn is supported on an insulating member **36** mounted on the base **2** of the apparatus. A dressing electrode **204** is mounted to slide in an insulating guide or ways **206** and is pressed lightly against the grinding wheel by a spring **210**. The insulating guide or ways **206** is supported by a suitable bracket **208** from the bed **2**. An electrolyte nozzle **202** supplies electrolyte just ahead of the dressing electrode. Electrical connections are made to brush **32** and dressing electrode **204**, and in these connections a rheostat **60** is placed for the purpose of providing adjustment. The electric current source will ordinarily be a direct-current source having a voltage between 2 and 30 volts. When a direct-current source is used, the negative pole is connected to the dressing electrode **204** and the positive pole is connected to brush **32**. When current is applied as the grinding wheel **9** is running, and as electrolyte is supplied through nozzle **202**, an electrolytic action will occur between dressing electrode **204** and the metal of abrasive-bearing ring **14** in a direction such that metal will be removed from the abrasive-bearing ring **14**.

Before such electrolytic operation can occur in a normal manner, it will be necessary to establish a spacing distance between the metal of the abrasive tool **9** and the conductive portion of dressing electrode **204**. This may be done by initially dressing the abrasive tool mechanically or by an initial etching away of some of the metal on the working surface. Or, at the start of operation, dressing electrode **204** may be slightly withdrawn so as not to make contact with the abrasive tool. If this is done, it should be withdrawn just as little as conveniently possible so that there is room for the passage of a flow of electrolyte between the dressing electrode and the abrasive tool, but so that the spacing distance is not too great. If, for example, the dressing electrode is temporarily withdrawn to about .010" and if then the apparatus is operated with a fairly high voltage applied to the electrolytic circuit, enough metal will be removed from the abrasive tool in a few minutes so that the dressing tool may be allowed to move into contact with the abrasive tool. Contact will be made, of course, with the abrasive particles protruding above the metal of the abrasive tool, and these particles will establish a spacing distance to permit the continuation of the electrolytic process. Ordinarily, such spacing distance will be of the order of .001", but it may be as great as .005" or even .010" where large grit sizes are used in the abrasive particles. After the initial operation when the dressing electrode is held out of direct contact with the abrasive tool, during which time high voltage is applied, and at the time when the dressing electrode is allowed to move forward to make contact with the abrasive particles of the abrasive tool, the voltage will be reduced to the intended running voltage.

The result will be that the metal will be removed slightly below the working surface established by the abrasive particles and, by this means, their cutting action will be markedly improved. The electrolytic dressing action may continue, of course, while the grinding wheel is being used, thus maintaining at all times a slight protrusion of the abrasive particles above the metal of the abrasive-bearing ring. If the current source is set at a fixed voltage, preferably without use of rheostat **60**, then, as the metal is removed and the gap through the electrolyte increases, the resistance of the electrolytic circuit will rise, and the rate of removal will decrease; thus, there is a tendency toward self-regulation with the point at which

such regulation occurs being determined by the amount of voltage applied. Of course, the electrolytic removal does not cease altogether, and care must be taken that the electrolytic dressing action does not proceed at too fast a rate, and particularly not through inadvertence when the grinding wheel is not being actually used.

In practice, it will be customary to use a direct-current source, usually a rectifier system taking its supply from the conventional alternating-current supply as shown in Fig. 1. However, a less expensive arrangement is to use alternating current, recognizing that the reverse-current cycle will not be effective to remove material from the grinding wheel but will, in fact, remove material from the dressing electrode **204**. Some current will be wasted and the dressing electrode will be used more rapidly, but for some applications where initial low cost is of importance the alternating-current arrangement may be found desirable.

The dressing electrode **204** may be of soft material, such as bronze, so that it will not itself tend to wear down the abrasive particles. However, a hard material, such as a cemented tungsten carbide, may be used with a very light pressure exerted by spring **210**. The tungsten carbide dressing electrode will, of course, last longer than one of soft material. Moreover it provides a certain amount of mechanical dressing, tending to true up the working surface of the grinding wheel, whereas a soft material tends to conform to any irregularities created by heavier grinding action on one part or another of the grinding wheel caused by the location and pressure of workpiece **18** against the grinding wheel.

One advantage of the electrolytic dressing technique is that it permits the use of smaller abrasive particles in the abrasive-bearing ring **14**. Since the removal of metal may proceed at a carefully controlled rate and precisely evenly, the smaller particles may be exposed in such a way as to make very effective cutting agents. As an abrasive tool of this kind is used, the surfaces of the abrasive particles are flattened by wear and lose their cutting effectiveness. However, this action seems to be less pronounced when very small particles are used. It is possible with this arrangement to use particles of the order of 275 to 400 grit size, whereas ordinarily particles of 100 to 120 grit size are used. Apparently, the flattening action on numerous small particles does not impair their cutting action as much as does a similar flattening action on a smaller number of larger particles provided that the requisite protrusion of the small grains is maintained.

An important mechanical and electrical system is shown in Fig. 3. The reference numerals common to Fig. 1 show the same components arranged in the same way except that an additional electrolyte nozzle **20***a* is provided to assure adequate supply of electrolyte, both to the working area around workpiece **18** and to the dressing area around dressing electrode **404**. The electrical system is somewhat different. The positive lead **40** from a direct-current source is connected to the workpiece **18** ordinarily by grounding through tool rest **16** (shown here and in other schematic figures as leading directly to workpiece **18**).

The negative lead **38**, however, is connected to the center arm of a potentiometer **402**, which forms part of a bridge circuit. The right-hand end of the resistor of potentiometer **402** is connected to brush **32**. The left-hand end is connected to a dressing electrode **404**, slidably guided on insulating ways **406**, which in turn are mounted on a support **408** attached to bed **2** in any convenient manner, so as not to interfere with the handling of workpiece **18**. Dressing electrode **404** is urged very lightly by a spring **410** against tool electrode **9**.

The resistance arm of potentiometer **402** has a value chosen to be substantially in excess of the resistance of the electrolytic path between dressing electrode **404** and tool electrode **9**. For example, in a typical situation the resistance of the electrolytic path will be of the order of one-tenth (0.1) of an ohm or less, and the resistance arm of the potentiometer will have a value of the order of three-tenths to five-tenths (0.3–0.5) ohms.

When the center arm potentiometer **402** is at the right-hand end of the resistance, substantially all of the current will pass through brush **32** to abrasive tool electrode **9**, as the contact resistance between the brush **32** and the hub **10** is very, very low while the alternate path through the resistance of the potentiometer to dressing electrode **404** and thence through the electrolyte to abrasive tool electrode **9** is comparatively many times higher.

But if the potentiometer arm is moved to the left-hand position, then a substantial amount of current will flow through dressing electrode **404** to abrasive tool electrode **9** through the electrolyte. The path through the resistance arm to brush **32** and thus to tool electrode **9** now has a much higher resistance than the path through dressing electrode **404**.

Under this condition, as current passes from dressing electrode **404** to tool electrode **9**, the tool electrode is an anode relative to dressing electrode **404**. Accordingly, metal will be removed from the tool electrode.

The rate of removal is determined by the flow of current through dressing electrode **404** to the tool electrode **9**. This is determined in part by the position of the arm of potentiometer **402** and in part by a helpful self-adjusting characteristic of the bridge circuit. Thus, if the spacing distance becomes very close due to a high rate of wear of the abrasive insulating spacers of the tool electrode, then the resistance path through the electrolyte from dressing electrode **404** to abrasive tool electrode **9** is reduced and, relatively, more current flows through this path than through the path which includes brush **32**. On the other hand, if the spacing distance increases due to a low rate of wear of the abrasive particles, then the resistance path through the electrolyte increases and less current follows this path and more follows the path through the brush **32**. The over-all result is that, as faster dressing removal rate is needed, a faster rate automatically occurs and, conversely, when a lower removal rate is called for, this automatically occurs.

The point at which the balance tends to be reached is determined by the position of the arm of potentiometer **402**. In general, high dressing removal rates will be called for when hard workpieces are used with substantial grinding pressures, and the potentiometer arm will be set accordingly. When softer workpieces (e.g., tool steel instead of tungsten carbide) are used, then the potentiometer arm will be set for a lower dressing removal rate. Ordinarily, for any given material no great amount of adjustment is needed due to the self-adjusting characteristic above described.

Battery **440** with step switch **450** (shown in dotted lines) may be provided as shown where it is necessary or desirable to provide an augmented removal rate for dressing. When the battery is used, it is inserted into the line, and the solid connection shown across it in the drawing should be considered broken. The battery may, of course, be supplanted by any other convenient direct-current source. It should be noted that the negative pole of the battery or other source is connected to the dressing electrode **404**. The result of using the additional battery or other source is to increase the rate at which metal is removed from the tool electrode. This may be necessary when very hard substances are being used as workpieces and are being pressed with substantial force against the abrasive tool electrode. The result may be that the abrasive particles wear more rapidly than can be kept pace with in the removal of metal by the system without the battery.

Fig. 4 shows schematically the system of Fig. 3 as applied to a tool electrode having its working surface on the periphery instead of on the side. The reference nu-

merals common to Figs. 1 and 3 designate the same or similar components.

A potentiometer is designated **502**; a dressing electrode is designated **504**; insulating ways are designated **506**; support is designated **508**; a spring is designated **510**; a battery is designated **540**; a step switch is designated **550**. All of these components function in the same way and for the same purposes as their counterparts in Fig. 3.

While preferred embodiments of the dressing of abrasive tools constituting this invention have been shown and described, it will be apparent that numerous modifications and variations thereof may be made without departing from underlying principles of the invention. It is, therefore, desired by the following claim to include within the scope of the invention all such variations and modifications by which substantially the results of this invention may be obtained through the use of substantially the same or equivalent means.

What we claim as new and desire to secure by Letters Patent is:

In the method of electrolytic grinding in which a voltage is applied across a normally anodic workpiece and a conductive metal bonded abrasive tool electrode and is normally held below the level at which substantial sparking and arcing occurs, the abrasive tool electrode having on its working face numerous small insulating and abrasive particles protruding from the metal bond of the tool a very small distance not greater than .010" and not less than .001" to determine a spacing distance in the range of .001" to .010" between the workpiece and the working face of the tool, and a fluid electrolyte is flowed into the small space between the workpiece and the working face of the tool, the improvement which consists of periodically raising the voltage applied across the workpiece and the tool when the said spacing distance is smaller than a predetermined distance between .001" and .010" to cause substantial sparking to remove load accumulated on the face of the tool during normal grinding and to remove a portion of the metal bond from the tool to dress the abrasive tool electrode and to obtain an adequate protrusion of the insulating and abrasive particles and the aforesaid predetermined spacing distance between the workpiece and the working face of the tool.

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