

Nov. 5, 1935.

A. E. JOHNSTON

2,020,117

CUTTING, GRINDING AND BURNISHING TOOL AND THE PRODUCTION THEREOF

Filed May 21, 1930

2 Sheets-Sheet 1

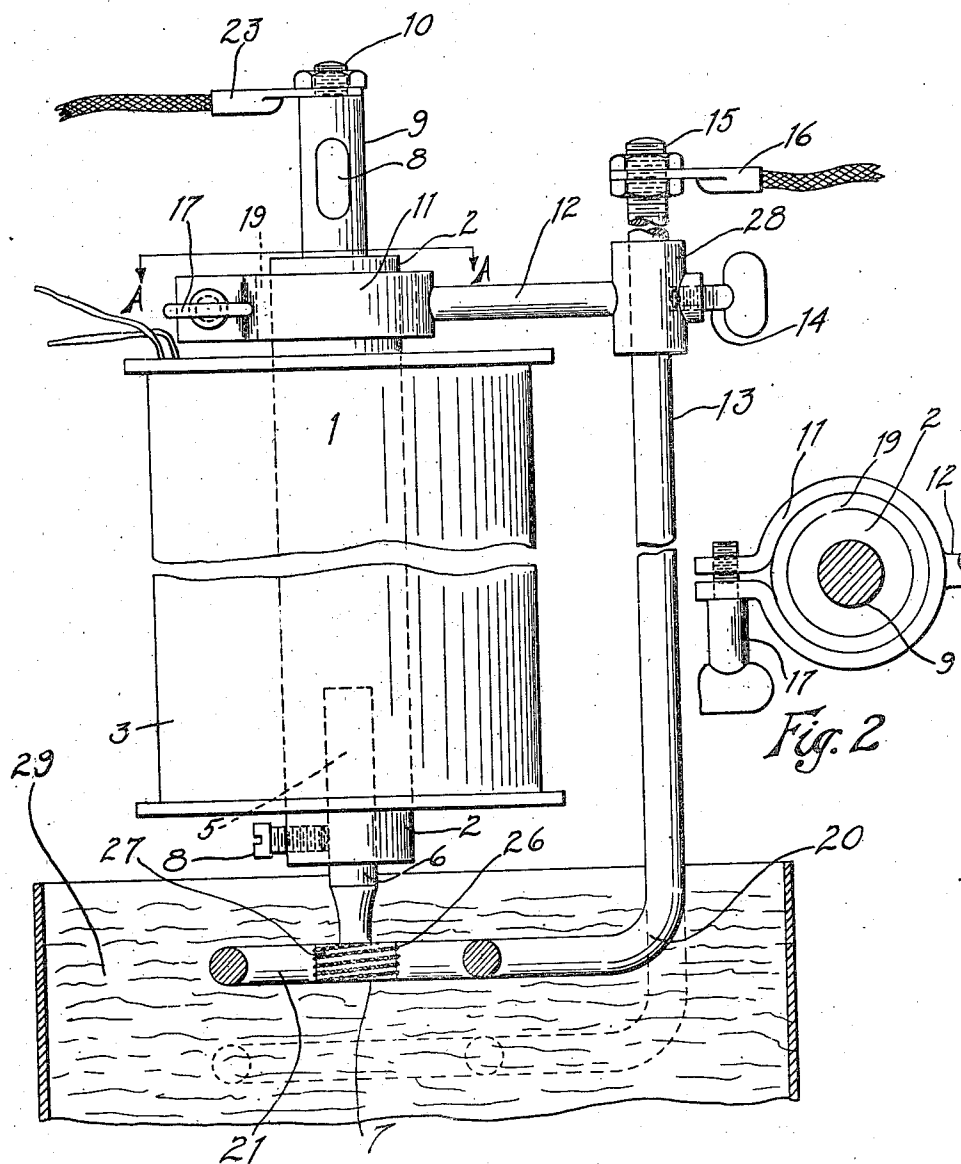


Fig. 1

Fig. 2

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2 Sheets-Sheet 2

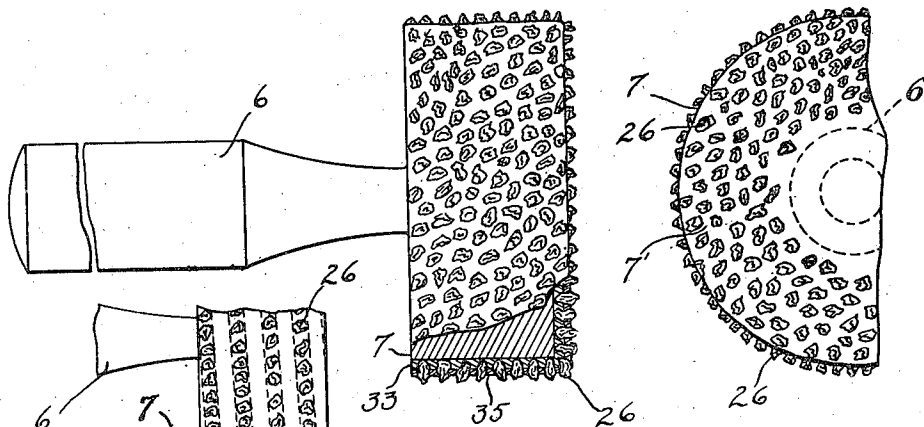


Fig. 4

Fig. 5

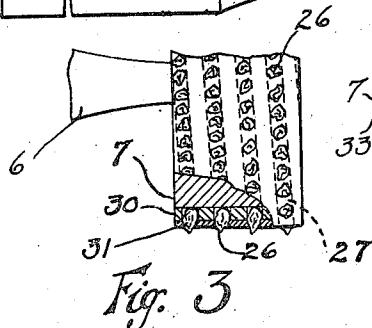


Fig. 3

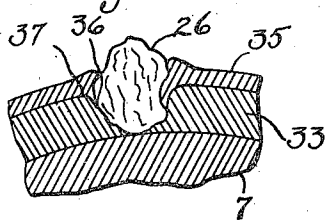


Fig. 6

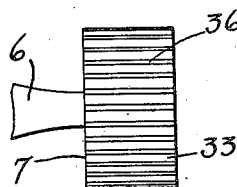


Fig. 7

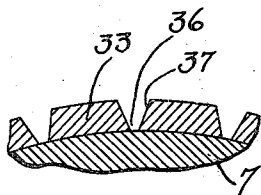


Fig. 8

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2,020,117

CUTTING, GRINDING, AND BURNISHING
TOOL AND THE PRODUCTION THEREOF

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by mesne assignments, to Calibron Products,
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Application May 21, 1930, Serial No. 454,262

24 Claims. (Cl. 204—6)

My invention relates to tools or instruments adapted to operate on articles of various degrees of hardness, such as porcelain, metals, and refractory materials, and more particularly to improved types of instruments adapted to be used by the dental profession for cutting and grinding the structure of human teeth. My invention also relates to improved methods and improved apparatus for producing such instruments.

10 In dental instruments of the character referred to, either hardened steel or carborundum has heretofore usually been employed as the abrasive agent for cutting or otherwise breaking down tooth structure. When an instrument employing either of these two substances as the abrasive agent, is used to cut the hardest part of the structure of a human tooth, the effect is a wearing away of the tooth, rather than a true cutting action, with the production of a great deal of friction at the point of contact of the instrument and the tooth. The heat resulting from this friction is most discomforting to a patient. Furthermore such instruments are likely to be dulled, to lose their form and to become quite ineffective after being in use for a short time, so that it is frequently necessary for the dentist to lose time in changing instruments. This not only results in financial loss to the dentist but also keeps the patient waiting in an uncomfortable position while the change is being made.

The present invention aims to produce improved types of instruments or tools which are adapted, when used, to obviate to a great extent, the disadvantages described above.

One of the objects of my invention is to produce improved types of dental instruments which will be effective in rapidly breaking down, preferably by a cutting rather than a wearing action, the structure of teeth with a minimum amount of friction and a consequent reduction of discomfort to the person whose teeth are being treated.

Another object of my invention is to produce improved types of dental instruments which will retain their effectiveness during long periods of use.

Another object of my invention is to produce improved types of tools adapted rapidly to cut, grind or burnish hard materials with but relatively little friction, and with but comparatively little wear to the tools or instruments.

A further object of my invention is to provide improved types of dental instruments which will not only conserve the time of the dentist in cut-

ting or breaking down the structure of teeth, but which will also be economical to use.

Still further objects of my invention are to provide improved methods and improved apparatus for producing tools and dental instruments of the character described above.

Further objects and features of my invention will be obvious upon an understanding of the preferred forms of tools or instruments and the methods and apparatus for producing the same, 10 hereinafter described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employing the invention in practice.

I prefer to use diamond particles or chips as 15 the cutting or abrasive agent or material of my improved tools or instruments, because diamond has a greater degree of hardness than any known substance. While other very hard materials, such, for example, as sapphire, carborundum or 20 emery, could be used, the life and effectiveness of the instruments would thereby be reduced to a certain extent.

The character of the work to be done by an instrument determines to a large extent the size 25 of the abrasive particles or chips which should be used for the working head or portion of such instrument. I have found in the production of dental instruments, that the best results are obtained by using a substantially uniform size of 30 such particles or chips for each individual instrument. Chips varying in size from 20 to 80 mesh are generally most suitable for the purpose, the exact size of abrasive chips used for a given instrument depending, of course, upon the character of the instrument and the work for which it is intended. It will be obvious upon an understanding of my invention, however, that abrasive particles or chips of other sizes might be used.

I have discovered that in a cutting, grinding 40 or burnishing tool or instrument, such as heretofore referred to, the best results are obtainable by distributing or scattering a large number of the chips or particles of abrasive material in fairly close association over the working head of 45 the tool or instrument or the working surfaces thereof, and then firmly securing such abrasive particles in fixed position by applying an adhering coating of metal to the said head or surfaces, which coating, in the finished tool or instrument, will embrace, but not completely cover, the abrasive particles. This can be accomplished in several different ways. I prefer, however, to employ either of two methods, which for purposes of illustration will be described herein in 55

connection with the use of diamond chips or particles as the abrasive material.

In carrying out one of the methods just referred to, I first select diamond chips of the proper size and coat them with a thin film of conductive material such as silver, by any of a number of known methods. For example, the chips after being chemically cleaned by boiling in dilute nitric acid for about 15 minutes and then thoroughly washed with distilled water, may be flashed with silver by placing them in an ammoniacal silver nitrate solution and adding the proper amount of a suitable reducing agent, such as cane sugar or formaldehyde. After silvering, the diamond chips are thoroughly cleaned by washing with distilled water and are then coated with a magnetic metal, such as nickel, by placing them in a plating basket constituting the cathode of a plating cell having a nickel anode, and impressing current on such cell. I prefer to form a very thin coating of nickel on the diamond chips by impressing on the cell a current of very low density, for a period of from 5 to 8 hours. Other magnetic metals, such, for example, as cobalt, can be used instead of nickel. I prefer to use nickel, however, because of its well known property or characteristic of being in a high state of tension when electro-deposited and the fact that it will therefore tightly grip objects on which it is electro-plated. By the application of the thin coating of nickel to the diamond chips, the latter are rendered susceptible to magnetic attraction.

A great many of these nickel coated diamond chips or particles are then applied to and distributed in closely associated but preferably substantially uniformly spaced relation over the working surface of the head of an instrument or tool and are temporarily held on said head in such relation by magnetic attraction, for which purpose the tool is formed of magnetic material and is magnetized; and while thus held on the working head of the tool, the said chips or particles are permanently secured to and incorporated as integral parts of the tool, by electro-depositing a layer of a suitable metal on the head and on and about such particles. Such a tool can, of course, be produced by merely distributing the abrasive particles in haphazard relation over the working surface of the head of the magnetic tool and then electro-depositing metal on the working head and on and about said particles, while the latter are held on the head in such relation by magnetic attraction. For some uses it is quite important to distribute the abrasive particles over the working surface of the head of the tool in substantially uniform spaced relation. Such distribution of the abrasive particles may be accomplished in many ways, for example, by roughening or serrating the working surface of a tool and placing the particles in the depressions formed by the roughening or serrations. However, I find that the best and most uniform results are obtainable by the following procedure:

The tool or instrument to which the diamond particles are to be applied and secured, is formed of a comparatively hard and durable magnetic metal, preferably steel, the working head of the tool being initially made of approximately the same shape it will have in the finished tool but of a slightly smaller size. The surface of the working head is then cleansed, preferably by subjection to the action of a suitable electrolytic bath, after which a fairly thick layer of some non-

magnetic metal such, for example, as copper or silver, is applied to said head. While this layer of non-magnetic metal can be mechanically applied, it is preferably applied by electro-plating at a fairly rapid rate for about 12 hours. This layer of metal, which is preferably copper, is now turned down to a smooth surface and to produce a coating of a uniform thickness of from five to ten one thousandths of an inch encasing the entire working head of the instrument. In certain cases where large abrasive particles are used and the tools are designed to be used for heavy work, a slightly thicker layer of copper will be desirable, the exact thickness thereof depending largely on the size of abrasive particles used, as will be apparent upon an understanding of the invention. In producing this copper layer it is desirable to coat the surface portions of the instrument, other than the working surface which is to be plated, with paraffin so as to prevent the electro-deposition of the copper on such portions. Suitable scores or grooves are cut through the copper layer on the head of the tool so as to expose the steel of which said head is formed. The scores may be of any suitable form depending upon the character of the instrument being produced, and they may be formed on the end surface of the working head as well as on the lateral surface thereof. The scores or grooves are preferably fairly close together to facilitate uniform distribution of the diamond particles to be disposed therein, and the depth of such grooves is somewhat less than the mean diameter of the diamond particles so that when the latter are disposed in the grooves they will extend outwardly beyond the surface of the copper layer. The term non-magnetic as used in this specification to describe a metal or material, means a metal or material commonly known to those skilled in the art as being non-magnetic for all practical purposes, that is to say, a metal or material whose magnetic susceptibility is negative or is negligibly positive as compared to the magnetic susceptibility of iron.

Before disposing the diamond particles in the scores cut in the copper layer on the working head of the tool, said head is preferably cleaned to remove all grease and oxidation therefrom, as by employing it as the cathode of an electrolytic cleaning cell, the bath of which may consist of a solution of sodium sulphate.

To facilitate the proper positioning and distribution of the nickel-coated diamond particles in the grooves referred to and for temporarily holding them so positioned and distributed, I preferably magnetize the working head of the tool so that the same will attract such particles. While, for this purpose, an ordinary permanent or electro-magnet may be used, or the tool itself may be permanently magnetized, I find that best results are obtained by using an electro-magnet apparatus of special construction, shown in Fig. 1, which is preferably also adapted and designed to form part of an electro-plating cell. This apparatus, which will be hereinafter more specifically described, comprises an electro-magnet consisting of a coil and a core which extends through the coil and a substantial distance beyond each end of the latter. The upper end of said core constitutes a binding post adapted to be connected to one side of an electric circuit, and the lower end thereof is recessed for the reception of the shank of the tool to which the diamond particles are to be applied. When this apparatus is in use the shank of the tool is held in the recess

provided in the core, the tool then being, in effect, a part of the core and having its working head positioned below the lower end of the core. A nickel ring, the size of which will depend upon the size and form of the working head of the tool being produced, is eccentrically supported from the lower end of a rod which is suitably mounted in vertical position so that the ring may be raised or lowered or turned about an eccentric axis with respect to the working head of a tool carried by the core. With this construction, if the coil is energized and the core and tool thereby magnetized, the direction of the lines of force in that part of the magnetic field adjacent the working head of the tool may be varied merely by raising or lowering or turning the nickel ring. The upper end of the rod carrying the nickel ring constitutes a binding post adapted to be connected to the other side of the electric circuit referred to above.

In using the electro-magnet apparatus described, a tool to which the nickel-coated diamond particles are about to be applied is mounted in the lower end of the core of the magnet, the nickel ring is adjusted to its proper position with respect to the working head of the tool and the electromagnet is energized. The coated diamond particles are then preferably picked up by a small camel's hair brush, which has preferably been dipped in a solution of sodium bicarbonate or some other non-oxidizing liquid, and are charged or disposed in the grooves of the copper coating on the working head of the tool, where they will be held by the magnetism of the tool. To secure better distribution of the diamond particles within the said grooves or scores, I preferably frequently adjust the position of the nickel ring with respect to the particular parts of the tool to which diamond particles are about to be applied so that the lines of force in the magnetic field will act to assist rather than retard such operation. Where the diamond particles used are quite small and the grooves or scores in the tool heads are correspondingly small, as in the case of dental tools or instruments, it is of assistance in properly disposing the particles in said grooves, to use a magnifying glass. The nickel coated diamond particles will, of course, be attracted only by the exposed magnetized metal at the bottoms of the grooves in the tool head, as the side walls of the grooves and the lands between the same are of non-magnetic material. Consequently when the nickel ring is properly adjusted and a particle adhering to the moistened tip of the camel's hair brush is brought into proximity with the exact point in one of the grooves where it is desired to lodge it, the particle will be drawn from the brush and will be held firmly in proper position against the bottom of the groove as long as the core is magnetized. During the operation just described, great care should be exercised to prevent oxidation of or the accumulation of dirt or grease on the surface of the head of the tool. The same is true as to the nickel-coated diamond particles and I therefore preferably use them as soon after they have been nickel-plated as is possible. If the surfaces of these particles have oxidized or have become dirty after being electro-plated, the same should be thoroughly cleansed, preferably in the same manner, heretofore described, as was the grooved copper-coated head of the tool.

When the application of diamond particles to a tool has been completed, the head of the tool, with the latter still mounted on the core of the

electro-magnet, is employed as the cathode of a nickel-plating cell; the said core constituting the cathode holder and the rod carrying the nickel ring being employed as the anode of such cell. The lower end of said core and that part of the shank of the tool extending from the core are preferably coated with paraffin to prevent the deposit of nickel thereupon. Current of very low density is then impressed on said cell until sufficient nickel has been slowly deposited on the working head of the tool to hold the diamond particles firmly in place without the aid of magnetic attraction. This usually takes from one-half an hour to one hour, after which the tool is preferably removed from the core and used as a cathode in another nickel plating cell, the latter cell preferably comprising a cathode holder which is rotatable about an inclined axis and on which the tool is so mounted that the working head thereof will be alternately immersed in and removed from the electrolyte of the cell as the cathode holder rotates. This rotating cathode holder is preferably of a construction and arrangement similar to that disclosed in U. S. Patent No. 1,600,722, dated September 21, 1926. It is not absolutely necessary to employ this second cell, as the nickel-plating process can be continued in the first cell, with the tool mounted in the core of the electro-magnet, until the desired amount of nickel is deposited. However, to complete such deposit, it is advisable to employ the nickel-plating cell having the cathode holder which is rotatable about an inclined axis, as it is well known that the use of such a cell produces a better quality of nickel-plating which is substantially free from porosity. In addition to this, the use of this second plating cell releases the electro-magnet for use in the preliminary steps of producing another tool or instrument.

The final step of the electro-plating operation just described, is continued for a period of from about 72 hours to about 96 hours. The density of the impressed current at the start is preferably very low, being approximately 1 to 2 amperes per square foot of surface deposited upon, but is gradually increased about every 4 hours until it is about 50 amperes per square foot. The density of the impressed current is made low at the start, in order to obtain a uniform, thin and tough coating or deposit of nickel which will grip the diamond particles and the surrounding metal under very high tension. The character of the tool produced is thus improved and dislodgement of the diamond particles when the tool is used is prevented.

Upon completion of the electro-plating operation, the tool is mounted in a suitable lathe, and the working head thereof is turned down to remove any lumpy deposits of nickel and to provide the same with a smooth surface. Care should be taken to avoid turning down the head so far that the diamond particles come in contact with the turning tool as they are likely to injure it. Preferably the working head is turned down so that the diamond particles are covered by but a very thin layer of the nickel plating, after which the nickel is ground away sufficiently to barely expose the tips or other minute portions of the diamond particles. The tool is now made the anode of a nickel-plating cell and more of the nickel in which the diamond particles are embedded is electrolytically removed until the tips or other minute portions of said particles are thoroughly exposed but sufficient nickel still remains to grip said particles under high tension

and firmly hold them on the working head of the tool. The tool is finally mounted in a lathe where its shank is trued up with respect to the working head. In this connection it is highly important that the shank be concentric with said head as otherwise, when the tool is used, the head will have an eccentric motion which will be quite annoying to the dentist and discomforting to the patient.

While the method just described is adapted to produce cutting tools or instruments of high quality, tools of very excellent quality may be more economically produced by the other of the two methods referred to above. This second method, which has the advantages of a less number of steps and of requiring less special apparatus, will now be specifically described as applied to the production of a dental tool or instrument.

After selecting the desired size of diamond particles to be used for the tool, the working head of the latter is turned the proper shape and size, consideration being given to the fact that the application of the diamond particles to the head will result in slightly increasing certain dimensions thereof.

The working head of the tool is preferably formed of steel, although other hard and durable substances, suitably treated, if necessary, to receive electro-deposited metal, may be used. A suitable shank is either formed integrally and concentrically with the working head or is concentrically attached thereto in any suitable manner.

A thin coating of some comparatively soft metal is now preferably affixed to the working head of the tool. This soft metal coating serves to temporarily hold the diamond particles in position before they are permanently affixed to the working head. The soft metal employed for such coating is largely determined by the uses for which the tool is designed and by the size of the diamond particles to be applied to the tool. It is preferable, especially for tools to which the coarser grades of diamond particles are to be applied, to form this coating of lead or some metal of a similar degree of hardness; although in tools to which diamond particles of the finer grades are to be applied, the coating may be of copper, aluminum, or some other metal having a comparable degree of hardness. If such coating is of lead the same will be applied either mechanically or electrolytically, preferably the latter; if of copper it will preferably be applied electrolytically; while if of aluminum it will generally be applied mechanically, because of the extreme difficulty of electro-plating aluminum. The thickness of this coating is determined largely by the size of the diamond particles used for the tool, and should be considerably less than the mean diameter of such particles, which, for a given tool, will be of a substantially uniform size. The purpose of this is to ensure that a substantial portion of the diamond particles will extend beyond the outer surface of the soft metal coating after such particles have been charged or embedded therein, it being understood that the particles will then extend through said coating to the hard base material of the working head. If desired the soft metal coating just described may be dispensed with by forming the working head of the tool of some durable but comparatively soft metal such as aluminum or copper, or even of some non-metallic composition and then flashing a conductive film thereon. However, I prefer to proceed as just described.

It is desirable, after applying the coating of soft

metal to the working head of the tool, to turn the coating down to the proper thickness just prior to charging the diamond particles therein. The purpose of this is to provide the coating with a bright clean surface upon which to electrolytically deposit a layer of metal after the diamond particles have been charged or embedded in said coating.

It is advantageous, but not absolutely essential, to score or groove the soft metal coating on the working head of the tool before applying the diamond particles thereto. The scores should be fairly close together in order to effect good distribution of the particles, and should extend substantially through the soft metal coating to the underlying hard metal base. These scores are also preferably made substantially wedge shaped in cross section so that the diamond particles will readily be located therein when applied to the working head of the tool and also in order to provide additional gripping surface for the metal thereafter electro-plated on said working head.

The diamond particles are now charged or embedded in the soft metal coating on the working head of the tool by any of the usual methods. Ordinary rolling tools are quite efficacious for this purpose, and are particularly well adapted for charging the coarser grades of diamond particles into such coating, especially where the latter is of lead or any metal of a similar degree of hardness. In charging the finer grades of diamond particles, it is preferable to use two hard metal plates, in which case the particles to be charged are spread on the surface of one of the plates and the working head of the tool is then rolled between the two plates. In embedding or charging the particles into any portion of a tool having a plane surface, such as the flat end of the tool, best results are obtained by using a rolling tool. In this manner, a fairly uniform distribution of the particles is obtained, and such particles are embedded in the soft metal coating and are quite firmly held thereby until the metal deposited in the electro-plating operation permanently and rigidly secures them in their distributed positions.

A thin layer of a suitable hard metal is now electro-plated on the charged working head of the tool. As heretofore explained, the surface of the soft metal coating should be clean and bright at the start of the electro-plating operation in order to obtain the best possible adhesion between said coating and the electro-deposited metal. Therefore the steps of scoring, charging and electro-plating should be performed immediately after turning the soft metal coating to the desired thickness, and care should be taken to see that the surface of said coating does not oxidize or become dirty between the time such coating is turned down and the electro-plated layer of hard metal is applied thereto. The thickness of the electro-deposited hard metal layer will depend largely upon the size of the diamond particles used and the extent to which they protrude beyond the surface of the soft metal coating in which they are embedded, the object of said layer of electro-plated metal being to firmly grip the diamond particles and to rigidly and permanently hold them in position with the tips or other minute portions thereof extending or protruding beyond such layer. In order to prevent an excessive deposit of metal upon the outer end portion of the working head of the tool during the electro-plating operation just described, a specially constructed wire cage, such as is frequently used in electro-plating and is commonly referred to as

a "robber", may be disposed about said end portion. The metal layer produced in this electroplating operation is preferably formed of nickel because of the fact that the same when electro-deposited is in a high state of tension and therefore tightly grips surfaces on which it is electroplated. Other hard metals, such, for example, as cobalt, may, however, be used.

The electro-plating operation can be carried out by using the working head of the tool as the cathode of an ordinary nickel plating cell. However, for reasons explained in connection with the method first described herein, I prefer to employ for such operation an electro-plating cell having a rotary cathode holder similar in construction and arrangement to that disclosed in U. S. Patent 1,600,722, hereinbefore referred to. A current of very low density (about one to two amperes per square foot of plating surface) is preferably impressed on the plating cell for substantially the first forty-five minute period of the electro-plating operation, in order to secure the best possible adhesion between the working head of the tool and the electro-deposited nickel layer; after which period the current so impressed is preferably gradually increased to about ten amperes per square foot of plating surface. The electro-plating operation is preferably continued for from three to six hours, or possibly longer, depending on the rate of deposit and the desired thickness of the electro-plated layer to be produced on the working head of the tool. The nickel thus electrolytically deposited may build up or "tree" at certain points so as to extend beyond and completely cover the diamond particles. These built up portions may be rubbed down with emery cloth or other suitable abrasive means; or, if desired, the tool may be made the anode of a nickel plating cell and such built up portions electrolytically removed, as hereinbefore described.

For a clearer understanding of my invention, attention is directed to the drawings accompanying and forming part of this specification and in which:

Figure 1 is a view in elevation partly in section and partly broken away, of a preferred form of the combined electromagnetic and plating apparatus for carrying out certain of the steps of the method first above described, a tool or instrument being shown mounted in the core of the magnet and immersed in the bath of the plating cell;

Fig. 2 is a cross sectional view, partly broken away, taken on line A—A of Fig. 1;

Fig. 3 is an enlarged view in elevation, partly broken away and partly in section, of a finished tool or instrument produced in accordance with the method first described herein;

Fig. 4 is a view similar to Fig. 3 of a finished tool or instrument produced in accordance with the second method described herein;

Fig. 5 is a fragmental end view of the working head of the tool or instrument shown in Fig. 4;

Fig. 6 is a greatly enlarged detailed sectional view of the tool illustrated in Fig. 4, showing a diamond particle embedded in the soft metal coating on the working head of the tool and the manner in which the electrolytically applied metal builds up about and grips the particle;

Fig. 7 is an enlarged view in elevation of the working head of a tool or instrument scored or grooved preparatory to charging the same with abrasive particles in accordance with the second method described herein; and

Fig. 8 is a greatly enlarged detailed sectional view showing the preferred form of the scores or grooves in the head of the tool shown in Fig. 7.

Referring to the drawings, and particularly to Figs. 1 and 2, numeral 1 represents an electro-magnet comprising a core 2 and a coil 3, the terminals of which are adapted to be connected to a suitable source of current for energizing the same. The core 2 is of special construction and extends through the coil 3 axially thereof to a point substantially below its lower end, the lower end portion of the core having a recess 5 adapted to receive the shank 6 of a tool or instrument. A set screw 8 is adapted to coact with the shank 6, when the latter is disposed in the recess 5, to thereby secure the tool firmly to the core 2 with its working head 7 positioned a considerable distance below the lower end of the core. The core also extends substantially above the upper end of coil 3 and has an opening 8 formed in its upper reduced end portion 9 and adapted to be engaged by a suitable member (not shown) for supporting the entire electro-magnet. The reduced portion 9 of the core is provided at its upper end with a suitable binding post 10 to which one terminal 23 of a suitable source of current is adapted to be connected. A split ring 11 which encircles the core 2 just above the coil 3, is separated from the core by an insulating ring 19, and is firmly but removably gripped in position thereon by means of screw 17. This split ring is fixed to one end of a horizontal arm 12 which has secured to its other end a vertically disposed cylindrical sleeve 28. A cylindrical rod 13 extends through sleeve 28 and is adjustably secured thereto by the set screw 14. At its upper end rod 13 is provided with a binding post 15 to which is secured the other terminal 16 of the source of current having the terminal 23. The rod 13, when secured to sleeve 28 in proper position, extends to a point substantially below the lower end of core 2 where it is bent to form a right angular arm 20 which is provided at its free end with a nickel ring 21. This ring will then be substantially parallel to the lower end of the coil 3, and the distances from the axis of the vertical portion of rod 13 to the axis of a tool or instrument secured in the core 2, and to the center of the ring 21 will be substantially equal.

It will be apparent that with the construction and arrangement described, the nickel ring 21 is maintained in an adjustable position below the core 2 of the magnet and that it may be raised, lowered or turned about the axis of the vertical portion of rod 13 to change its position with respect to the working head of a tool mounted, as described, in the core 2. It will also be apparent that if the magnet is energized, the tool so mounted in and held by the core 2 will also be magnetized, and that the magnetic field will be largely confined to the core, tool, nickel ring 21, rod 13 and the arm 12, as the magnetic lines of force will follow the path of least resistance. The principal point where such lines of force will not be confined within the parts just mentioned, is the air space between the ring 21 and the working head of the tool. As hereinbefore explained, this air space can be varied by moving the rod 13 to raise, lower or turn the ring 21 to thereby vary and control the direction of the lines of force between said ring and the working head of the tool. Thus when it is desired to dispose the diamond particles 26 coated with magnetic metal in their proper positions in the grooves 27 formed in the working head 7 of the

tool, as hereinbefore described, the direction of the lines of force of the magnetic field can be readily adjusted so that they will assist rather than retard the positioning of such particles.

After the said particles have been positioned on the working head they will be held in place by the magnetic attraction exerted thereon by said head. After the diamond particles are properly positioned on the working head of the tool, the magnet, still energized, is suspended from a suitable support, by means of a member (not shown) engaged with the opening 8 in core 2, at such a distance above the bath of the nickel-plating cell 29, that the working head of the tool and the nickel ring 21 will be immersed in said bath. It is desirable to keep the core 2 out of the bath so as to avoid the depositing of metal thereon, and as hereinbefore explained, both the lower part of the core and those parts of the tool which are not to be plated, are covered with a thin coating of paraffin. The negative terminal 23 of a source of current is then attached to the binding post 10 of the core and the positive terminal 16 of said source is attached to the binding post 15 of the rod 13, whereupon the working head 7 becomes the cathode and the nickel ring 21 becomes the anode of the cell. The external circuit of the source of current is provided with suitable meters and adjustable resistances so that the current flowing may be properly controlled. A current of very low density is impressed on the cell for a period of approximately one hour until sufficient nickel has been deposited on the working head 7 and the diamond particles to cause the latter to adhere to said head without the aid of magnetic attraction, at which time the magnet is de-energized and withdrawn from the plating bath. As hereinbefore described, the tool is then removed from the core 2 and mounted on the rotary cathode holder of a nickel-plating cell, such as disclosed in U. S. Patent 1,600,722, and subjected to a further nickel-plating operation for a period of from about 72 to about 96 hours. The lumpy deposit of nickel formed, as described, on the working head is then mechanically reduced until the outermost portions of the diamond particles are reached, whereupon the tool is employed as the anode of an ordinary nickel plating cell and more of the deposited metal is electrolytically removed from the working head 7 until the diamond particles 26 project slightly from the surface of the nickel deposit 31 on said working head, as is clearly shown in Fig. 3. Finally the shank 6 of the tool is turned down to the desired size and so as to be concentric with the working head 7.

Reference is now made to Fig. 3, which is a fragmental view, partially sectioned to show the internal construction, of one form of tool produced in accordance with the first method herein described. The shank 6 is preferably formed of steel and is attached in any suitable manner to the working head 7 of the tool, which head is also preferably formed of steel. The copper or other non-magnetic layer which is fixedly applied to the head 7, is designated by the numeral 30. The grooves or scores 27 which are cut through the copper layer 30 to the working head are shown in dotted lines. If desired, similar grooves can also be cut in the outer end of the head of the tool. The diamond or other abrasive chips 26 are shown positioned in the grooves 27 with small portions thereof projecting outwardly from the outermost layer of electro-deposited metal 31 (preferably nickel) which grips the chips and

secures them rigidly in their distributed positions on the working head.

One form of finished tool produced in accordance with the second method herein described, is shown in Figs. 4 and 5. The usual shank 6 of the tool is concentrically secured in any suitable manner to the working body 7, which is preferably formed of steel. Reference character 33 represents the layer of comparatively soft metal which is fixedly applied (either electrolytically or mechanically) to the working head 7 of the tool. The abrasive chips or particles 26 (preferably of diamond) are clearly shown embedded in the metal layer 33, such chips or particles being rigidly held in position on head 7 by the electrolytically deposited metal layer 35 (preferably of nickel). It is obvious that the abrasive chips may be applied to any desired portions of the working head. For example, they may be applied to the outer end of said head in the form of an annular band 20 7', as shown in Fig. 5.

Fig. 6 illustrates the manner in which the electrolytically deposited metal 35 in the form of tool shown in Figs. 4 and 5 builds up around the deformed edge portions 37 of a score 36 in the soft metal layer 33 and closes in around a diamond particle 26 in said score to hold the particle in its embedded position.

Fig. 7 illustrates a tool being produced in accordance with the said second method before the application of the diamond particles thereto, in which the soft metal layer 33 affixed to the working head 7 is provided with a series of parallel longitudinally extending grooves or scores 36. It will be understood that the grooves or scores 36 need not necessarily extend longitudinally of the head 7, for they may be formed to extend circumferentially thereof or otherwise. I prefer that the grooves or scores 36, in cross section be of the form shown in Fig. 8, i. e., tapering. This particular form is desirable because it affords surfaces for an abrasive particle 26 to deform and grip when it is pressed into the score. However, as hereinbefore explained, my invention can well be carried out without employing any scoring whatever, as the abrasive particles 26 can readily be rolled into a layer of soft metal having a comparatively smooth surface.

My invention, as embodied in the apparatus, methods and products specifically described herein, is subject to numerous changes and modifications without departure from the spirit of the invention or the scope of the appended claims, and it is accordingly to be understood that all matter contained herein is to be interpreted as illustrative and not in a limiting sense.

Having now described my invention, what I claim as new and desire to protect by Letters Patent, is as follows:

1. An article of the character described comprising a magnetic working head, a layer of non-magnetic material applied to said head and having a recess therein, an abrasive element disposed in said recess, and means holding said element in place comprising metal electrodeposited on said head and about the element.

2. A tool comprising a magnetic working head provided with a layer of grooved non-magnetic material, abrasive elements applied to said head, and means rigidly securing said element to said head, comprising metal electrodeposited on said grooved layer and about the elements.

3. A tool comprising a magnetic working head, a layer of non-magnetic material applied to said head and having a recess extending therethrough

to said head, an abrasive element disposed in said recess, and metal electrodeposited on said head within said recess and about said element acting to secure the latter rigidly to the head.

4. In an article of the character described, in combination, a working head comprising a coating of comparatively soft material, abrasive particles impressed in said coating and distributed in fairly closely associated relation over substantially the entire surface portion of the head which corresponds to the working area of the article, and a layer of metal harder than said coating applied and adhering to the said surface portion of the head and acting to secure said particles rigidly to the head.

5. In an article of the character described, in combination, a working head comprising a coating of soft material, abrasive particles embedded in said coating in scattered but fairly closely associated relation over substantially the entire surface portion of the head which corresponds to the working area of the article, and a layer of metal electrodeposited on the said coating and about said particles acting to secure the latter rigidly in respect to the head.

6. A tool comprising a working head having a comparatively soft surface portion, abrasive particles charged into said soft portion, and a layer of comparatively hard material adhering to said head and applied to said surface portion and about said particles acting to secure the latter rigidly to the head.

7. A tool comprising a working head having a comparatively soft surface portion, abrasive particles charged into said soft portion, and a layer of comparatively hard material electrodeposited on said surface portion and about said particles acting to secure the latter rigidly to said head.

8. A tool comprising a working head having a surface portion formed of lead, said surface portion having diamond particles partially embedded therein and projecting therefrom, and a layer of nickel electrodeposited on said surface portion and about the projecting portions of said particles.

9. A tool comprising a working head having a surface layer of softer material than that of the body of the head, abrasive particles embedded in said surface layer, such surface layer being of a thickness less than the mean diameter of said particles, and a layer of comparatively hard material applied to said surface layer and about said particles acting to rigidly secure the latter to said head.

10. The method, which consists in applying a coating of magnetic material to an abrasive element, holding said element in position on a body by magnetic attraction and uniting said element and body by electrolytically depositing metal on the same.

11. The method of producing a tool, which consists in applying a coating of magnetic material to a non-magnetic abrasive element, holding said element in position on the working head of a tool by magnetic attraction, uniting said element and said head by electrolytically depositing metal on the same, and then electrolytically removing part of said deposited metal.

12. The method which consists in applying a conductive coating to a non-conductive element, then applying a magnetic coating to said element, holding said element in position on a tool by magnetic attraction, and then electrodepositing metal on said tool and about said element.

13. The method which consists in coating a

non-magnetic element with a magnetic substance, then applying said element to a magnetized holder, and then electrodepositing metal upon said holder and element.

14. The method of producing a tool, which consists in coating a magnetic member with a conductive and non-magnetic material, forming a recess in said non-magnetic material extending therethrough to said magnetic member, coating a piece of non-magnetic abrasive material with magnetic material, magnetizing said magnetic member, disposing said piece in said recess where it is held by magnetic attraction, electrodepositing metal on said piece and said coated magnetic member to permanently secure said piece in said recess, and then removing part of said electrodeposited metal.

15. The method of applying pieces of material, each comprising a magnetic substance, to the working head of a tool in distributed relation thereon, which consists in magnetizing said head, placing such pieces in the magnetic field of said head and at the same time regulating the direction of the magnetic lines of force in said field in respect to said head, so that said lines will assist in distributing the pieces in the desired positions on said head.

16. The step in the method of producing a tool of the character described which consists in applying a layer of non-magnetic material to the working head of the tool, forming a recess in said layer extending therethrough to said head, magnetizing said head, coating a particle of non-magnetic material with a magnetic material, and disposing said particle in said recess under the influence of the magnetic field of said magnetized head.

17. The method of producing a device comprising a magnetic holder having one or more pieces of material comprising a magnetic substance rigidly attached thereto, which consists in magnetizing said holder and applying the said material thereto, then electrodepositing metal upon said material and holder, and then electrolytically removing part of the said deposited metal.

18. The method of producing a tool of the character described: which consists in coating a magnetic holder with non-magnetic material, forming a recess through said coating, magnetizing said holder, placing an abrasive piece comprising a magnetic substance in said recess under the influence of the magnetism of said holder, and then electrodepositing metal upon said holder and material, and then removing part of the metal so deposited.

19. The step in the method of producing a tool of the character described, which consists in magnetizing said tool, placing an abrasive piece comprising a magnetic substance in the magnetic field of said magnetized tool, and regulating the direction of the lines of force of said field in respect to said tool so that said lines will assist in directing and applying said piece to said tool in the position desired.

20. The method which consists in applying a layer of comparatively soft material to the working head of a tool, forcing comparatively hard abrasive particles into said layer, and then electrodepositing metal on said layer and about said particles.

21. The method which consists in applying a metal layer to the working head of a tool, forming in said layer a plurality of grooves extending laterally of said head, then applying abrasive

particles in scattered but closely associated relation on said layer, and then electrodepositing metal on said head and about said particles.

22. The method which consists in forming the
5 working head of a tool from a hard material, applying a layer of comparatively soft metal to the outer surface of said head, charging said layer with abrasive particles in scattered but fairly closely associated relation, and then applying
10 metal to said head and about said particles to secure the latter firmly to the head.

23. The method which consists in forming the

working head of a tool of comparatively soft metal, embedding particles of abrasive in fairly closely associated relation in said soft metal, and then electrodepositing comparatively hard metal on said head and about said particles.

24. The method which consists in applying a
5 metal layer to the working head of a tool, scoring said layer, then charging said layer with abrasive particles in closely associated relation, and then applying metal to said head so as to embrace said
10 particles and firmly secure the latter to the head.

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