

July 9, 1968

J. DAVIS

3,392,052

METHOD OF FORMING A NON-UNIFORM METAL COATING ON A CERAMIC BODY
UTILIZING AN ABRASIVE EROSION STEP

Original Filed July 7, 1961

5 Sheets-Sheet 1

FIG. 1

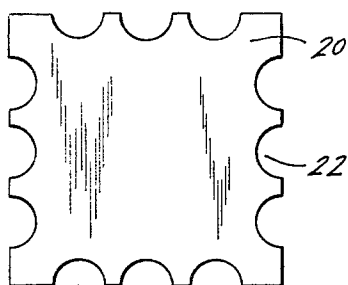


FIG. 2

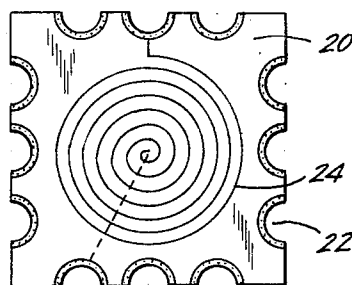


FIG. 3

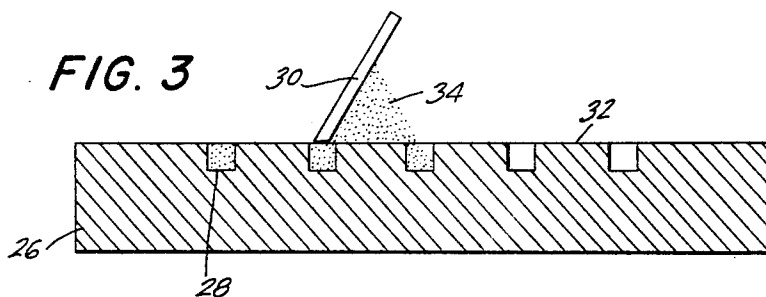


FIG. 4

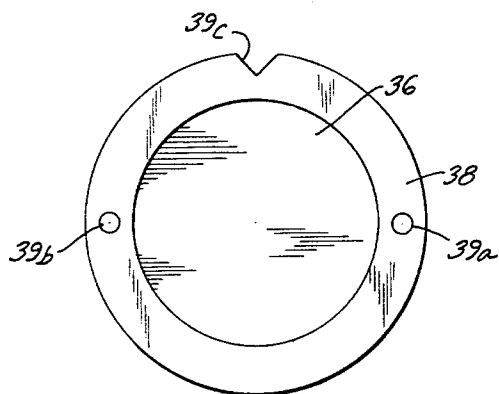
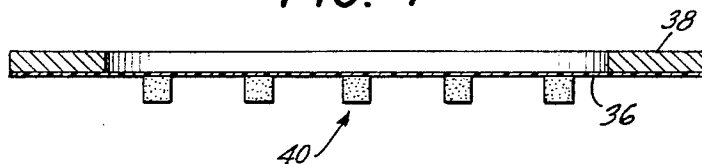


FIG. 5

INVENTOR
JESSE DAVIS

BY

ALAN K. ROBERTS
ATTORNEY

July 9, 1968

J. DAVIS

3,392,052

METHOD OF FORMING A NON-UNIFORM METAL COATING ON A CERAMIC BODY
UTILIZING AN ABRASIVE EROSION STEP

Original Filed July 7, 1961

5 Sheets-Sheet 2

FIG. 6

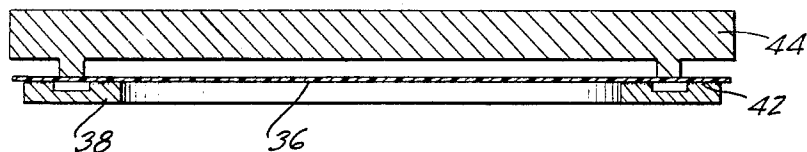


FIG. 7

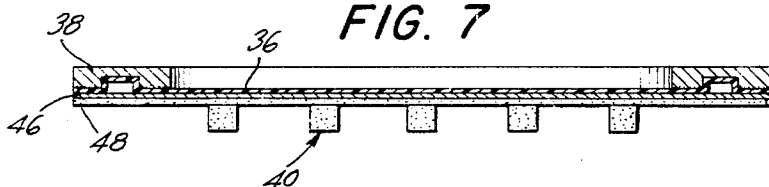


FIG. 8

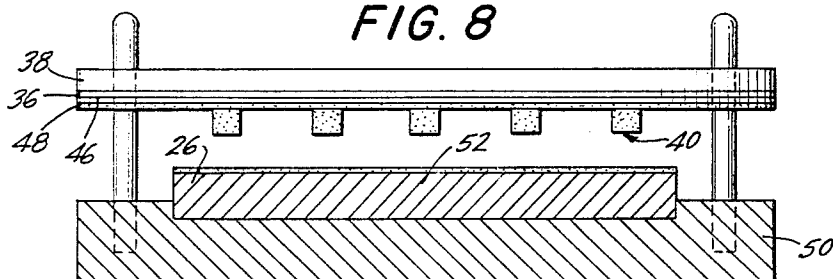
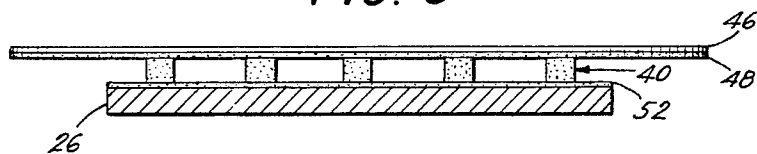


FIG. 9



INVENTOR
JESSE DAVIS

BY

ALAN K. ROBERTS
ATTORNEY

July 9, 1968

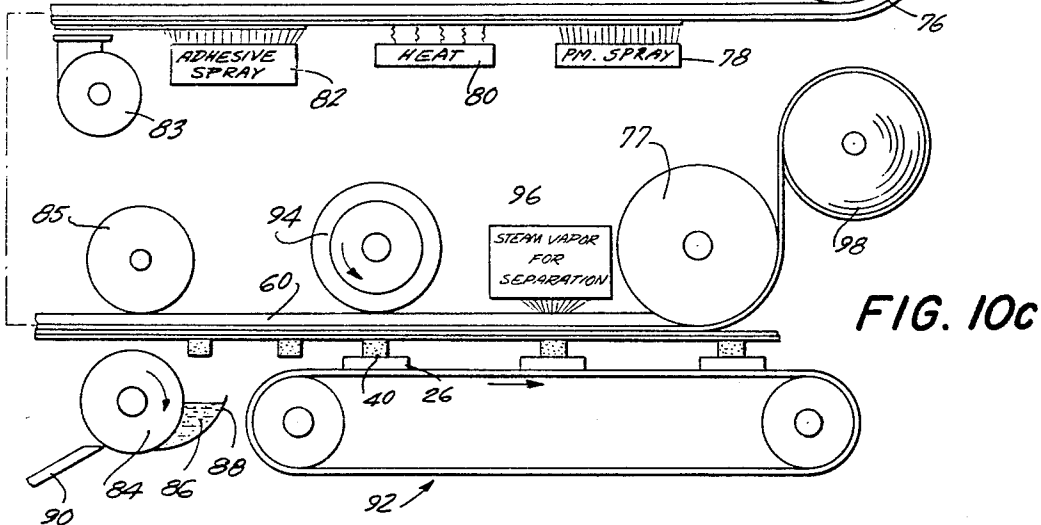
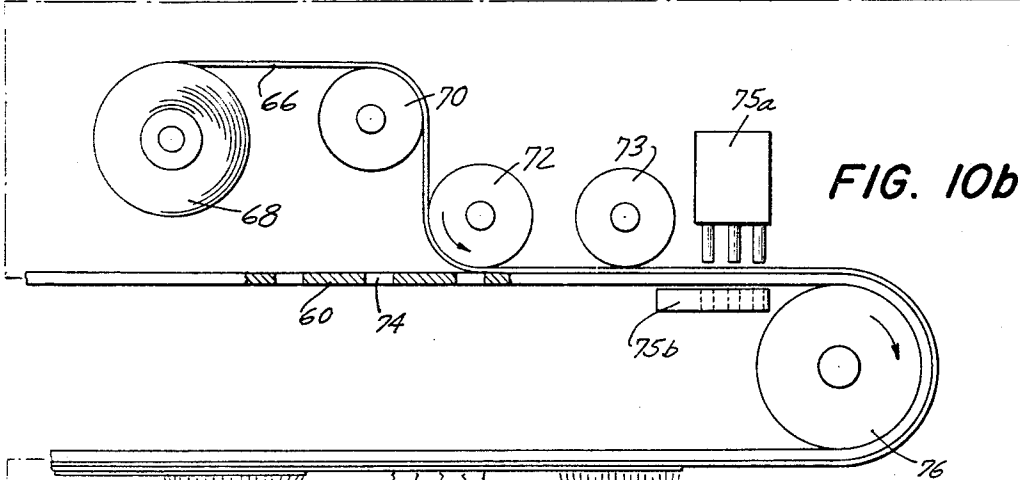
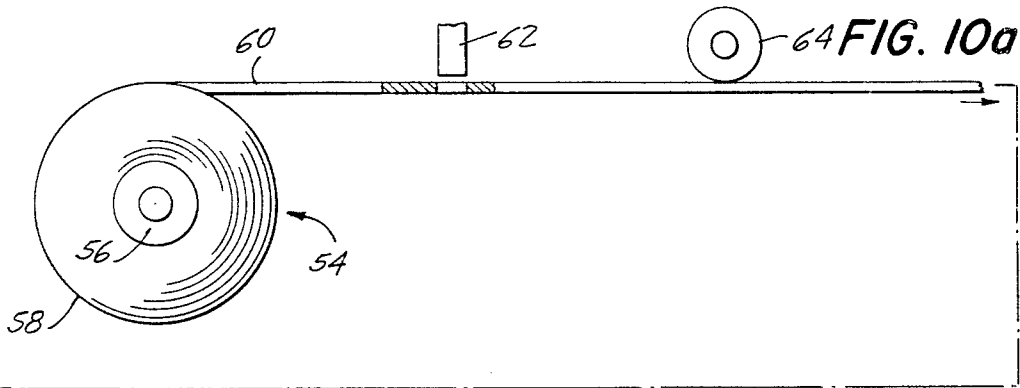
J. DAVIS

3,392,052

METHOD OF FORMING A NON-UNIFORM METAL COATING ON A CERAMIC BODY
UTILIZING AN ABRASIVE EROSION STEP

Original Filed July 7, 1961

5 Sheets-Sheet 3



INVENTOR.
JESSE DAVIS

BY

ALAN K. ROBERTS
ATTORNEY

July 9, 1968

J. DAVIS

3,392,052

METHOD OF FORMING A NON-UNIFORM METAL COATING ON A CERAMIC BODY
UTILIZING AN ABRASIVE EROSION STEP

Original Filed July 7, 1961

5 Sheets-Sheet 4

FIG. 11

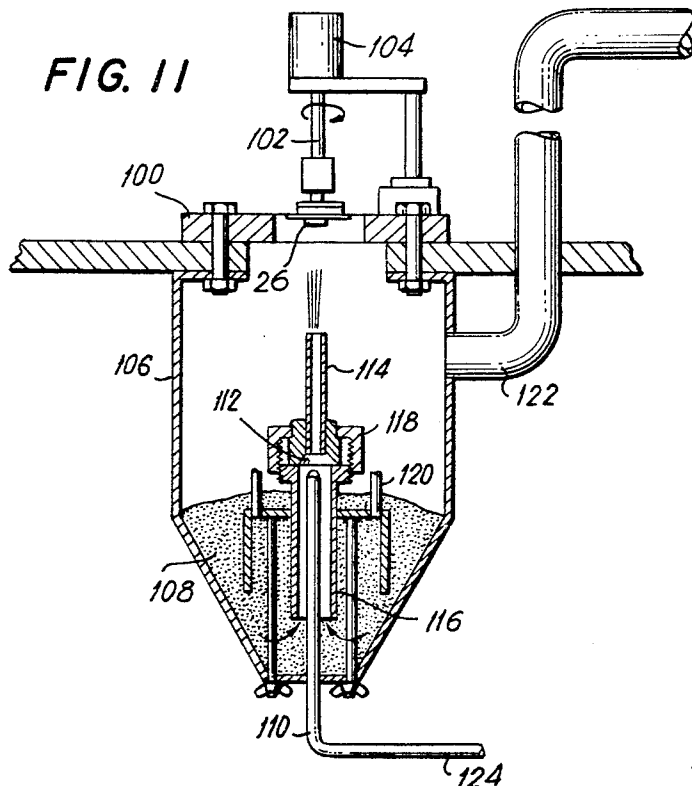


FIG. 13

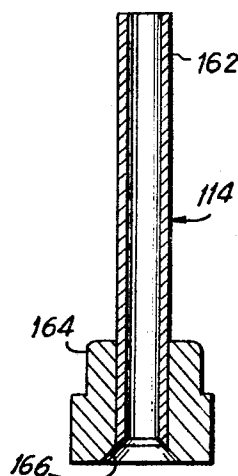
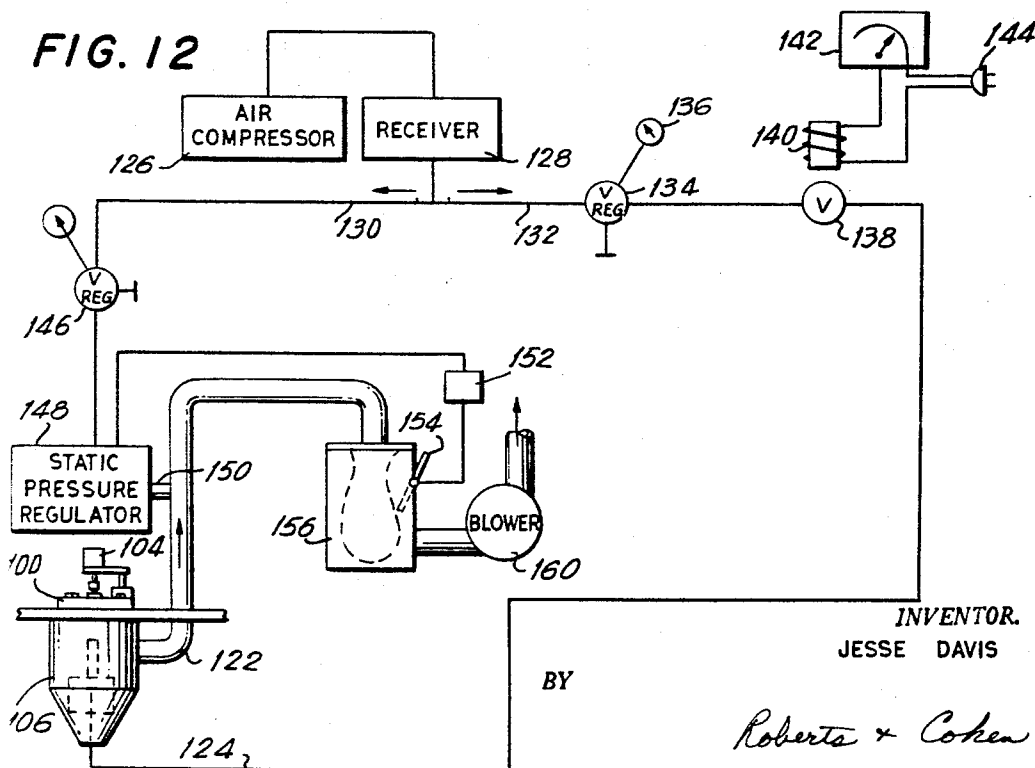


FIG. 12



INVENTOR.

JESSE DAVIS

BY

Roberts & Cohen
ATTORNEYS

July 9, 1968

J. DAVIS

3,392,052

METHOD OF FORMING A NON-UNIFORM METAL COATING ON A CERAMIC BODY
UTILIZING AN ABRASIVE EROSION STEP

Original Filed July 7, 1961

5 Sheets-Sheet 5

FIG. 14

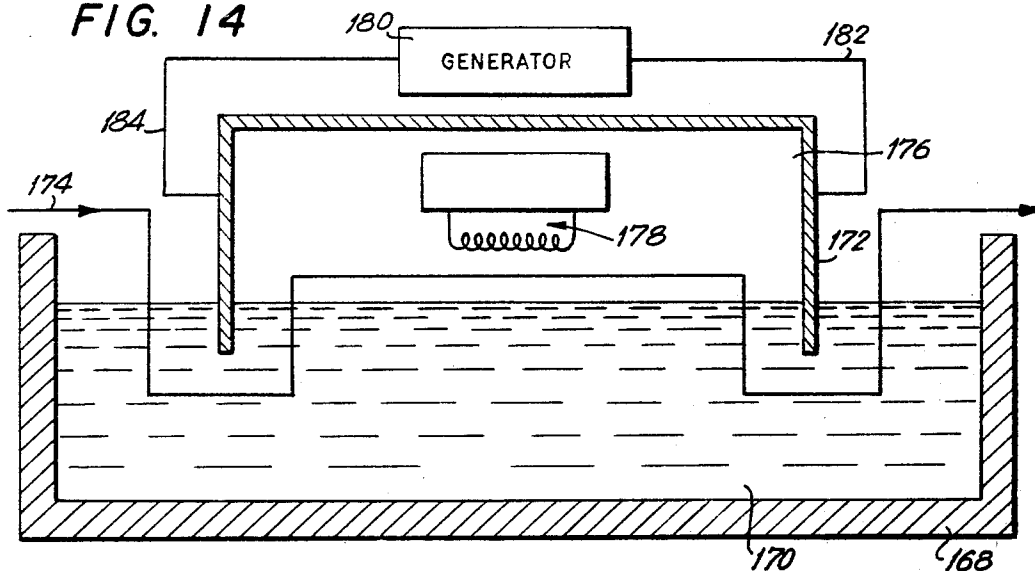


FIG. 15

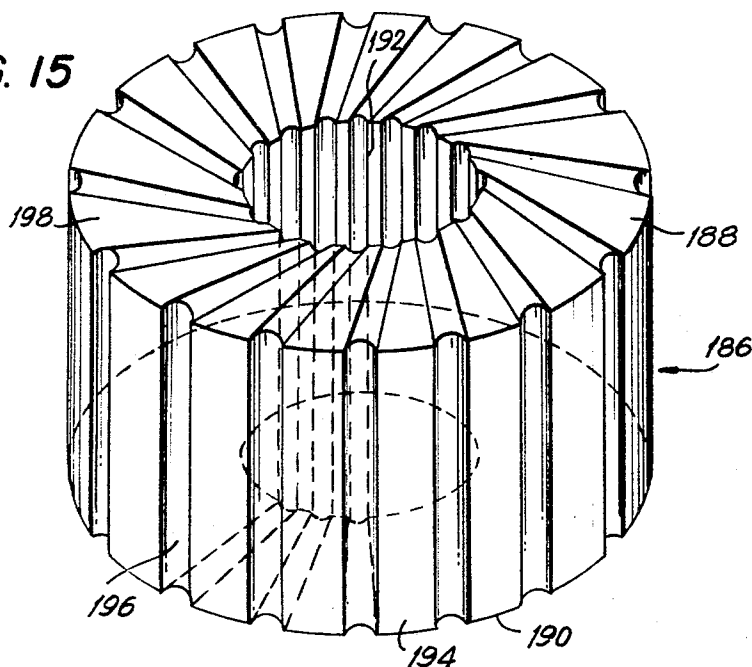
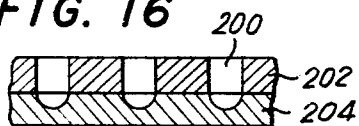


FIG. 16



BY

INVENTOR.
JESSE DAVIS

Roberts & Cohen
ATTORNEYS

1

2

3,392,052

METHOD OF FORMING A NON-UNIFORM METAL COATING ON A CERAMIC BODY UTILIZING AN ABRASIVE EROSION STEP

Jesse Davis, 196 S. Kilburn Road,
Garden City, N.Y. 11530

Original application July 7, 1961, Ser. No. 123,388, now
Patent No. 3,259,678. Divided and this application
Oct. 19, 1965, Ser. No. 505,128
8 Claims. (Cl. 117—212)

ABSTRACT OF THE DISCLOSURE

Method of making electrical components by eroding grooves in a substrate or metal thereon by the use of a propelled abrasive. Groove can be filled with a metal.

This application is a divisional of my co-pending application Ser. No. 123,388, filed July 7, 1961, and now Patent No. 3,259,678.

This invention relates to techniques and apparatus for the deposition of metals and metal-like substances on or in supporting bodies or substances to form electronic and magnetic components and the like, the invention further relating to products of said techniques and apparatus.

There are various known techniques for applying metals in determinable patterns on supporting bodies. Such techniques are, for example, employed in the production of printed circuits. An object of the invention to provide improved techniques superior to those heretofore known especially in connection with certain materials. A particular problem with which the invention is concerned is that of depositing metals in ceramic and ceramic-like materials, while avoiding the disadvantages inherent in procedures heretofore available.

One of the known techniques by means of which metals have been placed in predetermined pattern on substrates has involved the cladding or covering of surfaces of the substrate with a metal and the selective covering of the metal with a resist material. This procedure is then conventionally followed by the application of a corrosive material, such as an acid, which etches away the metal which is exposed or, in other words, not covered by said resist.

A difficulty inherent in this latter procedure is that the etching away of the metal is not readily controlled and it is not unusual for the metal to be undercut. It is therefore difficult to provide fine lines of metal since these may be completely undercut and therefore left unsupported.

With respect to the latter said procedure, it is an object of the invention to avoid the deficiency inherent therein and provide techniques whereby extremely fine lines of metal may be deposited in determinable pattern on or in a substrate without there being any possibility of undermining the support of the metal.

Reference will be made hereinafter to crystalline and ceramic or ceramic-like substrates and this expression shall be considered as applying to alumina, sapphire, glass, steatite and titanates. Other materials of generally similar physical characteristics may also be considered as coming within the scope of this expression, even though the electrical characteristics of these additional materials may differ considerably. Examples of said additional materials are ferrite, tungsten carbide, and other metallic oxide and carbide mixtures. These additional materials will be considered to be ceramic-like materials relative to the invention.

Generally the solution of the invention involves eroding into a substance a recessed pattern which is filled with a metal or any other substance to be accommodated on or in the substrate or alternatively eroding a pattern into a metal previously deposited on a substrate. The method of

the invention can also be applied to shaping the aforesaid materials either with or without the application of metals.

Providing a recessed pattern in or a shape for a ceramic-like material having straight or curved surfaces involves very many problems, the solutions for which are provided by the invention.

For example, ceramic-like materials are generally formed by compressing powders under extremely high pressures, the compressed powders being subsequently ejected from the pressing die or mold. The resulting product is very fragile and it is essential that special precautions be observed in order to avoid damaging the ceramic product during the ejecting step especially if there is a plurality of closely spaced through holes.

It is an object of the invention to avoid the necessity for observing the aforesaid precautions by avoiding the forcible ejecting of a formed ceramic body under harmful circumstances.

Further, it is typical of conventional procedures that ceramic articles formed as above are treated at elevated temperatures. This generally results in large, uncontrollable shrinkage which would necessarily distort the recessed pattern in any article so processed. However, distortion of a recessed pattern is intolerable under very many circumstances and in this regard it is an object of the invention to avoid the necessity of subjecting the recessed pattern to any treatment which would cause distortion in said pattern.

In addition, ceramic materials are highly abrasive and tools made for processing and forming such materials must be of a nature to resist the abrasive action of the same. It is in this regard an object of the invention to provide techniques whereby the need for expensive tools for handling abrasive powders is avoided.

It is further an object of the invention to provide improved techniques for the fabrication of electronic and magnetic components such as will hereinafter be referred to commonly as electric components.

To achieve the above and other of its objectives, the invention contemplates, in accordance with a preferred embodiment thereof, the provision of a master tool or other such means in which is formed, to precise dimensions, a recessed pattern.

This pattern is filled with a material which is resistant to a predetermined abrasive or to abrasives in general and the abrasive-resistant material is transferred by techniques which will be subsequently disclosed to the substrate which is to be processed. The substrate thus protected in part is eroded by the propulsion of an abrasive thereagainst, only those portions of the substrate which are exposed being so eroded.

The substrate may then be processed in order to fill or partially fill the eroded pattern with a metal or whatever other substance is to be deposited in the substrate and in this respect the invention generally contemplates the deposition of a metal from a readily decomposed and volatile metal bearing compound which is easily regenerated and lends itself extremely well to batch or continuous procedures.

There are various products with respect to which the invention facilitates manufacture and according to a feature of the invention one such product is a toroid having a substantially helical metallic winding thereon.

A further feature of the invention is the technique by which the abrasive-resistant material is transferred from the recessed pattern to the substrate while avoiding contact between the master tool and substrate so as to enhance the longevity of said tool.

Still another feature of the invention is the provision of apparatus adapted for the continuous production of ceramic articles of manufacture or the like in accordance with the above-listed techniques and objectives.

Still another object of the invention is the application of metal carbonyl techniques and the like to the attaining of a superior ceramic product as will be seen hereinafter.

The above and other objects and features of the invention, as well as advantages thereof, will become apparent from the following detailed description of some preferred embodiments as illustrated in the accompanying drawing in which:

FIGURE 1 is a top plan view of a substrate to which a predetermined pattern is to be applied;

FIGURE 2 illustrates diagrammatically the pattern to be applied to the substrate of FIG. 1;

FIGURE 3 diagrammatically illustrates in side view a master tool having a recessed pattern therein with abrasive resist being applied thereto;

FIGURE 4 illustrates diagrammatically a transfer device by means of which the abrasive resist is removed from said master tool;

FIGURE 5 is a top view of the device of FIGURE 4;

FIGURE 6 illustrates diagrammatically how the device of FIGS. 4 and 5 is formed;

FIGURE 7 illustrates diagrammatically how the abrasive resist is supported on the transfer device;

FIGURE 8 illustrates diagrammatically how the abrasive resist is transferred to the substrate;

FIGURE 9 illustrates the substrate with the abrasive resist thereon and with the transfer device removed;

FIGURE 10a illustrates diagrammatically a first portion of a continuously operating apparatus adapted to produce articles of manufacture in accordance with the invention;

FIGURE 10b illustrates diagrammatically the next sequential portion of said apparatus;

FIGURE 10c illustrates diagrammatically the next sequential portion of said apparatus;

FIGURE 11 diagrammatically illustrates the details of an eroding device employed in accordance with the invention;

FIGURE 12 illustrates the pneumatic system associated with the eroding device of FIGURE 11;

FIGURE 13 illustrates in axial section a nozzle employed in said eroding device;

FIGURE 14 illustrates diagrammatically a technique whereby metal is deposited on articles of manufacture of the invention from a metal carbonyl or the like;

FIGURE 15 illustrates a specific product which is readily fabricated in accordance with the techniques of the invention; and

FIGURE 16 is a longitudinal section of a workpiece illustrating a variation of the method of the invention.

To practice the invention in most economical and advantageous manner, it is necessary that a process be provided which is adapted to batch or continuous and automated techniques, the tooling required being adapted for repeated re-use or, alternatively, to be expendable. Manual processes are, however, also within the scope of the invention.

A typical problem with which the invention might be concerned is illustrated diagrammatically in FIG. 1 wherein is illustrated a body 20 made, for example, of a ceramic or ceramic-like material. The body 20 is in the form of a right quadrilateral and will be considered to be constituted by a fired and ground non-etchable substrate. The body 20 may be conventionally formed with a plurality of terminal recesses 22 peripherally arranged.

As shown in FIG. 2, there is to be deposited in the body 20 a fine metallic spiral 24 precisely positioned in the manner indicated. The dotted line represents a completely covered metal deposit.

According to the preferred technique of the invention, it is contemplated that a master tool be provided in which is formed the negative of the form of deposition desired. Thus the pattern recessed into the master tool is the negative of the pattern which it is desired be formed in the substrate or article of manufacture.

There are various procedures for forming such a master tool and one typical procedure contemplated in accordance with the invention will next be indicated hereunder:

A black and white drawing of FIG. 2 which is, for example, ten times the actual size, is made up with the areas to be engraved or machined into the tool being indicated with black ink on white paper. This drawing is photographically copied and reduced at the same time to actual size. A tool blank of copper or engraver's brass is then polished and a photo-resist is placed on a flat surface thereof. This may be dried, for example, with infra-red radiation. The resulting sensitized blank is placed in a vacuum frame of conventional nature and the disc is exposed to actinic light under vacuum the image being then developed and set by baking. The blank is then etched with a suitable etching material such as ferric chloride, acid, etc., in conventional manner and the photo-resist is removed with a conventional remover such as phenol.

The foregoing procedure is generally known and hence need not be described or illustrated in greater detail. Other conventional techniques for forming a master tool may also be employed such as, for example, pantograph engraving and so forth. The technique employed, however, must provide a recessed pattern of exact dimension and shape.

A tool 26 with a recessed pattern 28 therein is shown diagrammatically and in longitudinal section in FIG. 3. Also shown is a doctor blade 30 which is wiped across the upper surface 32 of said tool to deposit abrasive resist 34 in the recessed pattern 28.

The abrasive resist 34 may be any material adapted to resist the abrasive action of a predetermined abrasive. A particularly advantageous resist which has been employed is a combination of polyvinyl chloride resin made into a viscous solution with a plasticizer such as dibutyl phthalate with a dye added so that the deposit in the recessed pattern can be readily checked. More particularly, an advantageous abrasive resist is formed by mixing, for example 20 grams of polyvinyl chloride resin with ½ ounce of dibutyl phthalate, 5 grams of a suitable dye solution being added to aid in inspecting the resist in contrast to clear open areas.

With the abrasive resist in the recessed pattern in the master tool, the resist is set or cured by means of a heat treatment and after being so treated is ready for transfer to the ceramic substrate illustrated in FIG. 1.

FIGURE 4 illustrates diagrammatically a transfer technique whereby a membrane 36 on a supporting member 38 is employed to withdraw the resist pattern generally indicated by reference numeral 40. The membrane 36 and its support is such that the abrasive resist can be transferred to the substrate without distortion.

FIGURE 5 illustrates generally the transfer device in top plan view, the transfer device consisting generally of the supporting section 38 in the form of a flat annular body of metal, cardboard, or the like having registration means 39a-c, the membrane consisting, in the illustrated embodiment, of cellophane which may be, for example, .001" thick. Other dimensionally stable membrane materials may also be employed.

FIGURE 6 illustrates generally that the transfer device may be fabricated by heat bonding the membrane 36 to the supporting means 38 with a glue or other bonding agent 42 by means of a heated platen 44.

The membrane is coated with a parting material, the purpose of which is to permit the deposition of the resist pattern on the substrate after the pattern has been removed from the master tool. The adhesive characteristics of the parting material will be discussed in further detail hereinafter, but may, for example, consist of a mixture of gum arabic, water and a preservative. For example, the parting material may consist of ½ gram sodium benzoate, ½ ounce of glycerine, 20 grams of gum arabic flakes and 16 ounces of water. These proportions are not critical and may be varied in accordance with the

requirements of the other materials employed, as will become apparent hereinafter.

FIGURE 7 illustrates the transfer device with the parting material and a further adhesive thereon, the abrasive resist being bonded to this adhesive material.

More particularly, FIGURE 7 illustrates the supporting body 38 with the membrane 36 thereon, a layer 46 of parting material covering the membrane 36 and a layer 48 of adhesive covering the parting layer 46. The abrasive resist pattern 40 is shown adhering to adhesive layer 48.

The relationship of the various layers is significant. The affinity of the abrasive resist for adhesive 48 must be greater than the affinity of the abrasive resist for the master tool. Similarly, the affinity of the parting material 46 for membrane 36 and for adhesive layer 48 must be greater than the affinity of the abrasive resist for said master tool. Further, the adhesive which bonds membrane 36 to support 38 must have a greater affinity for these members than said abrasive resist has for the master tool.

The above qualifications being met, application of the transfer device with the various layers thereon to the master tool with the abrasive resist in the recessed pattern will remove the abrasive resist in said pattern from the master tool. This is illustrated in FIG. 7.

Various adhesives may be employed to remove the abrasive resist from the master tool. Preferably, this adhesive should be transparent and not an abrasive resist in itself. It must also serve as a transfer support. For this purpose, for example, chlorinated rubber has been successfully used to constitute layer 48. More particularly, Parlon (which is chlorinated rubber) dissolved in toluol in a portion of 15 grams per 4 ounces of solvent has proved very successful. Parlon can be purchased from the Hercules Powder Company.

The adhesive layer 48 is sprayed on the parting layer 46 and, as noted above, is preferably transparent. Also, this adhesive layer is preferably thermally activated and this requirement is met by the aforementioned mixture.

In FIGURE 8 is again illustrated the support 38 and the membrane 36 thereon. Also illustrated is the bonding layer 46 and the adhesive layer 48 with the resist pattern 40 thereon. The workpiece or substrate 49 is shown resting on a centralized nest 50. Atop the workpiece 49 is positioned an adhesive layer 52. A variety of adhesives may be employed to constitute the layer 52, but there are certain requirements for such an adhesive. This adhesive must have a greater affinity for the abrasive resist 40 than the parting material in layer 46 has for the membrane 36 so that the abrasive resist pattern 40 will be bonded by the layer 52 to the workpiece 49. A particularly suitable adhesive has been found to be a solution of modified vinyl chloride acetate in methyl ethyl ketone in a ratio of about 10 grams for each 4 ounces of the solvent.

FIGURE 9 shows the workpiece 49 with the adhesive layer 52 bonding the resist pattern 40 thereto. Adhesive layer 48 and parting layer 46 are superposed on the abrasive resist. This, however, is of no consequence inasmuch as layers 46 and 48 are not in and of themselves abrasive resists and therefore are readily removed when an abrasive is propelled at the workpiece, as will be indicated in greater detail hereinafter.

FIGURES 10a, 10b and 10c collectively and diagrammatically illustrate how the aforesaid procedure lends itself readily to mass production techniques of a continuous nature.

In FIGURE 10a is illustrated a source 54 constituted generally by a roller 56 supporting thereon a roll 58 of material adapted for supporting the above noted membrane. A strip 60 of the supporting material is continuously supplied to a punch 62 constituting a punch-out station whereat there are formed in the supporting material holes over which the membrane is mounted. Also illustrated in FIG. 10a is an adhesive roll 64 of conven-

tional structure applying to the upper surface of the strip 60 an adhesive adapted for bonding the membrane to the supporting material at least around the peripheries of the holes punched therein.

As shown in FIG. 10b, a strip 66 of membrane material such as cellophane is continuously supplied from a source or roll 68, and is fed via a roller 70 to a smoothing roller 72 whereat the membrane is fed to a heated sealing roller 73 sealing the membrane to the adhesive coated supporting strip 60. The holes which have been punched in the supporting material 60 are indicated generally by reference number 74. Elements 75a and b are means for punching registration holes in the supporting strip.

With the membrane applied to the supporting strip, the strip passes then along a supporting roller 76 and thence past a spray means 78 whereat the parting substance or material is sprayed onto the membrane under the conditions set forth hereinbefore. The parting medium is set by a heating means 80 and is then conducted past a means 82 which is adapted for spraying on the parting layer thus formed the adhesive intended to remove the abrasive resist from the master tool, as has already been indicated. Blower 83 dries the adhesive.

The strip 60 continues as illustrated in FIGURE 10c in inverted relationship with the adhesive layer lowermost and the supporting strip 60 uppermost. One or more master tools mounted on a means 84, opposed by roller 85, is supplied with abrasive resist 86 from a hopper 88, the excess being trowelled off by a blade 90.

The means 84 may consist of a roller or a chain driven system, the primary requirement being the bringing into contact of the adhesive on the strip 60 with the master tool mounted on the means 84. Further, inasmuch as distortion should be avoided with respect to the pattern deposited on the adhesive of the strip 60, the speed of the strip 60 past the means 84 should be the same as the peripheral speed of the means 84 in its rotary movement relative to said strip.

Workpieces 26 are continuously supplied to and by a conveyor system generally indicated by reference numeral 92. A roller 94 presses the strip 60 against the workpieces which are travelling at the same speed as said strip so that the resist pattern 40 is deposited on said workpieces. A steam vapor source 96 applies steam to the back of the membrane in order to render the bonding material ineffective to retain its adhesion to the membrane so that the supporting strip and membrane can be readily rolled by the use of a pickup idler 97 into a roller 98. The workpiece or article of manufacture then continues to the erosion station.

A preferred embodiment of an eroding device is illustrated in FIGURE 11. In FIGURE 11, workpiece 26 mounted on work holder 100 is adapted for being rotated by a shaft 102 and a motor 104. A chamber 106 is provided with an abrasive 108 which is preferably 150-180 grit silicon carbide or aluminum oxide. Feeding into the chamber 106 is an air tube 110 terminating adjacent the bottom venturi section 112 of nozzle 114. A skirt base 116 is coupled by a coupling nut 118 to the nozzle and there are additionally provided a number of venting pipes 120 which extend above the upper level of the abrasive. A take-away or evacuating conduit 122 is provided along with a supply conduit 124.

The chamber 106 is shown incorporated into a pneumatic system in FIGURE 12, wherein are further illustrated the exhaust conduit 122 and the supply conduit 124. Also shown in FIG. 12 are a compressor 126 and receiver 128 supplying compressed air via branch lines 130 and 132. A regulating valve 134 is incorporated in line 132 and a gauge 136 is operatively associated therewith. Also incorporated in line 132 is an interrupter valve 138 controlled by a solenoid 140 in turn controlled by an interval timer 142 of conventional construction supplied with electrical power by a source 144.

In line 130 is a valve 146 and a static pressure regulator 148. Regulator 148 is provided with a sensing tube 150 extending into exhaust conduit 122 whereby a pressure differential is measured by regulator 148 for use in controlling a control 152 for a damper 154.

Exhaust conduit 122 feeds into a cleaner 156 provided with a dust bag 158, the position of damper 154 controlling the speed with which the pneumatic medium can be exhausted through conduit 122 by means of blower 160.

The erosion device illustrated in FIGURES 11 and 12 is an upshot ejector assembly wherein a self-contained supply of abrasive preferably of the type indicated above is hopper fed into a low pressure area beneath the skirt 116. The low pressure created by the controlled flow of air through the venturi section 112 results in a controlled flow of abrasive, the flow propelling the abrasive vertically upwards against the workpiece which is held in position directly in line with or offset relative to the "hot spot" of the abrasive stream, the workpiece being rotated, or not, as desired, by the motor 104.

The area of the hot spot is closely controlled by the design of the nozzle which is illustrated more particularly in FIGURE 13. In FIGURE 13, the nozzle 114 is shown as comprising a tube 162 supported in a block 164, the venturi section component provided by the block 164 being in the form of a truncated cone 166 enclosing an angle of about 80°.

The intensity of the impinging stream of abrasive is controlled by the ratio of input air pressure and "take-away" vacuum. Depending upon the material of the substrate, the abrasive is propelled at the workpiece to impact against the same with velocities ranging from about 50-1500 feet per second. The depth of the groove or recessed pattern formed in the workpiece is controlled by the time of exposure of the workpiece to the abrasive, in addition to the velocity, weight and volume of the abrasive. These features can be empirically determined depending upon the depth of erosion desired. Depths have been successfully controlled to tolerances of ± 5 millionths of an inch.

It will be appreciated that what is eroded into the workpiece or article of manufacture is the negative of the abrasive resist pattern. In other words, those portions of the workpiece which are left exposed by the abrasive resist are those portions which are eroded.

The article of manufacture in this stage may then be processed to fill the eroded or recessed pattern with a metal or such other material as is desired be deposited in the substrate. In the case of electrical components, and this expression is intended to cover magnetic and other components as well, the material deposited will be one having predetermined electrical characteristics.

There are many modes by which metal may be deposited in the grooves in the substrate. For example, metals can be sprayed or otherwise plated onto the substrate and then lapped down so that the only metal remaining is that which is positioned in the recessed pattern, or mixtures of powdered metals in suitable vehicles can be doctored or brushed into the grooves and fired in suitable atmosphere furnaces.

There is, however, one particular procedure which lends itself very well to the production of articles of manufacture suitable for microminiaturization and this is a method by which a metal is deposited in the substrate from a readily decomposed and volatile metal bearing compound.

In accordance with this procedure, it is possible to utilize metal carbonyls, nitroxyl compounds, nitrosyl carbonyls, metal hydrides, metal alkyls, metal halides, metal carbonyl halogens, and the like, which are either liquids at normal temperatures and pressure conditions, or gases compressible to liquid under any commercially feasible temperature conditions or solids convertible to liquids at temperatures below the decomposition tem-

perature of the compound, or solutions or carbonyls in volatile solvents such as petroleum ether.

Useful metals which may be deposited from the metallic carbonyl compounds are copper, nickel, iron, chromium, molybdenum, tungsten, cobalt, tellurium, rhenium, and the like.

Illustrative compounds of the other groups are nitroxyls, such as copper nitroxyl, nitrosyl carbonyls, for example, cobalt nitrosyl carbonyl, hydrides, such as tellurium hydride, selenium hydride, antimony hydride, tin hydride, chromium hydride, the mixed organometallo hydrides such as dimethyl alumino hydride, metal alkyls such as tetraethyl lead, metal halides such as chromyl chloride, and carbonyl halogens such as rhodium carbonyl chloride, osmium carbonyl bromide, ruthenium carbonyl chloride, and the like.

The procedure whereby metal may be deposited from a readily decomposed compound is well known for other purposes and will not be described in great detail at this time. However, reference to FIGURE 14 will show diagrammatically how the procedure is effected.

In FIGURE 14 is shown a vat 168 in which is accommodated a bath 170 of a fluid such as water. An open bottomed chamber 172 dips into said bath to form a fluid lock therewith. Articles of manufacture are passed in any conventional manner along the path 174 so that for a period of time they are located within the closed chamber 176, wherein their recessed surfaces are heated by a heating means 178.

An atmosphere of said readily decomposed and volatile compound is maintained within the chamber 176 by means of a generator 180. Generator 180 supplies a compound such as metal carbonyl or one of the above compounds by supply line 182 and draws out the gaseous by-products by means of evacuating line 184. Further, generator 180 in conventional and well known manner continuously regenerates and supplies compound to the chamber 176 wherein the articles of manufacture are suitably supplied with metal.

The actual mechanism by which the metal is deposited on the substrates involves thermal activation and this is why the recessed surfaces of the articles of manufacture are heated by heating means 178. The temperatures required are not very high and for the various materials involved, such temperatures can be found in available literature. Nickel carbonyl, for example, starts to decompose at about 175° F. A preferred range of operation, however, is, for example, a range of about 375-400° F.

According to the invention, the entire article of manufacture can have its recessed surface coated and then subsequently milled down so that the sole remaining metal lies completely within the grooves which have been formed.

To better adapt the technique of the invention to mass production requirements, it is possible to treat the abrasive resist, which is maintained atop the substrate, in a manner whereby metal deposition is prevented other than directly in the grooves.

More particularly, the abrasive resist may be treated with a deposition inhibitor such as is indicated in Patent No. 2,970,064 (Jan. 31, 1961). This involves combining with the abrasive resist a polyhydroxy aliphatic such as glycerine ethylene glycol, propylene glycol and so forth.

As is known, during the course of gaseous deposition of the metal from its volatile compound, the inhibitor issues as a vapor and creates a vapor pressure at the surface of the abrasive resist which inhibits deposits of the metal from the metal bearing compound. This enables a selective deposition of the metal in the recessed pattern and avoids the necessity for subsequently lapping or melting the excess metal.

In accordance with the invention, it is possible to fill the recessed pattern to less than complete extent and to cover the metal so deposited with an insulator and finally

cover the insulator with additional metal to provide for cross-overs (see dotted line in FIG. 2).

A particular form of a product of the invention other than for those discussed above is illustrated in FIGURE 15 wherein is shown a flat inductor which is adapted for having spirally "wound" thereupon a metal "wire."

In FIGURE 15 is illustrated a toroid 186 having parallel flat or radial faces 188 and 190 and further having concentric inner and outer walls 192 and 194. Toroid 186 may be cast or extruded, but in any event is formed with corresponding axially disposed grooves 196. In fact the axially disposed grooves can also be eroded in accordance with the invention which, in contrast to the known art, can be applied to curved surfaces as well as flat surfaces.

In accordance with the invention, connecting grooves 198 are formed in the faces 188 and 190 in an offset relationship such that strips or grooves 198 and grooves 196 form a continuous spiral-like path around the body of the toroid. The forming of grooves 198 is effected by masking with an abrasive resist and eroding the grooves with an abrasive such as discussed above. The spiral-like path then has deposited therein a metal or other such material by one of the methods which have been discussed above.

Finally, as shown in FIGURE 16, the invention is applicable to cameo as well as intaglio types of processes whereby holes 200 can be cut into a metal coating 202 previously positioned on a substrate 204.

There will now be obvious to those skilled in the art many modifications and variations of the methods, articles of manufacture and apparatus set forth above. These modifications and variations will not, however, depart from the scope of the invention if defined by the following claims.

What is claimed is:

1. A method of manufacturing an electrical component by the deposition of a metal in predetermined pattern on a supporting body comprising covering a selected portion of said body with a substance resistant to a predetermined abrasive while leaving exposed a portion of said body corresponding to said pattern, facing the covered portion in downward direction, propelling said abrasive upwardly at said body to erode said pattern therein, treating the abrasive-resistant substance to render the same non-receptive to metal, depositing in the exposed and eroded pattern a metal from a metal carbonyl, and then removing the abrasive-resistant substance.

2. A method of manufacturing an electrical component comprising covering a selected portion of a metallic coating on a body with a substance resistant to an abrasive while leaving exposed a portion of said coating, facing the covered portion in downward direction, and propelling said abrasive upwardly at said coating to erode a pattern therein.

3. A method of manufacturing an electrical component by the deposition of a metal in predetermined pattern on a supporting body comprising covering a selected portion of said body with a substance resistant to a predetermined abrasive while leaving exposed a portion of said body corresponding to said pattern, facing the covered portion in downward direction, propelling said abrasive upwardly at said body to erode said pattern therein, and depositing said metal in the thusly eroded pattern.

4. A method comprising covering a selected portion of a body with a substance resistant to a predetermined

abrasive while leaving exposed a portion of said body corresponding to a predetermined pattern, facing the covered portion in downward direction, propelling said abrasive upwardly at said body to erode said pattern therein, treating said substance to render the same non-receptive to metal, depositing a metal in the exposed and eroded pattern, and then removing said substance.

5. A method comprising covering a selected portion of a body with a substance resistant to a predetermined abrasive while leaving exposed a portion of said body corresponding to a predetermined pattern, facing the covered portion in downward direction, propelling said abrasive upwardly at said body to erode said pattern therein, treating said substance to render the same non-receptive to metal depositing in the exposed and eroded pattern metal from a readily decomposed volatile metal bearing compound, and then removing said substance.

6. A method of manufacturing an electrical component by the deposition of a metal in predetermined pattern on a supporting body comprising covering a selected portion of said body with a substance resistant to a predetermined abrasive while leaving exposed a portion of said body corresponding to said pattern, facing the covered portion in downward direction, propelling said abrasive upwardly at said body to erode said pattern therein, treating said substance to render the same non-receptive to metal depositing said metal in the exposed and eroded pattern, and then removing said substance.

7. For processing a ceramic body, the method comprising the steps of forming a pattern of a substance resistant to a predetermined abrasive as a covering on a portion of said ceramic body, facing the covered portion in downward direction, propelling said abrasive upwardly at said ceramic body to erode the portions other than that covered by said substance, treating said substance to render the same non-receptive to metal filling the resulting exposed and eroded pattern with a metal, and then removing said substance.

8. A method involving the use of a master recessed pattern comprising forming an abrasive resist of dibutyl phthalate, and polyvinyl chloride, filling the pattern with said resist, depositing the substance from said pattern onto an article to be processed to cover a portion thereof, facing the thusly covered portion in downward direction, propelling an abrasive upwardly at the article to erode the same other than for said pattern, and filling the resulting erosion with a metal having predetermined electrical characteristics.

References Cited

UNITED STATES PATENTS

2,054,822	9/1936	Keith	118—257
2,255,953	9/1941	Vergobbi	156—238
2,556,078	6/1951	Francis	156—238
2,572,001	10/1951	Bennes	156—238
2,674,974	4/1954	Gwinn et al.	118—211
2,700,629	1/1955	Townsend	156—238
2,785,997	3/1957	Marvin	117—212
3,075,892	1/1963	John et al.	117—212
3,115,564	12/1963	Stacy	156—252
3,240,624	3/1966	Beck	117—5.5
2,850,409	9/1958	Boicey et al.	117—212
2,970,064	1/1961	Bolton	117—38

WILLIAM L. JARVIS, *Primary Examiner.*