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METHOD AND APPARATUS FOR MAKING RESISTORS

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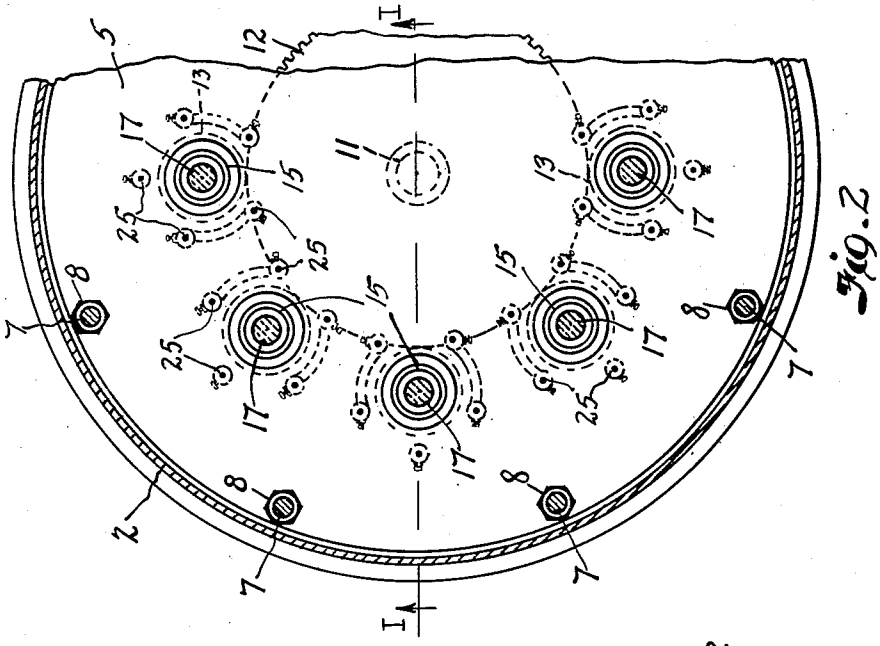


Fig. 2

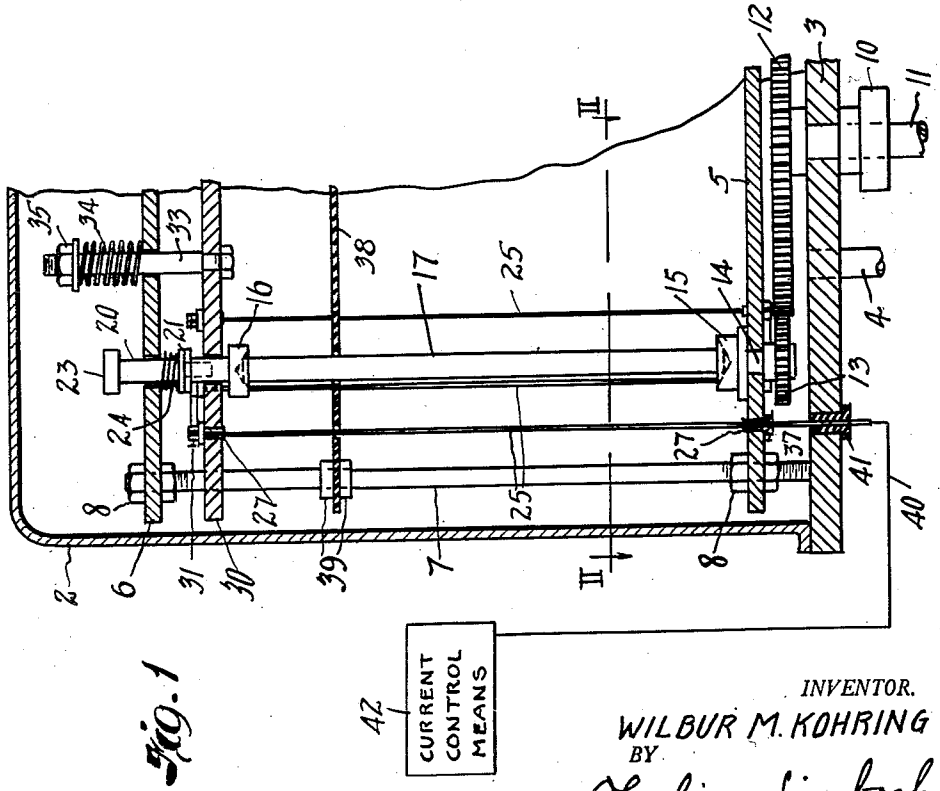


Fig. 1

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METHOD AND APPARATUS FOR MAKING RESISTORS

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In resistor construction involving metallic film resistance elements, it is important that the metal be of uniform thickness, and that it be irremovably secure on its insulation support. In the case of deposited metal film construction, involving ceramic or porcelain supports, a problem arises as to attainment of high precision uniform thickness metal film, and a high degree of satisfactory adhesion of the metal film to the ceramic support. I have found that the latter condition can be outstandingly met if a glazed ceramic or porcelain support be used and if the glaze be softened or fused such that the metal as deposited thereon takes up adhesion by virtue of the especially enforced conditions for union such as to determine a certain extent of bedding penetration instead of a merely superficial contact. Furthermore, I have found that vapor deposition or vacuum deposition of the metal to form the film is particularly effective, but the highest degree of uniformity of deposit requires some particular precautions. Thereby, high precision products can be attained, such as is not possible with mere general procedures. Further advantages and objects of the invention will appear from the following description.

To the accomplishment of the foregoing and related ends, said invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

Fig. 1 is a vertical sectional view showing an individual unit of a multiple combinational apparatus in accordance with the invention, other portions of the apparatus being broken away, this section being taken on the line I, Fig. 2; and

Fig. 2 is a fragmentary transverse sectional view taken on the line II, Fig. 1.

In general, the apparatus involves a hermetic sealable chamber 2, the main cover element thereof being securable and removable with respect to the stationary base plate 3, and through the latter a piping connection 4 provides a vacuum of desired extent, being connected to an air-exhaust means of any desired or suitable form. Within the chamber 2 is a support-frame comprising a lower plate 5 and an upper plate 6 preferably in annular form which are held in permanent spaced relation by rods 7, nuts 8 above and below the respective plates 5 and 6 serving to lock the plates in their position on the support rods. These rods are permanently secured below to the chamber foundation plate 3. Mounted through a suitable stuffing box 10 is a shaft 11 driven by suitable motor means at desired rate of speed, and this shaft has a gear 12 which meshes with pinions 13 mounted on stub shafts 14 in the plate 5, the pinions being in one circular row or in concentric rows about the gear as determined by the size of the apparatus required in any given case. Each pinion stub shaft carries a chuck 15 of desired or suitable form to coact with an upper chuck 16 which is spring-pressed preferably, whereby a ceramic blank 17 can be inserted between the two chucks and thus be held for treatment by metal deposition. The design of the chucks 15, 16 may vary, a general satisfactory form involving conically dished surfaces by which the included ceramic body is automatically centered. The upper chuck 16 is on the end of the stub shaft 20 which is slidable through the frame plate 6 and has a collar 21 whereby a coil spring 24 between the plate 6 and the collar 21 normally urges the chuck 16 downward against the ceramic blank to be held. To make possible the rotation of chuck 16 notwithstanding its association with the pressure spring 24, for instance the stub shaft 20 may be in two sections, the lower rotating on the upper, while the spring 24 bears stationarily against the plate 6 and the collar 21. For charging the apparatus, the cover member 2, which is usually of thick glass, is removed from the base plate 3, and the glazed ceramic blanks are positioned between the chucks 15 and 16. Manipulation of the chuck is a simple matter, it being raisable by grasping the flange top 23 and lifting against the spring 24, while the ceramic blank is inserted first in the lower chuck 15, and then the upper chuck is allowed to spring down into engagement with the upper end of the blank.

An important feature is the provision of a plurality of wires 25 spacedly about the ceramic blank 17 in number two and up as appropriate to the size of blank being treated. These wires are held in suitable support means and are supplied by controllable current, and they effect a two-fold function. In the first place, with current supply they become heating elements which heat and soften the glaze on the ceramic blanks. Then, by suitable increase of current, metal may be vaporized off from them, under the high vacuum of the vacuum chamber, and the metal vapor deposits on the ceramic blanks as rotated by the pinions 13. The wires may be of convenient size consistent with their heating by resistance, and for instance may be .030–.040 in. The material of the wires 25 is chosen in accordance with the particular resistance metal film desired on the ceramic cores 17. Thus, one desirable composition is an 80:20 nickel-chromium alloy. Other metals which may be used are substantially pure nickel, alloys such as "Constantan," "Nichrome," etc. The ends of the wires extend through insulating bushings 27 in the plates and are held in binding posts 37 supported on the flanged end of the insulating bushings on the upper side and the lower side of the respective plates 5 and 30. Binding screws 31 in each post hold the ends of the wires and the binding posts are elongated so that each except at the inlet serves two wires and acts also as a series connector between wires. Where the current supply is for instance 220 or 440 volts the wires are connected in circuit in series, and depending upon the overall size of the apparatus there may be one or more series circuits therefor. The binding post elements serving two wires, are appropriately positioned on the upper plate and then the lower plate, etc., as required, and with the entry supply line 40 from the current control means 42 through an insulating bushing 41 in the base 3, the end of such conductor wire positions alongside the wire 25 in the same binding post opening and the clamping screw 31 then holds both. At the top of the upper plate 30 the crossover binding post means 37 serially connects to the next wire, and this in turn at the bottom connects through another binding post means to the next wire, and the latter in turn connects at the top plate through another binding post

means to the next wire, and so on through all of the wires, and thence out by the exit line not shown. The plate **30** is a floating plate supported by stubs **33** which project from the plate upward through openings in the frame-plate **6**, such that the floating plate **30** with all its connecting wires is normally tensioned upwardly by coil springs **34** between the frame-plate **6** and the head of the stubs, such head being a washer and an adjustable nut **35** threaded on the stub for adjusting the spring tension. This arrangement gives a constant tension positioning of the wires, irrespective of expansion and contraction conditions undergone by them in heating and cooling cycles. The plate **30** in its movements is guided by its openings sliding on the support rods **7**.

In case a wire **25** breaks, damage is prevented by the provision of an insulation plate **38**, of native mica or suitable material, and respective openings allow the passage of wires therethrough, but if the wire breaks it cannot tangle disastrously with other elements. The plate **38** is held between nuts **39** on the support rods **7**.

The manner of operation is understood from the foregoing. With the top member **2** off of the base **3**, glazed ceramic blanks **17** are inserted between the chucks **15**, **16**, the latter being raised for this by manually lifting the flanged head **23** against the spring pressure **24**. Wires of the desired resistance metal are inserted in the binding posts **37**, and are secured by the binding screws **31**. The cover section **2** is replaced and secured on the base plate **3**, and the vacuum draw-off is started, and brought to the desired extent for metal deposition and it is advisable to hold for five minutes after reaching that point before applying metal-vaporizing current. The vacuum deposition technique per se follows the known technique (for instance as in "Vacuum Technique" by Sol Dushman, pub. John Wiley & Sons, Inc., 1949, pages 757–764) a vacuum of extent sufficient for the metal vapor deposition being applied, but the present procedure has the further feature that electric current is applied to the wires **17** first such as to heat and soften the glaze of the ceramic blanks, the amperage for this being for instance 4–6.5 depending on the wire size. Then, after the glaze is fused, the current is stepped up to an amperage of **8–12**, and under the vacuum which is being applied, metal is vaporized freely from the wires, and deposits on the surface of the softened glaze. The ceramic blanks **17** are meanwhile being rotated by the drive through the pinions **13** and gear **12**.

While in the drawing, the number of heating wires **25** surrounding each ceramic blank is illustrated as five, it will be understood that the number depends in one respect on the size of blanks and can be of any workable order more than two. It will be understood that the size of the blanks may be in accordance with the ultimate products to be turned out, and with large diameter blanks there are of course relatively fewer chucks and their operating pinions. The rate of rotation of the blanks in general may be for instance 1½–2 during the metal vaporizing part of the operation, it being seen that to some extent this is dependent upon the number of heating wires spaced around each blank, and the working temperatures selected during the glaze-softening operation and in the vaporization heating, and the thickness of coat desired.

It is seen that metal deposited in the present process is not a mere independent film on the surface of a ceramic body, but by reason of the first softening or fusing of the glaze the metal beds into union such that it cannot be scraped or cut off.

As an example. Rod-form glazed ceramic blanks, which may have several spaced circumferential groovings to facilitate ultimate severence into a plurality of finished units, are inserted in the chuck-holders and with wires of 80:20 nickel-chromium positioned in their binding posts, the cover member **2** is set into position, with a gasket, and suitably sealed, and vacuum draw-off is put on, reducing the pressure to about 3×10^{-5} mm. Hg, and electric current is supplied through the wires to the extent of about 5.5 amperes, for the stage of heating and softening the glaze on the ceramic blanks. Then, after making sure of the minimum vacuum, holding it for five minutes more, the current is increased to about 9 amperes, and the vaporization from the nickel-chromium wires proceeds. Meanwhile, the pinions have been rotating the blanks such that they are in constant motion in exposure to the wires. The desired film of metal having been deposited on the surface of the ceramic blanks, the vacuum is released, and the cover member removed, and the coated blanks are taken out of the apparatus.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In resistor manufacture, the steps of simultaneously rotating each of a plurality of glazed ceramic blanks before spaced-around wires of desired metal and supplying current to the wires first sufficient to heat and soften the glaze on the blanks, and then increasing the current to vaporize metal from the wires such as to deposit on the soften glaze, while subjecting all to a vacuum.

2. In resistor manufacture, the steps of simultaneously rotating each of a plurality of glazed ceramic blanks before spaced-around wires of desired metal and supplying current to the wires and heating and softening the glaze on the blanks, and then vaporizing metal from the wires to deposit on the softened glaze, while subjecting to a vacuum.

3. In resistor manufacture, the steps of simultaneously rotating each of a plurality of glazed ceramic blanks before spaced-around wires of desired metal and supplying current to the wires and heating and softening the glaze on the blanks, and then depositing vaporized metal on the softened glaze, while subjecting to a vacuum.

4. In resistor manufacture, the steps of rotating a glazed ceramic blank before spaced-around wires of desired metal and supplying current to the wires, and heating and softening the glaze on the blanks, and then increasing the current and vaporizing metal from the wires to deposit on the softened glaze, while subjecting to a vacuum.

5. In resistor manufacture, the steps of rotating a glazed ceramic blank before spaced-around wires of desired metal and supplying current to the wires, and heating and softening the glaze on the blank, and then vaporizing metal from the wires to deposit on the softened glaze, while subjecting to a vacuum.

6. In resistor manufacture, the steps of rotating a glazed ceramic blank and applying heat thereto to soften the glaze, and then supplying desired vaporized metal to deposit on the softened glaze, while subjecting to a vacuum.

7. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive shaft from outside into the chamber and having a gear, a plurality of pinions about said gear each having an article-holding chuck, a plurality of electric heating wires spaced about each chuck and article therein and held above and below to said plates so as to extend therebetween, an insulation guard-plate between said upper and lower plates and having openings for the wires, means for tensioning the wires including spring-suspension of the upper plate, and current-control means for supplying one current range to the wires for heating blanks in the article-holding chucks and another current range for vaporizing metal of the wires.

8. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive

shaft from outside into the chamber and having a gear, a plurality of pinions about said gear each to carry an article, a plurality of electric heating wires spaced about each chuck and article therein and held above and below to said plates so as to extend therebetween, an insulation guard-plate between said upper and lower plates and having openings for the wires, means for tensioning the wires including spring-suspension of the upper plate, and current-control means for supplying one current range to the wires for heating blanks carried by the pinions and another current range for vaporizing metal of the wires.

9. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive shaft from outside into the chamber and having a gear, a plurality of pinions about said gear, each to carry an article, a plurality of electric heating wires spaced about each article so carried and held above and below to said plates so as to extend therebetween, means for tensioning the wires including spring-suspension of the upper plate, and current-control means for supplying one current range to the wires for heating blanks carried by the pinions and another current range for vaporizing metal of the wires.

10. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive shaft from outside into the chamber driving a pinion for holding an article, a plurality of electric heating wires spaced around such article, the wires being held above and below to said plates so as to extend therebetween, an insulation guard-plate between said upper and lower plates and having openings for said wires, means for tensioning the wires including spring-suspension of the upper plate, and current-control means for supplying one current range to the wires for heating the article carried by said pinion and another current range for vaporizing metal of the wires.

11. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive shaft from outside into the chamber and driving a pinion to rotate an article, a plurality of electric heating elements spaced about the article so carried, said wires being held above and below to said plates so as to extend therebetween, means for tensioning the wires including spring-suspension of the upper plate, and current-control means for heating the wires to vaporization temperature.

12. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive shaft from outside into the chamber and rotating an article, a plurality of electric heating wires spaced about such article adapted to be heated to vaporization temperature, said wires being held above and below to said plates so as to extend therebetween, and means for tensioning the wires including spring-suspension of the upper plate.

13. Apparatus for resistor manufacture comprising a chamber, means for providing vacuum therein, framing in the chamber including lower and upper plates, a drive shaft from outside into the chamber for rotating an article, wire means extending between said lower and upper plates to which such article is exposed, means for heating the wire to vaporization temperature and means for tensioning said wire.

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