Oct. 23, 1934. G. E. MEGOW 1,978,163

METHOD OF MAKING ELECTRICAL RESISTANCE UNITS

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FIG. 1.

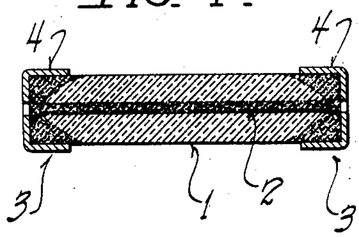


FIG. 2.

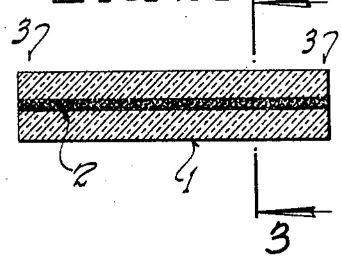


FIG. 3.

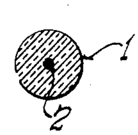


FIG. 4.

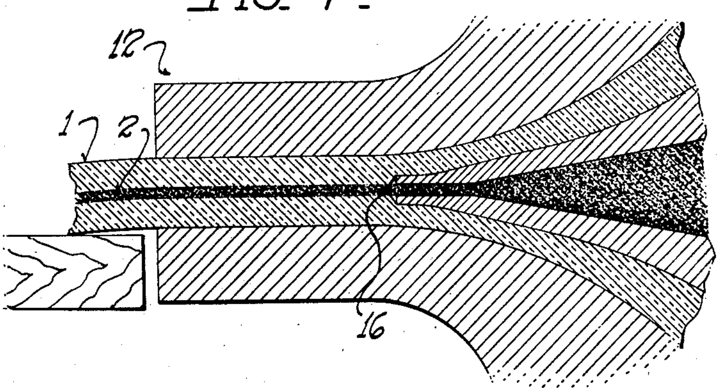


FIG. 11

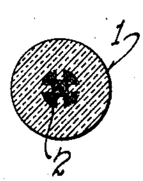
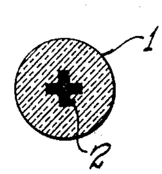


FIG. 12.



INVENTOR

George E. Megow

BY Ira Milton Jones

ATTORNEY

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METHOD OF MAKING ELECTRICAL RESISTANCE UNITS

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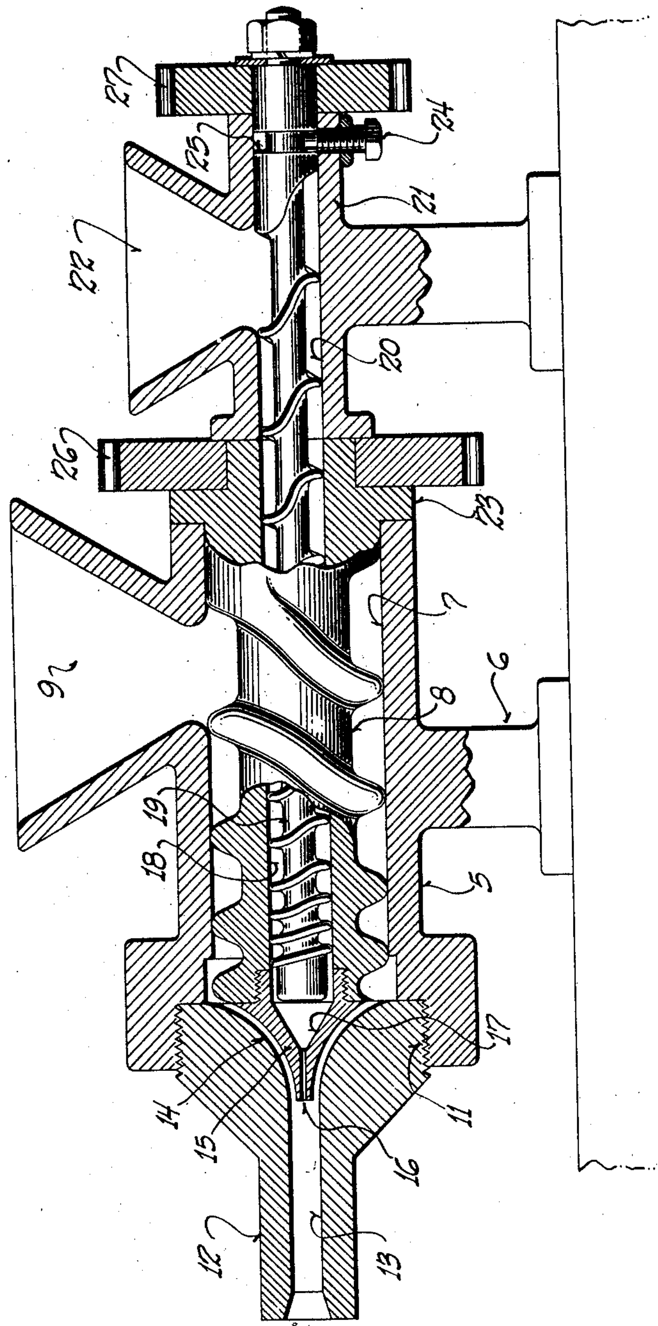
FIG. 5.



INVENTOR

George E. Megow

BY Ira Milton Jones

ATTORNEY

METHOD OF MAKING ELECTRICAL RESISTANCE UNITS

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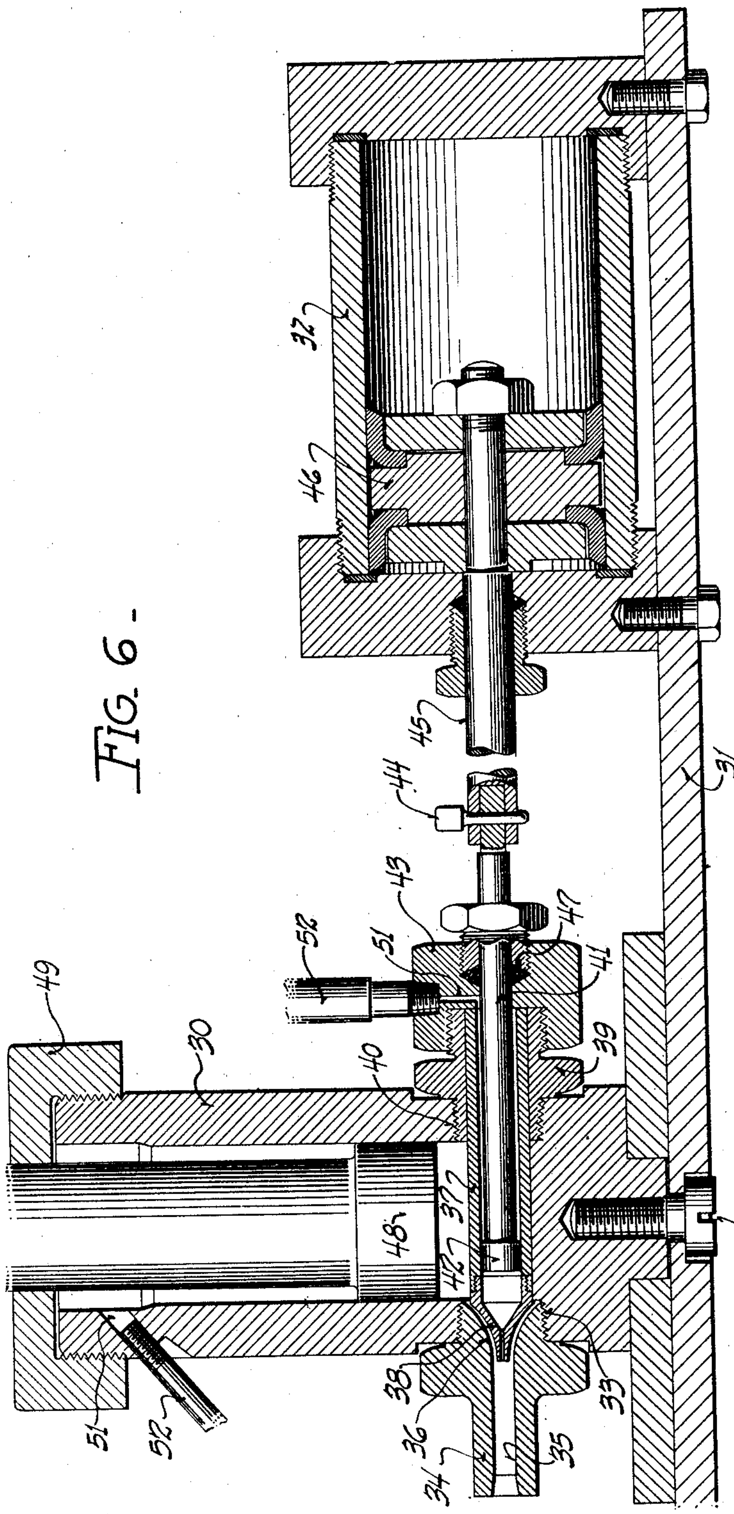
FIG. 6.



INVENTOR
George E. Megow
BY Ira Milton Jones
ATTORNEY

METHOD OF MAKING ELECTRICAL RESISTANCE UNITS

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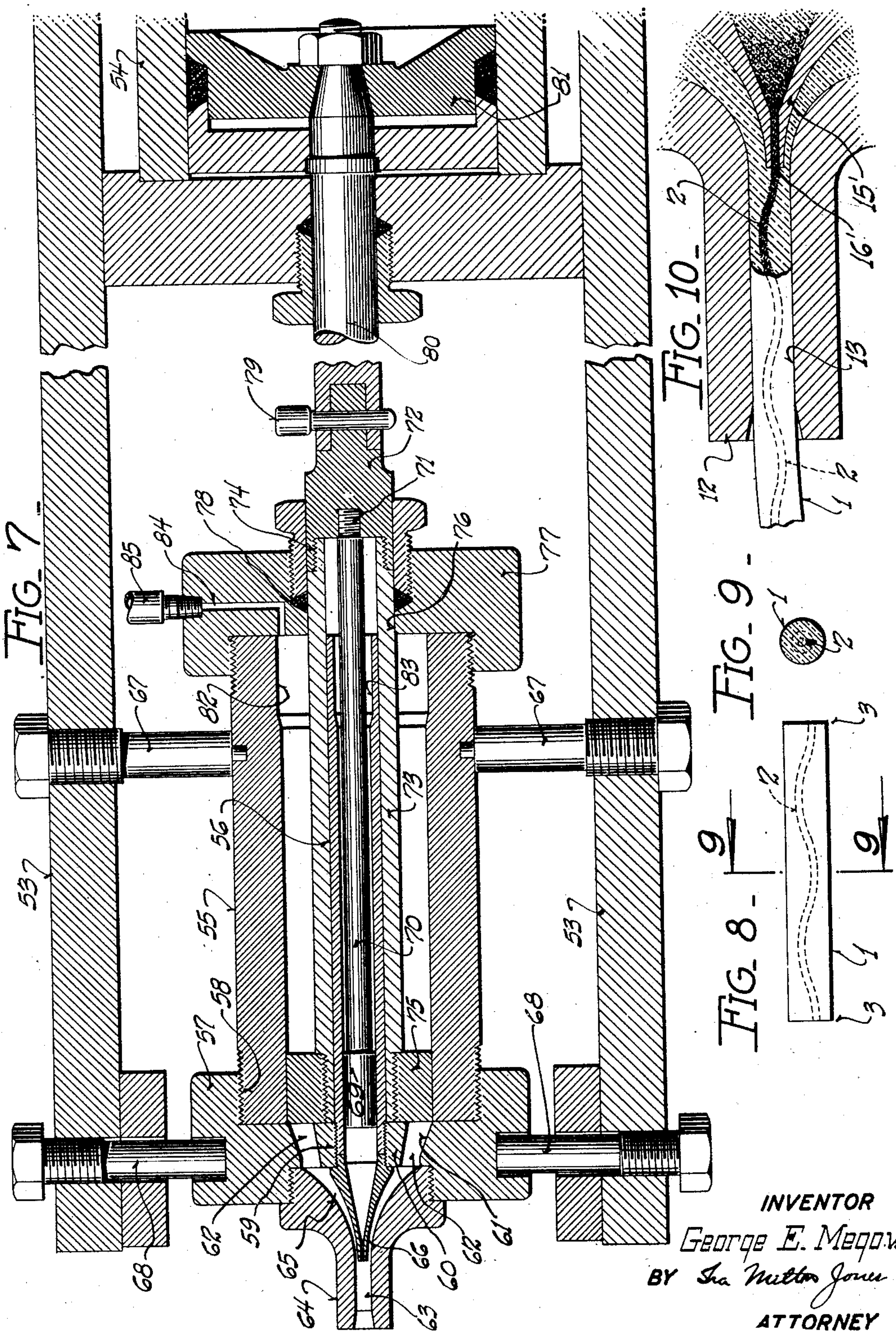

INVENTOR
George E. Megow
BY Ira Milton Jones
ATTORNEY

Patented Oct. 23, 1934

UNITED STATES PATENT OFFICE

1,978,163

METHOD OF MAKING ELECTRICAL RESISTANCE UNITS

George E. Megow, South Milwaukee, Wis., assignor, by mesne assignments, to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

Application September 16, 1931, Serial No. 563,135

10 Claims. (Cl. 18—59)

This invention relates to electrical resistance units and to a method of and apparatus for making the same, and refers more particularly to capacity and inductance free high resistances.

Resistance units of this character are used principally in radio apparatus which necessitates that the units be of unvarying accuracy and stability as to their resistance values.

The present highly competitive nature of this industry has also necessitated every possible reduction in the cost of the units, and the exceptionally wide range of resistance values required, which runs from below one thousand ohms upwardly to over ten million ohms together with a demand for reduced size and increased mechanical strength, has made the production of units having all the necessary qualifications extremely difficult.

To insure absolute stability of the unit, it is essential that the resistance material be protected against contact with moisture. The type of unit which is best adapted to these needs is a ceramic unit of rod shape with the resistance material forming a lengthwise core, but difficulty has been experienced with this type of unit in that the core of resistance material shrinks away from the insulation material surrounding it. This results in an undesirable clearance between the core and the insulation which invariably results in breakage of the core. Obviously such breakage of the core would change the resistance characteristics of the unit and in some instances would result in a dead open circuit. Another objection to even a slight clearance between the resistance material forming the core and the insulating body is that heat conduction from the core of the insulating body is poor.

With these and other objectionable features of the present ceramic type of unit in mind, this invention has as one of its objects to provide a novel method and apparatus for making units of this character wherein a perfect bond is produced between the resistance core and the insulating material surrounding it.

Another object of this invention is to provide simple and effective means for simultaneously extruding the resistance core and the insulation material surrounding it.

With the above and other objects in view which will appear as the description proceeds, the invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

In the accompanying drawings, are illustrated several complete examples of the physical embodiment of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a section view through a completed resistance unit constructed in accordance with this invention;

Figure 2 is a view similar to Figure 1, but illustrating the unit in its condition immediately after extrusion;

Figure 3 is a cross sectional view taken through Figure 2 on the plane of the line 3—3;

Figure 4 is a section through the die head of an extruding machine illustrating the manner in which the materials are extruded to form the units;

Figure 5 is a view partly in side elevation and partly in section of an extruding machine adapted for continuous operation;

Figure 6 is a view partly in side elevation and partly in section of a modified form of extruding machine wherein the resistance core and the insulation body material are extruded by separately operable plungers;

Figure 7 is a view partly in side elevation and partly in section of another modified form of extruding machine;

Figure 8 is a side elevation of a unit constructed in accordance with this invention, but having a helically shaped core;

Figure 9 is a cross sectional view taken through Figure 8 on the plane of the line 9—9;

Figure 10 is a section view through an extruding die head for forming the units shown in Figure 8; and

Figures 11 and 12 are cross section views through resistance units having cores of differently shaped cross section.

The completed unit constructed in accordance with this invention is illustrated in Figure 1 and comprises a body 1 of insulating material having a core 2 of resistance material extending longitudinally therethrough. Both the body 1 and the resistance core 2 are formed of porcelain forming clay or other suitable ceramic material and the resistance core is given the desired degree of conductivity by adding carbon black.

At the ends 3 of the unit, the insulating material contains carbon black which is deposited into its pores in the manner brought out in a copending application of Laurence E. Power, Serial No.

551,608, filed July 18, 1931, to provide low resistance contacts to facilitate the connection of the unit in an electric circuit.

As illustrated in Figure 1 and as more at length defined in the said copending application, the conducting material at the ends 3, contacts with the extremities of the resistance core and metal caps 4 are preferably pressed onto the ends 3 to enable wire leads, not shown, to be soldered thereto so that the connection of the unit in an electric circuit is facilitated.

The manufacture of the unit as illustrated in Figure 1, comprises generally the preparation of two batches of porcelain forming clay, one with a predetermined percentage of carbon black and the other without; the simultaneous extrusion of both materials while still moist into long rods having the material containing carbon black forming a resistance core within the non-conducting material, and cutting the rods to appropriate lengths. After the rods are cut into pieces of the desired length the material is still fairly moist but is sufficiently dry to maintain its shape. The pieces are then dried at approximately room temperature (68 degrees F.) for three or four hours and then baked at a temperature sufficient to increase their porosity. At the completion of this baking period, the ends of the units are immersed in a carbonaceous liquid, which may be a phenol condensation product varnish dissolved in denatured alcohol. This liquid contains a relatively high percentage of fixed carbon which penetrates into the pores of the end portions of the unit.

After having been immersed, the pieces are subjected to a temperature at which the carbon is freed from its carrier and becomes fixed in the porous ends of the structure. The unit is also vitrified during this latter baking to a substantially glass-like hardness. At this stage, the metal caps may be pressed onto the ends of the units.

The method by which the ends of the insulation body surrounding the resistance core are changed into a conductor to provide contacts, as stated forms the subject matter of the copending application, Serial No. 551,608, filed July 18, 1931, whereas this invention deals with the simultaneous extrusion of the resistance material and the insulating material into the rods from which the finished units are cut, and the preparation of the materials so as to obtain a close union between the resistance core and the insulation body surrounding it.

Several methods have been developed for insuring the desired intimacy of contact between the core and its insulating body. In each instance a difference in shrinkage between the resistance core and the insulation material surrounding it is obtained, with the insulating material shrinking more in volume than the resistance core so that during the baking processes the core is securely gripped by the insulating shell surrounding it.

One method of obtaining the desired difference in shrinkage of the materials consists in dividing the porcelain forming clay which has the desired amount of carbon black mixed with it and of which the resistance core is formed, into two batches of 70% and 30% by weight. The larger portion is calcined at approximately 2200 degrees F., a point on the low range of vitrification. This calcining reduces the shrinkage of the material. After being calcined, it is ground and mixed with the uncalcined material which is the batch of 30% by weight.

The porcelain forming clay of which the insulating body is formed is not calcined, and hence after both materials are extruded in the manner illustrated in Figure 4, the greater shrinkage of the insulating material during baking binds the resistance core and thus insures intimate contact between the two materials.

All of the material of which the resistance core is formed is not calcined, so that the uncalcined portion provides a moist carrier for the dry calcined portion.

A difference in shrinkage may be also obtained by selecting a material for the resistance core which vitrifies at a higher temperature than the material of the insulation body. To this end the material for the insulating body contains approximately 2% by weight of sodium or potassium oxides whereas the resistance core is formed of porcelain forming clay to which is added carbon black in the percentage required for the resistance desired. During the firing processes, the insulating body vitrifies before the core and thus shrinks more than the resistance core.

Another method of obtaining a difference in shrinkage to insure intimacy of contact between the core and the surrounding body of insulating material, consists in reducing the material for the insulating body to a finer degree of sub-division than the material for the resistance core. Both materials are a porcelain forming clay with the resistance material containing a percentage of carbon black, and it has been found that this material in different degrees of subdivision has different rates of shrinkage. Hence, during the firing, the insulating body being in a finer state of sub-division, shrinks to a greater degree.

Intimacy of contact between the core and the insulating material surrounding it, also results from the specific construction of the extruding die. The shape of the extruding die, see Figure 4, is such that the materials forced therefrom are compressed to a substantial degree so that any voids or clearance between the core and the insulating shell is impossible.

In some instances it has been found desirable to have the resistance material in a moist or semi-fluid state during the extrusion. Compression of the materials at the point of extrusion is thus impossible. In this case the extruded rods are allowed to dry for a predetermined period of time and with the insulating material still in a plastic state, the rods are compressed in a compression die or any other suitable mechanism.

The simultaneous extrusion of the materials may be obtained in several different ways, and in Figures 5, 6 and 7 three types of extruding machines which are particularly well adapted for this purpose, are illustrated and reference is now specifically directed to these figures of the drawings.

Referring to the machine illustrated in Figure 5, which is the preferred embodiment in that it permits continuous extrusion, the numeral 5 represents a cylinder supported by a foot 6. In the bore 7 of the cylinder is a tubular conveyer screw 8 and a material receiving hopper 9 communicates with the upper portion of the cylinder 5 to receive the material, of which the insulating shell of the units is to be formed.

The forward end 10 of the cylinder is counterbored and internally threaded, as at 11, to mount a member 12. This member 12 has a central bore 13 which is straight for the major portion of its length and flares outwardly, at 14, at its inner end to substantially the diameter of the cylinder bore 7. The bore 13 with its flared inner end thus forms a continuation of the cylinder bore 7 and the screw conveyer 8 which is rotatable in the bore 7, is arranged to force the material, deposited in the hopper 9, outwardly through the bore 13.

Mounted at the front end of the conveyer screw 8 is a nozzle-like member 15 whose outer surface is shaped to lie parallel with the adjacent portion of the flared inner end 14 of the bore 13. The space between the member 15 and the flared bore 14 permits the passage of material brought forward by the conveyer screw 8 into the opening 13.

The outer end of the member 15 extends to the juncture of the flared bore 14 with the straight bore 13 and has a small central bore 16 extending therethrough. The inner end of the bore 16 is taperingly enlarged, as at 17, to the diameter of a bore 18 extending axially through the screw conveyer 8.

Mounted within the bore 18 is a second spiral screw conveyer 19 which extends outwardly beyond the inner end of the screw 8 into a bore 20 which is a continuation of the bore 18 and is formed in a supporting member 21. The upper end of the supporting member 21 has a hopper 22 for the reception of the material which is to form the core of the finished units.

Upon rotation of both screw conveyers 8 and 19, the respective materials conveyed thereby are forced forwardly to the die head which comprises the members 12 and 15, and is forcibly extruded therethrough as best illustrated in Figure 4, to form a continuous rod having a core of resistance material surrounded by a body of insulating material. Any suitable support may be provided for the rod as it issues from the die head, and after the desired length has been extruded it is cut off and removed.

The screw conveyer 8 is held against longitudinal movement in the bore 7 by a flange 23 formed on its inner end which engages the adjacent end of the cylinder 5, and by having its extreme inner end abutting the supporting member 21. The internal screw conveyer 19 is held against longitudinal movement in its bore by a screw 24 threaded in the supporting member 21 and projecting into the bore 20 to engage its inner end in an annular groove 25 formed in the adjacent portion of the screw shaft.

The screws 8 and 19 are rotated in opposite directions and driving force is imparted thereto through gears 26 and 27 fixed to the screws 8 and 19, respectively, the gear 26 for the outer screw being confined between the flange 23 and the adjacent end of the supporting member 21 and the gear 27 being fixed to the end of the screw conveyer 19 outwardly of the supporting member 21.

By forcing the material through the die head by means of screw conveyers, the materials are compacted and air pockets are prevented inasmuch as the solids are carried forward by the action of the screws and air and other gases have ready egress through the hoppers 9 and 22.

The important advantage of this type of extruding machine, however, is that it enables continuous extrusion and the die head, which consists of the members 12 and 15 is readily detachable so that any one machine may be readily adapted to the extrusion of units of different diameters, it being necessary only to apply the proper die head.

In Figure 6 is illustrated a modified form of extruding machine. In this construction, an upright cylinder 30 is mounted on a bed plate 31 upon which a hydraulic cylinder 32 is also mounted at a distance from the upright cylinder 30. Adjacent the bottom of the cylinder 30 is a threaded opening 33 to receive the threaded plug of a member 34 which corresponds to the member 12 in the construction illustrated in Figure 5 and forms part of the extruding die head. As in the structure shown in Figure 5, the member 34 has a longitudinal opening 35 whose inner end flares outwardly, as at 36, to communicate with the interior of the cylinder 30.

Mounted in axial alignment with the member 34 is a horizontal cylinder 37 of relatively small diameter and which extends transversely across the bottom of the cylinder 30 to mount a nozzle member 38 which corresponds to the member 14 in the structure of Figure 5, and extends into the opening 35 in the member 34, and with the member 34 forms the complete extruding die head.

The transverse cylinder 37 is fixed in a nipple 39 threaded in an opening 40 formed in the wall of the cylinder 30 opposite the threaded opening 33. Slidably received within the cylinder 37 is a plunger 41 whose inner end 42 has a snug fit in the bore of the cylinder and whose outer end projects through a head 43 threaded on the nipple 39 to be detachably connected, as at 44, with the ram 45 of a piston 46 operating in the hydraulic cylinder 32.

A packing gland 47 provides a tight seal between the head 43 and the plunger 41. The hydraulic cylinder 32 is of conventional construction and has means, not shown, for admitting a suitable fluid under pressure on either side of the piston 46 so as to enable the piston 46 and consequently the plunger 41 actuated thereby, to be moved in either direction.

Operating in the cylinder 30 in a manner similar to the plunger 41 is a piston or plunger 48 whose outer end passes through a head 49 similar to the head 43 to be operated by a hydraulic ram, not shown, in the manner in which the plunger 41 is operated.

To load the cylinder 37 with resistance material to be extruded as the core of the units, the connection 44 between the plunger 41 and the ram 45 is disconnected and the entire cylinder 30 with its structure assembled thereon is swung about the axis of the cylinder 30 to enable the plunger 41 to be removed. The rotation of the cylinder 30 about its axis is made possible by the rotatable mounting 50. Any suitable means, not shown, may be provided for moving the driving mechanism of the plunger 48 out of line therewith to enable complete removal of the plunger from the cylinder 30 and the depositing of the material to form the insulating shell, therein.

In this form of the invention, means are provided for positively withdrawing any air in the cylinders in which the plastic material is received and to this end, both the head 43 and the head 49 have ports 51 leading to the interior of the cylinders 37 and 30, respectively, and the outer ends of these ports have tubes 52 leading therefrom for connection with any suitable mechanism for producing a vacuum. The means for creating the vacuum within the cylinders through the tubes 52 and the ports 51, is set in operation before the plungers begin their compressing strokes so that the possibility of air pockets in the materials is entirely eliminated.

The extruding machine illustrated in Figure 7 is similar to that just described in that the extrusion of materials is from cylinders having plungers operating therein and actuated from hydraulic rams. This structure differs, however, from that shown in Figure 6 in that both cylinders are axially aligned and that both their plungers are actuated from a single source.

The supporting structure of this form of extruding machine consists of two side plates 53 between one end of which a hydraulic cylinder 54 is mounted. Positioned between the other or outer ends of the side plates 53 are two axially aligned telescoped cylinders 55 and 56. The outer ends of both cylinders are fixed to a head 57, the outer cylinder 55 by being threaded, as at 58, in a counterbore formed in the head, and the inner cylinder 56 by being threaded, as at 59, in a hub 60 spaced from the inner walls of a bore 61 in the head, by spider arms 62.

The space in the bore 61 between the arms 62 and the hub 60 is communicated with the interior of the outer cylinder 55 and with the longitudinal bore 63 in a nozzle member 64 forming part of the die head. This member 64 is similar to the member 12 of the structure shown in Figure 5, and to the member 34 of the structure shown in Figure 6, and likewise has the inner end of its bore flaringly enlarged, as at 65. An inner nozzle member 66 which cooperates with the member 64 to complete the die head, is secured in the hub 60 outwardly of the inner cylinder 56 and has its tapered bore forming a continuation of the inner cylinder.

The cylinders 55 and 56 are supported from the side plates 53 by pivot pins or screws 67, secured in the side plates and having their ends projected into diametrically opposite openings formed in the outer wall of the cylinder 55. The cylinders 55 and 56 are thus pivotally mounted for swinging movement about the axis of the pins 67 for a purpose to be later described, and to hold the cylinders in proper axial alignment with the hydraulic cylinder 54, a second pair of removable screws or pins 68 is detachably secured in the plates 53 to project into openings formed in the head 57.

Sliding in the bore of the cylinder 56 is a plunger 69 whose stem 70 is connected, as at 71, with a member 72 to which a sleeve 73 is also secured, as at 74. The opposite end of the sleeve 73 is secured to a ring 75 which fills the space between the outer wall of the inner cylinder and the bore of the outer cylinder 55 to form a piston for the cylinder 55. This sleeve 73 passes through an opening 76 in a head 77 detachably secured to the cylinder 55 and a suitable packing gland 78 is provided to afford a tight seal between the sleeve 73 and the bore 76 in the head.

The member 72 has a detachable connection 79 with the ram 80 of the hydraulic cylinder 54 and as in the construction shown in Figure 6, the cylinder 54 is provided with means, not shown, for conducting fluid under pressure to either side of the piston 81 operating therein so as to enable the ram 80 and consequently the plungers 69 and 73 to be moved in either direction.

It is observed that the bore of both inner and outer cylinders is relieved, as at 82 and 83, respectively, at the ends of the cylinders adjacent the head 77 so that when the plungers 69 and 73 are fully withdrawn an air space is afforded past the plungers. The space past the outer plunger 83 enables communication between the interior of the cylinder 55 and a port 84 which is connected through a tube 85 with a suitable means for effecting a vacuum, not shown, and by reason of the communication of the bore in the cylinder 56 through the bore in member 66, with the interior of the cylinder 55, so that air pockets in the material to be extruded may be effectively eliminated. The open end of the bore 63 in the member 66 is preferably closed by some suitable plug, not shown, during the process of withdrawing the air from the material.

The pivotal mounting afforded by the pins 67 enables the cylinders to be swung out of alignment with the ram 80 upon removal of the connection 79 to enable the head 77 and the plungers 69 and 73 to be removed from the cylinders to facilitate loading of both cylinders with their respective materials. In this type of machine it is essential that the areas of the plunger heads be proportioned correctly so that the materials are extruded at the proper rates of volume.

Again referring to the extruding machine disclosed in Figure 5, it is observed that the opposite rotation of the screw conveyers which force the materials forwardly to be extruded, causes the materials to rotate with respect to each other. This relative rotation on the part of the materials as they pass through the extruding die head may be utilized to produce a unit in which the resistance core is of helical shape so as to increase its length without increasing the overall length of the unit.

A unit having a helically shaped resistance core is illustrated in Figures 8 and 9, and in Figure 10 is illustrated the manner in which the relative rotation of the materials as they pass through the extruding die head is utilized to form the helical core. As clearly shown in Figure 10, the member 15 which is carried at the outer end of the screw conveyer 8 is replaced by a member 15′ which is in all respects similar to the member 15 except that its outer end and its opening 16′ is off center. Thus as the screw conveyers rotate the outer end of the member 15′ and the bore 16′ rotate in a circle about the axis of the bore 13.

If great contact area is desired between the core and the insulation material surrounding it, the opening in the inner member of the extruding die head may be of irregular shape and in Figures 11 and 12, two different cross sectional shapes of cores are illustrated, each of which increases the contact area between the core and the insulation material.

From the foregoing description taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art to which an invention of the character described appertains, that the herein described method of forming electrical resistance units enables the production of a ceramic type unit in which a core of resistance material is embedded in a rod-like body of insulating material in a practical and economical manner, and that by reason of the difference in shrinkage between the materials forming the core and the insulation surrounding the core, a perfect bond is secured between the core and its enclosure.

What I claim as my invention is:

1. The method of making an electrical resistor element which includes embedding a vitrifiable material containing a conductor and a portion of which material has been calcined to decrease the shrinkage thereof, into a vitrifiable insulating material, and firing the formed materials to vitrify the whole and cause the encasing envelope to compress the inner core.

2. The method of making an electrical resistor element which includes embedding a vitrifiable material containing a conductor into an insulat-

ing material which vitrifies at a lower temperature than the first material, and firing the formed materials at a temperature to vitrify the first material.

3. The method of making an electrical resistor element which includes embedding a vitrifiable material containing a conductor into a vitrifiable material which is in a state of greater sub-division than the first material and firing the formed materials to a state of vitrification.

4. The hereindescribed method of making an electrical resistor element which comprises simultaneously extruding an insulating material and a resistance material with the resistance material forming a core embedded in the insulating material, the insulating material having a higher degree of shrinkage upon subjection to heat than the resistance material, and in vitrifying the extruded materials to cause the insulating material to compress the core of resistance material.

5. The hereindescribed method of forming an electrical resistance element which comprises preparing two batches of porcelain forming clay, one with a percentage of conducting material to form a resistance material, and the other without, in treating one batch of materials so that the resistance material has a lesser degree of shrinkage upon subjection to heat than the other material, in simultaneously extruding the materials with the resistance material forming a core within the insulating material, and in subjecting the extruded materials to a vitrifying temperature whereby the greater degree of shrinkage of the insulating material insures intimate contact between the resistance core and the insulating material.

6. The method of making an electrical resistance unit which includes simultaneously extruding an insulating material and a resistance material through eccentrically disposed discharge ports one within the other to form a body of insulating material having a core of resistance material, and revolving one of the discharge ports about the axis of the other so that the resistance core is given a helical shape.

7. The hereindescribed method of making an electrical resistor element which comprises extruding an insulating material and a resistance material with the resistance material forming a core embedded in the insulating material, said materials having different degrees of shrinkage upon subjection to heat with the insulating material having a higher degree of shrinkage, and in vitrifying the extruded materials to cause the insulating material to compress the core of resistance material.

8. The method of making an electrical resistor element which comprises, treating a mixture of vitrifiable material and conducting material to render the same plastic, calcining a portion of said treated mixture to minimize its possible shrinkage upon subjection to heat, remixing the calcined portion with the uncalcined portion of said mixture to provide a core forming batch of material, preparing another batch of plastic vitrifiable insulating material which contains no conducting material, embedding a quantity of material from said first batch in a shell formed of material from said second batch to form a body of the desired size and shape, and firing the formed body to a state of vitrification, the lesser possible shrinkage of the core causing the shell to compress the core during vitrification.

9. The hereindescribed method of making an electrical resistor element which comprises mixing a quantity of a plastic vitrifiable material with a predetermined quantity of conducting material to provide a core forming batch, mixing a fluxing agent with a quantity of the same plastic vitrifiable material to provide a shell forming batch which, by reason of its content of fluxing agent, vitrifies and contracts at a lower temperature than the core forming batch, extruding said materials simultaneously to form a body having a core composed of material from the first mentioned batch and an insulating shell composed of material from the second mentioned batch, and firing the formed body to vitrify the same throughout its entire internal structure so that the insulating shell contracting in advance of any contraction of the core shrinks onto and compresses the core.

10. The hereindescribed method of making an electrical resistor element, which comprises preparing two batches of plastic vitrifiable material, one with a conducting material therein, and the other without, reducing the material of the second designated batch to a finer state of sub-division than that of the other batch, embedding a quantity of material from said first designated batch in a quantity of material from said second designated batch to form a body having a resistance core and an insulating shell, and firing said formed body to a state of vitrification during which the insulating shell shrinks onto the core.

GEORGE E. MEGOW.