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METHOD OF MASS PRODUCING RESISTORS

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Fig. 1



Fig. 2

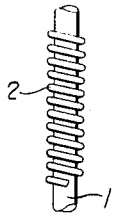


Fig. 3

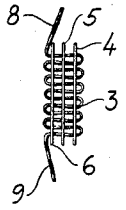


Fig. 4

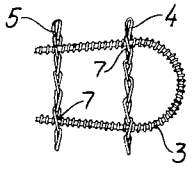


Fig. 5

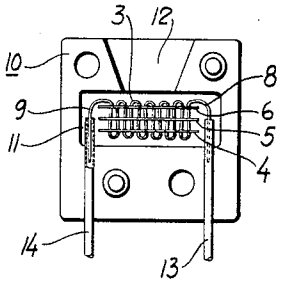


Fig. 6

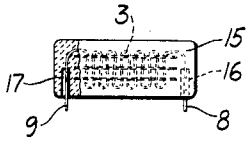


Fig. 7

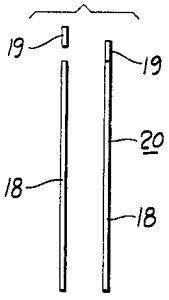
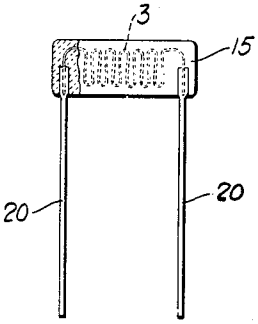


Fig. 8

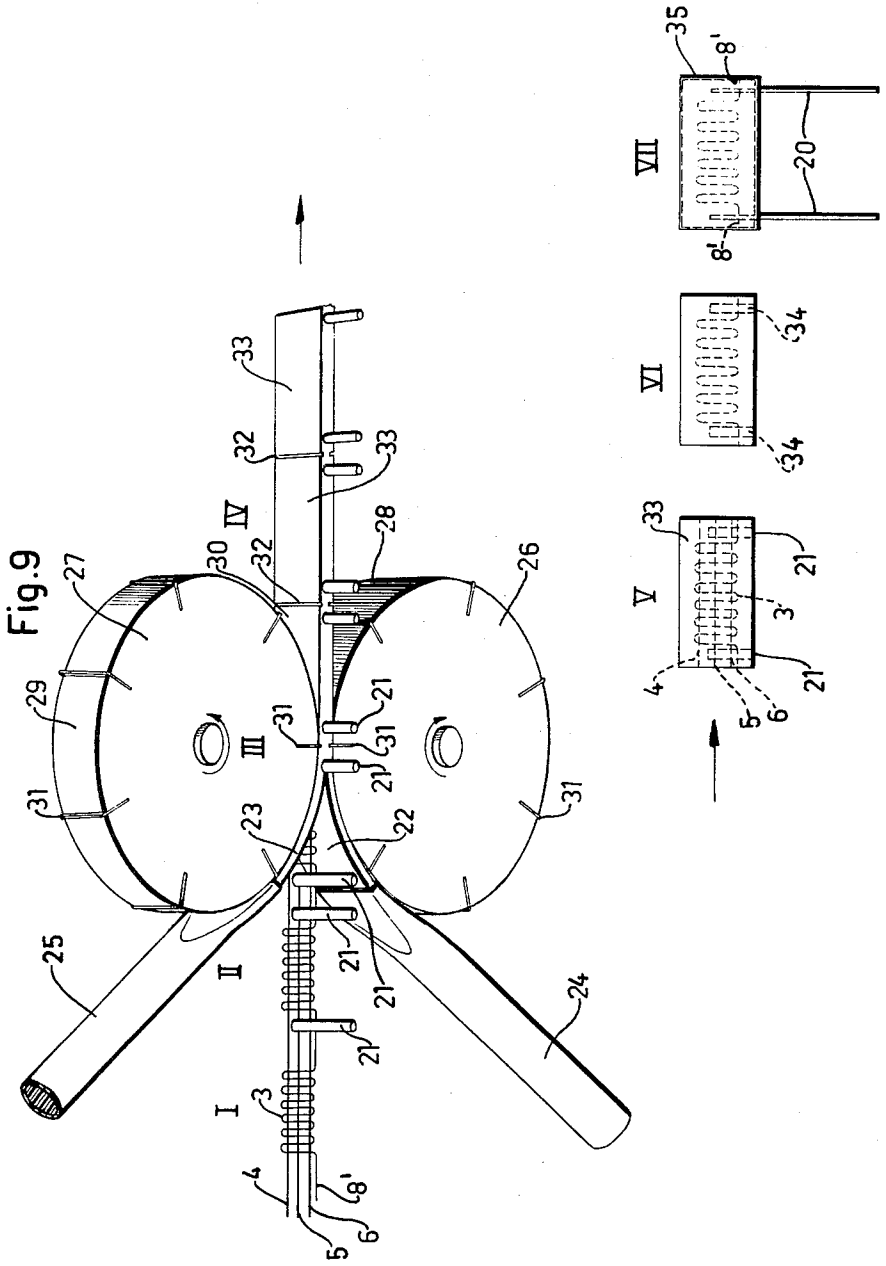


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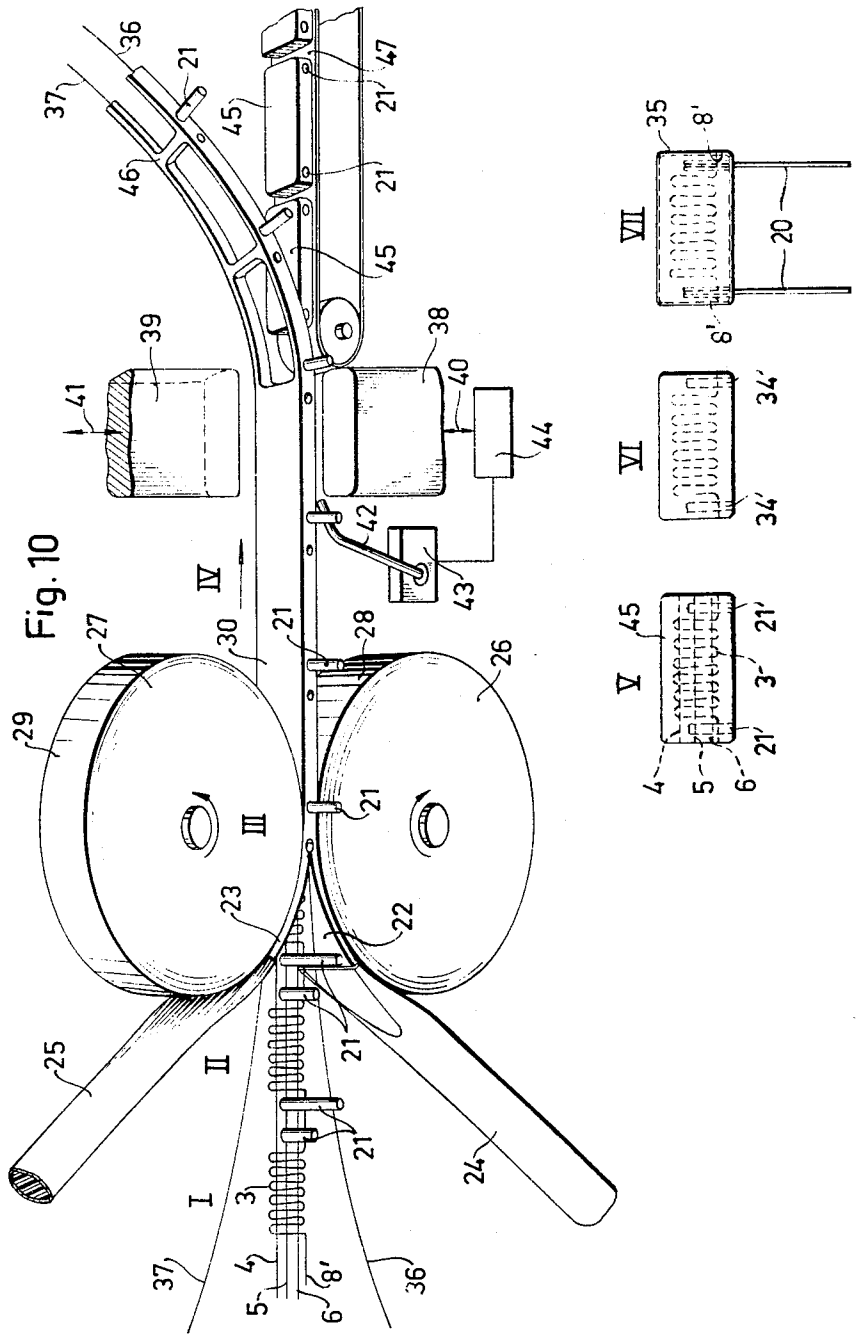
Fig.9



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Fig. 11

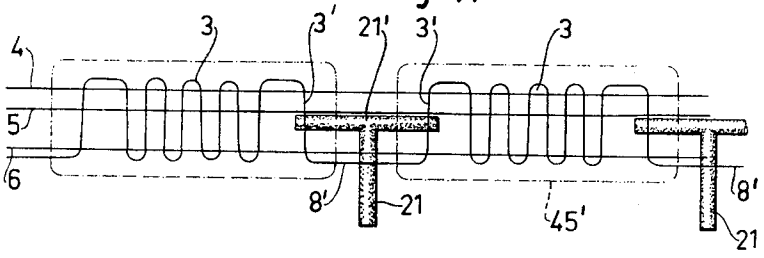


Fig. 12

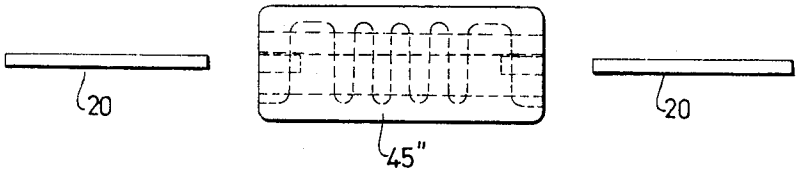


Fig. 13

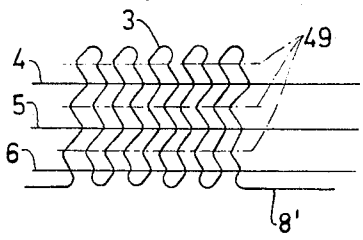


Fig. 14

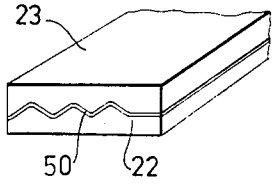
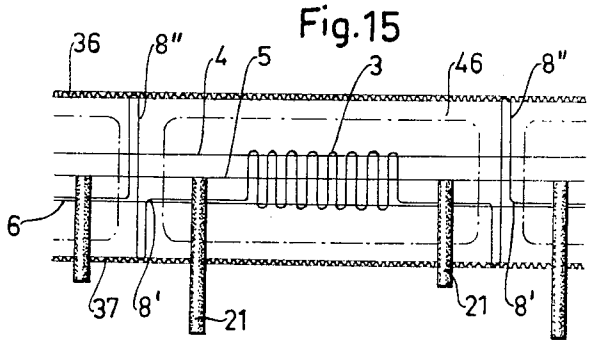


Fig. 15



United States Patent Office

3,221,397

Patented Dec. 7, 1965

3,221,397

METHOD OF MASS PRODUCING RESISTORS

Carl Otto Areskoug, Vimmerby, Sweden, assignor to Aktiebolaget Installationsmateriel, Vimmerby, Sweden, a corporation of Sweden

Filed Feb. 14, 1962, Ser. No. 173,210
Claims priority, application, Sweden, Mar. 29, 1961, 3,358/61
8 Claims. (Cl. 29—155.63)

It is known hitherto in the production of resistance elements intended to be embedded into ceramic insulating pastes to weave the resistance wire in the form of shoots into some suitable warp wire material to fix the resistance wire parts in their mutual positions. During the burning of the ceramic material combustion of the woven warp wire material generally takes place, so that only the resistance wire remains in the ceramic material. This method has some drawbacks in practice, however, in the form in which it has been applied hitherto. The ceramic paste frequently penetrates with difficulty into the spaces between the resistance wire parts to fill them by reason of the texture formed by the other warp wires carrying the resistance wire. Thus the resistance wire parts will not be accurately fixed in the ceramic paste after the supporting warp wires have been burned. By reason of the fact that a comparatively large quantity of material is burnt, non-desirable spaces will also be produced, which mechanically weaken the finished element and involve an irregular heat transfer from the other parts of the wire. In the weaving procedure of the resistance wire it is also very difficult to avoid parts of adjacent resistance wires from coming near one another, which after the burning procedure may cause short circuits between said parts. The present invention has for its object, inter alia, to avoid these disadvantages, and is based on a method of arranging a filamentary material formed into strings and comprising one or more meshes, wherein bends of a resistance wire are arranged transversely to the longitudinal direction of the strings and are separated from each other at various points thereof.

The present invention is principally distinguished by the feature that the bends of the resistance wire are arranged in groups along the strings, said groups being preferably enclosed together with the strings within a ceramic paste, whereupon the strings between said groups are severed and the ceramic paste, is fired and the element is provided with connecting means. In embedding the element a very close contact between the resistance wire and the material adapted to receive the element will be obtained through the arrangement of resistance wire and strings according to the method set forth, inasmuch as the resistance wire extends substantially as a self-supporting structure between the strings. The resistance wire may be said to be substantially self-supporting by the fact that it is carried by the warp wires only at few points along the length thereof. This, however, calls for a certain stiffness of the resistance wire in practice. This stiffness is ensured by the fact that the resistance wire, which is frequently of a small dimension and flexible, is wound about a textile thread, in connection with which in addition to an increased stiffness a great length of resistance wire will also be obtained within a restricted space, a free heat expansion of the spiral-shaped resistance wire placed within the fired porcelain being also attained (with the textile core thread burnt away). The method according to the invention is also exceedingly well suited for duplicate production, and the present invention therefore also refers to means for duplicate production of resistance elements preferably embedded into a ceramic material. Here, the ceramic paste is preferably applied continuously in strings about the elements.

The invention will be explained more closely with reference to the accompanying drawings, which illustrate an example of embodiment of the invention. FIG. 1 shows the core of a resistance wire, and FIG. 2 illustrates on a larger scale the way in which a resistance wire is wound onto said core wire. FIG. 3 shows the arrangement of the resistance wire spiral in strings formed with meshes, and FIG. 4 shows a portion of the arrangement according to FIG. 3 on a larger scale. FIG. 5 shows the arrangement of the element in a casting mould, and FIG. 6 shows the cast element when finished. FIG. 7 shows a connecting wire, and FIG. 8 shows the attachment thereof in the arrangement according to FIG. 6. FIG. 9 shows a further example of embodiment of the invention in different steps I–VII of the production, and FIG. 10 shows a modification of the last-mentioned form of embodiment. FIGS. 11 and 12 show an element according to the invention with connecting wires on the short sides thereof. FIGS. 13 and 14 show a construction for the accommodation of the largest possible quantity of resistance wire within a restricted space. FIG. 15 shows an arrangement of the resistance wire suitable in connection with a construction according to FIG. 10.

The method according to the invention, and hereinafter explained, includes forming cavities in the resistors for connection of leads thereto by using fugitive elements that are embedded in ceramic at least partially axially and caused to emigrate from the individual ressitors. For example, the cavity-forming elements may be made of a meltable material so that the resistors can be fired and the cavity-forming elements melted out or burned out so that cavities remain for connecting leads therethrough to the resistors. Moreover, in one embodiment of the invention the fugituve elements are removable tubes which are removed from the resistors after casting them in molds thereby to define the cavities.

To produce resistors according to the invention, the following method is employed.

As a starting material a thin core thread **1** of nylon, silk or the like is made use of, as shown in FIG. 1. A resistance wire **2** is wound spirally about the thread **1** in a manner such that the thread layers lie separated mutually, see FIG. 2. After that, three strings **4**, **5**, **6** consisting of thread meshes are produced by tying of nylon thread or the like. During this procedure the resistance wire spiral is arranged in reverse bends **3** extending to and fro, as will appear from FIG. 3, which bends are tied into the strings. In connection with high resistance values of the finished resistance element it will be found desirable to use a spiral winding as close as possible and also to use as many loops as possible. FIG. 3 may be said to illustrate this case. On the other hand, if low resistance values are called for, only one bend is provided, if desired, or, a very sparse spiral might be used, which extends almost in parallel to the warp wires, or in extreme cases an entirely straight sparse spiral without warp wires is made use of. FIG. 4 clearly illustrates the manner in which the bends **3** are tied and kept separated in their places by means of meshes or loops **7** longitudinally spaced in the strings. The various bends consequently cannot come into contact with one another to cause short circuits mutually. In practice, the strings are produced in paths, the resistance spiral being arranged in groups of bends along said paths, which form the resistance element intended. In FIGS. 3–8, only one such group is shown, wherein the resistance wire between the parts will extend substantially in parallel to the strings. Such bands carrying resistance elements will be treated more closely in connection with FIGS. 9–14. The resistance spiral is severed into portions between the groups so that two connecting parts **8**, **9** are formed.

The resistance unit thus formed inserted into a casting mould, as will appear from FIG. 3, is only one half of which is shown in FIG. 5. The strings are shown severed, although in series production they may be permitted to extend through grooves in the lateral walls of the mould halves to adjacent groups of resistance elements together with casing moulds pertaining thereto. The casting moulds are here arranged in succession after one another, and after the finishing of the casting of the respective elements the latter will cohere by the strings and the resistance wire.

Severing of the strings at each element here becomes a necessity. The mould is provided with a casting chamber **11**, into which the resistance unit is inserted, and with a casing paste inlet **12** leading to the same. Each connecting part **8**, **9** of the resistance unit is thrust into a tube **13**, **14**, respectively, the ends of said tubes projecting into the casting chamber **11**. The internal diameter of the tubes substantially equals the diameter of the wire parts **8**, **9**. The tubes **13**, **14** serve to produce a cavity about the connecting parts **8**, **9** in the casting object intended to secure outer connecting wires. After casting paste has been filled into the casting chamber **11** and the paste has solidified, a cast object **15** is obtained, as will appear from FIG. 6, the tubes **13**, **14** being pulled loose from the object **15** after the casting procedure. Here, the connecting parts **8**, **9** will depend through the cavities **16**, **17** formed by the tubes **13**, **14**, and in this case they will protrude somewhat through the mouths thereof. The element body thus produced is then heated to a temperature of approximately 800–1100 degrees centigrade, at which the ceramic paste is fired. During this process the strings **4**, **5** and **6** and the core **1** of the resistance spiral will be combusted, so that the resistance wire is burnt to stick to the ceramic material.

The elemental body is now ready for applying of connecting wires. As will appear from FIG. 7, such connecting wires may be produced of two rods, the one **18** of copper and the other **19** of silver solder or the like. These rods are welded together end to end, as will appear from the right hand portion of FIG. 7, so as to form a single rod generally denoted by **20**. Other ways of arranging the silver solder at the rod are of course conceivable within the scope of the invention. Two such rods **20** are thrust each into a recess **16**, **17** in contact with the connecting parts **8**, **9** of the element. The structure is then subjected to heating to a temperature of about 400–600 degrees centigrade, at which said silver solder **19** melts and fuses onto the connecting parts **8**, **9**. A very good electrical contact and mechanical strength in the connection between resistance wire and copper rods will be obtained by the fact that the connecting ends thereof are surrounded entirely by the solder in the casting operation. After the manufacturing process a resistance element is obtained such as will appear from FIG. 8.

In an element according to the invention, the casting material may penetrate freely between the bends **3** of the resistance element, whereby said bends will be fixed securely in their positions and are consequently prevented from coming mutually into contact with one another during casting and drying. This condition remains also after the burning of the strings **4**, **5** and **6**, which is one of the essential advantages of the present invention. The quantity of burnt material in the finished element will be extremely small. The cavities after the burnt strings likewise become very small, whereby the element becomes mechanically strong.

In connection with the use of strings **4**, **5**, **6** in paths, as stated, it is frequently suitable not to sever the resistance wire portions extending between the elements prior to the casting procedure. In the latter case the tubes **13**, **14** may be replaced by rods to provide the apertures **16**, **17**, the connecting wires **8**, **9** not then hanging down through said apertures but extending for instance transversely over the respective cavities.

In connection with the manufacture of resistance elements of said kind, mould pressing with pulverous porcelain paste with a suitably adapted moisture content may also be brought into consideration.

The method shown in FIG. 9 refers to a more continuously passing manufacture of resistance elements, which is particularly suitable in an extended duplicate production with the use of elements sticking together in bands, as stated above. The figure is divided into different manufacturing steps numbered I–VII.

Step I shows a band of resistance elements substantially in accordance with the representation of FIG. 3. The strings **4**, **5**, **6** are common to all elemental sections. The spirally wound resistance wire is carried essentially straight along the string **6** of a portion **8'** between all consecutive elemental sections. The whole band is taken to be fed continuously toward the right in the drawing.

The manufacturing step II consists in that a rod **21** of wax, plastic or similar material, which is easily fusible and easy to burn away, is applied transversely over the portions **8'**, the strings **5** and **6** and on each side of every elemental section, a portion of each rod then projecting outside the band. The arranging of said rods may preferably take place by two wax rods being applied on each side of the strings **5**, **6** and the resistance wire loop **8'**, whereupon the wax rods are pressed together into one rod symmetrically about the wire loop **8'** by means of a moulding tool. These wax rods **21** serve for the same purpose as the tubes **13**, **14** in FIG. 5, that is to say, in making cavities **16**, **17** in the product completed for the securing of the external connecting wires **20**, the respective resistance wire portions then extending diametrically through the respective cavities.

In the manufacturing step III, the elemental band, which is preferably impregnated with a solution of ceramic paste, is introduced between two strings **22**, **23** of ceramic material in a plastic state. These strings are mould-pressed from nozzles **24**, **25** in the feeding direction of the elemental band, and are pressed together about the elemental band between the peripheral surfaces **28**, **29** of two synchronously coupled rollers **26**, **27** to form a material tape **30**. Knife-like members **31** are radially arranged at these surfaces, the same projecting from the respective surfaces **28**, **29** to an extent such that when two members face one another these members project into the material string **30** in a manner to form a rupture or division indentation **32**. The arranging of wax rods **21** and the feeding of the elemental band between the rollers **26**, **27** are suitably synchronized with the rollers so that two opposite members **31** will always press into the material string **30** between two adjacent wax rods **21**, that is to say, in the middle of the portion **8'** of the resistance wire between all consecutive elements.

After the band has passed in between the rollers **26**, **27** and the two material strings **22**, **23** have been pressed together about the band and the wax rods **21**, a material string **30** will be obtained, as stated, where each elemental body **33** intended is defined between adjacent rupture or division indentations **32**. This will be clearly seen under IV. Before any further processing is undertaken, the ceramic paste is left to solidify. After that, the string **30** is divided according to the indentations **32**. A division according to the indentations **32** may in this case also take place prior to the drying of the ceramic material. The wax or plastic rods **21** must have such softening properties, and the drying of the ceramic paste string must take place at such a temperature that the ceramic material is permitted to shrink during the drying procedure, without the wax string breaking the material through its stiffness. If desired, the wax or plastic rods may be removed from the ceramic material by melting and trickling off of the rods, so that the apertures are uncovered before or during the drying procedure (the solidification) of the ceramic

paste. It is suitable, however, that the drying temperature be kept at a value such that wax remains in the element, because in any following trimming of surface irregularities it might be found suitable to keep the connecting apertures closed, so that grinding dust and other impurities cannot find their way in and cause bad contact between resistance wires and the connecting wires to be arranged in the apertures.

The manufacturing step V shows an elemental body which has been separated from a material tape **30** and has been dried and trimmed. To tighten porosities and openings in the porcelain one preferably proceeds so that liquid porcelain paste is applied to a punched and dried but non-burned porcelain plate at the short ends thereof, where the warp wires have been severed edgewise onto the porcelain, said porcelain paste being sucked up in a moderately thin layer by the dry porcelain and sealing the apertures that would otherwise be formed, after the warp wires and the core thread have been burned away. It will be seen from the figure how the strings **4**, **5**, **6** and the resistance wire loops **3** are arranged in the elemental body. The wax rods **21** are still in the element. The element is then heated in step VI for the burning of the ceramic material, the wax rods **21** then melting and leaving cavities **34** such as the cavities **16**, **17** provided by the tubes **13**, **14**, FIGS. 5 and 6. During the burning operation the wire strings **4**, **5**, **6** are combusted, and the resistance wire sticks by the burning process to the ceramic material.

After the element has cooled down, connecting wires **20** are introduced into the cavities **34**, for instance as shown in FIG. 7, which connecting wires are soldered by heating to alloying temperature at the wire ends **8'**. The silver solder will then melt and fill the cavities **34**. In order that the connecting wires shall not come loose from their attachments, it might be found suitable to form the inner portion of each cavity **34** as one, into which the silver solder is caused to flow. Such a cavity may be brought about by forming the wax rods **21** with a protuberance at the end located on the middle string **5**. The resistance element thus produced and the adjacent parts of the connecting wires are preferably provided with a layer **35** of enamel, lacquer, wax or the like as a moisture and dust shield.

In connection with FIG. 9 it should be noted that the rollers **26**, **27** may be constructed without any knife member severing the material string. The division of the material string may be effected in the following working steps. Knife members **31** may of course also be so arranged as to penetrate as far as to the strings **4**, **5**, **6**, the ceramic paste not then becoming coherent and said strings consequently keeping the issuing material string **30** together. According to the last-mentioned construction it is not necessary that the elemental wire carried in loops be divided into groups of loops separated from one another, inasmuch as the loops may be passed continuously along the strings **4**, **5** and **6**.

FIG. 10 illustrates a modification of the construction according to FIG. 9. The difference between these two forms of embodiment resides in that the rollers **26**, **27** have smooth peripheral surfaces, that is to say, are not provided with knife members **31**. In this construction, two carrying lines **36**, **37** are fed in together with the strings carrying the resistance wire, said carrying lines being located on each side of said strings, the line **36** being guided toward one side of the rods **21**. Said carrying lines are enclosed within the band **30** formed by the rollers **26**, **27**, whereupon the band is fed to a punching device having a lower punch **38** and an upper punch **39** formed with knife edges about the mantle surface. The members are movable toward and from one another, as indicated by the arrows **40**, **41**, and function as a cutting tool, the edges meeting at the middle plane of the band. As will appear from the figure, every second wax rod is adapted to project outside the band **30**, that is to say, by a projecting rod for each element. The projecting rods **21** are used to actuate an arm **42** of a micro-switch **43** or the like to release a driving means **44** actuating the punches. As soon as the arm **42** is actuated by a wax rod **21**, the punching operation will be released. Said punching contrivance is so adapted that an element **45** is punched out of the band **30** for each working operation, the portions between the elements of the band and the portion surrounding the carrying lines **36**, **37** being left behind and being deflected in a special track **46** to be disposed of, and the punched elements **45** being transported off on a conveyor **47** for drying and further processing in the manner described in connection with FIG. 9, the manufacturing steps V–VII.

It is often desirable to make resistance elements, in which the connecting wires proceed from the short sides of the elements. To effect this according to the invention, the outermost loops **3'** of the resistance wire **3** of each element are pulled out as appears from FIG. 11 between the strings **4**, **5**, **6** in such manner that a part of the loop **3'** runs essentially at right angles to the strings. A wax rod **21'** is arranged transversely over the last-mentioned parts and along the string **5**, the ordinary wax rod **21** being arranged at right angles to the rod **21'** and projecting from the latter outside the contemplated material band. Each element is punched after it has been embedded in ceramic material in the manner above described along the chain-dotted line **48**. FIG. 12 shows a finished element **45''**, before the connecting wires have been joined by soldering.

When the question is to provide a quantity of resistance wire as large as possible within a given space, it will be found suitable, as shown in FIG. 13, to fold the element wire so as to form ridges **49** extending in the longitudinal direction of the band, so that a substantially zigzag-shaped configuration is imparted to the same in cross section. Such an elemental band may be cast as a casting paste in a mould as shown in FIG. 5, without any special measures having to be taken for this purpose.

However, if such a folded band is to be used in connection with paste strings acording to FIG. 9 or FIG. 10, the surfaces facing one another of the strings will have to be profiled in accordance with the folding. Such paste strings **25**, **26** are according to FIG. 14 provided with profilations **50** fitting each other.

In order that the material string obtained after the punching of the elements **47** as in FIG. 10 shall present a greater mechanical strength, which is essential for the attainment of an off-transportation free from disturbances, the resistance wire portions **8'** between the elements may be arranged in loops **8''** and be secured to the carrying lines **36**, **37**, as shown in FIG. 15. The loops **8''** will form a transversely extending reinforcement of the string **46**. In the making of the elemental band, the carrying lines may of course be carried out as the strings **4**, **5**, **6**, and the loops **8''** may be tied into the carrying lines **36**, **37**.

The method according to the invention is not restricted to the arrangement of three or more strings **4**, **5** and **6** formed by wire meshes, the use of a single string or two strings being conceivable in certain cases. It is not necesary that the strings be made of a material insulated prior to the combustion. Nor is it necessary that the resistance wire be wound into a spiral **2** about a core **1**, a free-carrying spiral winding permitting also of being considered as well as a single resistance wire arranged in the manner shown for instance in FIG. 3. In addition to purely resistive adaptation facilities the spiral winding of the resistance wire also has the advantage that thermal expansion strains between the wire and the ceramic material become very small in comparison with those of a straight resistance wire. The wire material of the winding core **1** need not of course be insulating, the main point being that when heated it is combusted at a temperature falling below that temperature where the elec-

trical and mechanical properties of the resistance wire are influenced detrimentally. Such a selection of material for the winding core 1 is also conceivable that the latter remains in the finished element, that is to say, is not combusted; glass fibres, for example, may be brought into consideration. The casting of the element into an insulating paste may be effected in many ways in addition to those indicated above, the casting material consisting for instance of suitable fusible, mouldable or extrusive plastics.

The method of securing the connecting wires 20 in the element may also be varied in many ways within the scope of the invention. In special cases, soldering of the connecting wires and the combustion of the wire strings may take place in one and the same process. It is also possible to arrange the connecting wires in contact with the elemental wires by clamping them together. Here, the ends of the connecting wires may for instance be expanded and provided with barb-like projections to cooperate with the elemental wires in the recesses 16, 17 and 34, respectively.

What is claimed is:

1. A method of mass producing resistors comprising, forming reverse bends on a continuous resistance wire thereby defining loops arranged in successive groups each having a given number of loops and disposed longitudinally spaced in an elongated configuration, disposing between successive individual groups of loops two longitudinally spaced cavity-forming fugitive elements extending axially transversely of the longitudinal direction of said elongated configuration at positions designated as end portions of each two next adjacent ones of said successive groups, said cavity-forming elements each being disposed in position to be covered axially only partially with ceramic, embedding the formed resistance wire in a settable ceramic paste for forming an elongated ceramic-covered band confining said loops, and while embedding said resistance wire at the same time embedding said cavity-forming elements in said ceramic paste only partially axially thereby to allow at least an end surface of each of said cavity-forming elements to be disposed outwardly of said band, severing said ceramic covered band including the severing of said wire between the successive groups and said cavity-forming elements to form a plurality of resistors, and firing the individual resistors at a temperature insufficient to damage said wire and sufficient to completely set the ceramic, causing said cavity-forming elements to emigrate from said resistors thereby to define access cavities open to the exterior of said ceramic axial to the opposite end portions of said resistance wire within each resistor, and connecting leads to said resistance wire extending through said cavities in said resistors.

2. A method of mass producing resistors according to claim 1, comprising forming said reverse bends in substantially a common plane whereby said loops are disposed substantially in a common plane and including the formed resistance wire on parallel, longitudinally extending, separate, combustible threads with said loops disposed transversely of said threads, and each of said threads having loops spaced longitudinally thereof with said resistance wire passing through loops of the threads whereby said reverse bends are held and said threads being consumable by application of heat when said resistors are fired for setting said ceramic paste.

3. A method of mass producing resistors comprising, forming reverse bends on a continuous resistance wire thereby defining in a common plane loops arranged in successive groups each having a given number of loops and disposed longitudinally spaced in an elongated configuration, disposing between successive individual groups of loops two longitudinally spaced cavity-forming fugitive elements extending axially transversely of the longitudinal direction of said elongated configuration at positions designated as end portions of each two next adjacent ones of said successive groups, said cavity-forming elements each being disposed in position to be covered axially only partially with ceramic, embedding the formed resistance wire in a settable ceramic paste for forming an elongated ceramic-covered band confining said loops, and while embedding said resistance wire at the same time embedding said cavity-forming elements in said ceramic paste only partially axially thereby to allow at least an end surface of said cavity-forming elements to be disposed outwardly of said band, severing said ceramic covered band including the severing of said wire between the successive groups and said cavity-forming elements to form a plurality of resistors, firing the individual resistance elements at a temperature insufficient to damage said wire and sufficient to completely set the ceramic and to cause said cavity-forming elements to emigrate from said resistors thereby to define access cavities to the opposite end portions of said resistance wire within each resistor, disposing leads in said cavities for connection to said end portions, connecting said leads to said end portions by application of heat, and said leads extending through said cavities and externally of the individual resistors.

4. A method of mass producing resistors comprising, forming reverse bends on a continuous resistance wire thereby defining in a common plane loops arranged in successive groups each having a given number of loops and disposed longitudinally spaced in an elongated configuration, coating said wire with a suitable material for causing it and a ceramic to adhere to each other and disposing between successive individual groups of loops two longitudinally spaced cavity-forming fugitive elements extending axially transversely of the longitudinal direction of said elongated configuration at positions designated as end portions of each two next adjacent ones of said successive groups, said cavity-forming elements each being disposed in position to be covered axially only partially with ceramic, embedding the formed resistance wire in a settable ceramic paste for forming an elongated ceramic-covered band confining said loops, and while embedding said resistance wire at the same time embedding said cavity-forming elements in said ceramic paste only partially axially thereby to allow at least an end surface of each of said cavity-forming elements to be disposed outwardly of said band, severing said ceramic covered band including the severing of said wire between the successive groups and said cavity-forming elements to form a plurality of resistors, firing the individual resistors at a temperature insufficient to damage said wire and sufficient to completely set the ceramic, causing said cavity-forming elements to emgirate from said resistors thereby to define access cavities to the opposite end portions of said resistance wire within each of said resistors, and connecting leads to said resistance wire extending through said cavites in said resistors.

5. A method of mass producing resistors according to claim 4, in which said wire is coated with material comprising said ceramic paste in a liquid state before embedment thereof in said ceramic paste.

6. A method of mass producing resistors comprising, spirally winding a conductive wire on a burnable thread for making a continuous resistance wire, forming reverse bends on said continuous resistance wire thereby defining in a common plane loops arranged in successive groups each having a given number of loops and disposed longitudinally spaced in an elongated configuration, disposing between successive individual groups of loops two longitudinally spaced cavity-forming combustible elements extending transversely of the longitudinal direction of said elongated configuration at positions designated as end portions of two next adjacent ones of said successive groups, said cavity-forming elements each being disposed in position to be covered axially only partially with ceramic, embedding the formed resistance wire in a settable ceramic paste for forming an elongated

ceramic-covered band confining said loops, and while embedding said resistance wire at the same time embedding said cavity-forming elements in said ceramic paste only partially axially thereby to allow at least one end surface of each of said cavity-forming elements to be disposed outwardly of said band, severing said ceramic covered band including the severing of said wire between the successive groups and said cavity-forming elements to form a plurality of resistors, firing the individual resistors at a temperature insufficient to damage said wire and sufficient to completely set the ceramic and burn out said burnable thread, causing said cavity-forming elements to emigrate from said resistors thereby to define access cavities to the opposite end portions of said resistance wire within each resistor, and connecting lead connections to said end portions extending through said cavities and externally of the individual resistors.

7. A method of mass producing resistors according to claim 6, including disposing the resistance wire on parallel, longitudinally extending, separate, combustible threads with said loops disposed transversely of said threads, and each of said threads having loops spaced longitudinally thereof with said resistance wire passing through loops of the threads whereby said reverse bends are held, and said threads being consumable by application of heat when said resistors are fired for setting said ceramic paste.

8. A method of mass producing resistors according to claim 6, including treating the surface of said resistors with a sealing agent after firing them thereby to seal the surface thereof.

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JOHN F. CAMPBELL, *Primary Examiner.*

WHITMORE A. WILTZ, *Examiner.*