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METHOD OF MAKING ELECTRICAL RESISTANCE CARDS

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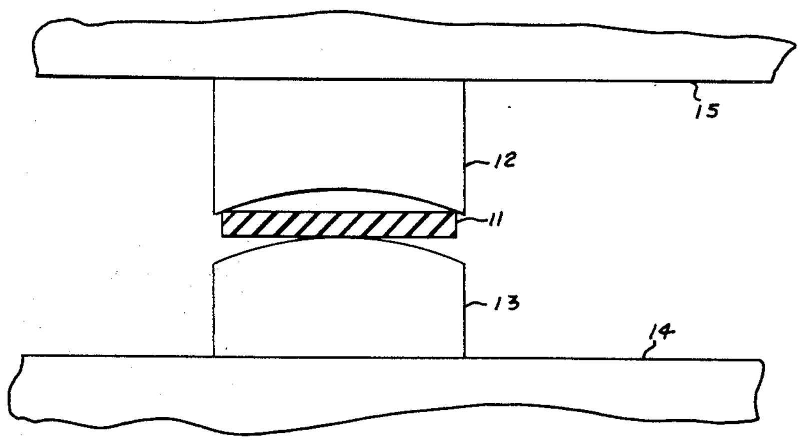

Fig-1

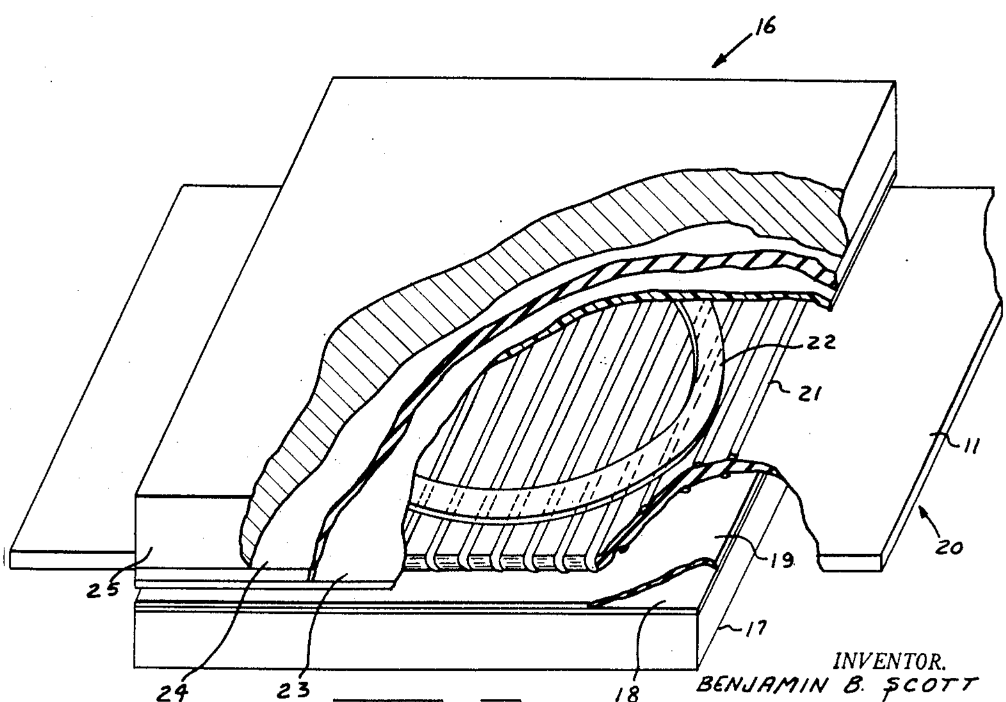

Fig-2

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METHOD OF MAKING ELECTRICAL RESISTANCE CARDS

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This invention relates to a method of making electrical resistance cards wherein a separable pressing strip is used during the hot-pressing step to produce an improved resistance card which is useful in potentiometers incorporated in armament control systems.

One form of conventional resistance card makes use of a resistance winding on a rectangular dielectric strip which is flat on one face and cylindrically machined on the other to a chord height of substantially 0.010″ over a card width of approximately 2″. The winding axis and the axis of the cylindrically curved face of the strip are parallel. The winding is arranged for circular brushing on the cylindrical face. Intimate contact between wire-turns and the curved strip surface permits satisfactory bonding by appropriate techniques. However, the contact tip of the brush is required to raise and lower itself a distance of about 0.010″ twice for each brush revolution, giving rise to large variation in brush-contact pressure, unequal wear on wire turns, poor contact and electrical-noise difficulties, uncertain operating life, etc. Also, the cylindrical variation in strip thickness prevents concatenated mounting of several cards to form a multiple unit operable from a single shaft. In earlier resistance card designs, the dielectric strips were made flat to accord with brushing and mounting requirements. These performed unsatisfactorily after relatively few brushing operations because of electrical noise caused by high bond difficulties and to turn breakage resulting from unsatisfactory turn bonding which permitted turns to move and allow brushes to penetrate between them thereby causing direct breakage. The present new system of card bonding was developed, accordingly, to overcome constructional and operational difficulties occurring with the conventional forms of cards and has been able to eliminate these completely.

It is an object of this invention to provide an improved method of making resistance cards which eliminates many manufacturing difficulties, simplifies manufacturing operations, improves product quality, and reduces substantially manufacturing losses by reducing recheck losses and construction labor.

It is another object of this invention to provide a method of making resistance cards wherein the dielectric strip used in making the card is cylindrically curved prior to winding the coil of resistance wire thereon and the curvature of the dielectric strip is removed in a subsequent hot-pressing operation, which also performs the additional function of firmly bonding the wire turns in the brush-contacting area to the dielectric strip of the card with the aid of a separable pressing strip.

It is an additional object of this invention to provide an improved method of making resistance cards having low bond height between wire turns and having the wire turns in the brush-contact area of the card firmly bonded to the dielectric strip of the card with the aid of a separable cellulose acetate pressing strip which covers the brush-contacting area during the hot-pressing operation.

It is a further object of this invention to provide an

improved method of making resistance cards having circular brush-contacting areas wherein a separable pressing strip is used to cover the brush-contacting areas during the hot-pressing operation to insure that the wire in the brush-contacting area is firmly bonded to the dielectric strip of the card.

These and other objects of the invention will become apparent as the detailed description of the invention proceeds.

Glass cloth impregnated with a polyester polyvinyl-acetyl resin is a dielectric strip conventionally used in the construction of resistance cards was found in practice to have slight thermoplastic characteristics although normally a thermosetting material. This slight thermoplastic property of the resin is not unique to this one type of resin and other resins having similar properties would be satisfactory. Advantage is taken of this characteristic in the present process to cylindrically-form the dielectric strip before their being wound and later to restore them to a flat condition after winding and bonding as a part of the bond-cure treatment in a platen press at elevated temperature and pressure. It is preferred to use this step of cylindrically forming the dielectric strip in my process but this step may be omitted and dependence for bonding the wire turns in the brush-contacting area is placed primarily upon the improved step of using a separable pressing strip during the hot-pressing operation. By incorporating the curved dielectric strip step an improved resistance card will result than if the step is not used.

The invention will be more clearly understood from the following detailed description of a specific example thereof read in conjunction with the accompanying drawings wherein:

Fig. 1 is a partial elevational view of a die, heated press platens and a strip of dielectric material in cross section; and

Fig. 2 shows a wire-wound dielectric strip after treatment with thermosetting resin and drying operations assembled in a curing fixture ready for the hot-pressing operation.

Fig. 1 shows dielectric strip **11** which may suitably be made of glass cloth impregnated with a polyester polyvinyl-acetyl resin positioned between upper die plate **12** and lower die plate **13**. These die plates **12** and **13** are contained in a hot-press (not shown in its entirety) having heated platens **15** and **14** for heating strip **11** and pressing it between the die plates. Other suitable thermosetting resins for impregnating strip **11** are described in detail in U.S. Patent No. 2,528,235. Die plates **12** and **13** and platens **14** and **15** are made from materials conventionally used, normally metals. Die plates **12** and **13** as well as dielectric strip **11** are rectangular in cross section. The surface of die plate **12** which contacts strip **11** is cylindrically concave having a chord depth of about 0.020″ for a strip width of approximately 2″, and the surface of die plate **13** is cylindrically convex to mate with its companion plate. In the forming operation the platens **14** and **15** are heated to about 170° C. and strip **11** is pressed approximately 100 p.s.i. for a period of about five minutes to cylindrically form the strip. With the above dimensions of card and die plates the chord height of the dielectric strip is about 0.006″. Following the press operation the cards are removed and are ready for the winding of the coil of resistance wire thereon. The above temperature and time of pressing the dielectric strip might vary somewhat depending on the particular resin which was used to impregnate this strip and the material and dimensions of the strip. That is, some resins might be longer curing or require a higher or lower curing temperature. Normally the 100 p.s.i. pressure will be sufficient for forming most types of dielectric strips. Obviously if this step of forming the curved strip is not used any type of conventionally used dielectric strip will be satisfactory whether or not a thermosetting resin having slight thermoplastic properties has been used to impregnate it.

The above described forming operation provides a dielectric strip which is effective to maintain the resistance windings properly spaced apart during the interval between the winding operation and the resin curing operation which will later be described. A cured strip formed of glass fibre and impregnated with a polyester polyvinyl-acetyl resin when cured is inherently resilient. When the wire is wound about the strip under uniform tension, the cylindrical strip is bowed slightly so that the winding is tensioned after the wound strip is removed from the winding mechanism. This tension need not be great but is sufficient to prevent accidental displacement of the winding during operations prior to the final curing operation.

The next step in forming the resistance card is to wind the coil of resistance wire on the resistance card by conventional winding techniques. That is, the resistance wire may be wound on the card either manually or mechanically. After the dielectric strip has been curved by the step described above, if this step is used, the resistance coil is wound around the dielectric strip with the winding axis parallel to the axis of the cylindrical surface of the strip. The resistance wire used for these cards is resistance wire conventionally used in making resistance cards. Normally this would be resistance wire which has been coated with an insulating coating of a suitable alkyd resin, polyvinyl-formal resin or a mixture thereof.

Next the wire-wound strip is treated with a solution of a thermosetting resin. Suitable thermosetting resins for treating the wire-wound strip are described in detail in U.S. Patent No. 2,528,235. A preferred method of treating this strip with the resin is to dip the strip in a solution of the resin which solution has a concentration such that the excess resin will drain from the strip when the strip is placed on one of its sides. Alternatively, the resin solution could be sprayed or otherwise added to the strip. If the strip is curved it is preferable to place it for draining of the excess resin solution with the convex surface of the card up.

The next step in forming the resistance card is a preferred though optional step wherein the product of the previous step is allowed to air dry at ambient temperatures for a short time to cause some of the solvent to evaporate and the resin to take on an initial set. It is possible though not desirable to eliminate this step and go directly from the dipping and draining step to drying at elevated temperatures.

As indicated, the next step in the operation is a drying step at elevated temperatures. The product of the ambient temperature drying step, or of the previous step if the ambient temperature drying step is eliminated, is placed in an oven at about 75° C. to remove substantially all of the solvent. This particular drying temperature used is based on the use of a low boiling solvent for the resin as is conventionally used for the resins described above. Specifically this drying temperature is based on a "Permafil-Formvar" resin solution. However, it is not necessary to use this specific resin solution and other resin solutions with drying temperatures tailored to fit the solvent could easily be adapted to this step by those skilled in the art. The unfinished resistance card is now ready for the hot-pressing operation.

Reference should be made to Fig. 2 which shows the product of the previous step incorporated in a curing fixture **16**. The assembled curing fixture **16** resembles a sandwich in appearance. Polished metal shim-plate **18** is placed on lower pressing plate **17** suitably made of metal to form the first two layers of the fixture. A parting sheet **19** made of cellophane or other suitable material is placed on plate **18** to form the next layer.

Uncompleted resistance card **20** having dielectric strip **11** as a base therefor and wire-turns **21** wound thereon is placed on sheet **19**. This uncompleted resistance card **20** has been treated by the steps described above and is the product of the drying step described immediately above. Card **20** may be flat or curved as described above. A ring-shaped pressing strip **22** which may suitably be made of cellulose acetate is placed on the upper surface of card **20** over wire-turns **21** covering the brush-contacting area of the card. If the brush-contacting areas of the card were straight rather than curved a straight strip would have been used rather than the ring-shaped strip **22**. The next layer of the curing fixture is a second parting sheet **23** made of cellophane or other suitable material which is placed over a strip **22** and card **20**. For the purpose of equalizing the pressure during the pressing operation a pressure-equalizing sheet **24** made of silicone-rubber or other suitable material is placed on sheet **23**. The final layer of curing fixture **16** is upper pressing plate **25** which is normally a metal plate.

Curing fixture **16** having card **20** therein is placed in a hot-press conventionally used for making resistance cards of the prior art. Pressure and heat are applied to the press, e.g., about 170° C., 50 p.s.i. for a period of about six minutes. These conditions might vary somewhat depending on the materials and dimensions of the card. Then the curing fixture is removed from the press (not shown) and the fixture is opened to expose the pressing ring **22**. This pressing ring is grasped at one edge suitably by a pair of tweezers and stripped from the resistance card **20**. It is preferable that this stripping operation be done while the card is still hot before the resin has completely hardened to avoid sticking difficulties. Upon removal of the cellulose acetate pressing ring it is found that the excess resin material has been wiped clean from substantially the upper 50% of the circumference of the wire-turns in the brush-contacting areas. Also the resin material has been forced inward and outward along the surface of the dielectric strip to produce a ridge of bonding material on either side of the brushing-circular area which furnishes enormous strength to the mechanical attachment of wire-turns to cards in this area.

The last step to complete the finished resistance card is to subject the upper portions of the wire-turns in the brush-contacting area to a conventional treatment with felt-wheel and jewelers' rouge wire-cleaning techniques for all removal of wire insulation and bonding material to give bare wires for electrical contact of the upper portions.

Loss of resistance cards due to unsatisfactory bonding of wire-turns to the dielectric strips can be reduced approximately 90% through the use of my process. Also, unit labor expenditures can be reduced approximately 50% because of simplified brush-contacting area clean-operations. The rejection loss of resistance cards from gradient-error caused by excessive cleaning has been eliminated together with an enormous amount of associated assembly and reassembly work required in testing operations.

Although the invention has been described in terms of specified apparatus which is set forth in considerable detail, it should be understood that this is by way of illustration only and that the invention is not necessarily limited thereto, since alternative embodiments and operating techniques will become apparent to those skilled in the art in view of the disclosures. For example, the method may be used to make resistance cards having straight or other shaped brush-contacting areas rather than the ring-shaped brush-contacting areas described in detail above. Accordingly, modifications are contemplated which may be made without departing from the spirit of the described invention or the scope of the appended claims.

What is claimed is:

1. A method of making resistance cards for side-

brushed potentiometers comprising step 1 of winding a coil of resistance wire around a strip of dielectric material, step 2 of coating the wire-wound strip with a thermosetting resin solution, step 3 of oven drying the product of step 2 at elevated temperatures for a time necessary to remove substantially all of the solvent from the resin, step 4 of placing a pressing strip on the wire over an area to be contacted by a brush, step 5 of hot-pressing the dried resin-coated dielectric strip with the pressing strip thereon to cure the resin coating on said dielectric strip and, by the action of said hot pressing on said pressing strip, to force the resin out from under said pressing strip and down the sides of the wire turns and to bond said wire turns under the said pressing strip intimately to said dielectric strip of material, step 6 of removing the cured resin-coated resistance card from the hot-press and stripping off the pressing strip from the card preferably while said card is at elevated temperatures residual from said hot-pressing step to avoid sticking, and step 7 of cleaning any residual insulation and resin from the surface of the wire turns only in the area to be contacted by a brush to give a finished resistance card.

2. The method of claim 1 wherein a cellulose acetate pressing strip is used.

3. The method of claim 1 wherein dipping the wire-wound dielectric strip in the resin solution is the method of coating used in step 2 and the excess resin solution is allowed to drain off after the dipping step.

4. The method of claim 1 wherein an additional step between steps 2 and 3 is used of air-drying the product of step 2 at ambient temperatures for a time necessary to remove some of the solvent and give the resin an initial set.

5. The method of making resistance cards for side-brushed potentiometers comprising step 1 of forming a flat strip of dielectric material impregnated with a resin having slight thermoplastic properties to have a slight cylindrical curvature, step 2 of winding a coil of resistance wire around the curved dielectric strip, step 3 of coating the curved wire-wound strip with a thermosetting resin solution, step 4 of drying the product of step 3 at elevated temperatures for a time necessary to remove substantially all of the solvent from the resin, step 5 of placing a pressing strip on the convex side on the wire over the area to be brush-contacted, step 6 of hot-pressing the dried resin-coated strip with the pressing strip thereon at a temperature and for a time such that the resin will be set and at a pressure acting on said pressing strip such that the portion of the wire turns in the area to be contacted by a brush area will be bonded firmly to the dielectric strip with the resin underlying said pressing strip being forced between the turns of said wire and the dielectric strip will again be made flat, step 7 of removing the cured resistance card from the hot-press and stripping off the pressing strip from the card preferably at elevated temperatures of the card residual from the hot-pressing strip to avoid sticking, and step 8 of cleaning any residual insulation and resin only from the surface of the wire turns to be brush-contacted to give a finished resistance card.

6. A method of making resistance cards for side-brushed potentiometers comprising step 1 of winding a coil of resistance wire around a strip of dielectric material; step 2 of coating the wire-wound strip with a thermosetting resin solution; step 3 of drying the product of step 2 at elevated temperatures for a time necessary to remove substantially all of the solvent from the resin; step 4 of assembling the product of step 3 in a curing fix-

ture comprising placing a polished metal shim-plate on a lower pressing plate, placing a cellophane parting sheet on the shim-plate, placing the product of step 3 on the cellophane parting sheet, placing a pressing strip on the product of step 3 covering an area to be contacted by a brush, placing a second cellophane parting sheet on the pressing strip, placing a silicone-rubber pressure-equalizing sheet on the second parting sheet, and placing an upper pressing plate on the pressure-equalizing sheet to complete the assembling of the product of step 3 in the curing fixture; step 5 of hot-pressing the assembled curing fixture containing the product of claim 3 by applying heat and pressure to said pressing plates; step 6 of removing the cured resistance card from the hot-press and stripping off the pressing strip from the card preferably while said card is at elevated temperatures due to residual heat from said hot-pressing strip to avoid sticking; and step 7 of cleaning any residual insulation and resin from the area of the wire-turns to be brush-contacted to give a finished resistance card.

7. A method of making resistance cards for side-brushed potentiometers comprising step 1 of forming a flat strip of dielectric material impregnated with a resin having slight thermoplastic properties to have a slight cylindrical curvature; step 2 of winding a coil of resistance wire around the curved dielectric strip; step 3 of dipping the curved wire-wound strip in a thermosetting resin solution and allowing the excess resin solution to drain off; step 4 of air-drying the product of step 3 at ambient temperatures for a time necessary to remove some of the solvent and give the resin an initial set; step 5 of drying the product of step 4 at elevated temperatures for a time necessary to remove substantially all of the solvent from the resin; step 6 of assembling the product of step 5 in a curing fixture comprising placing a polished metal shim-plate on a lower pressing plate, placing a cellophane parting sheet on the shim-plate, placing the product of step 5 with its convex side up on the parting sheet, placing a cellulose acetate pressing strip on the product of step 5 covering an area to be brush-contacted, placing a second cellophane parting sheet on the pressing strip, placing a silicone-rubber pressure-equalizing sheet on the second parting sheet, and placing an upper pressing plate on the pressure-equalizing sheet to complete the assembling of the product of step 5 in the curing fixture; step 7 of applying heat and pressure to the plates of the assembled curing fixture containing the product of claim 5 at a temperature and for a time that the resin will be set and at a pressure that the portion of the wire-turns in the brush-contacting area will be bonded firmly to the dielectric strip with the resin immediately underlying said pressing strip being forced between the turns of said wire and the dielectric strip will again be made flat; step 8 of removing the cured resistance card from the hot-press and stripping off the pressing strip preferably while said card is at elevated temperatures of the residual heat from step 7 to avoid sticking; and step 9 of cleaning any residual insulation and resin only from the surface of the wire-turns to be brush-contacted to give a finished resistance card.

References Cited in the file of this patent

UNITED STATES PATENTS

2,282,759	Gavitt	May 12, 1942
2,534,994	Scott et al.	Dec. 19, 1950
2,610,387	Borland et al.	Sept. 16, 1952
2,761,042	Scott	Aug. 28, 1956