United States Patent

Payne

[15] **3,659,245**

[45] **Apr. 25, 1972**

[54] VARIABLE RESISTOR PIN TERMINAL AND METHOD

[72] Inventor: **Robert L. Payne,** Riverside, Calif.

[73] Assignee: **Bourns, Inc.,** Riverside, Calif.

[22] Filed: **Mar. 29, 1971**

[21] Appl. No.: **129,236**

Related U.S. Application Data

[63] Continuation of Ser. No. 816,674, Apr. 16, 1969, abandoned.

[52] **U.S. Cl.** .....**338/312,** 29/630 D, 317/101 CC, 339/17 LC, 339/220 R

[51] **Int. Cl.**.....**H01c 7/00**

[58] **Field of Search**.....338/312; 339/106, 17 LC, 220 R; 29/630 D; 317/101 CC

[56] **References Cited**

UNITED STATES PATENTS

2,990,533	6/1961	Hughes	29/630 D
3,148,310	8/1964	Feldman	29/630 D
3,257,708	6/1966	Stricker	29/630 D

FOREIGN PATENTS OR APPLICATIONS

737,998	10/1955	Great Britain	29/630 D

Primary Examiner—E. A. Goldberg
Attorney—Fritz B. Peterson

[57] **ABSTRACT**

A pin terminal firmly affixed in a tapered aperture in a ceramic substrate with effective electrical connection with an electrical conductive film on the surface of the substrate, the pin terminal having an end swaged in the aperture to effect excellent mechanical connection to the substrate.

4 Claims, 3 Drawing Figures

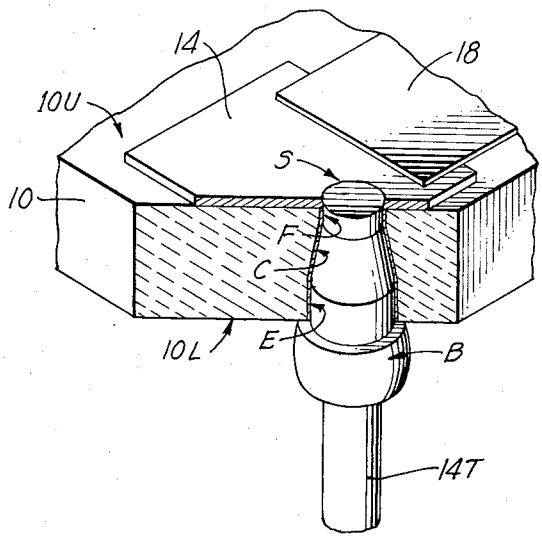


FIG. 1.

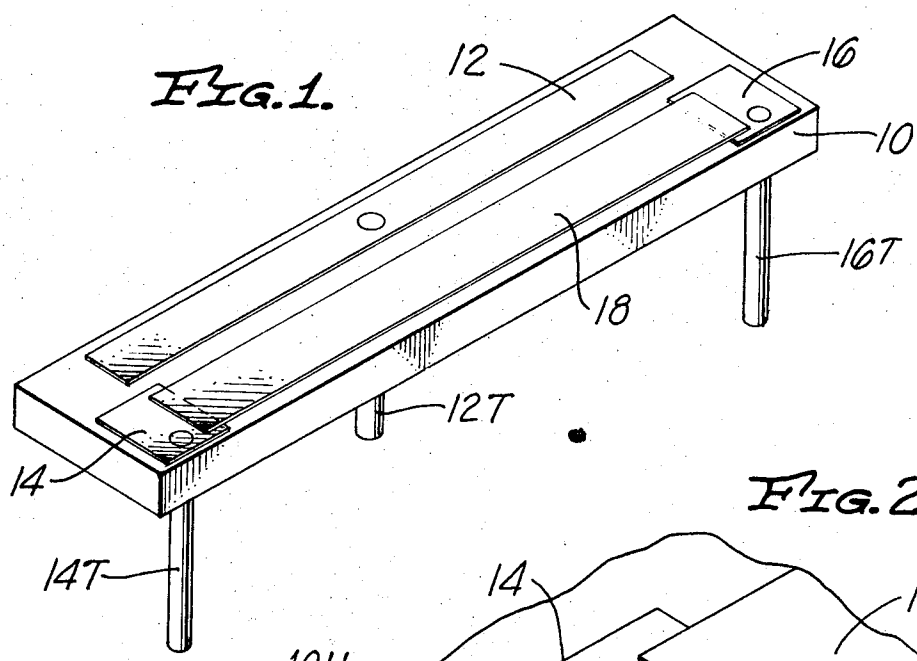


FIG. 2.

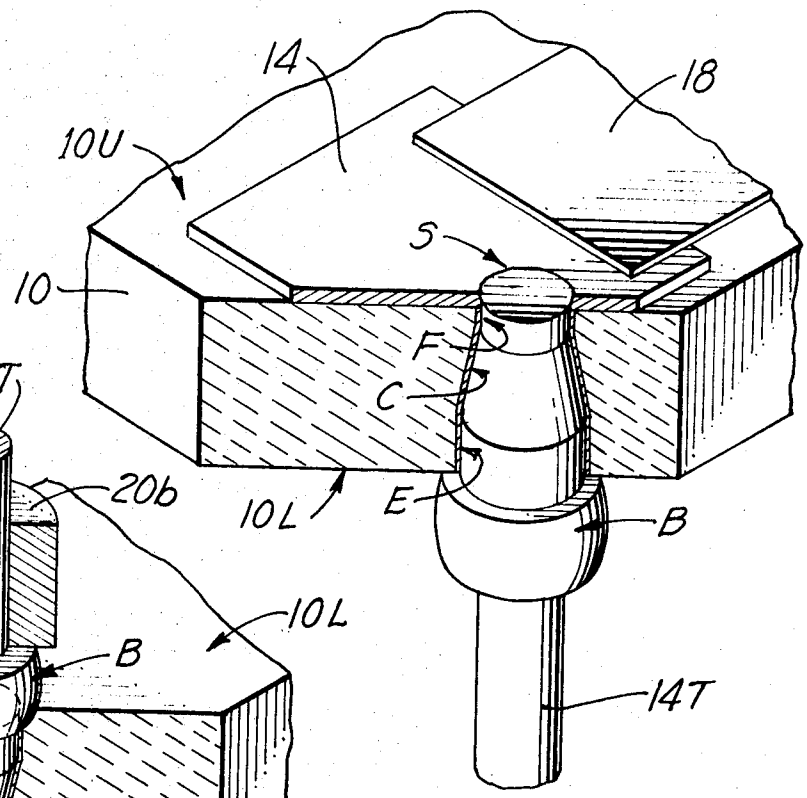
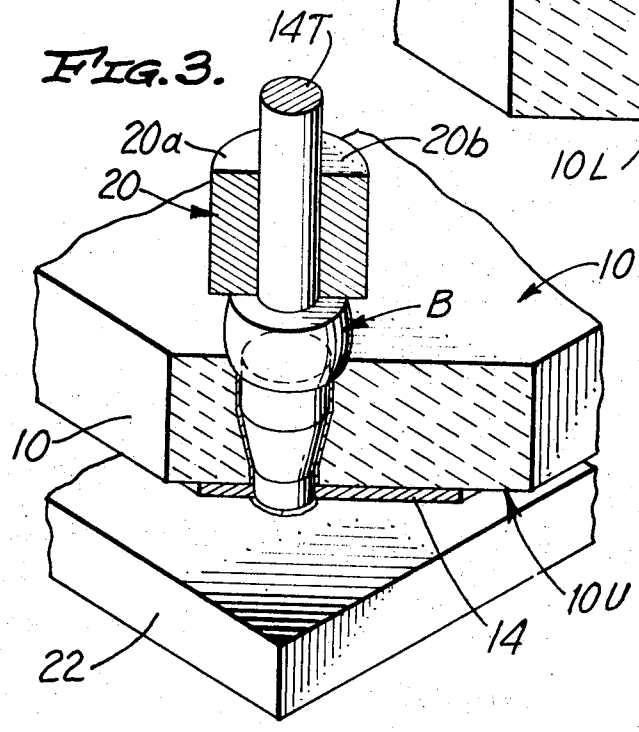


FIG. 3.



INVENTOR
ROBERT LEE PAYNE
BY

VARIABLE RESISTOR PIN TERMINAL AND METHOD

This application is a continuation of application Ser. No. 816,674, filed Apr. 16, 1969, now abandoned.

BACKGROUND OF THE INVENTION

With the advent of modern astronautical and aeronautical electronic systems, intense efforts have been made to reduce the weights (masses) of electronic circuit components to the greatest practical extents, while concurrently efforts have been made to maximize electrical ratings (power capabilities) and resistance to destructive and deteriorative effects of heat and high temperature. Thus in the case of potentiometers and similar variable resistors, resort has been taken to high-temperature ceramic materials, such as alumina, for substrates or bases for the resistance elements, and to self-adherent ceramic-metal (cermet) materials for the resistive elements. Such substrates, whether of circular form for use in rotary devices, or of rectangular form for use in screw-adjusted devices, are now generally made of very strong material and hence are made as thin as is practicable, whereby to reduce size and mass to minimum practical values. The substrates are generally required to support, and to have extending therefrom, conductive wire pins serving as terminals for the resistance element and the variable contact; the conductive pins being adapted to be pressed into conductive receptacles or perforations in a circuit board and to thereby support the substrate and other parts of the resistor. Thus the pins, despite being of very small diameter, may be subjected to considerable stress when the resistor is plugged in, or removed from, a circuit board.

While the terminal pins may be placed in the ceramic substrate while the latter is in the greenware state, and then fired in place; only very expensive pins can endure the high temperature during firing, and further, the nature of operations performed subsequent to firing render it undesirable to have the pins mounted in the substrate until after those operations have been performed. Such operations include producing conductive and resistive adherent members on the substrate, and usually involve a kiln-firing step or operation. For those reasons, it is nearly universal practice to produce the substrates as perforated wafers, and, following production of the conductive and resistive components thereon, (including a conductive film in and around the substrate apertures) to solder the ends of terminal pins in respective apertures in the substrate while holding the pins in proper position. The preceding procedure is time-consuming, and, due to shrinkage of solder during cooling, results in a high rate of rejection or failure of resistors because of loose pins and/or poor bonding of pin to conductive film. The troubles and difficulties mentioned are grossly accentuated as substrate thickness is decreased.

SUMMARY OF THE INVENTION

The invention obviates all of the noted objectionable features of prior art pin terminations and methods, primarily by (a) providing tapered apertures in the substrate, one for each pin, (b) applying metal around each aperture, (c) inserting an end of a respective pin or wire in each aperture with the end brought flush with the conductive coating and against an anvil at the small end of the aperture in each case, (d) gripping each pin or wire with swaging tongs or grips adjacent to but spaced from the opposite surface of the substrate, and (e) swaging the wire between the anvil and the grips by forcefully moving the grips toward the anvil, that is, forcing the wire within the aperture to expand, until the expanding metal of the pin or wire compressively engages the wall of the aperture and of the conductive metal coating over at least a major fraction of the wall surface. Thus the swaged terminal in each case is firmly gripped by the substrate and is effectively electrically connected to the respective conductive coat or film, with no shrinkage due to cooling. As is evident, it is a matter of choice whether each terminal pin to be mounted to a substrate is swaged in turn, or all are swaged concurrently. No soldering is required to retain the terminal in place nor to effect electrical connection with the conductive film; however, in the case of certain patterned resistive devices it is general practice to perform a dip-soldering procedure for electrically connecting components, and such procedure will only aid and/or augment the effectiveness of the anchoring of the terminal and the electrical connection.

BRIEF DESCRIPTION OF THE DRAWING

The invention in a selected presently preferred exemplary form as applied to an exemplary substrate of rectangular configuration, is illustrated in the accompanying drawing, with the method somewhat diagrammatically portrayed, and in which drawing:

FIG. 1 is a pictorial representation, grossly enlarged, of a rectangular substrate from a screw-adjusted variable resistor, with conductive and resistive members applied, and with a presently preferred exemplary form of terminals according to the invention;

FIG. 2 is a grossly enlarged fragmentary pictorial view, partly in section, illustrating details of the exemplary tapered configuration of the aperture formed in the ceramic substrate of FIG. 1, and of the pin terminal swaged in situ in the substrate; and

FIG. 3 is a grossly enlarged pictorial view, partly in section and of a fragmentary character, illustrating the procedure or mode of swaging the terminal in place in a tapered aperture of presently preferred shape in a substrate, using anvil means and swaging grips.

DESCRIPTION OF THE PREFERRED MODE AND EXEMPLARY EMBODIMENT

In FIG. 1, a ceramic substrate **10**, of alumina, is depicted as of rectangular plan form. The invention is equally applicable to substrates of circular or other configuration. The exemplary substrate is shown greatly enlarged to facilitate illustration; a typical specimen is 0.075 inches thick, 0.150 inches wide, and 0.675 inches long. The substrate carries an adherent elongate conductive film **12** which in a potentiometer of the leadscrew adjusted type (see, for example, U.S. Pat. No. 3,358,258) serves as a collector or return conductor. Film **12** may be, for example, of silver, or of precious metal, reduced in situ from an ink or paint screened onto the substrate and fired. Similarly, the substrate carries first and second typical conductive termination films **14** and **16**, similarly produced in accord with well-known techniques. Each of the conductive films encircles a respective one of specially shaped apertures formed through the substrate, and preferably extends into the aperture part or all of the way to the opposite substrate face, thus forming a very thin conductive wall in the aperture through part or all of its extent. The purpose of extending the conductive film into the aperture in each instance is to provide for improved or more extensive electrical contact with a terminal pin to be hereinafter described.

The substrate **10** further carries an adherent resistive film or element **18** which extends between and overlaps upon the two conductive films **14** and **16**. In the variable resistor or potentiometer in which such substrates are employed, a wiper or contact is movable along the element and collector to provide at the collector an adjustable fraction of the potential applied to conductive films **14** and **16**, or to effect a division or change of electric current.

The mechanical actuating means for effecting variations of electrical resistance exhibited between terminations in the variable resistors of the type in which the substrate **10** is used are well known and are not per se of the present invention. Typical actuating means are shown in the aforementioned patent.

In the practice of the present invention, the substrate, whether formed by powder-pressing techniques or by ceramic-tape or casting techniques, is provided with terminal apertures having a conical or tapering form, either continuous

from face to face of the substrate, or, as shown in FIG. 2, with a short cylindrical section at one or both ends of the tapered section, and with conductive coatings as above described. The exemplary terminal apertures are formed with a central portion or section C of tapered (preferably conical) form or shape, and for convenience in manufacture, with a short lower cylindrical portion or section E of diameter the same as that of the larger end of conical section C and an upper short cylindrical portion or section F of diameter equal to that of the smaller end of section C, all as indicated in FIG. 2. The diameter of section F, with which the section C merges, is such as to permit direct entry of a pin or wire terminal member without excessive driving force; and the diameter of section E, with which the tapered section also merges, is such that an end of a pin or wire terminal member may be presented thereto and moved inwardly into the aperture without interference from the lower face **10L** of the substrate irrespective of small dimensional variations in aperture locations due to manufacturing tolerances, substrate shrinkage, and the like. The apertures are formed prior to application of the conductive and resistive films, and hence if the conductive film is deposited on the interior surface of an aperture, allowance for that is made in dimensioning of the aperture. The apertures, while preferably of circular cross section, may be of other cross-sectional form, but must have a tapering configuration.

With terminal pin apertures formed in the substrate as shown and described and with the various films in place on the substrate, application of the pin terminals **12T**, **14T** and **16T** to the substrate is effected, either concurrently, or one by one, depending upon the apparatus employed. Since the procedure is essentially the same, the following description is restricted to application of a single pin terminal, **14T** (FIGS. 2 and 3), in the interest of brevity. Also, in the interest of brevity and simplicity of disclosure, the description is restricted to apertures and wire or pins of circular cross section, that being the preferred form.

In accord with the invention, the wire or pin which is to form the terminal **14T** is passed through a plural-jaw swaging grip or chuck **20** (FIG. 3), only sections of two jaws or grips **20*a*** and **20*b*** of which are shown, and a measured short length of the wire or pin is passed or drawn through beyond the lower face of the chuck. The jaws are then closed very tightly onto the wire or pin. The substrate, in this example, is placed face down on a swaging anvil **22** and held firmly thereon with the aperture aligned with the end of the wire or pin protruding from the chuck **20**. The chuck is then lowered until the end of the wire or pin contacts the anvil **22**; and then the chuck is forced downwardly toward the substrate into a position such as that indicated in FIG. 3. During the latter forced downward movement of the chuck, the wire or pin is swaged, expanding against the walls C, F and E of the aperture and into a bulge such as that indicated at B in FIGS. 2 and 3. In an alternative operation, especially adapted to swaging of the pin terminals when the latter are formed from a wire supplied by feed rolls from a reel of wire, the end of the wire is fed through the opened chuck or grip until the wire end is stopped by the anvil, the chuck or grip means are then tightly closed on the wire and are then forced downwardly to effect the swaging. Thereafter the gripping means are withdrawn and the wire is severed to provide a protruding terminal pin of desired length. In either of the above-described procedures the swaging of the wire or pin within the aperture effects diametral or cross-sectional expansion of the wire or pin into strong compressive engagement with the substrate, and firmly secures the terminal to the substrate and effects an excellent electrical connection of the wire to the conductive film. Also, the end of the pin or wire in contact with the anvil is caused to spread or splay slightly, as indicated at S in FIG. 2, further ensuring excellent electrical connection of the pin to the conductive film. The extent and character of the spreading of the end of the pin and of the expansion or bulging of the wire or pin between the substrate and the chuck, as at B in the drawings, is dependent, among other things, upon the mechanical characteristics of the material of which the wire is formed, the cross-sectional dimensions of the wire, the extent of backward movement or flow of wire material in the chuck (or slippage), and the initially unoccupied space in the aperture. As is evident, the swaging stroke and length of pin or wire protruding from the chuck are such as to cause effective cross-sectional expansion of the pin or wire in the aperture into firm holding contact with the aperture walls, followed by some bulging or expansion outside the substrate. The latter accommodates dimensional differences or tolerances from aperture to aperture in succesive substrates in a series to which terminals are affixed. Whether a single chuck is employed to successively swage terminals **12T**, **14T** and **16T**, for example, in a substrate, or a set of chucks is employed to concurrently insert and swage in situ all of the terminals, and whether swaging is effected upwardly, or downwardly as described, are matters of choice. Since the chucks may be merely a set of formed grippers operated by clamps and a press, or of the multiple-jaw power-operated type, and are not per se of this invention, they are not further herein illustrated or described. Even when very hard material is employed for the terminal wires or pins, there is a small amount of spreading of the inward end of the wire or pin, as indicated at S in FIG. 2. Such spreading or splaying of the terminal merely aids in securely affixing the swaged-in-situ pin or wire terminal to the substrate and in effecting excellent electrical connection of the terminal to the conductive film.

I claim:

1. An insulative substrate device for a variable resistor or the like, comprising:

a thin ceramic wafer providing an insulation substrate, said wafer having upper and lower faces and an aperture therethrough from face to face, said aperture comprising at least one central section of tapered form and upper and lower end sections of uniform cross section, said sections bounded by at least one wall defining the aperture and said aperture being of smallest cross section at the upper face of the wafer and of largest cross section at the lower face;

an adherent conductive film on said upper face of said substrate, said film extending at least around and into the upper section of said aperture; and

a pin terminal device having an upper end face substantially flush with the upper face of said wafer and having an upper end portion swaged in and occupying said aperture in said substrate and having a central tapered section complementary to said central section of said aperture, said upper end portion of said pin terminal within said aperture exerting compressive forces on said wall in said aperture and therein electrically contacting said conductive film,

whereby said terminal pin is securely affixed to said substrate by compressive engagement therewith and electrically connects with said conductive film and has an upper end surface substantially flush with the upper face of said wafer.

2. A device according to claim **1**, in which said central section of said aperture is of conical tapered form and in which said aperture comprises respective cylindrical sections extending inwardly from the upper and lower faces of said wafer and merging with the conical tapered section inwardly of said faces of the wafer.

3. A device according to claim **1**, in which the thin ceramic wafer has first and second such apertures and respective adherent conductive films extending around and in the apertures, first and second pin terminal devices swaged in respective ones of said apertures, and an adherent resistive film on said substrate extending between said conductive films and thereby electrically connected at its ends to said pin terminal devices.

4. A method of securing a pin terminal device to a ceramic wafer having upper and lower faces, said method including the steps of:

providing in such wafer an aperture having a tapered central section and end sections of cylindrical form, the aperture being smaller at one end than at the other end thereof;

positioning an anvil substantially flush with the surface of the wafer at the smaller end of the aperture, and holding the wafer fixed relative to the anvil;

inserting an end portion of a wire into said aperture from the larger end of the aperture and abutting the end of the wire against the anvil provided at the surface of said wafer at the smaller end of the aperture;

gripping the periphery of said wire at a location spaced away from the surface of said wafer adjacent the larger end of said aperture; and

while so gripping said wire, applying forces to the wire to force more wire into said aperture to thereby expand the wire in said aperture into contact with substantially the entire surface of the wall of the aperture to thereby swage said wire in and adjacent said aperture into firm frictional contact with said wafer at the wall of said aperture to firmly compressively attach the wire to said wafer in said aperture while leaving the said one end of the wire substantially flush with the surface of the wafer at the smaller end of the aperture.

* * * * *