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METHOD OF MAKING REED-TYPE SWITCH CONTACTS

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FIG. 1

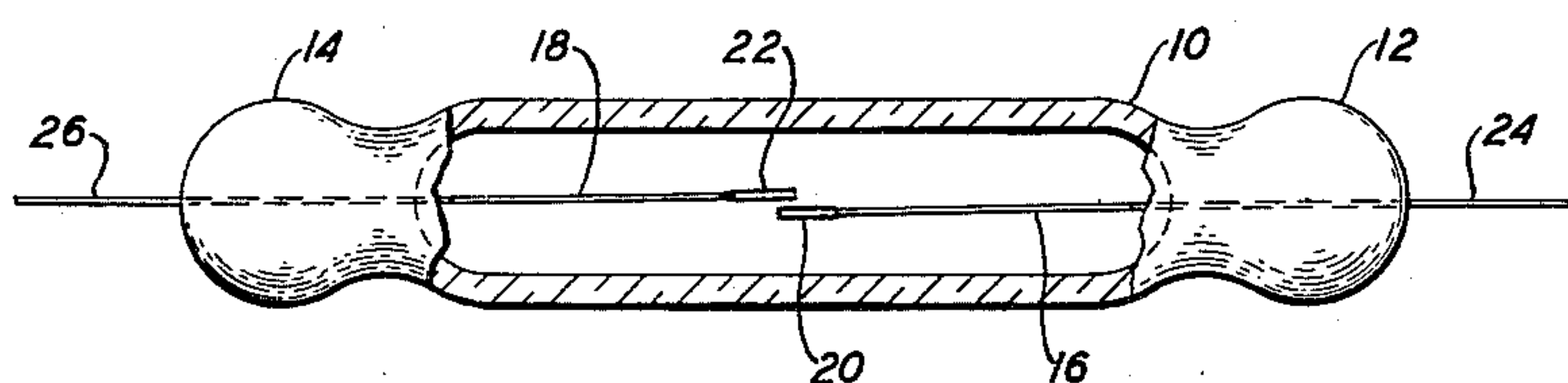
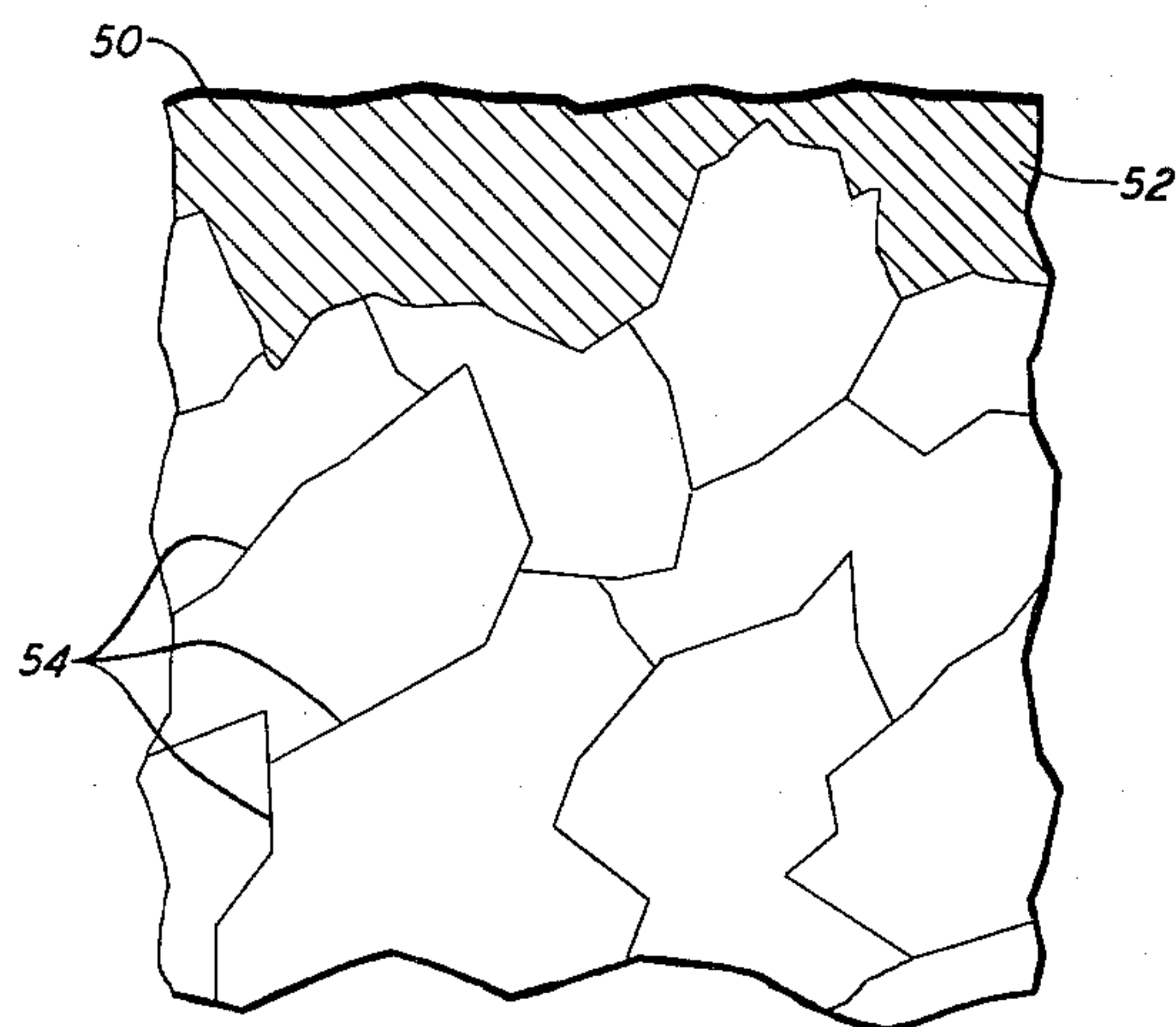


FIG. 2



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METHOD OF MAKING REED-TYPE SWITCH CONTACTS

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This invention relates to switching devices. More particularly, it relates to contacts for such devices and methods of fabricating the contacts.

In modern telephone systems, computing systems, data transmission systems and the like, extensive, complex and intricate switching facilities must be provided and must be capable of reliable, distortionless fault-free operation over long periods of time, during which periods individual switching devices are usually required to operate in the order of a million or more times. Furthermore, in view of the large number of switching devices employed in such systems, it is very important that the devices be as small as possible.

In typical telephone switching systems, by way of example, thirty or more switching devices in series may be required to effect the establishing of a circuit between two subscribers over which "voice" currents are to be transmitted. Obviously, a minimum and stable resistance and freedom from contact sticking must be realized by these switching devices. Variations in resistance of any device included in a circuit carrying voice currents, or other information bearing signals, are particularly objectionable since they may produce "noise" and probably appreciable distortion. Also, if the contacts of a switching device stick, the device is, of course, no longer capable of functioning properly.

The reed-type switch was invented over two decades ago and represents a distinct advance in the art from the standpoints of simplicity, reliability and small size for an electromagnetically operated device. In this switch relatively minute, closely spaced reeds of magnetic material are encapsulated in a glass tube containing an inert gas under pressure. The switch is operated by magnetic flux generated by a very small solenoidal coil surrounding the center of the tube. This switching device has proven suitable for extensive use in switching systems of the above mentioned types.

The course of the development of "reed switches" is described in detail, for example, in an article entitled "Development of Reed Switches and Relays" by O. M. Hovgaard and G. E. Perreault, published in the Bell System Technical Journal, volume 34, No. 2, for March 1955, pages 309 through 332, inclusive. Insofar as it is pertinent, this article is incorporated by reference as an integral portion of the disclosure of the present application.

In the "reed switch," as shown in the above mentioned article at page 311, a pair of flat reeds of a magnetic material are enclosed in a cylindrical glass tube, the reeds being supported as cantilevers with their free ends overlapping longitudinally at the center of the glass tube but being separated by a small gap. The supported ends of the reeds are sealed into glass seals at the opposite ends of the glass tube and extend beyond the glass seals to permit electrical connections to be made to the reeds. As mentioned above, a solenoidal coil placed centrally on the glass tube and surrounding the free ends of the reeds constitutes the operating means. Passage of current through the coil creates a flux which magnetizes the free ends of the reeds and draws them together. The glass tube is usually filled with a chemically inert gas at a pressure somewhat above atmospheric pressure prior to sealing.

At least three sizes of "reed switch," all relatively quite

small, have been used in appreciable quantities. A "medium" sized one is, for example, enclosed in a glass tube approximately one inch long and one-eighth inch in outer diameter, the movable portion of each reed within the glass tube weighing approximately 0.019 gram and being approximately 0.4 inch long, 0.05 inch wide and 8 mils thick. A "larger" sized reed switch employs reeds having movable portions within the enclosing glass tube which weigh approximately 0.19 gram, the over-all dimensions of the parts of this size switch being approximately three times those of corresponding parts of the "medium" size. A third "smaller" size reed switch is approximately one-half the size of the "medium" size and the active portions of the reeds are approximately one-half the weight of the active portions of the reeds of the "medium" size switch. Other "sizes" could, of course, readily be devised by those skilled in the art and undoubtedly have been devised for used where particular operating requirements can be more conveniently met by smaller or larger devices of this type.

By initial adjustment the spacing between the longitudinally overlapping portions of the reed switch within the glass tube is made very small, for example, six mils for a "medium" size switch. In typical reed switches as described above, the contacting force developed by the field of the coil may be low, for example only a few grams, so that it is necessary to employ a minimum thickness of non-magnetic materials over the surfaces which are brought into contact with each other since these materials obviously increase the reluctance of the magnetic path and therefore reduce the contacting force. An appreciably higher resistance in the contact area would, of course, result from any substantial decrease in contacting force.

Some of the difficulties which have been encountered with this type of switch during the past two decades are described in detail, for example, in the above mentioned article by O. M. Hovgaard and G. E. Perreault.

Previous efforts seeking to further reduce the possibility of contact failure due to sticking or high contact resistance in reed-type switches and relays, or an objectionable variation or increase after a short period of service in the resistance of the connections made are also described in detail under the heading "Contact Investigations," pages 319 through 322 of the above mentioned Hovgaard et al. article.

While, as described in the Hovgaard et al. article, a simple, light plating of gold infused into the surfaces of the contacting ends of the reeds substantially eliminates the incidence of failures due to sticking, increased and/or varying resistance effects are encountered in sufficiently numerous instances to indicate a very real need for further substantial improvement. This is particularly important if, as mentioned above, many of these switches are used in series in circuits carrying speech currents or coded signals since "noise" and/or distortion introduced by resistance variations, as well as the over-all cumulative losses resulting from a substantial increase in the total circuit resistance, are obviously objectionable.

As is further explained in the Hovgaard et al. article, difficulties appear to result in many instances from erosion of the contacting areas. The above mentioned article describes in detail three types of erosion which have been observed (see pages 320 to 322, inclusive).

Applicant has discovered that the number of failures resulting from increased resistance in reed-type switches can be very significantly reduced, as compared with switches the reeds of which have simply a single coating of gold diffused into them, by adding a very thin coating of silver over an initial thicker but still thin coating of gold and then subjecting the platings to suitable heat treat-

ment. Neither a coating of gold alone nor a coating of silver alone, heat treated as above, was found to produce a comparable reduction in the resistance of the contact made between the reeds of the switch.

Other materials such as rhodium, palladium and numerous others were also found to be less satisfactory in the sealed reed-type switch than silver when applied in similar manner over the layer of diffused gold. While a precisely demonstratable analysis of the compositions of the several layers of alloy formed on the reeds of the switch by the methods of the invention is not yet available, the examination of photomicrographs of sample cross sections of processed reeds indicates that the silver forms a very thin surface layer of a gold-silver alloy on the contact surface. This thin layer of alloy appears to prevent diffusion of the magnetic materials of the reed (usually 51 percent nickel, 49 percent iron) completely through the composite surface. The gold-silver alloy, when enclosed in an oxygen-free atmosphere, is found to have substantially ideal properties, that is, very low and stable resistance and no tendency to stick. It is further significant to note that gold-silver alloys are not completely satisfactory contact metals for use in the open air since tarnishing or corrosion may be sufficiently troublesome to limit their use to contacts in which an effective wiping action of the contacting surfaces on each other takes place and maintains the surfaces in a clean condition. The reed switch does not provide any appreciable wiping action and, as noted above, has a relatively very small force holding the contacts together when in the operated position. It was therefore not expected that merely placing a layer of silver over the layer of gold and heating the assembly would provide a satisfactory solution as a contact surface for reed switches.

The principal object of the invention is, accordingly, to significantly reduce the difficulties arising from high contact resistance and/or sticking of the contacts in reed-type switches and relays.

Other and further objects, features and advantages of the invention will become apparent from a perusal of the following detailed description of specific illustrative embodiments of the invention taken in conjunction with the accompanying drawing.

In the drawing:

FIG. 1 illustrates to an enlarged scale the reed assembly of a reed-type switch enclosed in its cylindrical glass tube; and

FIG. 2 illustrates to a magnification of 1,000 times the types of alloy layers formed on the contact surfaces of the reeds of a reed switch by the processes of the invention.

In more detail in FIG. 1, a "medium" size reed switch is shown to an enlarged scale and comprises a pair of reeds 16 and 18 which are of magnetic material, each held at one end only by members 24 and 26, respectively. Members 24 and 26 need not be of magnetic material but should have the same temperature coefficient of expansion as glass since they in turn are held by seals 12 and 14, respectively, at the ends of the enclosing cylindrical glass tube 10, as shown. By employing a material which has both suitable magnetic properties and a temperature coefficient of expansion equal to that of the glass of which the tube is made, the reed and its support may be made in one piece. The free ends of reeds 16 and 18 are adjacent but spaced apart by a small distance, as for example, substantially six mils for the medium sized switch. They "overlap" longitudinally by a short distance as for example by substantially 30 mils for the medium sized switch.

The reed 16 has a coating 20 on its left end and reed 18 has a similar coating 22 on its right end, the coatings being diffused into the reeds as will be described in detail hereinafter. Reeds 16 and 18 may be of any suitable magnetic material. A nickel-iron alloy containing 51 percent nickel is magnetically satisfactory and has the additional advantage that it has substantially the same temperature coefficient of expansion as readily available types

of glass and hence can be sealed into the ends of the glass tube. Other magnetic materials may require a two-piece construction, namely, a lead-out portion of a metal having a suitable coefficient of expansion welded to a reed portion having the appropriate magnetic properties. Conductive members 24 and 26 extend through the end seals 12 and 14 to provide convenient, accessible, electrical connecting means to their respective associated reeds. Typical dimensions for the reeds and tube are mentioned hereinabove. As previously mentioned, the glass tube is usually filled with a chemically inert gas at a pressure somewhat above atmospheric pressure.

A preferred process of the invention for applying coatings 20 and 22 on the free ends of reeds 16 and 18, respectively, comprises cleaning the surface thoroughly as, for example, by vapor phase degreasing followed by a hot acid dip using a 50 percent hydrochloric acid solution in accordance with conventional practice in the art, electrolytically depositing a layer of gold of from seven to fourteen milligrams per square inch over the end portion to be covered, electrolytically depositing a layer of silver of from one and one-half to two and one-half milligrams per square inch over the layer of gold, and diffusing the applied layers into each other and into the surface of the reed by heating to a temperature of from 800 to 950 degrees centigrade for a period of from ten to sixty minutes. In the majority of cases a period of fifteen minutes is sufficient. In general, the weight of silver deposited should be between one-quarter and one-sixth of the weight of the gold deposited. In general, the "large" size switch, mentioned above, should have noble metal layers near the maximum values mentioned above, median size switches should have median thickness layers and the small size switch near the minimum thicknesses mentioned above.

Photomicrographs were taken of cross-sectional portions of a nickel-iron reed (51 percent nickel) for a medium sized switch, the reed having been coated and diffused in accordance with the process described above. A particular representative photomicrograph of a section 60 of a reed so processed, taken with a magnification of 1,000 times, is graphically reproduced in FIG. 2. A very thin layer 50 believed to be essentially of a gold-silver alloy having a thickness of substantially one micron is formed on the outer surface. An appreciably thicker, irregular layer 52, believed to be of a varying composition alloy of gold, silver, nickel and iron, the proportions of nickel and iron decreasing appreciably with distance from the center of the reed, layer 52 having a thickness varying between two-tenths to six-tenths of a mil, is formed between the body of the reed and the first mentioned very thin layer 50. The surface represented in FIG. 2 was etched with acid to clean it. Lines 54 represent crystal boundaries of the nickel-iron reed. In general, the combined thickness of the alloy layers 50 and 52 should be between one-tenth and one-thirtieth of the thickness of the magnetic reed.

Substantially the same results can be obtained by including another and intermediate heat treatment at from 800 to 950 degrees centigrade for from five to fifteen minutes after depositing the layer of gold and before depositing the layer of silver.

Since it is believed that the outstandingly satisfactory operation of reed switches of the invention is attributable to the formation of the very thin gold-silver alloy layer 50, having substantially no base metals therein, as described above, if the additional intermediate heat treatment with the gold layer only on the reed is employed, the layer of silver should be applied and heat treated before the lapse of any long time interval to avoid the possibility that the base metals, usually nickel or iron, or both, should diffuse to the outer surface of the gold and subsequently into the gold-silver alloy.

Numerous and varied rearrangements and modifications of the above described illustrative structures and processes

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can be readily devised by those skilled in the art without departing from the spirit and scope of the principles of the invention.

What is claimed is:

1. The process of forming an electrical switching element including a contacting surface on a switch reed of magnetic material which comprises applying to the surface of the reed a first layer of gold, applying to the said gold layer on the reed surface a second layer of silver, heating the reed and said layers at a temperature approximating but less than the melting temperature of silver for a period of from ten minutes to one hour to form an outermost layer of a gold-silver alloy on the contacting surface of the reed and a layer of an alloy of the magnetic material, gold and silver intermediate the said outer layer and the reed, and assembling said switch reed into an electrical switching element.

2. The process of claim 1 in which the layer of gold is applied to a weight of from seven to fourteen milligrams per square inch and the layer of silver is applied to a weight of from one and one-half to two and one-half milligrams per square inch, the ratio of gold to silver by weight being in the range of from four to six.

3. A process of forming a contacting surface on a magnetic reed for use in a reed-type switch, the reed weighing only a small fraction of a gram, which comprises cleaning the surface of the reed, applying to the contacting surface

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a layer of from seven to fourteen milligrams per square inch of gold, applying on the gold layer a layer of silver of from one and one-half to two and one-half milligrams per square inch, the ratio of gold to silver by weight being in the range of from four to six, and subjecting the reed with said layers of gold and silver to a temperature of between 800 to 950 degrees centigrade for a period of from ten minutes to an hour.

4. The process of claim 3 with the additional intermediate step, following the application of the gold layer, of subjecting the reed to a temperature of between 800 to 950 degrees centigrade for a period of from five minutes to approximately one-quarter of an hour after which the silver layer is applied and the process completed as defined in claim 3.

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