Sept. 2, 1958 L. R. BREESE ET AL 2,850,602

RELAY CONTACT ARRANGEMENT

Filed May 16, 1955

Fig. 1

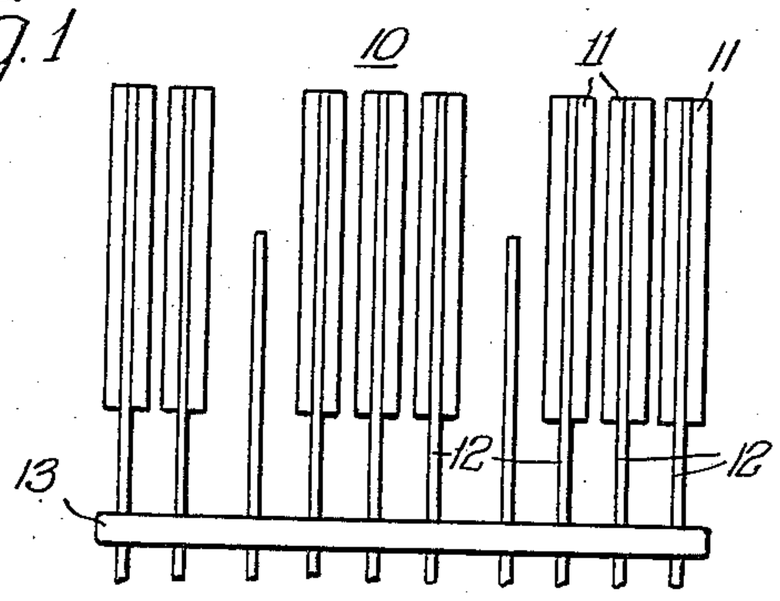


Fig. 2

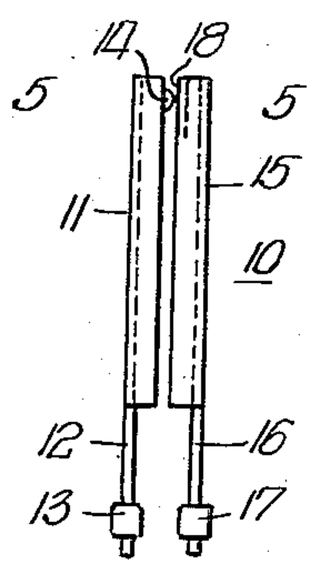


Fig. 3A

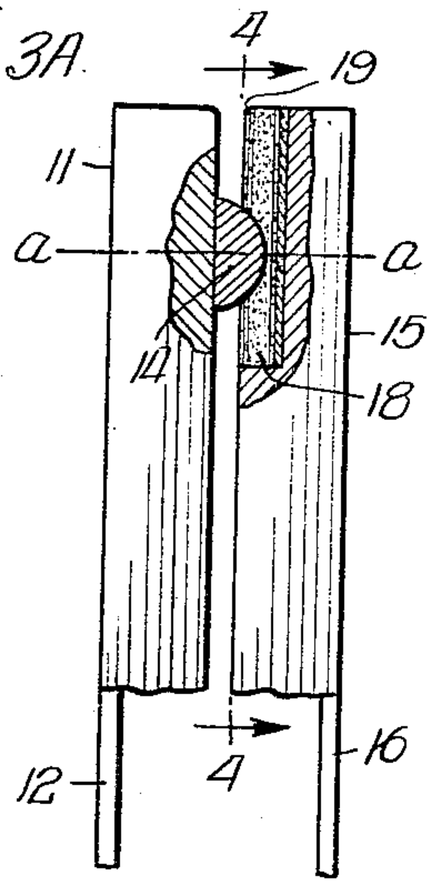


Fig. 3B

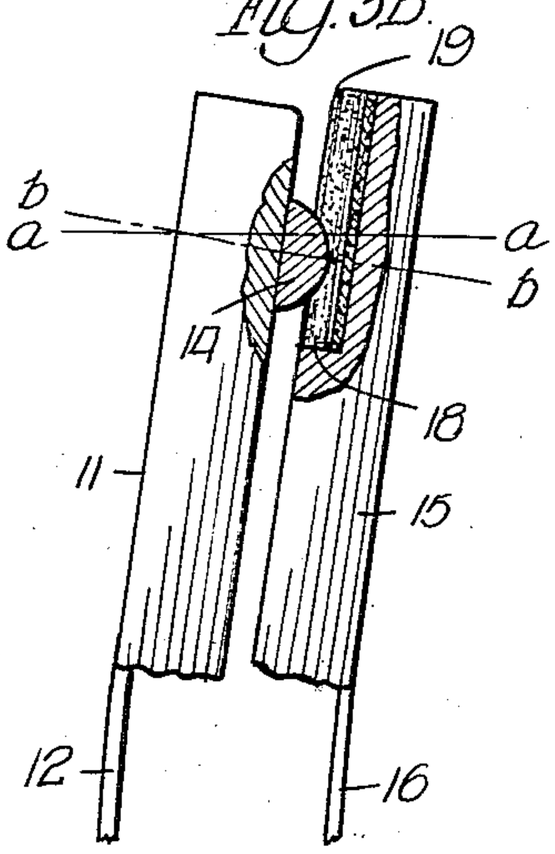


Fig. 4

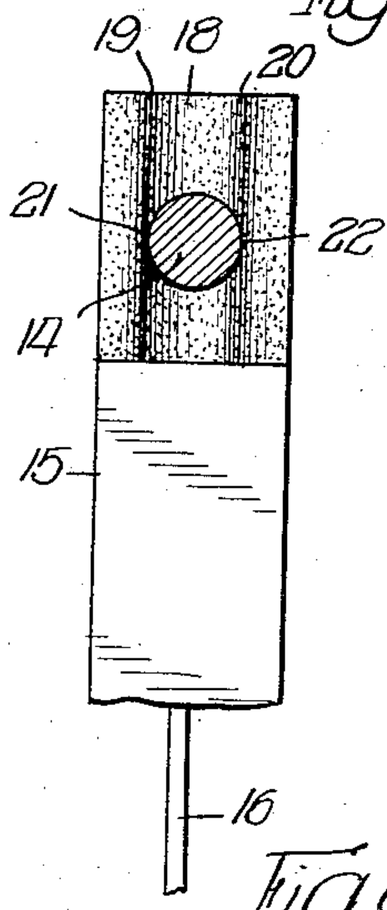


Fig. 5

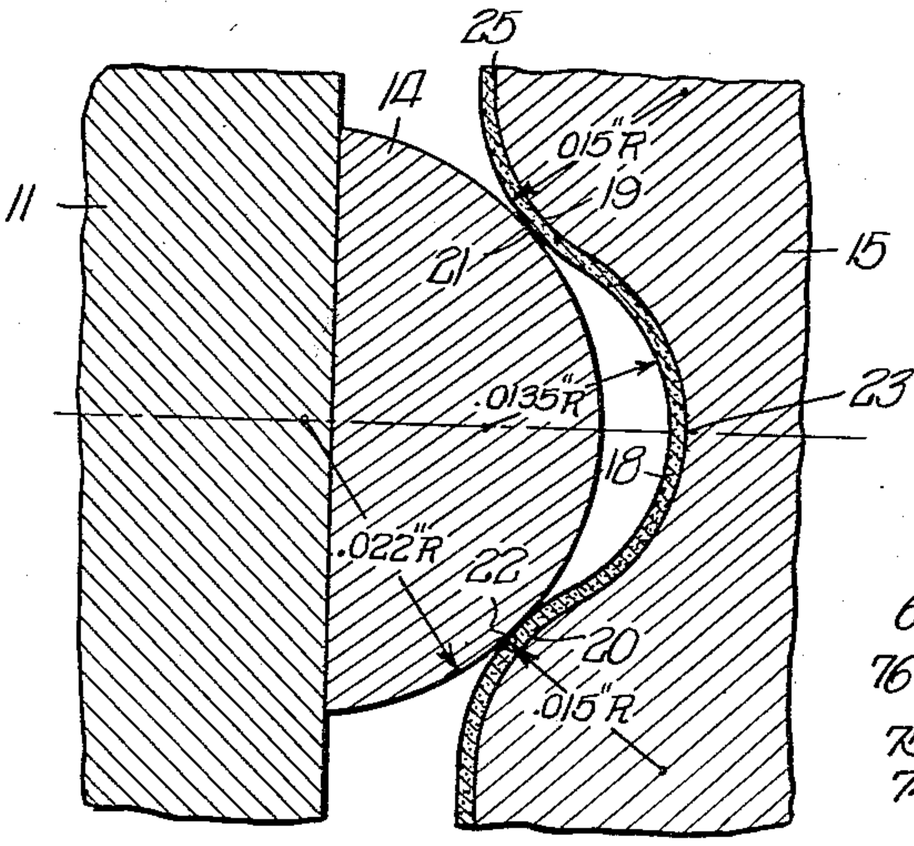
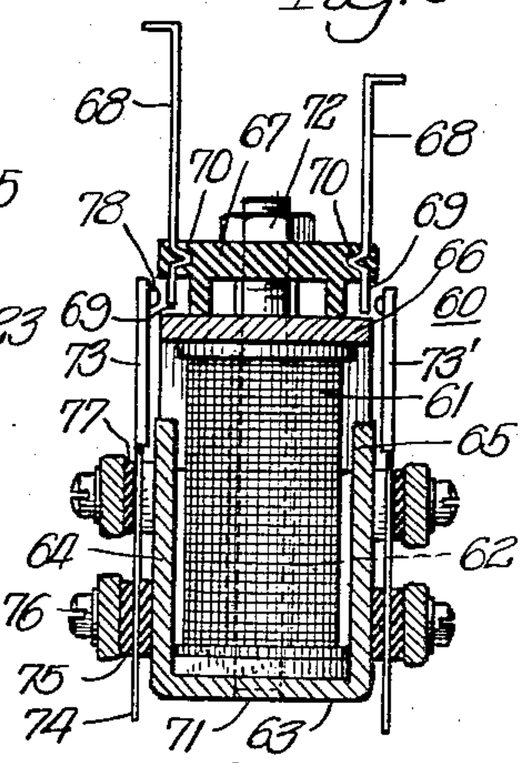


Fig. 6



INVENTORS.
Lemuel R. Breese,
BY Dorsey D. Simmons,
Brown, Jackson, Boettcher & Dienner
attys.

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RELAY CONTACT ARRANGEMENT

Lemuel R. Breese and Dorsey D. Simmons, Galion, Ohio, assignors to North Electric Company, Galion, Ohio, a corporation of Ohio

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The present invention relates to electrical contact elements, and particularly to novel electrical contact elements for use in relay structures.

There has been in recent years a rapid development of the industrial and military fields which has been at least partially accelerated by the increased use of electrical control equipment. Continued use is, of course, dependent upon the ability of the electrical equipment to provide reliable and dependable service; however, the operating conditions in the new uses and applications are such as to seriously deter the accomplishment of such type services with certain known types of contact structures. More specifically, certain newer systems of control require the contacts to control circuits reliably under unusual load conditions.

It is apparent that the provision of reliable and dependable service under the extreme operating conditions encountered in such control circuits is at least partially dependent upon the provision of electrical contact members which are capable of accomplishing repeated circuit control reliably.

Accordingly there is a need in industrial and military fields for electrical contact members which are capable of reducing the number of equipment failures resulting from unreliable operations of the contact structures in their circuit completing functions. Various attempts have been made to improve the reliability of the contact elements in their operation.

In certain low voltage and low current circuits, wherein voltages in the order of two or three volts, and currents in the order of a few milliamperes are encountered, the problems of accomplishing reliable closing and opening of such circuits becomes especially difficult. There seems to be reason to believe that the low order of voltage is sometimes unable to start electron flow through contact resistances encountered. Furthermore molecular films on the surfaces of the contacts tend to interfere with the conductivity of the contact sets. This condition is particularly serious in low voltage applications in that even the lighter films are sufficient to act as a barrier to the passage of low voltages and low currents which are applied to the contact sets. This difficulty cannot be overlooked in applications where unreliable circuit completion may have costly consequences.

Accordingly, one object of the present invention is the provision of a contact arrangement of improved reliability.

Another object is the provision of a contact arrangement of improved reliability for controlling low voltage circuits in the order of a few volts.

Another object of the present invention is the provision of a new and novel contact arrangement characterized by an essentially hemispherical member and a cooperating grooved contact member for overcoming such difficulties.

The present invention is directed to the provision of a novel contact element which is particularly adapted for reliable operation over an increased number of circuit

completing operations, and particularly, to a novel contact structure which lends itself to simple, economical and practical manufacture. The novel contact structure of the present invention basically comprises an essentially hemispherical contact member arranged to co-act with a second contact member which comprises a cooperating surface having a longitudinal groove with parallel bridges formed therein, the hemispherical contact member and the groove being so dimensioned that the surface of the hemispherical contact member touches the ridges of the groove at two points while a depression between the ridges is of sufficient depth to prevent contact therewith. The hemispherical contact member and ridges on the outer surface of the longitudinal groove are made more reliable in their operation by constructing same of highly conducting precious metals such as gold or platinum.

A feature of the invention is the manner in which the contact elements in one embodiment are mounted upon a relay structure in a contact structure comprised of a plurality of contact sets disposed in adjacent spaced relation, the portion of the respective contacts which depends from the contacting surfaces thereon extending in opposite directions to provide a structure which substantially minimizes crosstalk and reduces the capacitance effect between contacts. At least one contact carrying member of each of the sets is mounted on a flexible cylindrical reed which, by reason of its flexibility, permits a wiping and transverse action between the surfaces of the mating hemispherical and groove contact surfaces (as more fully explained hereinafter). As a result of such arrangement the meeting contacts tend to scrape off any insulating molecular film which normally tends to accumulate on the circuit completing surfaces of the contact structures, and accordingly, further improves the reliability thereof.

The contact burnishing feature of the present invention is also evidenced in another modification thereof in which the groove bearing contact element is rigidly held in position, while the contact carrying element to which is affixed a ball contact member is supported on a flexible reed. Upon the movement of the contact member toward the groove and flexure of the reed, contact is first made and subsequently upon further movement of the armature additional flexure of the reed results in a partial rotation and displacement of the contact member within the groove to cause an abrasive action which polishes the contacts.

Additionally, should the hemispherical contact through slight misalignment initially make engagement with one ridge only of the cooperating grooved contact member, the complete transverse freedom of the flexible reed allows the magnetic pull on the armature carrying the hemispherical contact to advance the hemispherical contact along the contour of the ridge until contact is made with the second ridge whereupon the magnetic pull on the armature causes a wedging action at the two points of contact which aids the establishment of an electrical circuit through the two contact points. This also provides a further type of wiping action.

Tests of the new contact arrangement indicate that they possess unusual reliability in closing circuits with millions of operations. This reliability is particularly appreciated in closing dry circuits or circuits involving potentials in the order of only several volts. Furthermore this reliability in conjunction with the degree of longevity make the contact arrangement particularly attractive for use in higher voltage applications such as telephone switchboard multiples.

The basic contact carrying elements may be constructed of any magnetic material attached to flexible shafts of stainless steel, or the like. A hemispherical or button

type contact member of precious metal may be attached to one of the contact carrying elements by spot welding or other suitable methods. The cooperating contact carrying element is formed with a groove extending longitudinally thereof, parallel ridges being provided on either side of a central depression. A groove of this type may be formed by a simple press punch operation on a gold inlay in the contact carrying member, the gold inlay taking the shape of the groove. Alternatively the punch press operation may make the groove in the contact carrying member and a precious metal layer may be plated on the surface and shoulders of the groove.

The above and further objects, features and advantages of this invention will be recognized by those familiar with the art from the following description of a preferred embodiment thereof, as illustrated in the accompanying drawings in the several figures of which like reference numerals indicate like elements, and in which:

Figures 1 and 2 are plan and end views respectively of a bank of movable contact members arranged according to the present invention;

Figures 3A and 3B are enlarged, partially cut-away views of the contact arrangements of the present invention under certain operating conditions thereof;

Figure 4 is a view, partly in cross-section, taken along line **4—4** of Figure 3A to illustrate a particular feature thereof;

Figure 5 is an enlarged, detailed cross-sectional view taken along the line **5—5** of Figure 2 illustrating representative dimensions of the cooperating contact members of the present invention, and

Figure 6 is a cross-sectional view of an alternative embodiment of the relay contact arrangement of the present invention.

Referring now particularly to Figures 1 and 2 of the drawings, it will be observed that reference numeral **10** designates a group of contact carrying members which are generally similar to those used conventionally in relays well known to those familiar with the telephone art. Such a conventional relay structure is disclosed in greater detail in United States Patents numbered 2,396,332 and 2,409,054, issued to Frank R. McBerty on March 12, 1946 and October 8, 1946, respectively, and assigned to the present assignee. In general the illustrated contact carrying members are transversely movable into contacting relationship under the influence of a suitable magnetic field generated by an electromagnet. For purposes of clarity and brevity only the pertinent portions of the contact carrying members and their individual contacts are herein illustrated.

Since corresponding individual contact carrying members are identical, only two complementary ones will be described in detail herein. Contact carrying member **11** comprises magnetic material, such as a nickel-iron alloy having suitable magnetic characteristics, and is of elongated rectangular shape with its longitudinal dimension exceeding greatly its width and depth. The specific form herein shown is illustrative only and other shapes will readily suggest themselves to those skilled in the art. The contact carrying member **11** is mounted on the upper end of a flexible metallic reed **12** which is preferably formed of stainless steel. A strip **13** of insulating material engages reeds **12** and is utilized to hold the individual reeds **12** in fixed relationship with one another and prevent their twisting out of alignment with their complementary armatures. Electrical connection to the metallic reed **12** is provided at the lower end thereof which projects below strip **13**.

Reference may be had to Figure 2 which illustrates contact carrying member **11** and its juxtaposed cooperating contact carrying member **15** in preset spaced relationship. The cooperating contact carrying member **15** is similar in construction to member **11** in that it comprises a block of magnetic material of rectangular form mounted on the upper end of a flexible reed **16**. The

two contact carrying members **11** and **15** are disposed adjacent each other but in non-contacting relationship prior to the energization of the electromagnet (not shown). A molded strip member **17** serves to position and maintain the reed members **16** in a preset relationship similar to that of reeds **12** so that each of the corresponding contact carrying members **11** and **15** is fixed with respect to one another.

As may be seen from Figure 2, a contact member **14** is affixed to the surface of member **11** facing its cooperating contact carrying member **15**. Contact member **14** is in this instance essentially hemispherical or button like in shape and preferably composed of a precious metal, such as gold or platinum, for greater electrical conductivity and resistance to erosion. Contact member **14** is shaped so as to contact the corresponding member **15** in at least two points. In practice contact member **14** may be spot welded to contact carrying member **11** near its top and should be centrally disposed with respect to its width. Alternatively, contact member **14** may be fashioned by deforming member **11** in a power press to produce a substantially hemispherical boss thereon. In this latter case the surface of the contact member should be plated with a precious metal for greater conductivity and longer life. Opposite contact **14**, a groove **18** is formed in contact carrying member **15** extending along the length thereof for a short distance. In one environment a length of $\frac{1}{16}$ inch for groove **18** was found suitable. Groove **18** may be stamped out by a punching operation performed on contact bearing member **15** and is formed in such a manner that its shoulders are spaced so close to each other that the depressed portion of the groove is prevented from contacting the contact completing surface of hemispherical contact member **14**. The shoulders or ridges (shown in greater detail in Figures 3A–5) on either side of groove **16** alone touch the conducting surface of contact member **14** to form a two-point contact.

As before mentioned the surface of the groove is of precious metal which may be an inlay which has taken the form of the groove by a punch press operation or which has been deposited by a plating process after the groove has been formed in the member **18**.

Reference has been made to the wiping action between the hemispherical contact **14** and its cooperating groove **18**. A more detailed explanation of this feature of the invention may be had with reference to Figures 3A and 3B in which Figure 3A is a partially cut-away side view of the contact bearing members **11** and **15** immediately upon the touching of contacts **14** and the ridges of groove **18** upon initial flexure of reed **12**. In Figure 3A contact carrying member **11** under the influence of a magnetic field produced by a source of electromagnetic energy (not shown) is urged to the right to a point where the conductive surface of contact **14** touches the ridges of groove **18**, with initial flexure of reed **12**. A single point on the surface of contact **14** in the horizontal plane of its center-line *a—a*, touches the rearmost ridge **19** of groove **18**. A second point on the surface of contact **14** in the same center-line plane spaced from the first contact point makes contact at the foremost ridge (not shown) of groove **18**. An effective wedging action caused by the movement of contact carrying member **11** against contact carrying member **15** ensues to force the two points on the surface of hemispherical contact **14** into tight engagement with the two spaced ridges or shoulders of groove **18**. As may be seen in Figure 3A the length of groove **18** is such that it extends a short distance below the center-line *a—a* of contact **14**. The purpose of such elongation of groove **18** will be apparent hereinafter.

Upon further urging by the magnetic field, contact carrying member **11** is moved further to the right and further flexes its supporting reed **12**. As the contact points on the surface of contact **14** press against the

ridges of groove **18**, the flexible reed **16** which supports contact carrying member **15** is also bent. Since the lengths of reeds **12** and **16** are fixed, a sliding action between contact **14** and groove **18** takes place so that member **15** is effectively moved upward with respect to contact carrying member **11** and carrier groove **18** with it. It is now evident that the surface of hemispherical contact **14** makes two point contact with the ridges of groove **18** at new points farther down the length of groove **18**. The new points of contact are in a plane containing line *b*—*b*. The distance between lines *a*—*a* and *b*—*b* taken along the outer edge of one of the ridges of groove **18** is indicative of the amount of wiping action taking place between contact **14** and its cooperating groove. Inasmuch as contact **14** rides along the outer surface of the ridges of groove **18** as the two contact carrying members **11** and **15** move with respect to one another, this wiping action takes place to penetrate any molecular insulating film which might have accumulated on the surfaces of either contact **14** or the ridges of groove **18**, and to bring the cooperating contact surfaces more firmly together.

The two point contact arrangement between contact **14** and the ridges of groove **18** may be more readily seen with reference to Figures 4 and 5 in which Figure 4 is a partly sectional view taken along line **4**—**4** of Figure 3A and Figure 5 is a sectional view taken along line 5—5 of Figure 2 upon the touching of contact **14** and the ridges of groove **18**.

With reference to Figure 4 it may be noted that ridges **19** and **20** of groove **18** extend longitudinally of contact carrying member **15** and form a parallel track upon which the hemispherical surface of contact **14** rides during the relative movement of contact carrying members **11** and **15**.

The surface of hemispherical contact **14** touches ridges **19** and **20** of groove **18** at points **21** and **22** respectively. As may be seen from Figures 3A and 3B these points of contact move vertically as the contact carrying members **11** and **15** are moved from their rest position and the flexure of reeds **12** and **16** occurs.

The two contact points **21** and **22** between the surfaces of hemispherical contact **14** and ridges **19** and **20** respectively are shown in the enlarged cross-sectional view of Figure 5. In this figure, groove **18** comprises two ridges or shoulders **19** and **20** flanking a depressed portion **23**. The surface of groove **18** consists of a coating **25** of gold or other highly conducting, erosion resisting metal to form a corrosion and erosion resisting contact, which surface is in the stamped precious metal inlay which has taken the form of the groove. Alternatively the groove can be stamped in the contact carrying member and a precious metal plated on the surface of the groove.

In Figure 5 may be found typical dimensions for the radius of the hemispherical contact **14** and the various surfaces of groove **18**. While these dimensions are derived from a practical operating embodiment of the invention, they are for illustrative purposes only and the invention should not be circumscribed by these specific dimensions.

The following chart is a summary of these illustrative dimensions:

Radius of curvature of contact **14**_____	.022 in.
Radius of curvature of ridges **19** and **20**__	.015 in.
Radius of curvature of depression **23**____	.0135 in.
Thickness of gold alloy **25**_____	.005 in.
Length of groove **18**_____	1/16 in. approx.

An actual commercial embodiment of the novel contact structure of the present invention is illustrated in Figure 6 wherein the groove carrying contact member is rigidly maintained with respect to the remainder of the relay structure proper shown generally by the reference character **60**. Relay **60** comprises an electromagnetic means including a coil **61** disposed on a core **62** of magnetic material which extends upwardly from a U-shaped back

bar or pole piece **63** having sides **64** and **65** which extend upwardly forward but fall short of a pole piece **66** to form air gaps. Pole piece **65** is carried by the upper end of coil **61**. A block of insulating material **67** in which are embedded the groove bearing contact elements **68** is mounted upon the upper surface of pole piece **66**. Each contact member **68** is disposed so that groove **69** is facing outwardly and is maintained in this position by virtue of a reentrant portion **70** embedded in block **67**. The complete relay including U-shaped pole piece **63**, core **62** and its encompassing coil **61**, upper pole piece **66** and insulating block **67** is held together by a countersunk bolt **71** threaded centrally through the above assembly and secured in place by a nut or other fastening means **72**.

Complementary contact carrying elements or armatures *73* and *73'* of magnetic material are vertically disposed adjacent to but spaced from sides **64** and **65** of pole piece **63** and extend upwardly to span the gap between pole pieces **63** and **66**. For convenience, only armature **73** will be described, it being understood that armature *73'* is identical in structure and operation. Contact carrying element **73** is supported by flexible reed **74** which is embedded in an insulating strip **75** which in turn is held in place by a bolt **76** tapped into pole piece **63**. A short distance below armature **73** is disposed a strip of insulating material **77** in which small grooves are cut to guide the reeds in their movement and prevent any excessive sideward movement thereof. At the upper end of armature **73** is a small herispherical contact member **78** which is disposed to engage contact receiving groove **69** to complete an electrical circuit therewith.

In operation the electromagnetic coil **61** is energized by an electrical circuit (not shown) connected thereto and generates a magnetic field which flows in an external circuit through U-shaped pole piece **63**, across the air gaps between pole pieces **63** and **66** and through pole piece **66**. The armature **73** which spans this gap, being of magnetic material, is therefore attracted toward the pole pieces until contact **78** carried thereby touches groove **69** in member **68** to complete an external electrical circuit (not shown). Because of the tractive force of the magnetic field thus produced, the armature is slightly further moved toward pole pieces **63** and **66**. Since the contact carrying end of armature **73** cannot move forward as it is wedged into groove **69** in rigid member **68**, the magnetic force causes the lower end of armature **73** to continue its movement toward side wall **64** of pole piece **63** for a short distance but far short of contact with side wall **64**. Thise movement of armature **73** after the closure of the contacts causes it to pivot longitudinally about contact **78**. This pivotal movement is imparted to the contact member **78** which partially rotates and abrades against the ridges of groove **69** to wipe off any accumulation of molecular film. Additionally, contact **78** moves up and down in groove **69** to increase the abrasive action and further polish the contacting surfaces. Consequently a polishing action occurs which insures good electrical contact even under such adverse conditions as occur in low voltage and low current circuits. If the hemispherical contact should touch one ridge only, it is pulled into contact with the second ridge. Any bouncing back and forth between contacts is rapidly damped and solid two point wedging contact established. Additionally this provides an additional wiping action.

It should also be observed that the two point contact arrangement reduces contact failure if a bit of foreign material lodges between the hemispherical contact and one of the shoulders of the groove.

Factors which make for reliability in the instant invention comprise precious metal contacts, wiping action, two point contact, reduced area of contact, and wedging action.

Thus the contact arrangement of the invention is par-

ticularly pertinent in providing reliability in low voltage applications and its good degree of longevity in conjunction with reliability make it applicable for higher voltage applications such as telephone switchboards, etc.

In summary the present invention is directed toward a relay contact structure which exhibits a greatly enhanced reliability by means of a two-point abrasive and wedging contact between a contact member having an essentially hemispherical circuit completing surface and a cooperating groove whose shoulders or ridges are disposed to receive the contact member. The circuit completing surfaces of the hemispherical contact member and the ridges of the groove are fashioned of a highly-conductive corrosion resisting metal, such as gold or platinum. The contact arrangement produces a wiping and wedging action which inhibits the accumulation of insulating films on the surfaces of the cooperating contact areas and bites through films.

In short the present invention is directed toward a new and novel contact structure characterized by an increased reliability combined with a simplicity of manufacture which results in a more economical and more desirable relay structure.

While what has been described is regarded to be a preferred embodiment of the invention it will be apparent that variations, rearrangements, modifications and changes may be made therein without departing from the scope of the present invention as defined by the appendant claims.

We claim:

1. A relay arrangement comprising a plurality of

contact sets disposed in spaced, adjacent relation; each of which sets includes a first contact carrying member having an essentially hemispherical contact surface thereon, a second contact carrying member having a groove contact surface integrally formed thereon with the sides of the groove fixedly positioned relative to each other, the portions of said contact carrying members which depend from said contact surfaces extending in opposite directions from said contact surfaces, support means for said first and second contact carrying members including a fixed support for one of said members and a flexible wire reed support for the other of said members to permit transverse movement of the contact surface of one member relative to the contact surface of the other member, whereby two point contact is provided; and magnetic field producing means operative to move said hemispherical contact surface of the first contact carrying member into mating relation with the groove surface of the second contact carrying member.

2. A relay structure as set forth in claim 1 which includes means for supporting said magnetic field producing means and the contact carrying member supported by said flexible reed to permit further flexing of said reed by said magnetic field producing means subsequent to mating of said contact surfaces.

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