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ARC-CONTROLLING AUXILIARY CONTACT ASSEMBLY FOR ELECTRIC SWITCHES

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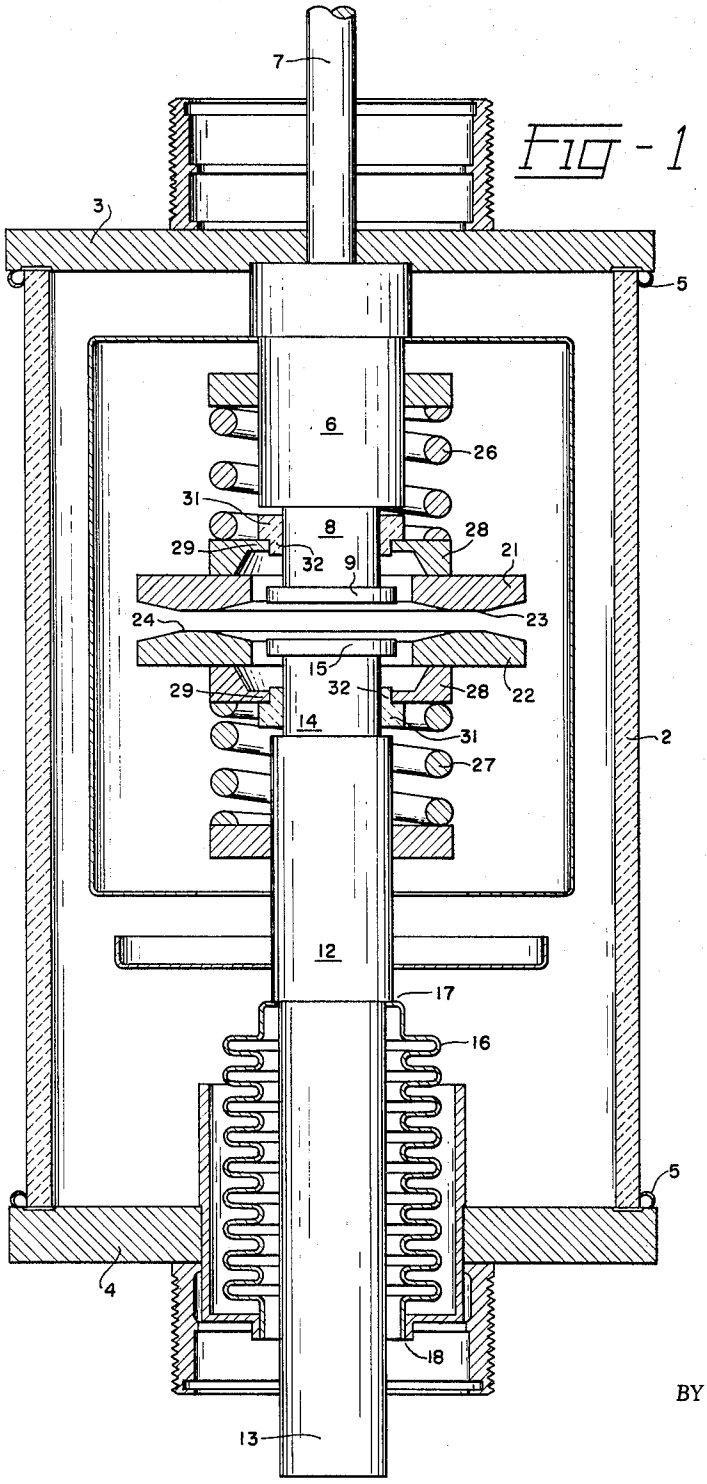


Fig - 1

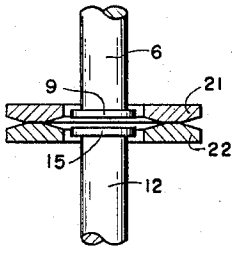


Fig - 2

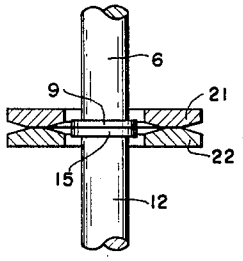


Fig - 3

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ARC-CONTROLLING AUXILIARY CONTACT ASSEMBLY FOR ELECTRIC SWITCHES

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The invention relates to vacuum switches; and more particularly to the electrodes or contacts thereof which make and break the circuit through the switch.

In vacuum switches of high current carrying capacity, for the purpose of reducing contact pitting and erosion, it is desirable that localized concentration of a high current arc between the contact surfaces be avoided by causing the arc to move about over the surface of the contact.

One of the objects of the present invention is to provide a vacuum switch contact structure having low contact resistance when the switch contacts are closed, while permitting rapid breaking of the circuit with a minimum of arcing and attendant vaporization, thus extending the life of the contact surfaces.

Another object of the invention is the provision of a novel vacuum switch contact structure that cooperatively associates a low resistance, high current-carrying contact and an auxiliary breaking contact of high melting point to form a contact assembly of high efficiency, low temperature operation, resulting in an increase of the working life of the switch many times what is normally to be expected of ordinary or single-contact switches.

Still another object of the invention is the provision of a switch contact assembly which permits rapid making and breaking action; and at the same time prevents rebounding or bouncing of the engaged contact elements such as would cause excessive arcing or welding together of the engaged contacts.

A still further object of the invention is the provision of a dual contact assembly for an electric switch in which parallel conductive paths are provided through the contact area of the switch, and in which single actuator means are provided for controlling the making and breaking of a circuit through each of the parallel paths.

A still further object of the invention is the provision of a contact assembly in which conduction of electric current through the switch when the switch contacts are closed is channeled through parallel paths, each of said paths being adapted to make and break at different times.

Other objects and advantages will be brought out in the following description of the invention. The invention is not limited to the showing made in the description and drawings, since variant forms of the invention may be adopted within the scope of the appended claims.

Referring to the drawings:

FIG. 1 is a vertical sectional view with some of the interior parts shown in elevation and illustrating the dual contact assembly embodied in a single-ended switch.

FIG. 2 is a fragmentary view of the contacts at the instant of closing the auxiliary circuit through the annular or ring contacts and immediately before the closing of the main circuit through the stud contacts. It also may be considered to illustrate the positions of the contacts at the instant when the stud contacts have been drawn apart to break the main circuit, leaving the ring or auxiliary contacts engaged and about to be drawn apart to break the auxiliary circuit.

FIG. 3 is a fragmentary view illustrating both stud and auxiliary contacts closed to provide parallel current paths through the dual contact assembly to permit a maximum flow of current through the switch.

In broadly descriptive terms the invention provides

a pair of stud contact assemblies each of which includes a high current-carrying stud contact for conducting most of the current when the switch is closed; and an annular auxiliary contact assembly constituting a making-breaking element of low vapor pressure material for initiating the closing and opening cycles. This use of dual contact assemblies achieves the advantage of low contact resistance and at the same time reduces arcing and vaporization of contact material. Stud contacts which may be of copper, carry major currents for either A.C. or D.C. They present low contact resistance and hence are able to carry high currents without over-heating. The annular auxiliary contacts on the other hand close before the stud contacts to "make" the circuit and "break" last to interrupt the main circuit, so that there is little or no destructive arcing across the relatively high vapor pressure stud contacts in the main circuit, and so that any arc that forms between the annular contacts is rapidly spun about the contact by the interaction of the magnetic field generated by current flowing through the coil-like conductors connected to the annular auxiliary contacts and the magnetic field generated about the current arc itself.

In more specific detail, the switch comprises a vacuumized envelope including a generally cylindrical dielectric shell **2**, conveniently of ceramics, hermetically closed at opposite ends by metallic end or terminal plates **3** and **4** on each of which a contact assembly is mounted.

Each terminal plate is hermetically united to the associated end of the dielectric shell by a flexible metallic seal ring **5** as shown. In a practical structure, the end plates **3** and **4** are conveniently fabricated from heavy copper, while the dielectric portion of the envelope is fabricated from an alumina-type ceramic material.

Inasmuch as the thermal coefficients of expansion and contraction of these two materials vary widely, it is desirable that some means be utilized which provides a compensating factor for such expansion and contraction between the two materials while providing the requisite rigidity. It has been found that the structure shown is adequate for this purpose.

Rigidly mounted on end plate **3** is a centrally disposed axially extending stud contact member **6**, having a portion **7** extending out of the envelope and useful as a means of connecting the switch into a circuit. The inner free end of the stud member provides an inner contact portion **8** of reduced diameter as shown, and on which a contact button **9** is brazed. In the construction shown the stud contact member **6** is conveniently fabricated from large diameter copper bar stock, while the contact button **9** may conveniently be fabricated from a more refractory material such as tungsten. The diameter of the contact button is preferably somewhat larger in diameter than the reduced diameter portion **8** of the conductive contact member **6** in order to force a current loop to form during the passage of current through the switch.

Slidably disposed on the end plate **4** is a second stud contact member **12**, having a portion **13** extending out of the envelope in opposition to the portion **7** of the opposed stud contact, and having an inner end contact portion **14** as shown of somewhat smaller diameter than the remaining portion **12** of the stud contact and also smaller in diameter than a flat plate-like contact button **15** brazed thereon. The slidable union between the conductive member **12** and end plate **4** is hermetically sealed by interposing a suitable expansionable metallic bellow **16** between the stem **12** and the end plate **4**. These unions may be made in any suitable manner as by brazing at the closed end **17** of the bellows and heliarc welding at the open end **18** of the bellows where it is united to the end plate **4**.

As thus shown, movement of the member **12** axially with respect to member **6** will result in the contact surfaces of contact members **9** and **15** being brought into or

out of engagement, depending on the direction of movement of the member **12**. It has been found that with high power vacuum switches so constructed, when the contact surfaces **9** and **15** are pulled apart, an arc tends to strike between the contact surfaces, such arc often eroding and pitting the contact surfaces and causing vaporized contact metal to be deposited on surrounding structure, including the dielectric wall between the end plates **3** and **4**. To prevent accumulations of such vaporized material on the dielectric member from forming a continuous conductive path between the end plates, elaborate shielding structures forming no part of this invention have been devised to intercept and condense vaporized contact material.

It has been found that the liberation and deposition of such vaporized contact material can be lessened materially and substantially eliminated in its harmful effect by providing auxiliary contacts in the contact assembly to carry the high momentary current when the main or stud contacts **9–15** are broken. As shown best in FIG. 1, the auxiliary contact assembly comprises a pair of annular plate-like contacts **21** and **22**, associated respectively with contacts **9** and **15**. As clearly shown in FIG. 1, the oppositely disposed annular auxiliary contact plates are provided, respectively, with annular contact zones **23** and **24**, each of the contact zones being radially spaced between the inner and outer peripheries of the respective contact plate. With respect to each of the annular auxiliary contacts, the contact zone is defined by conically tapered surfaces adjacent the inner and outer peripheries of the contact plate as shown.

To mount the annular auxiliary contact plates **21** and **22** on the associated contact members **9** and **15** so as to provide a parallel path through the contact assemblies, the annular contact plates **21** and **22** are resiliently supported coaxially about the associated contacts **9** and **15**, respectively, by heavy conductors **26** and **27**, each spirally coiled about the associated conductive contact members **6** or **12** respectively. The end of the coil conductor remote from the associated annular contact is rigidly secured in a mechanically strong and electrically conductive manner to the conductive member **6** at a point remote from the contact **9**. The other end of the coil conductor is rigidly welded to an annular insert **28** which is in turn brazed to the surface of the contact **21** opposite the contact zone **23** as shown. The insert **28** is provided with a radially extending flange portion **29** upon which is suitably secured a dielectric member **31** having a cylindrically extending flange **32** interposed between the flange **29** and the associated reduced cross-sectional portion **8** of the member **6**. The dielectric member **31** may be in the nature of a bushing slidably disposed on the reduced diameter portion **8** of the contact member **6** and may be secured to the flange **29** of insert **28** in any suitable manner such as by a split spring ring (not shown) or by brazing. The annular auxiliary contact-plate **22** is similarly supported on the contact member **12**, and like numbers have been utilized to designate like parts.

Referring to FIG. 1, it will be apparent from the relationship of contact zones **23** and **24** with respect to the associated contact surfaces **9** and **15** of the stud contacts that when the switch is in open position as shown in this figure, inward movement of the contact member **12** to close the contacts will result in inward movement of the contact **22** toward the contact **21**. The parts are proportioned so that such movement will bring the contact zones **23** and **24** of the annular contacts into abutting relationship before the contacts **9** and **15** abut. Therefore, upon closing of the switch into the position illustrated in FIG. 2, the circuit will first be made through the annular auxiliary contacts **21** and **22**. Continued movement of the contact member **12** in a closing direction will compress the coil conductor members **26** and **27**, thus placing the contacts **21** and **22** under a resilient contact pressure, and, simultaneously, will tend to bring contacts **9** and **15** into abutting relationship. As soon as this has occurred, it will be obvious that a parallel path is provided through the contact assembly to help carry the current load. Obviously, because of the relatively greater cross-sectional area of the stud contacts **9** and **15**, a major portion of the current will be carried through this set of contacts. It will of course be obvious that the resilient mounting of the initially "made" contacts **21** and **22** tends to prevent bounce or chatter between these annular contacts, so as to prevent arcing or sputtering of contact metal therefrom. At the same time, inasmuch as there is a parallel path to carry the load, any bounce or chatter which occurs between the main or stud contacts **9** and **15** does not result in arcing between these contacts.

Upon opening movement of the movable conductor member **12** from the position illustrated in FIG. 3 for example, it will be clear that the stud contacts **9** and **15** part immediately, thus breaking one of the parallel paths through the complex contact assembly, and shifting onto the other parallel path, namely through the coil conductors **26** and **27** and auxiliary contacts **21** and **22**, the momentary load of the full current being carried by the switch. This shifting of the current load through the auxiliary contacts prevents striking of an arc between contacts **9** and **15**, and insures an inlimited lift expectancy for these contacts. As movement in an opening direction continues, and the annular auxiliary contacts **21** and **22** part, an arc will be struck between the spaced contacts **21** and **22**, but because of the novel mounting for these contacts, the arc will be caused to spin in a circular path over the contact zones **23** and **24**, thus minimizing the vaporization of contact metal which would occur if the arc were permitted to stand in one spot. Spinning of the arc is accomplished by the interaction of the magnetic field which is generated by the coil conductors **26** and **27**, and the magnetic field which is naturally formed about the arc.

From the above, it is clear that one of the important functions of the electrically conductive heavy coil springs **26** and **27**, and annular auxiliary contacts **21** and **22** to carry a major portion of the mechanical and electrical burden imposed by the making and breaking sequences of the switch, while the stud contacts **9** and **14**, carry the major electrical burden only when both sets of contacts are closed.

Another important function of the annular auxiliary contact assembly is to provide a means of spinning the arc over a relatively large surface in order to minimize vaporization of contact metal. In this respect it is important to note that the coil conductors **26** and **27** are wound in the same direction with respect to the axis of the switch, so that both of the coils **26** and **27** cooperate to generate a single magnetic field. It is clear of course that if the coil conductors **26** and **27** are wound in opposite directions, each of the coil conductors will generate its own independent magnetic field, and the polarity of these fields will be in opposition to each other. The effect of opposed fields is to cancel out the fields and prevent interaction of a single magnetic field generated by the coil conductors with the magnetic field generated by the arc. The effect is manifested by the tendency to drive the arc toward the inner periphery of the annular contacts or at best keep it spinning in a circle having a fixed radius. It has been noted also that when the coils are wound in opposite directions the diameter of the arc itself is restricted. By comparison, when the coils are wound in the same direction as illustrated in FIGURE 1, the arc is forced toward the outer periphery of the annular contact, thus increasing the length of the path over which the arc moves, and the diameter of the arc is substantially greater, thus permitting the passage of more current. Additionally, tests have revealed that when the coils are wound in the same direction the arc does not follow a fixed circular path but tends to wander over the faces of the annular contacts, thus minimizing the generation of heat and the vaporization of contact metal.

I claim:

1. In a vacuum electric switch including an envelope having a dielectric portion closed at opposite ends by metallic end plates and coaxially disposed stud contacts supported on opposite end plates, one of which stud contacts is movable axially with respect to the other to make or break a circuit theretbetween, the improvement comprising a pair of auxiliary contacts coaxially disposed about the stud contacts, each said auxiliary contact having a contact surface lying in a plane substantially perpendicular to the axis of said stud contacts to permit non-sliding abutment of said auxiliary contact surfaces, and means mounting each of the auxiliary contacts for movement relative to the associated stud contact upon actuation of the switch.

2. The combination according to claim 1, in which the auxiliary contacts are proportioned to engage before the stud contacts upon closing of the switch to make a circuit therethrough and to disengage after such stud contacts upon opening of the switch to break the circuit through the switch.

3. The combination according to claim 1, wherein each of the auxiliary contacts comprises an annular plate having an annular contact zone radially spaced between the inner and outer peripheries thereof with the surface of the plate immediately adjacent the contact zone tapered away from the contact zone toward the inner and outer peripheries, respectively.

4. The combination according to claim 1, in which means are provided resiliently mounting each auxiliary contact respectively, on an associated stud contact.

5. The combination according to claim 4, in which a dielectric bearing is interposed between each of the auxiliary annular contacts and the associated stud contact.

6. The combination according to claim 4, in which said resilient means for mounting said auxiliary contacts comprises an axially aligned coil spring wound about the associated stud contact.

7. The combination according to claim 5, in which the end of each stud contact adjacent its contact surface is reduced in diameter to less than the diameter of the contact surface thereof and the dielectric bearing is slidably disposed on the reduced diameter portion of the stud contact to guide the associated auxiliary annular contact.

8. In a vacuum electric switch, a contact assembly comprising a pair of axially disposed stud contacts, a pair of auxiliary annular contacts surrounding said stud contacts, and resilient means connecting said auxiliary annular contacts to said stud contacts whereby upon actuation of the switch to make a circuit through the switch said auxiliary contacts make contact before said stud contacts to establish a parallel conductive path through the switch and upon actuation of the switch to break the circuit therethrough the stud contacts break contact before the auxiliary contacts so that the annular auxiliary contacts alone carry the momentary surge of current through the switch upon separation of said stud contacts.

9. The combination according to claim 6, in which the turns of the coil spring are wound in the same direction.

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