July 12, 1966 L. L. ALSTON ETAL 3,260,810

ELECTRIC SWITCH WITH FRANGIBLE AND EXPENDABLE ELECTRODES

Filed Nov. 20, 1964

FIG. 1.

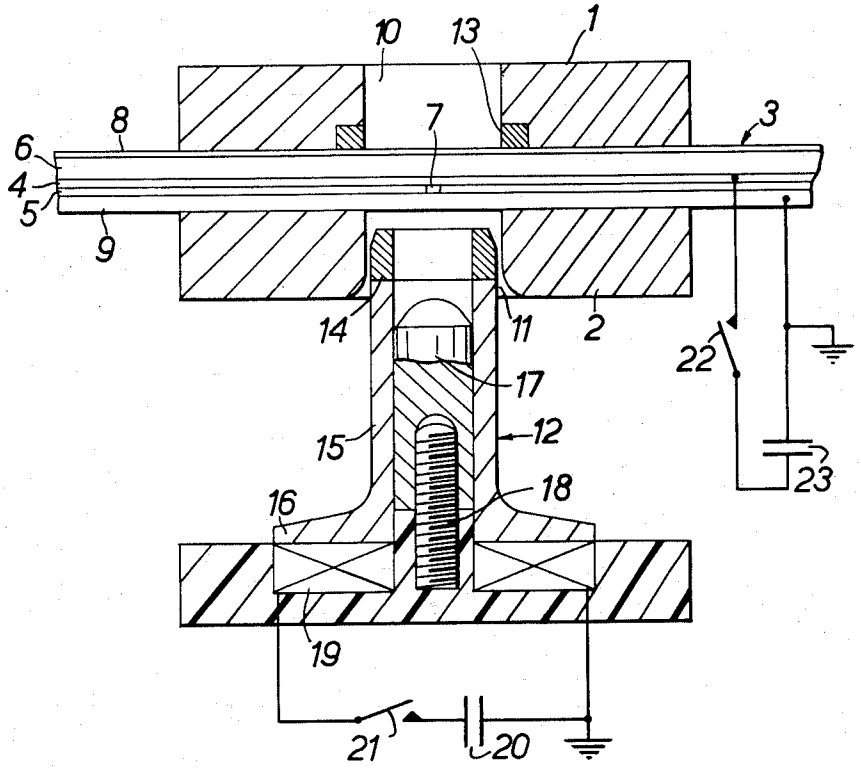
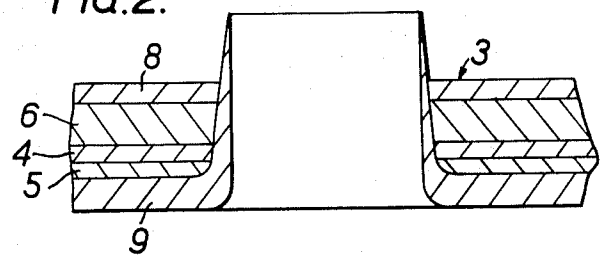


FIG. 2.



United States Patent Office 3,260,810 Patented July 12, 1966

3,260,810

ELECTRIC SWITCH WITH FRANGIBLE AND EXPENDABLE ELECTRODES

Liviu Leonard Alston, Abingdon, and Patrick Joseph Rogers, Oxford, England, assignors to United Kingdom Atomic Energy Authority, London, England

Filed Nov. 20, 1964, Ser. No. 412,674
6 Claims. (Cl. 200—61.08)

This invention relates to electric switches.

Copending United States patent application No. 403,891 discloses a switch comprising a layer of electrically-insulating material sandwiched between two metallic layers which form expendable electrodes, and two main electrodes between which the sandwich is held such that the two main electrodes contact the two expendable electrodes respectively. The electric supply to be switched is connected across the main electrodes which have in them a pair of aligned apertures normal to the general plane of the sandwich. The switch also includes a plunger and means operated when the switch is to be closed to force the plunger into the apertures such that the sandwich is pierced and deformed portions of the expendable electrodes are in contact and complete the electric path between the main electrodes.

A switch of this form can be made to close in about 40 microseconds with say 40 kilovolts across it. Although very fast by the standards of mechanical switches, this closing time is long by the standards of electronic switches.

An object of the present invention is to provide a switch of the general kind described above but with a shorter closing time.

According to the present invention, an electric switch comprises an inner metallic layer sandwiched between first and second layers of electrically-insulating material which in turn are sandwiched between two expendable electrodes, two main electrodes between which the sandwich is held such that the two main electrodes contact the two expendable electrodes respectively, the electric supply to be switched being arranged to be connected across the main electrodes, an aperture extending through the first layer substantially normal to the general plane of the sandwich, a pair of aligned apertures in the main electrodes substantially normal to the general plane of the sandwich, a plunger, and means operated when the switch is to be closed to cause an electric discharge from one main electrode via the aperture in the first layer to the inner metallic layer whereby said second layer is ruptured and an electric path is thereby completed between the main electrodes, said means also causing the plunger to be forced into the apertures in the main electrodes such that the sandwich is pierced and deformed portions of the expendable electrodes are in contact and complete a low resistance electric path between the main electrodes.

Each expendable electrode may be formed by a metallic layer, the expendable electrode first pierced by the plunger being formed of a relatively soft and ductile metal and the other expendable electrode being formed of a relatively hard metal. The expendable electrodes may be formed of annealed copper and hard rolled copper respectively.

A switch in accordance with the present invention will now be described by way of example with reference to the accompanying drawing, in which:

FIGURE 1 shows the essential parts of the switch diagrammatically, and

FIGURE 2 shows an enlarged detail of part of the switch after closure.

Referring now to FIGURE 1 of the drawing, the switch includes a pair of main electrodes **1** and **2**, between which is positioned a sandwich **3** comprising a metallic layer **4** between a polystyrene layer **5** and a polythene layer **6**. An aperture **7** extends through the polystyrene layer **5** substantially normal to the general plane of the sandwich **3**. The sandwich **3** also includes copper layers **8** and **9** which are adjacent the main electrodes **1** and **2** respectively, and which form expendable electrodes. The layer **9** is formed of soft annealed copper and the layer **8** is formed of hard rolled copper.

The main electrodes **1** and **2** have aligned apertures **10** and **11**, respectively, into which a plunger **12** is forced when the switch is to be closed. The inner edge of the main electrode **1** has a hard steel insert **13** on the side nearer the plunger **12**

The plunger **12** has a hollow, tapered tip **14** of steel at the end which is to pierce the sandwich **3**. The remainder of the plunger **12** is of duralumin and consists of a hollow shaft **15** and a disc **16**. The plunger **12** is movably axially on a brass guide **17** carried on an insulating rod **18**, and in the rest position shown has the disc **16** adjacent a resin-encapsulated coil **19**.

In one embodiment of the switch the apertures **10** and **11** each have a diameter of 1.025 inches, the plunger **12** has a diameter of 0.98 inch, and the tip **14** is tapered at an angle of 20° to the axis of the plunger **12** for a distance of 0.125 inch from the end.

A capacitor **20** is connected across the coil **19** by way of a very fast, subsidiary, electronic switch **21**, and the metallic layer **4** is connected by way of a very fast subsidiary, electronic switch to an energising capacitor **23** and thence to the expendable electrode **9** which is earthed. The switches **21** and **22** may be trigratrons.

The operation is as follows. The electric supply to be switched is connected across the main electrodes **1** and **2** which, with the switch open, are insulated from one another by the polythene layer **6**. The capacitors **20** and **23** are charged to suitable potentials.

When the switch is to be closed, the subsidiary switches **21** and **22** are closed so causing the voltage across the capacitor **23** to be applied between the expendable electrode **9** and the metallic layer **4** causing an electric discharge via the aperture **7**. This, in turn, causes a portion of the metallic layer **4** adjacent to the aperture **7** to be vaporised and the polythene layer **6** to be ruptured so that a current path is completed between the main electrodes **1** and **2**.

There is also a rapidly rising current in the coil **19** due to closure of the switch **21**, this current inducing an oppositely sensed current in the disc **16** which results in the plunger **12** being forced into the apertures **10** and **11**, so that the tip **14** of the plunger **12** pierces the sandwich **3**. This causes a section of the expendable electrode **8** (which is hard) to be punched out. The appropriate part of the expendable electrode **9** (which is soft and ductile) is however extruded to contact the expendable electrode **8** to which it may become welded due to the current which then flows between the main electrodes **1** and **2** via the expendable electrodes **8** and **9**. This extrusion which is illustrated in FIGURE 2, is such that the plunger **12** is protected from damage by arcing as any contact burning which occurs is largely confined to the electrodes **8** and **9**.

The operation is such that there is a very fast initial closure of the switch due to the discharge followed by subsequent closure due to the plunger **12**.

To reopen the switch the plunger **12** is withdrawn and a fresh sandwich **3** substituted ready for the next closure. This substitution can be arranged to be done automatically.

It will be appreciated that the aperture **7** need not be within the part of the sandwich **3** that the plunger **12** passes through. It may be preferably for it to be to one

side in which case it is desirable that vent apertures be provided through the main electrode 2 to relieve the pressure set up at the time of the initial closure.

It has been found that the reliability of the initial closure of the switch and in particular the jitter are dependent on the diameter of the aperture 7. In one embodiment of the switch the expendable electrodes 8 and 9 are 0.01 inch and 0.02 inch thick copper foil respectively, the metallic layer 4 is 0.001 inch thick copper or aluminum foil, the polystyrene layer 5 is 0.003 inch thick, and the polythene layer 6 is 0.02 inch thick. With the capacitor 20 having an energy of about 3 kilojoules and the capacitor 23 about 200 joules, the initial discharge current between the expendable electrode 9 and the metallic layer 4 being about 100 kiloamps and the frequency being about 1 megacycle per second, a diameter of 0.001 inch for the aperture 7 results in an initial closing time of about 1 microsecond and a jitter of about 0.2 microsecond. The subsequent closure, due to the plunger 12, occurs about 50 microseconds later, after which the switch has a resistance of a few microhms.

The sandwich 3 may be modified by making the expendable electrode 8 in the form of an annular copper ring. This may conveniently be arranged to fit into the main electrode 1 in the place of the steel insert 13. The aperture in the ring is aligned with the apertures 10 and 11.

We claim:

1. An electric switch comprising an inner metallic layer sandwiched between first and second layers of electrically-insulating material which in turn are sandwiched between two expendable electrodes, two main electrodes between which the sandwich is held such that the two main electrodes contact the two expendable electrodes respectively, the electric supply to be switched being arranged to be connected across the main electrodes, an aperture extending through the first layer substantially normal to the general plane of the sandwich, a pair of aligned apertures in the main electrodes substantially normal to the general plane of the sandwich, a plunger, and means operated when the switch is to be closed to cause an electric discharge from one main electrode via the aperture in the first layer to the inner metallic layer whereby said second layer is ruptured and an electric path is thereby completed between the main electrodes, said means also causing the plunger to be forced into the apertures in the main electrodes such that the sandwich is pierced and deformed portions of the expendable electrodes are in contact and complete a low resistance electric path between the main electrodes.

2. A switch in accordance with claim 1 wherein the expendable electrode first pierced by the plunger is formed by a metallic layer and the other expendable electrode is formed by an annular ring the aperture in which is aligned with said apertures in the main electrodes.

3. An electric switch comprising an inner metallic layer sandwiched between first and second layers of electrically-insulating material which in turn are sandwiched between two metallic layers which form expendable electrodes, two main electrodes between which the sandwich is held such that the two main electrodes contact the two expendable electrodes respectively, the electric supply to be switched being arranged to be connected across the main electrodes, an aperture extending through the first layer substantially normal to the general plane of the sandwich, a pair of aligned apertures in the main electrodes substantially normal to the general plane of the sandwich, a plunger, and means operated when the switch is to be closed to cause an electric discharge from one main electrode via the aperture in the first layer to the inner metallic layer whereby said second layer is ruptured and an electric path is thereby completed between the main electrodes, said means also causing the plunger to be forced into the apertures in the main electrodes such that the sandwich is pierced and deformed portions of the expendable electrodes are in contact and complete a low resistance electric path between the main electrodes.

4. A switch in accordance with claim 3 wherein the expendable electrode first pierced by the plunger is formed of relatively soft and ductile metal and the other expendable electrode is formed of relatively hard metal.

5. A switch in accordance with claim 4 wherein the expendable electrode first pierced by the plunger is formed of soft annealed copper and the other expendable electrode is formed of hard rolled copper.

6. An electric switch comprising an inner metallic layer sandwiched between first and second layers of electrically-insulating material which in turn are sandwiched between two metallic layers which form expendable electrodes, two main electrodes between which the sandwich is held such that the two main electrodes contact the two expendable electrodes respectively, the electric supply to be switched being arranged to be connected across the main electrodes, an aperture extending through the first layer substantially normal to the general plane of the sandwich, a pair of aligned apertures in the main electrodes substantially normal to the general plane of the sandwich, a plunger having at one end a tip portion adapted to enter said apertures in the main electrodes and at the other end a disc-like portion the general plane of which is normal to the length of the plunger, a coil situated adjacent said disc-like portion, and means operated when the switch is to be closed to cause an electric discharge from one main electrode via the aperture in the first layer to the inner metallic layer whereby said second layer is ruptured and an electric path is thereby completed between the main electrodes, said means also energising said coil so that a current of opposite sense to the current in said coil is induced in said disc-like portion and the tip portion of the plunger is forced into the apertures in the main electrodes such that the sandwich is pierced and deformed portions of the expendable electrodes are in contact and complete a low resistance electric path between the main electrodes.

No references cited.

BERNARD A. GILHEANY, *Primary Examiner.*

J. J. BAKER, *Assistant Examiner.*