May 5, 1959 J. W. DIESEL 2,885,511

ELECTROSTATIC RELAYS

Filed April 15, 1957

FIG. 1

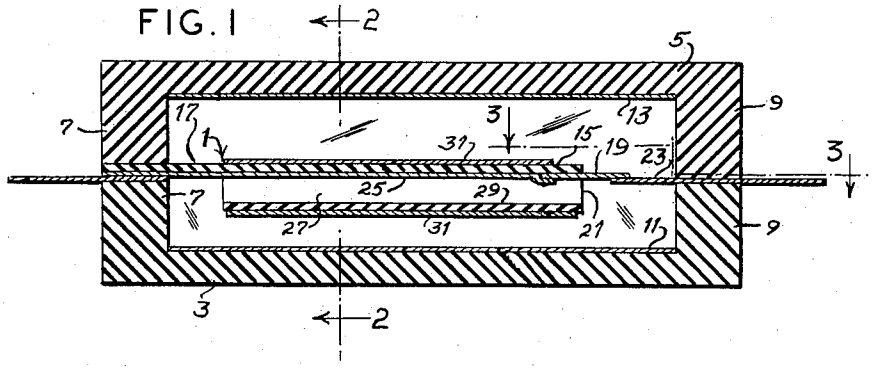


FIG. 2

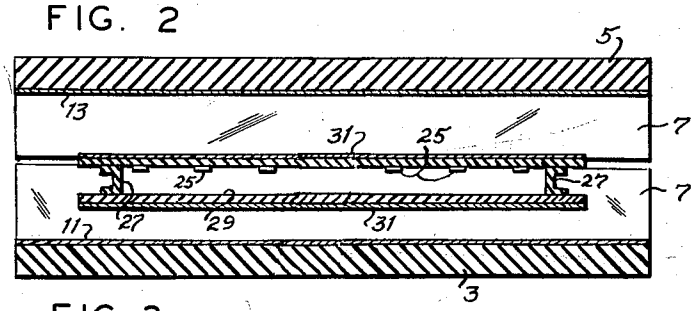


FIG. 3

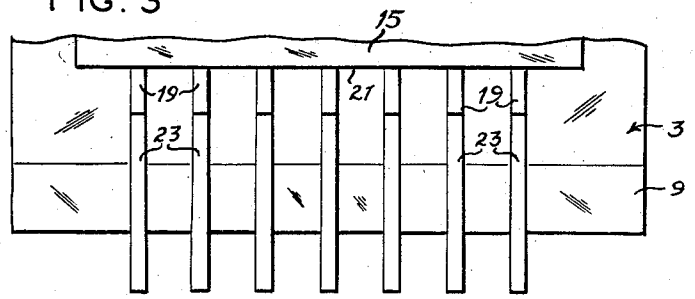


FIG. 4

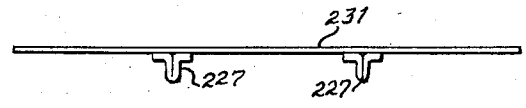
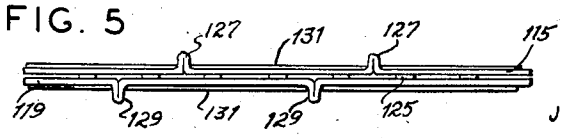


FIG. 5



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2,885,511

ELECTROSTATIC RELAYS

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8 Claims. (Cl. 200—87)

This invention relates to electrostatic relays, and more particularly is a continuation-in-part of my copending applications, Serial No. 441,057, filed July 2, 1954, for Electrostatic Controls, and Serial No. 571,098 filed March 12, 1956, for Electrostatic Relays and Controls.

Among the problems encountered with electrostatic relays is that of achieving substantial contact pressure. Since electrostatic forces are rather weak, it is desirable to have a light-weight relay arm, such as might be formed by a flat very thin metal foil or conductive plastic film, the contacts then being mounted on or actuated by the free end of the flap. A possible disadvantage of this arrangement is that the relay arm may bend, particularly if the relay arm or flap is long, as might be desirable in order to achieve a large area and thereby proportionately large electrostatic force. While a limited amount of bending may be permitted in certain circumstances, the close spacing of the plates in electrostatic relays is a factor which limits the amount of bending that can be tolerated without loss of contact pressure.

Accordingly, the object of the invention is to provide an electrostatic relay wherein increased contact pressure is achieved without sacrificing operating speed. While other objects will also be apparent in connection with the following detail disclosure, briefly the invention contemplates that the relay arm will be formed with a thin conductive panel having thin-walled reinforcing means secured to extend across at least one face of the panel. Preferably, the reinforcing means is formed of plastic insulating material and is non-conductive. The reinforcing means should have a wall thickness or dimension in the direction generally parallel to the surface of the panel which is substantially less than the height or dimension of the reinforcing means in the direction perpendicular to the panel of the relay arm.

In a specific embodiment, the relay arm is formed by a thin film of plastic insulating material which is covered with conductive paint, although other variations are possible. The reinforcing members are then formed as ribs of thin plastic insulating material secured to the main flat panel so as to project therefrom.

Other features of the invention will be in part apparent from and in part pointed out in the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a cross sectional view illustrating an electrostatic relay embodying features of the invention;

Fig. 2 is a detail section taken on the line 2—2 of Fig. 1;

Fig. 3 is a detailed section taken on the line 3—3 of Fig. 1;

Fig. 4 is a view similar to that of Fig. 2 but illustrating an alternative embodiment of the invention; and

Fig. 5 is a view similar to that of Fig. 4 but showing a further embodiment.

Referring to Fig. 1 of the drawings, there is shown an electrostatic relay which comprises a relay arm generally designated 1, a lower fixed member 3 and an upper fixed member generally designated 5. The fixed members 3 and 5 are formed of plastic insulating material with projecting portions 7 at one end of the relay and projecting portions 9 at the other end. Each member, in turn, carries a thin conductive plate in the trough formed between the projecting end portions 7 and 9. For example, there is a lower fixed plate 11 and an upper fixed plate 13.

The relay arm 1 is formed with a thin panel 15 of plastic insulating material, such as polyester film in a thickness of one or two-thousandths of an inch. One end of the panel 15 is sandwiched between the end portions 7 of the fixed plate members so as to form a hinge 17. It will be understood that the thin plastic panel 15 is sufficiently flexible to permit movement of the main body of the relay arm between the fixed plates.

Movable contact fingers 19 are arranged in a row along the free end 21 of panel 15 for cooperation with a row of fixed contact fingers 23, the latter being sandwiched between the projecting end portions 9 of the fixed insulating members. The fixed contact fingers 23 may be formed as thin metallic strips which are secured so as to project inwardly for cooperation with the movable contacts and outwardly for connection to suitable leads. Similarly, the movable contact fingers 19 might be formed as thin metallic strips adhered or otherwise secured to the panel 15. Conductive leads 25, which might be formed of silver paint, extend from the movable contact fingers 19 across the lower surface of the insulating panel 15 over the hinge at 17 to the end of the panel, where it is secured between the end portions 7 of the fixed insulating members. A row of thin metallic fingers may be inserted between the parts 7 in conductive contacting relationship with conductive leads 25 so as to project from the fixed insulating members, thereby facilitating connection with leads.

The invention further contemplates that the main body portion of the relay arm between the hinge 17 and the free end 21 will be reinforced or made relatively rigid in comparison with the hinge. For example, channel sections 27 of insulating material may be adhesively secured to the lower surface of panel 15 and a second relatively flat panel 29 may then be secured to the channel sections. The insulating members 15, 27 and 29 should all be very thin so as to have the least possible weight. Finally, the upper and lower surfaces of the panels 15 and 29 may be coated with the conductive material 31 so as to make the movable plates cooperable with the fixed plates 11 and 13. With this type of relay, the circuit connections (not shown) for the plates are such that the relay arm is pulled upwardly when the contact circuits are to be opened and is electrostatically biased downwardly when the contact circuits are to be closed. Details of the plate circuits are disclosed in the above-mentioned copending applications.

Referring now to Fig. 5, there is shown an alternative embodiment of the invention wherein a pair of thin panels 115 and 119 are creased and folded so as to form ribs, which would extend across opposite surfaces of the relay arm. For example, the upper panel 115 is formed with a pair of ribs 127 and the lower panel 119 is similarly formed with a pair of ribs 129. The conductive leads 125 are shown sandwiched between two panels, and the lower ribs 129 are offset from the upper ribs 127. Both panels 115 and 119 may be formed of insulating material and their surfaces are coated with conductive material 131 between the ribs so as to provide movable plate areas which cooperate with the fixed plates. With this arrangement, it is considered desirable for the rib portions 127 and 129 to be non-conductive. As such, the ribs will prevent the conductive plate areas 131 from moving too close to the fixed plates.

Also, it may be noted the relay arm might be formed with a single panel of the type shown at 115 or 119 in Fig. 5, especially if the panel is metal or material adapted to take a set or hold a deformation. The rib deformations preferably extend across the arm from the hinged

end toward the free end, but may terminate short of either end.

Fig. 4 illustrates an alternative embodiment wherein the relay arm is formed with a thin conductive metal foil 231 which is reinforced by rib members 227 formed of thin walled folded plastic insulating material, which are secured, as by adhesive, to the main panel 231.

In all instances, the ribs or reinforcing members are relatively thin walled in the sense that the dimension parallel to the surface of the relay arm or thin panel is substantially less than the dimension of the rib in the direction perpendicular to the relay arm or thin panel.

From the foregoing description, it is apparent that those skilled in the art will understand the structure, function and mode of operation of the invention herein disclosed, and appreciate the advantages thereof. Although several embodiments have been disclosed in detail, it is to be understood that the invention is not limited thereto, but the drawings and description thereof are to be understood as being merely illustrative. For example, a hollow cellular relay arm might be formed from expanded or foam plastic or the relay arm might be double-walled with a corrugated or honeycomb medium sandwiched between the two outer liners. It is realized that many modifications and variations will present themselves to those skilled in the art without departing from the spirit of this invention or the scope thereof as set forth in the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. An electrostatic relay comprising a lower fixed insulating member having projecting portions upstanding at opposite ends and an upper fixed insulating member having projecting portions depending therefrom at its opposite ends for cooperation with the projecting end portions of said lower insulating member, a fixed plate carried by one of said insulating members between the projecting end portions thereof, a relay arm in part sandwiched between the projecting portions of the two fixed insulating members at one end of the relay, said relay arm being flexible at least in the region adjacent said end of the relay so as to be otherwise movable between the fixed insulating members, and a row of fixed contact fingers constituted by metallic strips sandwiched between the projecting portions of the fixed insulating members at the other end of the relay, said metallic strips projecting inwardly for cooperation with the free end of the relay arm.

2. An electrostatic relay comprising a fixed panel formed with an electrode-forming conductive surface and a relatively movable panel formed with an electrode-forming conductive surface opposite said first electrode-forming surface, whereby said movable panel is electrostatically attracted toward the fixed panel upon energization of the opposed electrode-forming surfaces, said movable panel having a flexible hinge portion at one end and flexible movable contact means projecting at its other end, stiffening means formed on said movable panel to extend between but terminate short of said flexible end portions so that the center portion of the panel is relatively stiff in comparision with the end portions, said first end portion being secured in fixed spaced relationship from said first panel as a hinge support for the movable panel, and fixed contact means secured adjacent the other end of the second panel in fixed spaced relationship from said first panel in position for engagement by said movable contact means, whereby the flexible end portions of the movable panel are supported in spaced relationship from the fixed panel while the relatively stiff center portion of the movable panel minimizes bending of the movable panel and engagement of its electrode-forming surface with the other electrode-forming surface upon energization of such surfaces.

3. An electrostatic relay as set forth in claim 2, wherein said movable panel is formed of thin flexible sheet material, said stiffening means being ribs formed of plastic insulating material to extend across at least one surface of said panel.

4. An electrostatic relay as set forth in claim 2, wherein said movable panel is constituted by a pair of spaced sheets of thin flexible material, and rib-forming means sandwiched between said sheets and holding said sheets in spaced relationship, the spacing between the sheets being several times their thickness.

5. An electrostatic relay as set forth in claim 2, wherein said stiffening means comprises a discrete rib member secured to said panel, said rib member having a dimension in the direction perpendicular to said panel which is greater than its wall thickness.

6. An electrostatic relay as set forth in claim 2, wherein said movable panel comprises a sheet of flexible insulating material formed with a conductive electrode-forming coating on one face thereof, and insulated rib-forming means projecting from said coated face beyond said coating.

7. In an electrostatic relay of the type having a relatively fixed electrode-forming plate and a relatively movable electrode-forming plate mounted opposite said fixed plate, so as to be movable toward and away from the fixed plate under electrostatic force; the improvement that comprises a generally rectangular relay arm mounted so that at least one end margin thereof is movable toward and away from the fixed plate, the relay arm being formed from a generally rectangular panel of insulating material, said movable plate being secured to and carried by said panel so as to extend over a substantial area on one side of said panel, and a row of resilient metallic fingers secured to said insulating panel along the movable end margin thereof so as to project therebeyond as movable contacts, said fingers being spaced from one another and being resiliently movable independently of one another, and said row of fingers extending substantially the entire length of said end margin of the panel, and said relay further having a second row of cooperative fixed contacts disposed opposite said first row of contacts.

8. In an electrostatic relay of the type having a relatively fixed electrode-forming plate and a relatively movable electrode-forming plate mounted opposite said fixed plate, so as to be movable toward and away from the fixed plate under electrostatic force; the improvement that comprises a generally rectangular relay arm mounted so that at least one end margin thereof is movable toward and away from the fixed plate, the relay arm being formed from a generally rectangular panel of insulating material, said movable plate being secured to and carried by said panel so as to extend over a substantial area on one side of said panel, and a row of resilient metallic fingers secured to said insulating panel along the movable end margin thereof so as to project therebeyond as movable contacts, said fingers being spaced from one another and being resiliently movable independently of one another, the plate-forming area of the relay arm being relatively less flexible in comparison with that portion of the relay arm defined by the resilient fingers extending beyond said end margin of the insulating panel.

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