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[54] **PRESSURE SENSITIVE MAT SWITCH CONSTRUCTION**

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[51] **Int. Cl.** **H01h 13/16**

[58] **Field of Search** .... 200/86 R, 85 R; 340/272, 340/278

[56] **References Cited**

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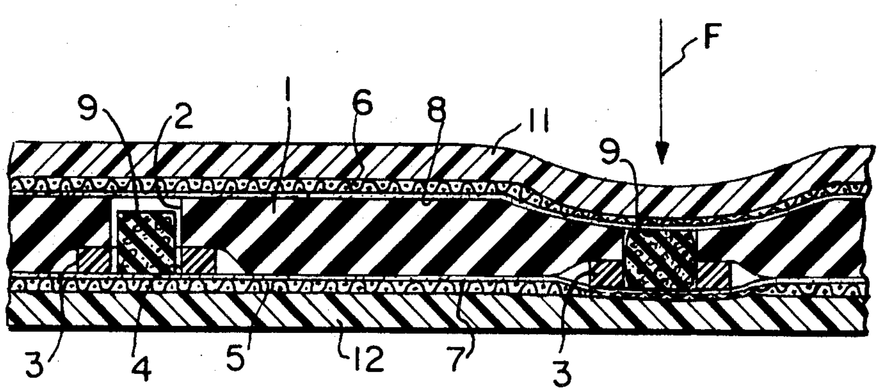
[57] **ABSTRACT**

A pressure sensitive switch useful in a mat of the kind adapted to operate a door in response to a person's stepping on the mat comprises a switch assembly composed of a pair of sheet-like electrical conductors between which is interposed a sheet of resiliently compressible and expansible non-conductive material such as foamed rubber or plastic having a plurality of openings therethrough in each of which is accommodated a bridging member operable to establish a conductive path between the two conductors when the latter are moved relatively toward one another in response to the application to the mat of a compressive force. The switch assembly is enclosed within a non-conductive rubber or plastic sheath. Conductive wires connected to the two conductors of the switch assembly extend through the sheath for connection to a source of energy and to the actuating mechanism for the door to be operated.

Means are provided for limiting the compressive force to which said bridging member may be subjected.

17 Claims, 4 Drawing Figures



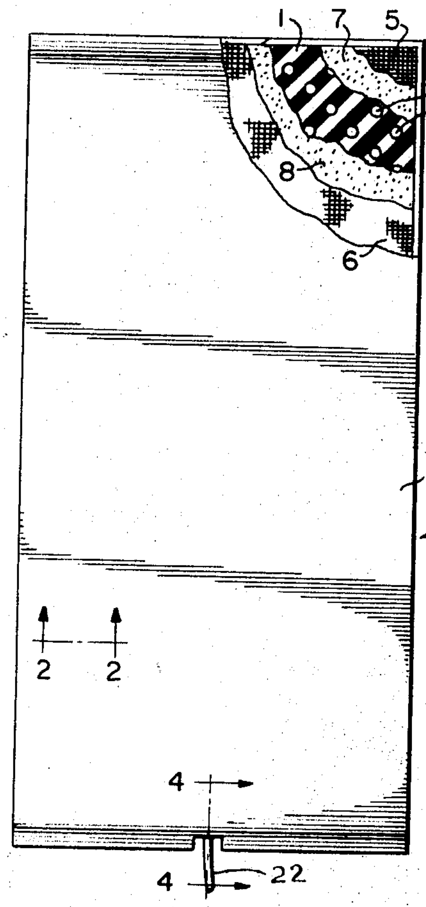


FIG. 1

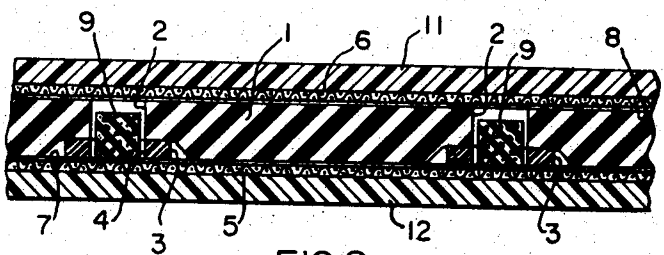


FIG. 2

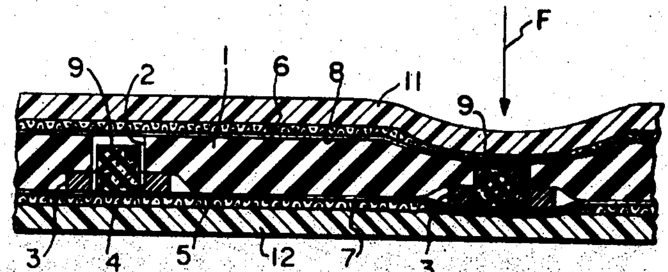


FIG. 3

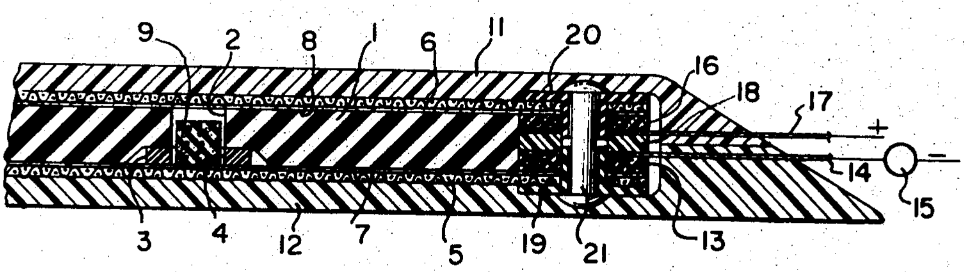


FIG. 4

PRESSURE SENSITIVE MAT SWITCH CONSTRUCTION

The invention disclosed herein relates to a pressure sensitive switch construction adapted to be incorporated in a mat which, when stepped upon by a person, will effect operation of mechanism for opening a normally closed door or the like. Mat switches of the kind referred to conventionally are located adjacent doors leading into and out of supermarkets, airports, and other public places so as to lie in the path of pedestrians approaching such doors. As a pedestrian approaches such a door he steps upon the mat, thereby compressing the latter and closing a normally open switch contained in the mat so as to actuate a mechanism for opening the door automatically.

Conventional mat switches have many problems associated therewith. For example, most of the mat switches currently in use employ a switch mechanism comprising a pair of conductive, metal plates held in spaced apart relation by a plurality of insulators. When a compressive force is applied to the upper plate it is deformed to engage the lower plate, thereby closing a circuit. If the compressive force is applied directly over one of the insulators, however, the insulator prevents engagement of the plates. Moreover, the force required to effect closing of the switch varies in accordance with the distance from an insulator that the force is applied. Other problems are created by this construction upon the installation of a mat switch on an uneven surface, by the entrapment of stones between the mat and its foundation, and the bending or warping of one or both of the steel plates.

Additional problems associated with metal plate mat switches of the kind referred to are those resulting from the sheer weight of the plates themselves and from the necessity of degreasing and cleaning the plates. Once the plates have been cleaned, they must be incorporated rather quickly in the switch assembly so as to prevent corrosion of the surfaces of the plates with consequent adverse effects on the electrical integrity of the switch assembly.

An object of this invention is to provide a mat switch construction which overcomes the disadvantages referred to above of previously known mat switches.

Another object of the invention is to provide a mat switch construction which enables operation of the switch at any part of the mat under a uniform force.

A further object of the invention is to provide a mat switch of the character described and in which the switch assembly incorporates means for automatically protecting the switch assembly against damage due to the application of excessive forces.

Other objects and advantages of the invention will be pointed out specifically or will become apparent from the following description when it is considered in conjunction with the appended claims and the accompanying drawings in which:

FIG. 1 is a plan view of a mat switch constructed in accordance with the invention with parts being broken away;

FIG. 2 is a sectional view taken on the line 2—2 of FIG. 1 and illustrating the switch in its open or non-conductive condition;

FIG. 3 is a view similar to FIG. 2, but illustrating the mat switch in its conductive condition; and

FIG. 4 is a vertical section view taken on the line 4—4 of FIG. 1 and illustrating the means for connecting the mat switch to a source of energy and to apparatus to be operated by the switch.

A switch assembly constructed in accordance with the invention comprises a flat sheet **1** of resiliently compressible and expansible, non-conductive material such as foamed rubber, polyurethane, or the like having a plurality of rows of spaced openings **2** extending therethrough. The openings in each row are uniformly spaced apart at about 2-inch intervals and adjacent rows are spaced about one inch apart, with the openings in adjacent rows staggered. Adhesively secured to the lower surface of the sheet **1** is a plurality of washers **3**, each of which has a bore **4**. The washers may be formed of any suitable phenolic or other non-conductive, rigid, relatively incompressible material. The washers **3** are so arranged that one washer is associated with one of the openings **2** and is so oriented with respect to its associated opening that the opening **2** and the bore **4** are coaxial. The washers constitute force limiting means as will be explained more fully hereinafter.

On opposite sides of the non-conductive sheet **1** are flexible, electrically conductive sheets **5** and **6** which preferably comprise copper screens. The screen **5** may be adhered to the sheet **1** by an adhesive **7**, if desired. The adhesive **7** preferably is electrically conductive, of which there are many known kinds, but if the adhesive **7** is not conductive, then such adhesive will be omitted at the openings **2**. The conductive screen **6** may have applied thereto a layer of adhesive **8** similar to the adhesive **7**. Again, the adhesive may be electrically conductive or non-conductive. In the latter case, the adhesive will be omitted at the openings **2**.

Accommodated in each opening **2** and in the bore of the companion washer **3** is a resiliently compressible and expansible switching or bridging member **9**, each of which preferably comprises a cylindrical module composed of an elastomeric, non-conductive material, such as silicone rubber, throughout which is dispersed a large quantity of electrically conductive, preferably spherical particles. Each bridging member may be electrically conductive in the absence of an external compressive force or, if desired, each bridging member may be non-conductive until it is subjected to a compressive force of predetermined magnitude. In either case, any one of the bridging members is capable of establishing an electrically conductive path between the conductive screens **5** and **6**.

The initial condition of conductivity of the bridging members **9** is determined in general by the concentration of the conductive particles and by the state of the elastomer. If the elastomer resin contains a relatively large number of particles and is molded under pressure, the bridging member may be normally conductive. If the number of particles contained in the resin is less, or if the resin is molded in the absence of pressure, the bridging member may be normally non-conductive. In this case, the application of a compressive force on the bridging member effects relative movement of the particles so that a sufficient number thereof move into engagement and establish a conductive path through the elastomer. Upon removal of the compressive force the elastomer expands, thereby enabling the engaged particles to move out of engagement and break the conductive path.

The size of the conductive particles is so selected as to enable them to accommodate currents up to a predetermined value, and to decompose or be consumed by the heat of a current in excess of the predetermined value, thereby enabling each bridging member to function as a fuse or circuit breaker. Not all of the particles in a bridging member will be consumed by an overload current, however, thereby enabling such member to function as a switching member when it again is subjected to compressive force.

The compressive force to which a given bridging member must be subjected to render it conductive depends upon several factors, such as the size and concentration of the particles, the hardness of the elastomer, and the dimensions of the bridging member. These factors are described in detail in pending application Ser. No. 857,941 filed Sept. 15, 1969, and to which reference may be had for a more detailed disclosure. Such factors also may be determined empirically.

Following assembly of the members **1, 3, 5, 6,** and **9** in the manner illustrated in FIG. **2,** the assembly may be enclosed in a molded, non-conductive sheath **10** composed of two mating halves **11** and **12** of a resiliently compressible plastisol such as polyvinylchloride. The two halves of the sheath then may be secured to one another by ultrasonic welding or the like so as to provide an air- and moisture-tight enclosure for the switch assembly.

When the switch assembly is enclosed within the sheath **10** the sheet **1** will be compressed adjacent each washer **3,** as is shown clearly in FIG. **2,** due to the presence of such washer. The height of each bridging member **9,** however, is less than the spacing between the conductive screens **5** and **6** so as to preclude any possibility of establishing a current path between the screens. The relative diameters of the openings **2,** the bore **4,** and the members **9** are such that clearance exists around each member **9** when the latter is in its normal, uncompressed condition.

Any suitable means may be utilized to connect the conductors **5** and **6** to a source of energy and to apparatus to be operated. FIG. **4** discloses suitable connection means comprising an annular, resiliently compressible and expansible contact member **13,** similar to the bridging members **9** except for its annular configuration, in engagement with the conductor **5** and in engagement with a conductive terminal **14** which extends through the sheath **10** for connection to a mechanism **15** to be operated electrically. A contact member **16** like the contact **13** engages the conductor **6** and a terminal **17** which is adapted for connection to a source of electrical energy. Between the terminals **14** and **17** is an annular insulator **18.** Insulating grommets **19** and **20** overlie the screens **5** and **6,** respectively. A rivet **21** maintains the grommets in axial alignment so as to subject the members **13** and **16** to sufficient compressive force to maintain them conductive. The terminals **14** and **15** are enclosed within an insulating sheath **22.**

To condition a mat switch constructed according to the invention for operation, the sheath-enclosed switch assembly may be positioned on a suitable foundation adjacent a door (not shown) with the terminal **14** connected to the door actuating mechanism **15** and the terminal **17** connected to an energy source. When a person steps on the upper surface of the sheath **10** a compressive force F is applied on the upper half **11** of the sheath so as to deform the latter and effect downward movement of the conductive screen **6** toward the conductive screen **5.** Downward movement of the conductor **6** is accompanied by compression of the insulating sheet **1** so as to enable the conductor **6** to bear against the upper surface of at least one of the bridging members **9** and axially compress the latter between the conductors **5** and **6,** thereby establishing a conductive path from the energy source through the conductor **6,** through the bridging member **9,** and through the conductor **6** to the mechanism **15.** The larger diameters of the opening **2** and the washer bore **4** enable the member **9** to be expanded radially as it is compressed axially. Upon removal of the compressive force F, the resilience of the sheet **1** and the bridging members will restore the parts to the positions shown in FIG. **2.**

A switch assembly adapted to be actuated by pedestrians must be capable of functioning under greatly varying forces. For example, such a switch should be operable by the weight of a child, as well as by the weight of a much heavier adult. Further, such a switch must be capable of accommodating an extermely high concentration of force, such as that imposed by the relatively small area of a woman's shoe heel. A switch assembly according to the invention is capable of functioning under the greatly differing load factors referred to inasmuch as the sheath **10,** the member **7,** and the bridging members **9** are all resiliently compressible and the conductors **5** and **6** are flexible.

The switch assembly can withstand greatly excessive compressive forces inasmuch as the washers **3** protect the bridging members **9** against excessive compression due to the incompressibility of the washers themselves. Thus, when the switch assembly is in the condition shown in FIG. **3,** an increase in the force F does not cause a corresponding increase in the compressive force applied to the adjacent bridging member **9** inasmuch as the latter cannot be compressed to a thickness less than that of the force limiting washer **3.** The bridging members, therefore, are protected by the washers against destruction or deterioration due to excessive compression, irrespective of the force applied on the switch assembly.

The disclosed embodiment is representative of a presently preferred form of the invention, but is intended to be illustrative rather than definitive thereof. The invention is defined in the claims.

I claim:

1. A pressure sensitive switch assembly comprising a resilient, compressible, non-conductive member having an opening therethrough; electrical conductors spaced apart by said non-conductive member, the compressibility of said non-conductive member enabling relative movement of said conductors toward one another; bridging means accommodated in said opening and operable in response to relative movement of said conductors toward one another to establish a conductive path between said conductors; and means for limiting the compressive force to which said bridging means may be subjected irrespective of the extent to which said non-conductive member may be compressed.

2. An assembly according to claim **1** wherein said bridging means normally is non-conductive and is rendered conductive in response to compression thereof.

3. An assembly according to claim **1** wherein said bridging means normally is conductive and has a height less than the spacing between said conductors when said non-conductive member is in its uncompressed condition.

4. An assembly according to claim **1** wherein said limiting means comprises a relatively incompressible member encircling said bridging member.

5. An assembly according to claim **4** wherein said relatively incompressible member is interposed between said non-conductive member and one of said conductors.

6. An assembly according to claim **1** including a non-conductive sheath enclosing said assembly.

7. An assembly according to claim **6** wherein said sheath is composed of resilient material.

8. An assembly according to claim **1** including means for connecting at least one of said conductors to a source of electrical energy.

9. An assembly according to claim **1** wherein at least one of said conductors comprises a metallic screen.

10. An assembly according to claim **9** wherein said screen is adhesively secured to said non-conductive member.

11. An assembly according to claim **1** wherein said bridging member comprises an elastomer throughout which is dispersed a plurality of electrically conductive particles.

12. An assembly according to claim **11** wherein the quantity of said particles is such that a sufficient number thereof are in engagement to establish a conductive path through said elastomer without the application of external compressive force to said elastomer.

13. An assembly according to claim **11** wherein the quantity of said particles is such that a conductive path may be established through said elastomer only upon the application of an external compressive force to said elastomer.

14. A pressure sensitive switch assembly comprising a pair of spaced apart sheet-like conductors; a sheet-like, non-conductive, resilient, relatively compressible and expansible member interposed between said conductors and having a plurality of spaced apart openings therethrough, the compressibility of said non-conductive member enabling relative movement of said conductors toward one another; a bridging member accommodated in each of said openings and operable in response to relative movement of said conductors toward one another to establish an electrically conductive path between said conductors; and relatively incompressible limit means interposed between said conductors adjacent each of said bridging members for limiting the extent of movement of said conductors toward one another and consequently limiting the compressive force to which said bridging members may be subjected.

15. An assembly according to claim **14** wherein each of said limit means comprises an annulus encircling a bridging member.

16. An assembly according to claim **15** wherein each of said annuli is interposed between said non-conductive member and one of said conductors.

17. An assembly according to claim **14** including a resilient, non-conductive sheath enclosing said assembly.

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