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H. C. INMAN

2,735,907

MOISTURE ACTUATED CIRCUIT CLOSER

Filed May 2, 1952

FIG. 1.

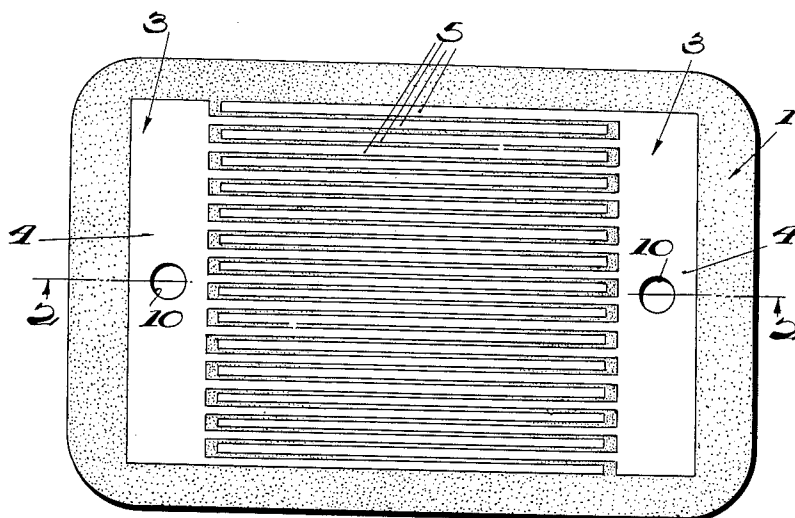


FIG. 2.

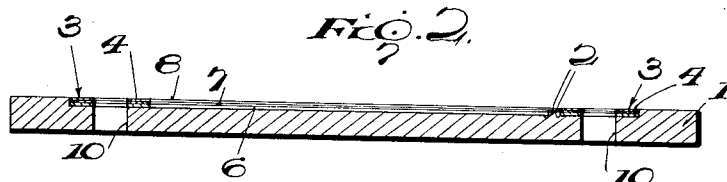


FIG. 4.

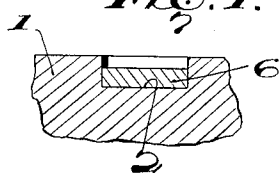


FIG. 3.

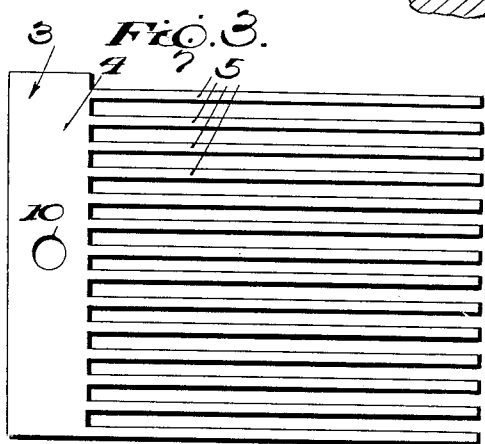


FIG. 5.

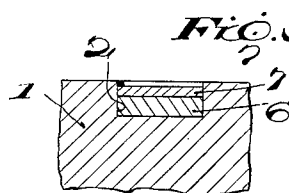
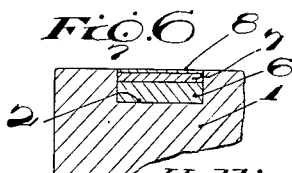


FIG. 6.



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MOISTURE ACTUATED CIRCUIT CLOSER

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6 Claims. (Cl. 200—61.05)

The present invention relates to a circuit closer and more particularly to a circuit closer adapted to be actuated by the falling of rain thereon. The invention further relates to the method of making the circuit closer.

It has heretofore been proposed to make devices which will automatically perform certain operations when it begins to rain. Such devices may be used, for example, to raise the top of convertible autos, close the windows of buildings or vehicles, close ports or hatches on ships, depress elevated mortars or field pieces, etc. Such devices usually include an electric or fluid motor whose operation is controlled by a moisture actuated circuit closer, and the present circuit closure is adapted for use in controlling all such devices.

According to the present invention, the circuit closer takes the form of a pair of conducting members of grid-like configuration secured to an insulating base member with the fingers of the grids interdigitated and close together but not touching. With this arrangement any drop of conducting liquid such as rain water falling on the device will bridge the gap between fingers of different polarity and by suitable electrical connections initiate actuation of the motor for performing the desired operation.

For many years it has been known that electrical circuits of definite configuration can readily and economically be produced by printing techniques. These techniques have been highly developed and are particularly suitable for mass production, but heretofore have found use only in applications where the currents carried are of low amperage such as encountered in high frequency electronic circuits and where the conducting elements are sheltered from the weather. By the present invention, I have produced a circuit closing device of the type described by employing printed circuit techniques with their attendant advantages but which can readily carry the necessary current loads and will survive years of use under exposure to the most adverse weather conditions.

Accordingly, it is a primary object of the present invention to provide a moisture actuated circuit closer, which may be rapidly produced by a method including a circuit printing technique and which is suitable for outdoor use.

Another object of the invention is to provide a circuit closer of the present type wherein the conducting portions are firmly adhered to an insulating base.

Still another object of the invention is to provide a circuit closer actuated by a conducting liquid in which the conducting elements have sharply defined boundaries.

A further object of the invention is to provide a circuit closer of neat and attractive appearance.

Another object of the invention is to provide a circuit closer actuated by a conducting liquid, which may be economically manufactured by mass production methods.

A still further object of the invention is to provide a process for manufacturing a circuit closer, which will have the above-enumerated properties.

Other and further objects will be apparent from the following detailed description of my invention taken in

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conjunction with the accompanying drawings in which:

Fig. 1 is a top plan view of the circuit closer;

Fig. 2 is a cross-sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a top plan view of one of the circuit conducting grid members of the present device; and

Figs. 4, 5 and 6 are enlarged, fragmentary sectional views showing various stages in the process of making the conducting grid members.

The outlines of the present circuit closer are laid down by a printing technique on the base member 1 which may comprise a sheet of any suitable insulating material. Moulded synthetic resinous materials are preferred, either alone or as an impregnant for a fabric or fibrous base and, as examples, may be mentioned phenolic condensation products, styrene polymers and polymers of various vinyl compounds, such as vinyl chloride and vinyl acetate and mixtures of the two.

Preferably the outlines of the circuit closer are first produced by forming grooves or recesses 2 in the base member 1 so that better adhesion of the subsequently printed conducting metal to the base is effected. The recessing may be accomplished in any suitable manner, such as by moulding, the employment of pressure dies, by routing, by milling or by a photo engraving process. In any event, in one operative form of the invention, the grooves are made about $\frac{3}{4}$ of an inch in width and about .004305 of an inch deep. Also the grooves constituting each grid are cut on centers spaced about $\frac{1}{8}$ of an inch apart, so that the wall between the grooves of adjacent grids is about $\frac{1}{4}$ of an inch thick.

The recesses are formed so as to provide the outlines of a pair of grid members 3, each having relatively wide base portions 4 and a plurality of narrow fingers 5 extending therefrom. The grid members are arranged so that the base portions 4 are substantially parallel and the fingers 5 are interdigitated so that they lie closely adjacent one another but without physical contact at any point. The portions 4 have a depth at least as great as the grooves 2 forming the fingers 5.

As shown in Fig. 4, there is applied by printing to the base of the recesses 2 a first layer 6 of a conducting metal, such as copper or silver. By the term "printing" as used in this specification and claims is meant any one of a number of suitable standard techniques which have gradually evolved and to which this generic term has been applied. For the most part these techniques fall into three principal groups, painting, spraying and chemical deposition. In the practice of all three types, a stencil is ordinarily used to define the boundaries of the circuit to be produced. In connection with the first two processes, the metal is brushed or sprayed over the stencil, which is applied to the base, in the form of an intimate dispersion of particles of conducting metal, usually silver or copper, in a volatile solvent solution of a binder for the particles. The dispersion of conducting metal is thus deposited on the insulating base member through the cutaway portions of the stencil and upon evaporation of the volatile solvent, the conducting particles are firmly adhered to each other and to the insulating base by the binder which was dissolved in the composition. A number of suitable conducting metal paints have been developed and are available on the open market and, hence, it is unnecessary to set forth the composition thereof herein.

The printing of circuits by chemical deposition is accomplished by pouring chemical solutions onto an insulating surface originally covered with a stencil. A thin metallic film is precipitated from the solution onto the surface in the form of the circuit desired.

When a pre-grooved base 1 is employed the conducting material or layer 6 is deposited in the grooves 2 through

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the openings in the stencil which conform to the outline of the conductor pattern. After the layer 6 has been formed by one of the standard procedures outlined above, additional operations must be carried out before a circuit closer adapted for outdoor use in the manner contemplated for the present invention can be produced. Even though the printed layer 6 may be relatively thick, it is not a good conductor of electricity because of the insulating effect of the binder present in the conducting metal paint. Accordingly, as shown in Fig. 5, a second layer 7 of conducting metal, such as copper or silver, is applied by a standard process of electrodeposition. In accordance with such a procedure a layer of conducting metal 7 of a thickness necessary to carry the required amounts of current may be electrically deposited from an acid type electrolyte including a saturated solution of a salt of the metal to be deposited, for example, a saturated solution of copper sulphate for depositing copper as a conductor. For optimum results in order to obtain a close grained deposit, it has been found best to employ relatively low current densities, for example, in the neighborhood of 1 to 2 amperes per square inch. As indicated, however, the electroplating procedure is standard in nature and the conditions of plating may be varied within quite wide limits to produce a conducting layer 7 of the desired thickness.

Since the usual conducting metals such as copper and silver are subject to oxidation and comparatively rapid deterioration when exposed to weather, it is essential that the present device be further treated before it can be employed for the purposes intended. For this reason, the exposed surface of the layer 7 is covered by a third metal layer 8, as shown in Fig. 6. The metal comprising this layer or coating must not only be a good conductor of electricity but must also be highly resistant to oxidation and corrosion. Gold, platinum or rhodium have been found to be particularly suitable and will effectively prevent oxidation and corrosion even when present only in the form of a "flash" or extremely thin coating. Although it is possible to apply the layer 8 in liquid or leaf form, it is preferred that this layer also be applied by electroplating and again standard procedures may be employed. It will be noted that the outer surface of the layer 8 is flush with the upper surface of the base 1 so that even a small raindrop can bridge the $\frac{1}{64}$ inch gap between adjacent fingers 5 and actuate the circuit closer.

If desired, apertures 10 may be formed in each of the grid structures through the widened base portions 4 and in the insulating body portion 1 so that suitable electrical connections may be made as by riveting a wire or strip conductor in place against the upper surface of the widened portions 4.

By way of illustration, and not limitation, a circuit closer made according to the above-outlined procedure and found to operate very satisfactorily embodied the following thicknesses of metal layers: printed base layer of copper .004 inches, silver conducting layer .0003 inch, protective layer of rhodium .000005 inch. However, it is to be understood that some deviation in the width and thickness of the conducting fingers 5 may be made, without departing from the principles of the invention, and particularly with respect to the thickness of the conducting layer which may be varied to meet different current carrying requirements.

By the above-outlined procedure, I have produced a circuit closer which will carry current loads of appreciable size and have extremely good weathering properties. Although the process has been described in connection with an initial recessing of the insulating base member, it is to be understood that this step is preferable but not essential. There are a number of available conducting paints which have been developed for the printing of electrical circuits which have such good adhesive qualities that they may be applied directly to the planar surface of an insulating sheet and be permanently adhered there-

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to. Moreover, although a particular grid-like structure has been described, this specific configuration, while preferred, also is not essential. Basically, it is only necessary that a pair of conductors be disposed in side by side relation so that a drop of conducting liquid, such as rain water, falling thereon will bridge the gap between them and thus close an electric circuit.

Having described my invention I claim:

1. A circuit closer for installation in a position exposed to the weather for signalling the occurrence of rain on contact therewith, comprising: a base of insulating material and a pair of elongated conductors secured to said base in separated but closely adjacent position so that the space between said conductors may be bridged by a drop of rain, each of said conductors including a first layer of conducting metal printed on said insulating base, a second layer of conducting metal applied to said first layer to improve its conducting properties, and a third layer of conduction metal inert to oxidation and corrosion covering said second layer, each of said layers being coextensive with each other, whereby said circuit closer is rendered adaptable for outdoor use.

2. A circuit closer for installation in a position exposed to the weather for signalling the occurrence of rain on contact therewith, comprising: a base of insulating material and a pair of elongated conductors secured to said base in separated but closely adjacent position so that the space between said conductors may be bridged by a drop of rain, each of said conductors including a first layer of conducting metal of the group consisting of copper and silver printed on said insulating base, a second layer of conducting metal of the group consisting of copper and silver electroplated on said first layer to improve its conducting properties, and a third layer of conductive metal of the group consisting of gold, platinum or rhodium inert to oxidation and corrosion covering said second layer, each of said layers being coextensive with each other, whereby said circuit closer is rendered adaptable for outdoor use.

3. A circuit closer as defined in claim 2, in which the first layer has a thickness of about .004 inch, the second layer has a thickness of about .0003 inch and the third layer has a thickness of about .000005 inch.

4. A circuit closer for installation in a position exposed to the weather for signalling the occurrence of rain on contact therewith, comprising: a base of insulating material having elongated recesses formed therein in side by side but non-contacting relation and a pair of elongated conductors secured to said base in said recesses and including a first layer of printed conducting metal of the group consisting of copper and silver, a second layer of conducting metal of the group consisting of copper and silver electroplated on said first layer to improve its conducting properties and a third layer of conductive metal of the group consisting of gold, platinum or rhodium inert to oxidation and corrosion electroplated on said second layer, each of said layers being coextensive with each other, whereby said circuit closer is rendered adaptable for outdoor use.

5. A circuit closer for installation in a position exposed to the weather for signalling the occurrence of rain on contact therewith, comprising: a base of insulating material and a pair of conducting grid members secured to said base, each grid member including a widened base portion and a plurality of spaced narrow fingers extending from said base portion, the base portions being arranged in substantially parallel relation and the fingers being disposed in closely adjacent but non-contacting interdigitated relation, and each grid member comprising a first layer of conducting metal of the group consisting of copper and silver printed on said base material, a second layer of conducting metal of the group consisting of copper and silver electroplated on and coextensive with said first layer to improve its conducting properties and a third layer of corrosion resisting conductive metal of the group consist-

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ing of gold, platinum and rhodium electroplated on and coextensive with said second layer of metal, whereby said circuit closer is rendered adaptable for outdoor use.

6. A circuit closer for installation in a position exposed to the weather for signalling the occurrence of rain on contact therewith, comprising: a base of insulating material having recesses formed therein to provide a pair of grid-like configurations, each configuration having a widened base portion and a plurality of spaced narrow fingers extending from said base portion, the base portions being arranged in substantially parallel relation and the fingers being disposed in closely adjacent but non-contacting interdigitated relation and a pair of conductors secured to said base in said recesses and including a first layer of printed conducting metal of the group consisting of copper and silver, a second layer of conducting metal of the group consisting of copper and silver electroplated

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on and coextensive with said first layer to improve its conducting properties and a third layer of corrosion resisting conducting metal of the group consisting of gold, platinum and rhodium electroplated on and coextensive with said second layer of metal, whereby said circuit closer is rendered adaptable for outdoor use.

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