

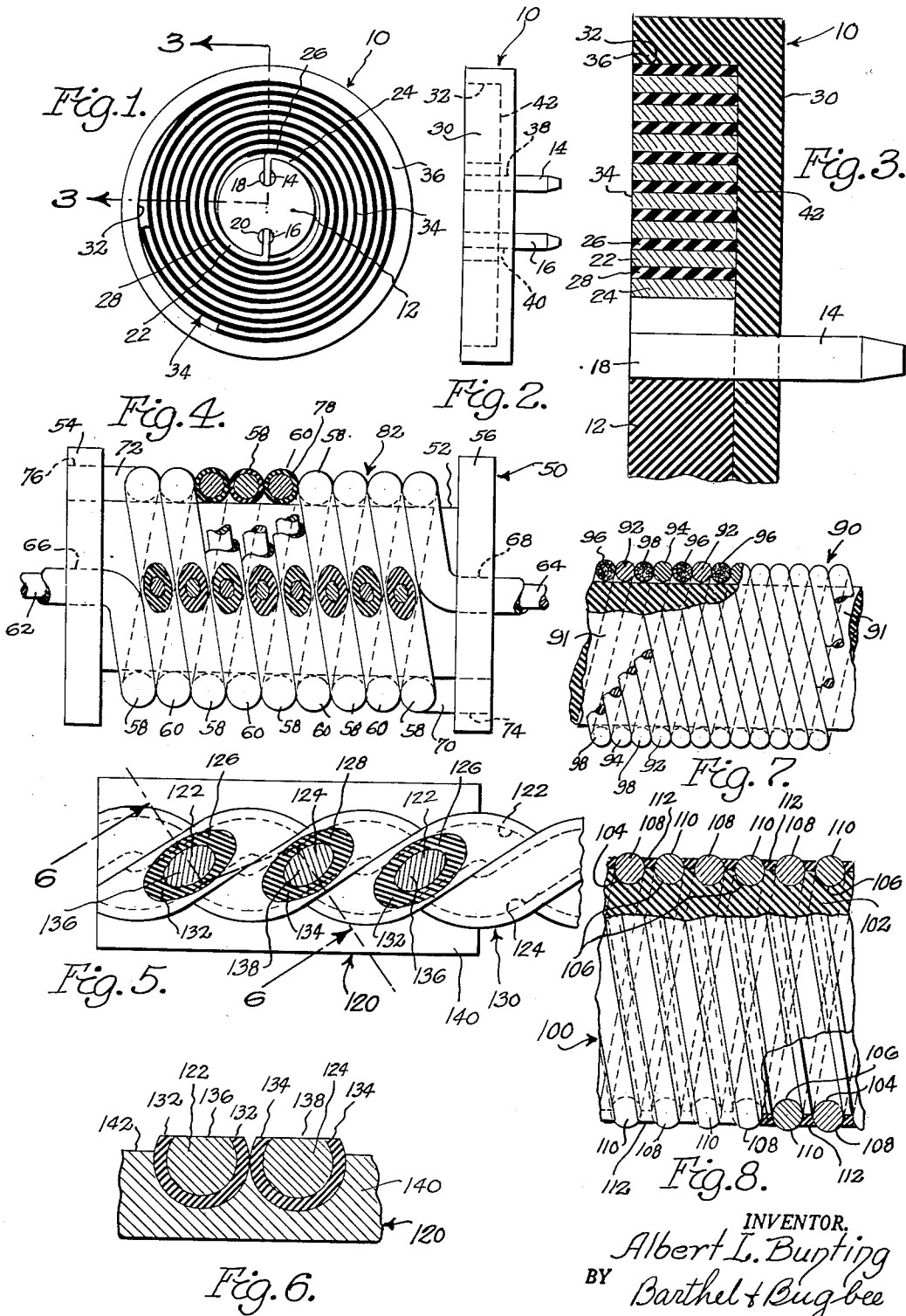
April 17, 1956

A. L. BUNTING

2,742,541

MOISTURE SENSITIVE RESISTOR

Filed June 2, 1953



1

2,742,541

MOISTURE SENSITIVE RESISTOR

Albert L. Bunting, Dearborn, Mich.

Application June 2, 1953, Serial No. 359,130

4 Claims. (Cl. 200—61.06)

This invention relates to electric circuit closers and, in particular, to moisture-responsive circuit closers, namely, circuit closers which are normally in an open circuit condition when dry, but which operate to close the electric circuit in the presence of moisture, such as rain, snow, heavy dew or heavy fog.

One object of this invention is to provide a moisture-responsive circuit closer which is more sensitive to the presence of moisture and more rapid in response thereto than circuit closers hitherto developed for that purpose, so that a much smaller quantity of moisture causes the circuit closer to close the circuit in a shorter time than hitherto, thereby especially adapting the present circuit closer for use in protective circuits, such as auto top or window raising devices where a small amount of moisture can create considerable damage or discomfort.

Another object is to provide a moisture-responsive circuit closer of the foregoing character which will operate repeatedly without becoming damaged or defective and without losing its sensitivity to moisture, so that the present circuit closer will perform its service satisfactorily over a long period of time, regardless of its being subjected to frequent applications of moisture.

Another object is to provide a moisture-responsive circuit closer of the foregoing character which is especially compact, so as to occupy the minimum amount of space as well as to be unobtrusive in appearance or position.

Another object is to provide a moisture-responsive circuit closer of the foregoing character which, after operation by being subjected to moisture, will dry itself out by its own self-contained action, without attention on the part of the operator.

Other objects and advantages of the invention will become apparent during the course of the following description of the accompanying drawing, wherein:

Figure 1 is a top plan view of a moisture-responsive circuit closer in spiral shape, according to one form of the invention;

Figure 2 is a side elevation of the circuit closer shown in Figure 1;

Figure 3 is an enlarged fragmentary vertical section taken along the line 3—3 in Figure 1;

Figure 4 is a top plan view of a second form of moisture-responsive circuit closer in helical shape;

Figure 5 is a top plan view of a third form of moisture-responsive circuit closer in twisted shape;

Figure 6 is an enlarged cross-section through the circuit closer of Figure 5, taken along the zigzag line 6—6 therein;

Figure 7 is a fragmentary side elevation partly in vertical section, of a fourth form of moisture-responsive circuit closer of helical shape employing bare wires with cord separators; and

Figure 8 is a side elevation, partly in vertical section, of a fifth form of moisture-responsive circuit closer in helical shape wherein the wires are seated in helical grooves.

2

General description

Moisture-responsive circuit closers as hitherto used to close electric circuits when subjected to the fall of rain or snow, flooding by water or other conditions of heavy moisture for actuating protective devices, have been subject to the disadvantages of slowness or sluggishness of response. The result has been that considerable damage or at least discomfort or annoyance has occurred by rainfall or flooding before the protective circuit was actuated, such as, for example, for raising the top or windows of an automobile. Certain of such prior devices have employed reeds or wood strips which warp in the presence of moisture and close switch contacts, as shown in the Smith Patent 2,198,488 of April 23, 1940.

The present invention has solved the problem of sluggish response of prior moisture-responsive circuit closers by providing an extremely compact circuit closer wherein a pair of elongated conductors is disposed side by side at extremely small separations, with a narrow insulating layer between the conductors, a salt which causes moisture to become an electrolyte being applied to the circuit closer in order to accelerate its action. The present circuit closer, moreover, has a self-contained drying action whereby it dries itself out after it has been actuated to close the protective electric circuit, without attention on the part of the operator.

In the first form of the invention shown in Figures 1, 2 and 3, the two conductors are in the shape of metallic ribbons wound in a spiral separated from one another by ribbons of insulating material, whereas in the forms shown in Figures 4, 7 and 8, the two conductors are in the shape of wires wound side-by-side on a cylindrical core in a helical arrangement. In the form shown in Figures 5 and 6, the two conductors are in the shape of wires twisted together and having portions bared to accelerate the action, this form being well adapted for mounting upon the window sill of an automobile in order to close the windows automatically at the onset of a shower.

Spiral circuit closer

Referring to the drawings in detail, Figures 1 to 3 inclusive show a spiral form of moisture-responsive circuit closer or cell, generally designated 10, according to one form of the invention as consisting of a central core 12 of insulating material carrying a pair of spaced prongs 14, 16 for engagement in a suitable mounting socket (not shown) analogous to that used for mounting electronic tubes, and thereby connected to the protective or other circuit to be operated, such as, for example, the top-raising circuit of an automobile. A typical circuit of this nature is shown in the Nutter Patent 2,617,962 of November 11, 1952 for Automatic Rain-Responsive Top and Window Lifting System.

Secured at their inner ends 18, 20 to the prongs 14, 16 are two spirally-wound ribbons 22 and 24 respectively, these being separated from one another by ribbons 26, 28 of insulating material. The insulating ribbons 26, 28 may be of flexible material, such as the cellulose acetate or other plastic material used, for example, in motion picture film. Figure 1 shows the thicknesses of the conducting ribbons 22, 24 and insulating ribbons 26, 28 exaggerated for clearness of illustration, it being understood that in actual practice these ribbons are considerably thinner than shown. The rapidity of response of the circuit closer or cell 10 depends, in part, upon the closeness to one another of the conducting ribbons 22, 24, a spacing of $\frac{1}{1000}$ of an inch having been found satisfactory. It has also been found that the wetting characteristics of the insulating ribbons 26, 28 are improved by coating the film with gelatin or other hygroscopic substance. This sub-

stance also has the further advantage of drying out rapidly by the heat generated in the operation of the device.

The tightly wound spiral coil of conductor ribbons and insulating ribbons is then placed in a casing 30 which is preferably cup-shaped with a recess 32 for receiving the foregoing assembly, generally designated 34. The springing back of the assembly 34 as a result of its slight unwinding action after it is placed in the recess 32 seats it firmly in the recess 32 against the annular side wall 36 thereof. Holes 38 and 40 are provided in the bottom wall 42 of the casing 30 for the reception of the prongs 14 and 16 respectively. In place of the casing 30, a bottomless collar of plastic or metal may also be used, the latter of course requiring an insulating layer between it and the assembly 34. It will also be obvious that while the prongs 14 and 16 are shown connected to the inner ends of the conductors 22, 24, such connections may equally well be made at the outer ends of these conductors, or at any intermediate point. The use of the core 12 is also optional, as the insulating ribbons 26, 28 may themselves be wound to form a core at the center of the assembly 34.

To further enhance the sensitivity of the circuit closer or cell 10, a suitable salt is preferably applied thereto in order to convert the normally poorly-conducting rain water into an efficiently-conducting electrolyte. While sodium chloride or a similar salt may be used, its corrosive properties make the use of another less corrosive salt preferable, such as, for example, potassium carbonate. This salt may be applied to the cell 10 in the form of a solution by painting the solution onto the cell, a 10% solution of potassium carbonate having been found satisfactory. Under mass production conditions, the salt may be applied to the insulating ribbons or strips 26, 28 by running them through a potassium carbonate bath before winding them into the assembly 34, the bath also preferably containing formaldehyde in order to harden the gelatine layer on the film strips or ribbons. The insulating strips 26, 28, after being run through the formaldehyde-potassium carbonate bath, are then preferably run through a second bath of potassium carbonate not containing formaldehyde. This procedure has the advantage of enabling the testing of the cell on the assembly line without waiting for it to be subsequently treated with such a salt.

In operation, the spiral circuit closer or cell 10 is mounted in an exposed location where it will most readily be subjected to the moisture which it is intended to guard against. In a convertible automobile, for example, a suitable location for the cell has been found to be on the upwardly-facing top bow in its lowered position, or at the rear of the vehicle near the top, so as to be protected by the top from further wetting after the top has been raised. The cell or circuit closer 10, plugged into its suitable socket which in turn is connected to a protective electrical circuit of the type described above, is in open circuit so long as it remains in a dry condition. The protective circuit, such as the top raising circuit, shunts or bypasses the regular top raising switch in the normal top-raising circuit of the automobile.

When a drop of rain or heavy moisture such as a heavy dew falls upon the cell or circuit closer 10, it wets the salt on the insulating strips or ribbons 26, 28, which immediately converts the moisture to a high-conductive electrolyte, whereupon the electrolyte in turn short-circuits the conductors 22, 24 by establishing a current path between them. The closing of the circuit through the cell or circuit closer 10 preferably operates a relay which in turn actuates the protective device, such as the top-raising motor, to raise the top of the vehicle. The latter comes to a halt upon the actuation of a limit switch, as is usual in such circuits, inverting the cell 10 if it is located on its underside of the top bow in its raised condition. In this position, it is protected by the top itself from the further reception of rain or other moisture, and the heat

developed within the cell 10 dries it out and halts the flow of current between the conductors 22, 24.

The operator is free to actuate the top raising or lowering switch independently of the circuit-bridging action of the cell or circuit closer 10, so that if the moisture is the result merely of a sudden short shower, the top may be lowered immediately after the shower is over. The cell, having dried itself out, is in instant readiness to bridge the top-raising switch and close the top-raising circuit again upon the reception of further moisture, such as rain, snow or heavy dew or fog.

Helical circuit closer

The helical form of moisture-responsive circuit closer, generally designated 50, shown in Figure 4 represents a modification of Figure 1, in which a core 52 of cylindrical form with end flanges 54 and 56 supports insulated elongated twin conductors 58, 60 wound side by side in a helical coil and having leads 62 and 64 respectively taken off at opposite ends through holes 66 and 68 in the end flanges 54, 56 respectively. The conductors 58, 60 have their opposite ends 70 and 72 seated in holes 74 and 76 respectively in the end flanges 56 and 54 respectively. The two conductors 58, 60 are coated with an insulating layer 78 which is removed in a longitudinally-extending band as at 80 to expose the bare wire of the conductors 58 and 60. The layer 78 may consist of textile material, such as cotton, silk or other suitable textile, or it may consist of a coating of enamel, plastic or the like. In either case, the winding, generally designated 82, consisting of the helically-wound conductors 58 and 60 is preferably given an application of a salt adapted to cause rain water to become an electrolyte, for example, potassium carbonate applied either by spraying, painting or dipping.

The modified helical moisture-responsive circuit closer, generally designated 90, of Figure 7 is of similar construction to the helical circuit closer 50 of Figure 4 and is similarly wound in helical formation upon a similar cylindrical core 91 of insulating material with similar flanges or heads (not shown). The conductors 92 and 94 of Figure 7, however, are in the form of bare wires separated from one another by insulating cords 96 and 98 wound simultaneously on the core 91 with the wires 92 and 94. The cords 96 and 98 are preferably given an application of a salt in the manner described above, for converting water into an electrolyte.

The modified helical moisture-responsive circuit closer, generally designated 100, shown in Figure 8 is also similar in general construction and arrangement to the circuit closers 50 and 90 shown in Figures 4 and 7 respectively. The cylindrical core 102 of the circuit closer 100 is of insulating material and is provided with helical grooves 104 and 106 in the form of a double helical thread. In these grooves are wound twin conductors in the form of bare wires 108 and 110 respectively. Optionally, the space between the conductors 108 and 110 is partially filled with a layer 112 of a salt in the manner described above, in order to convert water falling upon it into an electrolyte. The salt layer 112 is shown of exaggerated thickness, for clearness of illustration. The wires 108 and 110 are also led out in any suitable way, such as shown in Figure 4, for connection to the protective circuit.

In operation, the helical moisture-responsive circuit closers 50, 90 and 100 are mounted in any suitable location, such as that described above in connection with Figure 1, and connected to the protective circuit in a manner also similar to that described above. In an automobile top-raising circuit, the protective circuit is arranged to shunt or bridge the usual operating switch for the top-raising and lowering motor. When moisture, such as rain, snow or heavy dew, falls upon any one of the circuit closers 50, 90 or 100, it short-circuits the two concurrently-running conductors 58, 60 (Figure 4) or 92, 94 (Figure 7) or 108, 110 (Figure 8), the flow of current being enhanced by the conversion of the rain water into

5

an electrolyte by the potassium carbonate or other salt which has been previously applied thereto. In consequence of the short-circuiting of the circuit closer 50, 90 or 100, the protective circuit connected thereto is operated, bridging the normal operating switch and causing the motor to operate the protective circuit in the manner described in connection with Figure 4.

Again taking for example an automobile top-raising circuit, when the top reaches its raised position, it shields the cell 50, 90 or 100 from the fall of additional moisture, and the heat generated by the operation of the cell or circuit closer 50, 90 or 100 evaporates the raindrops or other moisture which have fallen thereon, dries out the insulation with its coating of salt, and thereby opens the circuit between the respective twin conductors 58, 60 or 92, 94 or 108, 110, as before.

Twisted circuit closer

The twisted moisture-responsive circuit closer, generally designated 120 shown in Figures 5 and 6 is for a similar purpose as those described in connection with the other figures, but is in a form which is especially well adapted for mounting upon narrow surfaces, such as the window sills of automobiles, for actuating window closing circuits. The circuit closer 120 consists of a pair of insulated conductors 122 and 124 each provided with an insulating coating 126 or 128 respectively wound together in a twisted formation, generally designated 130. The insulating coatings 126 and 128 are of conventional material, such as textile or plastic, and portions on the upper side are scraped off as at 132 and 134 to reveal bare spots 136 and 138 of the conductors 122 and 124 respectively. The twisted formation 130, either before or after scraping, is preferably embedded in a base 140 in the form of a block of insulating material such as synthetic plastic. A convenient way of doing this is to use a thermoplastic material for the base 140, first heating it to softness and then pushing the assembly 130 into the upper surface 142 thereof. The assembly 130, as before, is preferably treated with a salt solution such as potassium carbonate in order to enhance its rapidity of response by converting rainwater falling thereon into an electrolyte.

In the operation of the twisted moisture-responsive circuit closer 120 of Figures 5 and 6, let it be assumed, as before, that the conductors 122 and 124 are connected into the relay operating portion of the protective circuit, such as an automobile top-raising circuit, in a manner such that it bridges or shunts the normal operating switch. When, as before, moisture falls upon the bare spots 136, 138 of the conductors 122, 124, it bridges the gap between these conductors and short-circuits them. The rapidity of bridging of the gap is enhanced by the conversion of the moisture to an electrolyte if it is in the form of rain or snow, which normally has a relatively low electrical conductivity. With the circuit thus bridged, the protective circuit is energized, causing the protecting action to take place, for example, the raising of the automobile top. If, as before, the circuit closer 120 is mounted in a position where it is exposed with the top down but shielded with the top up, the heat developed during its operation will cause it to drop itself out as before, breaking the circuit and bringing the apparatus to a halt.

Each of the moisture-responsive circuit closers described above has been found to be exceptionally sensi-

6

tive as compared with prior devices for the same or similar purposes, with a much greater rapidity of response due to the extremely narrow separations of the conductors in the particular cell or circuit closer. In such circuit closers, as actually constructed according to the foregoing description, tests have shown that they will frequently operate one or two seconds after a drop of rain falls upon them. It has been found that a raindrop is of the order of $\frac{1}{25}$ to $\frac{1}{50}$ cubic centimeter in volume.

What I claim is:

1. A moisture-responsive circuit closer comprising a pair of elongated conductors disposed side by side in an elongated path in laterally-spaced relationship, the edges of said conducting strips being exposed on at least one side thereof, and insulating material disposed in the spaces between said conducting strips, adjacent portions of said exposed edges of said conducting strips communicating with the atmosphere for engagement and short-circuiting by moisture impinging thereon, said conductors being disposed in a spiral formation.

2. A moisture-responsive circuit closer comprising a pair of elongated strips of conducting material of elongated cross-section and a pair of intervening strips of insulating material disposed side by side in laterally-spaced relationship in an elongated spiral formation, the edges of said conducting strips being exposed on at least one side thereof, adjacent portions of said exposed edges of said conducting strips communicating with the atmosphere for engagement and short-circuiting by moisture impinging thereon.

3. A moisture-responsive circuit closer comprising a pair of elongated strips of conducting material of elongated cross-section and a pair of intervening strips of insulating material disposed side by side in laterally-spaced relationship in an elongated spiral formation, the edges of said conducting strips being exposed on at least one side thereof, adjacent portions of said exposed edges of said conducting strips communicating with the atmosphere for engagement and short-circuiting by moisture impinging thereon, and a casing surrounding said formation in insulated relationship therewith, said casing having electrical connection terminals thereon electrically connected to said strips of conducting material.

4. A moisture-responsive circuit closer comprising a pair of elongated strips of conducting material of elongated cross-section and a pair of intervening strips of insulating material disposed side by side in laterally-spaced relationship in an elongated spiral formation, the edges of said conducting strips being exposed on at least one side thereof, adjacent portions of said exposed edges of said conducting strips communicating with the atmosphere for engagement and short-circuiting by moisture impinging thereon, said strips of conducting and insulating material being relatively thin in proportion to their widths.

References Cited in the file of this patent

UNITED STATES PATENTS

1,694,107	Starkins	Dec. 4, 1928
2,285,421	Dunmore	June 9, 1942
2,285,633	Venable	June 9, 1942
2,295,570	Dunmore	Sept. 15, 1942
2,510,018	Gillingham	May 30, 1950
2,554,440	Coburn	May 22, 1951