No. 736,033. PATENTED AUG. 11, 1903.

A. B. STETSON.

MEANS FOR PROTECTING TELEPHONE CIRCUITS AND APPARATUS.

APPLICATION FILED DEC. 15, 1902.

NO MODEL.

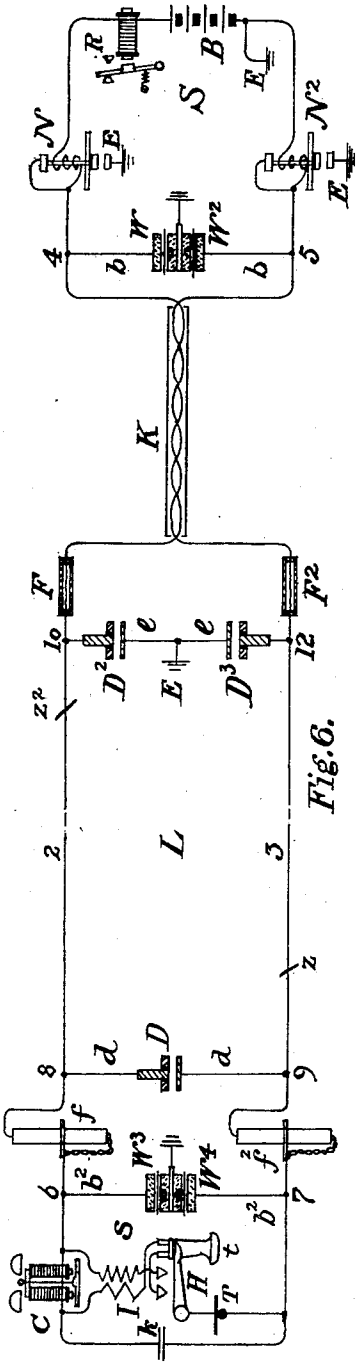

Fig. 6.

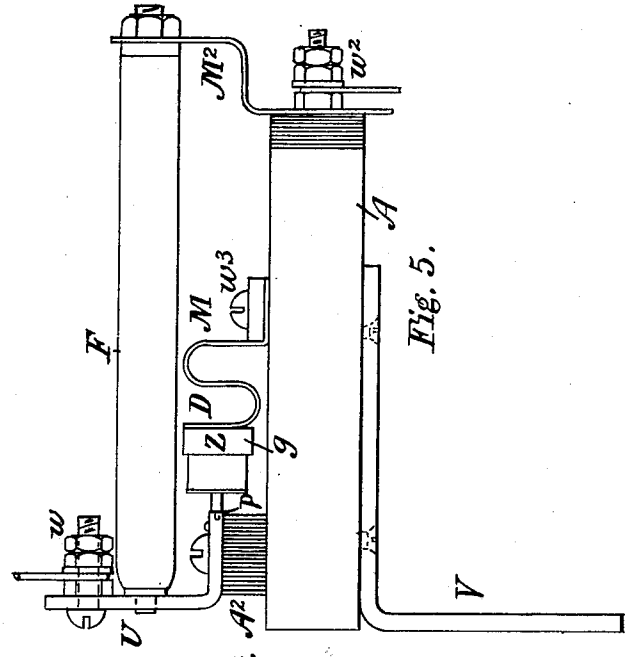

Fig. 5.

Fig. 3.

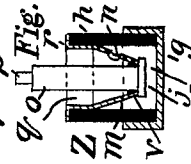

Fig. 4.

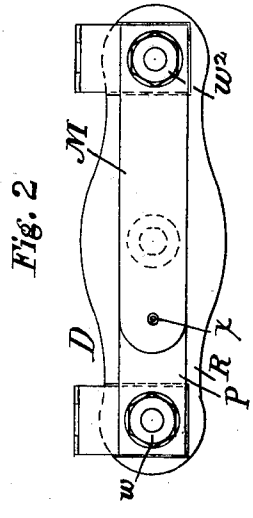

Fig. 2

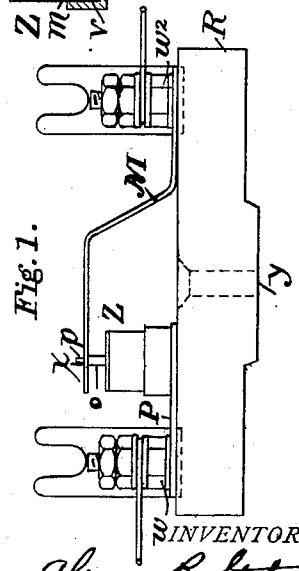

Fig. 1.

WITNESSES.

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No. 736,033. Patented August 11, 1903.

UNITED STATES PATENT OFFICE.

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MEANS FOR PROTECTING TELEPHONE CIRCUITS AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 736,033, dated August 11, 1903.

Application filed December 15, 1902. Serial No. 135,270. (No model.)

To all whom it may concern:

Be it known that I, ALMON B. STETSON, residing at Malden, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Means for Protecting Telephone Circuits and Apparatus, of which the following is a specification.

This invention relates to the protection of telephone circuits and apparatus from injury or damage due to the occurrence of contacts or crosses with the conductors of other circuits working with heavy electrical currents developed under high potentials or from some other undesigned cause.

Protective appliances of various kinds have heretofore been associated with telephone-circuits to guard them and the apparatus connected therewith from the effects of different kinds of heavy accidental or undesigned currents and discharges.

United States Patent No. 441,066, dated November 18, 1890, and issued to H. V. Hayes for a thermal protector, describes, for example, a device which has been extensively used for guarding against the destructive effects of currents, which while of no great volume or strength have still a strength considerably exceeding that of the currents which legitimately circulate in telephone-circuits and through the helices of telephone apparatus, and which have been popularly termed "sneak" currents, because when they come upon the circuit they are able, as it were, to sneak past the main conductors innocuously and past the other kinds of protectors inoperatively and to develop destructive heat only when they reach masses of insulated wire and instrument-coils. So in United States Patent No. 438,788, issued October 21, 1890, to Anthony C. White for an improvement in circuit and apparatus protectors, there is described an appliance operating by disruptive discharge or the passage of a spark between plates, the same being constructed and adjusted to become active when a minimum potential sufficiently high to be injurious—say three hundred and fifty volts—comes upon the line and acting by its operation to discharge the same to earth initially by disruptive discharge, but finally (in the event of said discharge being followed by a persisting arc) in the form of a current through a good conducting-path established by the action of said arc.

The systems of protection which heretofore have been employed have comprised devices based upon both of the foregoing inventions, associated, moreover, when the telephone-circuit conductors have been massed with others in a cable extending from some suitable external point into the central station with an ordinary fuse device located in the telephone-circuit at a point immediately outside of the outer end of such cable. Such systems have until a comparatively recent period afforded amply sufficient protection for telephone-circuits and apparatus against trespassing heavy currents, since the said trespassing currents have been developed under moderate potentials. Lately, however—that is, since arc-lighting by means of alternating constant currents with many arcs in series under high potentials ranging, say, from thirteen to fifteen thousand volts has been largely introduced—the conditions have materially changed and the foregoing compound system of protection is no longer of itself completely effectual. It has therefore become necessary to devise additional means of protection better adapted to meet present conditions and comprising new and improved forms of protective appliances for both the substation and central-station ends of telephonic circuits and for the apparatus connected in such circuits, which means shall not only of itself afford reliable protection against the said high-potential currents which have lately been introduced commercially, but shall also be constructed and arranged to harmoniously and efficiently coöperate with the preëxistent protective devices, producing when organized in connection therewith a complete and effective modernized system of protection.

In a pending application for Letters Patent of the United States filed by Wilton L. Richards July 26, 1902, Serial No. 117,098, for an improvement in protective fuse apparatus, there is described a specially-organized protective fuse device wherein a long fuse strip, ribbon, or wire is associated with and inclosed in a thickly-walled vulcanized-fiber

fuse-tube or tubular casing open at one end and closed at the other, the said fuse-wire being attenuated at or near the closed end to determine the point at which it shall first break down and being turned back over the exterior of the casing at the open end thereof to a terminal mounted on said external surface at some distance back from said open end, so as to be out of the line of discharge from the said open end accompanying the operation of the fuse.

The object then of the present invention is the more perfect and complete protection of telephone circuits and apparatus from destructive and damaging electrical currents and discharges of all kinds, and especially from such as are developed under potentials too high to be fully guarded against by such protective appliances as heretofore have been exclusively employed.

To this end there is provided as a characteristic feature of the invention an air-space protective cut-out or short-circuiting device formed with two contact members or electrodes held normally near to but out of contact with each other, the said electrodes having connection with attachments whereby the device may be introduced between any two desired points of a circuit, which points, however, have no conductive connection through the short-circuiting device as long as the normal condition of such device is maintained, but are brought into direct conductive connection through said device on the operation thereof. One of the electrodes is permanently fixed, but the other, though also normally fixed at an appropriate distance by being soldered to a suitable support, is movable under operative conditions into contact with the first for the establishment of conductive continuity between the terminals of the device, the said movable electrode being for this purpose constantly subjected to spring-pressure, which becomes effective when the solder attachment is melted or softened. The normal distance of separation between the electrodes of the short-circuiting device is so small as to facilitate the prompt formation of an arc between them when the high-potential current or charge against which the device is directed appears upon the telephone-circuit conductors, and the heat developed by said arc becomes at once effective to melt the soldered attachment and to bring the short-circuiting device into operation. Under the conditions which exist at the substations of telephone-circuits the short-circuiting device is preferably arranged in a simple normally open or incomplete bridge between the two main conductors of the circuit, and when brought into action it operates to close said bridge, and thereby to establish a short circuit or shunt around the apparatus to be protected or to serve as a cut-out for said apparatus; but when utilized for central-station protection it is preferred to employ two short-circuiting devices, one for each line conductor, connecting the electrodes of each to its own line conductor and to earth, respectively, or, in other words, to connect each air-space cut-out in a normally open earth branch from its own line conductor, the same to be closed by the operation of the device.

The invention consists also in associating the above-described air-protective space cut-out or short-circuiter with the several protective devices heretofore employed in a system of protection for telephone circuits and apparatus, also in associating the said short-circuiting device, the specially-organized fuse-protector hereinbefore mentioned, and the discharge protective device of the said patent of White with a telephone-circuit to constitute a means of protection for the stations and in particular for the substations of said circuit from the injurious effects of intrusive high-potential currents or charges reaching the said telephone-circuits from the heavy-current circuits to which the said intrusive currents properly belong.

It consists, further, in employing in a system for the protection of the central-station apparatus of a telephone-circuit and in connection with the conductors of said circuit and the usual and previously-employed protective devices thereof two air-space cut-out appliances associated, respectively, with the said circuit-conductors and a ground connection at each cut-out appliance normally detached from the associated circuit-conductor, but arranged to be attached thereto by the operation of said cut-out.

It further comprises a complete system of protective appliances for a telephone-circuit for the central and sub stations thereof and for the apparatus located at the said stations, the same being constituted by supplementing the standard and previously-employed protective devices at the central station by two air-space cut-out or short-circuiting appliances connected in normally incomplete earth branches of the two main conductors, respectively, and by supplementing the previously-employed protective devices at the substations by two of the specially-organized fuse devices connected directly in the main circuit-conductors, respectively, and an air-space short-circuiting device in a bridge between said main conductors, the said air-space short-circuiting devices at both stations being connected at a point outside of the station apparatus and previously-employed protective devices, and the said specially-organized fuse devices at the substation being connected in the circuit-conductors between the points of connection of said short-circuiting devices and said previously-employed protective devices.

In the drawings by which this specification is illustrated, Figure 1 is a side elevation of the open-space cut-out or short-circuiting device properly mounted and fitted with connection-terminals. Fig. 2 is a plan view of the same. Figs. 3 and 4 are respectively a plan

and vertical section of the contact-maker comprising the electrodes or fixed and movable contact members of the short-circuiting device in their normal relation, the same being detached from their mounting and fittings. Fig. 5 is a side elevation of the short-circuiting device mounted on a common support in association with a fuse-protector of the ordinary previously-employed type in a manner adapted for use in connection with central-station protection or at the outer end of a cable; and Fig. 6 is a diagram of a telephone-circuit extending between a central station and a substation, illustrating the application to such a circuit of the protective system and appliances described herein.

Referring first to the said diagram Fig. 6, L is a main telephone-circuit extending between a central station S and a substation or subscribers' station *s*, and 2 3, respectively, are its main conductors. R is a relay symbolizing the central-station telephone apparatus, B is the battery, and E wherever placed represents the earth or an earth connection. K is a cable through which the conductors of any practical number of telephone-circuits reach the central station. At the substation *s* C is the signal-bell; H, the automatic hook-switch; T, the telephone-transmitter; *t*, the telephone-receiver; I, the transmitter induction-coil, and *k* the condenser ordinarily interposed in the circuit of the primary winding of said coil.

The protection system as heretofore constituted and utilized comprised the two thermal protectors N N^2 of the Hayes patent, No. 441,066, the two discharge devices W W^2 of the White patent, No. 438,788, and the two ordinary four-inch fuse devices F F^2 at the central station, together with the two "White" discharge devices W^3 W^4 at the substations. As indicated, the thermal protectors were each placed in the main circuit-conductors at points near to and on the two sides of the central-station apparatus. The discharge devices were in normally discontinuous branches *b* and b^2 to earth E at the central and sub stations, respectively, at points 4 5 and 6 7, and the fuses F F^2 were in the main conductors at the outer end of the central-station cable K.

The function of the thermal devices N was and is to protect against the destructive effects of moderately-strong but slowly-heating intrusive currents. That of the discharge devices W is to protect against and provide for the innocuous passage to earth first as a spark and then as a current of damaging charges of moderately-high potential—say up to a maximum of three hundred and fifty volts—while the standard fuses are provided to guard against the effects of heavy and established currents of moderate potential.

In operation the thermal protectors N act to open and in many cases also to ground the circuit, the discharge devices either to pass the threatening charge harmlessly off as a spark, or in the event of such spark being followed up by a persisting arc to attach a ground connection to the affected conductor and the fuses F to open the circuit outside of the cable. To such previous system of protection there is added at the substation in accordance with this invention the bridged air-space cut-out or short-circuiting device D, which has been termed herein a "characteristic feature" of the said present invention, the same being in a normally open bridge *d* between the circuit-conductors outside of all of the substation apparatus and adapted as it becomes operative to close said bridge and short-circuit said apparatus, together with two of the specially-organized fuse-protectors ff^2, one connected in each circuit-conductor, these being respectively placed between the points 6 and 8 of main conductor 2 and the points 7 and 9 of main conductor 3, and in like manner there is or may be added at the central station to the previously-employed protective devices two of the open-space short-circuiting devices D^2 and D^3, one for each main circuit-conductor, the said devices being each in a normally open earth branch *e*, leading to earth E from its respective main conductor, and being, moreover, respectively connected with the circuit-conductors at points 10 and 12 outside of the ordinary fuses F.

The construction and arrangement of the open-space short-circuiting device D are shown by Figs. 1 to 4. In the working portion or contact-maker Z of this device a non-conducting sleeve *h* stands in a metallic cup or socket *g* and supports on its upper edge a hollow inverted cone *m*, having a flange *r*, which rests upon the upper edge of the said sleeve. A thick rod *o* projects from the apex of said cone backwardly to and beyond the base thereof, the same being provided at its forward end with a button *j*, normally soldered at *v* to and closing the otherwise open apex and terminating at its rear end in a shoulder and a smaller continuation-pin *p* projecting therefrom. The hollow part *q* of the cone *m* surrounds the rod *o* and is perforated with a hole or aperture *n*, which forms a channel from the chamber *u* between the closed end of the cone and the cup *g* for the escape of gas. The cup *g* constitutes one and the button *j* the other electrode or contact member of this device, and these, it will readily be seen, are normally insulated from one another by the insulating-sleeve *h* and separated mechanically by the soldered connection of said button *j* to the apex of the cone *m*. The cup *g* and the button *j* through the rod *o* may be conductively connected, respectively, to any desired two points, as 8 and 9, of a circuit. When the solder *v* is melted, the electrode *j* is forced into contact with the inner surface of the cup *g*, and the two points of the circuit connected with the rod *o* and cup *g* are thus directly united, a short circuit being thereby established between the said two points, and consequently between the two

main conductors and around any apparatus that may also be connected with said main conductors. In Figs. 1 and 2 these parts are shown as being mounted on a base R, of porcelain or other convenient non-conducting material, having a screw-hole y for attachment to any desired fixture. Two binding-screw attachments w w^2 are provided at opposite ends of the said base, one of which, w, secures and is continuous with a metal plate P, lying flat on the base, while to the other is attached a plate-spring M, bent upward and forward, as shown. The working portion Z of the short-circuiting device D is placed between the said plate P and spring M, resting by the flat surface of the under side of the metal cup g on the plate P and having the continuation-pin p of its rod o held in a small hole x, drilled through the spring M for the purpose. The said spring M is thus enabled to exercise the requisite pressure on the shoulder of the rod o, to which is attached the movable electrode-button j, so that when the solder v, which secures said button to the apex of the cone m, is melted or softened the said button is immediately forced forward and into contact with the inner surface of the cup g. The appropriate circuit-wires are to be attached to the binding-screws w w^2, respectively.

At the central station the short-circuiting device D may conveniently be mounted in close association and on a single base with the four-inch fuse F. This is shown in Fig. 5, where a base A, of wood or any desired non-conducting material, is supported on a bracket V. A block of hard rubber A^2 rests across said base and provides a seat for the brass angle-plate U. The fuse F is secured at one end to said angle-plate and at the other end to the spring attachment M^2. The main-circuit binding-screws w and w^2 are attached to the brass angle-plate U and the spring attachment M^2, respectively. The plate-spring M, which in this case assumes a double-U form, is attached at one end to the earth-connection binding-screw w^3, and the working portion Z of the short-circuiting device D is held between said spring and the end of the angle-plate U, the free end of said spring M pressing against the bottom of the cup g and the pin p of said working portion Z socketing in an aperture or socket bored into the said end of the angle-plate.

The air-space cut-out or short-circuiting device D is adapted to operate by the initial establishment of a small arc and the subsequent union of its electrodes or contact members whenever the difference of potential between the said contact members exceeds an approximate value of two thousand five hundred volts, and the specially-organized fuse device f is adapted to operate and to open the telephone-circuit at the point where it is placed when there is established in such circuit and through said fuse device a current having a volume corresponding to an electromotive force having such minimum value.

The action of the invention in operation is as follows: Let it be assumed that conductor 3 of the telephone-circuit has become crossed, as indicated at z, with the conductor of a constant-current circuit developed under any such extremely high potential as is now quite general for lighting and power plants, ranging, say, up to a maximum of fifteen thousand volts. This potential is at once propagated to the discharge-protector W^4, which being organized to protect against much lower voltages and to operate with potential as low, say, as three hundred and fifty volts promptly comes into action and conductively unites its line and ground carbon plates, thus providing conductor 3 with a perfect ground connection through the specially-organized long fuse device f^3. The intrusive voltage is thus enabled to develop a current of great volume in the portion of the circuit between the cross at z and the ground at the discharge-protector W^4, and consequently through the long fuse device f^2. This fuse device responding to the passage of the said heavy current instantly blows, thereby opening the circuit of conductor 3 between the substation instruments and the point 9, where the bridge d of the air-space short-circuiter D is attached. The intrusive high potential is thus diverted to the said bridge d and is of course sufficient to produce a small arc between the electrodes g and j of the short-circuiting device D, connected therein. The heat of the arc instantly melts the solder or metallic cement v, which normally attaches the movable electrode j and its plunger-rod o to the hollow cone m, and thereby holds it normally separate from the fixed electrode g, and the pressure on the shoulder of said rod exercised by the spring M, forcing the said movable electrode downward, brings it into firm contact with the fixed electrode g. Conductive continuity is thus established between the two conductors of the circuit and a discharge instantly occurring between the line and earth plates of the discharge-protector W^3 a direct earth connection is now given to main conductor 2. This in turn causes the special fuse device f to blow. The substation apparatus is now fully protected notwithstanding the continuance of the cross at z, since it is not only short-circuited in the open-space cut-out D, but is also actually disconnected from the conductors 2 and 3, which have been severed in their respective fuses f f^2. We may now assume that the cross has occurred at the point z^2 so much nearer the central station that the apparatus of that station is most liable to first suffer injury. Under these conditions also the low-potential discharge device W is the first to respond, which it does, grounding the conductor 2 at the inner end of the cable K through the branch b, extending from point 4 of said conductor. The po-

tential of the cross at once develops a powerful current through the ordinary fuse F, which immediately blows, opening the circuit of conductor 2. The entire potential energy due to the cross z^2 is, however, now directed upon the air-space cut-out D^2, producing an arc between the electrodes thereof and speedily bringing said electrodes together in the before-described manner, thereby grounding conductor 2 outside of the cable K.

It will be seen that the new form of protective device—viz., the open-space cut-out or short-circuiting device—is not devised to take the place of or be substituted for the older and previously-employed protective devices, but is designed to guard against a new adverse potential and current more powerful than any heretofore commercially utilized, and that while the said previously-employed appliances are still used each has a means of protection against some one particular class of adverse electromotive force or current—the low-potential discharge device and the specially-organized fuse device at the substation—and the said discharge device and the ordinary fuse at the central station constitute, with the short-circuiting device or open-space cut-out of the present invention, a new protective system severally and collectively guarding the substation and central-station apparatus of a telephone-circuit from the effects of all intrusive currents and all electromotive forces of destructive strength which are liable to appear in or upon the circuit.

The invention having been thus fully described, the claims are as follows:

1. A protective cut-out or short-circuiting appliance comprising two relatively movable electrodes or contact members normally insulated from one another and separated by an air-space; a support to which one of said electrodes is normally attached by solder or similar easily-fusible cement and thereby held opposite but near to and out of contact with the other electrode; and a pressure-spring acting steadily upon one of said electrodes to force the same into contact with the other electrode when said solder is melted or softened.

2. An air-space short-circuiting protective device comprising fixed and movable electrodes or contact members normally held apart in an insulating-case, and having between them an air-space sufficiently short to facilitate the formation under high potential of an arc; a support to which one of said electrodes is attached by an easily-fusible cement, said support and fusible connection acting to normally hold the electrodes apart; circuit-terminals for the said two electrodes respectively; a rigid connection extending from one of said circuit-terminals to the fixed electrode; and a resilient connection extending from the other of said circuit-terminals to the said movable electrode, and adapted to exert steady pressure thereon toward the said fixed electrode.

3. In an air-space short-circuiting protective device, a non-conducting sleeve; a metallic cup closing one end thereof and constituting an electrode or contact member; a hollow cone having a flange-bearing on the other end of said sleeve and projecting its apex thereinto; a conducting-button consituting a second electrode attached by an easily-fusible cement to said apex and held thereby separated from the other electrode but within arcing distance thereof; a metallic rod extending backward from the button through the hollow cone, and a spring exerting constant pressure to move the electrodes into contact upon the fusing of said cement.

4. In an air-space short-circuiting protective device, a non-conducting sleeve; a metallic element closing one end thereof and constituting an electrode or contact member; a support carried by and extending into the sleeve; and a second electrode attached to the support within the sleeve by an easily-fusible cement and held thereby separated from the other electrode but within arcing distance thereof.

5. In an air-space short-circuiting protective device, a non-conducting sleeve; a metallic element closing one end thereof and constituting an electrode or contact member; a support carried by and extending into the sleeve; a second electrode attached to the support within the sleeve by an easily-fusible cement and held thereby separated from the other electrode but within arcing distance thereof; and a resilient member exerting steady pressure to force the electrodes into contact upon melting or softening of said cement.

6. A protective cut-out or short-circuiting appliance for telephone circuits and apparatus, comprising fixed and movable electrodes or contact members normally insulated from one another and separated by an air-space; a support to which the movable electrode is normally attached by solder or similar easily-fusible cement, such separated movable electrode, being held thereby opposite and near to the fixed electrode; and a pressure-spring acting steadily upon said movable electrode to force the same into contact with said fixed electrode when the said solder is melted or softened; substantially as set forth.

7. An air-space short-circuiting protective device for telephone circuits and apparatus, comprising fixed and movable electrodes or contact members normally held apart from each other in an insulating-case, and having between them an air-space sufficiently short to facilitate the formation under high potentials of an arc; a support to which the said movable electrode is soldered, or attached, by any easily-fusible cement; circuit-terminals for the said two electrodes respectively; a rigid connection extending from one of said circuit-terminals to the fixed electrode; and a resilient connection extending from the other of said circuit-terminals to the said

movable electrode, and adapted to exert steady pressure thereon toward the said fixed electrode; substantially as set forth and for the purposes specified.

8. An air-space short-circuiting protective device, comprising a non-conducting base; a metal plate and a spring mounted thereon, and connected respectively with circuit-terminal attachments; and a contact-making portion consisting of a non-conducting sleeve, a metallic cup closing one end thereof and constituting a fixed electrode or contact member, a hollow cone resting by a flange at its base on the other end of said sleeve and projecting its apex thereinto, and a conducting-button attached by an easily-fusible cement to said apex and held thereby separated from said fixed electrode but within arcing distance thereof and constituting a movable electrode provided with a metal rod extending backward through said hollow cone and beyond the base thereof; the said contact-making portion being mounted between said metal plate and spring by the resiliency of the latter, in such wise that the fixed electrode thereof rests upon said plate, while the said movable electrode is under constant pressure from said spring; substantially as set forth.

9. In an air-space cut-out or protective appliance, the contact-making device Z consisting of the metal cup *g* constituting a fixed electrode or contact member attachable to one point of the circuit-conductors; the non-conducting sleeve *h* standing therein; the hollow inverted cone-support *m* resting by its base-flange on the upper end of said sleeve; the contact-button *j* soldered to the apex of said cone, constituting a movable electrode or contact member normally separate from but within arcing distance of said fixed electrode, the same being provided with the conducting-rod *o* projecting backwardly through said cone beyond the base thereof, and attachable thereby with another point of the circuit-conductors; and a spring forming the circuit connection of said rod and pressing thereon to bring the movable and fixed electrodes into contact when the former is released from its soldered connection; substantially as described.

10. In an air-space cut-out or protective appliance, the contact-making device Z comprising the metal cup *g* constituting a fixed electrode or contact member; the non-conducting sleeve *h* standing therein; the hollow inverted cone-support *m* resting by its base-flange on the upper end of said sleeve, and forming therewith a closed chamber, the said cone being perforated to permit the escape of gases from said chamber; the contact-button *j* constituting a movable electrode or contact member soldered to the apex of said cone and normally carried thereby separate from but near to said fixed electrode said button being provided with the rod *o* projecting backwardly through said cone beyond the base thereof; and a spring pressing upon the end of said rod to unite the movable and fixed electrodes when the normal soldered connection of the former is melted or softened; substantially as set forth.

11. In a protective system for telephone-circuits and station apparatus, the combination with the previously-employed protective appliances consisting of a fuse device in each main circuit-conductor; and a discharge device in a normally discontinuous earth branch from each main conductor attached to said conductor at a point between said fuse and the telephone apparatus; of an air-space cut-out or short-circuiter responsive to high potentials connected in a bridge between the said main circuit-conductors outside of said fuse devices, and comprising a fixed electrode connected with one and a movable electrode connected with the other of said main conductors, the latter being soldered to a fixed support and thereby held normally out of contact with the former, but within arcing distance thereof; and means for establishing contact between said electrodes on the formation of an arc between them and the melting of said soldered connection pursuant thereto; substantially as specified.

12. The combination with a telephone-circuit and at a substation thereof; of a protection system comprising the following coöperative devices; a specially-organized fuse-protector having a long fuse-conductor and an open-end casing therefor connected in each of the circuit main conductors at points external to the substation apparatus; a discharge device responsive to moderate potentials in a normally discontinuous branch extending to earth from each main conductor at a point between said specially-organized fuse device and the substation apparatus; and an air-space cut-out or short-circuiting device bridged between said main conductors outside of said fuse-protectors, and comprising two normally separated contact members, a soldered connection attaching one of said members to a fixed support and thereby maintaining such normal severance, and means for bringing said members into contact when the said soldered connection is dissolved; the said short-circuiting device being responsive to high potentials only, and adapted when subjected thereto to operate by the establishment of an arc between its contact members, and the consequent melting of said soldered connection; substantially as set forth.

13. The combination in a system of protection for a telephone-circuit and the central-station apparatus and conductors, with the main and cable conductors of said circuit; and the standard and previously-employed protective devices thereof, comprising a low-potential discharge-protector in a normally open branch from each main conductor at the inner end of the cable, and a fuse-protector of ordinary capacity in each conductor at the outer end of the cable; of two air-space

short-circuiting appliances associated with the said main conductors and in normally discontinuous ground branches thereof respectively, the said short-circuiting appliances being connected with said conductors outside of said fuse-protectors, and being adapted to operate under a high potential and thereupon to close and connect said ground branches; substantially as set forth.

14. A protective system for telephone-circuits, their central and sub stations and apparatus, consisting in the standard and previously-employed open earth-branch discharge devices at both central and sub stations; and serially-connected ordinary fuse-protectors at the central station; combined with and supplemented by two air-space short-circuiting devices connected in normally incomplete earth branches of the two main circuit conductors respectively, at the central station; and with two fuse devices specially organized to be responsive solely to heavy currents developed under high potentials; and an air-space short-circuiting device or cut-out in a normally incomplete bridge between the main conductors all at the substation; the said short-circuiting devices at both stations being connected with the circuit-conductors at points outside of the apparatus and other protective devices of said stations, and the said high-potential fuse devices at the substation being introduced into the circuit-conductors between said short-circuiting devices, and the said other protective devices; substantially as and for the purposes set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 10th day of December, 1902.

ALMON B. STETSON.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.