Dec. 19, 1950 C. F. WAGNER 2,534,935

SLEET-MELTING ON HIGH-VOLTAGE LINES

Filed June 11, 1948

Fig. 1.

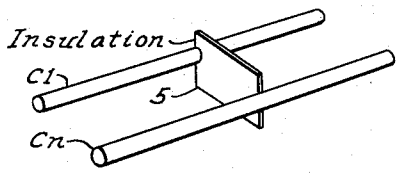


Fig. 2.

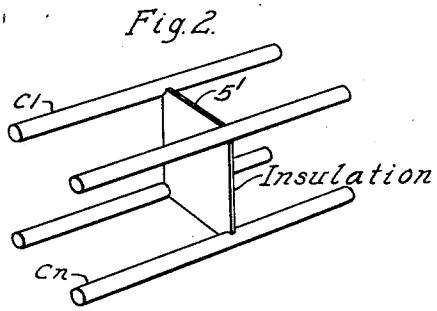


Fig. 3.

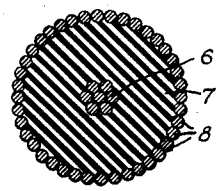
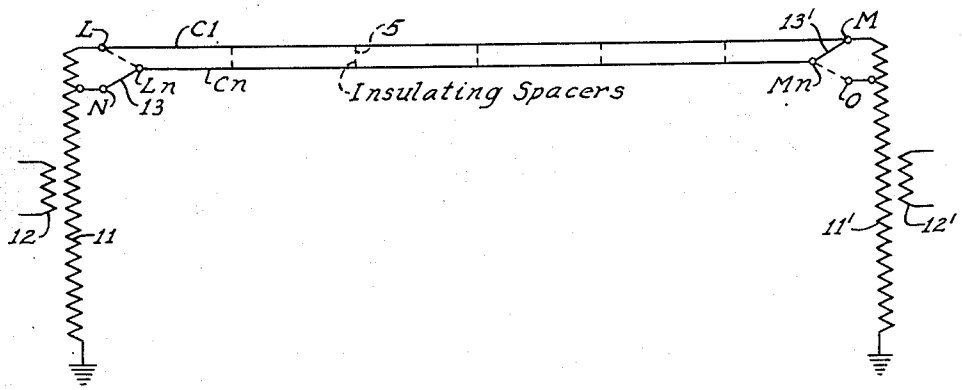


Fig. 4.



WITNESSES:

H. F. Susser.

Wm. L. Goodwin

INVENTOR

Charles F. Wagner.

BY O. B. Buchanan

ATTORNEY

Patented Dec. 19, 1950

2,534,935

UNITED STATES PATENT OFFICE

2,534,935

SLEET-MELTING ON HIGH-VOLTAGE LINES

Charles F. Wagner, Swissvale, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application June 11, 1948, Serial No. 32,345

5 Claims. (Cl. 171—97)

1

My invention relates to a means and method for preventing sleet or ice-formation, or for melting the same, once it has formed, on high-voltage lines. My invention has more particular application to sleet-melting or prevention on a line-conductor of a special type designed to increase the effective diameter of the conductor so as to increase the voltage of incipient corona, thus making possible the use of higher transmission-line voltages. Sleet and ice-formation on these special conductors, having increased effective diameter, is a particularly serious disadvantage because the increased diameter of the conductor enormously increases the mechanical and wind-loading on the conductor.

There are at least two types of increased-diameter conductors to which my invention is particularly applicable. One of these special types includes the so-called "bundle conductors" in which each phase or conductor of a single-phase or three-phase line consists of two, three or four conductors which are electrically connected in parallel to constitute, in effect, a single electrical conductor, and which are physically held in parallel spaced relation to each other by means of spacers at intervals of about 50 yards, more or less. Heretofore, these spacers have been made of conducting material, so as to constitute the means for connecting the plurality of spaced conductors in parallel-circuit relation. When applying my present invention to bundle-conductors, it is necessary to replace these conductive spacers with insulating spacers. Another type of increased-diameter conductor to which my present invention is particularly applicable is an expanded cable, which consists of a central core of strong conducting material, surrounded by an insulating spacer, which is finally surrounded by stranded electrical conductors.

A general object of my invention is to provide a means whereby heating-currents may be circulated over such plural-conductor assemblies, having increased effective diameters for corona-prevention, using one or more of the individual conducting paths as a return-conductor for the circulating heating-currents.

With the foregoing and other objects in view, my invention consists in the circuits, systems, combinations, methods and parts hereinafter described and claimed, and illustrated in the accompanying drawing, wherein:

2

Fig. 1 is a fragmentary perspective view of a two-conductor bundle-conductor in accordance with my present invention;

Fig. 2 is a similar view of a four-conductor bundle-conductor;

Fig. 3 is a cross-sectional view of an expanded conductor or cable of a type to which my invention is applicable; and

Fig. 4 is a diagrammatic view of the equivalent electrical circuit involved in the use of my invention.

As shown in Figs. 1 and 2, a bundle-conductor, for use in my invention, consists of any desired number of parallel-spaced conductors C1 to C*n*, which are held mechanically spaced from each other by means of insulating spacers 5 or 5', which may be distributed at intervals of 50 yards, more or less, along the length of the bundle-conductor. These spacers 5 or 5' may hold the individual conductors C1 to C*n* at any desired distance apart, such as 16 inches, more or less. When these individual conductors C1 to C*n* of any bundle-conductor are all at substantially the same high potential, the high-potential field surrounding the bundle-conductor assembly is a field which surrounds the entire group of individual conductors C1 to C*n*, as distinguished from a field which surrounds each individual conductor by itself, so that the effective conductor-diameter of the group or bundle, so far as the high-voltage electrostatic field is concerned, is much larger than the diameter of a single compact equivalent conductor having the same cross-sectional area as the total cross-sectional area of the sum of the conductors C1 to C*n*. Since the incipient corona-voltage, or the voltage at which corona first begins to appear, depends upon this effective conductor-diameter, and since the bundle type of conductor has a considerably increased effective diameter, as compared to the diameter of an equivalent single conductor of the same total cross-sectional area, the bundle type of conductor is an effective means for preventing corona when operating at extremely high voltages.

Fig. 3 shows an expanded cable, which is illustrated, by way of example, in the form of an expanded ACSR (aluminum conductor, steel-reinforced) conductor or cable, consisting of a cen-

tral core 6 of steel, for strength, surrounded by paper or other dielectric or insulating material 7, for a spacer, which is finally surrounded by strands 8 of aluminum or other conducting material for actually carrying the current, or at least carrying practically all of the current which is being transmitted by the cable. In this expanded-cable construction, the outside diameter is obviously much greater than the diameter of a single compact cable made up of the aluminum strands 8 without the core 6 or the insulating spacer 7, thus considerably increasing the voltage at which the cable can be operated, without producing corona. In applying my invention to such a cable, the aluminum strands 8 can be considered as one electrical conductor C1, and the steel core 6 may be considered as a return-conductor C*n*.

My invention is particularly applicable to these special types of conductors when they are used as aerial conductors for a high-voltage transmission-line suspended in air, each phase-conductor of the line consisting of one of the special conductors, such as are illustrated in Figs. 1, 2 and 3, or any other type of special conductor in which means are provided for increasing the effective diameter of the conductor for corona-prevention, and including at least two individual conductor-circuits which are normally insulated from each other along a material length of the transmission-line.

In applying my invention for the purpose of preventing the formation of sleet or ice on such conductors, or for melting such sleet or ice after it has once formed, I provide any suitable or convenient means for either continuously or temporarily circulating heating-currents through said conductors. The arrangement may be such that such heating-currents do not circulate unless two of the individual conductors C1 to C*n* of a bundle-type of conductor should become connected to each other by a bridge of sleet or ice, or the arrangement may be such that the circulating heating-currents are circulated, either continuously or only under certain weather-conditions, so as to prevent sleet-formation, regardless of whether there is already a sleet or ice-formation which short-circuits a plurality of conductors.

In either case, the equivalent electrical diagram of Fig. 4 may be considered as being illustrative of the circulating-current paths. In this figure, the special conductor, whether of the type shown in Fig. 1, 2 and 3, or any other type of special conductor having increased effective diameter, and having the two insulated conductors or circuits, is illustrated as comprising two separate conductors C1 and C*n*, which are normally electrically insulated from each other throughout a certain length, as from the point L to the point M. Each of these two conductors C1 and C*n*, in the equivalent diagram of Fig. 4, may consist of any number of parallel-connected strands or conductors. If there are more than two electrically insulated conductors, as, for example, in the case of the four-conductor bundle of Fig. 2, then these conductors may be grouped together in any desired combination, to produce the equivalent effect of two electrically insulated conductors C1 and C*n*, as shown in Fig. 4. If an expanded cable is used, as shown in Fig. 3, the aluminum strands 8 may be considered as the conductor C1 in Fig. 4, and the steel core 6 may be considered as the conductor C*n* in Fig. 4. If bundle-conductors are used, as shown in Figs. 1 and 2, the insulating spacers 5 or 5' may be considered to be diagrammatically represented at the points 5 shown in Fig. 4.

Considering the conductor-length between the points L and M in Fig. 4, it may be considered that these points L and M are the terminal points of the corresponding portion of the conductor C1. The corresponding terminal-portions of the conductors C*n* may be indicated at L*n* and M*n*, respectively. In accordance with my invention, a suitable source of circulating heating-currents should be provided, as by means of taps L and N on a transformer-winding 11, which may be the secondary winding of a high-voltage step-up transformer to which power is supplied by means of a primary winding 12. Then, in accordance with my invention, the conductor-terminal L*n* may be connected either to the transformer-tap N or to the transformer-terminal L, by means of a two-position switch 13, which is shown, in full lines, in a position to connect L*n* to N, and which is shown, in dotted lines, in a position to connect L*n* to L.

At the other terminal of the conductor-length L—N which is shown in Fig. 4, the two conductor-terminals M and M*n* may either be permanently connected together, as shown in full lines, or a two-position switch 13' may be provided, for connecting the conductor-terminal M*n* either to the point M or to a point 0, according as the switch 13' is in its full-line position or its dotted-line position, as shown in Fig. 4. The points N and 0 may be taps on any suitable transformer 11' which constitutes a suitable source of supply for circulatory heating-currents. By way of example, the transformer-winding 11' may be the primary winding of a step-down transformer which has a low-voltage secondary winding 12' which may be connected either to a load or to a source of power-supply.

There are obviously several methods of operation which are available, in practicing my invention. In the full-time position of the equivalent diagram shown in Fig. 4, the two conductors C1 and C*n* are connected together at the point M, which may be any point along the bundle-conductor or expanded conductor, which point M is spaced from a source L—N of circulatory heating-currents. These circulatory heating-currents may be circulated either continuously, or only under certain special weather-conditions, by suitable manipulation of the switch 13, as will be obvious from Fig. 4. According to this interpretation of the equivalent diagram of Fig. 4, the full-line position of the switch 13' may be regarded as a permanent electrical connection between the points M and M*n* of the two conductors C1 and C*n*.

It is obviously possible, in the equivalent diagram of Fig. 4, to operate the line with the switch 13' in either the full-line position or in the dotted-line position. If both of the switches 13 and 13' are in their uppermost positions at the same time, so that each switch connects together the ends of the two line-conductors C1 and C*n*, under such operating-conditions the two conductors are electrically connected together at both ends, so that there are no circulating heating-currents under any conditions. It is also obviously possible, however, for both of the switches 13 and 13' to be in their lowermost positions, in which case, the two ends of the top conductor C1 are connected to the two terminals L and M of the two transformers 11 and 11', respectively, while the two terminals of the bot-

tric power, comprising the combination of a plurality of transmission-line conductors suspended in the open air; each line-conductor being an expanded cable consisting of a central core of strong conducting material, a solid insulating spacer surrounding said core, and stranded bare electrical conductors surrounding said solid insulating spacer and exposed to the weather; and auxiliary supply-means, whereby circulatory heating-currents may be supplied to said core and said stranded bare conductors.

CHARLES F. WAGNER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,078,711	Whitehead	Nov. 18, 1913
2,008,109	Reher	July 16, 1935
2,020,128	Stricher	Nov. 5, 1935
2,075,073	Watson	Mar. 30, 1937
2,081,109	Ell	May 25, 1937

FOREIGN PATENTS

Number	Country	Date
461,498	Great Britain	July 17, 1935

tom conductor C*n* are connected to the respective tapped points N and 0 of the respective transformers 11 and 11'. These two tapped points N and 0 may both be at substantially the same electrical potential, in which case there will be no circulating heating-currents in the conductors C1 and C*n*, unless there should be an accidential or weather-produced short-circuit, as by means of sleet or ice-formation, at some intermediate point of the line, in which case heating-currents will be supplied, from both ends of the line, to melt the short-circuiting obstruction. Or, in a third case, the equivalent diagram of Fig. 4 could obviously be used with either one of the switches 13 or 13' in its upper position, and with the other switch in its lower position, in which case, circulating heating-currents will be supplied, regardless of the presence of sleet or ice or any other short-circuiting cause.

While I have illustrated my invention more particularly in connection with a single multiple-strand line-conductor, or a single-phase conductor, it will be obvious that the invention is applicable to each of the phase-conductors of an aerial multi-phase transmission line for commercial frequency power-transmission.

It will also be obvious that while I have shown the switches 13 and 13' diagrammatically, without any special operating-means therefor, for changing the positions of these switches, any suitable manipulating-means may be provided, such as are known for manipulating switches or contactors which are operating at extremely high voltages.

It will be noted that my invention accomplishes its avowed purpose of removing the ice-and-sleet hazard which has heretofore accompanied the use of special types of conductors having increased effective diameters for corona-prevention. It will be further noted that I have provided means for preventing or removing ice or sleet without the necessity for taking the line out of service during this process, as has been heretofore necessary in most, if not all, previous aerial-line transmission-systems.

While I have illustrated my invention in a single preferred form of embodiment, with a limited number of suggestions of alternative details, I wish it to be understood that my invention is not limited to the illustrative forms, as many changes of omission, addition, or the substitution of equivalents may be made in the design and application of my invention. I desire, therefore, that the appended claims shall be given the broadest construction consistent with their language.

I claim as my invention:

1. Remedial means for both ice and corona in a high-voltage aerial transmission-line for electric power, comprising the combination of a plurality of transmission-line conductors suspended in the open air; each line-conductor being an increased-diameter corona-remedial conductor, having an effective diameter which is increased over the diameter of a single compact equivalent conductor having the same total conducting cross-sectional area; each line-conductor further including a plurality of spaced individual-conductors, of which at least the outer surfaces, in each line-conductor, are bare; said plurality of spaced individual-conductors of each line-conductor including at least two individual conductor-circuits which are normally insulated from each other along a material length of the transmission-line; and auxiliary supply-means, whereby circulatory heating-currents may be supplied to said two individual conductor-circuits.

2. Remedial means for both ice and corona in a high-voltage aerial transmission-line for electric power, comprising the combination of a plurality of transmission-line conductors suspended in the open air; each line-conductor being an increased-diameter corona-remedial conductor, having an effective diameter which is increased over the diameter of a single compact equivalent conductor having the same total conducting cross-sectional areas; each line-conductor further including a plurality of spaced individual-conductors, of which at least the outer surfaces, in each line-conductor, are bare; said plurality of spaced individual-conductors of each line-conductor including at least two individual conductor-circuits which are normally insulated from each other along a material length of the transmission-line; a plurality of transformers at spaced points along the length of the transmission-line, said transformers having corresponding-voltage taps in addition to their terminal-voltage points; and means whereby one of the individual conductor-circuits is energized from the terminal-voltage points of successive transformers and whereby the other individual conductor-circuit is energized from the corresponding-voltage taps of successive transformers.

3. Remedial means for both ice and corona in a high-voltage aerial transmission-line for electric power, comprising the combination of a plurality of transmission-line conductors suspended in the open air; each line-conductor being a bundle-conductor assembly comprising a plurality of bare individual-conductors and a plurality of insulating spacers distributed at spaced points along said individual-conductors for holding the same physically in substantially parallel-spaced relation in air; said plurality of spaced individual-conductors of each line-conductor including at least two individual conductor-circuits which are normally insulated from each other along a material length of the transmission-line; and auxiliary supply-means, whereby circulatory heating-currents may be supplied to said two individual conductor-circuits.

4. Remedial means for both ice and corona in a high-voltage aerial transmission-line for electric power, comprising the combination of a plurality of transmission-line conductors suspended in the open air; each line-conductor being a bundle-conductor assembly comprising a plurality of bare individual-conductors and a plurality of insulating spacers distributed at spaced points along said individual-conductors for holding the same physically in substantially parallel-spaced relation in air; said plurality of spaced individual-conductors of each line-conductor including at least two individual conductor-circuits which are normally insulated from each other along a material length of the transmission-line; a plurality of transformers at spaced points along the length of the transmission-line, said transformers having corresponding-voltage taps in addition to their terminal-voltage points; and means whereby one of the individual conductor-circuits is energized from the terminal-voltage points of successive transformers and whereby the other individual conductor-circuit is energized from the corresponding-voltage taps of successive transformers.

5. Remedial means for both ice and corona in a high-voltage aerial transmission-line for elec-