July 19, 1927. 1,636,544

A. L. ATHERTON

LIGHTNING ARRESTER CONNECTION

Filed April 21, 1923 2 Sheets-Sheet 1

Fig. 1.

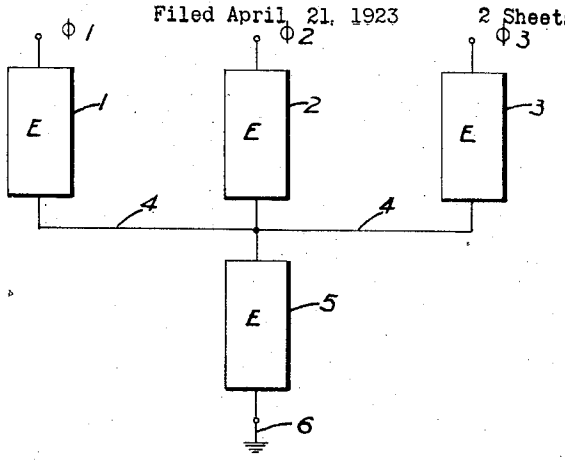


Fig. 2.

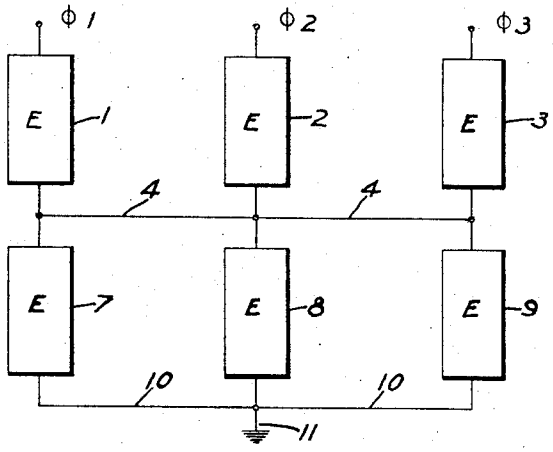
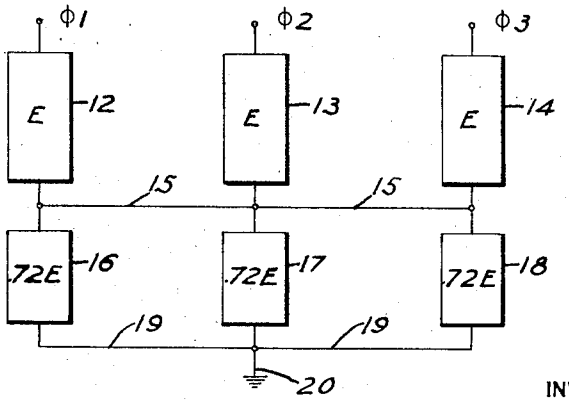


Fig. 3.



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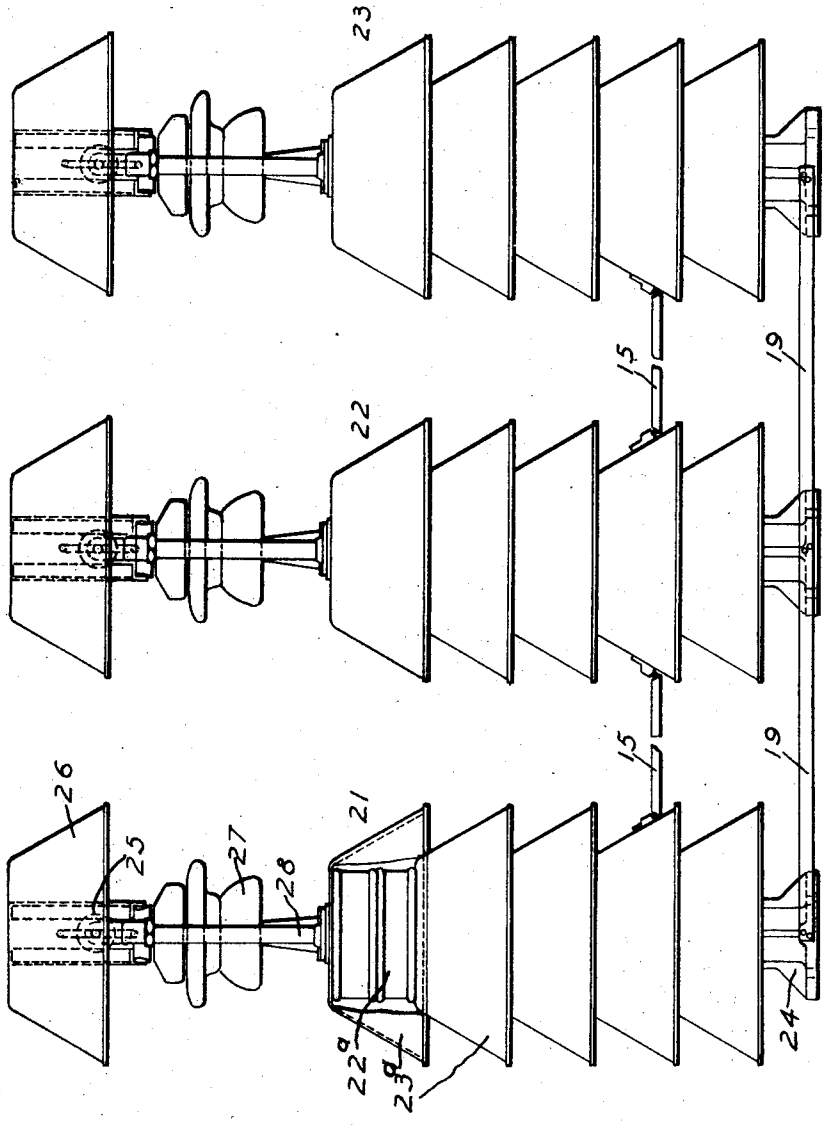


Fig. 4.

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UNITED STATES PATENT OFFICE.

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LIGHTNING-ARRESTER CONNECTION.

Application filed April 21, 1923. Serial No. 633,743.

This invention relates to excess voltage protective devices, more particularly to lightning arresters and to means for so connecting such devices as to give a maximum of protection to the system in which they are incorporated.

It has been common practice, in connecting valve-type lightning arrester elements in three-phase alternating current circuits, to use the so-called "multiplex" connection wherein one element is interposed between each line or phase wire and the ground, the lower ends of said elements being connected together and another lightning arrester element interposed between this connection or neutral and the ground. Such arresters are described, for example, in the patents to E. E. F. Creighton, Nos. 923,024; 923,338 and 933,826.

In excess voltage surges from exterior sources, such as atmospheric disturbances or lightning discharges, the three-phase wires are all charged to approximately the same excess voltage relative to the ground. In discharging the excess potential through the lightning arresters, the surge currents of the three lines pass through the three line elements and then combine at the neutral and pass through the ground element to ground. The impedance to the flow of the surge current is well recognized to be of great importance in the performance of the lightning arrester and this impedance should be considered at the voltage which the lightning arrester permits to exist on the line. In other words, the major portion of the surge current must flow through the arrester at such a safe voltage as to prevent accidental injury to the apparatus in the circuit.

In the well known multiplex connection, with a lightning discharge passing through the circuit, the surge current flows through each of the line elements and then through the ground element, giving a total effective impedance drop for each of the surge currents equal to four times that of a single lightning arrester element because of the fact that only one-third of the cross-sectional area of the ground element is available for discharge of the surge current from each line.

The disadvantages of the multiplex connection are obviated by my invention, it being among the ojects thereof to provide an arrangement of protective elements which shall have a relatively small impedance drop when discharging surge currents through the protective devices.

It is a further object of my invention to provide a certain arrangement and connection of protective elements for alternating current systems such that there shall be a substantially equal freedom of discharge between all points on the system having differences of potential due to surge conditions.

In the accompanying drawings constituting a part hereof and in which like reference characters indicate like parts,

Fig. 1 is a diagrammatic view showing the old and well-known multiplex connection of protective elements for a three-phase system;

Fig. 2 is a diagrammatic view showing one embodiment of my invention;

Fig. 3 is a diagrammatic view showing the preferred form of my invention, and

Fig. 4 is an elevational view of a lightning arrester embodying the principles of my invention.

As shown in Fig. 1, each of the phases of the alternating current system in the multiplex connection has protective elements 1, 2 and 3 of a discharge voltage designated as E, corresponding to the voltage from line to neutral so as to break down at a predetermined voltage sufficient to prevent the flow of dynamic current under line voltage conditions but which allows an overvoltage to be discharged, such protective elements being commonly designated as lightning arresters of the valve type. The elements are connected together at 4 and a similar ground element 5 is connected thereto and to ground 6. In case a lightning discharge strikes the system, the excess voltage causes a breakdown of elements 1, 2 and 3, the surge passing therethrough to connection 4 and through element 5 to ground. Because of the necessity of the surge current from all the phases passing through element 5, the total effective impedance drop caused by the flow of the surge current in any phase is four times that of a single element. This greatly decreases the protective value of the apparatus.

To obviate the disadvantage of the above connection, I have devised a new system such as shown in Fig. 2 embodying the phase

elements 1, 2 and 3 having the connection 4 therebetween as in the multiplex system. But in place of the single element 5, I insert elements 7, 8 and 9 in series with elements 1, 2 and 3, respectively. The latter elements are interconnected at 10 and are connected to ground 11.

When a lightning discharge strikes the system, the surge currents pass through the phase elements 1, 2 and 3, being equalized by the connection 4 and they then pass through elements 7, 8 and 9 to ground. It will be noted that the impedance drop in the protective devices caused by the flow of surge current is twice the impedance drop in single element. This is in contrast to four times the impedance drop in the multiplex connection. Thus, by the addition of 50% to the number of elements, the protective values of the apparatus has been doubled. It follows that, in order to obtain equal protection, the elements of my system may be half the size of those used with the multiplex connection.

I have discovered that still better results may be obtained by providing certain proportions of protective elements to give a still greater freedom of discharge for surge currents, as illustrated in Fig. 3. I provide protective elements 12, 13 and 14 connected to the phases of the circuit to be protected, each of the said elements having a discharge voltage corresponding to the voltage E from line to neutral, i. e. to approximately .58 of the voltage from line to line. The said elements are interconnected at 15 and similar elements 16, 17 and 18 are connected in series with elements 12, 13 and 14, respectively, the elements 16, 17 and 18 each having a discharge voltage corresponding to .42 of the voltage from line to line or to .72 of the voltage E from line to neutral. The ground elements are interconnected at 19 and are grounded at 20. Each line is thus connected to ground through a valve arrester unit or leg having a discharge voltage corresponding to the voltage from line to line, the individual units or legs having a neutral interconnection at a point corresponding to the voltage from line to neutral.

In the operation of this preferred form of my invention, when a lightning discharge strikes the system, the same passes freely from each of the phases or lines through its phase and ground elements to ground. The protective value of the lightning-arrester connection of Fig. 3 against the passage of the surge current is 2.32 times that of the multiplex connection of Fig. 1. Should differences in voltage occur between the phases of the circuit, as, for instance, between phase 1 and phase 2, a discharge will pass from element 12 through connection 15 to element 13, thus equalizing the voltage between the phases. It will be noted that this form of my invention allows substantially a maximum freedom of discharge from one phase to another as well as from a phase to ground by interposing between points having certain differences of potential protective elements proportional to such differences of potential.

In the practical embodiment of my invention, I provide a series of lightning arresters 21, 22 and 23, each of which consists of a plurality of protective units 22^a with interposed rain shields 23^a mounted upon a suitable support 24. In series with the protective units 22^a is a gap 25 having a protective shield 26 thereover, the elements of the gap being supported on an insulator 27 and a conducting pillar 28, respectively. This construction is described and claimed in my copending applications, Serial No. 630,270, filed April 6, 1923, and Serial No. 633,742, filed April 21, 1923, for lightning arresters. The protective elements 21, 22 and 23 are interconnected by connections 15 at a point approximately 58% of the impedance of the elements from the line to ground. The supports 24 are electrically connected by connections 19 and grounded. It will be noted that in a practical construction, such as is shown in Fig. 4, I utilize only three protective elements, each of which is of a capacity only slightly greater than those used in the multiplex connection but the impedance drop of the system to surge currents as compared to that in the multiplex connection is in the ratio of one to 2.32 with an increase of only 30% in the number of elements 22^a employed. For practical reasons the arrester elements are built up from individual units of a standard size, as shown at 22 in Fig. 4, each unit having substantially the same breakdown voltage and the same impedance.

The cost of making the connections for my new system is practically negligible, it being only necessary to secure connectors 15 at the proper point of the rain shields 23, and, by a simple change of this character, the result is a great increase in facility of discharge with only a slight increase in the number of elements hitherto utilized.

I claim as my invention:

1. An excess-voltage protective system for multiple-phase circuits comprising a plurality of excess-voltage protective devices connected to the several line conductors of said circuits, a star-connecting means for said devices having a negligibly small impedance to excess-voltage discharges, and excess-voltage protective means connected between the star point and ground, the discharge current-carrying capacity of said means being equal to the combined current-carrying capacities of all of said star-connected protective devices.

2. An excess-voltage protective system for

polyphase circuits comprising a plurality of excess-voltage protective devices connected in star to the several line conductors of said circuits, and excess-voltage protective means connected between the star point and ground, the discharge voltages of said line-connected devices being substantially proportional to the star-voltage of the line, and the discharge voltage of said grounded means being substantially proportional to the difference between the mesh and star voltages of said line.

3. An excess-voltage protective system for a three-wire three-phase line comprising a plurality of excess-voltage protective devices connected in star to said line, and excess-voltage protective means connected between the star point and ground, the discharge voltages of said line-connected devices being substantially proportional to the star-voltage of the line, and the discharge voltage of said grounded means being substantially proportional to 0.72 of said star voltage.

4. An excess-voltage protective system for a three-wire three-phase line comprising a plurality of excess-voltage protective devices connected in star to said line, and excess-voltage protective means connected between the star point and ground, the discharge voltages of said line-connected devices being substantially proportional to the star-voltages of the line, and the discharge voltage of said grounded means being substantially proportional to 0.72 of said star voltage, and the current-carrying capacity of said grounded means being substantially equal to the combined current-carrying capacity of all of said line-connected devices.

5. An excess voltage protective system for three-phase circuits comprising a protective element for each phase, said elements being connected to ground, and an interconnection between said elements at a point approximately 58% of the impedance of each element from the line.

6. An excess-voltage protective system for three-phase circuits comprising a protective element for each phase, said elements being connected to ground, each of said elements comprising a plurality of similar valve-cell units connected in series to have a total breakdown voltage corresponding to the voltage from line to line.

7. An excess voltage protective system for three-phase circuits comprising a protective element for each phase, said elements being connected to ground, each of said elements comprising a plurality of similar valve-cell units connected in series to have a total breakdown voltage corresponding to the voltage from line to line, and an interconnection between said elements at a point approximately 58% of the impedance of each element from the line.

8. A protective device for a polyphase line comprising a valve-arrester phase element for each phase of said line, each phase element having a breakdown voltage and a discharge impedance proportional to the voltage from each line to neutral, said phase elements being connected in star, and an additional valve arrester ground element connected between the star point and ground, said additional ground element having a current discharge capacity equal to the combined current discharge capacity of the several phase elements connected in parallel, the breakdown voltage of said ground element being so proportioned that the total breakdown voltage of a phase element and the serially connected ground element is substantially proportional to a voltage not less than the voltage from line to line and less than double the voltage from line to neutral.

9. An excess-voltage protective system for polyphase circuits comprising a protective element for each phase, said elements being connected to ground, each of said elements comprising a plurality of similar valve-cell units connected in series to have a total breakdown voltage corresponding to the voltage from line to line, and an interconnection between said elements at a point corresponding to the voltage from line to neutral.

In testimony whereof, I have hereunto subscribed my name this 14th day of April, 1923.

ALFRED L. ATHERTON.