R. B. INGRAM.

LIGHTNING ARRESTER.

APPLICATION FILED JUNE 25, 1906.

1,013,166.

Patented Jan. 2, 1912.

3 SHEETS—SHEET 1.

Fig. 1.

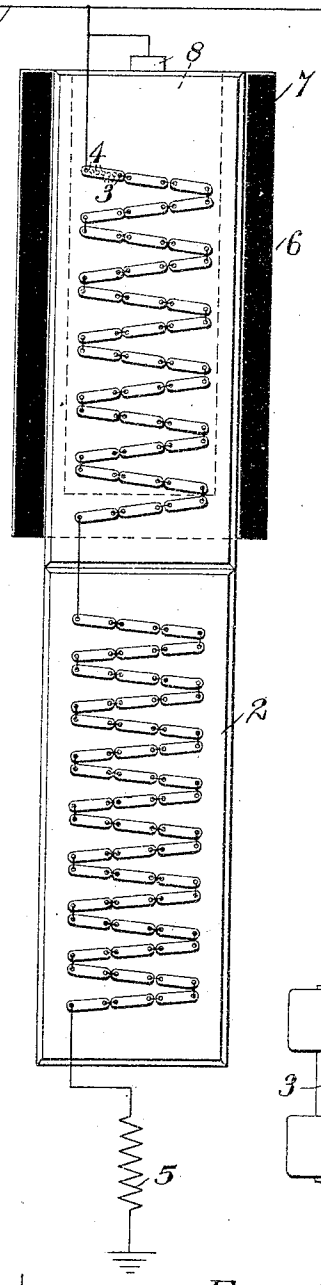


Fig. 2.

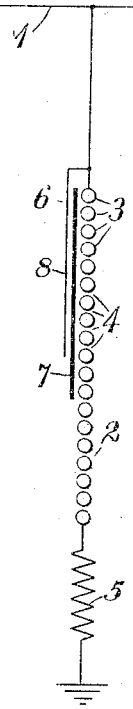


Fig. 3.

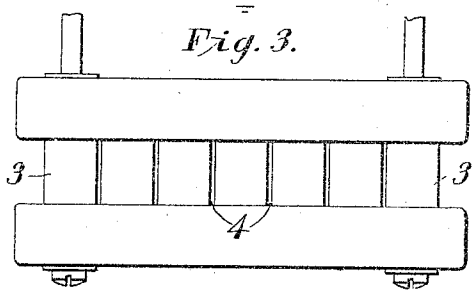
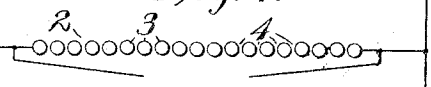


Fig. 4.



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3 SHEETS—SHEET 2.

Fig. 5.

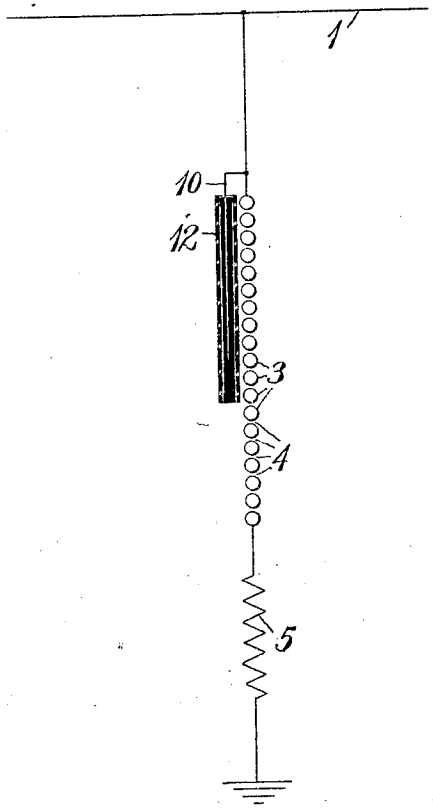
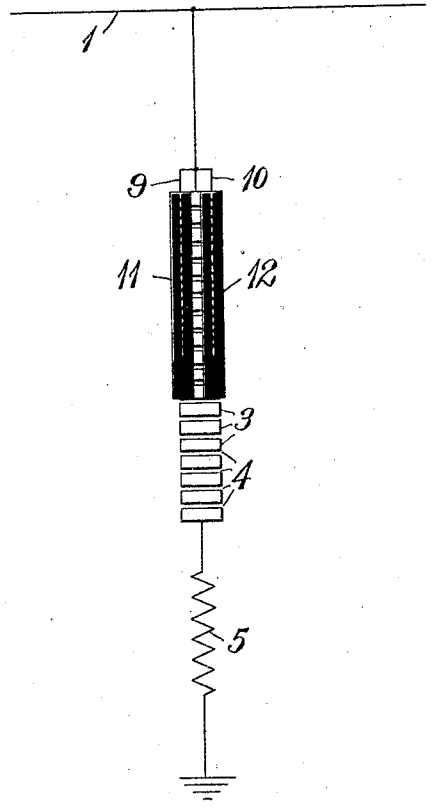


Fig. 6.



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3 SHEETS—SHEET 3.

Fig. 8.

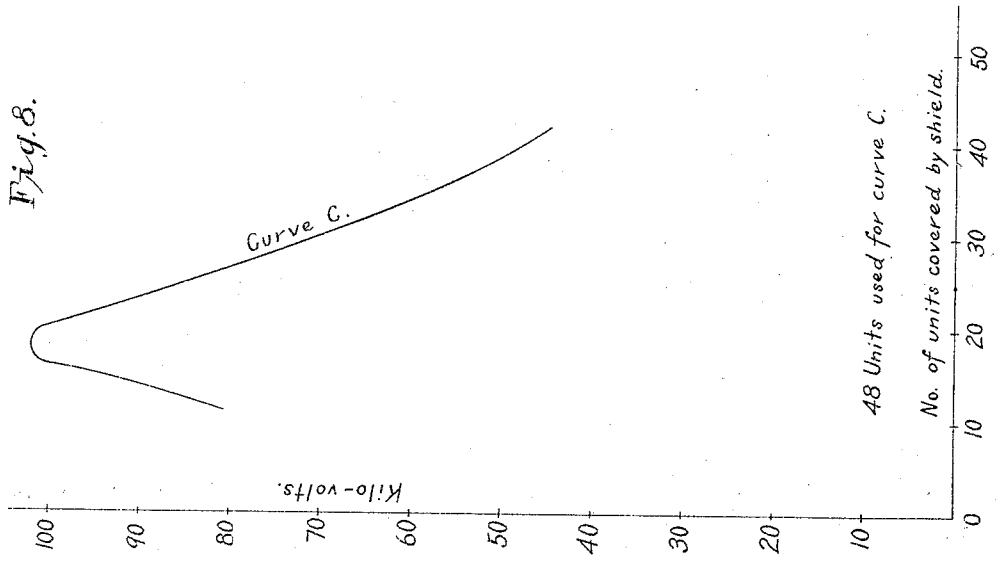
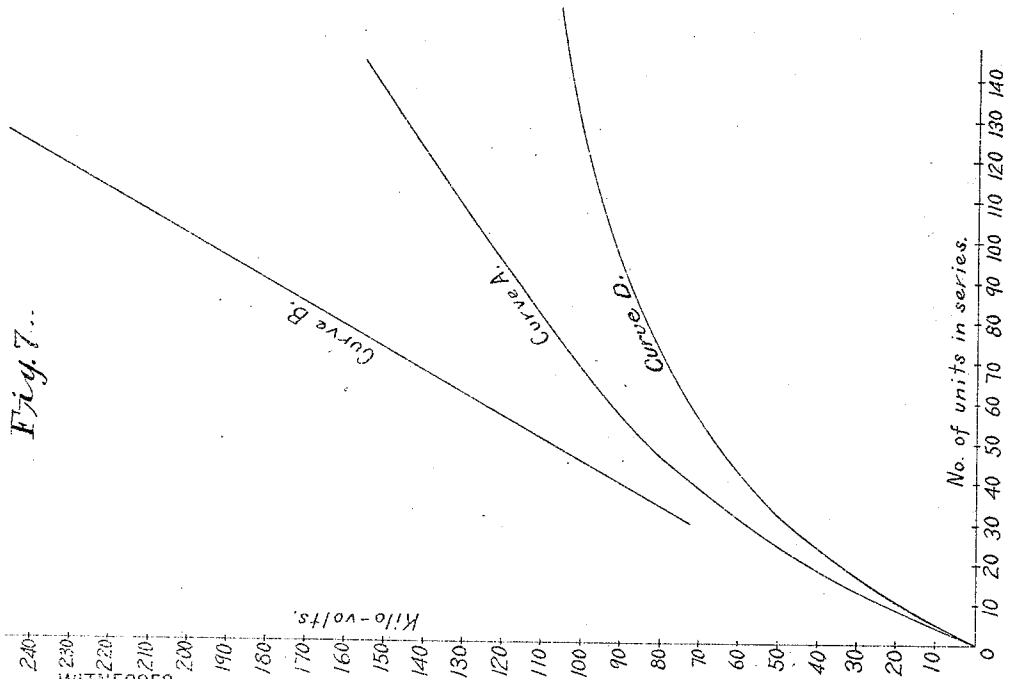


Fig. 7.



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LIGHTNING-ARRESTER.

1,013,166. Specification of Letters Patent. Patented Jan. 2, 1912.

Application filed June 25, 1906. Serial No. 323,361.

To all whom it may concern:

Be it known that I, RALPH B. INGRAM, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Lightning-Arresters, of which the following is a specification.

My invention relates to devices employed for protecting electric circuits and apparatus from injury by reason of lightning discharges and other static disturbances as well as dynamo currents of high potential which tend to follow the paths established by static discharges.

The object of my invention is to provide means for insuring an approximately constant ratio between the aggregate air-gap of a protective device and its critical voltage, that is, the lowest voltage at which a discharge will occur.

A well known form of protective device or lightning arrester comprises a series of air-gaps formed by a plurality of conducting blocks located at short distances from each other. When a device of this kind is adapted for the protection of relatively high voltage lines by increasing the number of air-gaps, it has been observed that, while the aggregate air-gap is increased, its voltage-sustaining or withstanding power is not correspondingly increased. This discrepancy may be attributed to a condenser action which takes place between the several conducting blocks and the earth. Under ordinary circumstances, this condition is undesirable, and, in order to avoid it, I provide a shield which destroys the condenser action between the conducting units and the ground and establishes a substantially constant ratio between the aggregate length of the air-gap in the protective device and its critical voltage.

In the accompanying drawings Figure 1 is a view partially in front elevation and partially in section and Fig. 2 a diagrammatic view of a protective device constructed in accordance with my invention. Fig. 3 is a detail view of a group of units such as are shown in Fig. 1, and Fig. 4 is a diagrammatic view of a protective device employed between two line conductors neither of which is grounded. Figs. 5 and 6 are diagrammatic views, at right angles to each other, of a modified shield structure which is adapted for use with high voltage lines. Fig. 7 shows a set of curves obtained by plotting the results of tests made on a lightning arrester by varying the number of units of which it is comprised and measuring the voltage at which an arc is established, with and without the shield of my invention. Fig. 8 is a curve obtained by varying the number of units, of a predetermined series, which are protected by the shield and measuring the voltage at which an arc is established across the units for each variation.

The shield itself may comprise a plate of conducting material or a conductor of any suitable form which may be electrically connected to the line to be protected, and be insulated from the units by a suitable dielectric, such as an insulating plate or tube, and which extends over or in proximity to a portion of the units comprising the device. If the device itself is mounted on a wall or near an object which is grounded, the shield is preferably located between the units of the lightning arrester and the nearest grounded object.

Referring to Figs. 1, 2, and 3 of the drawings, an electric line conductor 1 is protected from lightning or other static disturbances, by means of a lightning arrester 2, which comprises a series of blocks 3 of conducting material separated by relatively short air-gaps 4. One end of the series of conducting units is connected to line conductor 1 while the opposite end of the series is grounded through a suitable resistance 5 The lightning arrester 2 is provided with a shield 6 which comprises a plate 7 of insulating material and a conducting plate 8. The conducting plate 8 of the shield 6 is connected to the line conductor 1 and extends over, or in proximity to a number of the units 3, which may be definitely predetermined as hereinafter pointed out, the conducting plate being separated from the units by the insulating plate 7.

In Figs. 5 and 6, a modified form of shield is illustrated comprising a plurality of conductors 9 and 10 that are connected in multiple arc and are separated from the conducting blocks 3 by insulating tubes 11 and 12. This structure is of special advantage for use in connection with the pro-

tection of high voltage lines, since it is relatively easy to provide an insulating tube capable of withstanding very high voltages.

Reference may now be had to Fig. 7, curve A of which is obtained by varying the number of units 3 of which the lightning arrester is composed and measuring for each variation, without the use of the shield 6, the voltage at which an arc may be established from the line conductor to the ground. It will be observed that the first part of this curve which represents the conditions for the protection of low voltage lines is nearly straight, indicating that the critical voltage increases substantially in the same ratio as the aggregate length of the air-gap, while, as the number of units is increased for the protection of the higher voltage circuits, the curve is materially flattened, indicating that when the aggregate air-gap is relatively long the critical voltage is not correspondingly increased.

If a convenient number of units be taken and a shield, such as that already described, be so applied as to cover a varying number of units from the end which is connected to the line conductor and a breakdown voltage be obtained for each variation, the results will be indicated by a curve, similar to curve C of Fig. 6, having a peak that indicates the number of units which should be covered by the shield in order that the critical voltage may be maximum. If the total number of units in the lightning arrester be varied and, for each variation, a curve be obtained similar to the curve C, (Fig. 8), and if then a curve be drawn through the peaks of the several curves; the number of units which should be covered in a lightning arrester having any given aggregate air-gap (as indicated by the number of units of which the device is composed) may readily be determined.

By repeating the tests from which curve A was obtained, and using a suitable shield for each variation of the number of units, a curve similar to curve B in Fig. 7 will be obtained. This curve shows conclusively that the critical voltage of a lightning arrester having a predetermined number of units may be materially increased by the use of a shield arranged and proportioned as above indicated. It is also apparent that just the opposite result, viz: the reduction of the critical voltage will be effected if the shield is arranged adjacent to all, or nearly all, of the conducting blocks. Curve D of Fig. 7 clearly indicates the effect of arranging the shield in the manner just described.

In some cases it is desirable to decrease the critical voltage, making it easier for an arc to be established across the gaps. This result is accomplished by the arrangement disclosed by Patent No. 571,099, granted to the Westinghouse Electric & Manufacturing Co. November 10, 1896, on an application filed by Charles E. Skinner May 21, 1896, and forms no part of my present invention.

Tests have shown that with a shield of this kind, a constant ratio between the breakdown voltage and the aggregate length of air-gap is substantially maintained throughout the complete range of voltage which I have been able to obtain.

According to my present invention, it is desired to abrogate the forces which tend to reduce the voltage sustaining power of a predetermined aggregate air-gap in protective apparatus, and in order that this result may be accomplished it is essential that the shield be adjacent to only a part of the conducting blocks or cylinders of which the apparatus is composed. As clearly shown in curve C of Fig. 8, the effect of the shield is not only useless but actually detrimental to the operation of the device if more than a predetermined portion of the cylinders are covered.

When the protective devices similar to the lightning arresters already described are connected between two circuit conductors, neither of which is grounded, for preventing static disturbances, the most advantageous arrangement of the shield comprises, as illustrated in Fig. 4, two similar conducting members which are severally connected to the line conductors and which extend for a short distance toward each other, near the units comprising the protective device that are adjacent to the line conductors.

Obviously, the voltage strains are greater near the end of the plate or shield which is farthest from the line conductor to which it is connected, so that if air is used as a dielectric the end of the plate should be more widely separated from the conducting units as shown in Fig. 4.

It is conceivable that changes in the size and arrangement of parts may be effected in the apparatus illustrated, without departing from the spirit of my invention, and I desire that only such limitations be imposed as are indicated in the appended claims.

I claim as my invention:

1. In a lightning arrester, the combination with a series of blocks of conducting material which are separated by relatively short air-gaps, of means for maintaining a substantially constant ratio between the length of the aggregate air-gap and the voltage at which an arc will be established across the gaps.

2. In a lightning arrester, the combination with a series of blocks of conducting material which are separated by relatively short air gaps, of a conductor which is connected to an end block of the series and extends close to such a predetermined number

of the blocks as to maintain a substantially constant ratio between the length of the aggregate air-gap and the critical voltage of the arrester.

3. In a lightning arrester, the combination with an electric line conductor, and conducting members which form a series of air-gaps between the line and the ground, of a conducting shield disposed adjacent to a predetermined portion of the series of air-gaps whereby the critical voltage of the arrester is maximum.

4. The combination with a series of blocks of conducting material which are separated by relatively short air-gaps, of a conductor which is connected to an end block of the series and extends close to a predetermined number, less than half of the series, of the blocks adjacent to said end block.

In testimony whereof, I have hereunto subscribed my name this 23rd day of June, 1906.

RALPH B. INGRAM.

Witnesses:
GIRARD B. ROSENBLATT,
BIRNEY HINES.