(No Model.) 2 Sheets—Sheet 1.

E. THOMSON.

LIGHTNING ARRESTER.

No. 454,673. Patented June 23, 1891.

FIG. 1.

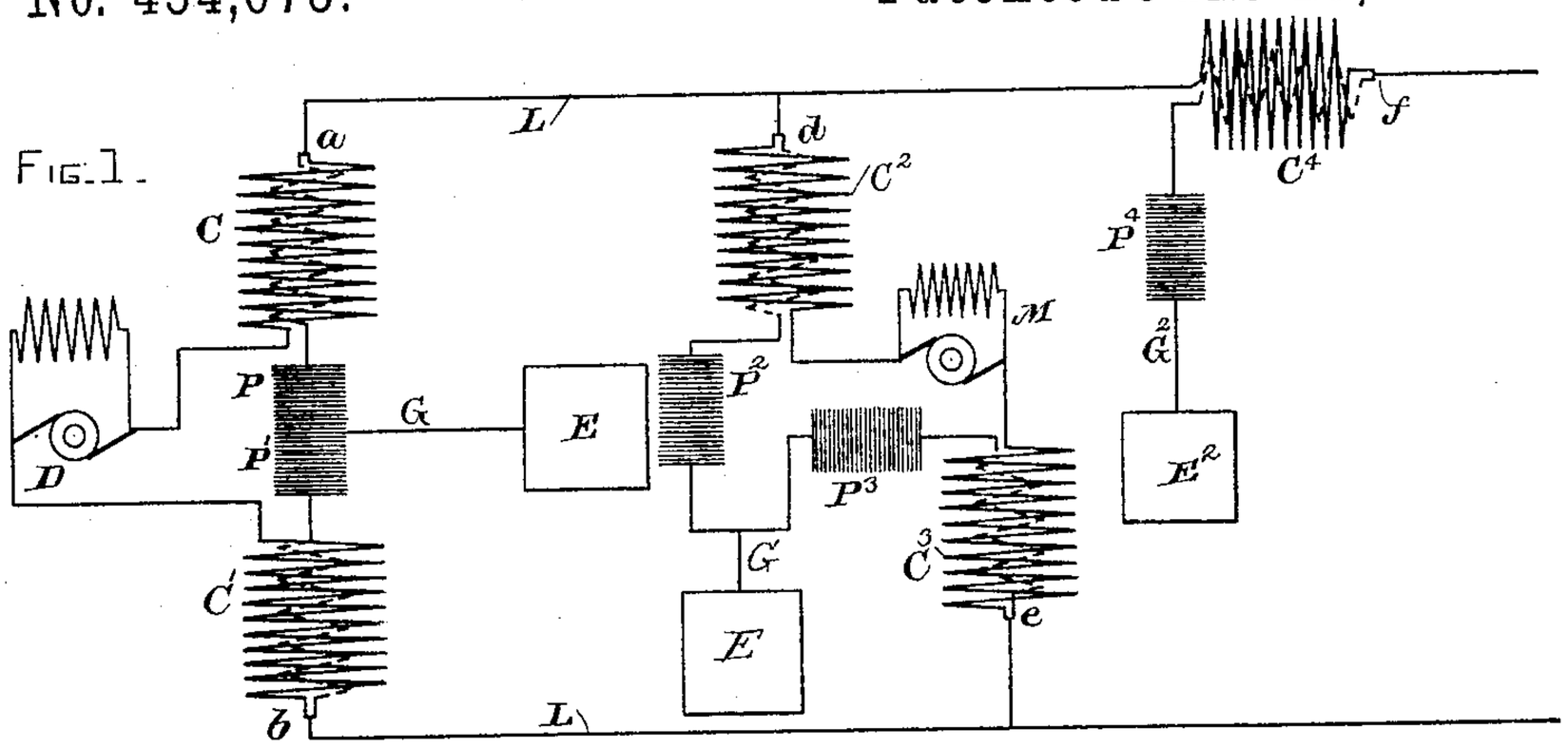


FIG. 2.

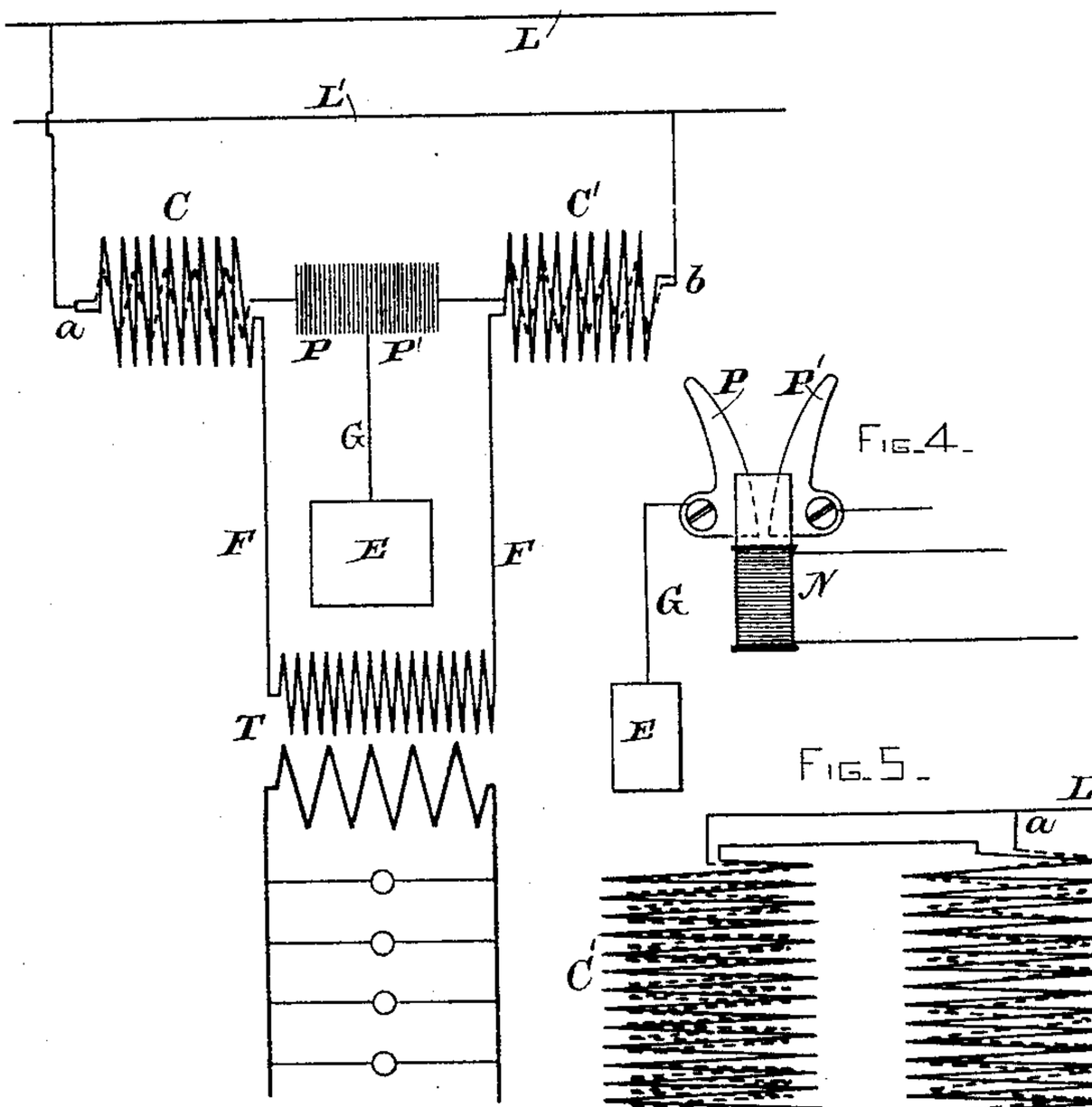


FIG. 3.

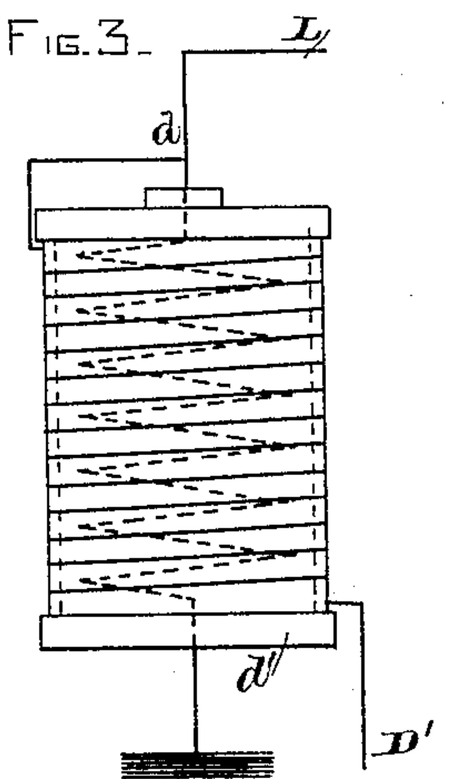
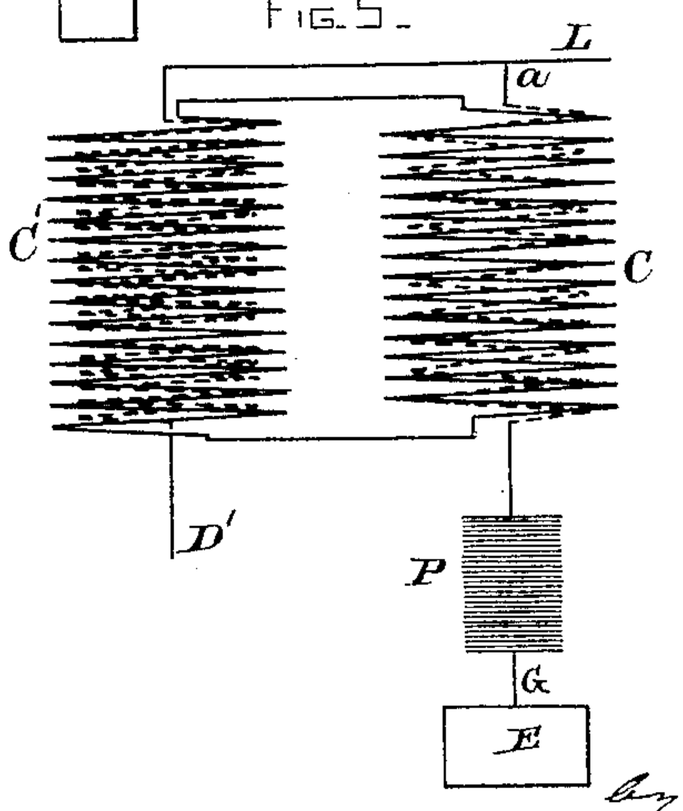
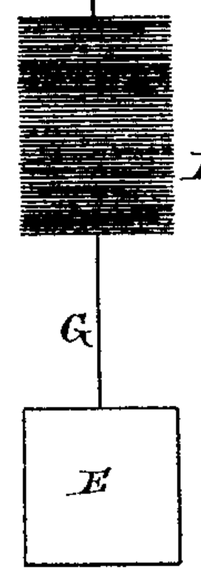


FIG. 4.

FIG. 5.





WITNESSES.

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(No Model.) 2 Sheets—Sheet 2.

E. THOMSON.

LIGHTNING ARRESTER.

No. 454,673. Patented June 23, 1891.

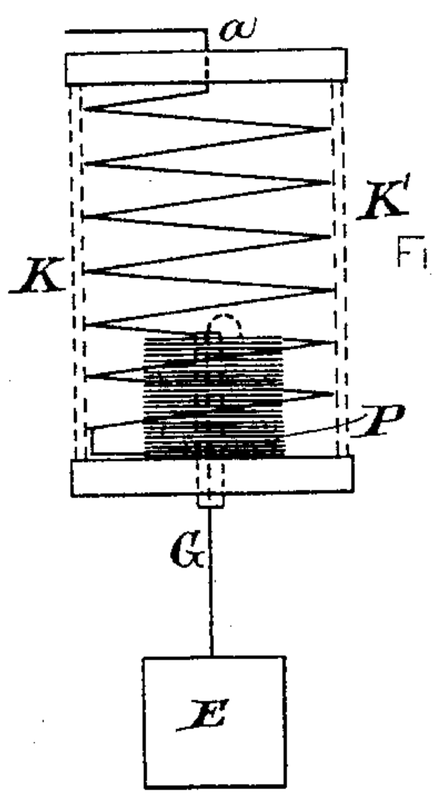

Fig. 6.

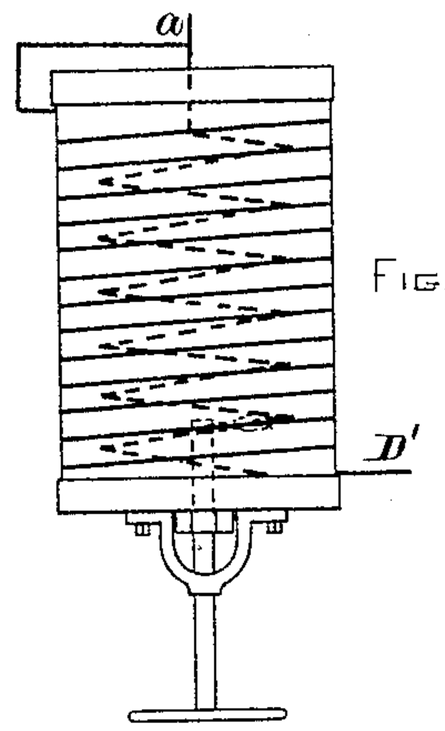

Fig. 7.

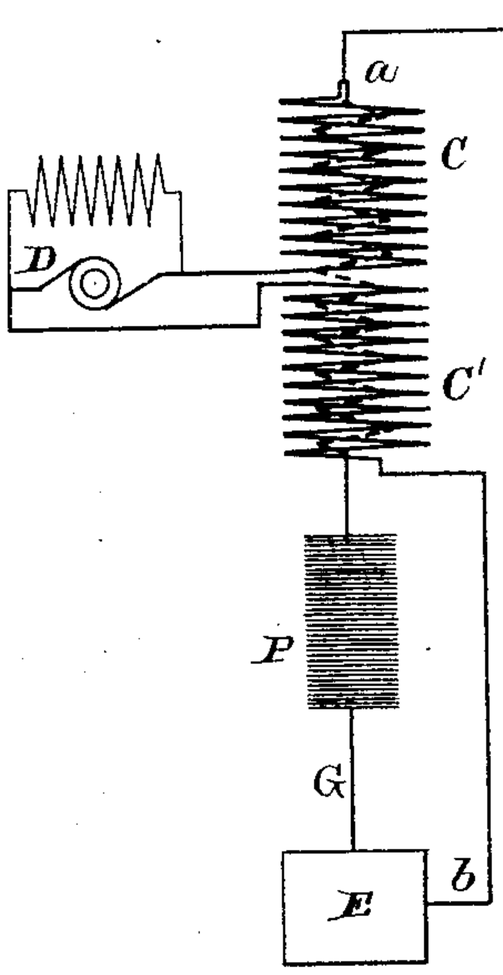

Fig. 8.

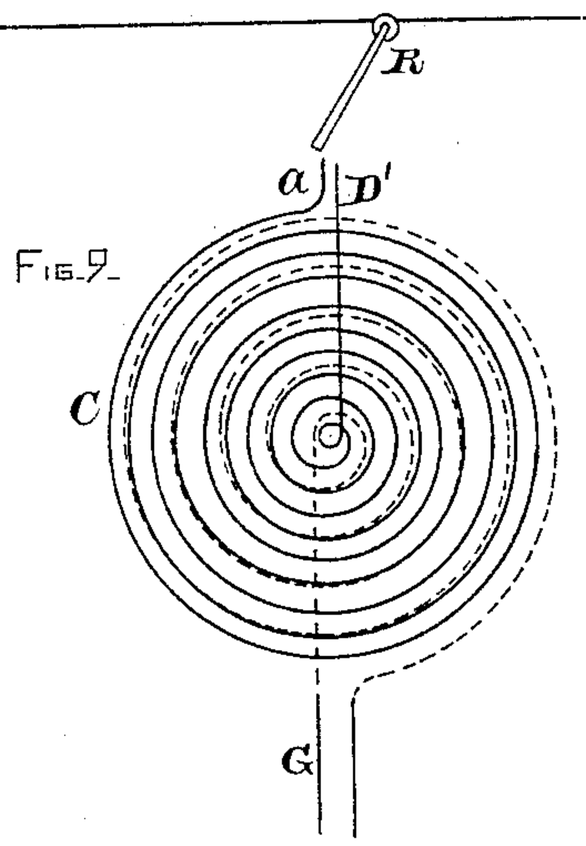

Fig. 9.

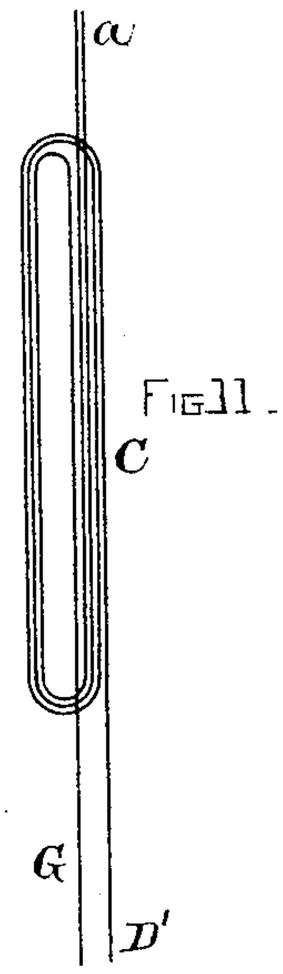

Fig. 11.

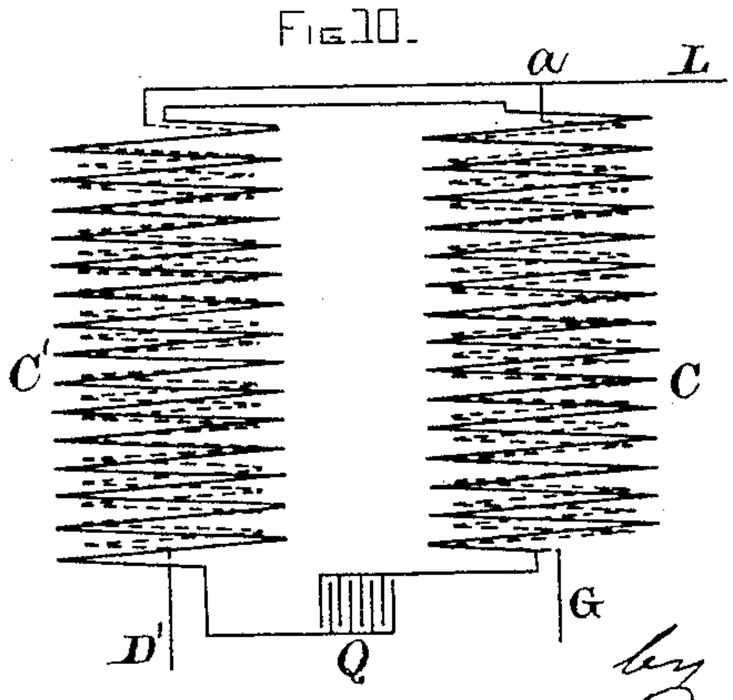

Fig. 10.

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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS.

LIGHTNING-ARRESTER.

SPECIFICATION forming part of Letters Patent No. 454,673, dated June 23, 1891.

Application filed January 31, 1891. Serial No. 379,845. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing at Swampscott, in the county of Essex and State of Massachusetts, have invented a certain new and useful Improvement in Lightning-Arresters, of which the following is a specification.

This invention relates to improvements on the type of lightning-arrester forming the subject-matter of my prior application, Serial No. 369,818, filed October 30, 1890.

The present improvements relate to the construction of the lightning-arrester and to the manner of applying it to systems of distribution.

In the accompanying drawings, Figures 1, 2, and 8 are diagrams of systems of distribution having my invention applied thereto. Figs. 3, 4, 5, 6, 7, 9, 10, and 11 show various forms of lightning-arresters embodying my present improvements.

In Fig. 1, L L represent a line connected to and fed by a dynamo, as at D. This line may be used for feeding lights, motors, or other devices, a motor being shown at M. The line L L may be supposed to be struck by lightning on one or the other of its legs, or at least to be inductively acted on, so as to cause a discharge to reach the apparatus supplied by it. In order to protect the dynamo D from such discharge, I establish one of my lightning-protectors on each leg or side of the line, as at C C′, each of these consisting of two coils of wire in inductive proximity or relation, but highly insulated from each other. One of these coils is connected into the main-line circuit, and the other is connected at one end to the main line and at the other end to one terminal of a suitable discharge device, whose other terminal is connected to ground. One of these coils is thus in the generator-circuit, while the other is in the ground branch, and, as described in my prior application, the action of the coils is such that when a lightning-discharge comes over the line and passes through the ground branch coil and discharge-plates to earth it will set up a counter electro-motive force in the main-line coil, which tends to prevent the discharge reaching the machine. My present improvement in this connection relates to the application of the inductive coil C C′ on both sides of the generator, so as to form a double-pole lightning-arrester, which shuts off a discharge from either side of the lines. The relation of the turns of the two windings is such as to produce an effective counter electro-motive force and will generally be in the relation of one turn of the ground branch winding to two of the main-line winding; but these windings may be varied as desired. The discharging devices shown consist of a series of insulating-plates P P′, which constitute a series of spark-discharge spaces, whereby a spark may pass to earth between the plates, which are sufficient in number to cut off any continuance of the discharge from the dynamo. The two ground-branch coils on opposite sides of the generator may be connected to the opposite ends of a single bundle of plates, the middle of the bundle being connected to ground, as shown. The ground connection G should be made of large surface, so as to be of great carrying capacity for sudden discharge, and of as little self-induction as practicable, and the earth connection should lead to other extended surfaces of metal buried in the earth. To protect a motor, as at M, the same arrangement may be applied with some slight modifications. The connection is made from M through one winding of coil C^2 to one side of the line L L and through one winding of coil C^3 to the other side. The other windings of these coils (shown in dotted lines) are connected to the two sides of line at points *d e* through the discharge-plates P^2 P^3, separated by spaces and having their ground terminals connected together. In this case should the discharge attempt to reach the motor M from either side of the line one or the other of the coils C C^2 will come into play, and the discharge is diverted through the ground-branch winding, setting up an opposing counter electro-motive force in the winding leading to the motor, so as to prevent a discharge from passing thereto. The plates P′ P^2 P^3 may represent or typify any form of arc-rupturing device with spark-gaps between the line and earth, and may also represent, as in the figure, a set of separated plates, the separations being quite small, and the number of plates being sufficient to provide a succession of arc-spaces, such as to extinguish or prevent the formation of arcs from line to

earth. I frequently insert into the line itself, as at C^4, one of these double-wound counter-inductive coils. The ground-branch winding is taken off from the main line at *f* and connected to the series of discharge-plates P^4 and to ground E^2 through branch G^2, the other winding of coil C being simply a continuation of the line. A lightning-discharge originating beyond coil C^4 will be diverted through the ground-branch coil and the discharger P^4 and on its discharge will set up a counter electro-motive force in the line-winding of coil C^4, which prevents the dangerous current from reaching the generator or other apparatus.

Fig. 2 shows the same arrangement of my lightning-arrester as in Fig. 1, except that it is here applied to a transformer T used on an alternating circuit. The primary line F F of the transformer is connected to the main line L L′ and has inserted in it a coil C C′ on each side of the transformer. One winding of each of these coils is in the primary line. The other winding is connected at *a b* to the primary line and leads to discharge-plates P P′, connected to earth E by wire G. The operation is substantially the same as that above described with regard to Fig. 1.

In Fig. 8 the two coils C C′ are applied to opposite sides of the generator D in a system having a grounded return—as, for example, an electric railway with an overhead line, upon which runs a trolley R, the return circuit being supposed to be made to the earth in the ordinary way. The circuit leads from one pole of the dynamo through one winding of coil C to line *a* and from the other pole of the dynamo through the corresponding winding of C′ to earth at *b*. The other windings of these two coils are connected to the line at *a* and to the series of lightning-arrester plates P and thence to earth. The object of this arrangement is to protect the dynamo D from the discharge of a static character arriving by the earth connection or from the line by setting up a counter-induction in the branch of the circuit or that portion of the circuit which leads directly to the dynamo, setting up this self-induction by virtue of the discharge sent across the plates at P. The motors or other apparatus fed by the line could of course be protected in the same manner.

Fig. 3 shows the elements of the lightning-arrester, L being the line, and *a* being the point of division of the two windings, which are supported on a cylinder *d*, of insulating material, preferably one inside and the other outside of said cylinder. It is preferred that the ground-branch winding should be placed within the cylinder and the line-winding be wound on the outside of the cylinder. In this figure the discharging device P is shown as separate from the coil.

In the modification shown in Fig. 6 the earth-winding starting at *a* and passing through a casing K K′, which may be a glass cylinder, is connected to the bottom of a series of discharge-plates P, while from the top plate of the series a connection is carried through an insulating-tube to the earth connection G and earth-plate E. The line-winding in this case will be wound on the outside of the glass cylinder K K′. The plates P may be separated by air-spaces, or they may be piled up one above another with layers of insulating material, such as washers of paper, mica, or other material interposed.

Fig. 7 shows an adjusting device for varying the relative length of the turns of wire in the windings in the coils. As before, the outer winding leading from *a* to D′ is in the line-circuit, while the inner winding (shown in dotted lines) is in the ground branch, and there is a handle arranged below provided with a contact for traversing the layers of the inner wire, which may be left bare for the purpose. By this means a fraction of a turn or the whole or any portion of the turns may be included, as may be required. This gives the power of adjustment to the conditions of practice and may be found useful in adapting the apparatus to work under peculiar or special conditions. Of course it is to be understood that the same apparatus for varying the relative number of turns of the coils might be applied as well to the outer winding as to the inner winding; or, in fact, the same device might be applied to both windings when it is necessary to make an exact and accurate compensation for difference of conditions. Any other form of lightning-arrester or lightning-discharger may be used in place of plates P P′, provided it has means for rupturing the arc which would tend to form across the discharge-spaces. For example, the lightning-arrester shown in Fig. 4, consisting of two plates P P′ in the ground-branch line and provided with an arc-rupturing magnet N, may be used, and this magnet may be energized in any suitable manner.

In Fig. 5 I have shown an arrangement whereby there is a separation of the earth-circuit and the line-circuit, and the two circuits or coils, which constitute each one winding of the coils C C′, are thrown into inductive relation by a tertiary or third circuit, which consists of a single winding around each of the coils C C′ connected together, so that a current set up in one will be carried through the other. This arrangement, while less effective than that shown in the other figures, could be made to work under limited conditions. A condenser Q could be interposed in the aforesaid tertiary circuit, as shown in Fig. 10, so that a current would be carried through by static induction.

Figs. 9 and 11 are intended to exemplify that the two windings of the coil C are not necessarily wound, as above described, but may be laid alongside of one another in any manner provided proper inductive relations

are maintained. Fig. 9 shows a volute winding, while in Fig. 11 the wires are simply laid alongside of each other in elongated flat coils.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination, with an electric line-circuit including an apparatus to be protected, of a discharge-circuit shunting such apparatus, and including discharging and arc-rupturing devices and inductive devices, respectively, in the line-circuit and shunt and arranged in inductive relation to one another, so that the passage of a discharge in the shunt-circuit induces in the line-circuit a counter electro-motive force opposing the passage of the discharge through the apparatus to be protected.

2. The combination, with an electric circuit including a dynamo, motor, or other apparatus, of discharge-circuits to ground from each side thereof, and including inductive devices in inducing relation to each side of the line-circuit, so as on the passage of a discharge through either discharge-circuit to set up a counter electro-motive force in the generator-circuit opposing the passage of the discharge to the generator.

3. The combination, with the primary circuit of a transformer, of discharge-circuits to ground from both sides of the transformer, including inductive devices in inducing relation to the primary circuit on both sides of the transformer, so as on the passage of a discharge through either discharge-circuit to set up a counter electro-motive force in the primary circuit opposing the passage of the discharge to the transformer.

4. The combination, with an electric circuit including a generator and apparatus supplied thereby, of a discharge-circuit leading to ground at a point distant from the generator, and including an inductive device in inducing relation to the generator-circuit, so as on the passage of a discharge through the ground branch to set up a counter electro-motive force in the generator-circuit opposing the passage therein of the discharge.

5. The combination, with the main circuit and the ground branch containing a discharging device, of an inductive apparatus consisting of an inner coil connected in the ground branch and an outer coil connected in the main line and an insulating-tube interposed between the two coils.

6. The combination, with a main circuit and a discharging-circuit, of two coils in inductive relation to one another, one being in the main and the other in the discharge circuit, and an adjusting device for bringing more or less of one of said coils into operation.

7. The combination, with a dynamo or other apparatus having one pole connected to a line and the other to ground, of a discharge-circuit from the line through a discharging device to ground, and including inductive devices in inducing relation to both the line and ground connections of the dynamo, so as on the passage of a discharge in the discharge-circuit to set up a counter electro-motive force in the generator-circuit opposing the passage of the discharge therein.

In testimony whereof I have hereto set my hand this 23d day of January, 1891.

ELIHU THOMSON.

Witnesses:
JOHN W. GIBBONEY,
EDWARD M. BENTLEY.