No. 827,523. PATENTED JULY 31, 1906.

L. DE FOREST.

WIRELESS TELEGRAPH SYSTEM.

APPLICATION FILED DEC. 6, 1905.

3 SHEETS—SHEET 1.

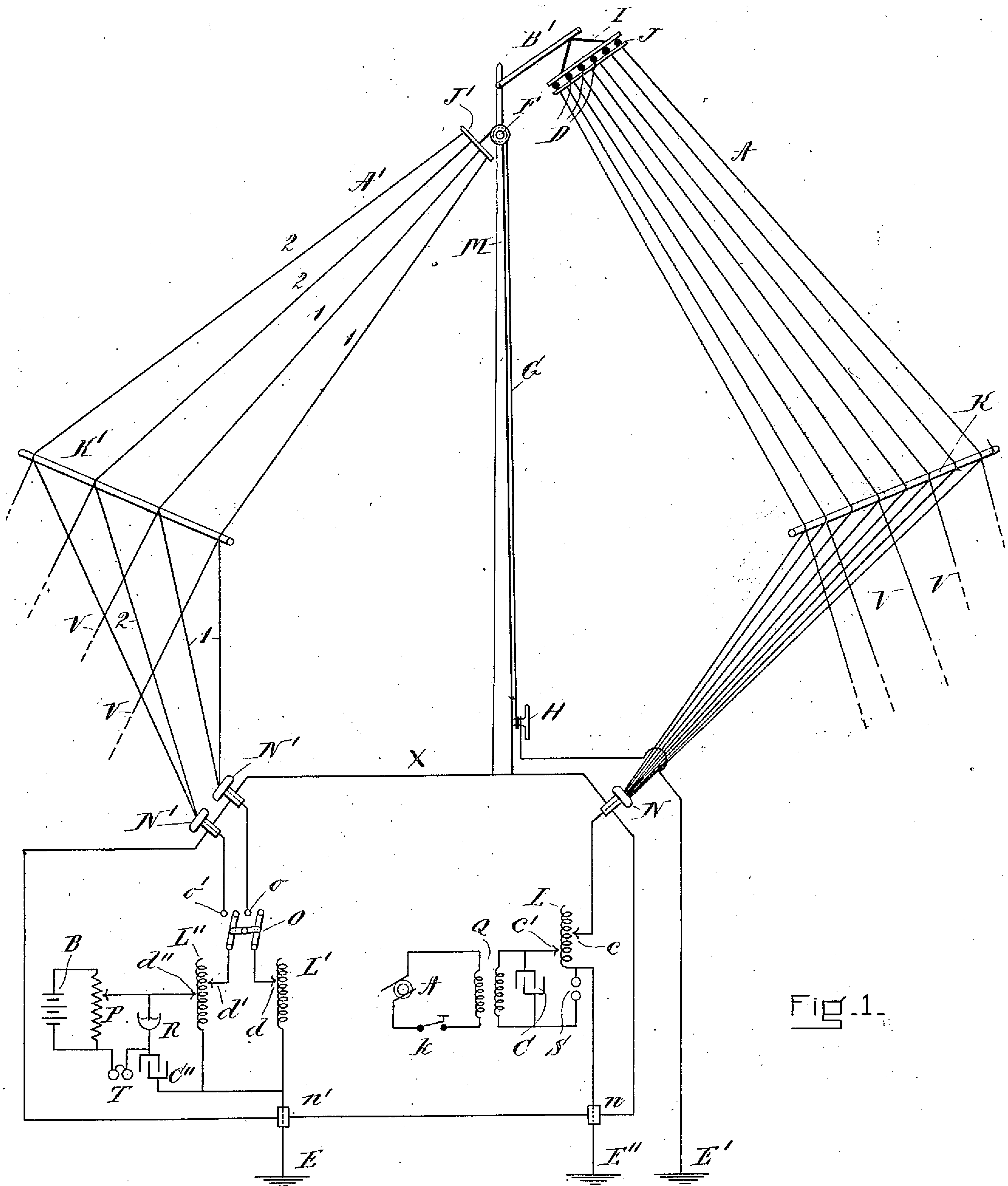

Fig. 1.

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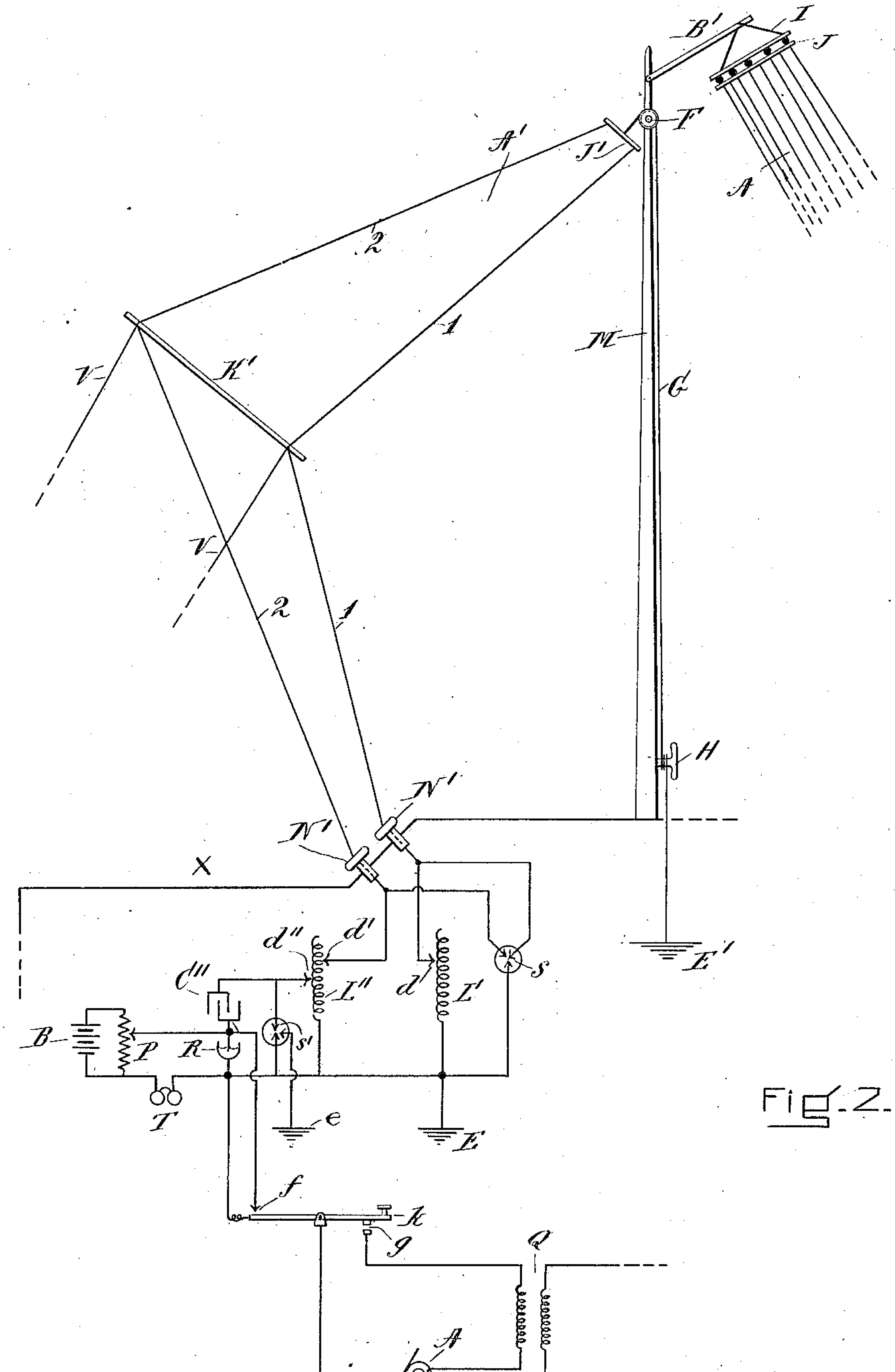

Fig. 2.

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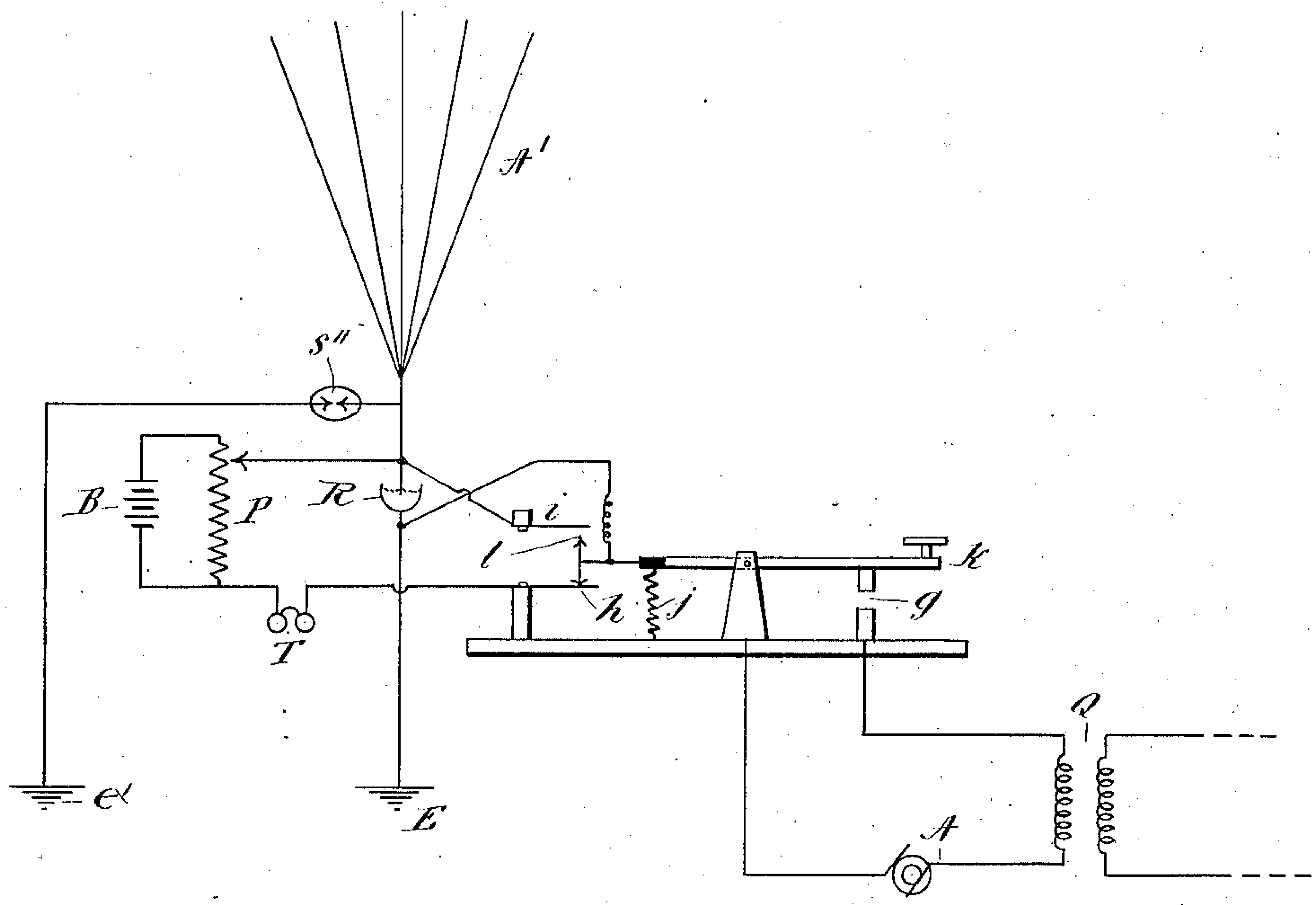

Fig. 3.

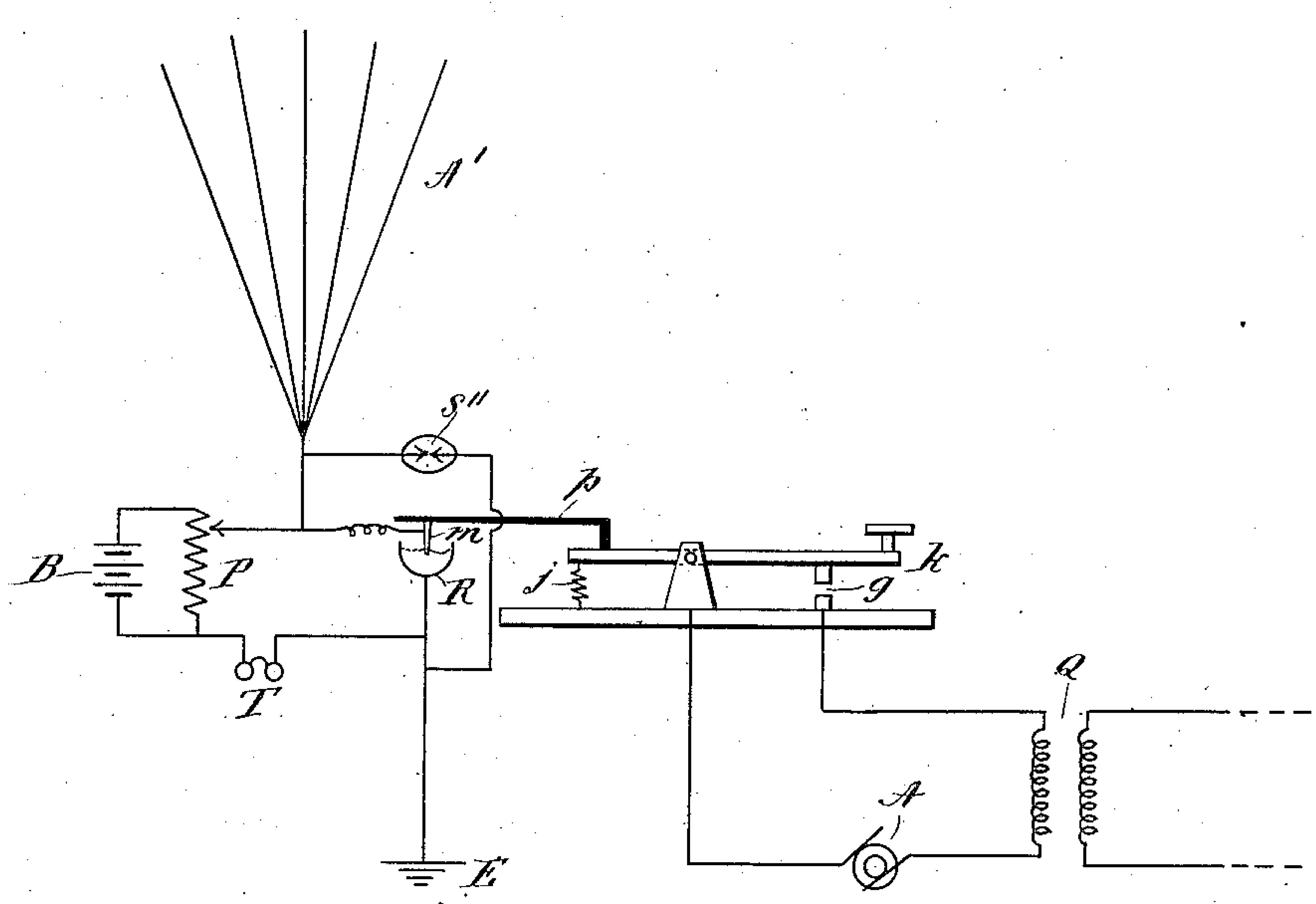

Fig. 4.

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UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

WIRELESS-TELEGRAPH SYSTEM.

No. 827,523. Specification of Letters Patent. Patented July 31, 1906.

Application filed December 6, 1905. Serial No. 290,567.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Wireless-Telegraph Systems, of which the following is a specification.

My invention relates to wireless telegraphy and has for its object a system which is provided with separate transmitting and receiving antennæ at the same terminal station and which thereby has the advantage that the receiving operator at said station is enabled to cut in upon and interrupt the transmitting operator at another station, as well as certain other advantages hereinafter set forth.

In the drawings which accompany and form a part of this specification and which illustrate diagrammatically several systems of circuits whereby my invention may be carried into effect, Figure 1 represents a transmitting and receiving system and Figs. 2, 3 and 4 represent receiving systems and a portion of their accompanying transmitting apparatus.

I shall first describe the system shown in Fig. 1 in which the transmitting and receiving sets are provided with separate antennæ and shall then show by reference to Figs. 2, 3 and 4 how such construction enables a receiving operator to interrupt the transmission from a distant station.

In Fig. 1, X represents the building in which the sending and receiving instruments are located and M represents a mast, tower, or other suitable support for the antennæ. The sending-antenna A is insulated at its upper end by the insulators D and is secured by the members I and J to the spar B′ which in turn is secured to the mast. The receiving-antenna A′ is not insulated at its upper end being conductively connected to the rod J′ of conducting material which by means of the cable G passing over the pulley F is supported at any desired height by the mast. The cable G is secured to the cleat H when the antenna A′ has been hauled up to the desired height and the lower end of said cable is connected to earth at E′.

It is preferred to give the two antennæ different shapes and for this purpose the conductors of the antenna A are separated by the spreader K a distance about ten feet apart while those of antenna A′ are separated by the spreader K′ a distance of about twenty-five feet apart. Preferably the spreaders K, K′ are equal in length and many more conductors are employed in the transmitting-antenna than in the receiving-antenna. The spreaders are guyed by the guys V, V, in the usual manner.

When the circuit of the generator A is closed by the key k the high-potential, low-frequency current developed in the secondary of the transformer Q charges the condenser C and said condenser discharges across the gap S thereby producing high-potential, high-frequency oscillations in the oscillation-circuit C S c' which, by means of the auto-transformer L, are conveyed to the antenna A which enters the station through the insulator N and passes out to the earth connection E″ through the insulator n. The ratio of transformation, as well as the periods of the oscillation-circuit and the antenna, may be varied by the adjustable contacts c and c', and preferably said periods are made equal.

A certain number of the wires of the receiving-antenna, herein shown as the two wires 1, 1, enter the station through one of the insulators N′ and the rest of the wires of said antenna enter through the other insulator N′, and each set of wires then passes to earth at E through the inductances L′, L″ and the insulator n'. By means of the variable contacts d, d', the desired amount of inductance may be included in the two sides 1, 1, and 2, 2, of the loop antenna A′, so that the period of the latter may be made equal to that of the tuned receiving-circuit d'' R C″ which includes the receiver R, the variable condenser C″ and a portion of the inductance L″, and so that said period may be made equal to that of the electromagnetic waves to be received. The local circuit which is connected across the terminals of the receiver R includes the head telephone T and potentiometer P which regulates the potential of the battery B to be impressed upon said receiver.

O is a switch for connecting the two sides 1, 1, and 2, 2, of the loop antenna A′ to the receiving apparatus during the receipt of messages and for disconnecting said antenna from said apparatus during the transmission of messages.

It is not new in wireless telegraphy to employ a switch for the purpose of connecting an antenna alternately to the transmitting and the receiving apparatus at a station, but so far as I am aware no system heretofore has been devised in which separate transmitting and receiving antennæ are provided at the same station and in which a switch is employed as above set forth. Some of the advantages of this construction are that it permits the employment for transmitting and receiving of the kind of antennæ required, respectively, for such purposes, and also that it permits the employment of a small switch of small throw in connection with the receiving-antenna. During transmission an enormous difference of potential exists between all parts of the transmitting-antenna above the transmitting apparatus and the earth, so that in stations where one antenna is employed alternately for transmitting and receiving, the switch employed to connect such antenna to the transmitting and receiving apparatus must be a large switch of large throw in order to prevent the potential difference between the point of attachment of the switch to the antenna and the earth from rupturing the dielectric intervening between the switch and the receiving apparatus. In some of the commercial wireless-telegraph stations of my construction, I have been able to draw a spark one foot in length from the transmitting-antenna, and in such case it will be obvious that in order to make use of the same antenna for transmitting and receiving a switch for alternately connecting said antenna to the transmitting and receiving apparatus would have to be over one foot in length and to have a throw of over one foot. However, when a separate antenna is used for receiving, a small, low-potential switch may be used to disconnect the receiving apparatus during transmission because but relatively small potentials are developed in such receiving-antenna by the oscillations created in the transmitting-antenna at the same station. In some of my stations constructed as shown in Fig. 1, the difference of potential between the points o, o', and the earth during the operation of the transmitting system is so small as to produce a spark of only one and one-half inches in length, and hence it will be seen that the switch O need have a throw of but little longer than one and one-half inches.

Another advantage incidental to separate transmitting and receiving antennæ is that thereby the receiving-operator is enabled to cut into and interrupt the transmission from a distant station, and various means for accomplishing this result are shown in Figs. 2, 3 and 4.

In Fig. 2, a portion only of the transmitting-antenna and of the transmitting-circuits is shown, but it is to be understood that said antenna and circuits are arranged as shown in Fig. 1, and also that in Figs. 3 and 4, in each of which a portion only of the transmitting-circuits is shown, said circuits also are arranged as shown in Fig. 1. At points above the connections d, d', of the antenna-wires 1, 2, with the inductances L', L'', two conductors connect said antenna-wires to two pointed terminals of the anchor spark-gap s, which consists of three or more spark-gaps each about one sixty-fourth inch long, and the third pointed terminal of said gap is grounded at E. A similar anchor spark-gap s' has two of its members connected in shunt to that portion of the inductance L'' which is included in the tuned receiving-circuit and the third member of said gap is grounded at e.

It will now be obvious that as the oscillations created in the receiving-antenna by the transmitting-antenna A are of sufficient potential to bridge the gaps in the anchor spark-gap s such oscillations will pass to earth by way of said gap and will not therefore affect the tuned receiving-circuit or the receiver R. While the gap s is generally sufficient, it may, as an extra precaution, sometimes be desirable to employ the gap s', which, in case any appreciable difference of potential exists across the terminals of the coil L'', conducts the oscillations creating said potential to earth at e.

While, with receivers of certain types it would be possible to transmit signals from the transmitting side of the system (shown in Fig. 2) without affecting the receiver R when the anchor spark-gaps s and s' are connected as shown, nevertheless with other and more sensitive receivers it is necessary to adopt a still further protection. Such protection is afforded by shunting the receiver when the key k closes the circuit of the generator A and primary of the transformer Q, and such shunting may be effected by connecting one terminal of the shunt to the outer end of said key and causing said outer end to contact with the other terminal f of the shunt when the key closes the generator-circuit at g. It will be noted that the anchor spark-gaps do not interfere with the reception of signals from a transmitting-station because the potentials developed in the receiving-antenna are far too feeble to bridge said gaps, and hence, when the key is in such position that the shunt around the receiver R is open, any signals which may be sent out from a distant station may be read by the operator at the station shown in Fig. 2, who keeps the telephone T in position while sending.

It will be noted that when the shunt around the receiver R is closed at f, the battery B is practically short-circuited, and, inasmuch as the said shunt is closed from six hundred to one thousand times a minute in commercial signaling, the battery soon runs down. In order to remedy this defect, the circuits may be arranged so that the key will open the battery-circuit as well as shunt the receiver. One arrangement whereby this result may be effected is shown in Fig. 3 in which for the purpose of illustration the receiver is shown connected in series with the antenna A′ and not in a tuned receiving-circuit as in Figs. 1 and 2. An anchor spark-gap s'', connected to the antenna at point above the receiver and to earth at e', performs the same function as the gap s of Fig. 2 performs with respect to the loop antenna shown in Fig. 2. It will be obvious that as the key k of Fig. 3 is depressed, the double-pointed contact l, which normally is held in contact with the spring h by the retractile spring j, is moved out of contact with h, thereby opening the circuit of the battery B, and immediately afterward is brought into contact with the spring i, thereby closing the shunt around the receiver R.

Another way of protecting the receiver during transmission and at the same time preventing the battery from running down by opening its circuit, is shown in Fig. 4, in which one terminal m of the receiver R is attached to the insulating member p which projects from the end of the key, so that when the key closes the contact g, the member m is moved out of contact with the electrolyte in which its lower end normally is immersed. However, in view of the rapidity of vibration of the member p during the operation of the key in commercial working, the member m of the receiver is subject to a certain amount of wear, so that I prefer an arrangement, such as that shown in Fig. 3, in which the members of the receiver are not subject to motion.

It is not necessary that the separate transmitting and receiving antennæ at a station should be supported by the same mast for it will be obvious that each antenna may be provided with a mast and that said masts may be separated by sufficient distance to permit of duplex working. For example, the transmitting and receiving antennæ of a station may be separated by a substantial distance of, say, ten miles, which separation will make it possible for the receiving apparatus to receive signals transmitted from a distant system by waves of one wave length or frequency at the same time that the transmitting apparatus of said station is transmitting signals by waves of different wave length or frequency. In such case the transmitting and receiving apparatus of the station may be connected by a "pony" telegraph-line so that the receiving operator can inform the sending operator by wire telegraph just what he is receiving.

I do not limit myself to the specific apparatus and circuits which I have herein described for the purpose of more fully explaining my invention inasmuch as many modifications may be made therein by those skilled in the art without departing from the spirit of my invention.

I claim—

1. In a wireless-telegraph system, the combination with transmitting and receiving systems at a terminal station, of separate multiple antennæ for said transmitting and receiving systems, the transmitting multiple antenna comprising a larger number of conductors than the receiving multiple antenna and having its conductors more closely spaced than those of the receiving-antenna, and means attuning said transmitting and receiving antennæ to different frequencies.

2. In a wireless-telegraph system, the combination with transmitting and receiving systems at a terminal station, of separate multiple antennæ for said transmitting and receiving systems, the transmitting multiple antenna comprising a larger number of conductors than the receiving multiple antenna.

3. In a wireless-telegraph system, a receiving-antenna, a receiver associated therewith, and means associated with said antenna for protecting said receiver from the effects of excessive electrical potentials.

4. In a wireless-telegraph system, a receiving-antenna, a receiver associated therewith, and an anchor spark gap so connected with said antenna as to protect said receiver from the effects of excessive potentials.

5. In a wireless-telegraph system, a receiving-antenna, a tuned receiving-circuit associated therewith, a receiver connected in series with said tuned receiving-circuit, means associated with said antenna for protecting said receiver from the effects of excessive potentials and other means associated with said tuned receiving-circuit for protecting said receiver from the effects of excessive potentials.

6. In a wireless-telegraph system, a transmitting system including a transmitting-antenna, a receiving system including a receiving-antenna and a receiver, a transmitting-key associated with both systems, and means operated by said key for closing a circuit around said receiver to protect the latter from the electrical effects developed in said receiving-antenna by the oscillations created in said transmitting-antenna.

7. In a wireless-telegraph system, a receiver, a battery associated therewith, a transmitting-key and means for closing a circuit around said receiver and opening the circuit of said battery by the operation of said key.

8. In a wireless-telegraph system, a transmitting system including a transmitting-antenna, a receiving system including a receiving-antenna and a receiver, a transmitting-key associated with both systems, and means associated with said key for protecting said receiver from the electrical effects developed in said receiving-antenna by the oscillations created in said transmitting-antenna.

9. In a wireless-telegraph system, a receiv-

ing-antenna, a tuned receiving-circuit associated therewith, a receiver connected in series with said tuned receiving-circuit, a spark-gap shunted around said receiving-circuit and connected to earth, and a spark-gap connected in shunt to said receiver and so constructed and arranged as to protect said receiver from the effects of excessive potentials.

10. In a wireless-telegraph system, a receiver, a spark-gap consisting of at least three pointed electrodes connected in shunt to said receiver and a connection to earth for one of said pointed electrodes.

11. In a wireless-telegraph system, a receiver, a spark-gap connected in shunt thereto, a transmitting-key and means for closing a circuit around said receiver by the operation of said key.

12. In a wireless-telegraph system, a receiving-antenna, a receiver associated therewith, an anchor spark-gap so connected to said antenna as to protect said receiver from the effects of excessive potentials, a transmitting-key and means for further protecting said receiver by the operation of said key.

13. In a wireless-telegraph system, a receiving-antenna, a receiver associated therewith, means associated with said antenna for protecting said receiver from the effects of excessive potentials, other means associated with said receiver for protecting said receiver from the effects of excessive potentials, a transmitting-key, and means for further protecting said receiver by the operation of said key.

14. In a wireless-telegraph system, a receiving-antenna, a receiver associated therewith, means associated with said antenna for protecting said receiver from the effects of excessive potentials, other means associated with said receiver for protecting said receiver from the effects of excessive potentials, a transmitting key, and means for closing a circuit around said receiver by the operation of said key.

In testimony whereof I have hereunto subscribed my name this 29th day of November, 1905.

LEE DE FOREST.

Witnesses:
PHILIP FARNSWORTH,
A. E. PARKER.