R. A. FESSENDEN.

APPARATUS FOR ELECTRIC SIGNALING.

APPLICATION FILED MAR. 31, 1908.

1,101,914.

Patented June 30, 1914.

5 SHEETS—SHEET 1.

Fig. 1

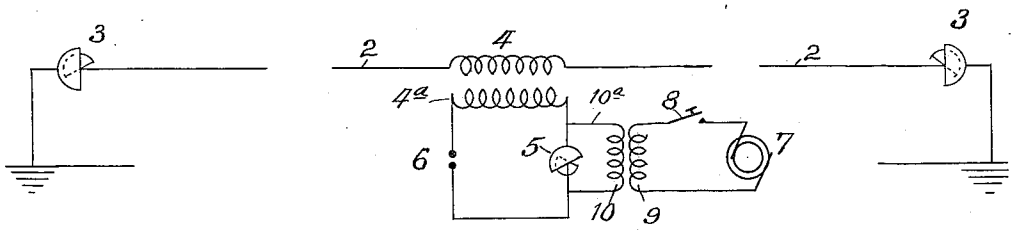
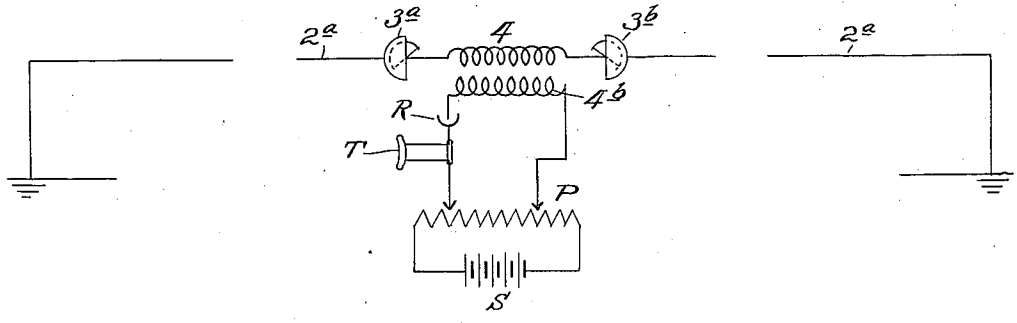


Fig. 2



Witness:
Chas. S. Lepley.
Fred. Stanl.

Reginald A. Fessenden
Inventor,
By F. W. H. Clay
Atty.

R. A. FESSENDEN.

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5 SHEETS—SHEET 2.

Fig. 3

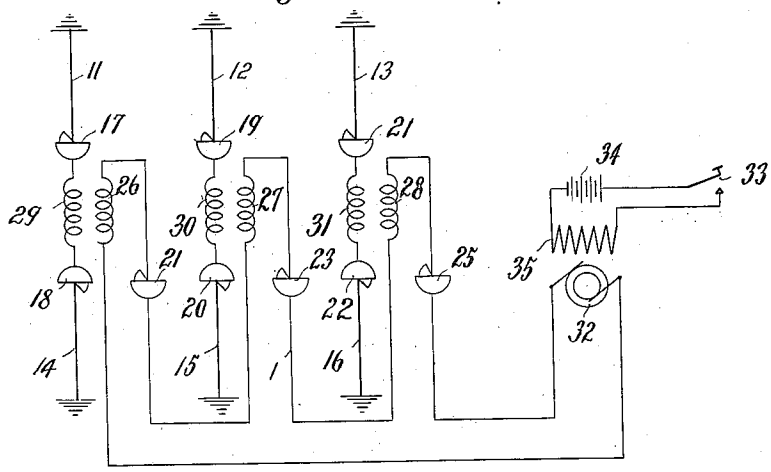
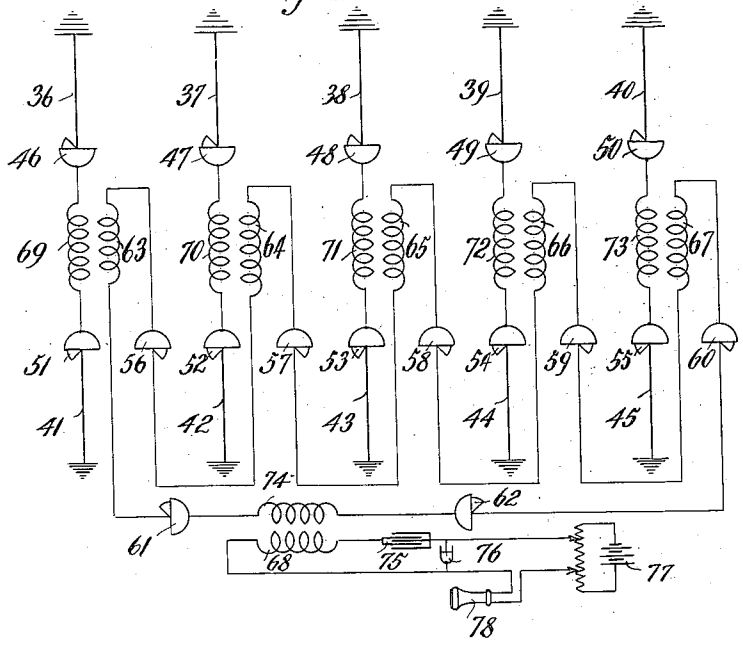


Fig. 4



WITNESSES:

Jessie C. Bent.

INVENTOR.

Reginald A. Fessenden

R. A. FESSENDEN.

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5 SHEETS—SHEET 3.

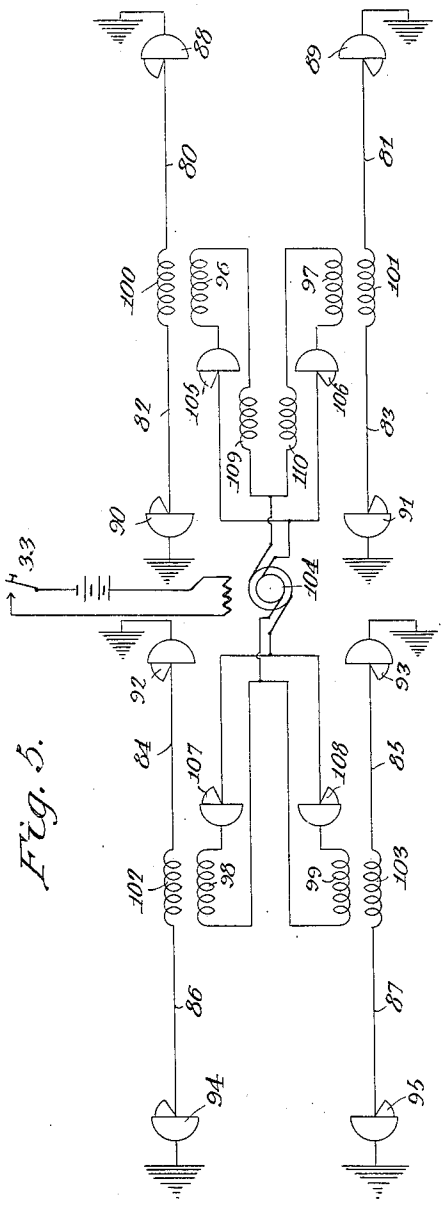


Fig. 5.

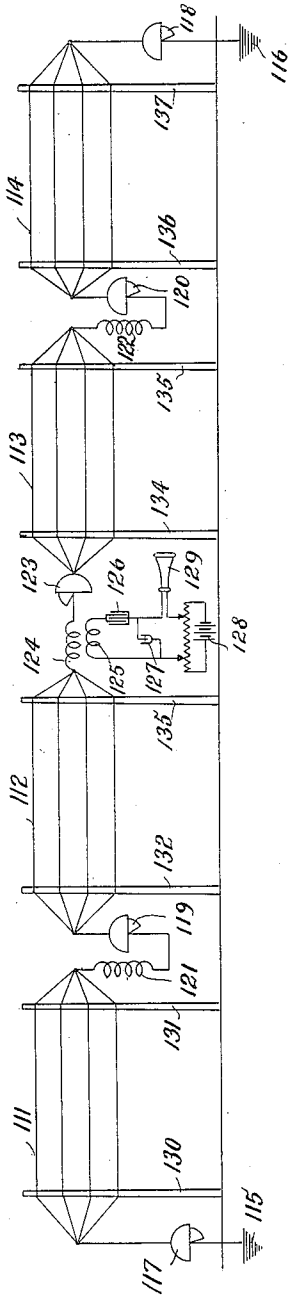


Fig. 6

WITNESSES:

Jessie E. Bent

INVENTOR.

Reginald A. Fessenden.

R. A. FESSENDEN.

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Patented June 30, 1914.

5 SHEETS—SHEET 4.

Fig. 7.

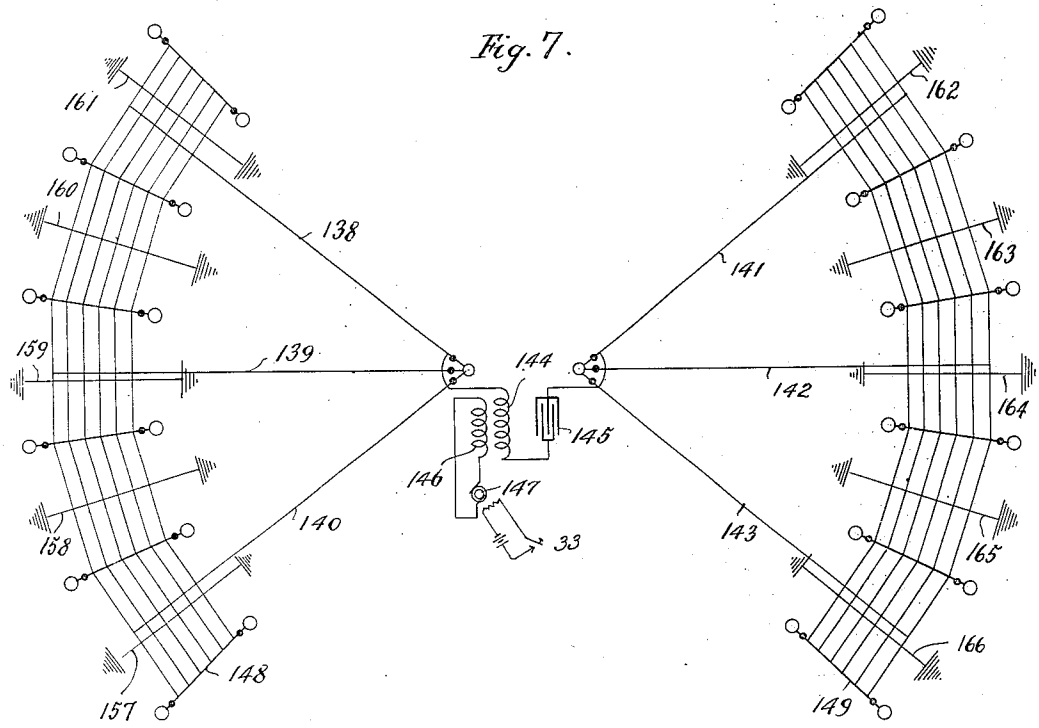
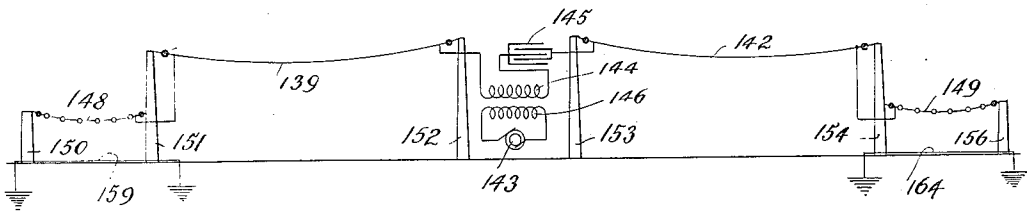


Fig. 8



WITNESSES:

Jessie E. Bent.

Albert G. Davis

INVENTOR.

Reginald A. Fessenden

R. A. FESSENDEN.

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APPLICATION FILED MAR. 31, 1908.

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5 SHEETS—SHEET 5.

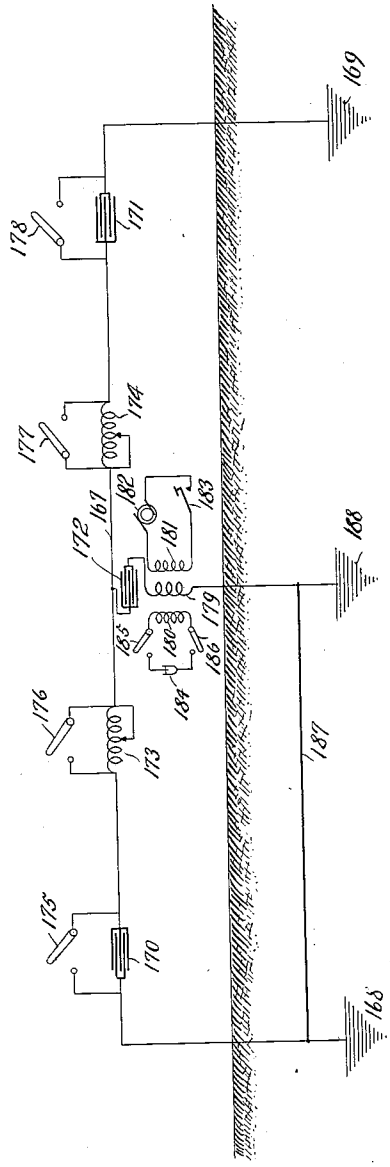


Fig. 9.

WITNESSES:

Jessie E. Bent

F. P. Hausbeck

INVENTOR.

Reginald A. Fessenden

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF BRANT ROCK, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO SAMUEL M. KINTNER, OF PITTSBURGH, PENNSYLVANIA, AND HALSEY M. BARRETT, OF BLOOMFIELD, NEW JERSEY, RECEIVERS.

APPARATUS FOR ELECTRIC SIGNALING.

1,101,914. Specification of Letters Patent. Patented June 30, 1914.

Application filed March 31, 1908. Serial No. 424,372.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, residing at Brant Rock, in the State of Massachusetts, have invented certain new and useful Apparatus for Electric Signaling, of which the following is a specification.

My invention relates to the art of wireless signaling, and more particularly to the so-called antennæ for transmitting and receiving the impulses. Its primary objects are; to avoid the great cost of erecting and maintaining high supporting structures; to enable more efficient transmission and receipt of signals without interference from atmospheric disturbances or other causes, and to generally improve the methods and means of signaling by electro-magnetic waves.

The invention is illustrated in several forms in the accompanying drawings, wherein—

Figure 1 is a diagram illustrating one simple and effective form of my apparatus for sending wireless messages. Fig. 2 is a diagram of apparatus used for receiving messages. Figs. 3 and 4 are diagrams illustrating forms of antennæ in which several elements are connected in parallel. Fig. 5 shows a modification in which the elements are connected in parallel series. Fig. 6 is a diagram showing in elevation a further modification of apparatus for my purposes. Figs. 7 and 8 are respectively a plan and an elevation diagram of another form of apparatus suitable for carrying out the invention. Fig. 9 is an elevation of still another form.

Heretofore it has been customary to generate and receive electro-magnetic waves by using either vertical antennæ which may or may not have a horizontally extended portion, or vertical loops, which respectively utilize the electro-static and the magnetic components of the waves. Horizontal antenna, broadly, also have been used, as shown in applicant's prior Patent No. 706738 of August 12th, 1902.

In order to utilize the electrostatic and electromagnetic components it has been necessary to erect high towers or large loops. The great height of the towers or loops has rendered their construction very expensive, as a tower 600 feet high would cost approximately $48,000, while a loop to accomplish the same results would cost still more, since two towers are necessary in such case.

I have discovered a new way of generating and receiving the waves, by utilizing what may be considered as the current component of the waves. For this purpose, instead of using a high tower or great loop, I use a long approximately horizontal conductor, or a conductor having a horizontal component, extending, or having its horizontal component extending, in the direction of propagation of the waves and grounded either directly or inductively at both ends, and connect the transmitting or receiving instrument in this horizontal conductor. This plan has a number of advantages: For example, it is very much cheaper, since a horizontal conductor 600 feet long will give practically the same results as a tower 400 feet high. The cost of land necessary is less, since a tower requires a large amount of land for guying and stretching the antennæ, while for the horizontal antennæ only a right of way is necessary, the horizontal wires being merely elevated to a height sufficient to permit of traffic passing under it. It is also advantageous in that the horizontal conductor receives and sends mainly in the direction of its length from two directions diametrically opposite to each other and so produces little or no interference with stations placed alongside of it. It also enables one to obtain without limit the effect of high towers. For example, it would evidently be impossible to erect a tower a mile high, but there is no difficulty in constructing such a horizontal aerial several miles long.

The method and apparatus have been found to be efficient in actual practice. With a horizontal antenna of an effective length of 600 feet and consisting of a single wire grounded at both ends, with condensers inserted in the circuit for tuning, and with a receiver conductively connected in the horizontal conductor, I have received messages transmitted over a distance of 900 miles. Also by inductively connecting an oscillatory sending circuit to a horizontal aerial of this type I have transmitted messages over a distance of hundreds of miles.

The novelty of my device, in so far as the theory is now known, resides in utilizing the

current set up in the earth with a conductor and placing a receiver in the conductor so that the currents which would otherwise flow through the earth, flow through the horizontal conductor in shunt to the earth, and thus effect the receiver. Similarly in generating the waves it is now supposed that the high frequency oscillating circuit sets up rapid oscillations between the two ends of the horizontal conductor the high frequency currents generated by the source flowing into the ground at both ends of the conductor and being propagated outwardly over the earth's surface. Such a horizontal antenna used in receiving should have some component pointing toward the wave source. The best arrangement is to have the horizontal antenna point as a whole toward the source from which the waves come, and similarly the sending antenna should be directed toward the receiver. This fact indicates that it is the current component which is being utilized.

In prior systems the components of the electromagnetic waves utilized were the components at right angles to the direction of propagation, and therefore the effectiveness of the apparatus depended to a considerable extent upon the height of the antennæ or loops used. In my system the component used is the component in the direction of propagation, and it is for this reason that the horizontal wires both at the sending and receiving ends should lie in the direction of propagation.

In Figs. 1 and 2, which illustrate respectively the sending and receiving stations of an apparatus constructed in accordance with my invention, 2 represents the horizontal antenna, which preferably extends parallel with the surface of the ground and is supported on poles which may be constructed like ordinary telephone poles, and grounded at the ends through variable capacities 3, which may be of any known construction. This antenna is of considerable length, and, as above stated, I have found an effective length of 600 feet to be suitable for transmitting and receiving messages at a distance of 900 miles. Ordinary copper wire may be employed to constitute the antennæ. The sending instrument for sending the electric waves is interposed at some suitable point in the conductor, as I show at 4, the primary 4 of a transformer interposed in the antenna, the secondary 4^a of which is in circuit with a condenser 5 and a spark gap 6. An electric generator 7 is in circuit with a transmitting key 8 and connected by a transformer 9, 10, to circuit 10^a and the circuit of the spark gap on opposite sides of the condenser 5.

In the receiving apparatus shown in Fig. 2 the antenna 2^a may be of construction similar to that in Fig. 1, and it is provided with variable capacities 3^a, 3^b which in this figure I have shown in proximity to the transformer 4, 4^b, of the receiving instrument. The secondary 4^b of the transformer is in circuit with receiver R which may be an electrolytic receiver or a receiver of any other suitable type. It is connected to the telephone receiver T in circuit with a potentiometer P and a local source S. These latter parts of the apparatus of course may be varied without departure from my invention.

In the other figures of the drawings I show modifications of my invention which are designed to give greater efficiency to the general apparatus as just described and illustrated in Figs. 1 and 2.

In Fig. 3, I show a series of approximately horizontal sending conductors each of whose ends 11, 12, 13, and 14, 15, 16 respectively, are grounded and which contain variable condensers 17, 18, 19, 20, 21, 22, for tuning the circuits, and coils 29, 30, 31, respectively, which form the secondaries of transformers whose primaries 26, 27, 28, are in a local exciting circuit, operated by a source such as the high frequency alternator 32. The field 35 of the alternator, excited by battery 34 has in circuit a key 33 which upon being depressed causes the alternator to produce electric oscillations in the horizontal conductors, and the waves are sent out mainly in the direction of said conductors. The circuit of the primaries also contains variable condensers 23, 24, 25 for tuning the circuits. By this use of a number of horizontal conductors in parallel I attain much stronger effects and greater efficiency. The circuit of the alternator 32 should be tuned so as to give the maximum amount of power for the desired frequency.

In Fig. 4 I show a series of substantially horizontal receiving conductors grounded at their ends 36, 37, 38, 39, 40, and 41, 42, 43, 44, 45, as shown, and containing the variable condensers numbered 46 to 55 consecutively, similarly as before. These conductors also contain the primaries 69, 70, 71, 72, 73, of transformers whose secondaries 63, 64, 65, 66, 67, are in series and contain variable condensers 56, 57, 58, 59, 60, 61, 62, as before for tuning the circuits, and the primary 74 of another transformer whose secondary 68 is in circuit with a condenser 75, which may be variable, a receiver 76, which is preferably a liquid barretter, a potentiometer 77, and an indicating instrument such as the telephone receiver 78. By this arrangement the cumulative effects of a number of the horizontal antennæ are added together and give an increased effect on the receiver.

In the arrangement of Fig. 5, the sending antennæ 80, 82, 81, 83, 84, 86, 85, 87, similar to those heretofore described and similarly containing variable condensers 88, 89, 90, 91,

92, 93, 94, and 95, are arranged in parallel series and contain the secondaries 100, 101, 102, 103, of transformers whose primaries are 96, 97, 98, 99. The circuits of all the primaries are connected to a high frequency alternator 104, and the signaling is done by key 33 as before described in the case of Fig. 3. The primary circuits also contain the variable condensers 105, 106, 107, 108, and the inductances 109, 110, arranged as shown, and used for tuning the primary circuits.

In the modification of Fig. 6 the horizontal receiving conductors or antennæ 111, 112, 113, 114, are connected in series, and consist each of a number of parallel wires as shown; the series is grounded at 115, 116, through variable condensers 117, 118, and supported upon insulated posts numbered 130 to 137 consecutively. Between the several groups of conductors are condensers 119, 120, 123, and inductances 121, 122, for tuning the circuit in sections. 124 is the primary of a transformer whose secondary 125 is in circuit with condenser 126, receiver 127, potentiometer 128, and indicating instruments such as a telephone receiver 129.

In the modification of Figs. 7 and 8, I provide for sending, a series of horizontal wires 138, 139, 140, 141, 142, 143, joined together at their inner ends through the capacity 145 and secondary 144 of a transformer whose primary 146 is in circuit with a high frequency alternator 147 or any other suitable means producing the oscillations, such for example as an arc. The outer ends of the horizontal conductors are connected to sets of parallel circumferentially arranged horizontal conductors 148, 149. These are preferably arranged nearer the ground than the other conductors 138 to 143, so that the outer circumferential portion of the antennæ has greater capacity to ground than the radial portion, while at the same time by using a number of radial conductors, the self-induction is kept as small as possible without interfering with the capacity to ground at the outer ends being maintained large. The conductors are supported through insulators on posts 150, 151, 152, 153, 154, 156, as shown in Fig. 8, and I preferably provide also the conductors numbered respectively 157 to 166, which form a wave chute or artificial ground, which I find to produce an increased and more reliable effect.

Fig. 9 shows a preferred modification in which the horizontal conductor 167 is grounded at both ends at 168 and 169 and also in the middle at 188.

170, 171, and 172 are condensers, preferably variable.

173 and 174 are variable inductances.

175, 176, 177, 178 are switches for cutting out the condensers and inductances when desired.

179 is a transformer coil and 180 and 181 are transformer coils in inductive relation to coil 179.

182 is a high frequency alternator and 183 a sending key.

184 is a receiver such as a liquid barretter, and 185 and 186 are switches for disconnecting the liquid barretter when sending with the key 183.

The grounded ends may be connected by a metallic conductor as shown at 187.

It will be seen that the circuits 179, 172, 173, 170, 168 and 179, 172, 174, 171, 169 virtually form two circuits such as shown in the prior part of the specification, but placed back to back so that when used for sending the phases of the impulses at the two outer ends are the same at the same instant.

By means of the construction above described, electrical waves of great intensity can be transmitted and are mainly localized in the direction of the antenna. By this means I also avoid the great expense of constructing high towers and other elevated supports, besides being unlimited in gaining the effects of the high vertical antennæ. I thus not only greatly reduce the cost of operation but reduce the amount of power necessary. The possibility of interference and especially atmospheric disturbances, which interfere with signaling when using high towers, is to a great extent avoided.

It is preferable that the resistance of the horizontal conductor to ground should be low. Where terminal capacities are used they should therefore be very large so as to produce a small back voltage. Where direct grounds are used they should be constructed in such a way that their ohmic resistance is much lower than that of the usual ground, for example by constructing a trench of some length, say 100 feet, preferably at right angles to the direction of propagation or receipt. As an illustration, the resistance of the grounds should be a small fraction of an ohm, such as one hundredth of an ohm, instead of five to twenty five ohms as is the case with the grounds usually constructed.

It will be noted that by the use of a high frequency alternator in this apparatus, I produce the minimum of disturbance in the other circuits, and by this device in connection with my devices for maintaining constant intensity of radiation, and devices for signaling by changing the tune, interferences with other stations can be avoided entirely.

Having thus described my invention and illustrated its use, what I herein claim as new and desire to secure by Letters Patent, is the following:

1. Apparatus for signaling by electromag-

netic waves comprising a radiating conductor in close proximity to the earth and grounded at both ends and lying in the direction of propagation of the radiated waves.

2. The combination of several sets of antennæ the series grounded at both ends and adapted to operate by the earth current of the waves, said sets connected in series and each series containing tuning devices.

3. Several composite and cumulatively acting horizontal component antennæ connected in series and means to separately adjust the parts of said series.

In testimony whereof I have hereunto signed my name in the presence of the two subscribed witnesses.

REGINALD A. FESSENDEN.

Witnesses:
THOMAS B. BLACKMAN,
JESSIE E. BENT.