R. A. FESSENDEN.

ELECTRIC SIGNALING APPARATUS.

APPLICATION FILED JULY 27, 1905.

1,050,441.

Patented Jan. 14, 1913.

3 SHEETS—SHEET 1.

FIG. 1.

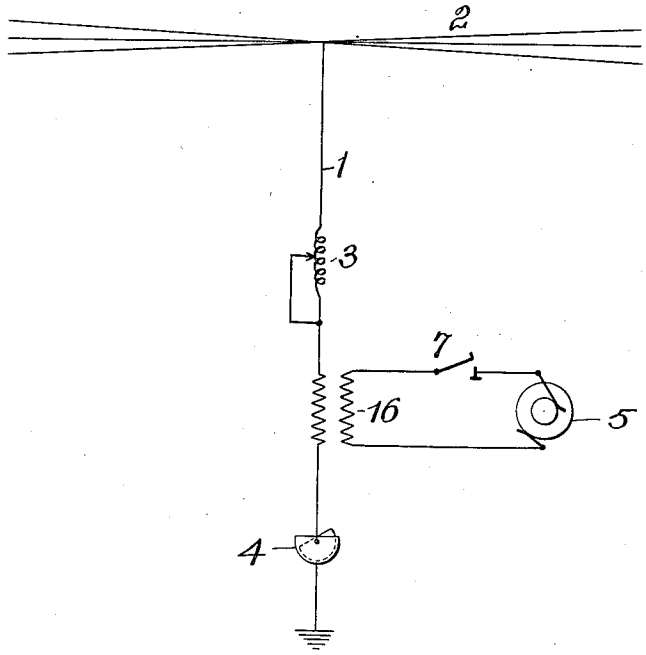
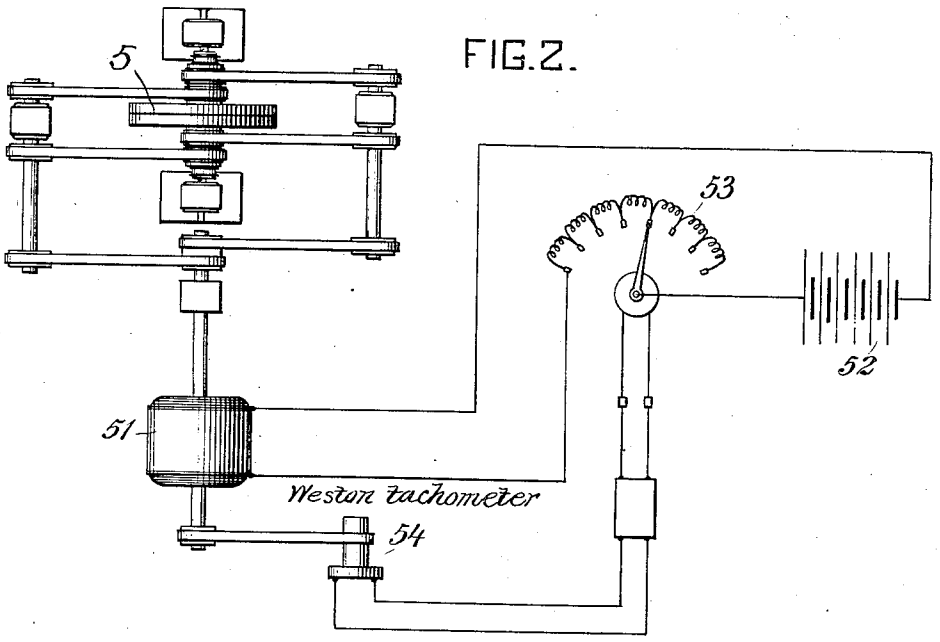


FIG. 2.



WITNESSES:

Herbert Bradley.

Dwight Benton.

INVENTOR

Reginald A. Fessenden

by Damon S. Wolcott Atty

R. A. FESSENDEN.

ELECTRIC SIGNALING APPARATUS.

APPLICATION FILED JULY 27, 1905.

1,050,441.

Patented Jan. 14, 1913.

3 SHEETS—SHEET 2.

FIG. 4.

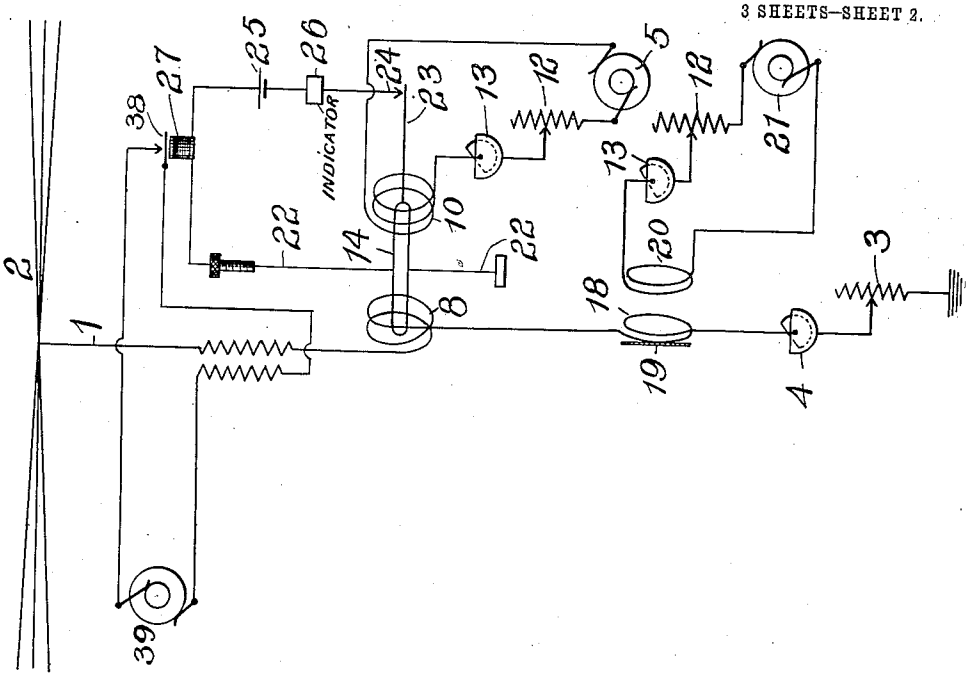
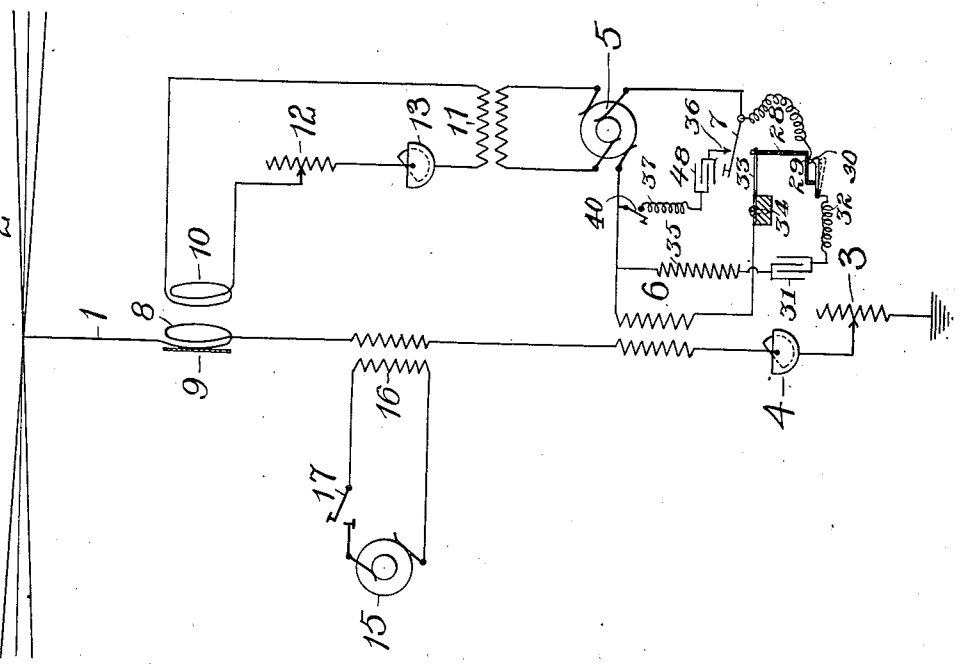


FIG. 3.



WITNESSES:

Herbert Bradley.

Dwight Benton.

INVENTOR

Reginald A. Fessenden

by Dennis B. Wolcott Atty

R. A. FESSENDEN.

ELECTRIC SIGNALING APPARATUS.

APPLICATION FILED JULY 27, 1905.

1,050,441.

Patented Jan. 14, 1913.

3 SHEETS—SHEET 3.

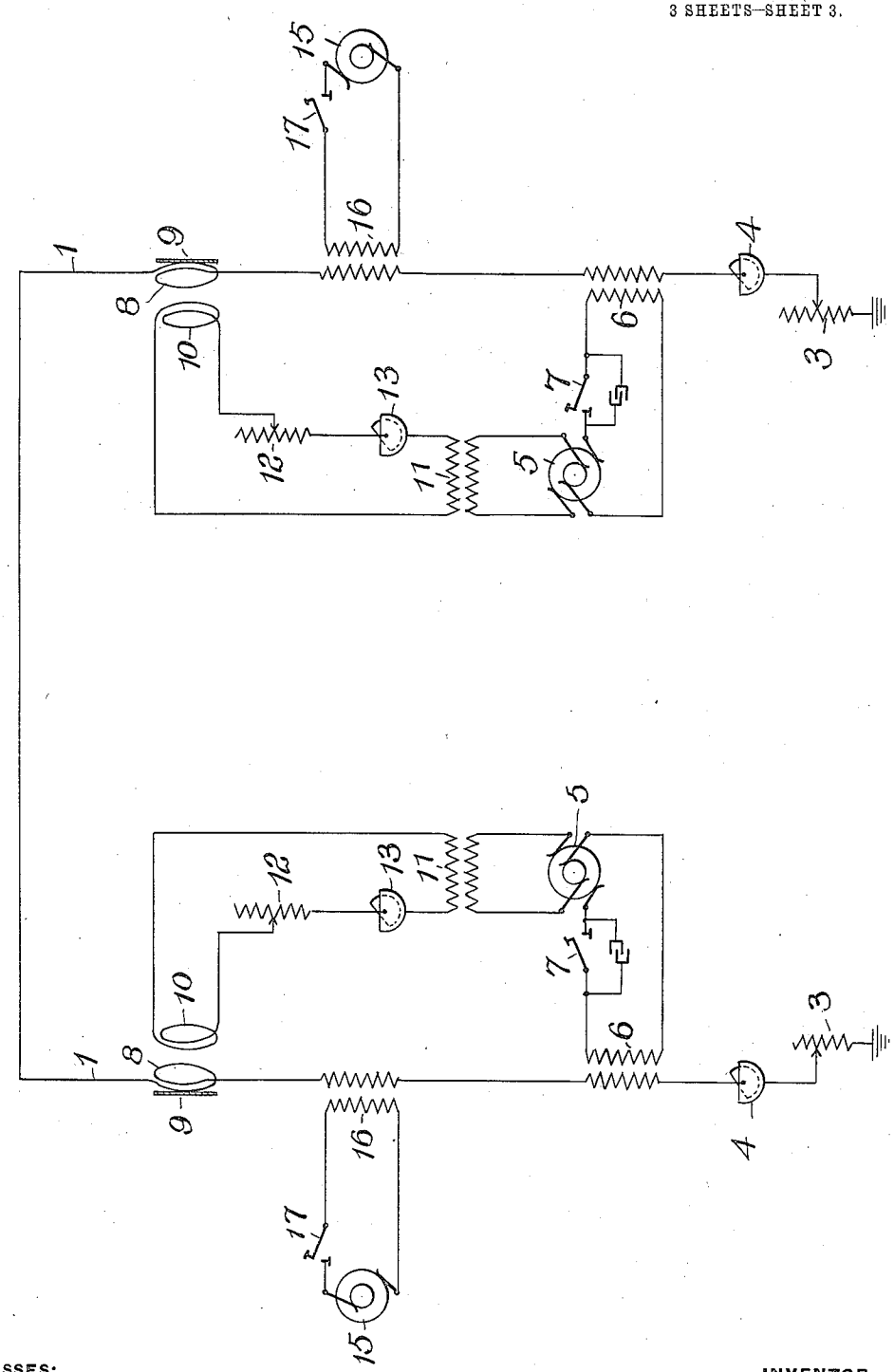


FIG. 5.

WITNESSES:

Robert Bradley.

Dwight Betton.

INVENTOR

Reginald A. Fessenden

by Dennis B. Wolcott Atty

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.

ELECTRIC SIGNALING APPARATUS.

1,050,441. Specification of Letters Patent. Patented Jan. 14, 1913.

Application filed July 27, 1905. Serial No. 271,539.

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 county of Plymouth, State of Massachusetts, have invented certain new and useful Improvements in Electric Signaling Apparatus, of which the following is a specification.

My invention relates more particularly to signaling by electromagnetic waves, and one of its primary objects is to utilize the interaction of forces produced by a continuously maintained stream of oscillations as they are received, with forces produced at the receiving station by oscillations practically continually produced by a local source, as will be hereinafter more fully described.

In the accompanying drawings, Figure 1 represents diagrammatically a sending station. Fig. 2 is a plan view and diagram illustrating a preferred manner of driving and controlling a high frequency generator. Figs. 3 and 4 are diagrammatic views of two modifications of combined sending and receiving stations. Fig. 5 illustrates means for utilizing my invention in connection with line wires.

A great source of trouble in telegraphing is the liability of interference with the signals by disturbances, either atmospheric or those emanating from stations other than that from which it is desired to receive signals. This difficulty and others are overcome by the means described herein, and great sensitiveness is obtained, besides which a number of messages or signals may be sent and received at the same time. Furthermore, these results can be obtained without making use of resonance, although resonance effects may be used when desired and for some purposes they are preferably used.

In the practice of my invention I prefer to use for sending, a means for producing continuous radiation, which may be for example a high frequency alternating generator having the characteristics described in U. S. Patent 706,737. I also prefer to use low voltage, as my apparatus is especially adapted for use with comparatively low voltages, and using a practically continuous emission of waves, interrupted only by the signal producing means such as the sending key, the effects of sunlight are largely overcome, interference with other stations is reduced, and received signals are more sharply selected. It is also preferred to employ an aerial having a large capacity, such as described in Reissue Patents 12,168 and 12,169, and to arrange the aerial horizontally as in U. S. Patents 706,738 or 753,864. For receiving I prefer to employ an aerial similar to that employed for sending, though this is not necessary, and the aerial or collector may have more inductance and less capacity than the sending conductor. A circuit through which the received oscillations may flow is arranged in operative relation to the receiving antenna, and at the receiving station I use a frequency determining element controlling a locally produced field adapted to interact with the received energy, as with an electrostatic or an electromagnetic field produced by the received oscillations.

As a frequency controlling device I prefer to use a high frequency alternator, or a mercury lamp producing oscillations whose frequency is maintained constant, that is to say not intermittent, by automatic means. Any other suitable source for producing unintermittent oscillations may be used, such for example as a device operating by direct current with or without a discharge gap, as described in my U. S. Patent 706,742, dated August 12th, 1902, or a selector device as described in Patent 793,652, dated July 4th, 1905. In this case a high frequency alternater 5 is used (see Fig. 2) and the field is placed near the axis of rotation to avoid centrifugal effects. This may be driven by steam or gas turbine or an electric motor 51 supplied from a storage battery 52.

The frequency is preferably maintained constant to about one-tenth of one per cent. by attaching a Weston tachometer 54 to the shaft of the motor 51 and placing an adjustable contact on the indicating pointer of the tachometer, so that when the speed rises or falls a suitable mechanism as rheostat 53 will change the resistance in the field or armature and thereby restore the speed to its proper value. (See Fig. 2). While this means of regulation is preferred, because the contact of the tachometer is capable of being adjusted to any desired point, and when so adjusted the speed is automatically maintained constant, yet I may of course use other means of regulation. In order to determine whether or not the frequency has

the proper value, irrespective of mechanical means, a local independent resonant circuit comprising a condenser and inductance and sending or receiving device may be kept at the station for the purpose of forming a standard of frequency.

While a variety of forms of receiving device may be used with my invention, the construction shown in Fig. 3 is convenient and desirable. It consists of a light coil of wire 8 attached to a telephone diaphragm 9, and a second coil 10 is arranged in operative relation to coil 8, the latter being operatively connected to the receiving antenna. Impulses generated and determined as by the current from the high frequency dynamo 5, through transformer 11 connected therewith, flow through the coil 10. In circuit with this coil is a variable inductance 12 and adjustable capacity 13, and the phase of the current from the dynamo may thus be given any desired value.

It will be understood of course that the particular instruments used and as above generally described are not the essence of my invention, but it consists broadly in the combinations of means set forth in the claims. The apparatus here shown is merely illustrative.

In Fig. 1 is shown a form of sending apparatus consisting of an antenna, 1 having a horizontal portion 2, an inductance 3, and a capacity 4, both preferably adjustable, for tuning purposes where this is desired. A high frequency alternator 5, is operatively connected to the antenna 1, preferably through the transformer 16. A key 7, or other suitable means, is employed for regulating or controlling the emissions of radiations from the antenna either by direct make and break as shown or by changing the intensity or frequency of the emitted radiation. The method of using the key to effect a change in the character or amount of the radiation while keeping the load on the generator constant is preferred as shown in Fig. 3 by the contact 36, capacity 48, and inductive resistance 37.

On the receipt of oscillations, current will flow through the coil 8, (Fig. 3), and the oscillating field so produced will interact with the field produced by the coil 10. If the field from the coil 10, which is continuously active, is of a frequency exactly the same as of the field from coil 8, produced by the received oscillations, no indication, or only a weak one, may be produced, as the phase of the current may not be suitable the force exerted during one part of the cycle being counterbalanced by a force in the opposite direction during the other part of the cycle, as is well known. It is preferred, therefore, to have the frequency of the dynamo producing a field by coil 10, different from the frequency of the received oscillations, and this difference may amount preferably to about one-fifth ($\frac{1}{5}$) of one per cent. (1%), though a larger or a smaller difference may be used. If the frequency of the transmitted waves be 100,000 per second, and the frequency of the alternator 8, be one-fifth ($\frac{1}{5}$) of one per cent. (1%) different from this; *i. e.* 100,200, beats will be produced, which will cause the telephone diaphragm to vibrate and emit a musical note. If the frequency difference be too great, either beats will not be produced at all, or their pitch will be too high to be audible; while if the frequency difference be too small, the pitch of the beats will be too low to produce a musical note or even to produce an audible indication.

The pitch of the note may be altered at will so as to produce mechanical resonance with the telephone diaphragm, or with a resonator of any desired type, by changing the speed of the alternator 5. When in calling up the station beat tuning is used as it may be though it is not preferred, then after the station is called up the desired beat frequency can be obtained by adjusting the position of the fixed contact or by the Weston tachometer relay or other speed regulating or frequency determining device.

If it is desired to send while receiving, the key 7 is depressed so as to make a signal, and the alternator 5 generates electromagnetic waves in the antenna by means of the transformer 6, whose secondary is operatively connected to the aerial 1. In this case the transmitted oscillations will produce no indication on the telephone diaphragm 9, because the frequency of the sending oscillations which oscillate in the antenna 1, and coil 8, will be of the same frequency as those in the coil 10, and hence no beats will be produced. The interaction between the coils 8 and 10, due to the sending, can be made smaller by changing the phase in the coil 10, by means of the adjustable inductance 12, or adjustable capacity 13, so as to make the phase of the currents in coils 10 and 8 different by 90 degrees.

Another form of receiver is shown in Fig. 4, consisting of a ring 14, preferably oval or oblong, movably suspended or supported in such relation to the coils 8 and 10, as to be within the influence of the fields produced by said coils. The ring or circuit 14, is adjusted to such an angle that the current produced by received oscillations in coil 8, will generate currents in the ring. The coil 10 which, as stated, is connected to the alternator through the variable inductance 12 and variable condenser 13, produces a magnetic field, which interacting on the currents in the ring 14, causes the latter to move. The motion of the ring can be utilized to produce an indication in any of the many ways known in the art. The electrical con-

stants of the ring, *e. g.* its resistance or self-inductance, may be empirically arranged so as to produce a maximum effect; and with a similar end in view, the phases of the current in the coil 10 may be altered so as to give a maximum effect on the ring by means of the capacity 13, or the inductance 12.

It will be understood that although it is preferred to use the same generator for producing a field by the coil 10, and also for sending, independent generators may be used for these purposes, as shown in Fig. 4. As shown in Fig. 3 two or more signals, indications or messages may be sent at the same time by the employment of two or more dynamos, as 5 and 15, the alternator 15 having a frequency different from that of the alternator 5, and being operatively connected to the antenna 1, preferably through a transformer 16. A key 17, or other suitable means, is employed for controlling the emissions produced by the alternator 15. Two or more signals, indications or messages may be received simultaneously, in which case a second receiver, consisting of a coil 18, secured to a diaphragm 19, is operatively connected to the aerial, and a fixed coil 20, is in circuit with an alternator 21, a variable inductance and a variable capacity being also preferably included in the circuit. The frequency of the alternator 21, should preferably be different from that of the alternator 5.

Where it is desired to send two or more messages, or receive two or more messages simultaneously, it is preferable to have the alternators of such periodicity that no beats or inaudible beats, will be produced between the alternators used at the same station. Where desired, all or any of the circuits may be electrically tuned in accordance with methods well known in the art, the advantages and effects of such tuning being well known.

Instead of using the above described arrangement for maintaining the load on the generator constant, which comprises the contact 36, condenser 48 and inductive resistance 37, another arrangement may be used when desired, and as shown in Fig. 3. The switch 40 above the coil 37 is open for this purpose. The fixed contact for the key 7 is mounted on the spring 33 which is carried by the support 34, and this spring also carries the bent insulating rod 28 with a contact 29 at the elbow of its bent portion. In normal position of the key the contacts 29 and 30 are connected, thus completing the circuit which contains inductance 32, condenser 31, resistance 35, and the generator 5. On depressing the key 7 the circuit including the contact on spring 33, the primary of the transformer 6 and the generator 5 is closed and waves are sent out, while the contacts 29, 30 being separated by the end of rod 28 depressing the part 30, the circuit 32, 31, 35, 5, 29 is open. The release of the key 7 again closes this last mentioned circuit and opens circuit 33, 6, 5, 7, thus maintaining the electrical constants of the generator circuit the same whether the key is depressed or not.

Again referring to Fig. 4, the ring 14 may be used to open and close the circuit and thereby operate a bell or other indicating instrument, or a relay as here shown. The ring 14 being preferably suspended by a fine phosphor bronze wire 22 and having a contact point 23 adapted to move to make contact with a point 24 upon movement of the ring, and thus close a circuit containing a battery 25, and indicating instrument 26. A relay 27 may also be included in this circuit and employed to operate any desirable mechanism for sending out the received signals, either from the same or another antenna for the purpose of relaying the signal. As shown in this Fig. 4 this relay 27 operates a key 38 to cause a high frequency generator 39 to send out signals from the antenna 1. It will be understood that this generator could rather be connected to an independent antenna if preferred. This sending key or any other signal controlling mechanism, whether it be operated by hand or a relay or otherwise may in lieu of making and breaking a circuit, be used to alter the intensity or frequency, after the manner described in my Patent 706,742, dated August 12th, 1902, for example.

The advantages of the above described system, are numerous and the invention is applicable to the transmission of signals by induction by line wires, as well as for signaling by electromagnetic waves, for which it is especially valuable. One advantage is that the method is practically independent of resonance, although resonant circuits may be used if desired, and hence the selectivity can be, and is necessarily very sharp, being independent of resonance. Thus a signal from a source less than 100 feet away cannot interfere with receipt of signals, or even weaken them, if its frequency differs more than a fraction of one per cent. (1%) from that of the impulses which it is desired to receive. The ability to send and receive simultaneously, and to work multiplex is also a great advantage, as is also the ease of operation, since the sending does not interfere at all with the received messages.

Another advantage of the beats method herein described, as against having the same frequency at the sending end, is that if the frequency at the receiving end were the same as that at the sending end, (though this is commercially impracticable) the fixed coil would generate by induction currents in the moving coil many thousand times greater than the currents to be received, and hence

the effect of the received impulses would be drowned by the currents generated by the local or fixed coils. The use of a constantly active frequency determining element is very important since it enables the locally generated impulses to be maintained at a constant intensity, and not die off as trains of waves do. Where the intensity dies off, the effects produced would greatly vary, and to such an extent that it would be difficult to operate practically and commercially. Furthermore, by the means described a greatly intensified effect is attained, and great certainty of operation, by maintaining the frequency determining element at the receiving station in a constantly active condition, and also by using at the sending station the means to produce a practically continuous emission of oscillations of a frequency maintained slightly different from that of the frequency determining element at the receiving station. Since by the apparatus described, signals may be simultaneously sent and received with absolutely no mutual disturbance, it is obviously especially adapted for relaying.

In connection with the line wire apparatus, as illustrated in Fig. 5, the frequency of the oscillations is preferably made considerably lower, and signals may be produced by shifting the phase of the transmitted impulses by shunting an inductance or capacity across the key, so that when the key is closed the inductance or capacity of the whole circuit is altered.

The sending or receiving aerials, or both of them, may be dead beat,—that is not resonant to any particular periodicity. Obviously two or more aerials may be used at the station, as one for sending, one for receiving, and one for relaying. However, aerials are not necessary since I may use the magnetic component method described in my co-pending patent 1,020,032, of March 12, 1912, application filed July 27th, 1903. When desirable, the aerials may be tuned to a definite frequency, and where two or more antennæ are used they may have a common portion, while the different sending or receiving devices may be placed in the branches, as is well known in this art. This may also be done in the case where the sending and receiving conductors are not resonant, but practically dead beat.

I do not herein claim the methods described, but the same I claim in my co-pending application 275,165 filed August 21st, 1905, which is a division of the present application. But

What I claim herein and desire to secure by Letters Patent is the following:

1. A signaling system having in combination a sustained sending source, and at a receiving station, a constantly operating frequency determining element of a frequency differing from that of the received oscillations.

2. A signaling system having in combination at a receiving station, a receiver and a constantly operating frequency determining element of a high frequency slightly different from that of the received oscillations.

3. A signaling system having in combination at a receiving station, a receiver and a constantly operating frequency determining element having a frequency differing from that of the received impulses to such an extent as to cause beats to be formed at the station on the receipt of transmitted impulses.

4. A signaling system having in combination at a receiving station, a constantly operating frequency determining element having a frequency differing from that of the received impulses to such an extent as to cause beats of mechanical frequency to be formed at the receiving station.

5. A signaling system having in combination at a receiving station, a receiver, a constantly operating frequency determining element having a frequency differing from that of the received impulses to such an extent as to cause beats to be formed on the receipt of the transmitted impulses and means for automatically regulating the frequency of the frequency determining element.

6. In apparatus for the electrical transmission of energy by high frequency currents, the combination with a sustained sending source, of a receiving station having a local sustained producing source of oscillations of different frequency, and an instrument operated by coöperation of the received and the locally produced oscillations.

7. In an electric wave signaling system the combination at a receiving station of a receiver, a constantly operating frequency determining element having a frequency differing from that of the received impulses to such an extent as to cause beats to be formed on the receipt at the station of transmitted impulses, means for adjusting the frequency of the determining element, so as to have any desired value and means for automatically maintaining it at the desired frequency.

8. A wireless telegraph signaling system having in combination at a receiving station means for producing an indication operated by the interaction of received impulses and impulses controlled by a local constantly active frequency regulator.

9. A signaling system having in combination at a receiving station, means for producing an indication operated by the interaction of received impulses and impulses controlled by constantly operating frequency determining elements, the frequency

of the frequency determining element at the station being different from the frequency of the received impulses.

10. A signaling system having in combination a receiver, a constantly operating source of energy in the receiving circuit, in coöperative relation to the receiver and a constantly active frequency regulator of period slightly different from that of the received energy controlling the local source of energy.

11. Apparatus for signaling by high frequency currents having in combination a receiver, an antenna in operative connection with the receiver, a constant source of energy at the receiving station in operative relation to the receiver and a constantly active frequency determining element of frequency slightly different from the received wave currents controlling the current for the local source of energy.

12. A signaling system having in combination a receiver comprising means for producing a constantly operative varying field of force, means for producing an interacting varying field of force by the received impulses and a constantly active frequency regulator varying the value of the interaction between the two fields.

13. A signaling system having in combination a receiver and a constantly operating source of energy at the receiving station in operative relation to the receiver and a constantly operating frequency determining element controlling the local source of energy, the frequency of the determining element being different from the frequency of the received impulses so as to form beats on the receipt of the impulses at the station.

14. A signaling system having in combination means at the sending station for producing a practically continuous emission of electro-magnetic waves and at the receiving station a receiver comprising a constantly operative field of force, a field of force produced by the radiations emitted from the sending station and a constantly active regulator periodically varying the value of the interaction between the two fields.

15. A wireless telegraph signaling system having in combination at the sending station a constantly operating alternator producing currents of low potential, a receiver at the receiving station and a constantly operating source of energy in active relation to the receiver and a constantly operating frequency regulator controlling the local source of energy.

16. A signaling system having in combination an aerial, a constantly operating high frequency generator, a step-up transformer connecting the generator with the aerial at the sending station and at the receiving station a receiver and a constantly operating frequency determining element of a frequency differing from that of the oscillations emitted from the sending station.

17. A signaling system having in combination at the receiving station a fixed coil, operatively connected to an antenna, a second fixed coil operatively connected to a frequency determining element and a ring arranged in operative relation to said coils whereby the ring may be shifted by interaction between the current in the ring and the field of one of the fixed coils.

18. In a signaling system the combination at the receiving station of two fixed coils, one operatively connected to the antenna, and the other similarly connected to a frequency determining element and a movable member arranged in the fields of said coils.

19. In a high frequency signaling system the combination at the receiving station of two fixed coils, one operatively connected to the antenna, and the other operatively connected to a frequency determining element of slightly different frequency, a ring arranged in the fields of said coils and an indicating mechanism controlled by said ring.

20. In a signaling system the combination at a station of an antenna, a fixed coil operatively connected to the antenna, a fixed coil operatively connected to a frequency determining element, a ring arranged in the fields of said coils, and means for producing radiations in operative relation to the antenna and controlled by the ring.

21. In a wireless signaling system the combination of an antenna, a receiver operatively connected to the antenna, a constantly operating frequency determining element, a constantly operating high frequency generator in operative relation to the antenna, and means for controlling the current from the generator.

22. A wireless telegraph signaling system having in combination at a receiving station means for constantly producing oscillations of practically constant amplitude and having a frequency differing from that of the received oscillations.

23. A wireless telegraph signaling system having in combination at a receiving station a receiver and means for producing sustained oscillations of practically constant amplitude and of a frequency different from that of the received oscillations.

24. In apparatus for transmitting energy, the combination of an alternating current transmitting station, a receiving station, a receiver at the receiving station and a source of practically continuous high frequency oscillations of periodicity differing from that of the received current operatively connected to the said receiver, substantially as described.

25. In wireless telegraph apparatus for transmitting energy, the combination of a

transmitting station having apparatus for sending practically continuous high frequency oscillations, a receiving station, a receiver at the receiving station and a source of practically continuous high frequency oscillations operatively connected to the said receiver, substantially as described.

26. In apparatus for wireless telegraphy, the combination of a sending station having means to emit practically continuous high frequency oscillations, a receiving station having a source of practically continuous high frequency oscillations, and a receiver arranged to respond to the combined effects of the oscillations from the sending and from the local sources.

27. In wireless telegraphy apparatus, the combination with a sending source of sustained high frequency oscillations, and at the receiving station a device forming a field excited by the received oscillations, of a local producing source of practically continuous high frequency oscillations at the receiving station, and a signal-producing device actuated by coöperation of the received and the locally produced oscillations.

28. The combination of a sending source of sustained high frequency oscillations, a receiving apparatus comprising a local source of practically continuous high frequency oscillations and a field excited thereby, means for maintaining a slight difference of frequency between the received and locally produced oscillations, and an indicator operated by the beats produced by the interaction of the received and locally produced oscillation effects, substantially as described.

29. Electric signaling apparatus comprising a receiving station having an absorbing circuit, an indicator, a local generator of alternating current of frequency different from that of the received current, and means to operate said indicator by beats produced thereby in conjunction with the received current.

In testimony whereof, I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:

THOMAS B. BLACKMAN,

JESSIE E. BENT.