No. 609,154. Patented Aug. 16, 1898.

O. J. LODGE.

ELECTRIC TELEGRAPHY.

(Application filed Feb. 1, 1898.)

(No Model.) 2 Sheets—Sheet I.

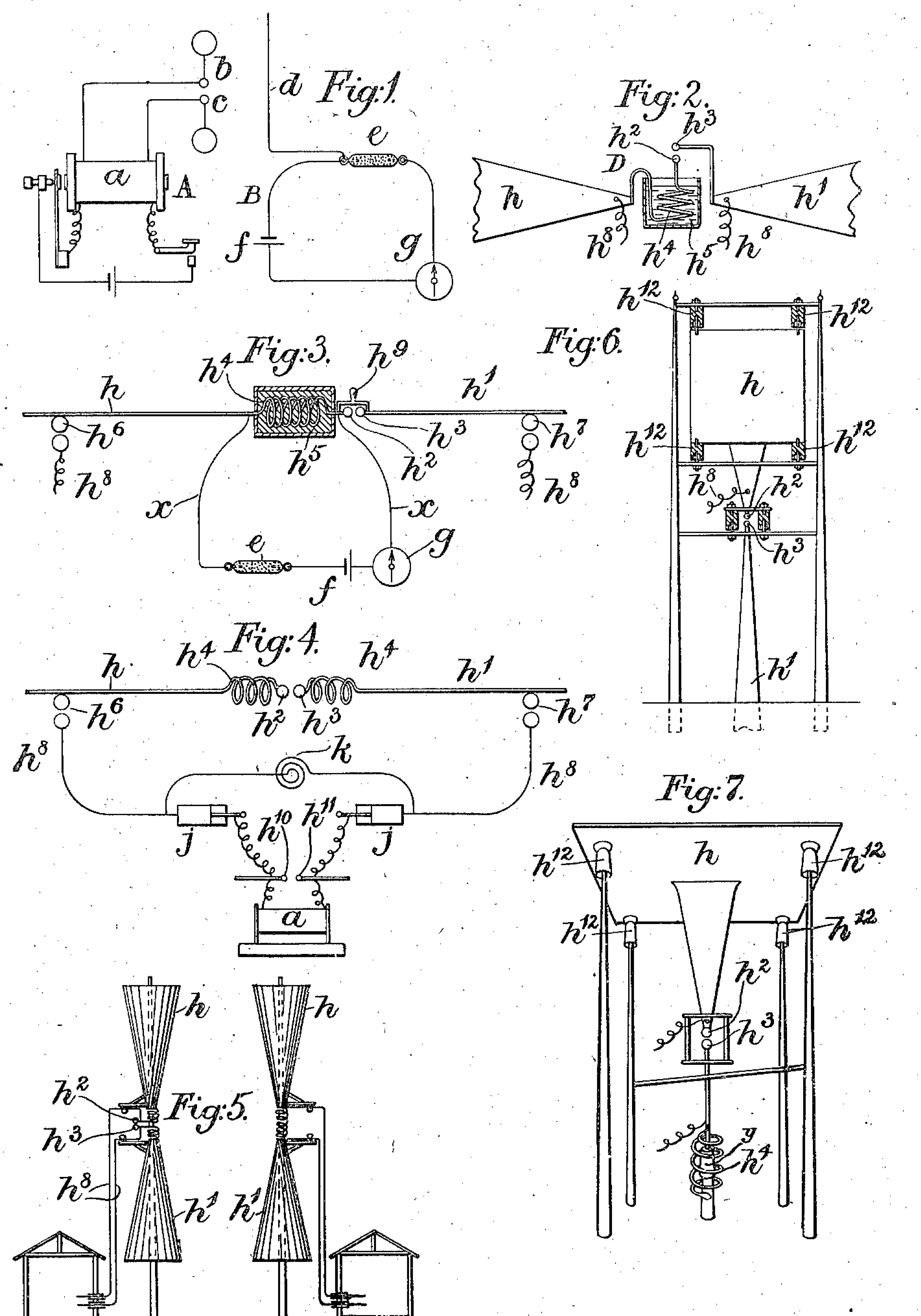

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Fig:8.

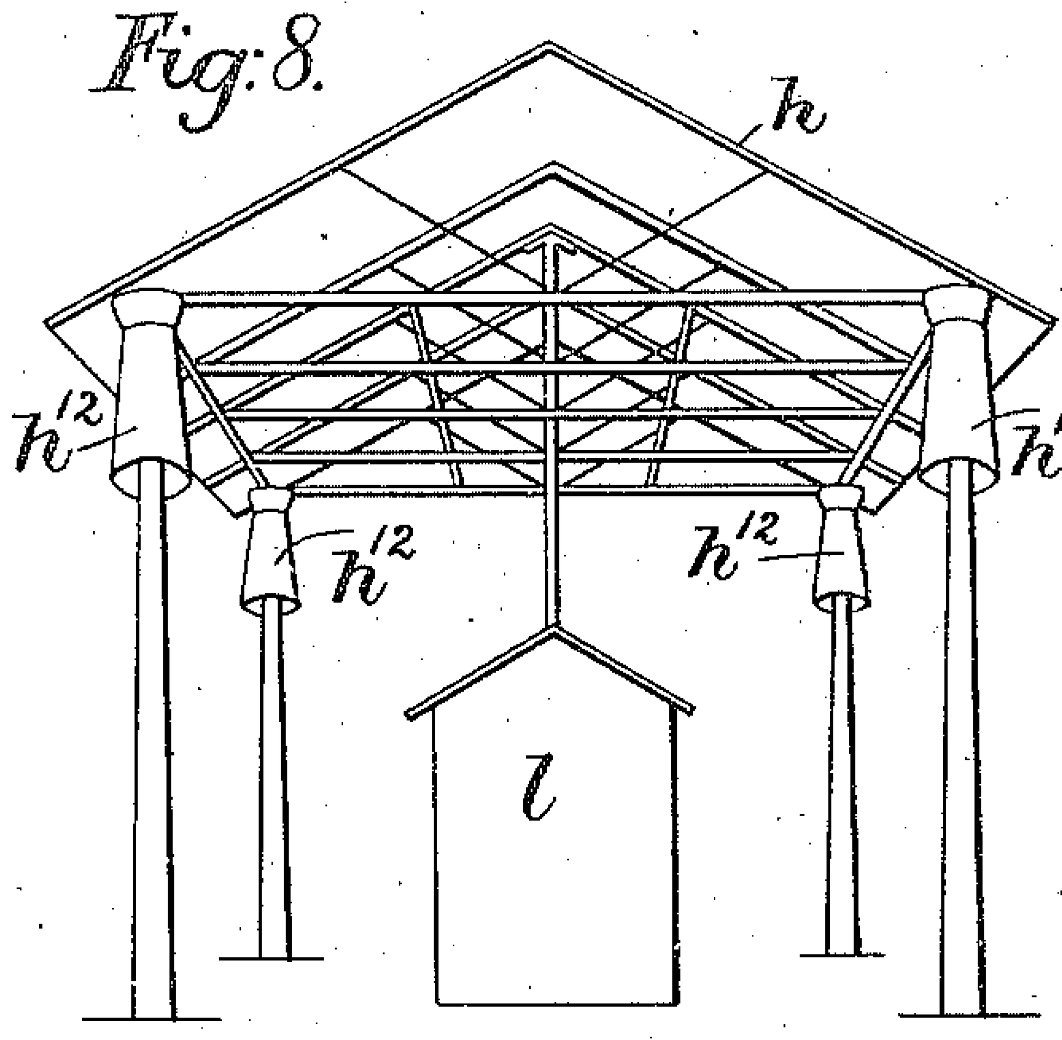


Fig:9.

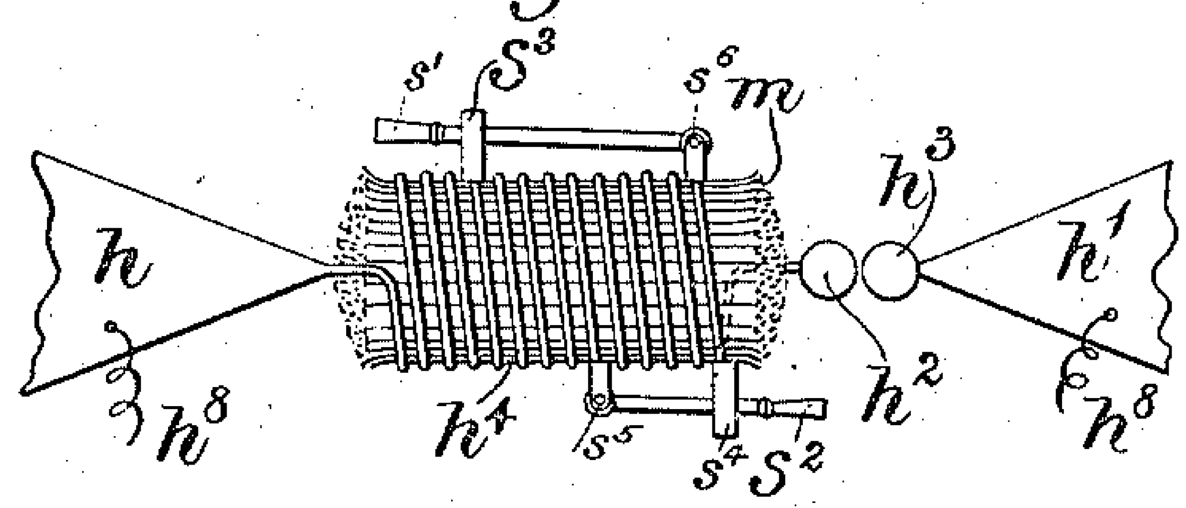


Fig:12.

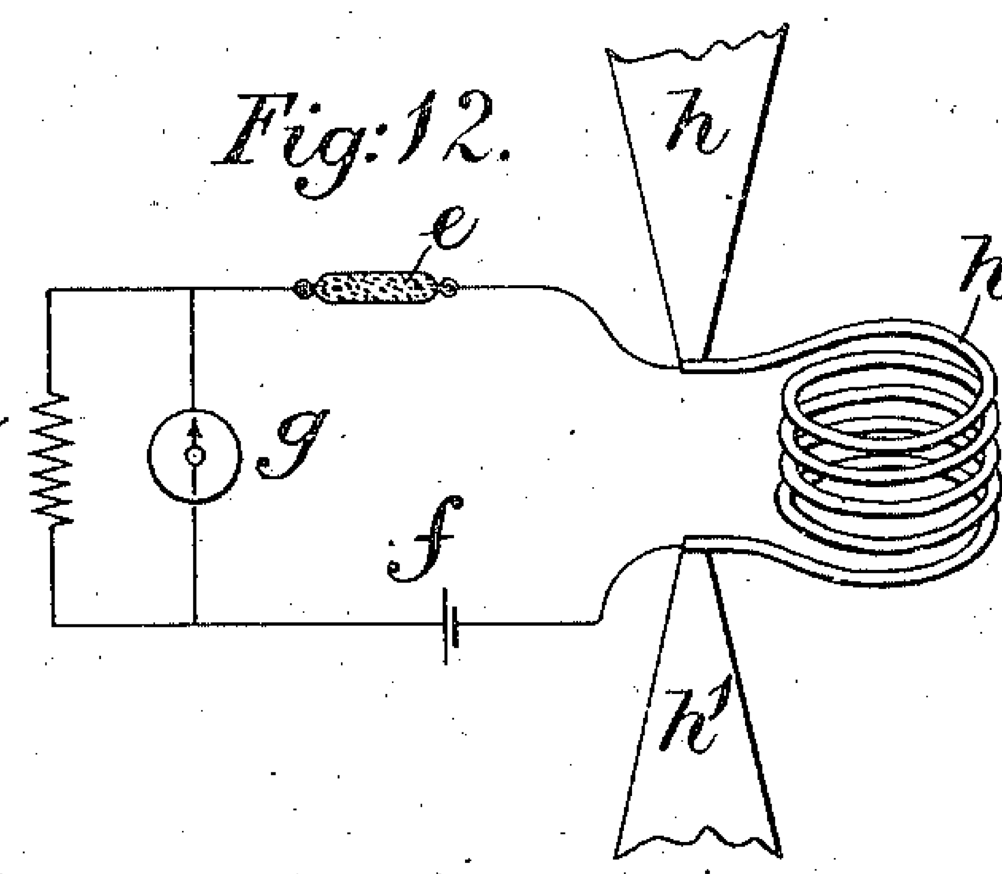


Fig:10.

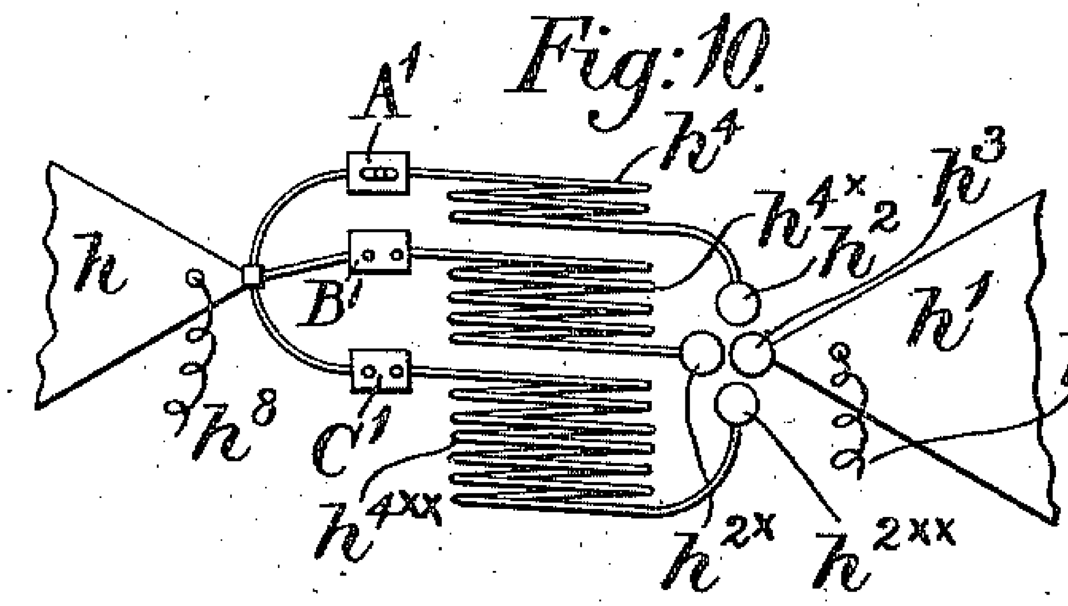


Fig:11.

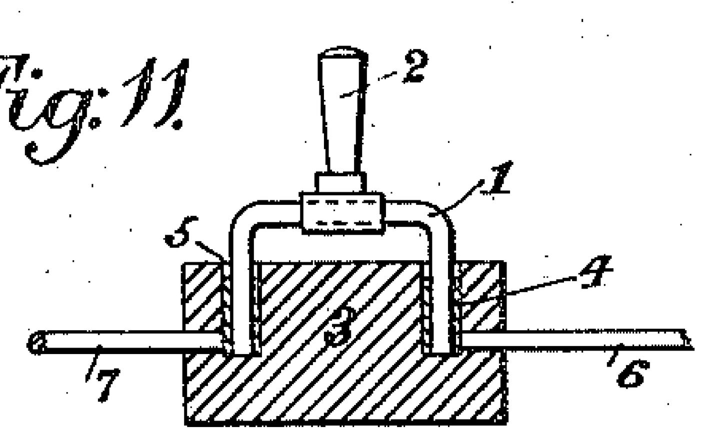
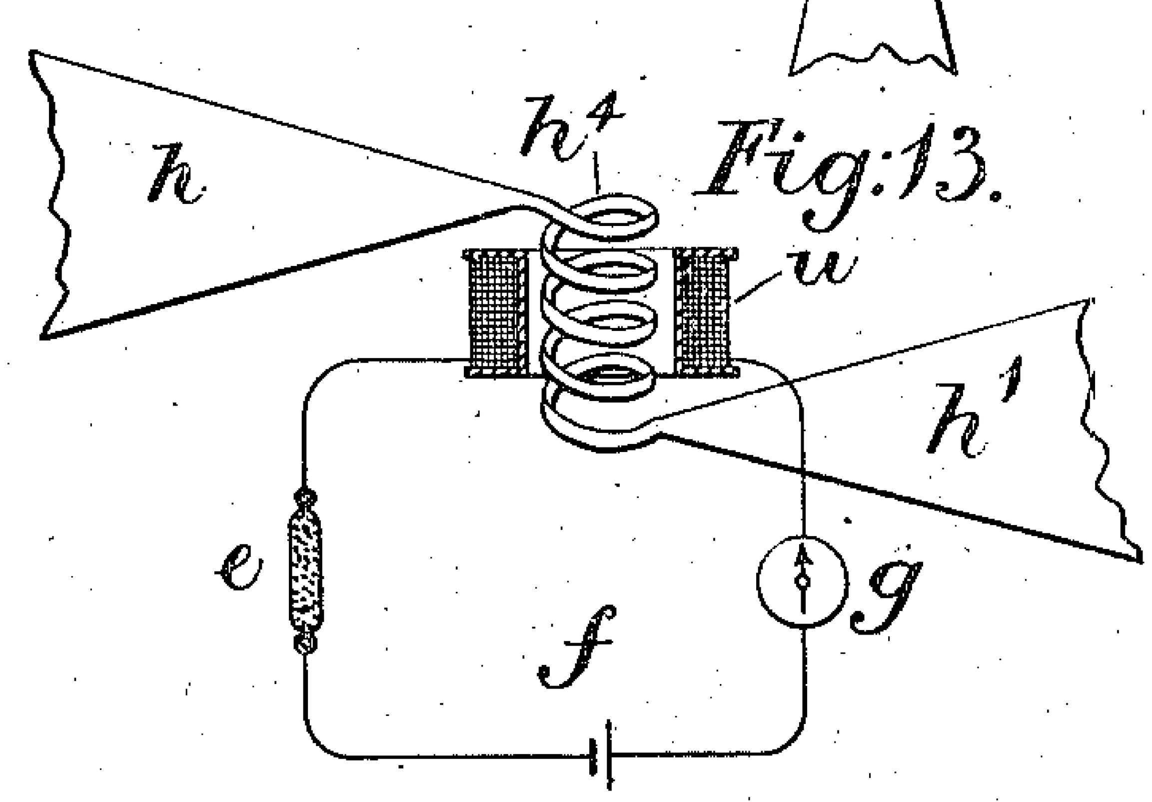


Fig:13.



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UNITED STATES PATENT OFFICE.

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ELECTRIC TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 609,154, dated August 16, 1898.

Application filed February 1, 1898. Serial No. 668,752. (No model.)

To all whom it may concern:

Be it known that I, OLIVER JOSEPH LODGE, a subject of the Queen of Great Britain, residing at Liverpool, in the county of Lancaster, England, have invented certain new and useful Improvements in Electric Telegraphy, of which the following is a specification.

The object of my invention is to enable an operator, by means of what is now known as "Hertzian-wave telegraphy," to transmit messages across space to any one or more of a number of different individuals in various localities, each of whom is provided with a suitably-arranged receiver, and to effect the ancillary improvements the nature of which are hereinafter more particularly described and claimed.

The method of intercommunication consists, according to my invention, in utilizing certain processes and apparatus for the purpose of producing and detecting a sufficiently-prolonged series of rapid electric oscillations and in so arranging them that the excitation of a particular frequency of oscillation at the sending-station may cause a telegraphic instrument to respond at a distant station by reason of being associated, through a relay or otherwise, with a subsidiary circuit capable of electric oscillations of that same particular frequency or of some multiple or submultiple of that frequency. Another distant station will similarly be made to receive messages by exciting at the sending-stations alternations of a different frequency, and so on, and thus individual messages can be transmitted to individual stations without disturbing the receiving appliances at other stations which are tuned or timed or syntonized to a different frequency. Each station will usually be provided with both sending and receiving apparatus.

In the accompanying drawings, which are diagrammatic representations, Figure 1 shows the simplest arrangement of emitter and receiver heretofore in use. Figs. 2, 4, 6, 7, 8, 9, and 10 show alternative arrangements to be adopted at signaling-stations or appendages thereto in accordance with my invention. Fig. 3, in addition to showing an emitter, serves to show a receiving-circuit and means whereby parts of the emitting arrangement is utilized for receiving purposes. Fig. 5 depicts the more prominent features of a long-distance arrangement, both sending and receiving. Figs. 12 and 13 illustrate alternative forms of connection of apparatus in a syntonic receiving-circuit with appendages, and Fig. 11 is a detail view hereinafter more particularly referred to.

Like letters and figures of reference indicate similar parts throughout the drawings.

A complete installation of Hertzian-wave telegraphy consists, in its simplest form, of the arrangement depicted in Fig. 1, wherein A represents the emitting apparatus, and B the receiving apparatus.

In the emitter illustrated in Fig. 1 electricity from a suitable source, such as a Ruhmkorff coil *a*, is supplied to a pair of conductors which discharge into each other from knobs *b* and *c* and thus excite oscillations, which emit one or two waves before they are damped out.

The receiving-circuit consists, essentially, of a collector *d*, a coherer *e*, a battery *f* or other suitable source of electrical energy, and a telegraphic receiving instrument *g*, all in electrical connection, as shown.

In carrying out my invention, and referring now to the subsequent figures of the drawings, I use a definite radiator consisting of a conductor or pair of conductors h h' of large capacity, arranged either as a Leyden jar or preferably spread out separately in space, one of them being the earth when desired. I join to h and h', respectively, which I denominate "capacity areas," a pair of polished knobs h^2 h^3, protected by glass from ultraviolet light, which form the adjustable spark-gap. Between either capacity area and its knob I place a syntonizing self-inductance coil—that is, a coil of wire or metallic ribbon h^4, preferably insulated with any solid or fluid insulator, as in Fig. 2, or in air, of shape suitable to attain greatest inductance with a given amount of resistance—the object of this coil being to prolong the electric oscillations occurring in the radiator, so as to constitute it a radiator of definite frequency or pitch and obtain a succession of tone-waves emitted, and thereby to render syntony in a receiver possible, because exactitude of response depends on the fact that the total number of oscillations in a suitably-arranged circuit is very great, so that a very feeble impulse is gradually strengthened by cumulative action until it causes a perceptible effect on the well-known principle of sympathetic resonance.

I supply the electricity to the radiator from Ruhmkorff or from a Tesla coil or from a Wimshurst or other known or suitable high-tension machine *a* in one of three ways, according to circumstances.

The first way is by leading wires from the machine *a* to the two knobs h^2 h^3, which is the customary plan and gives a discharge which follows upon fairly steady electric strain.

The second way consists, as shown in Fig. 3, in having a supplementary pair of spark-gaps h^6 h^7, (which I call the "supply-gaps,") one knob of each (called the "receiving-knob") being attached to the middle or other convenient point of each capacity area *h* h', and the other knob of each pair (called the "supply-knobs") being connected by wires h^8 to the Ruhmkorff coil and brought moderately near the first, so that when the coil is in action the capacity areas shall receive their positive and negative charge by aerial disruption—that is, in a sudden manner—rather than by the slower process of metallic conduction, and shall then be left to discharge into each other through the connecting-coil h^4 and across the short spark-gap between the knobs h^2 h^3. The best width of this gap depends upon circumstances, and it may be closed altogether without stopping the action. The gap between the knobs h^2 h^3 may be optionally closed by a shunt h^9.

In the third plan, as indicated in Fig. 4, I interpose in each of the wires h^8 leading from the Ruhmkorff coil *a* to the supply-knobs a Leyden jar or other suitable condenser *j* able to stand a high potential, so that the knobs are supplied from the outer—that is, the uninsulated—coat of each jar, while between the inner coats or coil-terminals I arrange a third spark-gap, (called the "starting-gap,") also consisting of suitable knobs h^{10} h^{11}. The outer coats of the jars must not be insulated from each other, and I usually join them by an induction-coil of fairly thin wire *k*, so as to permit thorough charging. When the discharge occurs, this wire acts as an alternative path or by-pass, but does not prevent the sparks at the supply-gap.

By both of the means described with reference to Figs. 3 and 4 I charge the two capacity areas *h* h' (which, together with the inductance-coil between them, constitute the radiator) by aerial disruption or impulsive rush. The advantage of this is that charges so communicated are left to oscillate free from any disturbance due to maintained connection with the source of electricity, and therefore oscillate longer and more simply than when supplied by wires in the usual way. Moreover, the capacity areas of a radiator are more conveniently employed as the capacity areas of a receiver without need of disconnection.

The arrangement described with reference to Fig. 4 illustrates most completely the method of charging the capacity areas *h* h' with an impulsive rush. The action is as follows: The Ruhmkorff machine *a* charges the jars *j*, whose outer coats are connected, and discharges them at the starting-gap h^{10}. This spark precipitates a discharge at the supply-gaps h^6 h^7 and suddenly supplies the capacity areas *h* h' with electric charges, which then surge through the connecting-coil h^4 (divided into two parts in this figure) and spark into each other at the discharge-gap between the knobs h^2 h^3. This last discharge is the chief agent in starting the oscillations which are the cause of the emitted waves; but it is permissible in the arrangements of Figs. 3 and 4 to close this last gap when desired and so leave the oscillations to be started by the sparks at the supply-gaps only, whose knobs must in that case be polished and protected from ultra-violet light, so as to supply the electric charge in as sudden a manner as possible.

As charged surfaces or capacity areas spheres or square plates or any other metal surfaces may be employed; but I prefer, for the purpose of combining low resistance with great electrostatic capacity, cones or triangles or other such diverging surfaces with the vertices adjoining and their larger areas spreading out into space; or a single insulated surface may be used in conjunction with the earth, the earth or conductors embedded in the earth constituting the other oppositely-charged surface.

Radiation from an oscillator consisting of a pair of capacity areas is greater in the equatorial than in the axial direction, and accordingly when sending in all directions is desired it is well to arrange the axis of the emitter vertical. Moreover, radiation polarized in a horizontal plane—that is, with its electric oscillations vertical—is less likely to be absorbed during its passage over partially-conducting earth or water. A pair of insulated capacity areas arranged for long-distance signaling is shown on the left-hand side of Fig. 5. Fig. 6 shows a single insulated capacity area *h* with the earth acting as the other surface and leading up to the spark-knobs h^2 h^3 by a triangular sheet or cone h', so as to afford good conductance even to rapidly-alternating currents. The wire h^8 in this case leads to one terminal of the Ruhmkorff coil, the other terminal of which is taken to earth. The capacity area *h* is insulated, as indicated at h^{12}.

In cases where it is required that the apparatus shall offer less resistance to wind the arrangement may be such as that illustrated in Fig. 7, where instead of being vertical, as shown in Fig. 6, the capacity area h is slanting or horizontal.

In Fig. 7 the syntonizing-coil h^4 is shown as surrounding a large telegraph-insulator y, which insulator divides the upper from the lower part of the rod carrying the discharge-knob h^3. The spiral h^4 bridges over the gap thus caused, uniting the rod above and below the insulator and so affording an earth connection.

Fig. 8 shows an insulated metal surface in the form of a roof of a shed or building which may be used as a capacity area, with suitable connection and apparatus (not shown) inside the little house l.

The self-inductance coil represented at h^4 in all applicable figures is a coil of highly-conducting wire or ribbon, well insulated by air or by some other medium, as already described, or else covered to a sufficient thickness with insulating material of such shape as to have maximum self-inductance for a given resistance, and it may be either a flat coil inclosing a considerable plane area or it may be a cylindrical coil wound upon a finely-subdivided iron core, as shown at m in Fig. 9, the core being either ring-shaped or U-shaped or straight.

The discharge-knobs h^2 h^3 may be arranged at one end of such coil, as shown in Figs. 2, 3, 7, and 9, or the coil may be in two halves with the knobs inserted in the middle, at pleasure. (See Figs. 4 and 5). Several such coils h^4 $h^{4\times}$ $h^{4\times\times}$, with their knobs h^2, $h^{2\times}$, and $h^{2\times\times}$, may, as shown in Fig. 10, be arranged for use with a single pair of capacity areas, and any one of them may be brought into action by a suitable switch, so that the desired frequency of vibration or syntony with a particular distant station is attained by replacing one coil by another, for the frequency can be adjusted either by varying the capacity of the condenser or jar or other conductor employed or the charged body on the one hand or by varying the number and position of coils or other portion of the discharge-circuit on the other. That discharger is in action whose spark-gap is allowed to operate, and a switch A′ B′ C′ can determine which of a set of different coils shall be utilized for a given distant station. Fig. 11 illustrates the form of switch indicated in Fig. 10.

In Fig. 11 the numeral 1 designates a metallic union-piece. 2 is its handle, of insulating material, and 3 is a suitable insulating-base. The union-piece 1 dips into mercury-cups 4 and 5, with which the leads 6 and 7 are connected.

A plan alternative to that described with reference to Fig. 10 is to connect the capacity areas through one pair of knobs and a single large coil of a considerable number of turns, as shown in Fig. 9, and to have keys or plugs or switches s' and s^2, whereby some of the spires or turns of the coil can be shunted out of action, so that the whole or any smaller portion of the inductance available may be used in accordance with the correspondingly-attuned receiver at the particular station to which it is desired to signal.

Fig. 9 shows two hand-levers s' s^2 hinged, respectively, to the coil at s^5 s^6. The bar of each lever is made of metal, while the handle is of insulating material. s^3 s^4 are movable metallic spring-clips connected to the said coil and adapted to grip the levers when they are depressed, so as to make good contact. Thus each lever, when pressed down shuts out all the spires of the coil between the two ends of such lever. This arrangement may be used either in lieu of or in combination with interchangeable inductance-coils, such as shown in Fig. 10, and in the latter case they are useful for correcting slight errors in tuning for any one station. The one I call an "adjustable" coil and the other I call "replaceable" or "interchangeable" coils, and both, since they tend to a like end and behave similarly, may be included by the term "variably-acting" coil.

A receiver or resonator consists of a similar pair of capacity areas connected by a similarly-shaped conductor or self-inductance coil, the whole constituting an absorber arranged so as to have precisely the same natural frequency of electrical vibration as the radiator in use at the corresponding emitting-station, so that it can accumulate the received impulses—that is to say, can act cumulatively; but it must not have a spark-gap, such as h^2 h^3, or if it have a spark-gap the same must be carefully closed or shunted or bridged across by a good short conductor—for example, like Fig. 11—before the arrangement can be properly used as a cumulative receiver. Identically the same capacity areas and self-inductance coil can be used at will either as emitter or as receiver—that is, either as radiator or as resonator (see Fig. 5)—if it be convenient to do so, on condition that the "discharge" spark-gap h^2 h^3 of the radiator is perfectly closed whenever acting as receiver.

Thus referring to Fig. 3 it will be seen that that diagram illustrates a combined emitting and receiving apparatus. When in use as a radiator, the gap between the discharge-knobs h^2 h^3 is left open. When utilized as a resonator, the said gap is closed by the shunt h^9, (there supposed to be like Fig. 11,) and the coherer e, battery f, and telegraphic receiving instrument g are connected through a thin wire x from each end of the coil h^4—that is, from each of the capacity areas.

If the Ruhmkorff machine a has been actually connected to the capacity areas h h', as in Fig. 2, then it must be detached and substituted by the coherer-circuit when a receiver is wanted; but if the charge was supplied through supply-gaps h^6 h^7, as in Figs. 3 and 4, (and this is the best plan,) then the Ruhmkorff connections can be left unaltered, as the action of the resonator is then in no way affected, provided always that the coil is not put into activity while the receiving-circuit is connected up.

A coherer consists of any arrangement which drops in resistance on receipt of an electric impulse and rises to its old resistance on being subjected to a mechanical impulse, such as a tremor or a tap.

A coherer-circuit is any known arrangement for observing or recording effects due to fluctuations in the electrical resistance of a coherer.

As coherer I use either a light single-point contact or Branly's arrangement of a pair of conductors embedded in metallic grains or powder or filings; but I prefer selected iron filings of uniform size sealed up in a good vacuum and with the communicating surfaces or electrodes reduced to points or thin platinum wires fused into the glass and with their ends close together; or I may use any other suitable apparatus with an appropriate device for tapping back. In some cases I find that a coherer restores itself sufficiently without specially-arranged tremor and that in these cases a telephone is the quickest responder that can be used.

As coherer-circuit I usually arrange the coherer in simple series with a battery (voltaic or thermal) and a galvanometer, telephone, or other indicator, or a recorder of fluctuations of current, and I then connect the terminals of this series of instruments to the capacity areas of the receiver close to its self-inductance coil, so that this same coil of wire completes and forms an essential part of the coherer-circuit. The coherer is thus affected by every electrical disturbance occurring in the connecting-coil or in its capacity areas and by aid of the battery at once enables the telegraphic or telephonic instrument to appreciate and indicate the signals. This plan is shown in Figs. 3 and 12. It is an improvement on any mode of connection that has previously been possible without the connecting-coil.

In some cases I may, as shown in Fig. 13, surround the syntonizing-coil of the resonator with another or secondary coil u (constituting a species of transformer) and make this latter coil part of the coherer-circuit, so that it shall be secondarily affected by the alternating currents excited in the conductor of the resonator, and thus the coherer be stimulated by the current in this secondary coil rather than primarily by the currents in the syntonizing-coil itself, the idea being thus to leave the resonator freer to vibrate electrically without disturbance from attached wires.

In all cases it is permissible and sometimes desirable to shunt the coils of the telegraphic instrument by means of a resistance or a capacity, as shown at w in Fig. 12, in order to connect the coherer more effectively and closely to the capacity areas or receiving arrangement whereby it is to be stimulated.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system and constituting such a system a radiator of definite frequency or pitch.

2. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system, thus constituting the system a resonator or absorber of definite frequency or pitch, and a distant radiator of corresponding period capable of acting cumulatively.

3. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of electrical means having a spark-gap inserted between them and serving to syntonize them and means for bridging or shunting the spark-gap, whereby the apparatus is adaptable for use at will either as a radiator or resonator.

4. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a number of self-inductance coils having different amounts of self-induction each of which is capable of being switched in or out of circuit, serving to syntonize any such radiator to a corresponding resonator or vice versa, whereby signaling may be effected between any two or more correspondingly-attuned stations without disturbing other differently-attuned stations.

5. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a variably-acting self-inductance coil, serving to syntonize such a radiator or resonator to any other such resonator or radiator, whereby signaling may be effected between any two or more correspondingly-attuned stations without disturbing other differently-attuned stations.

6. In combination, a pair of capacity areas connected by a coil of wire serving as the radiator in a system of Hertzian-wave telegraphy, means for syntonizing such radiator, and means for charging it by aerial disruption or impulsive rush.

7. In a system of Hertzian-wave telegraphy, the combination of a pair of capacity areas such as h, h', means for syntonizing such capacity areas, a receiving-circuit completed through one or both of such capacity areas, and means for bridging over the discharge-gap between such capacity areas when they are to be used as a receiver, whereby such capacity areas are rendered adaptable for use at will either as a radiator or resonator.

8. In combination, in a system of syntonic Hertzian-wave telegraphy, a pair of capacity areas, a self-inductance coil and a secondary

coil surrounding said self-inductance coil, which secondary coil forms part of the coherer-circuit substantially as and for the purpose set forth.

9. The combination, in the receiving-circuit of a system of Hertzian-wave telegraphy, of a variably-acting self-inductance coil, connecting the capacity areas, a coherer, a battery, a receiving instrument, and a shunt across the coils thereof substantially as and for the purpose set forth.

In testimony whereof I have hereunto subscribed my name.

OLIVER JOSEPH LODGE.

Witnesses:
A. F. SPOONER,
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