N° 13,678 A.D. 1905

Date of Application, 3rd July, 1905—Accepted, 12th Oct., 1905

COMPLETE SPECIFICATION.

"Improvements in Signalling by Electro-magnetic Waves"

I, REGINALD AUBREY FESSENDEN, of 1737 Riggs Place, City of Washington, District of Columbia, United States of America, Electrical Engineer do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention described herein relates to certain improvements in the generation, transmission and receipt of energy by electro-magnetic waves, but especially to controlling the generation or transmission of such electro-magnetic waves or both, by other waves or impulses such as sound waves. The invention is hereinafter more fully described with reference to the accompanying drawings in which Fig. 1 is a diagrammatic view illustrating a combination of parts or elements for the generation, transmission and wave control of electro-magnetic waves; Fig. 2 is a similar view illustrating certain modifications; Fig. 3 is a view partly in side elevation and partly in section illustrating a construction of high frequency generator; Figs. 4 and 5 are end views thereof Fig. 6 illustrates a manner of controlling the generation and transmission of electro-magnetic waves at a central sending station from a distant point as a private telephone; Fig. 7 is a plan view partly broken away of the controlling condenser shown in Fig. 6; Fig. 8 shows front and sectional elevations of the spark gap mechanism employed in Fig. 1; Fig. 9 shows similar views illustrating the spark gap mechanism controlled by an ordinary wire telephone; and Figs; 10 and 11 are diagrammatic views of receiving apparatus.

In Fig. 1 is shown means for the generation of electro-magnetic waves substantially similar to that shown in Fig. 10 of the Specification to British Patent No. 17705 of 1902, the continuous current dynamos 3 (one, two or more in number) being driven by a suitable motor 17. When two or more generators are employed, they are arranged in series as shown and have their terminals connected to the sending conductor and to ground. Suitable means such as a rheostat 7 are employed for regulating the current from the generators. A circuit including an inductance 8 and a capacity 9 is arranged in operative relation to the sending conductor and spark gap (which is grounded) for the purpose of maintaining sustained oscillations of practically constant frequency. One of the terminals 11 of the spark gap is attached to a diaphragm 10 which for telephoning would form the diaphragm of a transmitter; this terminal being electrically connected with the conductor 1. The other terminal of the spark gap is formed by a disc 12 on the shaft of a suitable motor 4 adapted to impart a high peripheral speed which may be as high as twenty miles per minute, to the disc, and so arranged that the sparking terminal 11 is eccentric to the axis of the disc, The terminals of the spark gap may be formed of any suitable material as platinum iridium aluminum or carbon. One of the terminals as 11 is connected to the sending conductor and the other to ground through a brush 13 bearing on the disc or its shaft. The circuit containing the condenser 9 inductance 8, spark gap, brush 13 and leads 14 and 15, is preferably tuned to the period of the sending conductor. As the sparking

[*Price 8d.*]

terminal 11 moves with the diaphragm 10 the vibration of the latter, when acted on by impulses such as sound waves, will vary the length of the spark gap and the discharge potential will be responsive to the pressure on the diaphragm. With the regulator 7 in a given position, the number of discharges per second will depend upon the proximity of the discharge terminals and this will also influence the potential at which the condenser 9 is discharged, since the potential will depend upon the length of the spark gap. If the circuit containing the inductance 8 and capacity 9 is tuned to the sending conductor and the regulator 7 is adjusted to cause the number of discharges per second to be the same as the natural periodicity of the sending conductor, the number of discharges per second and hence the resonance will be altered by the vibration of the diaphragm 10. On the vibration of the diaphragm which will respond to impulses such as sound waves the radiation from the sending conductor will vary in response to the sound waves and the radiated electro-magnetic waves will re-produce such vibrations in a suitable receiving apparatus such for example as that shown in Fig. 11.

The inductance 8 and capacity 9 may be omitted and the number of discharges per second be made as many as desired by means of the regulator 7, only the capacity and inductance of the sending conductor being used.

In the construction shown in Fig. 2, I employ any suitable high frequency dynamo 18 such as, for example is shown in Figs. 3, 4 and 5. It is preferred to employ a transformer 19 in connection with such a generator in order to raise the voltage. A double spark gap is employed one of the terminals such as 25, being connected with the transformer and the sending conductor the latter connection being formed if desired by switch 24. The other outer terminal 23 is connected to ground and to the other terminal of the transformer. The intermediate terminal 21 which is electrically connected with the sending conductor, is attached to a diaphragm 22 as for example the diaphragm of a telephonic transmitter. On exciting the transformer, a discharge may be caused to pass from the terminal 25 to the terminal 21 and thence to terminal 23. The potential across the terminals 25 and 23 may be made to have any desired value by regulating the potential of the transformer 19 or the current flowing in the field circuit containing battery 26, and adjusting the resistance 28. If the switch 24 be left open, the potential of the intermediate terminal 21 and therefore that of the upper portion of the sending conductor, will vary with the position of the terminal 21 and on the vibration of the diaphragm, caused for example by sound waves, the intensity of the radiation from the sending conductor will be caused to vary in a manner corresponding to the sound waves.

In order to overcome a scratching sometimes found in the telephone receiver of the receiving circuit and probably caused by irregularities in the spark discharge, the terminals in the spark gap in the form of apparatus shown in Figs. 1 and 2 should be suitably adjusted. Such adjustment includes the selection of proper material for the terminals and also regulating the size and shape of the terminals and is mainly determined by experiment to suit particular cases depending upon the distance between the sending and receiving stations and other conditions. Aluminum, iridium, platinum and carbon have been found to be suitable materials for the terminals of the spark gap.

The apparatus may be used for the transmission of signals such as words, by closing the switch 24 and adjusting the terminals of the spark gap so that little or no discharge passes between terminals 25 and 21 but mainly between terminals 21 and 23. This arrangement gives good results as the radiation from the sending conductor will vary as the gap between the terminals 21 and 23 varies with the movement produced in the diaphragm by the sound waves. The resistance 28 may be so constructed as to form a flexible support for the terminal 25, and capacity and inductance may be arranged across the spark gap in the same manner as shown in Fig. 1 if desired.

The adjustment of the spark gap is determined by trial, the parts being adjusted until sound is heard at the receiving end with the greatest distinctness and loudness.

A third method of using the apparatus shown in Fig. 2 is to employ a telephone transmitter 27 which may be at a distance from the transmitting station as a resistance for regulating the field of the generator, which is preferably of small inductance. In such case the terminals 21 and 25 are brought into contact and the switch 24 is opened. On speaking into the transmitter 27 the excitation of the field of the generator will vary producing a change in the intensity of the discharge between 21 and 23 and of the electro-magnetic waves emitted, corresponding to the sound waves impinging on the diaphragm of the transmitter 27.

A fourth method of using the apparatus is to employ a dynamo capable of producing directly in the sending conductor the desired wave frequency as for example a dynamo having frequencies up to 300,000 per second, and capable of generating several horse power. In such case the terminals of the spark gap are so separated that no discharge will pass and the switch 24 is closed. Inductances and capacities may be used in the primary or sending circuit of the transformer 19 as shown. On speaking into the transmitter 27 the field of the dynamo will be varied and the intensity of the radiation from the sending conductor will vary to correspond with the tones of the voice. The advantages of this method are pointed out in the Specification to Patent No. 17706 of 1902.

Several phenomena have been noticed in connection with these methods of wireless telephony which are of interest. One is that under certain conditions not yet fully understood the pitch of the transmitted speech may be raised, sometimes one octave and sometimes two octaves. This only occurs however with certain methods or with certain adjustments and may in most cases be obviated by altering the adjustments. It does not however in any case seriously affect the distinctness of the speech.

A second point of interest is the extreme clearness and sharpness with which the speech is transmitted, the sound appearing at the receiving end as if it did not come from a telephone but from a person speaking in the room very sharply and clearly. This statement does not however apply to the case where a telephone transmitter is used for varying the field excitation as here the sound seems more like that of an ordinary telephone.

One cause of this extraordinary clearness of articulation is found in the fact that the capacity effect which is so prejudicial to good speech is absent in the transmission of electro-magnetic waves and the higher harmonics of the voice are transmitted without distortion.

It is found that clearness of the speech varies very considerably with the frequency of the discharges. With the apparatus described in Patent No. 17706 of 1902, the number of discharges was ten thousand per second. With the apparatus herein described with reference to Figs. 1 and 2 a frequency of twenty thousand was generally used with a marked improvement and there would appear to be some improvement up to as high as forty thousand discharges per second.

The fact may also be noted that sound may be transmitted from a very long distance with a comparatively low potential, even the potential used in an ordinary electric lamp being sufficient for commercial work. In practice, however, in many cases, it is preferable to use higher voltage, as for example fifty thousand volts. The reason why lower voltages may be used than those commonly used in wireless telegraphy is readily seen when it is pointed out that at a frequency of ten thousand per second, corresponding to twenty thousand discharges per second, a sending conductor of ordinary height and capacity will radiate half a horse power. Experiments have shown that twenty-five miles may be considered a minimum distance to which speech may be transmitted with this energy and voltage, and that there is every reason to believe the

distance really may be measured in hundreds of miles, with of course still larger distances with more horse power and higher potentials.

This fact that it is possible to use low potentials is of considerable value inasmuch as it renders the control of comparatively large amounts of sound waves very simple and easy, while to control a spark discharge such as is used for ordinary wireless telegraphy would be very difficult.

This ability to get speech over long distances is a peculiarity of the receivers described in the Specifications to Patents Nos. 17705 of 1902, 17706 of 1903 26553 of 1902, 28291 of 1903, and elsewhere, *i.e.* current operated, cumulatively acting receivers. In fact it is hardly conceivable that wireless telephony should be possible without the use of receivers of this type as these receivers differ from the imperfect type in that they conserve and store up the energy of a train of discharges and produce an indication proportional to the amount of energy in the train of discharges and not an unproportional indication dependent on the wave of maximum intensity which occurs in the train.

In Figs 3 and 4 is shown a construction of high frequency dynamo suitable for use in the apparatus shown in Fig. 2, the multipolar field being indicated at 30 and the armature at 31. On the shaft 32 of the armature is secured a disc 33 having a series of terminals 34 mounted thereon. These terminals, of which there are double the number that there are of armature segments or pairs of poles, are moved by the rotation of the disc past a terminal 35 carried by a diaphragm as in Figs. 1 2 and 8 or by a suitable fixed support as shown in Fig. 3. As there are twice as many terminals in the disc as there are segments in the armature, there will be two discharges for each alternation. By the employment of additional terminals 36 and having in the disc a number of terminals 34 which shall be some multiple or sub-multiple of the number of armature segments, the apparatus may be arranged to operate as a selector. The field 30 may be caused to rotate in a direction opposite that of the rotation of the armature.

Figs. 6 and 7 show a modification of the method and apparatus illustrated in Fig 2 of Patent No. 17706 of 1902. The sending conductor 1 is grounded at 39 through a condenser formed by a metal diaphragm 38 and an adjustable metal disc 40, said parts being arranged in a tank or shell 45 containing gas under pressure and forming a condenser such as described in a separate application for Letters Patent of even date herewith. Suitable means are employed for generating electro-magnetic waves consisting of a source 44 of high frequency voltage and a spark gap 41 with a capacity 42 and an inductance 43 in shunt around the spark gap. In practice the sending conductor including the capacity formed by 38 and 40 is tuned to the resonant circuit 42, 43, preferably when the diaphragm 38 is in the normal position. This forms the armature of the electro-magnet 48 which is controlled by the telephone transmitter 51 by means of the battery 50 and induction coil 49.

The condenser formed by the parts 38 and 40 may be situated at any suitable place as at a transmitting station outside a city and the transmitter 51 may be the transmitter of any local telephone in the city. When the transmitter 51 is spoken into the diaphragm 38 will be vibrated in correspondence with the sound waves and by reason of its movement relative to the disc 40 will vary the intensity of the radiation from the sending conductor in correspondence with the sound waves, and the varying radiations acting on the apparatus at the receiving station will cause a reproduction of the words spoken at the sending station. By this combination of ordinary and wireless telephony communication between telephones now in use in widely separated places can be readily effected.

In Fig. 9 is shown means for operating the discharge controlling diaphragm of Figs. 1 and 2 at a transmitting station, by a local telephone transmitter. As therein shown the diaphragm 10 is vibrated by the electro-magnet 52 which as in Fig. 6 is controlled by a local telephone transmitter through a battery and telephone induction coil.

In Figs 10 and 11 are shown diagrammatically suitable forms of receiving apparatus, 53 being the receiving conductor in operative relation to a receiving circuit including a current operated cumulatively acting receiver 54, a capacity 55. A local circuit the current in which is controlled by the receiver 54, includes a telephone 58, which may be at a distance from the receiving conductor 53, and a source of electric potential derived from the battery 57 and regulated by the potentiometer 56.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In a system for transmitting signals wirelessly in which the electro-magnetic waves are generated practically continuously the method of transmitting speech by causing sound waves to cause variation of the potential of the oscillations which are utilised to produce the electromagnetic waves, substantially as described.

2. The herein described method of signalling by electromagnetic waves which consists in producing the radiation of such waves by a high frequency generator and changing or modifying such radiations by varying the field of the generator by a telephonic transmitter in the field circuit, substantially as described.

3. In the system of wireless transmission of signals of the preceding claims, the method of utilising a transmitter in a local circuit at a distance from the wireless station to cause variation in the intensity of the electromagnetic waves transmitted from the said station, and the waves received at the receiving station to cause variations in the intensity of the currents flowing in a receiver in a local circuit at a distance from the receiving station, substantially as described.

4. In apparatus for signalling by electro-magnetic waves, a spark gap having one terminal mounted to move in unison with a diaphragm which is responsive to sound waves or impulses.

5. Apparatus for signalling by electro-magnetic waves comprising in combination a sending conductor, a high frequency generator in operative relation therewith, and means for varying the field of the generator.

6. In the apparatus claimed in the preceding claim, varying the field of the generator by means of an apparatus of the character of a telephonic transmitter, substantially as described.

7. Apparatus for signalling by electro-magnetic waves, comprising means for the practically continuous generation of electro-magnetic waves or impulses at a transmitting station and means at a local station for modifying or changing the character of such waves or impulses without interruption of their continuity, substantially as described.

8. In the apparatus claimed in the preceding claim, means for modifying or changing the character of the electro-magnetic waves or impulses consisting of the equivalent of a telephonic transmitter at the local station and the equivalent of a telephonic receiver in operative relation therewith at the transmitting station, the movements of the diaphragm of the said receiver being arranged to vary the spark gap, or to vary the capacity of a condenser in operative relation with the spark gap or with the sending conductor or with both, substantially as described.

9. Apparatus for the production of electro-magnetic waves comprising a high frequency generator and a series of sparking terminals rotating synchronously with the generator armature and equal in number to a multiple or sub-multiple of the armature sections, the said terminals being presented in succession to another terminal or terminals and within sparking distance thereof, substantially as described.

Dated this 3rd day of July 1905.

ABEL & IMRAY,
Agents for the Applicant.

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Fig. 1.

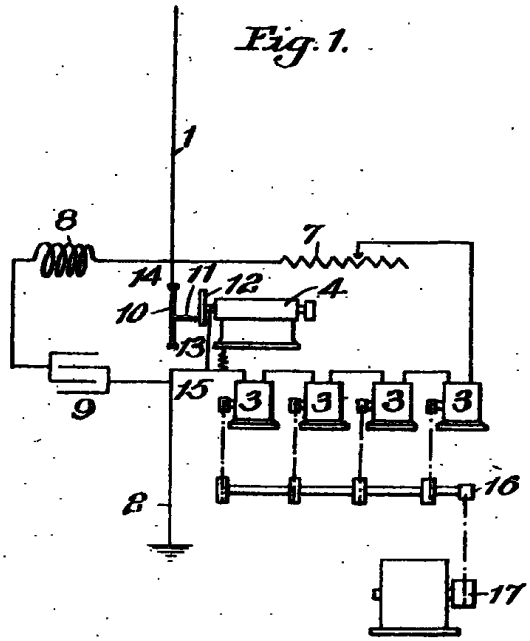

Fig. 2.

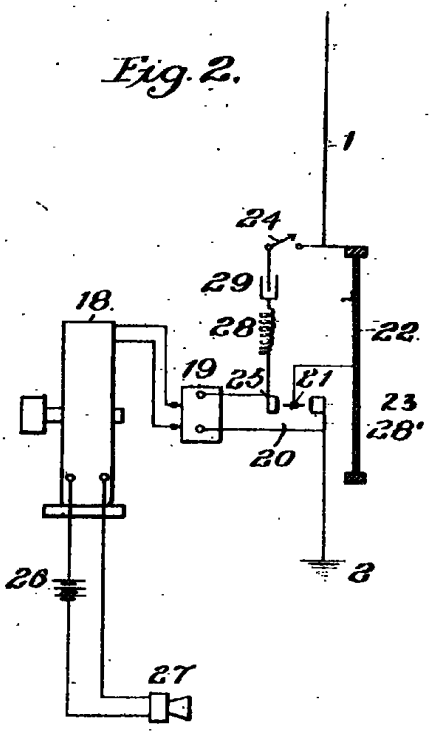

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Fig. 3.

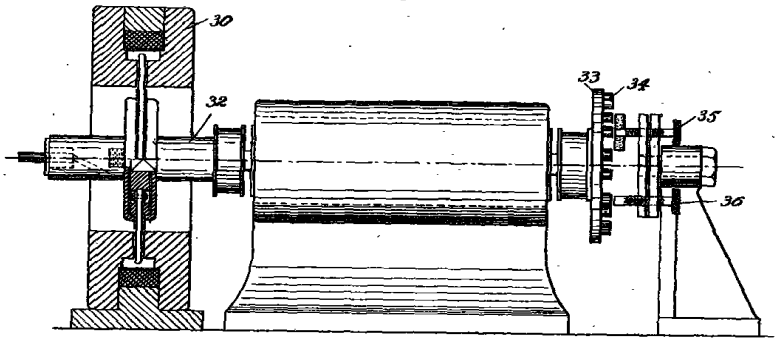


Fig. 4.

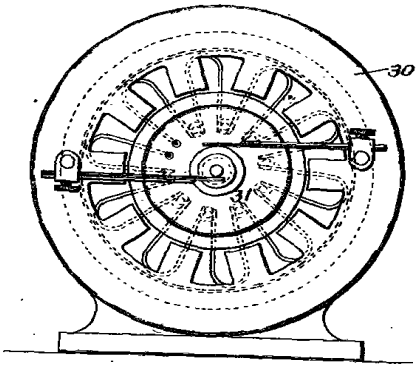
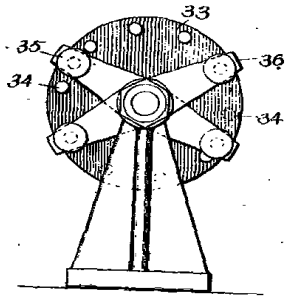


Fig. 5.



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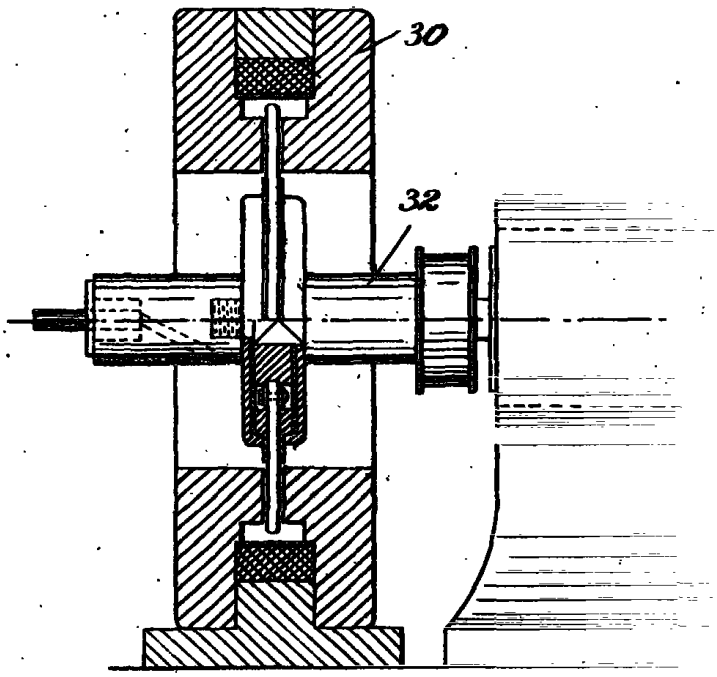
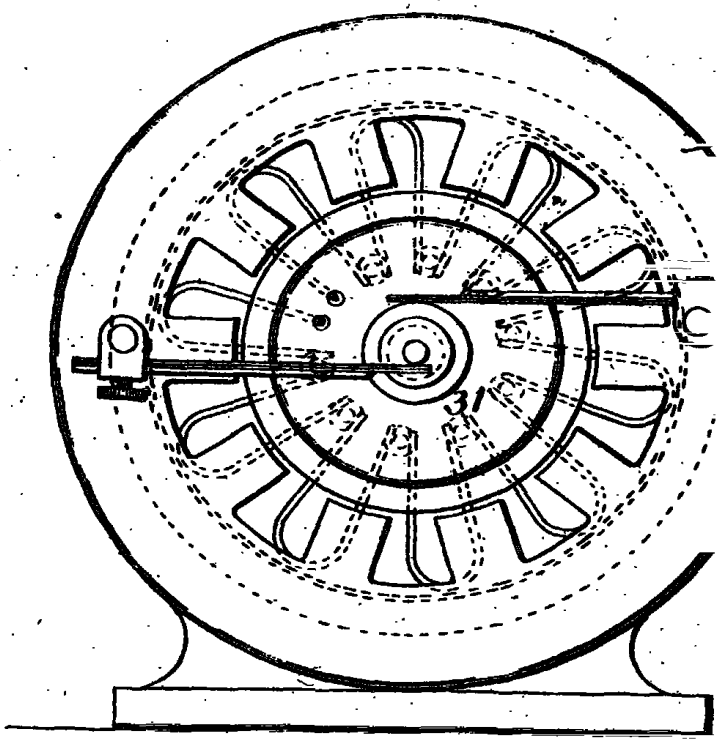


Fig. 4.



SHEET 2.

Fig. 3.

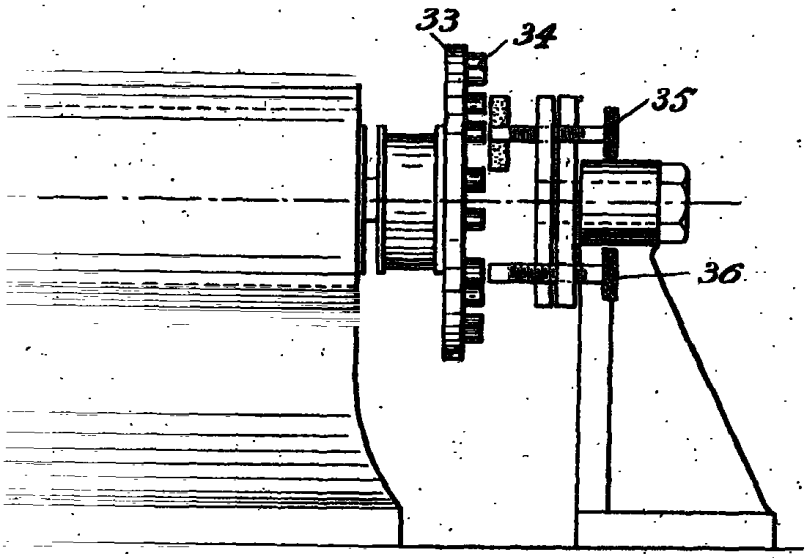


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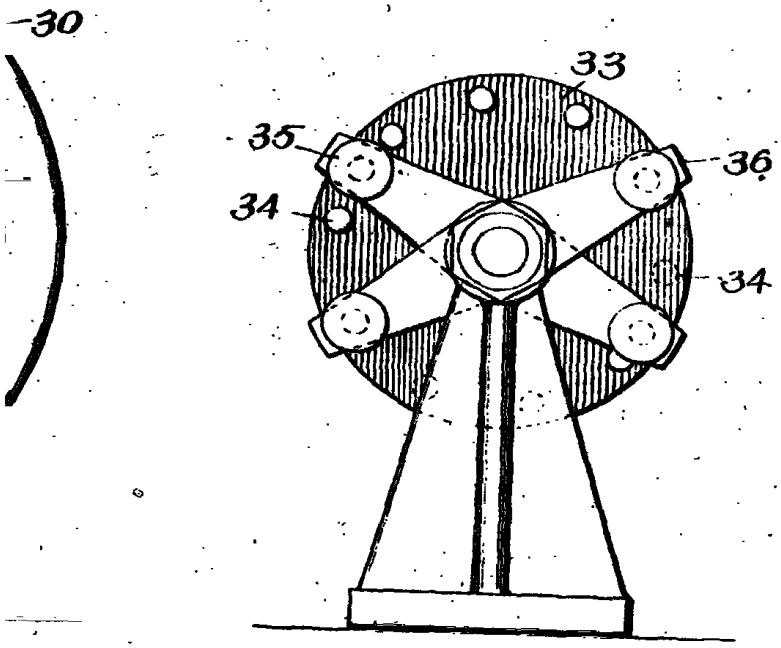
Fig. 5.



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[8 SHEETS]

SHEET 4

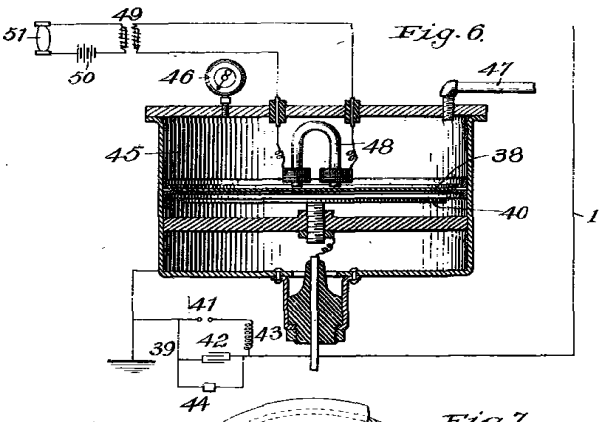

Fig. 6.

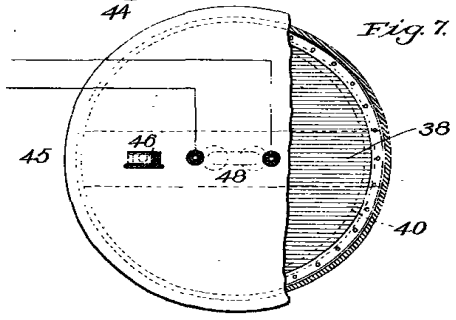

Fig. 7.

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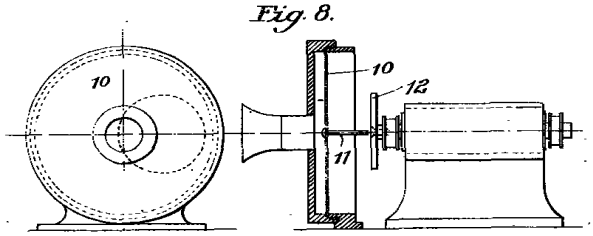

Fig. 8.

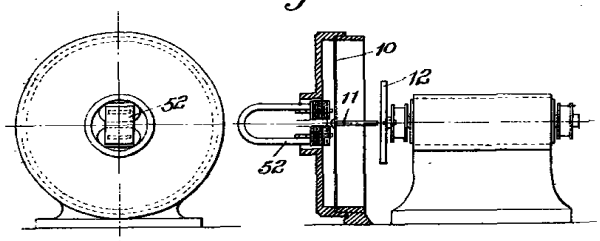

Fig. 9.

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Fig. 6.

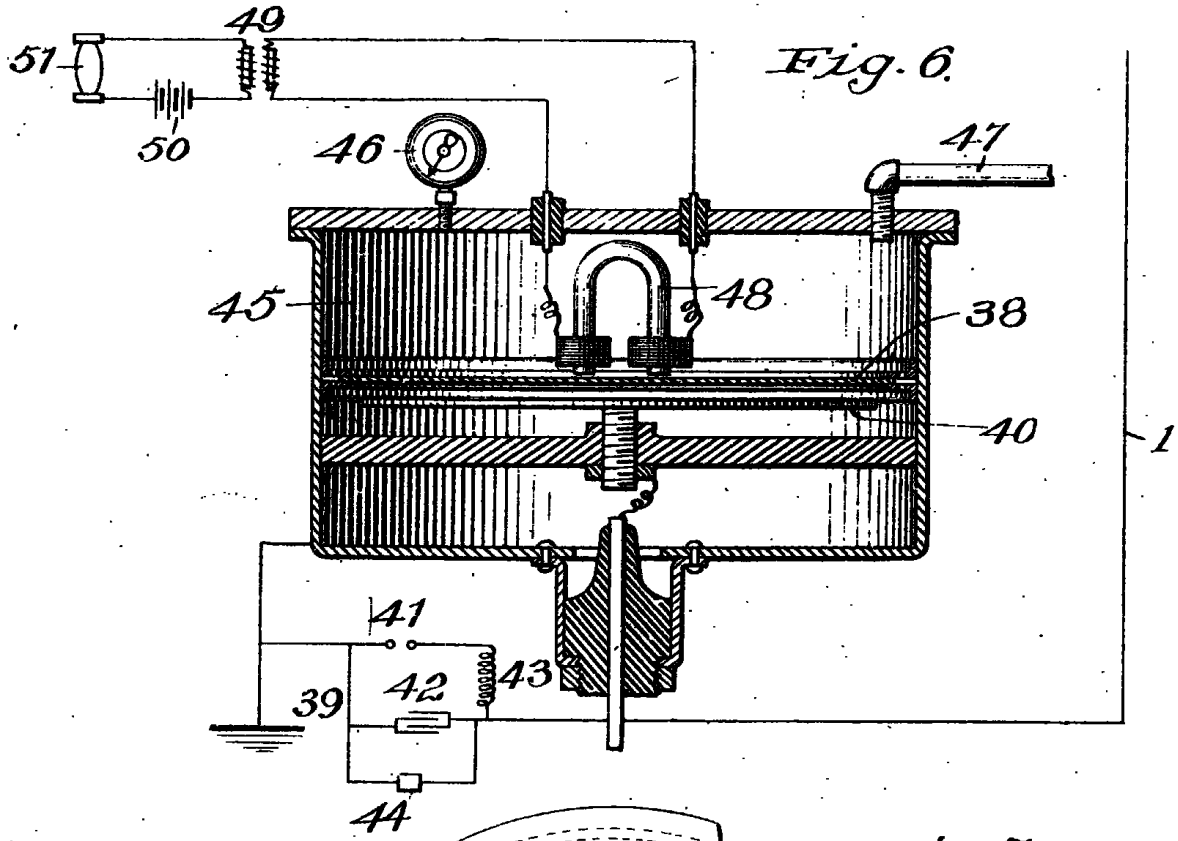

Fig. 7.

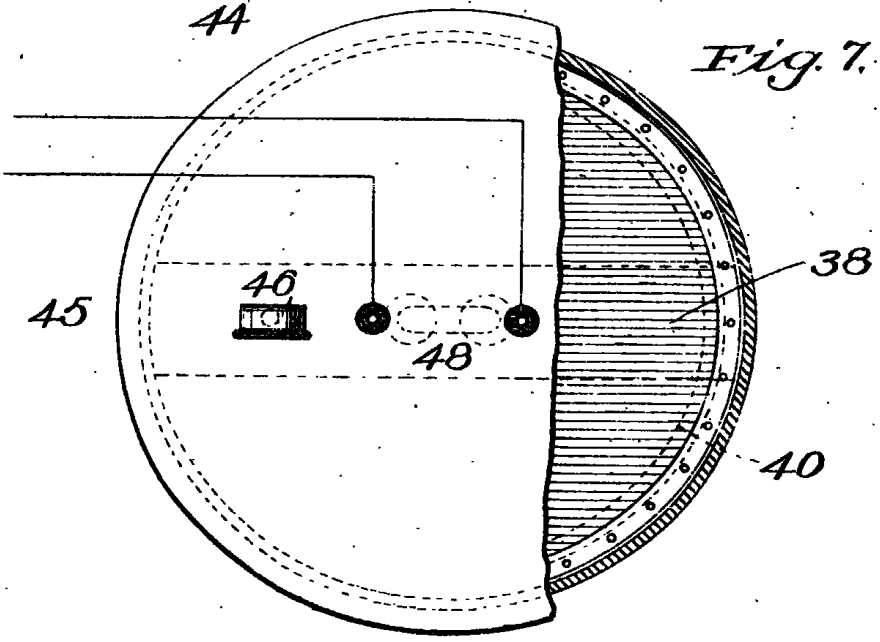

Fig. 8.

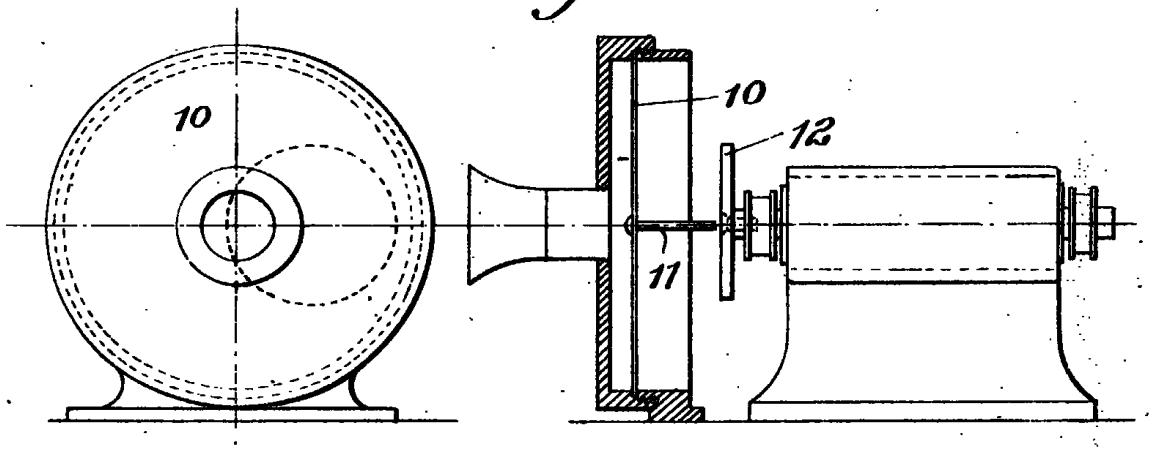

Fig. 9.

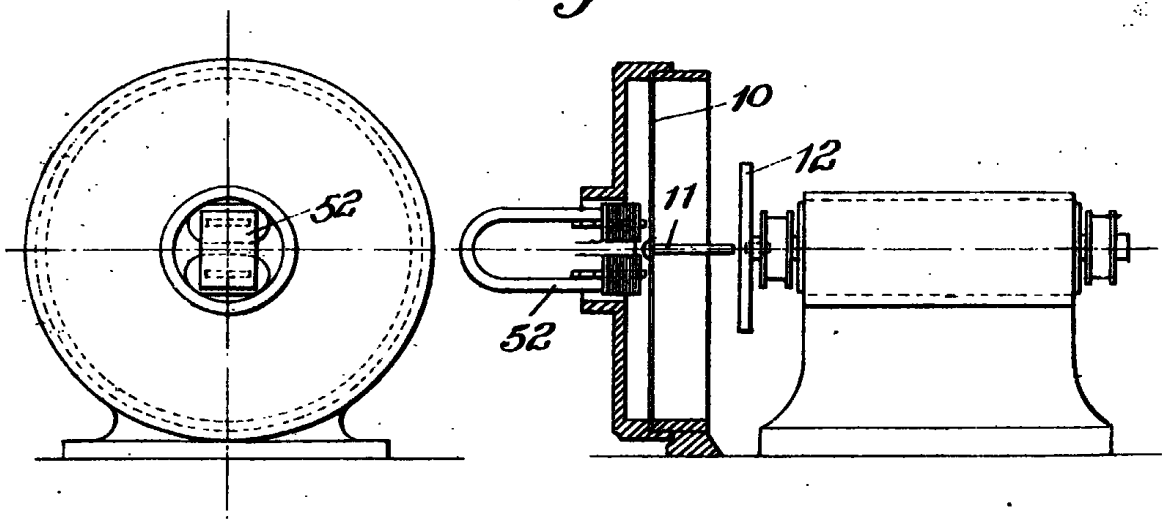

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Fig. 10.

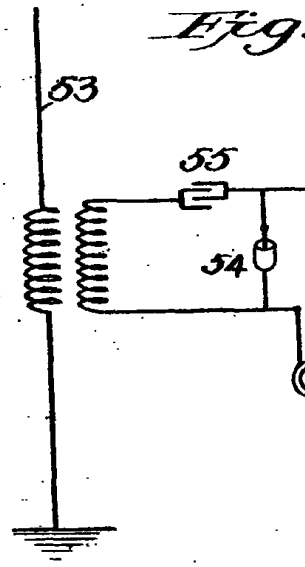
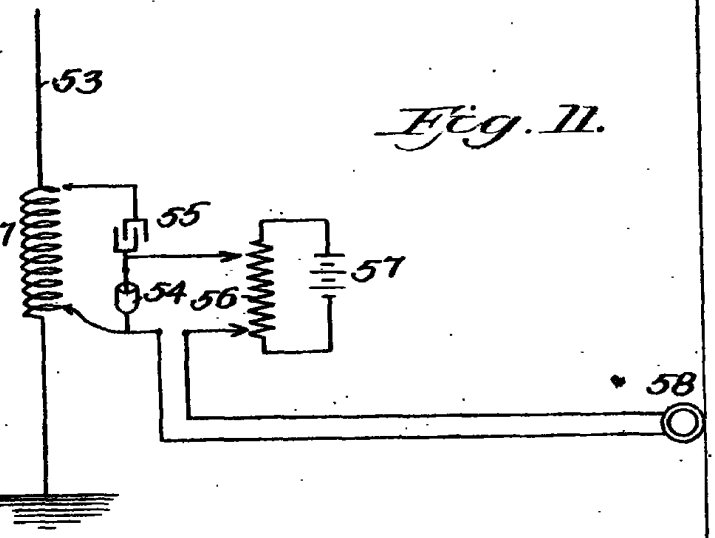


Fig. 11.



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