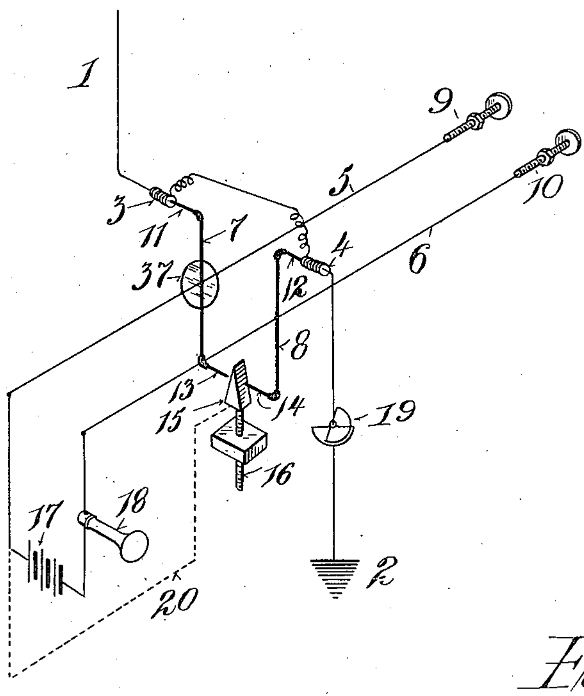
R. A. FESSENDEN.

ELECTRICAL APPARATUS.

APPLICATION FILED APR. 18, 1906.

962,017. Patented June 21, 1910.

Fig. 1.



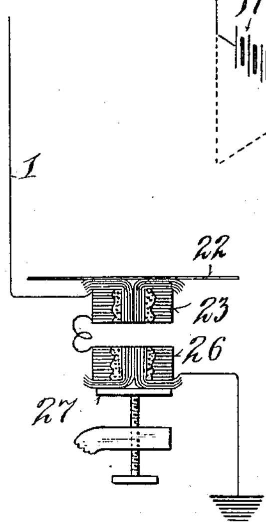
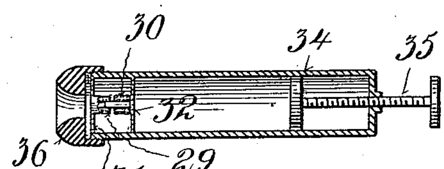


Fig. 2.

Fig. 3.



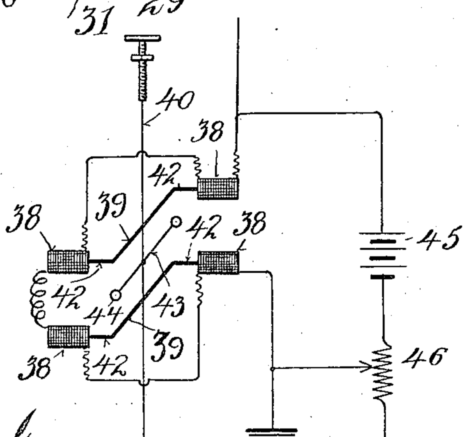


Fig. 4.

Witnesses
C. M. Benjamin
[illegible]

Inventor
Reginald A. Fessenden
By his Attorney Darwin S. Wolcott

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF BRANT ROCK, MASSACHUSETTS.

ELECTRICAL APPARATUS.

962,017. Specification of Letters Patent. Patented June 21, 1910.

Application filed April 18, 1906. Serial No. 312,520.

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 Improvements in Electrical Apparatus, of which the following is a specification.

The invention comprises certain improvements in current-operated devices, which are especially adapted for use in connection with currents of high frequency such as are employed in the transmission of energy by electro-magnetic waves.

The invention is hereinafter more fully described and claimed.

In the accompanying drawings, forming a part of this specification, Figure 1 is a diagrammatic view illustrative of a form of my invention; and Figs. 2, 3 and 4 are similar views illustrating other embodiments of the improvement.

Many electrical-indicating instruments were wound with coarse wire and formed of coils of large diameter, such, for example, as the tangent galvanometer. Later, Lord Kelvin and others constructed instruments having greatly increased sensibility by winding the coils of much finer wire and using a larger number of turns. The Thomson galvanometer was an example of such improved instrument. The limit was, however, reached in this direction, on account of the high resistance of the wire and the fact that increasing the number of turns brought the outside turns so far away from the core or axis that they produced no good effect.

I have found it possible by making a radical change in the construction of current-operated instruments to obtain a very large increase in sensibility. This change involves abandoning the large diameter of the coil used by Kelvin and others, by constructing my coils of what might be called microscopic and microbaric dimensions, since as a rule they are best wound under a microscope. As illustrating the radical change effected by my improvement, the coil of a Thomson galvanometer is usually about four inches in diameter and one inch in thickness, whereas a suitable size of coil for what I call my micro instrument is about four one-hundredths of an inch in diameter and one one-hundredth of an inch in thickness. The relative volumes of the coils are in the ratio of one to one million. These coils not only furnish very suitable instruments for ordinary uses, but are especially and peculiarly adapted to signaling by electro-magnetic waves, for the reason that these microscopic coils concentrate the magnetic effects to such a great degree that the opposition to the current due to self-induction is considerably greater than the opposition to the current due to ohmic resistance, and hence the coils act very efficiently and are capable of sharp tuning.

As an illustration of the enormous advantages to be gained by the use of coils of these microscopic dimensions, it may be stated that it is possible to obtain an intensity of magnetism greater than can be obtained by any permanent magnet. Moreover, on account of the small dimensions of the coils, a current much larger than that which large coils will carry proportionately can be used without undue heating.

The effectiveness of the microscopic coils can be still further increased by inserting extremely fine laminated iron wire cores in these coils, the laminated iron wire being preferably about one one-thousandth of an inch in diameter, or such that ten of them twisted together will form the thickness of a human hair.

An additional advantage is obtained where the coil itself forms one of the moving members of a current-operated device. If such a microbaric coil be attracted by another similar coil, it is found that the amount of movement taking place in a given time decreases with a very high power of the diameter of the wire used, and that by halving the size of the wire the movement taking place in a given time may be increased more than one hundred times.

In the construction shown in Fig. 1, the aerial indicated at 1 is grounded at 2. Micro coils 3 and 4, preferably supported so as to be adjustable, are operatively connected to the aerial. Fine wires or fibers 5 and 6, preferably formed of phosphor-bronze, are arranged in such relation to the coils 3 and 4 as to support the needles 7 and 8 in operative relation to the coils as hereinafter described. The wires 5 and 6 are placed under suitable tension as hereinafter described, by means of screws 9 and 10. The needles 7 and 8, which are preferably formed of aluminum, are secured, as shown, to the wires 5 and 6 and are provided at one end with small cores 11 and 12 formed of soft iron or nickel-wire, and preferably consisting of about fifty pieces of wire each of about one one-thousandth of an inch in diameter. The coils 3 and 4 are preferably wound with wire one one-thousandth of an inch in diameter so as to have about fifty turns each, and the coils to have a diameter of about four one-hundredths of an inch. These wires, which may be copper, silver, or other suitable metal, are covered with insulation such as a thin coating of shellac, lacquer, or cellulose. At their opposite ends the needles 7 and 8 are preferably provided with fine platinum iridium contacts 13 and 14, between which is arranged a wedge 15, preferably of similar material and adapted to be adjusted by a screw 16. A local circuit is formed by the battery 17 and indicating mechanism 18, the wires 5 and 6, needles 7 and 8, and wedge or contact 15.

In the operation of this apparatus, the the screws 9 and 10 are turned until the natural periods of vibration of the needles 7 and 8 carried by said wires are equal, and preferably equal to the group-frequency of the signals which it is desired to receive. The contact piece 15 is then adjusted so as nearly to make contact with the points 13 and 14 carried by the needles. The coils 3 and 4 are adjusted to such position as to produce a maximum effect on both the movable cores 11 and 12. A fixed core may also be used for increasing the sensitiveness of the device as arranged in Fig. 2. The receiver, consisting of the micro-coils 3 and 4, may be tuned in any of the usual ways practiced in the art, as, for example, by a variable condenser 19.

Should any mechanical vibration disturb the receiver, both needles 7 and 8 will move in the same direction, and hence only one of them will make contact with the wedge 15, and the local circuit will not be closed. When, however, waves strike the aerial 1, the currents produced in the micro-coils 3 and 4 will attract the movable cores 11 and 12, causing both contacts 13 and 14 to bear against the wedge 15 and so close the local circuit containing the indicating mechanism 17.

When desired, any suitable arrangement of the contacts and circuits may be used, such, for example, as that indicated in Fig. 1a at 20.

As indicated at 37 in Fig. 1, a mirror may be employed for indicating signals in lieu of the local circuit, such mirror being attached to one or the other of the needles 7 and 8.

In Fig. 2, my improvement is shown applied to a telephone indicating mechanism. A micro-coil 23, as shown in section and preferably made as above described, is secured to the telephone diaphragm 22 and is connected to the aerial 1. Another micro-coil 26 is secured to a mount 27 and is connected to the coil 23, and also to ground, as shown. The mount 27 is adjusted by means of a screw or other suitable means so as to bring the coils 23 and 26 in the most effective relation to each other. When the current is generated by the action of electromagnetic waves of the aerial, the coils 23 and 26 will attract each other, causing the diaphragm to move, thereby producing a sound.

In the construction shown in Fig. 3 for similar purposes, the coils 29 and 30 are secured to diaphragms 31 and 32, (the diaphragm 32 being similar to a telephone diaphragm, while the other diaphragm is made sufficiently heavy to prevent movement of the coil attached thereto) arranged in a resonator-tube 34, said tube being provided with a piston adjustable by a screw 35, so as to produce resonance to any desired group-frequency. In this construction, the removable core is omitted and the fixed coil, which may have a fixed core, preferably projecting into the movable coil, acts on the movable coil, which is preferably smaller than the fixed coil. The tube is provided with a phonographic ear-piece 36, which may be inserted in the ear as is customary in using these devices, and loss of sound thereby prevented. As shown in Fig. 4, a plurality of micro-coils 38 may be used, said coils being arranged in pairs. In the construction, the needles 39 are secured to a common wire 40, which is placed under tension, as in the construction shown in Fig. 1, and are provided at their ends with cores 42 arranged in operative relation to the coils. As an indicating device, I employ a minute capillary glass tube 43 secured to the wire 40, said tube being provided at its end with small pieces of mirror 44. Such an arrangement of mirrors, if given sufficient illumination, is capable of resolving to the same extent as a large mirror. The effect of any lack of parallelism in the small mirrors is removed by any of the well-known arrangements of prisms or mirrors. A local circuit adjustable in strength may be used in conjunction with this form of current-responsive device and gives greater ease of adjustment and sensibility. Such local circuit is shown in Fig. 4, where 45 is a local source of current and 46 adjustable resistance.

It is characteristic of my invention that I employ a microbaric coil, *i. e.* a coil of small wire so wound as to produce a relatively high magnetic concentration for a given current, a given length of wire, and a given mass, as compared with coils ordinarily used for electrical instruments. That is, in my claims the terms "microbaric coil", "large coefficient of induction per unit mass", and "high intensity of magnetic induction per unit mass and unit of current", mean these quantities are of high order of magnitude compared with coils now in use, as in U. S. Patents 711,445 of Oct. 14th, 1902 and 711,184 (see p. 3, line 104).

I claim herein as my invention:

1. Electrically actuated means for producing an indication comprising a coil having a large co-efficient of magnetic induction per unit of mass *i. e.*, a ratio of self inductance to mass of more than one hundred thousand.

2. Electrically actuated means for producing an indication comprising a coil of such small dimensions as to give the coil a ratio of magnetic induction per unit of mass of the order of 100,000.

3. Electrically actuated means for producing an indication, comprising a coil having a high magnetic concentration and a co-efficient of magnetic inductance per unit of mass greater than 100,000.

4. Electrically actuated means for producing an indication comprising a movable indicating member and a coil in operative relation to said movable member, having high co-efficient of magnetic inductance per unit of mass *i. e.*, a ratio of self inductance to mass of more than 100,000.

5. Electrically actuated means for producing an indication comprising a coil having a ratio of self-induction to mass, greater than 100,000, a movable element, controlling a local circuit, and means in the local circuit for producing an indication.

6. A receiver for electro-magnetic waves comprising two relatively movable elements, of which one is attached to a coil having a large co-efficient of magnetic induction per unit of mass of the order 100,000.

7. A receiver for electro-magnetic waves comprising a microbaric coil and a movable core therefor and indicating means operated by the motion of the core.

8. A receiver for wireless telegraphy comprising a solenoid of which the coil is of minute relative dimensions having high magnetic concentration per unit of mass and per turn so as to respond to signals, substantially as described.

9. A receiver for wireless signaling comprising several relatively movable members, an indicating device attached to one of said members, and one of said members including a microbaric coil of minute dimensions, of the order of magnitude of .001 of an inch for the wire, whereby high magnetic concentration sufficient to respond to electro-magnetic oscillations is obtained.

In testimony whereof, I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:

ROBT. S. KEARNEY,
DARWIN S. WOLCOTT.