R. A. FESSENDEN.

RECEIVER FOR ELECTROMAGNETIC WAVES.

APPLICATION FILED MAR. 22, 1905.

1,042,778.

Patented Oct. 29, 1912.

4 SHEETS—SHEET 1.

FIG. 1.

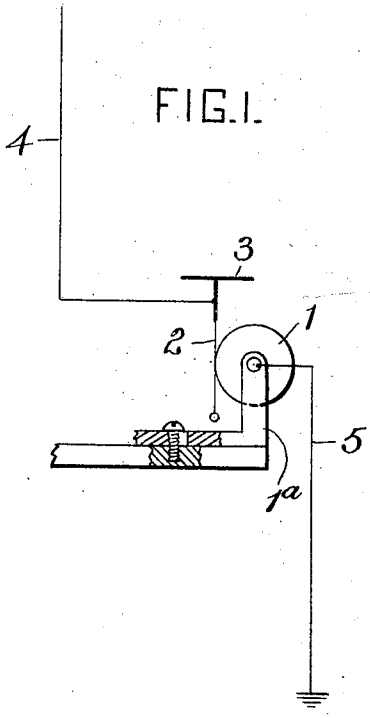


FIG. 2.

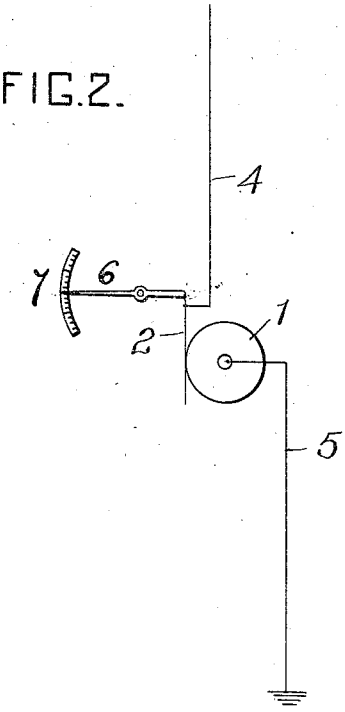


FIG. 3.

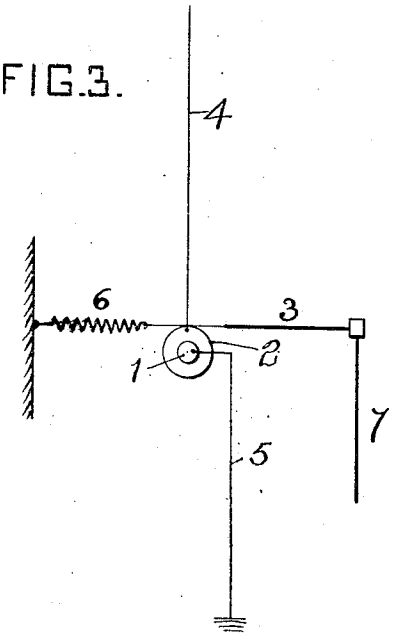
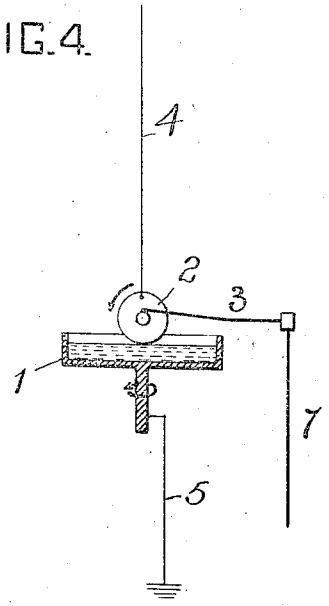


FIG. 4.



WITNESSES:
Herbert Bradley
Fred Kirchner

INVENTOR
Reginald A. Fessenden
by Dennis B. Wolcott Atty

R. A. FESSENDEN.

RECEIVER FOR ELECTROMAGNETIC WAVES.

APPLICATION FILED MAR. 22, 1905.

1,042,778.

Patented Oct. 29, 1912.

4 SHEETS—SHEET 2.

Fig. 5.

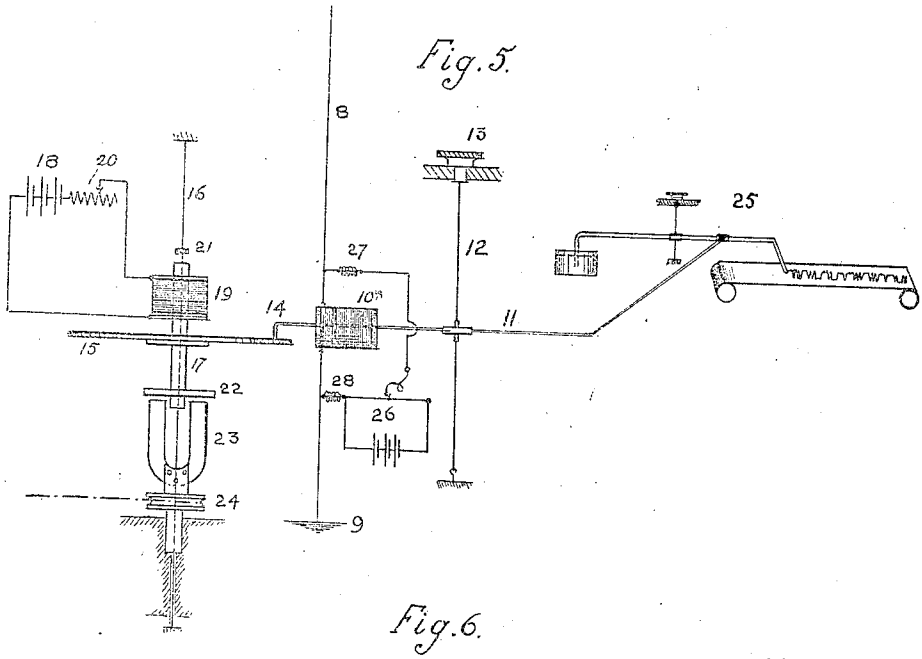


Fig. 6.

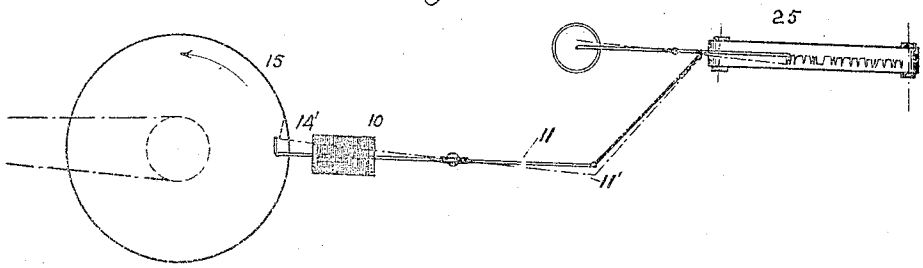
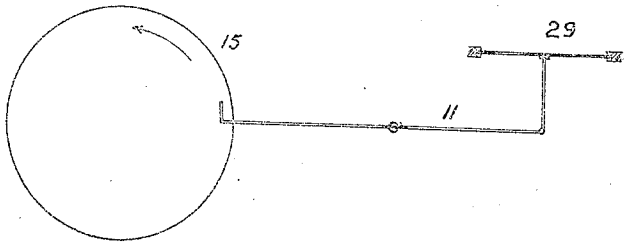


Fig. 7.



WITNESSES.

Cornelis van Rossum.

C. H. Walker.

INVENTOR.

Reginald A. Fessenden

by Dennis S. Wolcott

ATTORNEY.

R. A. FESSENDEN.

RECEIVER FOR ELECTROMAGNETIC WAVES.

APPLICATION FILED MAR. 22, 1905.

1,042,778.

Patented Oct. 29, 1912

4 SHEETS—SHEET 3.

Fig. 8.

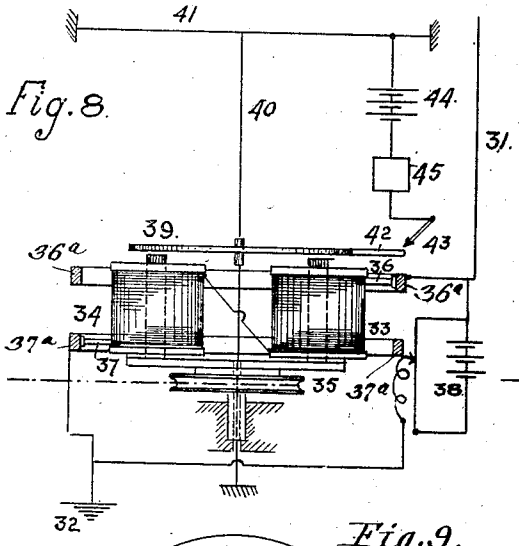


Fig. 10.

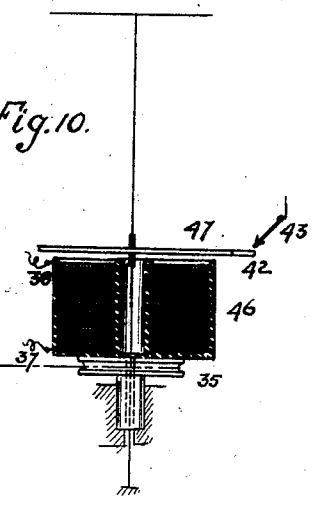


Fig. 9.

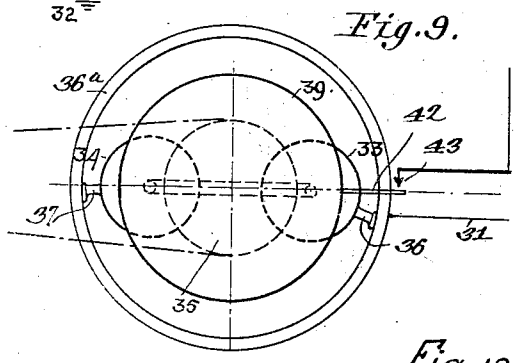


Fig. 11.

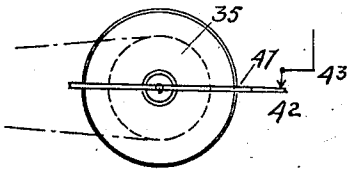
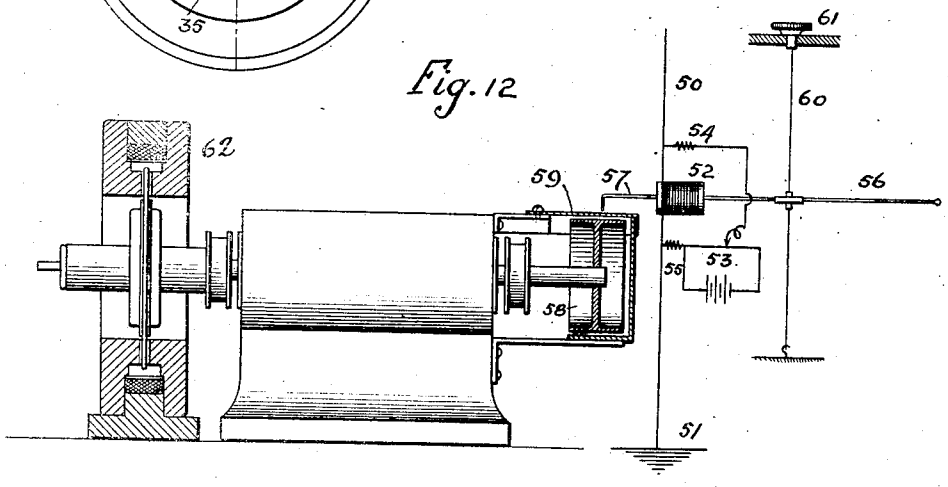


Fig. 12



WITNESSES.

Cornelis van Rennes

C. H. Walker

INVENTOR.

Reginald A. Fessenden

by Dennis S. Wolcott

ATTORNEY.

R. A. FESSENDEN.

RECEIVER FOR ELECTROMAGNETIC WAVES.

APPLICATION FILED MAR. 22, 1905.

1,042,778.

Patented Oct. 29, 1912

4 SHEETS—SHEET 4

Fig. 13.

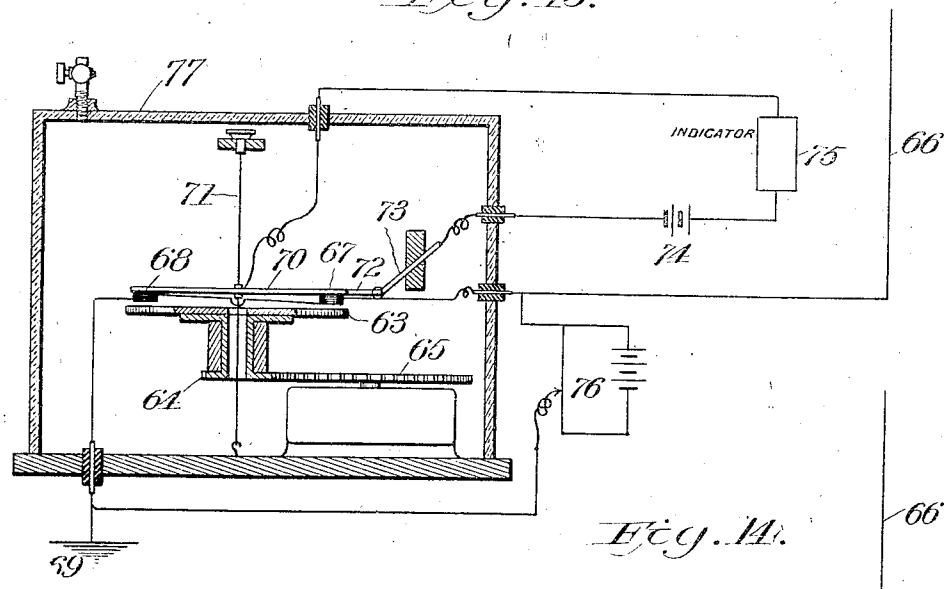
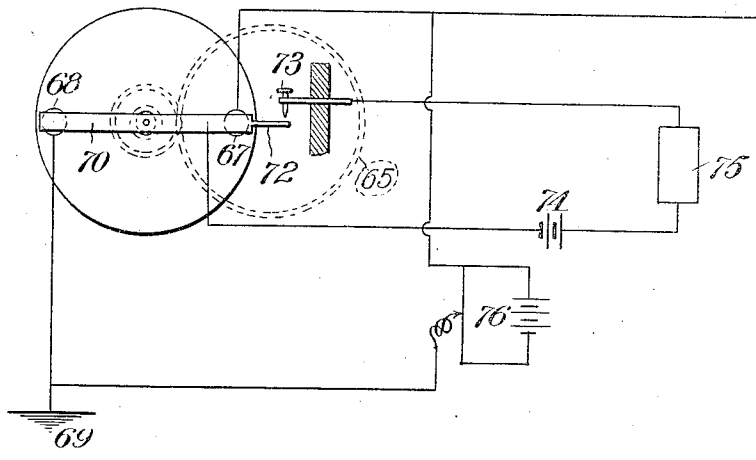


Fig. 14.



Witnesses:

Cornelis van Rennes.

C. H. Walker

Inventor.

Reginald A. Fessenden

by Dennis B. Wolcott

Attorney.

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF WASHINGTON, DISTRICT OF COLUMBIA, ASSIGNOR TO THE NATIONAL ELECTRIC SIGNALING COMPANY, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF NEW JERSEY.

RECEIVER FOR ELECTROMAGNETIC WAVES.

1,042,778. Specification of Letters Patent. Patented Oct. 29, 1912.

Application filed March 22, 1905. Serial No. 251,538.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, residing at Washington, in the District of Columbia, a citizen of the United States, have invented or discovered certain new and useful Improvements in Receivers for Electromagnetic Waves, of which the following is a specification.

The invention herein described relates to receivers for wireless signaling and more particularly to a new type of receiver in which the waves are caused to produce directly mechanical effects instead of to produce direct electrical effects such as changing the conductivity or continuity of a local circuit, and to securing the necessary persistence of effect.

More particularly still it relates to a new type of receiver in which the waves are caused to act directly upon moving bodies in frictional or frictional relation to vary such relation. The specific factor of frictional effect which is varied directly by the electro-magnetic waves is that known technically as the amount of friction.

My invention therefore involves at least two conductors, one of them preferably a solid, arranged to develop frictional or other tractional stress with or without contact of the parts, transmitting or tending to transmit motion; the modification of such stress by the electro-magnetic wave and finally the utilization of the change of stress directly or indirectly to produce a signal or indication. While the bodies between which the frictional stress is developed may be normally at rest and the change of stress be utilized, as by movement of one or both of them, to produce the desired indication or signal I prefer to develop said stress between relatively moving bodies between which there is a tractional effect causing one of them to tend to move the other, such tendency being opposed and partially counterbalanced by stress in the opposite direction. In such an arrangement friction causes tendency to movement of one of the bodies in the direction of the other in proportion to the amount of the friction and the counterbalancing force acting in the opposite direction. Any variation in friction by the action of the electro-magnetic waves, whether increase or decrease, will unbalance the normally balanced forces and cause bodily movement of the normally balanced member either in the direction of the frictional stress or in the direction of the counterbalancing force according as the effect of the electromagnetic waves is to decrease or increase the total amount of friction. In most cases I prefer to arrange matters so that the total amount of friction will be increased by affecting an increase in the value of the factor known as the co-efficient of friction, or the pressure of the magnetic friction.

Figures 1, 2, 3 and 4 of the drawings show partly in diagram certain forms in which I have embodied my invention. They also show similar forms in which the persistence of effect necessary to practical operation is secured. Figs. 5 to 11 show other forms. Fig. 12 is a view partly in section and partly in elevation, illustrating a modification of my improvement; Figs. 13 and 14 show in elevation and plan a further modification of the invention.

In Fig. 1 I have shown the frictional stress as developed between a rotating wheel 1, which may be driven by clockwork or by an induction or other motor and a body 2 resting against 1 and tending to follow the direction of movement of the latter but restrained and counterbalanced in such movement by the diaphragm 3 with which it is connected. This diaphragm is preferably very thin and correspondingly delicate.

The rotating wheel 1 may be made of silver, nickel, 10 per cent. bismuth-gold alloy or other suitable material and the body 2 may be a piece of thin gold leaf, though I do not confine myself to this particular material as amalgamated copper foil may be used especially when amalgamated copper is used for the wheel. This receiver is operatively connected in any desired receiving circuit, as for example, by connecting the body 2 to the vertical 4 and the wheel to the ground connection 5.

In operation the wheel 1 is rotated and the body 2 resting against its periphery is pulled or pushed as the case may be in the direction of movement of the wheel to an extent depending upon the co-efficient of friction of the surfaces of the bodies and the

pressure with which one is forced against the other. This pressure may be suitably adjusted by gravity, as by shifting the position of the wheel support 1', or by magnetism or in any other suitable way.

The telephone diaphragm 3 by reason of its connection with the body 2 will be displaced by an average amount depending upon the pull or push exerted by the wheel upon the latter and the amount of the counterbalancing force, the latter being determined in this case by the elastic reaction of said diaphragm 3. With the parts in this normal condition the incidence of the electro-magnetic waves will change the amount of friction between the body 2 and the wheel 1 thus leaving the body 2 unbalanced as against the pull of the elastic diaphragm 3. This will cause a sudden change in the position of the diaphragm which may be used to effect an indication either by direct action upon the air to produce a sound or it may be utilized to control the operation of any desired apparatus or medium. Used to operate directly upon the air to produce sound, it has produced good results.

Many other forms of mechanism adapted to give an indication upon movement in response to a slight change in push or pull may be employed. For instance, a form is shown in Fig. 2 similar to Fig. 1 with the exception that instead of a diaphragm a pointer 6 and scale 7 are used for an indicating mechanism.

Fig. 3 shows a third form, in which there is a rotating shaft 1 upon which rests the collar 2 carrying the fine thread 3 attached to the siphon 7. 6 is a spring which holds the collar from rotating with the shaft 1. 4 is a vertical antenna which may be attached to the collar and 5 is a ground which may be attached to the rotating shaft 1. In operation the shaft 1 rotates, and drags the collar 2 with it until the frictional force is equal to the restoring force of the spring 6. On the passage of electrical waves the co-efficient of friction is increased and the collar 2 is displaced from its mean position, thereby causing the siphon 7 to produce an indication. Any suitable lubricating fluid whether electrolyte or not may be used between the collar and shaft, for example oils of various degrees of viscosity and of electrical conductivity, depending upon the character of the work for which the receiver is to be used. Glycerin or graphite may also be used, either in the forms shown in Fig. 3 or in the other forms.

In Fig. 4 I have shown a form wherein one of the conducting bodies between which tractional stress is developed is a fluid. Mercury or water for example may be used in this form and the mercury may be in continuous motion and may be used to displace the position of the wheel a normally constant amount depending upon the tractional effects and the counterbalancing force. As in the other cases the amount of the displacement is varied upon receipt of the waves. As shown in Fig. 4 this principle is embodied in a device wherein a rotating cup 1 contains mercury, contacting with which is an amalgamated copper disk 2. Usually the mercury is covered with a film of insulating material as for example, oxid or air. The traction of the mercury upon the disk 2 may be counterbalanced by the spring of the wire connection to the aerial 4 or in any desired manner. The rotating cup is connected to the ground 5. The change of traction of the disk 2 upon receipt of the waves may be utilized to produce an indication in any desired way, the means employed in connection with the collar 2 of Fig. 3 being appropriate.

In Fig. 5 is shown another embodiment of the invention in which the highly oscillating currents to be detected act to produce a magnetization, which magnetization in turn produces an alteration in the friction. In this Fig. 8 is an antenna grounded at 9, and having in series with it a coil 10, so that the highly oscillatory currents pass through this coil. 11 is a very fine iron wire, which may be 1/1000 of an inch in diameter, supported by a quartz fiber 12, which latter is adjustable by a milled nut 13. The fine iron wire 11, is preferably bent at one extremity 14, so as to be in light contact with the rotating disk 15, which may be of any magnetic material, for example it may be of brass covered with a plating of nickel or iron. This disk is preferably ground so as to be very true before and after plating with nickle. The rotating disk may be supported and driven in any suitable manner, for example by a magnetic suspension, as shown, where 16 is a wire, 17 is a tube encircling the wire, and attached to the disk 15; 18 is a local battery in the circuit of which is a magnetic coil 19; which operates to draw up tube 17, and 20 is an adjustable resistance. 21 is a projection on the wire 16 so as to prevent the tube 17 being drawn up too high.

Among other methods of driving the disk, a magnetic drive may be used as shown, where 23 is a rotating magnet driven by a pulley 24 and 22 its armature.

The motion of the wire 11 may be used to operate any suitably connected electrical or mechanical mechanism, for example, as shown, the siphon recorder 25.

The pressure of the wire 11, 14, on the disk 15 may be adjusted in any suitable way, as for example, by an auxiliary magnet, here shown as an electromagnet, the coil 10 being connected to the potentiometer 26, so that by adjusting the potentiometer the wire 11 can be magnetized to a greater or less

degree, and hence made to press more or less heavily on the disk 15.

Choke coils 27, 28, are used for preventing the electric oscillations from being shunted through the potentiometer.

Fig. 6 is a plan view of the apparatus where 15 is a disk, 11 the fine iron wire, 10 the coil, 25 the siphon recorder.

Fig. 7 shows the fine wire 11 displaced by the disk 15, and made to operate a telephone diaphragm 29 instead of the siphon recorder. In operation the disk 15 revolves and the needle of the fine wire 11 pressing upon it is displaced, to a greater or less extent, depending upon the friction, as shown in 11′ 14′, Fig. 6. Upon the receipt of the electrical oscillations by the antenna 8, the wire 11 is still further magnetized and the friction increased, whereby the wire 11 is drawn still further to one side, and an indication is produced on the siphon recorder 25 or telephone 29.

Figs. 8, 10, show two other forms, 9 and 11 being plan views. In Fig. 8, 31 is the antenna grounded at 32, and the waves pass through two electromagnetic coils 33, 34, which may have magnetic cores as shown, in which case the cores are formed of very fine iron wire. These cores are caused to revolve by a pulley 35. 36, 37 are sliding contacts in the form of bunches attached to the coils and engaging the fixed rings 36^a and 37^a for leading the highly oscillatory currents and the current from the potentiometer 38 into and out of the coils 33, 34. 39 is a disk supported by the fine wire 40 which is suspended from another fine wire 41. This disk carries a contact arm 42. In operation the magnets 33, 34, revolve and in revolving drag around the disk 39 to an extent depending upon the current flowing from the potentiometer 38. This current is so adjusted that the contact arm 42 does not make contact normally with the fixed contact 43. When however, the oscillatory currents flow through from the antennæ through the coils 33, 34, the torque or magnetic friction of the disk 39 is altered and the contact arm 42 makes contac with the fixed contact 43, and the current from the local battery 44 flowing through the circuit actuates the mechanism 45, thereby producing an indication.

In Fig. 10 a single annular coil 46 is used instead of the two coils 33, 34, with sliding contacts 37, 38, as before. The annular coil is driven by the pulley 35, and the cylindrical tubes between which the coil 46 is wound are made of insulating material. In this case, instead of the disk 39 a thin iron wire 47 is dragged around by the magnetic friction, this fine iron wire carrying the contact arm 42 and being adapted to make contact as in the case of the mechanism shown in Fig. 8 with the fixed contact 43.

In the plan views shown in Figs. 9 and 11 the numbers have the same significance as in the elevations.

Fig. 12 shows another embodiment of the invention in which 50 is the antenna grounded at 51 and 52 is a coil through which passes the high frequency oscillations and also the current from the potentiometer 53; 54, 55 being choke coils 56 the fine wire of magnetic material, preferably iron, bent at the point 57, so as to come nearly in contact with the rapidly revolving pulley shaped disk or wheel 58, made preferably of copper, and driven by alternator 62. 59 is a very thin piece of mica or glass so arranged as to lie between the surface of pulley 58 and the fine iron wire 57. 60 is a quartz fiber or fine wire supporting the fine iron wire 56; and 61 is a nut for adjusting the position of the fine iron wire. In practice the wheel 58 revolves very rapidly, the fine wire 56 being magnetized to any extent from zero upward to that desired by means of a potentiometer 53. The action of the rapidly revolving disk 58 pulls the fine wire 56 to one side, into a steady position, which may be called the zero position. On the passage of the highly oscillatory currents through the coil 52, the magnetization in the iron wire 56 is altered, which in turn alters the amount of the interaction between the revolving wheel 58 and the iron wire 56 so that the position of the iron wire is shifted from zero and an indication is produced either visual, as shown, or mechanical, as shown in Figs. 5 and 7. The object of the thin piece of mica or glass 59 is to prevent the action of the air currents from causing motion to the wire 56, and such a diaphragm may also be used in other forms where actual contact is not necessary to produce the friction, for example, in Fig. 10.

In Fig. 13 is shown another form in which a disk of copper, 63, is mounted on the hollow shaft 64, and driven by a mechanism 65. In this form the oscillatory currents from the antennæ 66, flow through the coils 67, 68, to ground at 69. These two coils are supported on a horizontal arm 70 which is in turn supported by a wire 71, and the horizontal arm carries the contact arm 72, adapted to make contact with the fixed contact 73, and thereby closes the local circuit through the battery 74, and indicating mechanism 75. A potentiometer 76 may be used to cause a constant current to flow through the coils 67, 68, and thereby adjust the position of the horizontal arm 70. The passage of the high frequency oscillations from the antennæ through the coils 67, 68, cause a change in the amount of drag of the disk 63, and thereby closes the contacts 72, 73, and operates the indicating mechanism 75.

Fig. 14 is a plan view of the apparatus. The coils 67, 68 and the arm 70 should be as

small and light as possible. Instead of using a mica disk as in Fig. 12 to obviate the effect of the air currents, the whole apparatus may be placed in a box 77, from which the air may be pumped so as to produce a vacuum.

The change of friction is not always in the direction of an increase, as in some instances, the friction is decreased, particularly where an electrolyte is employed, as in the Edison chalk cylinder telephone, but it is not practicable to attempt to state a law upon which this depends.

I am aware that the Edison chalk cylinder telephone has been used as a receiver on telegraphic lines, as well as for telephoning. I am also aware that attempts have been made to use this receiver as a wireless receiver, but these attempts have been without success.

While I do not limit myself to any particular means for obviating the difficulty by increasing the distance passed over during a period, I prefer to accomplish it either by giving great velocity to the moving member, or prolonging the time of action, or preferably by both.

In Fig. 12 is shown a convenient means for producing the result in the former method. Here the rotating wheel 58 is fastened to the shaft which is capable of being driven at approximately two thousand revolutions per second. In this case if the wheel is one inch in diameter, the surface of the wheel will move at the rate of approximately six thousand inches per second, and if the spark should last but for one one-millionth of a second, the distance passed over by the disk during that time would be nearly one one-hundredth of an inch, which is sufficient to produce an indication on any suitable mechanism such as a relay or siphon recorder. If a train consisting of 20 waves is used, the distance passed over will be more than an eighth of an inch, which is, of course, larger than is necessary. This method of rapid motion of the moving parts is not limited to the particular form here shown, but may be used with other forms, either in actual contact as in Fig. 1, or separated by an air shield as in 59, Fig. 12.

No claim is made herein to the method described with more or less particularity as the same forms the subject matter of application, No. 269,647, filed July 14th, 1905.

The particular form of receiver in which I employ a liquid as one of the members in tractional or frictional relation, forms the subject matter of a separate co-pending application No. 364,626, filed March 26th, 1907 (now Patent No. 917,574.)

What I claim is:

1. In a system of electro-magnetic wave telegraphy a receiver including in combination conducting bodies and means for developing a frictional stress between said bodies together with means for utilizing the change in the amount of such stress in response to received electro-magnetic waves, to produce directly a sensible indication or effect.

2. In a system of electro-magnetic wave telegraphy a receiver including in combination relatively moving conducting bodies, means for developing a tractional stress between said bodies, means for causing received electro-magnetic energy to act upon said bodies to change such stress and means made operative by said change of stress to produce an indication.

3. In a system of electro-magnetic wave telegraphy a receiver including in combination two bodies in frictional relation, means for relatively moving them and means for causing electro-magnetic waves to change the amount of friction.

4. In a system of electro-magnetic wave telegraphy a receiver comprising two parts having continuous relative movement, means for causing electro-magnetic waves to produce during their receipt a change in the relation of said parts and means whereby such changed relation operates directly to produce an indication.

5. A receiver for electromagnetic wave energy comprising two relatively movable elements having a condition of traction between them, means operated by the received electromagnetic waves to produce a change in said condition of traction contemporaneous with the duration of the received waves, and means for indicating changes of position of the members consequent upon said change of tractional stress.

6. In a system of electromagnetic wave telegraphy, the combination of two bodies in frictional relation, means operative by electromagnetic waves for changing such relation and a part or member shiftable by said bodies when changing their normal relative positions.

7. A receiver for electromagnetic wave energy comprising the combination of two bodies in tractional relation, means for continuously moving one of the bodies at high velocity, the other body having small inertia and means operated by the received electromagnetic waves to change the amount of tractional stress contemporaneously with the duration of the received waves, and means to indicate the resulting change of position of said bodies.

8. In apparatus for electromagnetic wave telegraphy, a receiver comprising members in a relation of frictional stress adapted to be changed by prolonged trains of waves, and an indicator operated by said changes of stress.

9. In apparatus for electromagnetic wave telegraphy, the combination of two bodies and means for maintaining them with condition of tractional stress between them and moving one of them at high velocity and means for altering said tractional relation by the agency of prolonged trains of waves, the effect of the waves being contemporaneous with the duration thereof, substantially as described.

In testimony whereof, I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:

THOMAS P. BROWN,

LEONA FEATHERS.