May 29, 1923. 1,456,595

C. A. HOXIE

RECORDING APPARATUS

Original Filed April 13, 1918 3 Sheets-Sheet 1

Fig. 1.

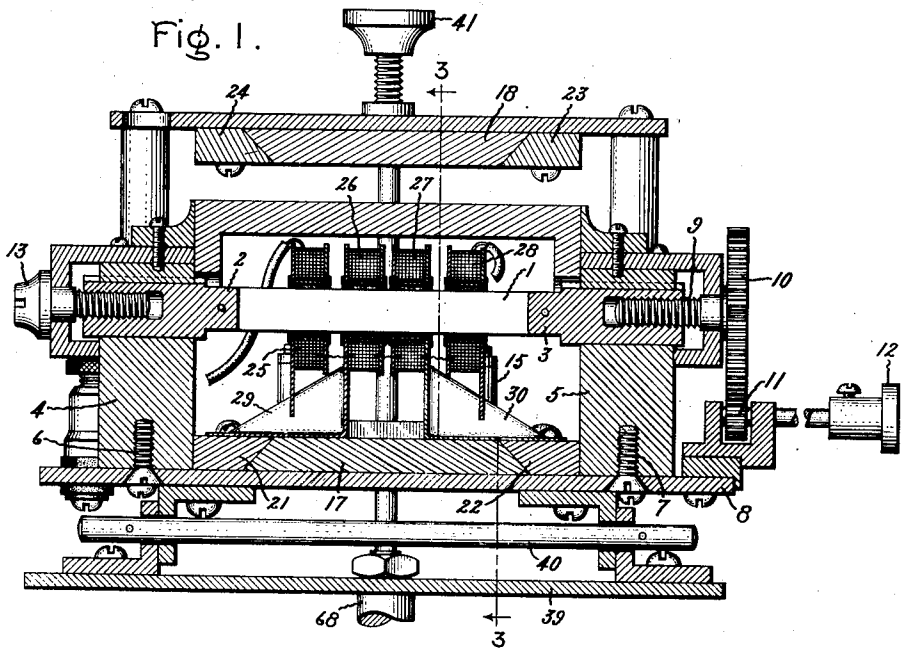
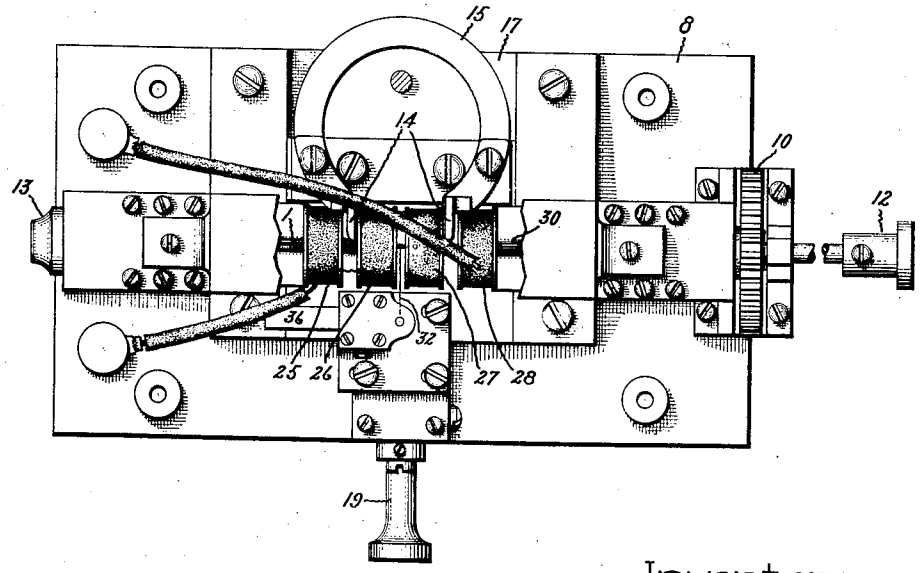


Fig. 2.



Inventor:
Charles A. Hoxie,
by Albert G. Davis
His Attorney.

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Original Filed April 13, 1918 3 Sheets-Sheet 2

Fig. 3.

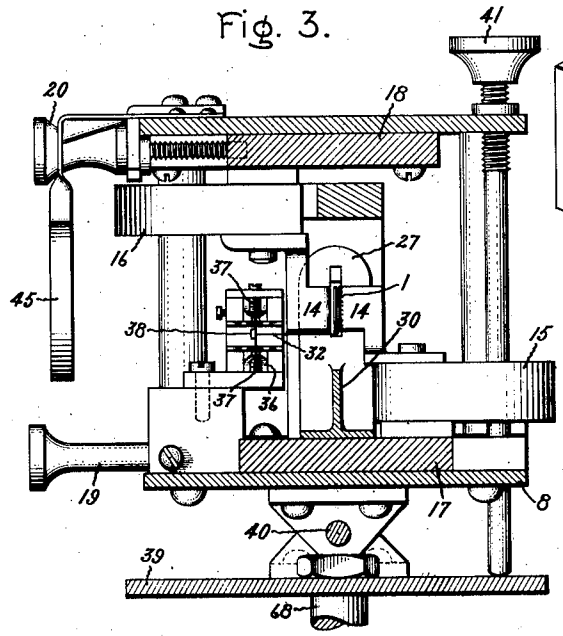


Fig. 5.

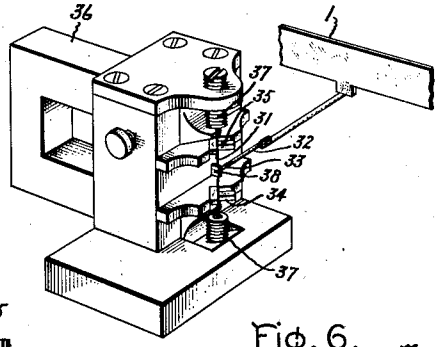


Fig. 6.

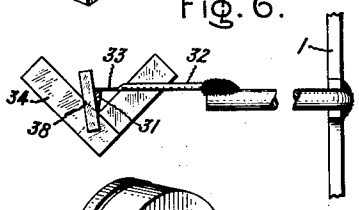
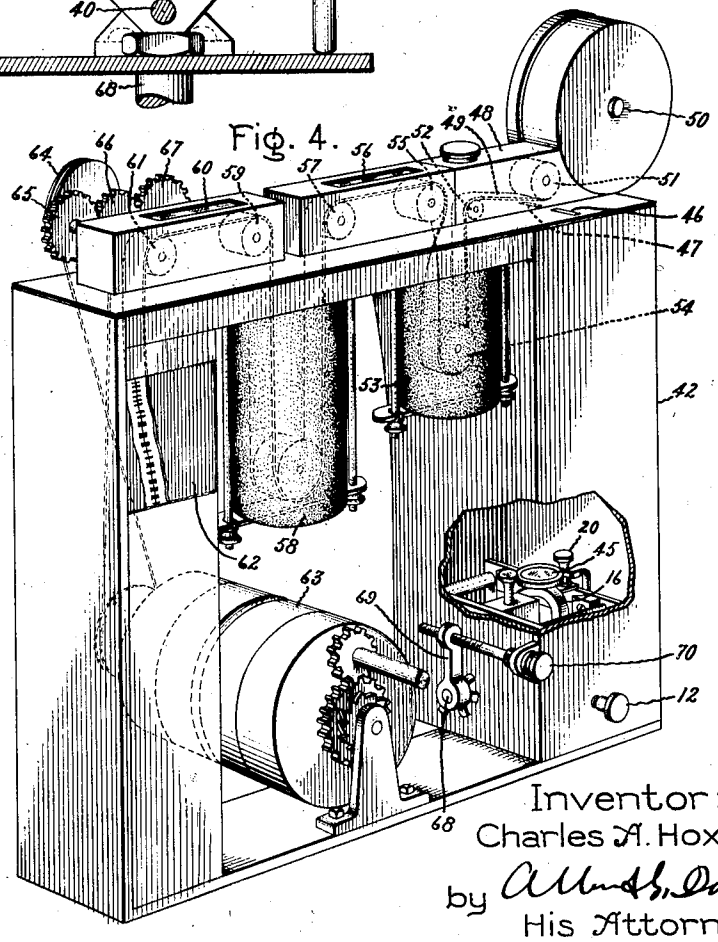


Fig. 4.



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Original Filed April 13, 1918 3 Sheets-Sheet 3

Fig. 9.

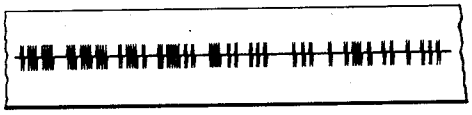


Fig. 10.

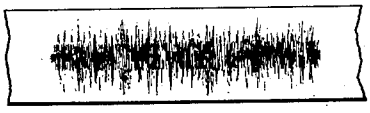


Fig. 11.

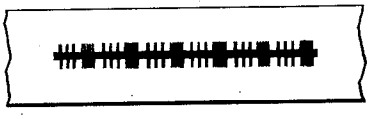


Fig. 7.

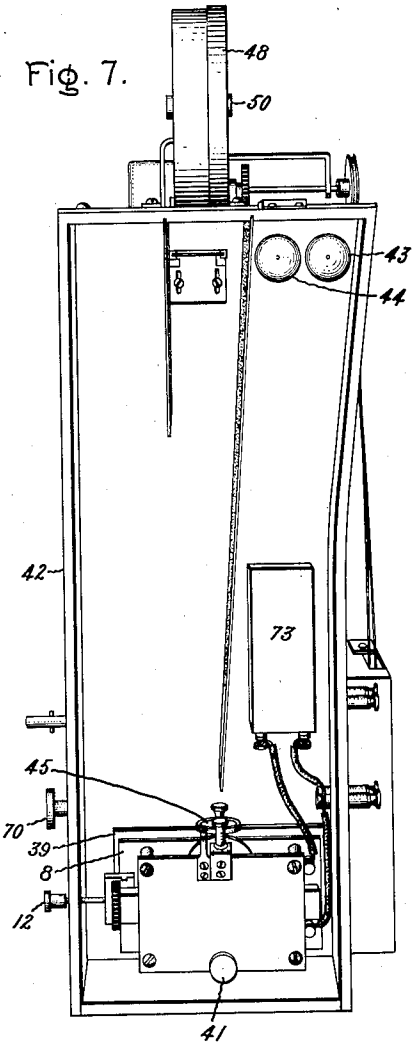
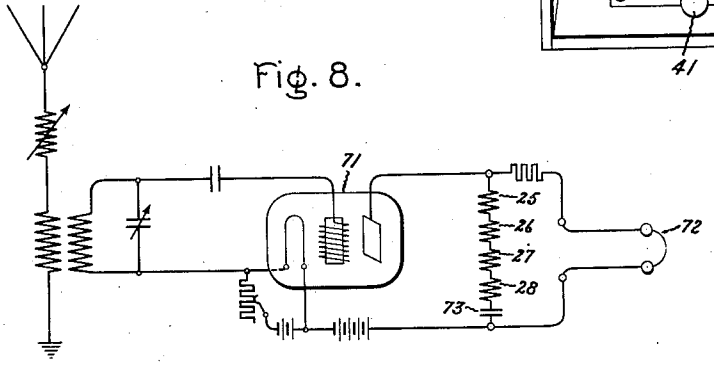


Fig. 8.



Inventor:
Charles A. Hoxie,
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His Attorney

Patented May 29, 1923. 1,456,595

UNITED STATES PATENT OFFICE.

CHARLES A. HOXIE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

RECORDING APPARATUS.

Application filed April 13, 1918, Serial No. 228,320. Renewed April 4, 1923.

To all whom it may concern:

Be it known that I, CHARLES A. HOXIE, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Recording Apparatus, of which the following is a specification.

My present invention relates to an apparatus for and a method of making a record of small electric current impulses and more particularly for recording photographically impulses corresponding to received radio signals.

In receiving radio messages it has been customary heretofore to employ at the receiving station some form of detector which will be acted upon by the high frequency wave received, in such a way as to produce a current capable of operating an ordinary telephone receiver. The reception of the message has depended upon the ability of the receiving operator to translate the sounds heard by him in the receiver into the characters or letters making up the message. This method has the disadvantage that in case the operator fails to understand any of the letters or words it is necessary to have part of the message repeated in order to make sure that it is correctly received. In case the receiving apparatus is affected by stray impulses or so-called static, which may be of much greater intensity than the signaling impulses, the response in the receiver produced by these stray impulses is so much greater than that produced by the signaling impulses that their effect upon the ear persists even after the stray impulse has passed and the effect of a single stray impulse may be of sufficient duration to prevent the operator from hearing several of the characters of the message. This method of signaling also has the disadvantage that it is physically impossible for an operator to receive messages which are sent at a rate greater than twenty to thirty words per minute.

The object of my invention is to provide a receiving system which will overcome the disadvantages above mentioned as well as others. In carrying out my invention I provide means for making an oscillographic record upon a tape, of the signaling current which in the old system acts upon the telephone receiver. The photographic impression upon the tape is automatically developed immediately after it is made and the apparatus so arranged that the message may be read from the photographic record very soon after the record has been made. The apparatus which I provide is also capable of recording messages at a much faster rate than they can be received by ear, the possible speed of the operation being several hundred words per minute instead of twenty to thirty. The effect of stray impulses upon the recording device will last only as long as the impulse itself lasts and will not affect the reception of any of the succeeding characters of the message. Hence a stray impulse, which with audio receiving might obliterate a whole word, may affect only a single letter of the photographic record and not interfere at all with the proper receiving of the message. It will also be apparent that the degree of skill required to read a photographic record of the message will be much less than that required to receive the message by ear.

The novel features which I believe to be characteristic of my invention are pointed out with particularity in the appended claims. The invention, itself, however, together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 is a cross-sectional view of my apparatus for producing a movement of a beam of light corresponding to the variations in the signaling current; Fig. 2 is a plan view of the apparatus with the upper portion removed; Fig. 3 is a cross-sectional view on the line 3—3 of Fig. 1; Fig. 4 is a perspective of the complete apparatus; Fig. 5 is a fragmentary enlarged perspective showing the arrangement of the mirror by which a beam of light is reflected upon the sensitized tape; Fig. 6 is a still more enlarged plan view showing the movable element which carries the mirror; Fig. 7 is an end view of the completed apparatus with the end wall removed; Fig. 8 is a diagram of a circuit which may be employed for receiving and detecting the signaling impulses and Figs. 9, 10 and 11 are samples of photographic records made with my apparatus under different conditions of operation.

As indicated in the drawings my apparatus comprises an elongated member, dia-

phragm or reed 1 of magnetic material the ends of which are fastened to and held in place by means of the members 2 and 3, which in turn are adjustably connected to the supports 4 and 5, these supports being held in place by the screws 6 and 7 upon the base plate 8. In the operation of the device the diaphragm 1 should have a natural rate of vibration equal to the frequency of the current to be recorded. The natural rate of vibration of diaphragm 1 may be adjusted by varying the tension thereon by means of the screw 9 which is adapted to be turned by the gears 10 and 11 and the handle 12. The screw 13 may also be turned to assist in the preliminary adjustment of the diaphragm.

The diaphragm 1 is held between the poles 14 of two permanent magnets 15 and 16. These magnets are secured to the movable supports 17 and 18, and the spacing between the magnet poles and the diaphragm may be adjusted by means of the screws 19 and 20, the turning of these screws causing a movement of the supports 17 and 18, in the grooves in which they are held by the blocks 21, 22, 23 and 24. Coils 25, 26, 27 and 28, through which the signaling current to be recorded is passed, surround the diaphragm 1 and cause it to move in unison with the changes in the current in these coils. The coils are held in place by means of brackets 29 and 30 which are secured to the fixed blocks 21 and 22. The movement of the diaphragm 1 causes a slight rotation of a triangular shaped shaft 31 of magnetic material which is connected to the diaphragm by means of the member 32 the ends of which are securely attached to the diaphragm and the shaft as indicated in Fig. 6. The end of member 32 is flattened at 33 where it is secured to the shaft 31 so as to provide in effect a flexible connection with the shaft which will permit the shaft to rotate around its bearings without any lost motion. The shaft 31 is held against the V-shaped jeweled bearings 34 and 35 by means of a permanent magnet 36, these bearings being formed adjacent the poles of the magnet 36. Jeweled adjustable bearings 37 are also provided at the ends of the shaft 31 but these bearings serve only as guides. The rotation of the shaft 31 causes a movement of the mirror 38 which is mounted thereon and thereby produces a movement in a beam of light which is reflected by the mirror upon a photographic tape in a manner which will be explained later.

The unit which has thus far been described is mounted upon a base 39 in such a way that it is capable of limited movement relative to this base around the axis 40. An adjusting screw 41 permits the position of the unit with respect to the base 39 to be fixed as desired. The complete unit illustrated in Figs. 1, 2 and 3 is mounted in a light-proof casing 42 as indicated in Figs. 4 and 7. This casing contains two incandescent lamps 43 and 44 and the unit is so positioned that by adjustment of the screw 41 two beams of light from the lamps 43 and 44 are reflected from the mirror 38 through the lens 45 upon the two slits 46 and 47 in the top of casing 42. Since the slit 47 is covered by the housing 48 through which the photographic tape 49 moves the slit 46 is provided to enable the operator to tell from the position of one of the light beams on that slit when the other beam of light is properly directed upon the slit 47. The photographic tape is held upon a reel which is pivoted at 50 within the housing 48. From this reel it moves under the roller 51 so that its under side is exposed to the beam of light coming through slit 47. From here it passes over the roller 52 down into the tank 53 which is filled with a developer solution. The tape passes under the roller 54 which may be supported in the tank 53 in any desired manner. The tape is turned in passing through the tank 53 and as it emerges therefrom and passes over roller 55 so that the side which has been exposed to the light comes on top. After passing over roller 55 the tape moves under the ruby glass 56 and the developed record may then be read if desired. After passing under ruby glass 56 the tape moves over roller 57 down into a tank 58 which is filled with a fixing solution. From the fixing tank the tape passes over roller 59 under a clear glass 60, where the record may again be read, and down over roller 61 into a receiving receptacle 62. The tape may be driven through the above described cycle of movement by means of any desired form of motor. For the purpose of illustration I have shown a spring motor 63 which drives the roller 61 through a pulley 64 and a train of gears 65, 66 and 67.

The base of the unit illustrated in Figs. 1, 2 and 3 is secured to a shaft 68 which projects through the casing 42 as indicated in Fig. 4. By means of a crank 69 on the end of this shaft and an adjusting screw 70 the unit may be rotated with the shaft to assist in adjusting the light beams to their desired position.

In Fig. 8 I have indicated a simple receiving circuit for the purpose of illustrating the general manner in which the signaling impulses may be applied to operate my recording device. As here shown the coils 25, 26, 27 and 28 are connected in the plate circuit of the detector 71. The usual telephone receiver 72 may also be included in shunt to these coils to assist in adjusting the receiving circuits to obtain the maximum amplitude of the signaling current in the coils 25, 26, 27 and 28. A condenser 73 is preferably used in series with the coils so that only the alternating component of the signaling cur-

rent will pass through them. Fig. 9 is a specimen of a record made with ordinary hand telegraphic sending under commercial conditions.

The operation of the diaphragm 1 whereby the movement of the mirror 38 is produced is as follows:

The magnets 15 and 16 are so arranged that the north pole of magnet 15 is opposite the south pole of magnet 16 and hence the south pole of the magnet 15 is opposite the north pole of magnet 16. When an alternating current is passed through the coils 25, 26, 27 and 28, the polarity of the portions of the diaphragm opposite the magnet poles changes in accordance with the changes or alternations in the current. Thus it will be seen that an impulse in one direction will cause the diaphragm to be attracted to one of the magnets and an impulse in the opposite direction will cause the diaphragm to be attracted to the other magnet. I have found that this specific arrangement of the magnets and exciting coils is particularly sensitive for operation with the extremely small currents which are available for the operation of the diaphragm. I have also found that it is desirable that the rate of vibration of the diaphragm should be as high as it may conveniently be made. Careful experiments have shown that when the diaphragm vibrates at a frequency of 2000 cycles per second the effect of ordinary static impulses on the record is very much less than when the diaphragm is vibrated at the rate of 1200 cycles per second. This effect is illustrated in Figs. 10 and 11, Fig. 10 being a record made with practically continuous static and the diaphragm vibrating at the rate of 1200 cycles per second, and Fig. 11 being a record made with the same static conditions and the diaphragm vibrating at the rate of 2000 cycles per second. On account of this fact I find it preferable that the diaphragm should have a rate of vibration of at least 1500 cycles per second.

It will of course be recognized that the simple receiving circuit shown in Fig. 8 is adapted only for the reception of damped waves and that the rate of vibration of the diaphragm with such a circuit arrangement should correspond to the spark or group frequency of the wave to be received. It will, however, be obvious that the apparatus which I have described will operate in the same manner to record continuous wave impulses received by the heterodyne method. Because of the previously mentioned advantage of higher frequencies, when damped wave transmission is employed a spark frequency of at least 1500 should be used. With continuous wave transmission it will, of course, be a comparatively simple matter to adjust the frequency of the signaling current at the receiving station to 1500 cycles or any higher value desired.

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

1. A selective signal receiving device, comprising a magnet, a diaphragm resonant to a definite frequency located in the field of said magnet and a stationary winding surrounding said diaphragm and adapted to carry current impulses of a frequency equal to that to which the diaphragm is resonant.

2. A selective signal recording device, comprising a diaphargm which is resonant to the frequency of the impulses to be recorded, said diaphragm being mounted in the field of a permanent magnet, stationary windings surrounding said diaphragm, adapted to carry received current impulses which are to be recorded and thereby produce a movement of the diaphragm corresponding to said impulses and means for recording the movements of said diaphragm.

3. Means for recording current impulses photographically comprising a diaphragm which is resonant to the frequency of the impulses to be recorded, said diaphragm being mounted between the poles of two permanent magnets, a set of windings surrounding said diaphragm adapted to carry the current impulses which are to be recorded and thereby produce a movement of the diaphragm corresponding to said impulses and means for moving a mirror in response to the movements of the diaphragm.

4. Means for recording current impulses photographically comprising a diaphragm of magnetic material which is mounted between the poles of two permanent magnets, a set of windings surrounding said diaphragm, means for passing the current impulses to be recorded through said windings to actuate said diaphragm, means for moving a mirror in response to the movements of said diaphragm and means for adjusting the natural rate of vibration of said diaphragm to correspond to the frequency of the impulses to be recorded.

5. Means for recording current impulses photographically comprising a diaphragm which is resonant to the frequency of the impulses to be recorded, said diaphragm being mounted between the poles of two permanent magnets, a set of windings surrounding said diaphragm, means for passing the current impulses through said windings to actuate said diaphragm, a shaft held magnetically against a V-shaped jeweled bearing and connected to said diaphragm in such a way that a movement of the diaphragm will produce a rotation of said shaft around its bearing and a mirror mounted on said shaft.

6. In combination, in an apparatus of the class described of a diaphragm adapted to vibrate, a shaft formed with a knife-edge, a

V-shaped jewel bearing, means for holding the knife-edge of said shaft against said V-shaped bearing by magnetic attraction, a connection between said diaphragm and said shaft whereby a vibration of the diaphragm will produce a rotation of said shaft around its bearing and a mirror mounted upon said shaft.

7. The combination in an apparatus of the class described of a diaphragm adapted to vibrate, a shaft having a triangular cross section and having one of its edges held by magnetic attraction in a V-shaped jeweled bearing, a connection between said diaphragm and the side of said shaft remote from the bearing whereby a vibration of the diaphragm will produce a rotation of said shaft around its bearing and a mirror mounted upon said shaft.

8. The combination in an apparatus of the class described of a diaphragm adapted to vibrate, a shaft having a triangular cross section and having one of its edges held by magnetic attraction in a V-shaped bearing, a connection between said diaphragm and the side of said shaft remote from the bearing whereby a vibration of the diaphragm will produce a rotation of said shaft around its bearing, a mirror mounted upon said shaft and means for adjusting the natural rate of vibration of said diaphragm.

9. The combination in an apparatus of the class described of a permanent magnet, a V-shaped bearing adjacent each of the poles of said magnet, a shaft of triangular cross section having one of its edges held by magnetic attraction in said bearings, a mirror mounted upon said shaft, and means for producing a movement of said shaft around said bearings.

10. The combination in an apparatus of the class described of a diaphragm adapted to vibrate, a permanent magnet, a V-shaped bearing adjacent each of the poles of said magnet, a shaft of triangular cross section having one of its edges held by magnetic attraction in said bearings, a mirror mounted upon said shaft and a connection between said diaphragm and said shaft whereby a movement of said diaphragm will produce a movement of said shaft around said bearings.

11. Means for recording current impulses photographically comprising a diaphragm mounted between the poles of two permanent magnets, a set of windings surrounding said diaphragm and adapted to carry the current impulses to be recorded, a permanent magnet having a V-shaped bearing adjacent each pole, a shaft of triangular cross-section having one of its edges held by magnetic attraction in said bearings, a mirror mounted upon said shaft and a connection between said diaphragm and said shaft whereby a movement of said diaphragm will produce a movement of said shaft around said bearings.

12. The combination in an apparatus of the class described of a diaphragm adapted to vibrate, a permanent magnet, a V-shaped bearing adjacent each of the poles of said magnet, a shaft of triangular cross-section having one of its edges held by magnetic attraction in said bearings, a mirror mounted upon said shaft and a flexible connection between said diaphragm and said shaft whereby a movement of said diaphragm will produce a movement of said shaft around said bearings without any lost motion.

13. The combination in an apparatus of the class described of a permanent magnet, a diaphragm adapted to vibrate, a shaft of triangular cross section having one of its edges held by magnetic attraction in a V-shaped bearing and a flexible connection between said diaphragm and the side of said shaft remote from the bearing whereby a vibration of the diaphragm will produce a rotation of said shaft around its bearing without any lost motion.

14. The combination in a radio signaling system of means for producing at the receiving station by means of received impulses, an audio frequency signaling current having a frequency of at least 1500 cycles per second, a diaphragm having a natural rate of vibration corresponding to the frequency of said signaling current, windings surrounding said diaphragm through which said signaling current may be conducted to actuate said diaphragm and means cooperating with said diaphragm to record the movements thereof.

15. The combination in a radio signaling system of means for producing at a receiving station by means of received electromagnetic waves an audio frequency signaling current having a frequency of at least 1500 cycles per second, a diaphragm having a natural rate of vibration corresponding to the frequency of said signaling current, windings through which the signaling current may be conducted to actuate said diaphragm, and means for producing by means of the movement of said diaphragm a corresponding movement of a beam of light upon a photographically sensitized surface.

16. The combination in a radio signaling system of means for producing at a receiving station by means of received electromagnetic waves an audio frequency signaling current having a frequency of at least 1500 cycles per second, a diaphragm having a natural rate of vibration corresponding to the frequency of said signaling current, windings through which the signaling current may be conducted to actuate said diaphragm, a mirror mounted upon a rotatable shaft and a flexible connection between said diaphragm and said shaft whereby the movement of said diaphragm will produce a

rotation of said shaft without any lost motion and thereby cause the mirror to produce a corresponding movement of a beam of light upon a photographically sensitized surface.

17. The combination in an electrical apparatus of an elongated member having its ends rigidly supported and an intermediate portion of which is supported in an air gap between opposed magnetic poles and a stationary winding surrounding the middle portion of said member and adapted to carry signaling currents, the middle portion of said member being adapted to vibrate in response to signaling currents supplied to said winding.

18. The combination in an electrical apparatus of a pair of opposed magnetic poles, a flexible elongated member having its ends rigidly supported and an intermediate portion supported in an air gap between said magnetic poles and a stationary winding surrounding said member and adapted to carry signaling currents, the middle portion of said member being adapted to vibrate in response to signaling currents supplied to said winding.

19. The combination in an electrical apparatus of two adjacent pair of opposed magnetic poles, an elongated member having its ends rigidly supported and an intermediate portion supported in an air gap between said magnetic poles and a stationary winding surrounding said member between said adjacent pairs of poles and adapted to carry signaling currents, the middle portion of said member being adapted to vibrate in response to signaling currents supplied to said winding.

20. Means for producing an indication of signaling currents comprising a member of magnetic material adapted to vibrate and which is mounted between the poles of two magnets, a stationary winding surrounding said member, means for passing signaling currents through said winding to produce a vibration of said member corresponding to the signaling currents and means associated with said member for producing an indication of the vibrations thereof.

21. Means for producing an indication of signaling currents comprising an elongated member of magnetic material supported at its ends and having an intermediate portion supported in air gaps between the poles of two magnets, a stationary winding surrounding said member, means for passing signaling currents through said winding to produce a vibration of said member corresponding to the signaling currents and means associated with said member for producing an indication of the vibrations thereof.

22. Means for producing an indication of signaling currents comprising an elongated member having its ends rigidly supported and an intermediate portion of which is supported in an air gap between opposed magnetic poles, a stationary winding surrounding said member, means for passing signaling currents through said winding to produce a vibration of said member corresponding to the signaling currents and means associated with said member for producing an indication of the vibrations thereof.

23. Means for producing an indication of signaling currents comprising two adjacent pair of opposed magnetic poles separated by short air gaps, a member of magnetic material which is supported at two points outside of said air gaps and which is adapted to move back and forth across said air gaps, a stationary winding surrounding said member between said adjacent pairs of poles, means for passing signaling currents through said winding to produce a vibration of said member corresponding to the signaling currents and means associated with said member for producing an indication of the vibrations thereof.

In witness whereof, I have hereunto set my hand this 12th day of April, 1918.

CHARLES A. HOXIE.