C. W. EISENMANN.

CURRENT DETECTOR.

APPLICATION FILED AUG. 3, 1916.

1,292,279. Patented Jan. 21, 1919.

Fig. 1.

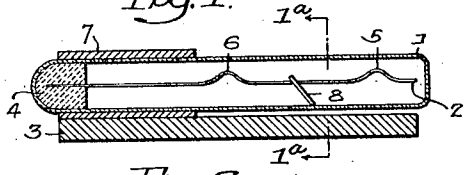



Fig. 1a

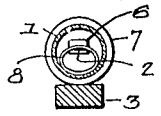



Fig. 2.

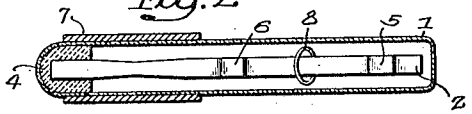



Fig. 13.

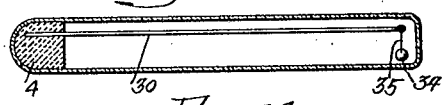



Fig. 3.

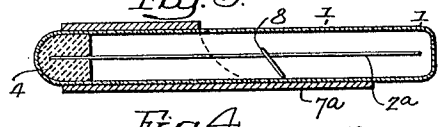



Fig. 14.

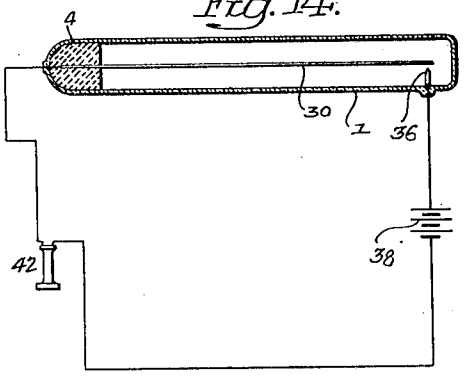



Fig. 4.

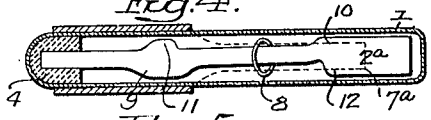



Fig. 5.

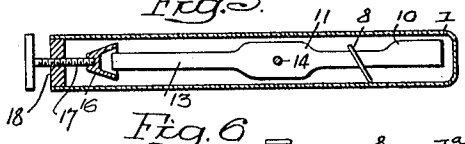



Fig. 6

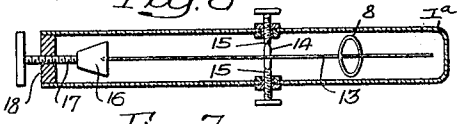



Fig. 15.

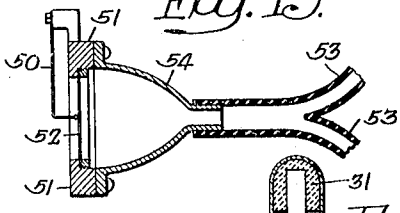



Fig. 7.

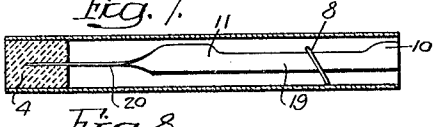



Fig. 8.

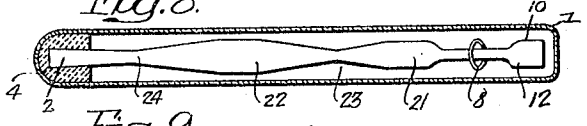



Fig. 17.

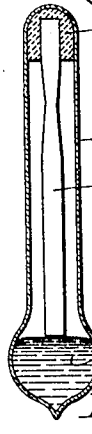



Fig. 9.

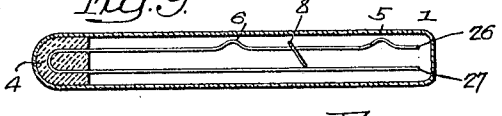



Fig. 10.

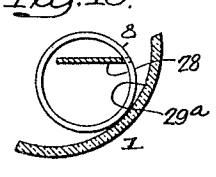
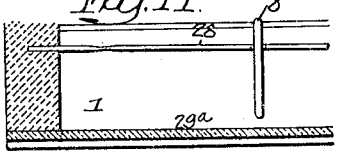



Fig. 11.




Inventor.—

Carl W. Eisenmann.

by his Attorneys.—

Howson & Howson

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

# UNITED STATES PATENT OFFICE.

CARL W. EISENMANN, OF NEBRASKA CITY, NEBRASKA.

## CURRENT-DETECTOR.

1,292,279. Specification of Letters Patent. Patented Jan. 21, 1919.

Application filed August 3, 1916. Serial No. 112,984.

*To all whom it may concern:*

Be it known that I, CARL W. EISENMANN, a subject of the Emperor of Germany, residing in Nebraska City, Otoe county, State of Nebraska, have invented Current-Detectors, of which the following is a specification.

One object of my invention is to provide a simple, inexpensive and conveniently portable device for giving visual, aural or other indication of the flow of an alternating current or of a varying direct current;—the arrangement of parts being such that the instrument is caused to operate when brought adjacent to a single conductor even though the current flow be relatively small.

These objects and other advantageous ends I secure as hereinafter set forth, reference being had to the accompanying drawings, in which,

Figures 1 and 2 are respectively longitudinal sections at right angles to each other, illustrating a simple form of my invention;

Fig. 1ª is a transverse section on the line 1ª—1ª Fig. 1;

Figs. 3 and 4 are sections similar to those of Figs. 1 and 2, illustrating a modified form of the invention;

Figs. 5 and 6 are longitudinal sections taken at right angles to each other, illustrating a form of the invention employing a rigid instead of a flexible vibratory element;

Figs. 7, 8 and 9 are longitudinal sections of other modifications of the invention;

Figs. 10 and 11 are respectively a transverse section and a side elevation of a form of my invention in which the indicating member is caused to rotate when the instrument is placed within a varying magnetic field;

Figs. 12 and 13 are longitudinal sections of further modifications of the invention;

Fig. 14 is a diagrammatic view showing my invention as adapted to actuate an aural indicator; and

Fig. 15 is a fragmentary section, to some extent diagrammatic, illustrating another form of my invention.

In Figs. 1 and 2 of the above drawings, 1 represents an elongated glass tube from which the air is preferably though not necessarily exhausted and which has extending longitudinally within it a vibratory element 2 in the form of a thin elongated strip of magnetic material, such as steel, which may be either permanently magnetic or be magnetized in any manner, as by induction from a magnet 3. Said strip is rigidly held at one end by a body of cement 4 so as to extend longitudinally of the tube 1, and it is noted that its width is gradually diminished from the point at which it leaves the cement to a point of minimum width some distance therefrom, beyond which it widens to its normal width. This construction is adopted for the purpose of preventing an abrupt change in the strip from a condition of flexibility to one of rigidity with a consequent possibility of crystallization and breakage.

At a point adjacent its free end, the magnetized strip or reed is provided with an upwardly deflected portion 5 and also has a second deflected portion 6 at about its middle part, while between these two portions I mount upon said reed a light ring 8 of non-magnetic material such as aluminum, making it of circular or other suitable outline, and of such diameter that it is supported partly upon the smooth surface provided by the glass tube and partly by the strip 2. As a result of this arrangement said ring normally rests in the position shown;—inclined at an angle of from 45° to 60° to a vertical plane. If desired I may also provide an iron tube 7 surrounding a part of the glass tube, in order to reduce the reluctance of the magnetic circuit which includes the vibratory member 2, and I also shield the latter from strong stray alternating magnetic fields, which might otherwise demagnetize it. This shield may also be made to include the permanent magnet when the reed is inductively magnetized.

If the above described device be approached to an alternating current conductor in such position that the strip 2 lies in a plane at right angles to the line thereof, the varying magnetic flux set up by the current flow in the conductor will cause vibration of the member 2 in a plane at right angles to its own plane, the amplitude of such vibrations depending upon its elasticity and flexibility, and their frequency upon that of the alternating current in the conductor.

When the strip is thus vibrated, the ring 8 is caused to creep or travel longitudinally

thereof in the direction in which it happens to be inclined. Upon reaching the projection 6 for example, it creeps up on the same until it is clear of the bottom of the tube, whereupon it falls back into an oppositely inclined position and travels toward the deflected portion 5 of the reed which again reverses its direction of movement. In other words, when the detector is approached to a current-carrying conductor and properly held in position, the ring 8 continuously travels back and forth between the parts 5 and 6, thus visibly indicating the existence of a varying electric current.

If desired, the ring 8 and projections 5 and 6 may be omitted and by other suitable means the visible vibrations of the strip 2 be relied on to detect the current in the conductor. I find however that the ring provides a simple and reliable means of indicating the less easily observed vibration of the reed or strip and I preferably use it. Without departing from my invention, the iron tube 7 may be omitted, as may also the magnet 3, which serves to increase the reaction between the field of the conductor and that of the vibratory member.

In that form of my invention shown in Figs. 3 and 4, I provide a flat strip $2^a$ of magnetic material having lateral enlargements 12 and 10 adjacent one of its ends and a second pair of oppositely placed projections 11 and 9 respectively spaced away from said first projections. Of these, the two first serve to reverse the direction of the movement of the ring 8 in the same manner as do the projections 5 and 6 in the other form of the invention, and the projections 11 and 12 serve to limit the movement of the ring while preventing it from jamming on the strip. In case the magnet 3 is omitted as in this form of the invention, I preferably extend the iron tube 7 as shown, so that it projects at one side, parallel with the reed $2^a$ and toward the free end of the same. Owing to the magnetization of said reed it is slightly attracted toward this extended portion and is thus made more sensitive to variations in any magnetic field into which it may be introduced. When the magnet 3 is employed the reed is obviously biased toward its nearest pole.

In Figs. 5 and 6 I have illustrated another form of my invention in which a rigid vibratory magnetic bar 13 is provided with trunnions 14 operative in bearings 15 at opposite sides of the glass inclosing tube 1. In the case shown this latter is not exhausted, although it may be constructed as shown in Figs. 1 to 4 inclusive if desired. That part of the bar 13 on one side of and adjacent said trunnions 14 has a laterally projecting portion 11 and at the outer end of said portion has another lateral projection 10, with a ring 8 supported partly by its intermediate comparatively narrow portion and partly by the tube 1. The second end of the bar 13 is extended into a conical socket 16 carried by a screw 17 adjustably mounted in one end 18 of the tube $1^a$ so that as the bar is vibrated under the action of an alternating current as above described, the amplitude of its oscillations may be adjusted by turning the screw 17 to move the socket toward or from its end.

In that form of the invention shown in Fig. 7, I provide a flat strip 19 of magnetic material having one end rigidly fixed in a body of cement 4 as in the case of Figs. 1 to 4 inclusive, and its opposite end provided with an enlargement 10, between which and a second enlargement 11 a ring 8 is movably mounted as before. In addition to having a portion 20 of reduced width adjacent its point of entrance into this cement 4, this strip 19 has its main part twisted to lie in a plane at right angles to that of said reduced part, so that in vibrating about the latter as a hinge or pivot, its main outer portions move edgewise in their own plane, thereby materially reducing the resistance of the air to such movement. In all of the above cases the reed or vibratory member is adjusted or tuned to respond or vibrate to a maximum extent when exposed to the magnetic field produced by an alternating current of definite frequency.

If it is desired that the device shall be capable of indicating the presence of either of two alternating currents of different frequencies, I may construct the strip as indicated in Fig. 8, with two relatively wide portions 21 and 22 connected by a narrow neck 23. The portion 22 is connected, through a part 24 of diminished section, with the end 25, which is embedded in the cement or supporting structure 4. The outer portion 21 has a relatively narrow extension terminating in a head 10—12 and coöperating with the interior surface of the tube to support the ring 8. In this case the part 21 with the ring-supporting section is tuned to vibrate in response to the field of an alternating current of a definite frequency, while these parts, with the part 22, are tuned to vibrate as a unit when placed in the field produced by a current of a second frequency. In either case, vibrations are indicated by the movement of the ring longitudinally of the strip as above described.

In the instrument shown in Fig. 9, I provide a vibratory member in the form of a horseshoe magnet, which is preferably mounted in an exhausted glass tube and is carried by a body of cement 4 engaging that portion of its body formed by the junction of its two branches 26 and 27. Of these, the first may be tuned to respond to cur-

rents of one frequency, while the second may be tuned to another frequency, although if desired both branches may be tuned to be vibrated by currents of the same frequency. In any case I preferably form the upper branch 26 with a pair of projections 5 and 6 and a ring 8 operative between them, while the branch 27 is so adjusted as to serve as the partial supporting means for said ring. In this case when either branch vibrates, the ring 8 travels back and forth between the projections 5 and 6 and the same action occurs if the device is so tuned that both branches respond to the same frequency.

If desired, the movement of the vibratory member or reed under the action of the field produced by an alternating electric current may be emphasized by causing the ring 8 to rotate rather than move longitudinally of a supporting structure. For this purpose I provide a thin strip 28, Figs. 10 and 11, of magnetic material supported at one end so as to extend to one side of the center line of the tube 1 substantially parallel with but spaced away from a suitable supporting structure such as the interior surface of said tube, presenting an inclined face $29^a$ below but to one side of it and positioned to partially support the ring 8. When said strip vibrates, its first movement toward said inclined surface allows said ring to roll or fall toward it for a short distance, and as the strip thereafter moves up, said ring is lifted. On the next downward movement of the strip 28, the ring again rolls upon the inclined surface and again falls toward said strip, with the result that when said vibrations occur at the rate characterizing alternating current frequencies, the ring is given an intermittent and easily perceptible rotation on its central axis.

With the above noted arrangement of parts, the vibratory member or reed itself may be depended on to indicate visually by its vibrations the flow of an alternating current in a conductor to which it is approached, so that it is particularly valuable in tracing current leaks or in indicating current flow. Obviously however, means other than a ring may be utilized to emphasize or magnify the vibrations of the reed or current-vibrated member. For example, in Fig. 12 I have shown a form of the invention in which the vibratory member 30 is held by one end in a body of cement 31 within a closed, and if desired, exhausted glass vessel 32. In the lower and preferably laterally enlarged portion of this latter I place a liquid such as mercury 33 which, when the member 30 vibrates, is visibly agitated. For the mercury, I may substitute a powder such as lycopodium, or several unmixable gases of different colors such as air and bromin, and in the first of these cases the vibration of the member 30 would visibly agitate the powder, while in the latter case it would disturb the relative positions of or tend to temporarily mix the two different colored gases, thus giving a visible indication of the movement of the reed.

Another possible arrangement is shown in Fig. 13 in which the vibratory member has a weight 34 of suitable form connected to it through a relatively flexible connection 35 and so proportioned that its natural period of vibration is different from that of the member 30. As a result even a comparatively slight vibration of the member 30 will cause the weight 34 to be violently agitated, and provide an easily visible signal. If desired, the ring 8 instead of being supported partly by the reed and partly by the tube as in Figs. 1 and 2, may be so proportioned as to be carried solely by said vibratory member.

As illustrated in Fig. 14 the vibratory member 30 may be combined with an auditory device to give a signal when actuated by an alternating current or other form of varying magnetic field. For this purpose a contact 36 is mounted in a tube 1 immediately adjacent but normally out of engagement with the end of the member 30, which with it is connected in an electric circuit including a source of current 38 and a device such as a telephone receiver 42. The vibration of the member 30 under the action of a varying magnetic field will then cause said member to alternately engage and disengage the contact 36, thus making a succession of easily recognizable sounds in the receiver 42.

In that form of my invention shown in Fig. 15, I mount the vibratory reed 50 on a projection from an annular structure 51 and connect what would ordinarily be its free end to or permit it to bear upon, a diaphragm 52 suitably mounted in said structure. A set of ear tubes 53 is then connected through a resonating chamber 54 to the structure 51 so that when as before the reed 50 is set in vibration by reason of its entrance into a varying magnetic field, the diaphragm 52 is caused to vibrate and the resulting sound waves are transmitted by the member 54 and the ear tubes 53 to the ears of the person making the test.

From the above description it will be noted that I utilize the vibration of a tuned reed or oscillatory member to indicate in any of a number of ways, the presence of an alternating current in a single wire;—so embodying the invention that it may be inexpensively made and utilized in portable form. Moreover, while I preferably so proportion the dimensions of the reed or oscillatory member 30 that it may properly be described as tuned to respond to the varying magnetic flux, it may for some pur-

poses and without departing from my invention, be utilized without being tuned, since in any case it will be moved by and thus indicate the presence of an alternating current, a varying direct current or a direct current which is alternately completed and cut off.

It is to be particularly noted that my device is of the widest practical utility, for it may be conveniently used not only to locate grounds and short circuits but also for the purpose of testing circuits or of singling out wires in telephone or power cables; in fact to permit of the recognition of a conductor in which such flow occurs.

In some cases I may employ a testing current of definite frequency and supply it by a vibrator, interrupter or special generator. The current detector would then be tuned to respond only to this special current without being influenced by the stray fields of other circuits and could be used with advantage for locating faults in conductors or the identification of any particular conductor.

I claim:—

1. A current detector consisting of a supporting structure; a relatively thin elongated strip of magnetic material supported thereby and free to vibrate when placed in a varying magnetic field; with a member supported in position to be caused to continuously slide on said strip when it is vibrated.

2. A current detector consisting of a supporting structure; a relatively thin elongated strip of magnetic material supported thereby and free to vibrate when placed in a varying magnetic field; and a movement-indicating ring supported partly by said structure and partly by the strip for visually indicating vibration of the latter.

3. A current detector consisting of an inclosing tube; a reed of magnetic material mounted therein so as to be free to vibrate and including projecting portions; with a member movably carried by said reed for visually indicating its vibration and formed to have its direction of movement reversed by said projections.

4. A current detector consisting of a transparent inclosing structure; a relatively thin strip of magnetic material mounted therein and tuned to vibrate in response to the effect of a varying magnetic field; with a member movably mounted on the strip and formed to be continuously moved by vibration thereof.

5. A current detector consisting of a tuned reed of magnetic material; a member movable longitudinally of said reed in response to vibration thereof; and means coacting with the reed for causing said member to travel continuously thereon when said reed is vibrated.

6. A current detector consisting of a tuned reed of magnetic material; with a ring mounted on said reed and also partially supported independently thereof to travel continuously longitudinally thereof in response to its vibration.

7. A current detector consisting of a reed tuned to vibrate in response to the action of a varying magnetic field; a member mounted to travel longitudinally of the reed when the latter is vibrated; and means for reversing the direction of movement of said member.

8. A current detector consisting of a tube; a reed mounted therein and tuned to vibrate in response to the action of a varying magnetic field; a member supported partly by the tube and partly by the reed for giving visual indication of the vibration of the latter; with means for reversing the direction of movement of said member when it has traveled to one end of said reed.

9. A current detector consisting of a tube; a strip of magnetic material mounted in said tube and free to vibrate in response to the action of a varying magnetic field; a ring loose on the strip and supported partly by the tube; with projections on the strip for reversing the direction of movement of the ring when vibration of said strip causes it to move thereon.

10. A current detector consisting of an exhausted glass tube; a strip of magnetic material mounted therein and tuned to vibrate when placed in a varying magnetic field; with means in the tube actuated by said strip for giving visual indication of its movement.

11. A current detector consisting of a supporting structure; with an elongated strip of magnetic material tuned to vibrate as a whole when placed in the field of an alternating current of a definite frequency and including a portion tuned to vibrate when placed in the field of an alternating current of another frequency.

12. A current detector consisting of an inclosing structure; with a strip of flexible magnetic material rigidly held at one end and free to vibrate when placed in a varying magnetic field; the cross section of said strip being reduced at a point spaced away from its point of engagement with the supporting structure.

13. A current detector consisting of a glass tube; a strip of relatively thin magnetic material rigidly held at one end therein; a ring loosely mounted on said strip so as to be free to slide thereon and supported partly thereby and partly by the tube; with projections from the strip formed to alternately reverse the direction of movement of said ring when it is caused to slide longitudinally of said strip by vibration thereof.

CARL W. EISENMANN.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."