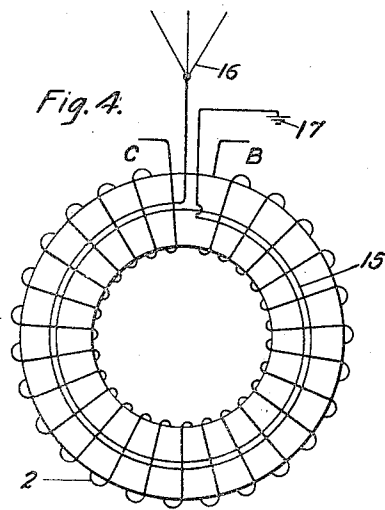
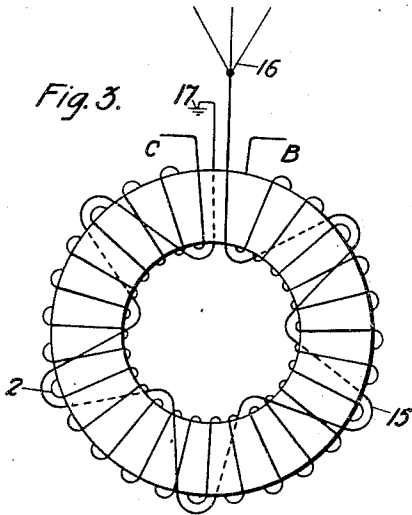
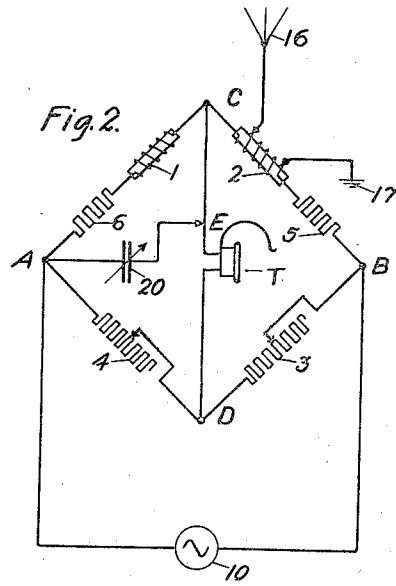
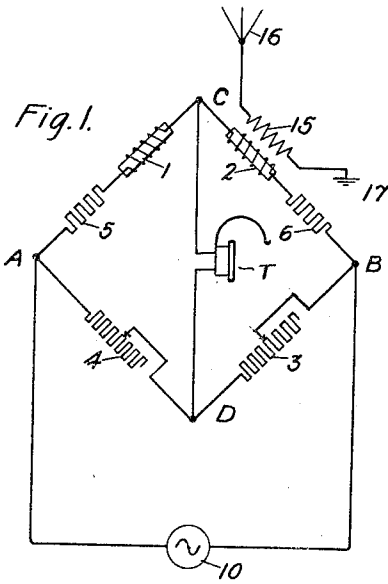


G. W. ELMEN.
HIGH FREQUENCY DETECTOR.
APPLICATION FILED NOV. 23, 1915.

1,289,418.

Patented Dec. 31, 1918.



Inventor:
Gustaf W. Elmen.
by *J. F. Roberts* Att'y.

UNITED STATES PATENT OFFICE.

GUSTAF W. ELMEN, OF BOGOTA, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

HIGH-FREQUENCY DETECTOR.

1,289,418.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, GUSTAF W. ELMEN, originally a subject of the King of Sweden, who arrived in Philadelphia from Sweden on August 1, 1893, when sixteen years of age, declared my intention of becoming a citizen of the United States on October 5, 1900, and again on April 30, 1915, have been a constant resident of the United States since my arrival, but have not taken out my final naturalization papers, am now residing at Bogota, in the county of Bergen and State of New Jersey, and have invented certain new and useful Improvements in High-Frequency Detectors, of which the following is a full, clear, concise, and exact description.

This invention relates to an apparatus for detecting the presence of oscillatory currents in a conductor, and in particular to a detector of high-frequency oscillations of the type generally known in the art as magnetic detector.

When an alternating or pulsating current traverses a coil having an iron or other magnetic core, a certain amount of energy is lost due to the hysteresis in the iron. This energy must be supplied by the source which causes the iron to pass through the hysteresis cycle, and may be looked upon and expressed as being equivalent to the work done in overcoming a certain amount of resistance, which may be called the effective resistance in the coil due to hysteresis. If W is the total energy per unit of time and E and I are the voltage and current respectively used in the coil, then

$$W = EI = I^2 R \text{ or } R = \frac{W}{I^2}.$$

R here represents the so-called effective resistance of the coil, and is made up of the factors which contribute to W . In general these factors are ohmic resistance, eddy currents and hysteresis. By suitably selecting the iron and constructing the coil, it is possible to make the ohmic and eddy consumption losses very small, and the loss will be practically wholly due to hysteresis. It may be desirable under certain conditions to reduce the hysteretic energy which must be supplied by a given alternating or pulsating current source, and for this purpose I make use of the discovery that the superposition on the iron or other magnetic core of an alternating current of appreciably higher fre-

quency will reduce the energy supplied by the low frequency; that is, it will reduce the area of the hysteresis loop for the low-frequency current. Apparently the high-frequency oscillations act in a manner to shake up the iron molecules and reduce the force required to set them into motion, thus saving low-frequency energy, the energy required to do this shaking-up being supplied by the high-frequency source.

In practice I find that it is not necessary that the high-frequency shall be excessively high. I find, for example, that if the low-frequency is about 15 per second that a high-frequency of 60 per second is sufficient to cause the reduction of the hysteresis loop on the low-frequency side to practically zero. If the low-frequency is raised, then the high-frequency must be raised correspondingly and may be made very much higher than the low-frequency.

I have found that this effect may be made use of in constructing a sensitive and reliable detector of high-frequency waves by using means which will note a change in the hysteretic energy supplied by the low-frequency source. Heretofore in magnetic detectors use has been made of the sudden induced effects produced in a receiver circuit when the hysteresis cycle in a body of iron is brought partially or wholly into phase with the magnetizing force by the received high-frequency oscillations. This sudden breaking down of the magnetic condition gives a sharp click or signal in the receiver or translating device which is independent of the frequency of the low-frequency magnetizing force. In my invention, however, I do not primarily make use of this sudden induced electromotive force, but I make use of the change in the hysteretic energy which must be supplied by the low-frequency source when high-frequency oscillations are received. This change in the hysteretic energy is equivalent to a change in the effective resistance of the coil surrounding the iron, and any method for indicating or measuring this change in effective resistance will be useful in indicating the presence of the high-frequency current.

Inasmuch as one of the most sensitive and reliable methods of measuring resistances or indicating changes in resistances is the Wheatstone's bridge, I have made use of such a circuit to carry out my invention, and

this will be better understood by reference to the following specification and accompanying drawings, in which Figure 1 shows one circuit arrangement for detecting the presence of high-frequency oscillations. Fig. 2 shows a modification of this circuit, and Figs. 3 and 4 show forms of coils which I have found to be useful.

In Fig. 1, I have shown a Wheatstone's bridge circuit in which 1 and 2 represent two arms of the bridge and consist of coils with iron or other magnetic cores. Preferably these two coils are made as nearly identical as possible and of such form and material that the ohmic and eddy losses are very small. Also the core should be one of low coercive force and high remanence. 3 and 4 represent two other arms of the bridge, and consist of non-inductive resistances which, in general, would be made adjustable. Connected to the corners A and B of the rectangle is a source 10 of alternating or pulsating current, which source or generator will hereafter be spoken of as the source of low frequency currents or oscillations. Between the corners C and D is connected an indicating or translating device T of any suitable form. This translating device may consist of a vibration galvanometer or of a telephone receiver or other device which is responsive to oscillations of the frequency generated by the source 10. Inductively connected to the coil 2 is the coil 15, which forms a part of the receiving system of high-frequency oscillations which are to be detected, such, for example, as are used in wireless telegraphy. It is to be understood, however, that the invention is not limited to wireless telegraphy but may be used wherever it is desirable to show the presence of oscillations of a frequency relatively high as compared to the frequency of source 10. I have shown this coil connected at the one end to the aerial 16 and at the other end to the earth at 17.

The operation of this device is as follows: The bridge is balanced both for ohmic resistance and for reactance, in a manner well-known in the art, so that no current shall flow through the indicating device T. In order to assist in this adjustment, it may be desirable to place the non-inductive resistances 5 and 6 in the branches containing the coils 1 and 2, but these will not always be necessary, for if the coils 1 and 2 are made as nearly identical as possible, any slight difference in them can be adjusted for by means of the resistances 3 and 4. Under these conditions, low-frequency oscillations will pass continually through the network, and the iron cores of the coils 1 and 2 will be caused to pass through a magnetic cycle, and energy will be consumed because of the hysteresis of the iron. Since the bridge is balanced, however, no current will

pass through the translating device T. When high-frequency oscillations are impressed upon the coil 2 by means of the coil 15, the magnetic condition of the core of this coil will be suddenly brought into phase, wholly or partially, with the magnetizing force. As a result the bridge will be thrown out of balance and an indication will be given at T. In general this lack of balance is due to two factors, the first of which may be designated as e_1 and is due to the change in the flux in the coil 2, giving rise to a sudden induced electromotive force, which causes a flow of current through the device T. In addition to this effect there is a second effect which may be designated as e_2 , and as explained earlier in this specification, is due to the reduction in the hysteretic energy absorbed as a result of the hysteresis cycle through which the iron is carried by the low-frequency source 10. This reduction in the amount of the hysteretic energy represents a reduction in the amount of energy which is consumed in the coil 2, and is therefore equivalent to a reduction in the effective resistance of the coil. This change in effective resistance produces a lack of balance in the bridge, and consequently there is a flow through the translating device T of current from the source 10. It will be noticed that the first effect e_1 corresponds to the effect which is ordinarily made use of in magnetic detectors as heretofore constructed and that the effect produced in T is simply a sharp click due to the sudden induced electromotive force. The second effect e_2 , however, is independent of this, and is due to a lack of balance in the bridge, as a result of which there will be heard in the telephone receiver T a note which corresponds to the frequency of the generator 10, which note will persist as long as the coil 2 is subjected to the high-frequency oscillations.

I wish it to be understood that while I have shown and explained thus far a simple Wheatstone's bridge, that any other network which is adapted to measure inductances may be used. Such a circuit, for example, is shown in Fig. 2, in which a variable condenser 20 is connected from the point A to some point E on the branch CD, which in this case has a small resistance.

The bridge in this case is brought into balance either by an adjustment of the capacity 20 or by an adjustment of the point of contact E. Having brought the bridge into balance, no current from the generator 10 will flow through T, but upon the receipt of high-frequency oscillations the bridge will be thrown out of balance and a signal will be received at T.

In this Fig. 2 I have also shown a modified form of connecting the bridge to the receiving antenna, in this case the aerial 13

and the ground connection being made directly to the coil 2, with adjustable contacts, as shown.

While in these two figures above described I have shown the coils 1 and 2 as open core coils, these will not in general be entirely satisfactory, for it is desirable that the core of each coil shall be one of low coercive force and high remanence. In order to obtain such a condition, it is desirable to use a closed core, as shown in Figs. 3 and 4. Furthermore, in order to reduce the eddy currents, these cores should be laminated or stranded in a manner well understood in the art. In Fig. 3 the high-frequency coil is shown as wound upon the core in the same manner as for the coil 2. In Fig. 4 this antenna or high-frequency coil is shown as being wound parallel to the core and preferably embedded in the center thereof. It has been found that in this case the effect of the high-frequency oscillations in reducing the hysteresis loss is as effective as in the coils shown in Fig. 3. Furthermore, it will be noticed that in this Fig. 4 the coil 15 is at all points at right angles to the coil 2, and that therefore there is no induced effect of the coil 15 upon the coil 2.

Whatever form of coil is used, it is to be understood that generally the coils 1 and 2 will be as nearly identical as possible in order to facilitate the operation of bringing the bridge into balance, but it is to be understood that this is not essential for the operation of the device.

The frequency of the generator 10 may be varied between wide limits. If the translating device T is to be the ordinary telephone receiver, then it is obvious that the frequency should be within the limits of audibility, and in this case I have found that a frequency of about 800 is very good indeed. If the translating device is a vibration galvanometer or some such device, the frequency may be made either lower or higher than the limits of audibility, this being determined by the frequency for which the device is adapted to be used.

What is claimed is:

1. The method which comprises producing a low frequency magnetic flux in a magnetic body and causing an indication by the change produced by a high frequency flux in the hysteresis energy required to maintain the low frequency flux.

2. The method of detecting high frequency currents which comprises subjecting a magnetic body to the simultaneous magnetizing action of said high frequency currents and a low frequency current and causing an indication by the variation in the value of the hysteresis energy supplied by the low frequency current during the action of said high frequency currents.

3. A receiving device for high frequency currents comprising a magnetizable member, a magnetizing winding and a high frequency circuit associated with said magnetizable member, and means for detecting the change of impedance of said magnetizing winding when high frequency currents flow in said high frequency circuit.

4. A receiving device comprising a source of electrical energy, a Wheatstone bridge having an arm comprising a magnetic core connected to said source and means whereby the impedance of said arm is varied.

5. A receiver of high-frequency currents or oscillations comprising a network, one branch thereof containing a coil with an iron core, a source of low-frequency current connected in one branch and arranged to cause said iron core to pass through a magnetic cycle, a source of high-frequency oscillations associated with said coil, a translating device arranged in a branch conjugate to the low-frequency source and adapted to be responsive to changes in the hysteretic energy supplied to said coil upon receipt of the high-frequency oscillations.

6. A receiver of high-frequency currents or oscillations comprising a Wheatstone's bridge network, a coil in each of two branches of said network, each coil containing an iron core of large hysteresis loss, a source of low-frequency oscillations in the battery branch of said network adapted to cause the iron cores to pass through a magnetic cycle, a source of high-frequency oscillations associated with one of said coils, and a detecting device connected in a branch of said network and adapted to respond to the low-frequency source upon the receipt of high-frequency oscillations.

7. A receiver of high-frequency currents or oscillations comprising a balanced Wheatstone's bridge network, a coil in each of two adjacent arms of said network, each coil containing a closed iron core of large hysteresis loss, a source of low-frequency oscillations in the battery branch of said network adapted to cause the iron cores to pass through a magnetic cycle, a source of high-frequency oscillations inductively associated with one of said coils, and a detecting device connected in a branch of said network conjugate to the battery branch and adapted to respond to the low-frequency source upon receipt of high-frequency oscillations.

8. A receiver of high-frequency currents or oscillations comprising a balanced Wheatstone's bridge network, a coil in each of two adjacent arms of said network, each coil containing a closed iron core of large hysteresis loss, a resistance in each of the other two arms of said bridge adjusted to balance the network, a source of low-frequency oscillations in the battery branch of said network adapted to cause the iron cores to pass

through a magnetic cycle, a source of high-frequency oscillations inductively connected with one of said coils, and a detecting device connected in a branch of said network conjugate to the branch and adapted to respond to the low-frequency source upon the receipt of high-frequency oscillations.

9. A magnetic detector of high-frequency currents and oscillations comprising a Wheatstone's bridge, one arm of said bridge including a coil with an iron core, said bridge being normally balanced and being rendered unbalanced during the receipt of high-frequency oscillations.

10. A magnetic detector of high-frequency currents and oscillations comprising a Wheatstone's bridge, one arm of said bridge including a coil with an iron core, a source of low-frequency oscillations for magnetizing said iron core, said bridge being normally balanced for said low-frequency oscillations and being rendered unbalanced for said low-frequency oscillations during the receipt of high-frequency oscillations.

In witness whereof, I hereunto subscribe my name this 19th day of November A. D., 1915.

GUSTAF W. ELMEN.