Dec. 20, 1955

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2,728,003

FREQUENCY RESPONSIVE RELAY

Filed Feb. 13, 1953

Fig. 1.

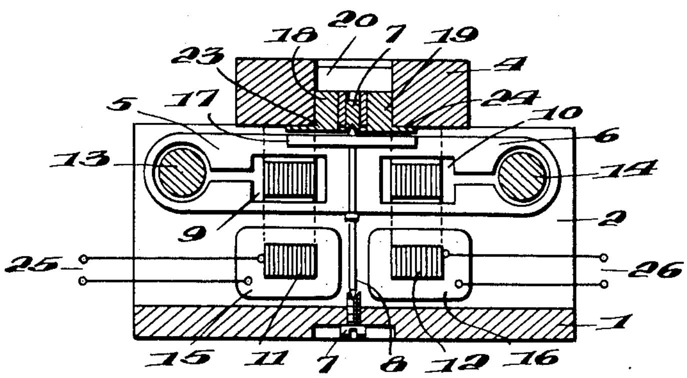


Fig. 2.

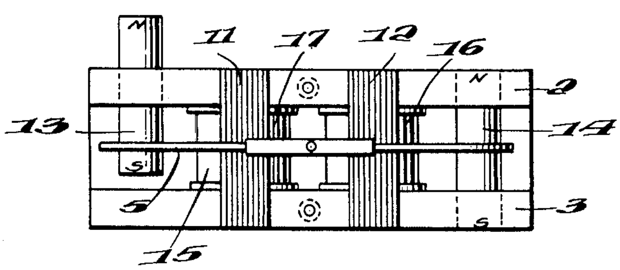
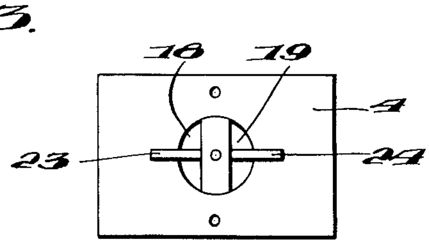


Fig. 3.



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2,728,003
Patented Dec. 20, 1955

2,728,003

FREQUENCY RESPONSIVE RELAY

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Application February 13, 1953, Serial No. 336,841

Claims priority, application Sweden February 27, 1952

7 Claims. (Cl. 310—113)

The present invention refers to a frequency-responsive electrodynamic relay, more particularly, a relay of the type comprising a loop conductor movable in a permanent magnetic field. In this type of relays, the leads for the current supplied to or derived from the relay often present difficulties in that friction forces and directing forces of an unpredictable nature are encountered.

It is an object of the invention to provide a relay that is free from the disadvantages referred to, and, also, to provide in a relay of the type referred to good selectivity even at very low frequencies, means being provided for adjusting the selectivity.

The frequency-responsive electrodynamic relay according to the invention comprises means for creating a magnetic field, and a first loop conductor movable in said field, the relay being characterized in that said loop conductor comprises two portions, one portion forming the secondary of a transformer adapted when energized to induce a current in the loop, the other portion being positioned in said magnetic field, thereby to impart motion to said loop in response to current induced therein.

The movement performed by the loop under the influence of an applied voltage may be utilized in various ways. It is thus possible, according to an embodiment of the invention, to let the movable loop control directly a contact for making or breaking a circuit so as to provide a vibrator or rectifier arrangement. According to another embodiment, the first loop is made to drive mechanically a second loop, which oscillates in a second permanent magnetic field. The second loop forms the primary of a transformer, the output voltage of which has an amplitude which is determined by the frequency of the applied voltage and by the resonant frequency of the relay.

The invention will be described below as illustrated in the drawing in the form of an embodiment whose principle of operation is substantially of the last-mentioned type. Fig. 1 shows an elevation of the relay in partial section and Fig. 2 a top plan view of the same. Fig. 3 illustrates a detail of the relay.

The relay comprises a frame of non-magnetic material having a bottom piece **1** and two wall pieces **2** and **3**, onto which is screwed a lid **4**. The two conductor loops are formed by two portions **5** and **6** of an aluminium disc or plate, which is supported by a shaft **8** journalled in a pair of screws **7** in the lid and the bottom, respectively. The disc portion **5** has therein an aperture **9**, through which extends a transformer core **11** and a permanent magnet **13**. Similarly, the disc portion **6** has an aperture **10** for a transformer core **12** and a permanent magnet **14**. The portions **5** and **6** are electrically insulated from each other so that a current induced in one portion does not reach the other. The cores **11** and **12** are provided with windings **15** and **16**, respectively, which are connected to external circuits for the relay.

The apertures **9** and **10** are shaped so as to let each of the corresponding loops enclose as completely as possible its transformer core and magnet. Each aperture

therefore has two wider portions joined by a narrow slot.

The relay is provided with means for producing a controllable directing force for holding the disc 5 in its neutral position when it is not carrying current. The arrangement is such as to make the directing force free from friction effects and to make it possible to adjust the same continuously from zero to its maximum value. A strip **17** of iron is attached to the aluminium disc 5 and is influenced magnetically by the field of a permanent magnet **20** having pole shoes **18** and **19**. The magnet **20** has the shape of a flat circular disc and is magnetized so as to have poles at diametrically opposed points in the manner indicated in Fig. 1. The magnet **20** is rotatable and it is apparent that, in the position indicated in the drawing, a strong magnetic field is formed between the pole shoes **18** and **19**, and that this field is gradually diminished down to zero value as the magnet is turned to a position at right angles to the initial one.

Each of the pole shoes **18** and **19** may be provided with an extension **23** or **24**, respectively, in accordance with Fig. 3, in order to concentrate the directing force to the longitudinal plane of symmetry of the relay. The pole shoes are held in position by an intermediate non-magnetic member, which serves also the purpose of accommodating the uppermost journalling screw **7**. Besides providing a fixed zero position for the disc **5** the directing force is also adapted to determine the resonant frequency of the oscillating system. Thus, the frequency is highest when the magnet is in such a position that the directing force has its greatest value and decreases with a decrease in the directing force.

The magnet **13**, which produces the magnetic field for driving the loop **5**, is supported by the wall member **2** and is so positioned as to make the loop **5** oscillate always on the same side of the neutral plane of the magnet. This makes the relay unsensitive to the second harmonic of the resonant frequency to which it is tuned. A displacement of the magnet **13** alters the character of the magnetic field in which the loop **5** is oscillating. This alters the damping of the oscillatory circuit of which the loop **5** forms a part and so also the Q of this circuit. It is thus possible in a simple manner to alter the shape of the resonance curve and thereby the selectivity of the relay.

It is apparent that the magnetic field deriving from a current through the loop **5** will interact with a radially directed magnetic field from the magnet **13**. In the event that it is of importance that the circuit Q should be independent of the oscillatory amplitude of the loop **5** care should be taken that the loop **5** is always oscillating in a homogeneous field. Such a field may be obtained, for example, by providing for the magnet **13** an elongated pole shoe and positioning the magnet so that the loop is always within the area corresponding to the pole shoe.

The loop **6** is driven by the loop **5** and moves in the field from the magnet **14**, which is inserted in an aperture in the wall members **2** and **3** and is so positioned that the neutral position of the loop **5** is in the neutral plane of the magnet. This causes the damping to be small for small amplitudes of the oscillation, so that the oscillatory system is easily started. Furthermore, the current induced in the loop has double the frequency of the oscillation. This is particularly advantageous when the relay is tuned to a very low frequency of only a few cycles per second and the output voltage of the relay is applied to an amplifier in that the circuit elements of the amplifier can then be of more suitable proportions. Also, no voltage is induced at small amplitudes, although the voltage increases sharply with increased amplitudes.

The voltage to be analyzed is applied to the transformer winding **15** via the connecting terminals **25**. The alternating voltage of the winding **15** sets up a magnetic field in the core **11,** which induces a current in the loop **5,** making the latter function as a secondary of the left hand transformer. The induced current interacts with the field of the magnet **13** and tends to move the loop **5** in synchronism with the applied voltage. Since the relay is tuned to a predetermined resonant frequency, the disc is made to oscillate about its neutral position only if this particular frequency is present in the applied voltage.

The oscillations performed by the loop 5 at the resonant frequency of the relay make the loop **6** oscillate in a corresponding manner in the field of the magnet **14.** This gives rise to a voltage which is transformed into a higher voltage in the right hand transformer, and which can then be derived from the winding **16** through the connecting terminals **26.**

As will be apparent from the above description, the disc forms two loops of two electrodynamic systems, one of the loops functioning as the secondary of an input transformer and the other loop functioning as the primary of an output transformer. Furthermore, the loops are directly joined to each other in such a way that the secondary of the one transformer drives mechanically the primary of the other.

The frequency-responsive relay according to the invention has several advantages. It is tunable to and is characterized by a marked sensitivity and selectivity at very low frequencies. The frequency characteristic of the relay and the resonant frequency thereof are continuously adjustable independently of each other. The magnetic directing force gives a resonant frequency which is independent of the oscillatory amplitude. The relay is mechanically balanced, which makes it insensitive to external mechanical influences of a kind that is apt to arise in connection with use in vehicles of various kinds. Finally, the relay doubles the applied frequency, which facilitates the proportioning of succeeding amplifying stages, particularly at low frequencies.

What I claim is:

1. A frequency responsive relay having a first portion and a second portion, said first portion comprising, a primary winding, a first movable loop conductor and a first permanent magnet, said primary winding having a magnetic core, said first loop conductor encircling both a portion of said magnetic core and a portion of said first permanent magnet; said first permanent magnet, and said winding when energized by a varying current, each being adapted to create a magnetic field in said loop, the field in said loop created by said permanent magnet interacting with the magnetic field created by said winding to cause said loop to oscillate in resonance with said energizing current; said second portion comprising, a second winding, a second movable loop conductor, and a second permanent magnet, said second winding having a magnetic core, said second loop conductor encircling both a portion of the magnetic core of said second winding and a portion of said second permanent magnet, said second movable loop conductor being electrically insulated from but rigidly joined with said first loop, to be actuated thereby; said second loop having a relationship of being the primary of an output transformer, whereby an output current is generated in said second winding due to the oscillation of said movable loop conductors.

2. The relay as defined in claim 1 wherein said first permanent magnet is adjustable with respect to said first movable loop conductor, whereby it is possible to alter the shape of the resonance curve of the relay, and thereby alter the selectivity of the relay.

3. The relay as defined in claim 1 wherein means are provided for selecting the frequency at which said movable loop conductors will oscillate.

4. The relay as defined in claim 1 wherein said movable loops when connected together, take the form of an elongated plate, said plate being rotatably mounted upon a shaft, so as to be able to oscillate thereabout.

5. The relay as defined in claim 4 wherein said plate has magnetized portions at diametrically opposed locations with respect to said shaft; a movable pole magnet generally aligned with said shaft and capable of being adjusted with respect to said magnetized portions, whereby the resonant frequency of the oscillating system can be set.

6. A frequency responsive relay comprising, first and second movable loop conductors, said loops being electrically insulated from each other but rigidly joined so as to be able to oscillate together; a permanent magnet and a winding having a magnetic core, associated with each loop, and encircled thereby, so that upon a varying current being impressed upon the winding associated with said first loop, the loops may be caused to oscillate, and a current to be thereby generated in the winding associated with said second loop.

7. The relay as defined in claim 6 wherein means are provided for selecting the frequency at which the loops will oscillate.

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