

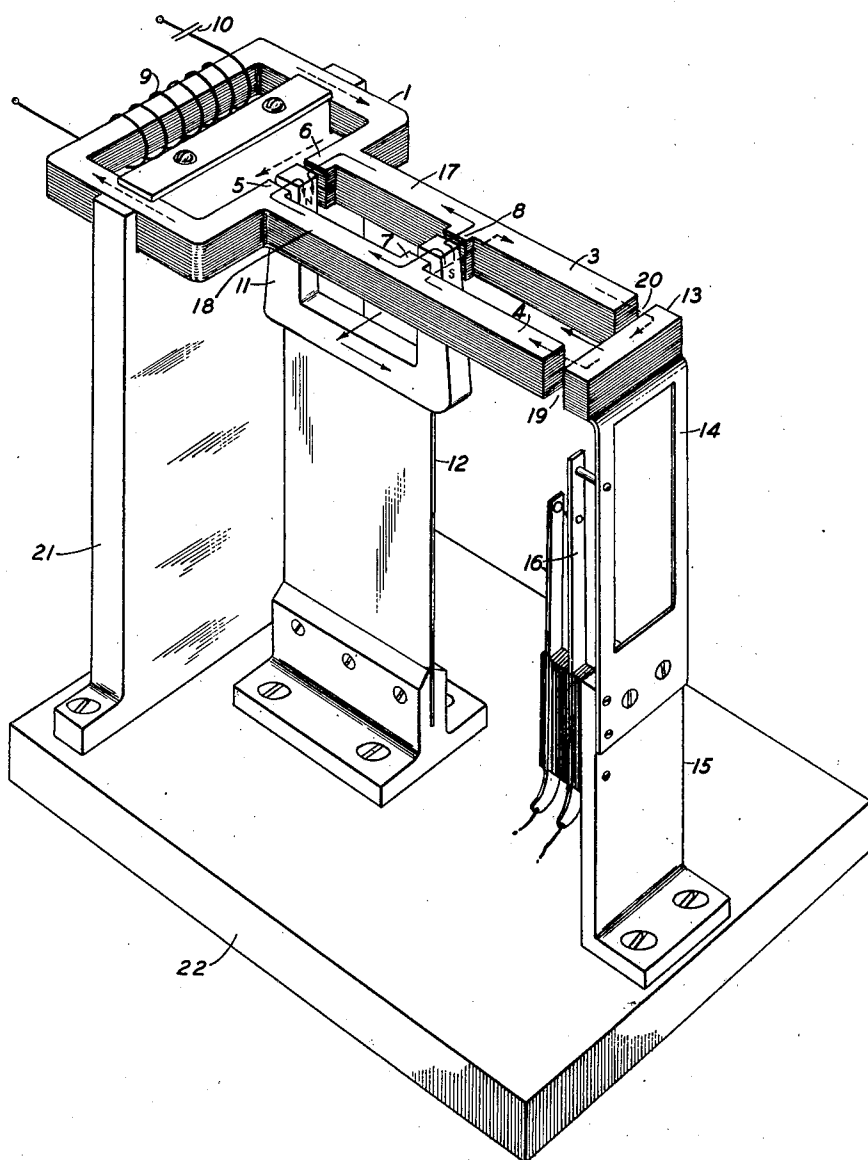
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RELAY

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RELAY

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This invention relates to alternating current relays and has for its object to improve the operating characteristics of such relays.

An alternating current relay may be defined as a device such that when one or more sinusoidal electromotive forces having different frequencies are applied at the electrical terminals of an electromechanical network an electrical contact is made by two mechanical members for stated intervals of time. From this statement it follows that somewhere in the system the alternating motion or forces (electrical, magnetic or mechanical) must be rectified. The most convenient form of rectifier to use appears to be an unpolarized electromagnet.

When a number of such sinusoidal electromotive forces are impressed across the terminals of such an electromagnet the resulting currents will generate alternating magnetic fluxes of the corresponding frequencies. The total mechanical force acting on the armature is proportional to the square of the total flux and hence may be resolved into a number of sinusoidal force components.

In the following theoretical discussion the term "pulsatance" is used. This term may be defined as 2π times frequency and has been adopted in carrier current signaling calculations as a somewhat more graphic unit than the frequency alone.

To understand the objects of this invention it will be helpful to consider the present method of operating multiplex carrier telegraph systems.

A number of carrier frequencies ranging from 250 cycles to 2,750 cycles are generated at the point of transmission. In order to impress the desired intelligence or signal on the carrier, each carrier, say of pulsatance ω , is modulated by a square topped wave by the process of "keying". This keying is carried on at a pulsatance ω_1 , which is in general, considerably lower than the lowest carrier frequency.

Each modulated carrier may be shown to be mathematically equivalent to an infinite number of sinusoidal currents composed of a carrier pulsatance ω and side-bands of pulsatance $\omega \pm \omega_1$, $\omega \pm 3\omega_1$, etc.

To conserve the frequency spectrum, only the frequencies written down above are transmitted. These are adequate for defining a signal having a square wave.

The problem at the receiving end is to sort out each carrier and its associated side-bands and to recover from each the original message. In accordance with present practice a number of electrical wave filters of the band-pass type are

used, each filter being capable of accepting only those frequencies whose pulsatance lies between $\omega - 3\omega_1$ and $\omega + 3\omega_1$. The output of each filter is passed on to an electrical demodulator and a signal resembling the square topped wave is recovered. This signal is then impressed on a conventional type of relay and an amplified, interrupted direct current is obtained.

The object of the present invention is to combine within one piece of apparatus the functions of a wave filter, a demodulator and a relay.

The invention will be more clearly understood from a consideration of the following description read in connection with the drawing which gives a schematic perspective showing of one embodiment of the invention.

As shown in the drawing, the combined structure comprises a laminated core member 1 mounted on bracket 21 secured to the base block 22. This core is shaped to form a rectangular loop 2 with two lateral extensions made up of intermediate portions 17 and 18 and polar extensions 3 and 4 from which project two sets of pole-pieces 5, 6 and 7, 8. Around the loop is wound a coil 9 connected in series with the condenser 10. Mounted between the pole-pieces is a U-shaped permanent magnet 11, one pole of the magnet largely filling the air-gap between the pole-pieces 5 and 6 and the other pole entering the air-gap between the pole-pieces 7 and 8. This magnet is mounted on a reed member 12 also secured to the block 22. Opposite the ends of the lateral extensions 3 and 4 is mounted an armature 13. This armature is mounted in adjustable relationship with the extensions 3 and 4 by spring 14 secured to the bracket 15 also mounted on the block 22. The armature controls the contact springs 16.

The manner in which the object of the invention is accomplished by this apparatus is as follows. The permanent magnet 11 and its supporting reed 12 are tuned to the carrier pulsatance ω . The coil 9 and condenser 10 are likewise tuned to pulsatance ω . By the proper proportioning of these elements with respect to the electromechanical force factor of the device, the elements described form an electromechanical band-pass filter capable of passing with substantial uniformity all frequencies whose pulsatances lie between $\omega - 3\omega_1$ and $\omega + 3\omega_1$, and rejecting all other frequencies.

More specifically, if the wave form were constructed of those components of the electrical current flowing, whose pulsatances are between $\omega - 3\omega_1$ and $\omega + 3\omega_1$ then the wave form of the in-

stantaneous displacement of the pole tips of the vibrating magnet would be a reasonably faithful copy of the aforesaid current wave, except for a possible difference in their phases. Currents of pulsance other than those included between $\omega-3\omega_1$ and $\omega+3\omega_1$ are strongly attenuated and have practically no influence on the motion of vibratory magnet 11.

The motion of the permanent magnet then generates a corresponding wave of magnetic flux whose seat is in the air-gaps lying between polar projections 7 and 8 and the pole of the magnet therein included.

By the proper proportioning of the apparatus, most of this flux can be made to flow along core piece 3, into the air-gap 20, thence through the armature 13, back through gap 19, into the core piece 4.

The important point to note at this stage is that on analysis the wave form of the magnetic flux in air-gaps 20 and 19, would be found to consist entirely of sinusoidal components whose pulsances would be in the range $\omega-3\omega_1$ and $\omega+3\omega_1$ and that there would be no component of frequency zero, that is, there would be no polarizing flux. Mathematically, this may be expressed as follows:

$$\begin{aligned} \varphi_{20} \text{ (or } \varphi_{19}) = & [\varphi_1 \sin \omega t + \varphi_2 \sin (\omega - \omega_1) t \\ & + \varphi_3 \sin (\omega - 3\omega_1) t + \varphi_4 \sin (\omega + \omega_1) t \\ & + \varphi_5 \sin (\omega + 3\omega_1) t] \end{aligned}$$

where φ_{20} or φ_{19} represents the flux in the respective gaps 20 and 19 and $\varphi_1 \dots \varphi_5$ represent the amplitudes of the component flux waves.

By Maxwell's law, the force acting on the armature 13 is proportional to the square of the flux in the air-gaps 19 and 20. If this calculation were carried out, the following force components would be found to exist

$$\varphi_1 [\varphi_2 + \varphi_4] \cos \omega_1 t + \varphi_1 [\varphi_3 + \varphi_5] \cos 3\omega_1 t,$$

a steady force whose value is the sum of the squares of φ_1 , φ_2 , etc., and also a large number of undesired terms of high order, such as $2\omega_1$, $4\omega_1$, $6\omega_1$, $2\omega + \omega_1$, $2\omega \pm 3\omega_1$, etc.

The force terms $\varphi_1 [\varphi_2 + \varphi_4] \cos \omega_1 t + \varphi_1 [\varphi_3 + \varphi_5] \cos 3\omega_1 t$ when added have the wave form of that much of the original modulating signal as was permitted to be transmitted. That is to say, it is a copy of that much of the original square topped wave as is necessary to define the signal.

If the armature 13 and its associated spring 14 are tuned to a pulsance somewhat higher than $3\omega_1$ the armature will respond proportionately to all forces having a pulsance less than $3\omega_1$ and will not respond to the higher frequency terms.

It can be seen from the foregoing that there is an essential difference between the vibratory properties of magnet 11 and reed 12 and armature 13 and its spring 14.

The former combination responds uniformly over a band of frequencies whose pulsances lie between $\omega-3\omega_1$ and $\omega+3\omega_1$. The latter combination responds only to pulsances not appreciably higher than $3\omega_1$.

It is to be noted that the laminations in the core, pole-pieces and armature are parallel with the direction of flow of the fluxes. In the form

shown in the figure these laminations may be formed by a single punching operation. However, if desired for compactness and convenience in mounting, the loop portion 2 and extension portions 3 and 4 of the core may be formed separately from the intermediate sections 17 and 18 and turned at a right angle, thereby permitting the armature 13 to be moved in a vertical direction. The intermediate sections 17 and 18 are so formed or treated as to be less permeable to alternating flux than to direct magnetic flux, and in the modified form suggested may be made of solid bars.

What is claimed is:

1. An electromagnetic device comprising in combination a mechanical filter and a relay, said device including in a unitary structure a tuned vibratory armature and a contact controlling armature, and means for generating a demodulated force under the control of said tuned armature to act on said contact carrying armature.

2. An electromagnetic device comprising a coil, pole-pieces therefor, an armature mounted to vibrate between said pole-pieces, a pair of additional pole-pieces magnetically linked to said first pole-pieces, said armature also vibrating between said additional pole-pieces and a second armature controlled by said additional pole-pieces.

3. An electromagnetic device comprising a coil, pole-pieces therefor, a permanent magnet mounted as an armature to vibrate between said pole-pieces, a pair of additional pole-pieces magnetically linked to said first pole-pieces, said armature also vibrating between said additional pole-pieces and a second armature controlled by said additional pole-pieces.

4. An electromagnetic device comprising a coil, a pair of pole-pieces for said coil, a second pair of pole-pieces magnetically linked with said first pole-pieces, a flexibly mounted permanent magnet having poles cooperating, respectively, with said sets of pole-pieces to set up a polarizing flux, and a second armature associated with said second pair of pole-pieces.

5. An electromagnetic device comprising a coil, a pair of pole-pieces for said coil, a second pair of pole-pieces magnetically linked with said first pole-pieces, a flexibly mounted permanent magnet having poles cooperating respectively with said sets of pole-pieces to set up a polarizing flux, and a second armature associated with said second pair of pole-pieces responsive to the demodulation products of alternating current applied to said coil.

6. An electromagnetic device comprising a coil, a pair of pole-pieces for said coil, a second pair of pole-pieces magnetically linked with said first pole-pieces, a flexibly mounted permanent magnet having poles cooperating respectively with said sets of pole-pieces to set up a polarizing flux, means for applying alternating current to said coil to vibrate said magnet, and a second armature associated with said second pair of pole-pieces responsive to the demodulation products generated by the motion of said magnet relative to said second pair of pole-pieces.

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