

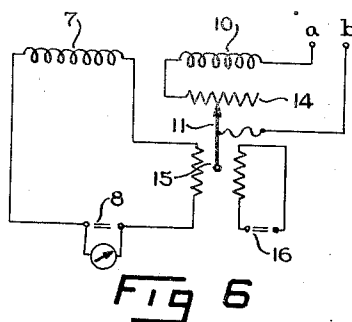
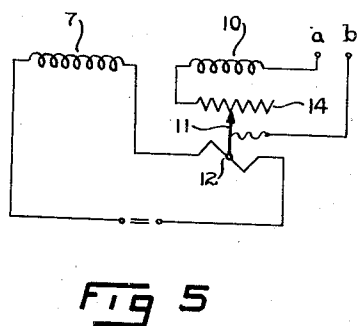
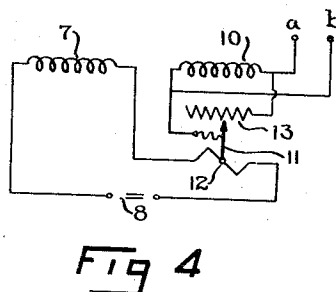
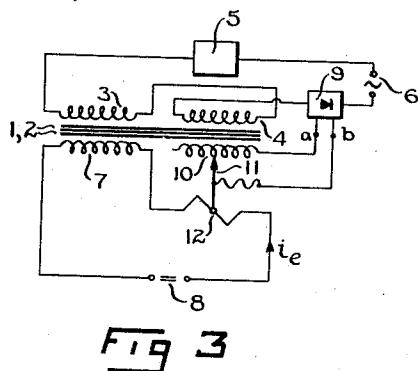
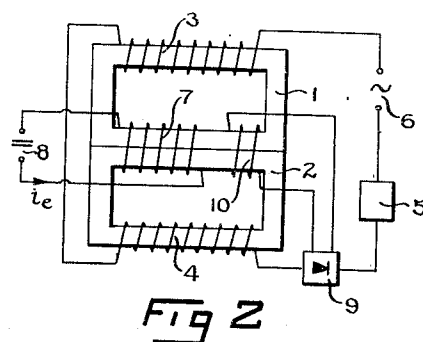
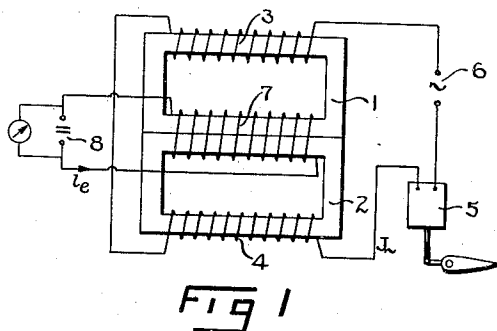
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POWER AMPLIFIER

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POWER AMPLIFIER

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7 Claims. (Cl. 171-242)

This invention relates to an arrangement for adjusting an organ, particularly a control surface or the like in airplanes or seagoing vessels.

In the copending application Serial No. 290,968 filed August 19, 1939, is described an arrangement for adjusting an organ, particularly a control surface or the like in airplanes or seagoing vessels in accordance with instruments capable of being loaded only to a slight extent, such as directional indicators, for instance, compasses, gyro-indicators or the like.

According to the above copending application the electrical magnitude transmitted by said instruments is transmitted to a magnetic amplifier arrangement connected to a feed back circuit and is amplified by the amplifier arrangement in such a manner that the output energy which the amplifier supplies to the current consuming device, for instance, to an electrical directional drive, has such a value as to bring about an adjustment of the organ.

The present invention relates to an improvement in the novel magnetic amplifier provided in the arrangement according to the above copending application.

Before proceeding with the description of the invention the operation of the magnetic amplifier disclosed in the above copending application is hereinafter briefly repeated with reference to Figs. 1 and 2.

In Fig. 1, 1 and 2 denote cores consisting of a material of high magnetic permeability, for instance, of an iron-nickel alloy. The two cores are provided each with a winding 3 and 4 respectively. The two windings 3 and 4 are arranged in series and in series with the current consuming device 5 energized by the alternating-current source 6. In the windings and therefore in the current consuming device 5 flows an alternating current J whose magnitude depends upon the alternating-current resistance of the windings. The magnitude of this resistance depends upon the permeability of the two cores in accordance with the working point on the magnetization curve. On the two cores is arranged a common winding 7 which is traversed by the direct current i_d supplied by an impulse transmitter (not shown). The two windings 3 and 4 are so wound that the voltages induced in the winding 7 by the current flowing in the windings 3 and 4 annul each other. The direct current flowing in the winding 7 produces in both cores magnetic fluxes which displace the working point on the magnetization curve. By displacing the working point the permeability changes

according to the magnetization curve and therefore changes the alternating-current resistance of the windings 3 and 4. The alternating-current resistance of these windings depends therefore upon the direct current i_d flowing in the winding 7 and varies with the direct current.

If the output current is plotted against the input current in a diagram for an arrangement according to Fig. 1 without consuming device, the inclination of the tangent on this curve in the working point is to be considered as the steepness of the magnetic amplifier. The amplification factor of the arrangement depends upon this steepness.

In the arrangement according to the above copending application an increase of the amplification factor is attained by the fact that the alternating current flowing in the windings 3 and 4 is rectified and is rendered effective in the sense of a self-amplification by the feed back by supplying the alternating current to an additional winding which is allotted to the two cores in the same manner as the winding 7 of Fig. 1. The effect of this feed back will now be briefly explained with the reference to Fig. 2 in connection with the disclosure of the above copending application. In Fig. 2 the same parts are denoted by the same reference numerals as in Fig. 1. 1 and 2 denote the cores consisting of a material of high magnetic permeability, 3 and 4 the windings arranged on these cores and traversed by the alternating current, 5 the current consuming device and 6 the power source. 7 designates the winding traversed by the direct current supplied by the directional indicator 8. The alternating current flowing in the windings 3 and 4 traverses a rectifier arrangement 9. The current rectified with the aid of this rectifier arrangement is supplied to the additional winding 10 which is allotted to the cores 1 and 2 in the same manner as the winding 7. Consequently, a periodically variable current whose effect may be attributed to the effect of a direct current flows in the winding 10. The current in this winding displaces the working point on the magnetization curve and therefore varies the permeability of the cores 1 and 2 as well as the alternating-current resistance of the windings 3 and 4 in the same manner as above described for the effect of the current i_d flowing in the winding 7. Depending upon the direction of flow of the current in the rectifier arrangement 9 and upon the direction of the current flowing in the winding 7 the current in the winding 10 produces in the cores 1 and 2 mag-

netic fluxes which have both either the same or opposite direction as the fluxes which are produced by the current i_e in the winding 7, i. e., the fluxes may be either added or subtracted. It is first assumed that $i_e=0$. The current J flowing in the windings 3 and 4 and in the current consuming device 5 is denoted in this case by J_0 and the current j flowing in the winding 10 is denoted by j_0 correspondingly to the zero current J_0 . The working point on the magnetization curve of the cores 1 and 2 is determined by the currents J_0 and j_0 . If a current i_e flows in the winding 7 in the direction that the magnetic fluxes in the cores produced thereby have the same direction as the fluxes which are produced by j , the working point on the magnetization curve is shifted by the effect of the current i_e so as to reduce the permeability of the cores and therefore the alternating-current resistance of the two windings 3 and 4. With decreasing alternating-current resistance J increases, which in turn brings about an increase of j . To the increase of j corresponds an increase of the flux in the cores produced by this current, which increase causes a further decrease of the permeability, therefore a further decrease of the alternating-current resistances of the windings 3 and 4 as well as a further increase of the current J . Consequently, the current j causes an increase in the effect of the input current i_e in the form of a self-amplification and therefore an increase in the amplification factor.

In this arrangement the feed back is constant. The magnitude of the feed back and therefore the amplification factor cannot assume any high value for the following reason. The resistance of the two windings 3 and 4 retains always a definite value also in case the winding 7 is de-energized, i. e. an alternating current flows in this arrangement also in this zero position. This zero current J_0 produces a magnetic bias and thereby decreases the initial permeability as well as the initial resistance of the windings 3 and 4. This means an undesirable increase in the zero current with increasing number of turns of the winding 10 with respect to an arrangement without feed back and at the same time a restriction of the controllable resistance range of the windings 3 and 4, since the smallest resistance value which these windings may assume is the value for which the two cores 1 and 2 are completely saturated. Upon these two moments depends the selection of the magnitude of the constant feed back.

According to the present invention means are provided in the feed back circuit for preferably automatically controlling the feed back so as to influence the amplification factor.

Further details of the invention will be apparent from the following description taken in connection with the accompanying drawing, in which

Figs. 1 and 2 diagrammatically show the magnetic amplifier described in the above copending application.

Fig. 3 shows an embodiment of the novel arrangement in which the effective number of turns of the feed back winding may be varied.

Figs. 4 and 5 show further embodiments of the invention in which regulable resistances are employed.

Fig. 6 shows an embodiment of the invention with two impulse transmitters serving as regulating organs.

In Fig. 3, in which are diagrammatically illus-

trated the parts shown in Fig. 2, 1 and 2 denote the two cores, 3 and 4 the windings traversed by the alternating current J , 5 the current consuming device, 6 the alternating-current source, 7 the winding traversed by the input current i_e , and 8 the impulse transmitter supplying the input current. The feed back winding 10 is on the one hand directly connected to the rectifier arrangement 9 and on the other hand through a slide contact 11. The slide contact is operated by an instrument 12 operating in this embodiment in the form of a measuring mechanism and which is traversed by the current i_e . The slide contact causes depending upon its position more or less turns of the feed back winding 10 to be traversed by the rectified alternating current so as to increase more or less the feed back. In this case the arrangement is so designed that for an input current $i_e=0$ no or only a few turns of the winding 10 are inserted in the circuit, that with increasing current i_e the number of the turns inserted increases and that for the maximum value of the input current i_e the desired greatest number of feed back windings lie in the feed back circuit.

If the input current is very small, the effect of the feed back is very slight. The effect may be reduced to a minimum, which implies that the zero current in the arrangement may be reduced to an output value as is desired for an arrangement without feed back. In this manner at the same time the complete controllable resistance range of the windings 3 and 4 is maintained as in the case of the arrangement without feed back. It is now thus possible to give the feed back for the greatest value of i_e and therefore the amplification factor of the magnetic amplifier any high value.

Fig. 4 shows another embodiment of the invention. The arrangement of the parts 1 to 6 and 9 is the same as that shown in the embodiment of Fig. 3 and is therefore not shown in this figure. In Fig. 4 the feed back winding 10 is connected to the points a and b of Fig. 3 and the number of turns of the winding 10 is so chosen that for the maximum value of i_e the desired maximum feed back is attained. Parallel to this feed back winding is connected a resistance 13 whose effective magnitude is controllable in accordance with the intensity of the input current i_e with the aid of the slide contact 11 operated by the instrument 12. In this case the arrangement is, for instance, so designed that for the maximum value of i_e the slide contact 11 lies on the free end of the resistance which is so chosen that in this case it is practically ineffective as a shunt for the winding 10, whereas for $i_e=0$ the slide contact 11 lies on the opposite end of the resistance 13 and the winding 10 is thus practically short circuited and therefore the feed back is ineffective.

In Fig. 5 the resistance 14 is series connected to the feed back winding and is controlled in a similar manner as in the embodiment shown in Fig. 4 by the instrument 12 with the aid of the slide contact 11, in which case, however, the resistance 14 for $i_e=0$ assumes its maximum value and for the maximum value of i_e the desired minimum value.

By means of the resistance 14 it is at the same time possible to equalize in a simple manner the non-uniformities which occur in the case of mass production, for instance, owing to the non-uniformities of the material, particularly of the core material which presents in the case of high-

ly permeable materials great fluctuations as to the permeability.

Furthermore, it is possible by the choice of the magnitude and the characteristic of this resistance (logarithmically, quadratically etc.) to influence the characteristic of the amplifier—relation between output current and input current—and to adapt it to a great extent to the corresponding purpose. In this case it is, of course, possible to use the invention in a manner other than the above described, for instance, in such a manner that in contradistinction to the embodiments previously described the feed back is kept large for small input currents i_e and small for large input currents i_e .

According to the invention it is also possible to control the feed back by hand alone or in connection with the automatic control. The automatic control may be controlled by the input current or also by an auxiliary current alone or in connection with the input current which is supplied by another impulse transmitter. Such an embodiment is shown in Fig. 6 in which 15 denotes a double instrument which is operated on the one hand by the input current i_e and on the other hand by the auxiliary current i_z supplied by the impulse transmitter 16.

Of course, any electrical magnitudes supplied by the impulse transmitters may be employed for the control.

What is claimed is:

1. A magnetic amplifier comprising a magnetizable core carrying a pair of windings connected in series opposed relation, a source of alternating current connected to energize said pair of windings, means for rectifying the output current of said windings, a direct current input circuit including a third winding on said core whereby during current flow in said third winding the reactance and output current of said pair of windings are varied, feed back means for said core for additionally varying the reactance of said pair of windings in accordance with the output current of the rectifying means, and control means electrically connected with said feed back means and said rectifying means and energized by the current flowing in the direct current input circuit for controlling the effect of said feed back means on said core as a function of the current flowing in said direct current input circuit.

2. A magnetic amplifier comprising a magnetizable core carrying a pair of windings connected in series opposed relation, a source of alternating current connected to energize said pair of windings, means for rectifying the output current of said windings, a direct current input circuit including a third winding on said core whereby during current flow in said third winding the reactance and output current of said pair of windings is varied, feed back means connected with said rectified output current and associated with said core for additionally varying the reactance and output current of said pair of windings in accordance with the output current of the rectifying means, and control means electrically connected with said feed back means and said rectifying means and energized by the current flowing in the direct current input circuit for controlling the effect of said feed back means on said core as a function of the current flowing in said direct current circuit.

3. A magnetic amplifier comprising a magnetizable core carrying a pair of windings connected in series opposed relation, a source of alternating current connected to energize said

pair of windings, means for rectifying the output current of said windings, a direct current input circuit including a third winding on said core whereby during current flow in said third winding the reactance and output current of said pair of windings is varied, feed back means comprising a fourth winding wound on said core and connected with said rectified output current for additionally varying the reactance and output current of said pair of windings in accordance with the output current of the rectifying means, and control means electrically connected with said feed back means and said rectifying means and energized by the current flowing in the direct current input circuit for controlling the effect of said fourth winding on said core as a function of the current flowing in said direct current circuit.

4. A magnetic amplifier comprising a magnetizable core carrying a pair of coils connected in series opposed relation, a source of alternating current connected to energize said pair of coils, means for rectifying the output current of said coils, a direct current input circuit including a third coil on said core whereby during current flow in said third coil the reactance and output current of said pair of coils is varied, feed back means including a fourth coil having a plurality of turns mounted on said core and connected with said rectified output current whereby current flows therethrough to additionally vary the reactance and output current of said pair of coils, resistance means in circuit with said fourth coil, and means energized by the current flowing in the third coil and associated with said feed back means for engaging and variably selecting the value of said resistance means whereby the effect of said fourth coil upon said pair of coils is varied as a function of the input current of said third winding.

5. A magnetic amplifier comprising a magnetizable core carrying a pair of coils connected in series opposed relation, a source of alternating current connected to energize said pair of coils, means for rectifying the output current of said coils, a direct current input circuit including a third coil on said core whereby during current flow in said third coil the reactance and output current of said pair of coils is varied, feed back means including a fourth coil having a plurality of turns mounted on said core and connected with said rectified output current whereby current flows therethrough to additionally vary the reactance and output current of said pair of coils, resistance means in circuit with said fourth coil, and control means actuated in accordance with the direct current flow in said third coil for slidably engaging and variably selecting the value of said resistance means whereby the effect of said fourth coil upon said pair of coils is varied as a function of the input current of said third winding.

6. A magnetic amplifier comprising a magnetizable core carrying a pair of windings connected in series opposed relation, a source of alternating current connected to energize said pair of windings, means for rectifying the output current of said coils, a direct current input circuit including a third winding on said core whereby during current flow in said third winding the reactance and output current of said pair of windings is varied, feed back means including a fourth winding on said core and connected with said rectifying means output whereby current flows in said fourth winding to additionally vary

the reactance and output current of said pair of windings, a resistor in parallel with said fourth winding, and means slidably engaging said resistor for variably selecting the value of said resistor in accordance with the value of current flowing in said third winding whereby the current flow in said fourth winding is controlled as a function of said input current.

7. A magnetic amplifier comprising a magnetizable core carrying a pair of windings connected in series opposed relation, a source of alternating current connected to energize said pair of windings, means for rectifying the output current of said coils, a direct current input circuit including a third winding on said core where-

by during current flow in said third winding the reactance and output current of said pair of windings is varied, feed back means including a fourth winding on said core and connected with said rectifying means output whereby current flows in said fourth winding to additionally vary the reactance and output current of said pair of windings, a resistor in series with said fourth winding, and means slidably engaging said resistor for variably selecting the value of said resistor in accordance with the value of current flowing in said third winding whereby the current flow in said fourth winding is controlled as a function of said input current.

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