PUBLISHED

JULY 13, 1943.

BY A. P. C.

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ELECTRIC APPARATUS FORMING PARTS OF INDICATING, MEASURING, REGULATING AND STEERING SYSTEMS

Filed Feb. 15, 1943

Serial No. 476,022

4 Sheets-Sheet 1

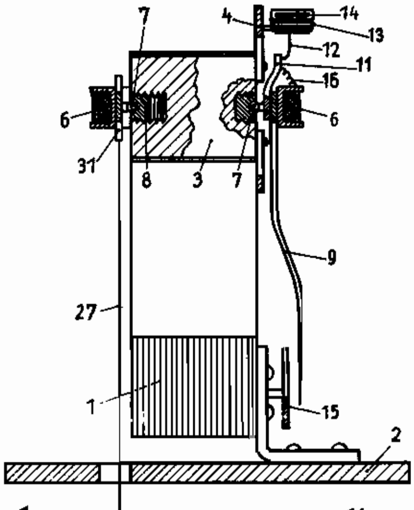

Fig.1

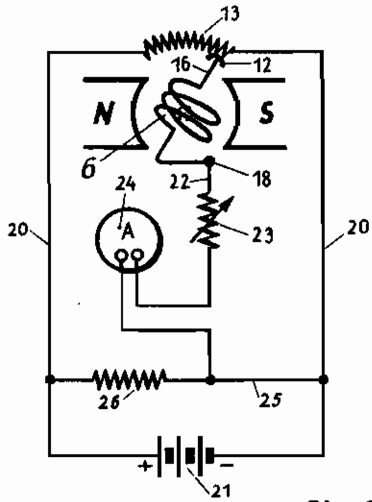

Fig.3

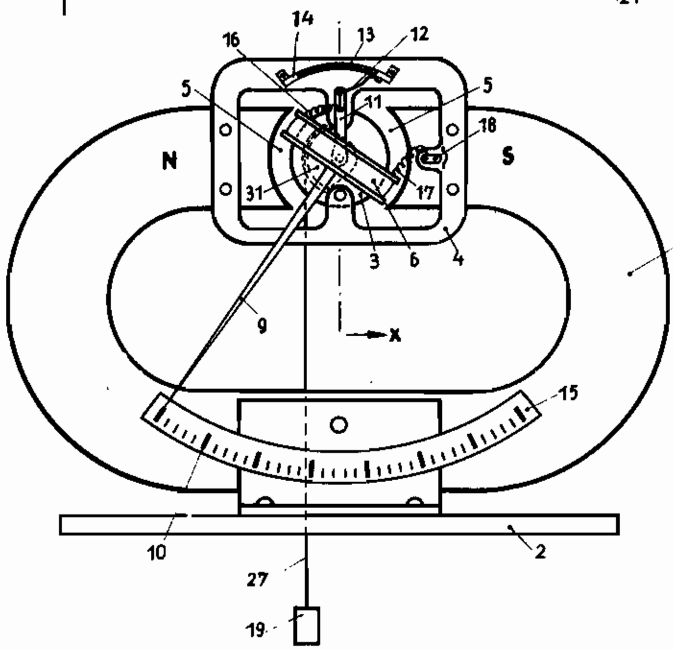

Fig.2

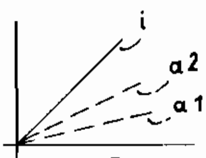

Fig.4

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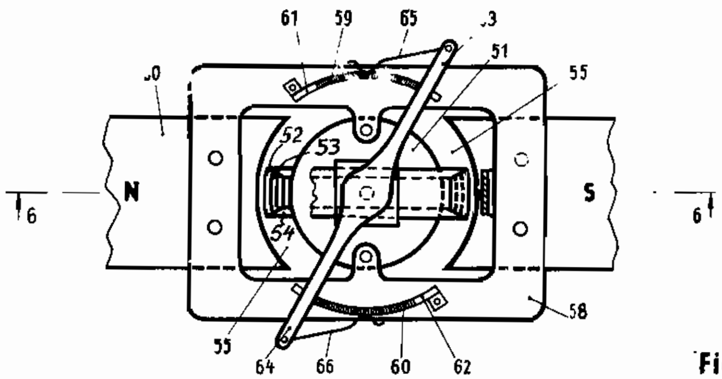

Fig. 5

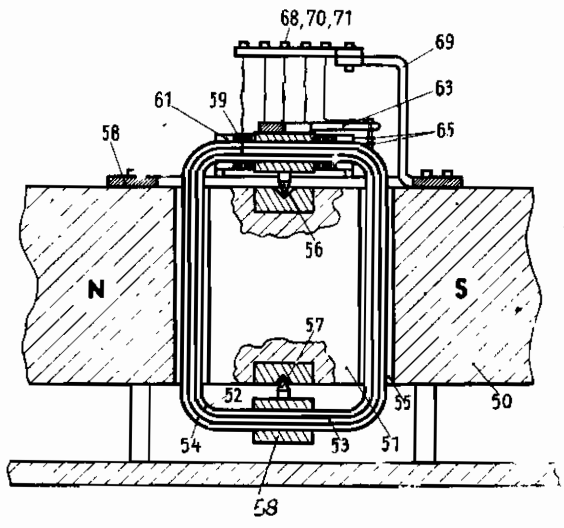

Fig. 6

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PUBLISHED

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4 Sheets-Sheet 3

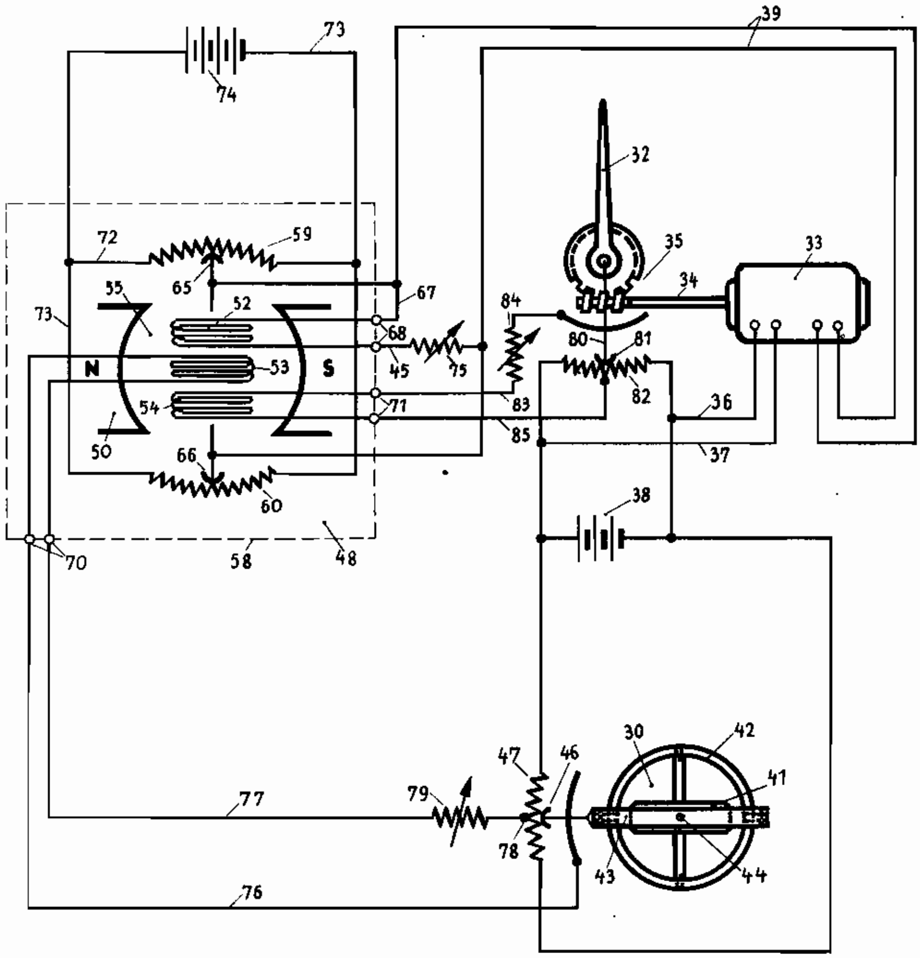

Fig. 7

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4 Sheets-Sheet 4

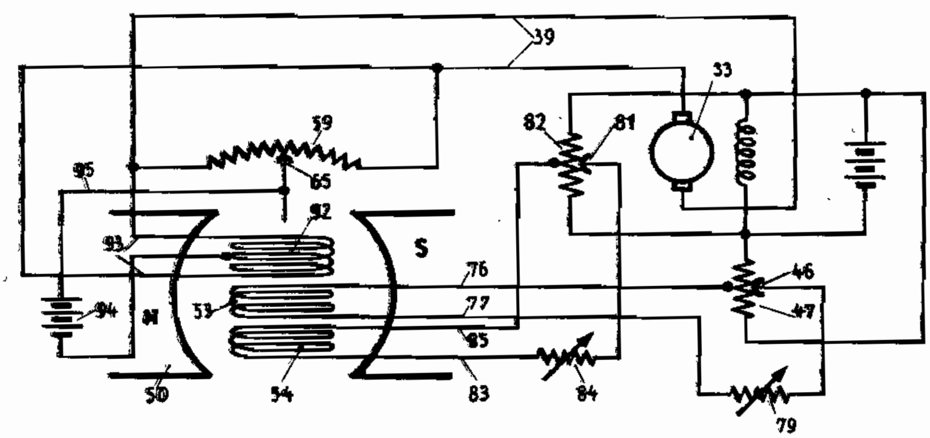

Fig. 8

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Published July 13, 1943 Serial No. 476,022

ALIEN PROPERTY CUSTODIAN

ELECTRIC APPARATUS FORMING PARTS OF INDICATING, MEASURING, REGULATING AND STEERING SYSTEMS

Albert Patin, Berlin, Germany; vested in the Alien Property Custodian

Application filed February 15, 1943

My invention relates to improvements in electric apparatus forming parts of indicating, measuring, regulating and steering systems, and more particularly in devices having the function of a spring and tending to hold a movable element or elements in an initial position and adapted when the said element or elements have been moved to return the same into said initial position. My device may be used for example in measuring systems and relays, and generally in sensitive systems, and in such systems the device has the function to return a movable element or elements into initial position when the said element or elements have been brought out of the said initial position by a force acting thereon. One of the objects of the improvements is to provide an apparatus which is constant in operation and independent of outer influences, and which therefore is adapted to set the said element or elements exactly in the same initial position. In this respect my improved apparatus is distinguished from springs now in use which are subject to fatiguing and to influences by temperature, and which therefore must be constantly under control by an attendant. Another object of the improvements is to provide an apparatus of the class indicated which may be readily varied as to its directing force even while the system is in service. With these and other objects in view my improved apparatus comprises electromagnetic means including means to generate a magnetic field and a conductor adapted to be energized by electric current and when thus energized to produce a magnetic field cooperating with the aforesaid magnetic field, the said means to produce a magnetic field and conductor being movable relatively to each other under the influence of the force resulting from the said fields, current regulating means operatively connected with said electromagnetic means and movable in accordance with the relative displacement of said field generating means and conductor, a source of electric energy, and a circuit connecting said conductor, current regulating means and source of electric energy in such a way that when said conductor and field generating means are moved relatively to each other by an outer force, a current flows through the said conductor and generates a magnetic field, the said fields tending to return the conductor and field generating means into initial relative position, the said device forming a part of a system such as has been referred to above.

For the purpose of explaining the invention several examples embodying the same have been shown in the accompanying drawings, in which the same reference characters have been used in all the views to indicate corresponding parts. In said drawings

Fig. 1 is a diagrammatical sectional elevation showing a system acting as a dynamometer,

Fig. 2 is a side elevation of Fig. 1,

Fig. 3 is a diagram showing the electrical circuits of the apparatus shown in Figs. 1 and 2,

Fig. 4 is a diagram illustrating the operation of the apparatus shown in Figs. 1 to 3,

Fig. 5 is a diagrammatical plan view showing a modification,

Fig. 6 is a fragmentary sectional elevation taken on the line 6—6 of Fig. 5,

Fig. 7 is a diagram showing the circuits of a system including the apparatus shown in Figs. 5 and 6, and

Fig. 8 is a diagram showing the electrical circuits of a system similar to that shown in Fig. 7.

In Figs. 1 to 3 my improved apparatus has been shown embodied in a system for measuring forces or gravities. As shown, the apparatus comprises a permanent magnet 1 supported on a base plate 2, a soft iron core 3 located between the poles N—S of the said magnet and fixed to a plate 4 secured to the magnet 1 and providing annular gaps 5 therewith, and an electric coil 6 rotatably mounted coaxially of the core 3. The said coil is mounted by means of trunnions 7 in suitable bearings provided in the core 3. To the coil 6 a hand 9 is secured which plays on scale marks 10 made on a segmental plate 15 fixed to the magnet 1. Further, an arm 11 is secured to the said coil and the said arm carries a fine and exceedingly resilient spring contact 12 which is in sliding engagement with a coil 13 of bare and closely wound wire placed on a carrier 14 mounted on the plate 4.

One end of the coil 6 is connected by a lead 16 with the spring contact 12. The opposite end of the coil is connected with a terminal 18 secured to and insulated from the plate 4 so as to permit free movement of the coil. As shown the connection consists of a flexible wire 17.

To the coil 6 a segmental disk 31 is secured which has a tension element 27 trained on its circumference. To the said tension element the force to be measured is applied which has been represented in Fig. 1 by a weighted body 19.

The resistance coil 13 is included in a circuit 20 including a source of electric energy such as a battery 21 (Fig. 3). The terminal 19 is connected by a lead 22 with a resistance 23 and an ammeter 24, and the said lead 22 is connected to a lead 25 connected to the circuit 20 at opposite sides of the battery 21 and including a resistance 26. Preferably the resistance 26 is substantially equal to the resistance 13.

The operation of the system is as follows:

When no force is applied to the system the parts are in the positions shown in Fig. 2. The spring contact 12 engages the resistance coil 13 at the right hand end, and the hand 9 is in zero position relatively to the scale marks 10. The ends of the coil 6 are connected to the same potential, and therefore no current flows through the coil. If now the force to be measured is applied to the tension element 27 the coil 6, the arm 11 and the hand 9 are turned anticlockwise and in the direction of the arrow x shown in Fig. 2. By the said rotary movement the spring contact 12 is made to slide on the resistance wire 13 to the left, and therefore the potential of the lead 16 and of the left hand terminal of the coil 6 is reduced. Thus a current flows through the said coil and a magnetic field is produced by the said coil which cooperates with the permanent field N—S, the coil being wound so that the force produced thereby acts in opposition to the force represented by the weighted body 19, until the current flowing through the coil and the force produced thereby balance the moment exerted by the force.

The angle through which the hand 9 is turned is a measure of the force.

The wire 13 is uniformly wound into a coil, and therefore the annular displacement of the hand 9 is proportional to the force. Thus the system acts in the same way as an exact spring.

I wish it to be understood that my invention is not limited to the construction shown herein in which the windings of the coil 13 and the scale marks are uniform. In some cases it may be desirable to provide a coil 13 in which the wire is non-uniformly wound and in which the scale marks 10 are arranged accordingly. This may be desirable in order to permit more accurate measurements to be made in a certain range of the resistance and scale marks.

The current flowing through the coil 6 and therefore the directing force of the system may be varied or regulated by means of the variable resistance 23. Thereby the system may readily be set for measuring widely different forces.

The force exerted on the system is represented not only by the intensity of the magnetic field generated by the coil 6, but also by the current flowing through the said coil, and the potential difference at the ends of the coil. Therefore the said force may be measured not only by means of the hand 9 and the scale marks 10, but also by the ammeter 24, which is valuable for the reason that the said ammeter may be located at a suitable part remote from the system. I have found that measuring by means of the ammeter 24 or a voltmeter connected to the ends of the coil 6 is more accurate than measuring by means of the hand 8 and the scale marks 10, because the accuracy of the last-named measurement depends on the uniformity of the winding of the coil 13, while the said electrical values measured by the said ammeter 24 or the said voltmeter are proportional to the force exerted on the system when the coil 13 has not been accurately wound.

The diagram shown in Fig. 4 illustrates the dependence of the angular movement of the hand 9 and the current flowing through the coil on the force 19 to be measured. The lines a_1 and a_2 show measurements made with different resistances 23, the line a_1 corresponding to a small resistance, and the line a_2 to a larger resistance 23. The current i made to flow through the coil by a certain force is independent of the resistance 23. The diagram shows the values a_1 and a_2 corresponding to uniform winding of the resistance 13. If the winding of the said resistance is not uniform, the lines a_1 and a_2 are curved, while the line i remains rectilinear.

While in Figs. 1 to 3 I have shown my improved apparatus as used in a system for measuring forces or gravities, I wish it to be understood that my invention is not limited to such use.

In Figs. 5 to 7 I have shown my improved apparatus embodied in a controlling system, the said controlling system being used for example for steering a ship or an air craft. The figures also show a modification of the improved apparatus.

In the example shown in the figures the system is used for setting the rudder 32 of the craft, the setting mechanism being controlled by a gyroscope 30. The rudder is operated by means of a direct current motor 33, a shaft 34 and a worm gearing 35. The field winding of the motor is connected by leads 36 and 37 with a source of electric current 38, and current is supplied to the armature by means of leads 39. The gyroscope 30 includes a rotary body 41 which is mounted in an annular frame 42 pivotally mounted in an annular frame 43, and the said frame 43 is pivotally mounted by means of a vertical axis 44 in a frame (not shown) fixed to the craft. To the frame 43 a contact 46 is secured which slides on a resistance 47.

The controlling movement of the gyroscope is transmitted to the motor 33 by means of a relay 49 including my improved apparatus.

The said relay comprises a permanent magnet 50 between the poles N and S of which a stationary soft iron core 51 is located, the said core being fixed to a plate 58 secured to the magnet 50. Concentrically of the said core three coils 52, 53 and 54 are mounted the side portions of which are located in annular gaps 55 provided between the poles N, S and the core 51. The said coils are mounted on a common carrier 58 which is pivotally mounted at 56 and 57 on the core 51. Concentrically of the coils resistance coils 59 and 60 are mounted on carriers 61 and 62. To the coils 52, 53, 54 arms 63 and 64 are secured which carry thin contact springs 65 and 66 sliding on the resistance coils 59 and 60.

In the relay 48 the coil 52 provides my improved electric device which has the function of a spring. The coil 52 is connected with fixed terminals 68, the connection being so that the rotary movement of the coil is not interferred with, and one of the said terminals is connected by a lead 67 with the contact spring 65. The terminals of the coils 53 and 54 are connected with contacts 70 and 71 respectively. The said contacts 68, 70 and 71 are mounted on a bracket 69 rising from the magnet 50.

The resistances 59 and 60 are included in a circuit 72, 73 including a source of electric energy 74, the said resistances being connected in shunt.

One of the contacts 68 connected with the terminals of the coil 52 has a lead 45 connected thereto, and the said lead includes a regulatable resistance 75.

The terminals 79 of the coil 53 are connected by leads 76 and 77 respectively with the contact 46 carried by the frame 43 and a contact 78 located at the middle of the resistance 47, and the lead 77 includes a regulatable resistance 79.

The rudder 32 is connected with an arm 80 carrying a contact 81 sliding on a resistance 82, and the contact 81 is connected by a lead 83 including a regulatable resistance 84 with one of the terminals 71 of the coil 54, and the other terminal 71 of the said coil is connected by a lead 85 with the middle of the resistance wire 82.

The operation of the system is as follows:

Normally, that is when the craft is at the desired course, the rudder 32 is in the position shown in Fig. 7 in which the arm 81 engages the coil 82 at its middle. The contact 46 of the frame 43 likewise engages the resistance wire 47 at its middle. The coils 53 and 54 are adapted to be energized by current from the source 38. But in the median positions of the contact arm 81 and the frame 43 no current is supplied to the coils, because the terminals of the coils have the same potential. The set of coils 52, 53, 54 is held in the median position shown in Fig. 7, because any displacement of the coils from the median position would cause energization of the coil 52, and the magnetic field of the coil thus produced would return the set of coils into median position.

When the craft leaves the desired course the contact 46 slides on the resistance 47 either to the right or left by the well known action of the gyroscope. Thereby a potential difference is produced between the contacts 46 and 78, so that the coil 53 is energized for turning the set of coils 52, 53, 54 clockwise or anticlockwise, according to the change of the course of the craft. Thus, the contacts 65 and 66 are shifted on the resistance coils 59 and 60 clockwise or anticlockwise. Assuming the coils to have been turned clockwise, the current flows from the battery 74 through the right hand portion of the circuit 73, the right hand portion of the resistance coil 59, one of the terminals 68 of the coil 52, the coil 52, the second terminal 68 of the coil 52, the resistance 75, the contact spring 66, the left hand portion of the resistance 60, and the battery 74. Thus a magnetic field is produced by the coil 52 which limits the movement of the set of coils to a point in which the forces resulting from the fields of the coils 53 and 52 are in equilibrium, and which tends to return the set of coils 52, 53 and 54 into initial position. From the terminals 68 current flows through the leads 39 and the armature of the motor 33, whereby the said motor and rudder 32 are turned in one or the other direction, according to the direction of the displacement of the contact 46 and the contact spring 65. Thus the rudder is turned in a direction for returning the craft into the normal course. It will be understood that the coil 53 counteracts the coil 52 so that for the present coil 52 is not able to return the set of coils into initial position.

By the movement of the rudder 32 the contact 81 is shifted on the resistance 82, and thereby a potential difference is produced between the contact 81 and the lead 85, so that also the coil 54 is energized. The coils 53 and 54 are wound so that by each change of the course fields are produced in the said coils which counteract each other, and therefore, when the rudder is set in the manner just described the magnetic field produced by the coil 54 counteracts the field produced by the coil 53, and, finally, an equilibrium of the fields of the coils 53 and 54 is established. Therefore the coil 52 is able to return the set of coils into the median position, in which the motor 33 is arrested. Further the current flowing through the coil 53 gradually falls off by the craft returning to its normal course and the contact 46 moving toward its median position.

Now the force created by the magnetic field of the coil 54 exceeds that created by the field of the coil 53, and therefore the set of coils is further turned beyond its initial position and in a direction for supplying current from the contacts 65 and 66 to the motor 33 for starting the same in a direction opposite from that in which it has before been operated, that is in a direction for setting the rudder into median position, and this return movement begins before the craft has assumed its normal course. By the return movement of the rudder the coil 54 is deenergized, and the coil 52 finally returns the set of coils into median position.

All the parts are regulated so that the rudder arrives in initial position when the rudder arrives on its normal course. Such regulation is made by means of the resistances 75, 79 and 84 included respectively in the circuits of the coils 52, 53 and 54.

As has been stated above the coils 53 and 54 are arranged so that the fields produced thereby act in opposition to each other. The angular displacement of the rudder 32 depends on the angular displacement of the frame 43 relatively to the resistance 47 and the deviation of the craft from the desired course. Therefore, the more the craft is brought out of course the larger is the angular displacement of the rudder.

In the system shown in Figs. 1 to 3, a single resistance coil 13 is provided for cooperation with the spring contact 12, while in the modification shown in Figs. 5 to 7 two resistances 59 and 60 are provided, the resistance 59 replacing the resistance 23 shown in Figs. 1 to 3. But I wish it to be understood that, as far as the system shown in Figs. 5 to 7 is concerned, my invention is not limited to the use of two resistances 59 and 60 cooperating with the slide contacts 65 and 66 controlled by the coils 52 to 54. But I prefer to provide two such resistances for the reason that thereby a stronger current is supplied to the motor 33.

While in the construction shown in Figs. 1 to 3 the whole current flowing through the contact spring 12 and the resistance winding 13 flows through the ammeter 24, in the modification shown in Figs. 5 to 7 the corresponding current flowing through the contact springs 65 and 66 is divided into two parts one flowing through the coil 52 and the other being supplied to the armature of the electric motor 33. I prefer the construction shown in Figs. 5 to 7, for the reason that the current energizing the coil 52 and providing the directing moment of the system is independent of the load on the relay, that is, in the example shown in the figures of the load of the motor 33, because the said current energizing the coil 52 does not pass through the electric motor. On the other hand the current flowing to the motor 33 depends only on the angular displacement of the coils 52, 53 and 54 and it is independent of the resistance 75. Therefore, the said resistance 75 has merely the function to regulate the sensitiveness of the system.

In the system shown in Figs. 5 to 7 the uniformity of the winding of the resistance coils 59 and 60 is not essential, because the slide contacts 65 and 66 will always find points on the resistance wires 58 and 60 where the potential difference is zero, and which provide the neutral position of the system. Further, with a definite total number of ampere windings of the coils 53 and 54, the intial voltage between the contact springs 65 and 66 is dependent only on the resistance 75, and it is independent of the resistances 59 and 60 and the accurate winding thereof.

In the construction shown in Figs. 5 to 7 the electrical connection of the relay is made substantially in the form of a Wheatstone system. In Fig. 8 I have shown a modification in which a compensating connection of other type is provided. The construction of the relay is the same as that described with reference to Figs. 5 to 7, and the same reference characters have been used to indicate corresponding parts. Therefore, the construction and the electrical circuit will be understood though various parts such as the electric motor, the rudder and the gyroscope have been entirely omitted or represented only by some of their parts. Between the poles N and S of the permanent magnet 50 the coils 53 and 54 and a coil 92 are mounted on a common carrier, and the contact 65 slides on the resistance 59. The coil 53 is included in a circuit 76, 77 with the resistance 47 and the slidable contact 46 controlled by the gyroscope (not shown), and the said circuit includes the regulatable resistance 79. The coil 54 is connected by the leads 63, 85 with the resistance 82, the contact 61 sliding thereon, and the regulatable resistance 64. In lieu of the coil 52 shown in Figs. 5 to 7 the coil 92 is provided. The terminals of the said coil are connected by leads 93 with the ends of the resistance 59. The middle of the coil 92 is connected by a lead 95 with the contact 65, and the said lead includes the battery 94 which has the function of the battery 74. The circuit 39 of the armature winding of the electric motor 33 is connected to the end terminals of the resistance 59.

In the median position of the slide contact 65 the potential difference at the ends of the resistance 59 is zero, and no current is supplied to the motor 33. But when the said contact has been shifted on the resistance to the right or left, the said potential difference is either positive or negative, and accordingly the motor 33 is operated for turning the rudder to the right or left.

The operation of the system is as follows:

In the normal position of the parts shown in Fig. 8 the contact 65 engages the resistance 59 at its middle, and therefore currents of equal intensity flow from the contact 65 through both branches of the resistance 59 and through the upper and lower branches of the coil 92. The total number of ampere windings of the coil 92 is zero, and therefore the said coil does not generate a magnetic field. If, however, the set of coils 92, 53 and 54 is turned clockwise or anticlockwise in the manner described with reference to Figs. 5 to 7, the contact 65 is shifted on the resistance wire 59 to the right or left, and thereby the currents flowing through the upper and lower branches of the coil 92 are different, and therefore the said coil produces a magnetic field. The windings and other connections are such that the magnetic field thus produced tends to return the set of coils into the zero position shown in the figure, whether the set of coils is turned clockwise or anticlockwise.

The function of the coils 53 and 54 and the parts connected therewith is the same as that of the corresponding parts shown in Figs. 5 to 7. Therefore the operation of the whole system will be understood without further explanation.

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