Feb. 17, 1942. P. SPECHT 2,273,600

TORQUE AMPLIFIER

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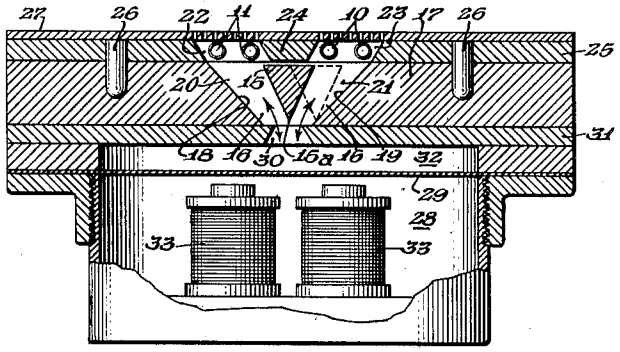


FIG. 1

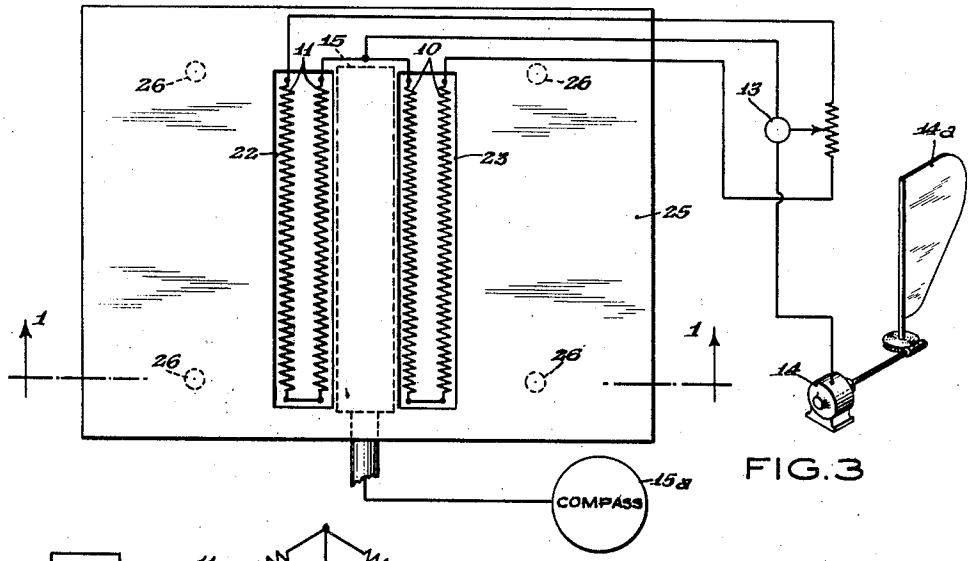


FIG. 3

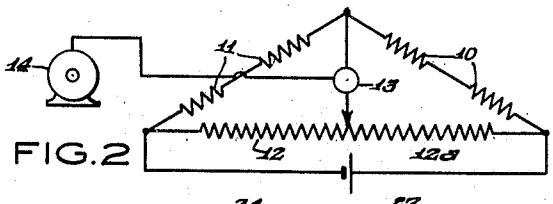


FIG. 2

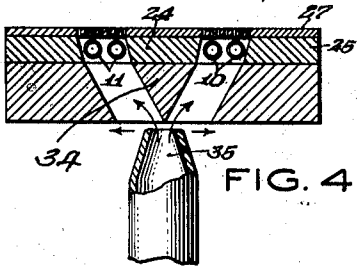


FIG. 4

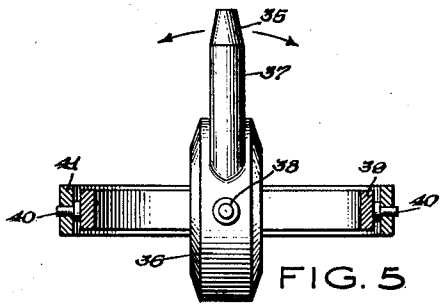


FIG. 5

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TORQUE AMPLIFIER

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6 Claims. (Cl. 201—48)

This invention relates to means for amplifying a control force, and more particularly to a bolometer apparatus.

Devices have heretofore been proposed for amplifying control forces by governing a resistance differential between two electrical conductors, for example, in bridge connection, the differential being governed by controlling a fluid flow to each of said conductors, there being a temperature differential between the conductors and the fluid. Suitable amplifying means, for example, a servo-motor can be controlled by said bridge connection. However, such devices in order to be sensitive, are complicated and expensive, and further require elaborate and very delicate adjusting means. Also, prior apparatus of this character have required bulky screening members for avoiding the disturbing effect of stray currents of air upon the conductors.

One of the objects of the present invention is to provide novel means for amplifying or "picking up" a control force, which means are simple, inexpensive, and rugged.

Another object of the invention is to provide novel means of the above character which may be easily controlled and adjusted.

A further object is to provide novel means for amplifying a control force without a friction or inertia reaction of the parts thereof.

An additional object is to provide novel means for amplifying a control force, which means are not hypersensitive but which are highly efficient.

The above and further objects and novel features will more fully appear from the detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for purposes of illustration only and is not intended as a definition of the limits of the invention, reference for this latter purpose being had to the appended claims.

In the drawing, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a side elevation partly in section and with parts broken away of one embodiment of the invention;

Fig. 2 is a diagram of a wiring connection which can be employed in the present invention;

Fig. 3 is a plan view of the embodiment of Fig. 1;

Fig. 4 is a side elevation partly in section and with parts broken away of a portion of a second embodiment of the invention; and,

Fig. 5 is a side view of a gyroscope device which can be employed with the second embodiment of the invention.

The forms of the invention illustrated in the accompanying drawing, by way of example, comprise means for amplifying a control force produced by a compass for governing the control surfaces of a vehicle such as an aircraft. The amplification is accomplished by governing a temperature differential, and hence a resistance differential between a pair of electric conductor elements, for example, in bridge connection, there being a suitable servo-motor or other amplifying means operatively connected to the elements and responsive to changes in resistance differentials therein, the motor being for controlling a rudder. Each of the conductor elements are mounted in the fluid flow path of a conduit, the latter merge adjacent a common inlet, there being thus formed a forked interconnection of the conduits. A flow regulator, or control member is mounted adjacent the forked interconnection in such a manner that the position thereof governs the ratio of the flows in the conduits. The control member is operatively connected to the member the displacement or movement of which is to be measured, as above mentioned, for example, a compass.

In the form shown in Fig. 1 suitable electric conductors **10** and **11** are in bridge connection, for example, as shown in Fig. 2 with conductors **12**, **12***a*, there being a bridge member or instrument **13** conventionally connected across the bridge comprising, e. g., a relay which is operatively connected to a servo-motor **14**, the latter governing a rudder **14***a* of a vehicle such as an aircraft.

The relative resistances of conductors **10** and **11** is governed by a device comprising a control member **15** which in the form illustrated in Fig. 1 is constituted by a wedge shaped element of triangular cross-section situated adjacent a common inlet **16** in a conduit element **17**. One of the edges **15***a* of the wedge element is directed against the direction of fluid flow. Preferably member **15** in combination with diverging walls **18**, **19** of element **17** forms a pair of conduits **20**, **21** in forked connection, which conduits respectively direct a fluid flow therein to conductors **10** and **11**. In order to avoid the disturbing effects of stray air currents the conductors are preferably mounted in recesses **22**, **23** separated by a center piece **24** in a frame member **25** which is removably secured to conduit element **17** by means of pins **26**. The side walls of the recesses are suitably slanted and aerodynamically adapted to the walls

of the branches of the fork, and the recesses are covered by a protective perforated plate 27. The position of control member 15 determines the ratio of the fluid flows which are directed to the conductors, said element preferably being adapted for movement with the longitudinal axis thereof parallel to said conductors. The element 15 is, for example, operatively connected to and governed by a compass 15a, there being suitable means (not shown) for adjusting the position of said element to a desired course.

Suitable means are provided for producing a fluid flow comprising, for example, a diaphragm air pump 28 having a diaphragm 29 beneath a converging nozzle 30 formed in a plate 31, the diaphragm being in spaced relation to the plate and forming a chamber 32 therewith. The nozzle 30 is in register with inlet 16. Alternately energizable electro-magnets 33 are mounted on the side of the diaphragm opposite to the chamber 29 and are adapted for vibrating the diaphragm in a conventional manner for producing the fluid flow.

In operation, when the control element 15 is centralized relative to the center piece 24 the flow in both conduits is equal, the bridge is balanced and motor 14 is de-energized. However, if, for example, the vehicle should depart from a predetermined course, the compass 15a will shift the element 15 away from the central position thereby changing the fluid flow ratio of the conduits and the temperature differential of conductors 10, 11. The bridge will therefore become unbalanced in response to the amount and direction of the course departure, and the servo-motor 14 will angularly shift surface 14a to restore the compass and control element to their predetermined positions.

In the above embodiment the duct 30 is stationary and the member 15, which splits the current of fluid or cooling medium, is movable; conversely, it is possible to make the nozzle duct movable thereby constituting the nozzle duct a "control member," and to fixedly mount the part which splits the current of cooling fluid. Such an embodiment is shown in Fig. 4 wherein a wedge member 34 is stationarily mounted centrally beneath the center piece 24.

Instead of employing a diaphragm pump, as above, a nozzle tube 35 is provided which is movably mounted beneath the wedge 34 in such a manner that it is shiftable in the direction of the arrows as shown in Fig. 4.

In operation the stream of fluid emitting from the nozzle 35 strikes against the edge of the wedge 34 such that, in a manner analogous to that of the first embodiment, the fluid flow fed to bolometer filaments 10, 11, via the branches of the forked conduits, is a function of the position of said nozzle relative to the dividing edge of the wedge 34.

If the latter embodiment is employed for the "picking up," measuring, or amplification of gyro movements it is possible to use the exhaust air, or "ventilation air" of the gyro for the fluid directed to the filaments 10, 11, thereby eliminating a separate fluid pump which otherwise would be necessary. Fig. 5 illustrates such a gyro and nozzle device wherein a gyro in a housing 36 having an exhaust nozzle 37 is mounted by means of trunnions 38 in a gimbal frame 39, the latter being conventionally mounted by means of trunnions 40 upon bearings 41.

There is thus provided novel means for amplifying or indicating the magnitude of a control force. The means are extremely simple and strung in construction, and are inexpensive to manufacture. The apparatus provides a reactionless "pick-up" of control or adjusting forces and is applicable to a wide variety of means for producing such forces, for example, in addition to the above mentioned compass and gyro, the apparatus is applicable to an electric current indicating instrument.

Although only two embodiments have been illustrated and described in detail it is to be expressly understood that the invention is not limited thereto. For example, instead of the control element 15 being movable with the longitudinal axis thereof parallel to the filaments 10, 11 it is possible for the member to be angularly shiftable about a point, in which case the filaments should be arranged radially thereabout. Also, instead of arranging two conductor elements 10, 11 in the recesses 21, 22 it is possible to employ one or a large number of such elements which may be connected in series or in parallel. Instead of the wedge 34 a simple separating wall may be employed in order to reduce the width of the device. The filaments or conductors are normally of nickel, platinum, or other metal having high resistance temperature coefficients. However, non-metallic conductors such as copper oxide may be used, the resistance temperature coefficients of which is greater than that of metal. Mica carriers, for example, can be employed for the copper oxide. The conductors instead of being wires may be in the form of thin bands, the larger surface of the bands permitting a more rapid temperature equalization, and a higher controlling speed than the wires. Various changes may be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention reference will be had primarily to the appended claims.

What is claimed is:

1. In apparatus of the class described, an electrical bridge circuit having two arms thereof formed of temperature responsive resistor elements, a source of current for said bridge circuit, a source of fluid pressure whose temperature differs from the normal temperature of said resistor elements, a pair of conduits for normally conveying fluid pressure from said source equally to said resistor elements thereby maintaining said elements at like temperatures whereby said bridge is balanced, said conduits being in communication and forming a fork, a nozzle for directing fluid pressure from said source to said conduits, and a wedge-shaped member whose diverging sides constitute a side for each of said conduits and having an apex thereof disposed in said forked connection opposite said nozzle, said nozzle and wedge-shaped member being relatively displaceable whereby fluid pressure flows unequally from said source through said nozzle to said resistor elements thereby unequally varying the temperature and resistance of said elements whereby said bridge is unbalanced and current flows therethrough.

2. In apparatus of the class described, an electrical bridge circuit having two arms thereof formed of temperature responsive resistor elements, a source of current for said bridge circuit, a source of fluid pressure whose temperature differs from the normal temperature of said resistor elements, a pair of conduits for normally

conveying fluid pressure from said source equally to said resistor elements thereby maintaining said elements at like temperatures whereby said bridge is balanced, said conduits being in communication and forming a fork, a stationary nozzle for directing fluid pressure flow from said source to said conduits, and a wedge-shaped member whose diverging sides constitute a side for each of said conduits and having an apex thereof disposed in said fork connection opposite said nozzle and adapted for movement thereby varying the fluid pressure flow in each of said conduits to unequally vary the temperature and resistance of said elements whereby said bridge circuit is unbalanced and current flows therethrough.

3. In apparatus of the class described, an electrical bridge circuit having two arms thereof formed of temperature responsive resistor elements, a source of current for said bridge circuit, a source of fluid pressure whose temperature differs from the normal temperature of said elements, a pair of conduits for normally conveying fluid pressure from said source equally to said elements thereby maintaining said elements at like temperatures whereby said bridge is balanced, said conduits being in communication and forming a fork, a nozzle for directing fluid pressure flow from said source to said conduits and being adapted for angular movement relative to said conduits, and a stationary wedge-shaped member whose diverging sides constitute a side for each of said conduits and having an apex thereof disposed in said fork connection for normally equally directing said fluid pressure to said conduits during a normal position of said nozzle and variably directing said fluid pressure to said conduits during angular movements of said nozzle whereby the temperature and resistance of said elements is unequally varied and said bridge circuit is unbalanced having current flow therethrough.

4. In apparatus of the class described, an electrical bridge circuit having two arms thereof formed of temperature responsive resistor elements, a housing embodying said elements and having a pair of channels, said channels having a common inlet, a source of fluid pressure whose temperature differs from the normal temperature of said elements, a nozzle for directing fluid pressure flow to said channels to impinge equally upon said elements maintaining the temperatures thereof the same whereby said bridge is balanced, and a wedge-shaped control member whose diverging sides constitute a side for each of said channels for governing the flow of fluid pressure in said channels, the control member having an apex thereof directed against the fluid flow, said nozzle and control member being mounted for relative movement with respect to each other whereby fluid pressure flow is varied in said channels to thereby unequally vary the temperature and resistance of said elements whereby the bridge is unbalanced and current flows therethrough.

5. In apparatus of the class described, an electrical bridge circuit having two arms thereof formed of temperature responsive resistor elements, a housing embodying said elements and having a pair of channels, said channels having a common inlet, a source of fluid pressure whose temperature differs from the normal temperature of said elements, a nozzle mounted for angular movement normally directing fluid pressure flow to said channels to impinge equally upon said elements maintaining the temperatures thereof the same whereby the bridge is balanced, and a stationary wedge-shaped control member whose diverging sides constitute a side for each of said channels for governing the flow of fluid pressure in said channels, the control member having an apex thereof directed against the fluid flow whereby during angular movement of said nozzle fluid flow is varied in said channels thereby differentially varying the temperature and resistance of said elements causing unbalancing of the bridge circuit whereby current flows therethrough.

6. In apparatus of the class described, an electrical bridge circuit having two arms thereof formed of temperature responsive resistor elements, a housing embodying said elements and having a pair of channels, said channels having a common inlet, a source of fluid pressure whose temperature differs from the normal temperature of said elements, a nozzle for directing fluid pressure flow to said channels to impinge equally upon said elements maintaining the temperature thereof alike whereby said bridge is balanced, and a movably mounted wedge-shaped control member whose diverging sides constitute a side for each of said channels for governing the flow of fluid pressure in said channels, whereby upon movement of said control member the cross-sectional area of said channels is varied so that fluid pressure flow is directed unequally through said channels to impinge upon said elements unequally thereby differentially varying the temperature and resistance of said elements whereby said bridge is unbalanced and current flows therethrough.

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