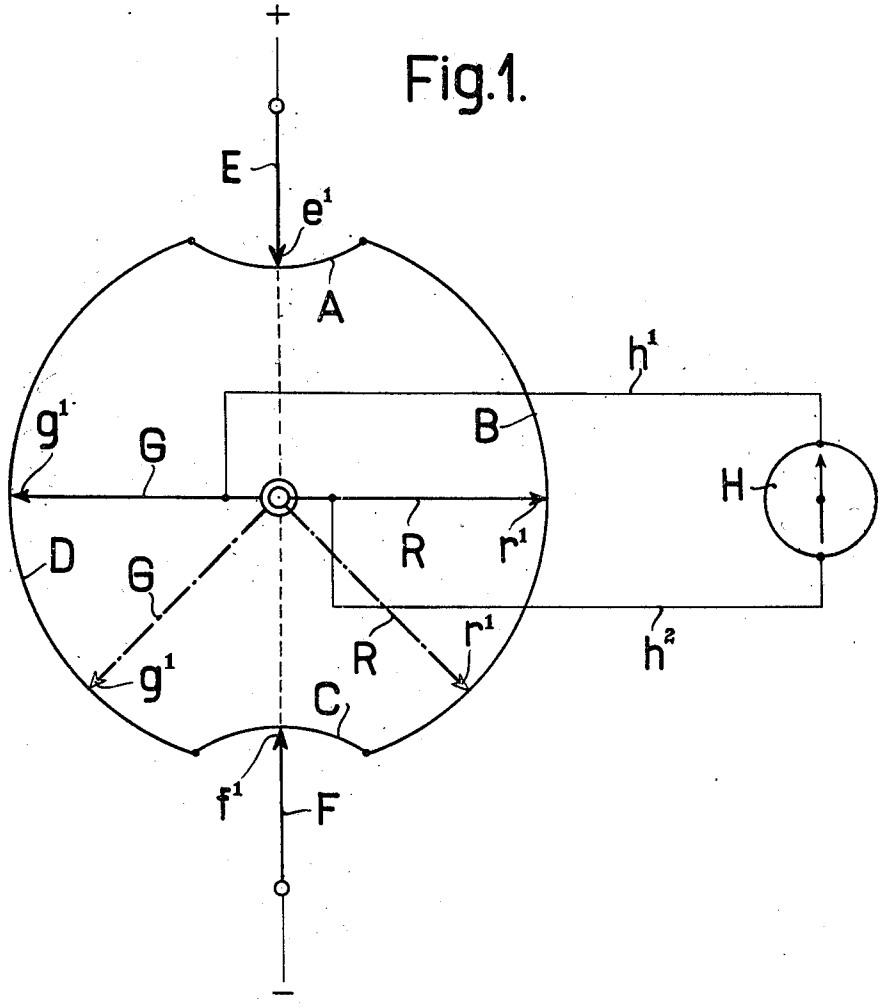
Aug. 21, 1923. 1,465,532

H. SUNDHAUSSEN

SUPPRESSION OF GYROSCOPIC PRECESSION

Filed Sept. 25, 1920 2 Sheets-Sheet 1

Fig.1.



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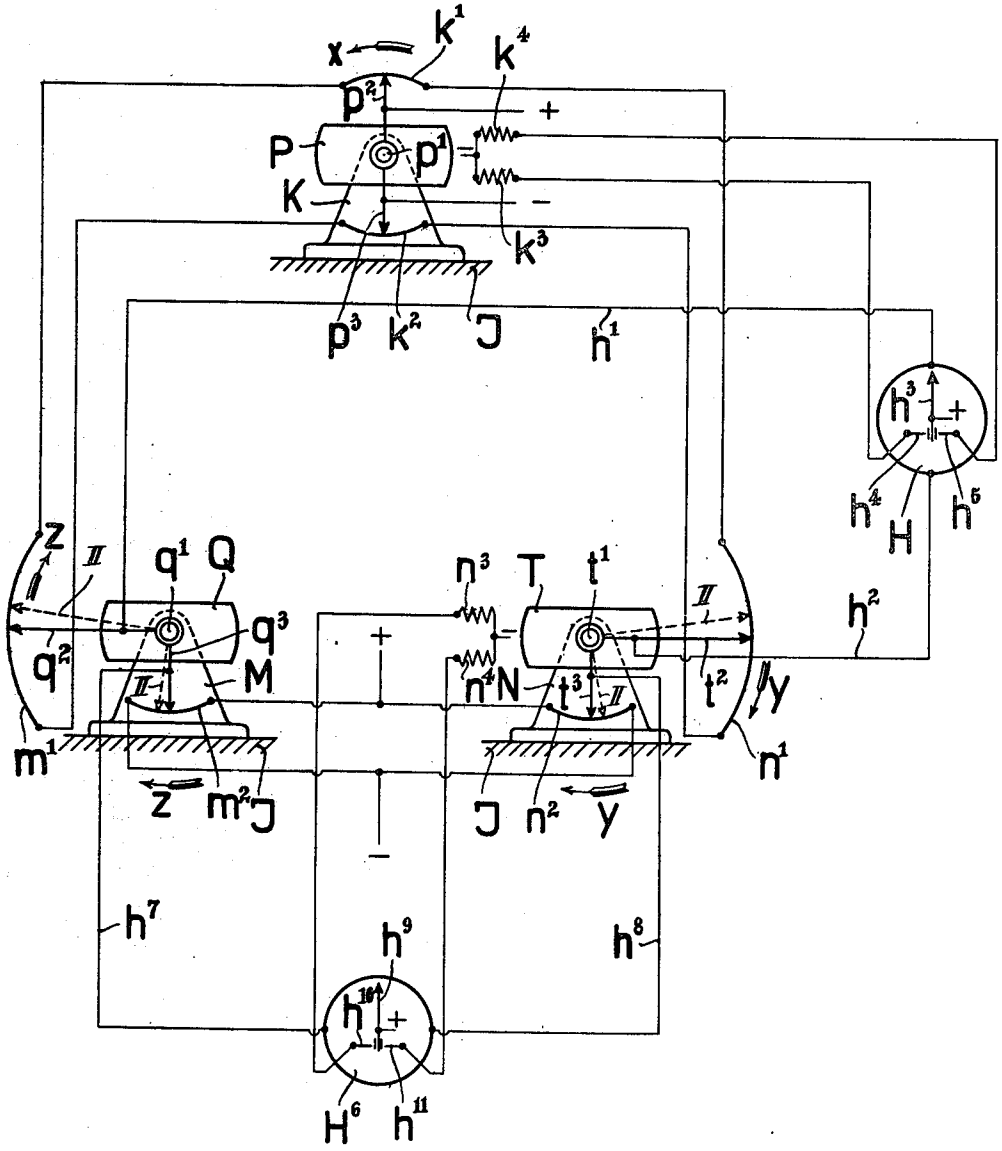
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Fig.2.



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UNITED STATES PATENT OFFICE.

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SUPPRESSION OF GYROSCOPIC PRECESSION.

Application filed September 25, 1920. Serial No. 412,896.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

To all whom it may concern:

Be it known that I, HERMANN SUNDHAUSSEN, residing at Essen, Germany, a citizen of the German Republic, have invented a certain new and useful Improvement in Suppression of Gyroscopic Precession, of which the following is a specification.

The present invention resides in a resistance switch, comprising three or more resistance coils, with the same number of sliding resistance contacts, together with a current indicator, and its object is to provide means whereby the position of the index on the current indicator may be made to show whether the position of any of the sliding pieces is changed or not, with regard to the corresponding resistance wire.

The present invention has for example particular application as an addition to gyroscopic apparatus where it is desired to inhibit variations of direction (precessional effects) with respect to a bed plate upon which such apparatus may be mounted. This is of distinct importance in the art.

Two embodiments of the invention are diagrammatically shown on the drawing.

Fig. 1 shows in particular the embodiment of the resistance switch as such and

Fig. 2 illustrates the application of the device to a gyroscopic arrangement. For simplicity portions of the bed plate have been displaced to more clearly bring out the features of the electric circuits and controls. The broad conception just illustrated will now be described:

Four resistances, A, B, C and D, of the same material, preferably polished wire of uniform resistance, arranged in a circle, are connected to a closed circuit. Two of the resistance wires A and C are curved convex, and the two others B and D are curved concave with regard to a point in the middle of the resistance circuit A, B, C, D, the concave and convex wires alternating.

Each of the resistances A, B, C, D has connection with one of the electric contact slides e', r', f' and g'. The slides e', r', f' and g' are attached to arms E, R, F and G electrically connected with a source current, the fulcrum of each arm constituting the center around which the corresponding wire is curved. The two arms G and R which revolve around the same point are insulated from each other. The arm E carrying the slide e' is connected to the positive pole, while the arm F carrying the slide f' is connected to the negative pole of a direct current source. The two other slides g' and r' are connected with a galvanometer H through conductors h' and h^2, which are attached to arms G and R.

In order to describe the function of the device, it will be supposed that arms E, F, G and R have such a position that the slides e', f', g' and r' contact with the resistances A, C, D and B in the middle. In this position of the slides the circuit branch h', H, h^2, containing the galvanometer H, is without current, and as a consequence the galvanometer needle will show zero, while the slides g' and r' contact with points of the same potential on their respective resistance wires D and B. For the same reason the galvanometer branch h', H, h^2 will always be without current so long as the sum of the resistances situated between the contact points of the slide pair g', r' is halved by the contact points of the other slide pair e', f'; compare, for instance, with the dot-and-dash line position of G and R.

On the other hand, the galvanometer needle must swing to one side or the other, as soon as the contact points of the slide pair g', r' come to points of dissimilar potentials through turning of one or more of the slides e', f', g' and r'. It will thereupon be necessary to turn one or more of the slides in order to reestablish the equilibrium and return the galvanometer needle in zero position.

It should be mentioned that a variation of the resistance wires A and C can take place yet with a field branch point for the current at the place of the corresponding slides, without materially affecting the working method of the present invention.

Furthermore, the slides e' and f' may be connected to the galvanometer instead of to the current source, and reversely the slides g' and r' connected to the current source instead of to the galvanometer.

The second embodiment of the invention shown in Fig. 2 relates to a gyroscopic arrangement involving three gyroscopes ar-

ranged with a resistance switch of the type above disclosed with the end in view of inhibiting variations in direction (precessions or the like) of a stabilized shaft of one of the gyroscopes with respect to the bed plate upon which the latter may be mounted. The details of the gyroscopic arrangement and control is gone into below:

On a common bed plate J (shown displaced in Fig. 2) three gyroscopic supports K, M and N are provided for three gyroscopes, the spinning members of which (not shown) universally supported in gimbals are enclosed within revoluble housings P, Q and T. From the four resistance coils of the above-mentioned resistance switch, two coils k' and k^2 are secured to the stand K of the gyroscopic device K, P, which in the following will be designated as "main gyroscopic device"; while the other two coils m' and n' are secured to the stands M and N, respectively, of the gyroscopic devices M, Q, and N, T, hereafter called "auxiliary gyroscopic devices."

The resistances k', m', k^2 and n' are connected together in series to form a closed circuit. Each of the resistance coils is bent to form a circular arc, the center of which coincides with the axis of the shaft to be stabilized through the action of the corresponding spinning member. The slide contacts cooperating with the resistance wires are mounted fixedly on arms p^2, p^3, q^2, t^2 of the stabilizing shafts p', q', and t' though it must be added the arms p^2 and p^3 on the shaft p' are electrically insulated from each other and form an angle of 180° to each other. The sliders of arms p^2 and p^3 contact with the middle of the corresponding resistance wires k' and k^2 when the position of the arms p^2 and p^3 is perpendicular to the plane of the bed plate of the gyroscopic arrangement, whilst the sliders of arms q^2 and t^2 contact with the center of the resistance wires m' and n' when the arms q^2 and t^2 are in a position parallel to the plane of the bed plate.

The arms p^2 and p^3 of the main circuit are connected with the opposite poles of a direct current source, but the arms q^2 and t^2 of the two auxiliary gyroscopic devices are connected with a galvanometer H through lines h' and h^2.

Near one end of the galvanometer needle h^3 in the galvanomter H are located two current-closing pieces h^4 and h^5, which are arranged so that the needle h^3 contacts with the current-closing pieces h^4 and h^5 when it deflects to one side or the other from its zero point.

To one end of each of the two current-closing pieces h^4 and h^5 are connected two electromagnetic coils k^3, k^4, their other ends being connected together and with one pole of the direct current source, whereas the galvanometer needle h^3 is connected with the other pole of the current source. The electromagnets k^3, k^4 are mounted on the supporting base of the main gyroscopic device K, P and are intended to exert from time to time a turning movement on the proper gimbal ring supporting the main gyroscope to cause an oscillation of the gyroscope about the axis of its stabilizing shaft, and consequently also set up a displacement of the stabilizing shaft itself.

Upon the supports M and N respectively are also provided resistances m^2 and n^2. These resistances are arranged circularly about the stabilizing shafts q', t' as center, which resistances are connected in parallel to a source of direct current indicated in Fig. 2. Sliders mounted on arms q^3, t^3 contact with the resistances m^2, n^2. The arms q^3 and t^3 mounted at right angles to the respective arms q^2 and t^2 with respect to the stabilizing shafts q' and t' are insulated from the latter. The sliders of the arms q^3, t^3 contact with the middle point of the resistances m^2, n^2 when the sliders of the arms q^2, t^2 contact with the middle point of their respective resistances m', n'.

The arms q^3 and t^3 of the two auxiliary gyroscopes are by means of conductors h^7 and h^8 connected with a galvanometer H^6, which is provided with two current-closing pieces h^{10} and h^{11} on both sides of the galvanometer needle h^9 in exactly the same manner as has been described in connection with galvanometer H. The current-closing pieces h^{10} and h^{11} are each connected with one end of two electromagnets n^3 and n^4, and their other ends are joined with one pole of the direct current source, while the galvanometer needle h^9 is connected to the other pole. The electromagnets n^3 and n^4 are fixed to the stand of the auxiliary gyroscopic device N, T, and tends to give to its corresponding spinning member a displacement about the axis of its stabilizing shaft as long as the deviation of the galvanometer needle h^9 from its zero position takes place. This tendency continues until an equilibrium condition has been established in the resistance arms q^3, t^3, m^2, n^2 forming a Wheatstone bridge, so that the galvanometer needle h^9 can return to its zero position.

In describing the operation of the gyroscopic device it will be assumed that all three spinning members are running and the stabilizing shafts p', q' and t' take up such angular positions that the arms p^2, p^3, q^2, q^3 and t^2 t^3 secured thereon contact with the middle of the corresponding resistances. During operation of the gyroscopic devices K, P, M, Q and N, T, the shafts of the spinning members have the tendency to produce precessional movements so that their axes tend to travel in such direction for example

that the stabilizing shaft p', on the one hand together with the arms p^2, p^3 secured thereon, turns in the direction of arrows X, whilst on the other hand the stabilizing shafts q' and t', together with the arms q^2, q^3 and t^2, t^3, turn in the direction of arrows Z and Y. As soon as the sliders on arms q^3 and t^3 have moved in the direction of the arrows Z and Y away from the middle of the corresponding resistance wires m^2 and n^2, they contact in points having different potentials. As the slider belonging to arm q^3, moves away from the positive pole of the direct current source, and the slider belonging to arm t^3 simultaneously moves closer to the same pole, the difference in potential becomes so great, even for a slight angular displacement of the arms q^3 and t^3, that a current will be set up in the galvanometer circuit h^7, H^6, h^8, which will cause needle h^9 to deflect. The deflection of needle h^9 will then take place to such a degree that the current-conducting part of the needle h^9 contacts with current-closing piece h^{10}. The electromagnet n^3 thereupon excites its corresponding magnetic core and the electromagnet therefor produces a turning movement about one of the gimbal rings of the gyroscopic device N, T. The direction of the turning movement has been so predetermined that the stabilizing shaft t' is unable to continue its turning in the direction of the arrow Y, which latter movement had been set up due to the influence of the precessional effect of the axis of the spinning member. Indeed, thereafter it tends to turn in an opposite direction to the arrow Y.

The last mentioned turning of shaft t' naturally continues until the slider belonging to arm t^3 has arrived at a point on the resistance n^2 where the potential is the same as that of the point where the slider belonging to arm q^3 contacts. (Compare position marked 11 of the sliders belonging to arms q^3, t^3). As soon as the latter point is reached the current in the galvanometer circuit h^7, H^6, h^8 ceases to flow, the electromagnet n^3 becomes demagnetized and the turning of the shaft t' stops. The sliders of arms q^2, q^3, and t^2, t^3 thus take up an effective position denoted by 11, corresponding to an angle equal and opposite to that originally taken up.

At the time of the turning movement of the shafts q' and t', the shaft p', as has already been stated, also commences to turn, together with the arms p^2, p^3 secured thereon, and actuated by the precessional movement of its spinning member and in the direction of arrow X, so that the sliders of arms p^2, p^3 deviate from the middle position of the corresponding resistances k', k^2. However the deflection angle from the initial position is very small.

Immediately following upon the turning of the arms p^2, p^3, q^2 and t^2, the sliders of arms q^2 and t^2 contact necessarily with points of different potential, and as a matter of fact, such difference of potential for the given direction of turning of the three stabilizing shafts becomes quite considerable even for a very small angular deflection of the arms p^2, p^3, so that a current immediately flows in the galvanometer circuit h', H, h^2 and causes a deflection of the pointer h^3.

The reason for the rapid increase of the potential difference is that the resistance lying between the contact points of the sliders belonging to arms q^2 and p^2 diminishes for a two-fold reason, whereas the resistance which lies between the sliders of arms p^2 and t^2 increases from a two-fold reason. The deflection of the pointer h^3 takes place in the direction that the current-closing piece h^4 contacts with the conducting portion of the pointer h^3. The magnet winding k^3 receives the corresponding current and its magnet coil produces a turning on one of the gimbal rings of the gyroscopic device K, P. The direction of the turning is so predetermined that the shaft p', together with the sliders of the arms p^2, p^3, is unable to continue the rotary movement in the direction of the arrow X, but instead a rotary movement of the shaft p' in the opposite direction of the arrow X is immediately set up. This working movement of the shaft p' continues until the sliders of arms p^2, p^3 again take up their middle position with regard to the resistance k', k^2, after the sliders of the arms q^2, t^2 have previously attained the position denoted by 11 in the previously described manner. As soon as the above is the case, the sum of the resistances situated between the sliders of the arms q^2 and t^2 will be bisected by the sliders of the arms p^2, p^3, so that the sliders of arms q^2, t^2 again contact with points of similar potential and the corresponding galvanometer circuit h', H, h^2 becomes devoid of current. The pointer h^3 then returns to its zero position, current in the magnet winding disappears, and the rocking movement in a direction opposite to the arrow X is discontinued. The arms p^2, p^3 finally return therefore to their initial position with respect to the bed plate J, enabling sliders to contact with the middle of the corresponding resistance wires. The direction of the stabilizing shaft p' by virtue of the arms p^2, p^3 mounted on the main gyroscopic device is therefore practically assured against precessional changes or the like relative to the bed plate J. The gyroscopic device MQ is so designed that the precessional movements of its shaft produce an oscillatory movement of the arms q^2, q^3 back and forth across the centre positions shown on the drawing. Thus, even after repeated displacements of

the arms p^2, p^3 away from their centre positions, the ends of the arms q^2, q^3, and consequently the ends of the arms t^2, t^3, are maintained in contact with their respective resistances m', m^2, n', n^2.

The disclosure of the method of operation, in accordance with the method of least squares for the most probable case, has been given for the precessional action of the spinning axes in which one of the stabilizing shafts has a rocking action opposite to the other two; and it has been shown for the above condition that even for very small movements of the arms p^2, p^3, the difference of potential between the points contacted by the sliders on the arms q^2 and t^2 of the resistances m' and n' becomes so great that a return movement of the sliders immediately begins.

The same thing really applies also to the less probable case when due to precessional action of the axes of the spinning members all three of the stabilizing shafts have a movement in the same direction. In this case due to the action of the turning members or coils n^3, n^4 by virtue of the galvanometer H^6 the reversal in the direction of rocking of the stabilizing shaft t' immediately takes place so that again one of the shafts turns in a direction opposite to that of the other two. In all cases therefore the result is achieved by means of the present gyroscopic device that the sliders p^2, p^3 return after very small rocking of the shaft p', in other words after very slight changes from a predetermined direction of the arms p^2, p^3 with respect to the bed plate J. Consequently by virtue of the arms p^2, p^3 the greatest accuracy of direction is maintained against possible variation with respect to the bed plate. The fact that the arms q^2 and t^2 swing past the centre position by reason of precessional movement of the gyroscopes MQ and NT results in the advantage that for a given small displacement of the arms p^2, p^3, the arms q^2 and t^2 are also displaced in a direction which increases the potential difference effected beyond what it would be if the arms q^2 and t^2 were stationary. Consequently the sensitiveness of the correcting means is enhanced and a very small precessional movement of the gyroscope KP will cause the correcting means to function.

Claims:

1. In combination with a gyroscopic device, switching means controlled by the precessional movement of said gyroscopic device and correcting means for said gyroscopic device controlled by the action of said switching means.

2. In combination with a gyroscopic device, a plurality of auxiliary gyroscopic devices, and means controlled by the precessional movement of the first mentioned gyroscopic device and operated by said auxiliary devices for correcting the said precessional movement.

3. In subcombination with a gyroscopic device, a Wheatstone bridge, comprising a relay in the bridge circuit, a source of electrical energy for said bridge, a plurality of movable contact arms controlled by the gyroscopic movements and contacting with the sides of said bridge, said arms being connected with said electrical source, and gyroscope correcting means controlled by said relay.

4. In means for correcting the variable movement of a gyroscope, a Wheatstone bridge, a main gyroscope and two auxiliary correcting gyroscopes, resistance determining sliders on said bridge controlled in their setting by the movements of said gyroscopes, a relay means in the bridge circuit, and correcting means operated by the relay through the relative movements of said gyroscopes with respect to said sliders and said bridge for automatically correcting the variable movement of said main gyroscope, the movements of the auxiliary gyroscopes operating to increase the effect produced by the movement of the main gyroscope.

5. In combination with a Wheatstone bridge, a main gyroscope operating sliders on two of the resistances of said bridge by the variable movement of said main gyroscope, two auxiliary gyroscopes each operating sliders on the remaining resistances of said bridge, and a galvanometer indicating means for said bridge, the movements of the auxiliary gyroscopes operating to increase the effect produced by the movement of the main gyroscope.

6. In combination with a Wheatstone bridge a main gyroscope operating sliders on two of the resistances of said bridge by the variable movement of said main gyroscope, two auxiliary gyroscopes each operating sliders on the remaining resistances of said bridge, a relay means for said bridge, and an electromagnetic device operated by said relay for correcting the variable movement of said main gyroscope, the movements of the auxiliary gyroscopes operating to increase the effect produced by the movement of the main gyroscope.

7. In combination with a Wheatstone bridge a main gyroscope operating sliders on two of the resistances of said bridge by the precessional movement of said main gyroscope, two auxiliary gyroscopes each operating sliders on the remaining resistances of said bridge, a relay means for said bridge, and an electromagnetic device operated by said relay for correcting the precessional movement of said main gyroscope, the precessional movements of the auxiliary gyro-

scopes operating to increase the effect produced by the precessional movement of the main gyroscope.

8. In combination with a Wheatstone bridge, a main gyroscopic device and two auxiliary gyroscopic devices, movable resistance controlling slider arms for said bridge operated by said main gyroscopic device and said two auxiliary gyroscopic devices, and a relay means operated by the setting of said Wheatstone bridge to correct the precessional movement of said main gyroscopic device, the precessional movements of the auxiliary gyroscopic devices operating to increase the effect produced by the precessional movement of the main gyroscopic device.

9. In combination with a Wheatstone bridge a main gyroscopic device and two auxiliary gyroscopic devices, movable resistance controlling slider arms for said bridge operated by said main gyroscopic device and said two auxiliary gyroscopic devices, and a relay means operated by the setting of said Wheatstone bridge to correct the precessional movement of said main gyroscopic device, a second Wheatstone bridge, further movable resistance controlling slider arms for said second bridge operated by said two auxiliary gyroscopic devices, and a relay means operated by the setting of said second Wheatstone bridge for correcting the precessional movement of one of said auxiliary gyroscopic devices, the precessional movements of the auxiliary gyroscopic devices operating to increase the effect produced by the precessional movement of the main gyroscopic device.

10. In combination with a Wheatstone bridge a main gyroscopic device and two auxiliary gyroscopic devices, movable resistance controlling slider arms for said bridge operated by said main gyroscopic device and said two auxiliary gyroscopic devices, and a relay means operated by the setting of said Wheatstone bridge to automatically correct the precessional movement of said main gyroscopic device, a second Wheatstone bridge, further movable resistance controlling slider arms for said second bridge operated by said two auxiliary gyroscopic devices, and a relay means operated by the setting of said second Wheatstone bridge for automatically correcting the precessional movement of one of said auxiliary gyroscopic devices, the precessional movements of the auxiliary gyroscopic devices operating to increase the effect produced by the precessional movement of the main gyroscopic device

The foregoing specification signed at Barmen, Essen, this 16th day of June, 1920.

HERMANN SUNDHAUSSEN.

In presence of—

HANS GOTTSMANN,

JOHANN DECKERS.