

Sept. 16, 1958

C. H. SCHLESMAN
METHOD AND APPARATUS FOR TELEMETERING
INFORMATION FROM A MISSILE IN FLIGHT

2,852,208

Filed April 11, 1950

3 Sheets-Sheet 1

FIG. 1.

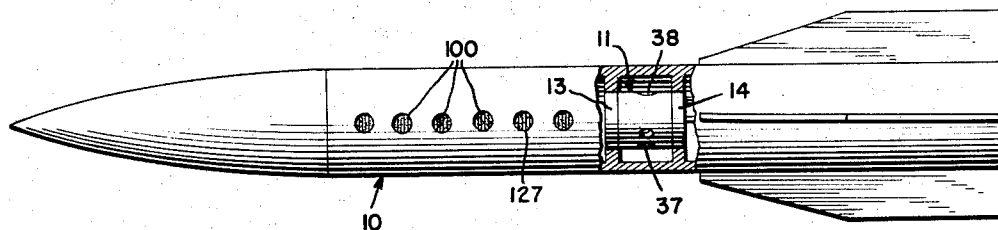


FIG. 2.

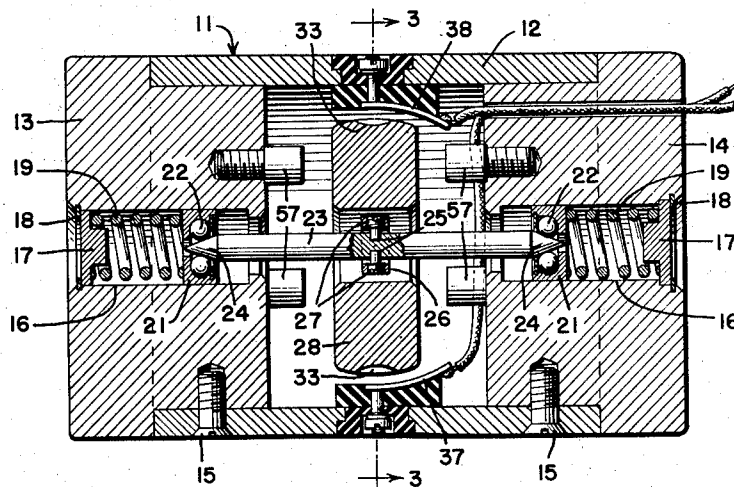


FIG. 3.

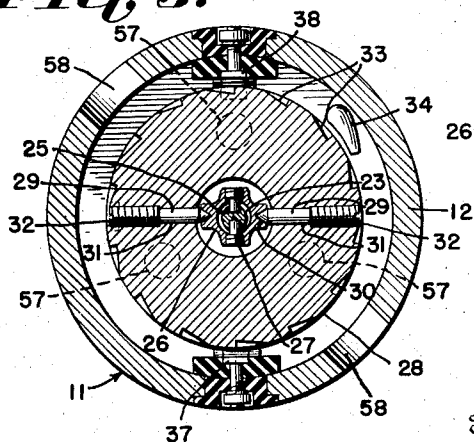
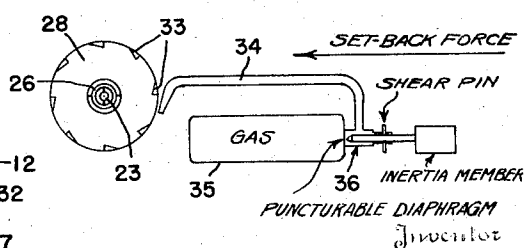


FIG. 4.



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3 Sheets-Sheet 2

FIG. 5.

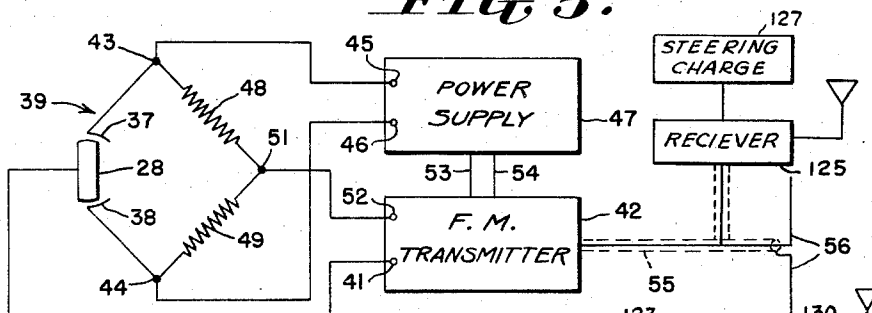


FIG. 6.

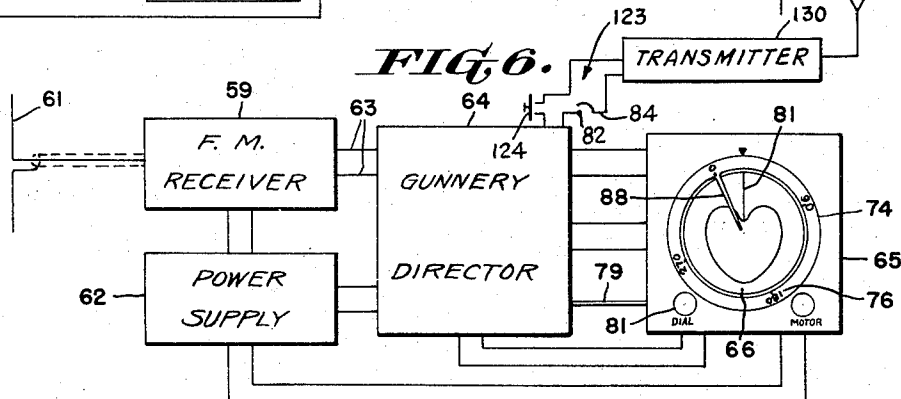
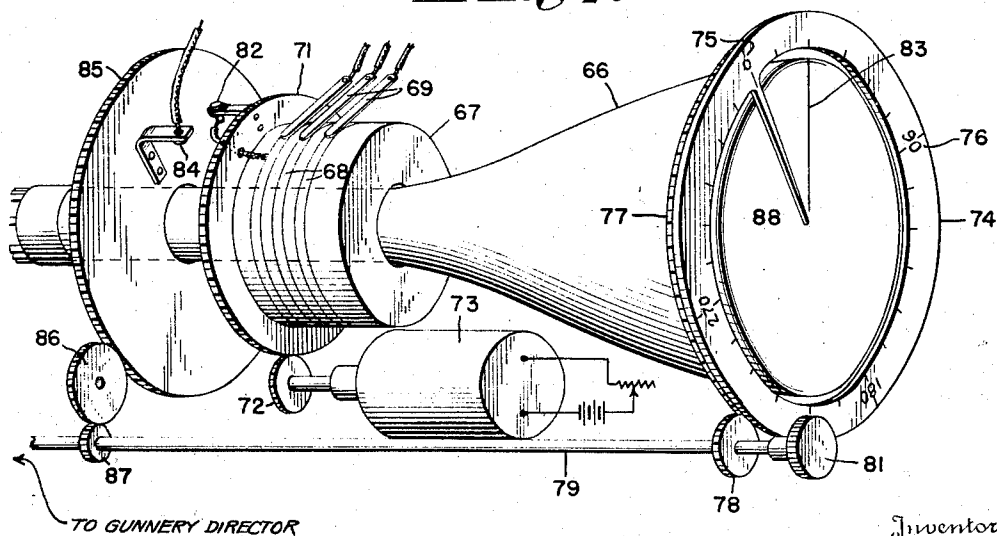


FIG. 7.



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3 Sheets-Sheet 3

FIG. 8.

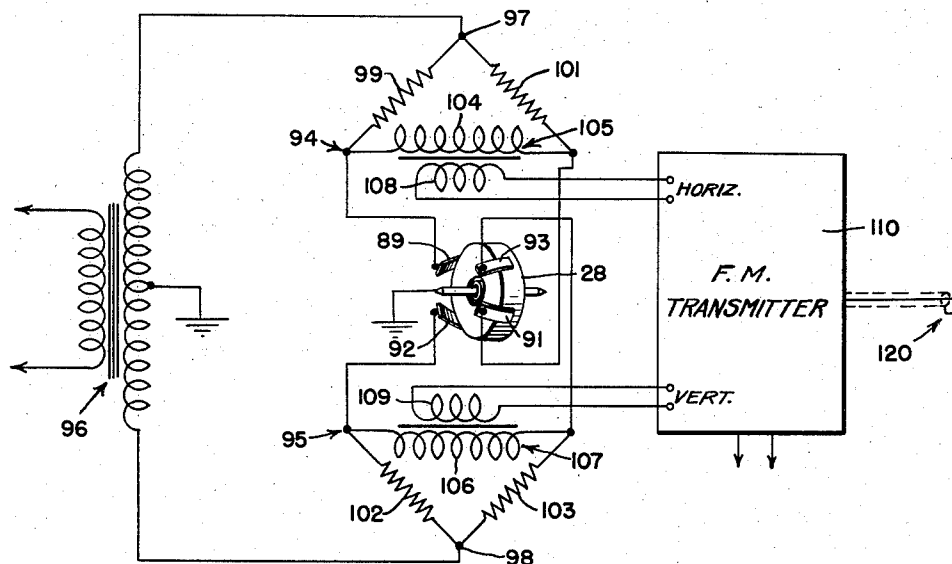
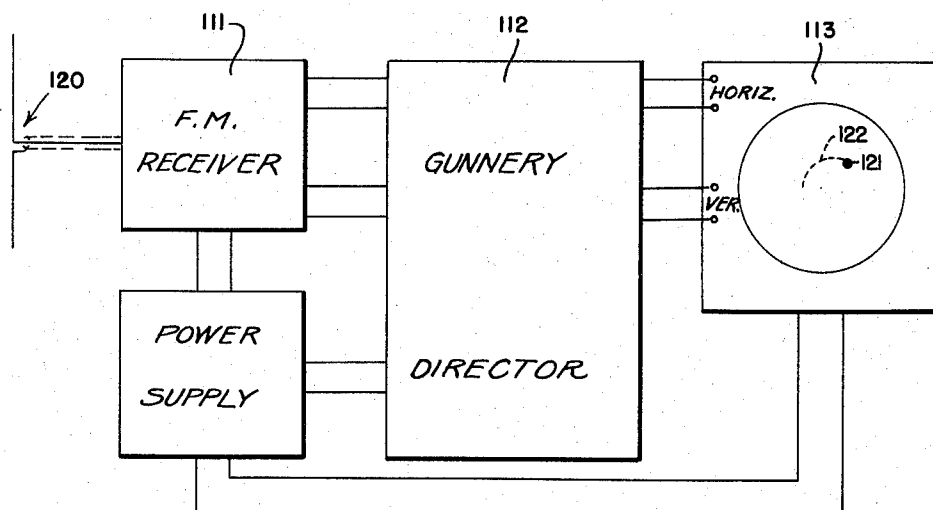


FIG. 9.



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1

2,852,208

METHOD AND APPARATUS FOR TELEMETERING
INFORMATION FROM A MISSILE IN FLIGHT

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Application April 11, 1950, Serial No. 155,316

7 Claims. (Cl. 244—14)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The present invention relates to gun-launched rotating missiles and like ordnance devices and more particularly to a method and apparatus employing a gyro-stabilized reference for telemetering from the missile in flight instantaneous signals indicative of the declination angle and rotational position in space of the missile and for utilizing the signals to indicate visually the aforesaid angle and position at the director's station.

It has been found difficult in prior art devices for use in shells or missiles to transmit therefrom accurate signals indicative of the instant declination angle and rotational position in space of the missile throughout the flight thereof. The present invention is well suited for such use and is of particular advantage for indicating the angle of declination and for controlling the time of firing of the steering charge of rotating missiles in relation to the rotational position thereof. Such a missile containing a steering charge for providing a change in course of the missile upon firing of the charge is disclosed and claimed in the copending application of Harold J. Plumley for Method and Apparatus for Steering a Gun-Launched Missile, filed December 6, 1949, Serial No. 131,441.

The device of the present invention comprises a preferably gas or air driven gyroscope having its principal rotating axis aligned with the rotating axis of the missile at the time of launching. The gyro rotor, however, is especially constructed and arranged to provide for tilting of the rotor with respect to the missile as the declination angle thereof varies during flight. In order to protect the gyroscope from the high acceleration forces to which it is subjected during the launching of the missile, the gyroscope rotor is supported in such a manner that damage thereto by such forces is substantially nullified. To this end, the supporting means is arranged to release the gyroscope rotor when the acceleration forces are reduced to a point where the gyroscope may be operated without damage thereto.

A pair of electrodes or capacitor plates are fixedly arranged at diametrically opposite points adjacent the periphery of the rotor of the gyroscope in such a manner that as the gyroscope tilts with respect to the casing, the capacitance between the electrodes or plates and the rotor varies proportionally to the degree of tilt of the rotor axis away from the axis of rotation of the missile.

These variations in capacity are utilized in a bridge circuit to produce sinusoidal amplitude alternations which preferably are transmitted by way of the telemetering link as frequency changes in the signals transmitted from the missile and receivable by suitable apparatus at the launching point. The sinusoidal amplitude alternations are reproduced at the launching point and utilized to visually indicate declination angle and instantaneous rotational position of the missile.

This visual indication, according to one embodiment of the invention, is accomplished by utilizing a single bridge circuit in the missile and applying the sinusoidal signal

2

reproduced at the launching point to energize the beam deflection control coil of a cathode ray tube, the coil being biased with an D. C. signal and rotated in synchronism with the missile whereby a circular trace is produced on the screen of the tube in the absence of a signal applied to the coil, i. e., when the bridge is balanced, and a cardioid trace is produced on the screen in response to the signal. The extent of the inward dip in the cardioid trace provides a measure of the declination angle as, it will be recalled, the rotor axis is initially aligned with the rotational axis of the missile at the time of launching.

The rotating deflection coil carries a contact which is arranged to engage an adjustable contact once during each revolution of the coil. The adjustable contact is initially set to different angular positions in accordance with movements imparted thereto by the gunnery director. When the director has determined that the missile is in the proper position in space for firing the steering charge, a firing circuit is completed to the contacts so that the charge is fired as the contacts engage, this being at a time when the missile is in the proper rotational position to effect the desired steering of the missile.

The bridge output signal reproduced at the launching point is also utilized in the gunnery director to determine the position in space of the missile, and this information is correlated with information relating to the target position to determine and control the time of firing of the steering charge.

According to another form of the invention, a double bridge arrangement is provided in the missile to measure simultaneously with the measurement of the declination angle the amount of yaw of a slowly rotating missile. The outputs of this bridge arrangement are in quadrature and, as reproduced at the launching point, are applied to the vertical and horizontal amplifiers of an oscilloscope to produce on the screen thereof a moving dot which can be followed by the operator.

An object of the present invention is to provide a telemetering apparatus whereby information relative to the declination angle and the instantaneous position in space of a missile or shell in flight is effectively transmitted to the launching point thereof.

Another object is to provide a new and improved gyroscope for varying the capacity of a bridge circuit in accordance with the variations of the declination angle of a missile or shell whereby a transmitter is influenced thereby to effectively transmit a signal indicative of such variations to the launching point.

Still another object is to provide a new and improved method of telemetering information from a missile or shell to the launching point thereof in a simple and efficient manner.

A further object is to provide means for utilizing the signals transmitted by way of the telemetering link and indicative of the declination angle to provide a visual indication of variations of the angle during flight of the missile and to control the time of firing of the steering charge of the missile when it has reached the rotational position effective to produce the desired change of course of the missile.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a view in side elevation of one of a variety of missiles in which the gyroscopic device of the present invention may be employed;

Fig. 2 is a sectional view taken along the axis of the

device and showing the gyroscope of the present invention;

Fig. 3 is a sectional view on line 3—3 of Fig. 2;

Fig. 4 is a schematic view of the means for driving the gyroscope;

Fig. 5 is a diagrammatic view of the signal transmitting system employed in the missile;

Fig. 6 is a diagrammatic view of the signal receiving system employed at the launching point of the missile;

Fig. 7 is a schematic perspective view of the cathode-ray tube and associated apparatus employed in the receiving system of the present invention;

Fig. 8 is a diagrammatic view of the signal transmitting system employed in a modified form of the invention and having a double bridge circuit; and

Fig. 9 is a diagrammatic view of a signal receiving system employed in the modified form of the invention.

Referring more particularly to the drawings wherein like characters indicate like parts throughout the several views, 10 indicates generally a missile containing a differential gyroscope indicated generally at 11 having the principal axis thereof coincidental to the longitudinal axis of the missile. A tubular casing 12 is closed at the ends thereof by massive closures 13 and 14, each of the closures being secured to casing 12 by a plurality of screws 15.

The closures 13 and 14 are respectively provided with an axial bore 16, the outer end of each of the bores being closed respectively by a spring support 17 which is secured therein by a locking washer 18. Slidably mounted in each of the bores 16 is a bearing race 21 having a plurality of balls 22 therein. Springs 19 are mounted between the races 21 and the spring supports 17.

A shaft 23, having the tapered ends 24 thereof rotatably mounted in the balls 22, has a pair of diametrically opposed radial bores 25 at a point midway the ends thereof. A ring 26 is suspended around the shaft 23 by means of a pair of screw pivot pins 27 threaded therein and extending into the bores 25. A pair of tapered bores 30, positioned at 90° from pins 27, are formed in the ring 26.

A rotor 28 is pivotally mounted on ring 26 by means of a pair of tapered pins 29 extending into the tapered bores 30 and supported in bores 31 of the rotor 28. Pins 29 are held in bores 31 by means of screws 32 threaded into the outer ends of the bores. From the foregoing it is apparent that the rotor 28 is mounted for rotation with the shaft 23 and has a limited amount of angular motion with respect to the shaft about the pivot axes formed respectively by pins 27 and 29.

The rotor 28 has a plurality of turbine buckets or depressions 33 in the periphery thereof. A tube 34 is arranged within casing 12 to direct a jet of high pressure gas such, for example, as carbon dioxide against the buckets 33 to drive the rotor 28 at high speed. Tube 34 is connected to a gas container 35 through an inertia operated gas release mechanism 36 which is arranged to puncture a diaphragm to release the gas into the tube 34 by reason of the setback force imparted to the inertia member by the launching operation, thereby to drive the rotor. It is, of course, understood that the rotor also may be driven by a jet of air picked up by a scoop on the outer periphery of the missile casing, or by any well-known means.

Positioned within casing 12 and adjacent the periphery of rotor 28 are the electrodes or plates 37 and 38 which, with the rotor, comprise a pair of capacitors in a capacity bridge circuit indicated generally at 39 in Fig. 5, as will be hereinafter more fully described.

Fig. 5 illustrates in diagrammatic form a circuit of electronic apparatus carried in the missile for use with the gyroscope of the present invention and in which the gyroscope rotor 28 and the electrodes or plates 37 and 38 are shown as elements in the capacity bridge circuit 39, the rotor being connected to terminal 41 of a fre-

quency modulated transmitter 42 while the electrodes 37 and 38 are connected at points 43 and 44, respectively, by individual leads to output terminals 45 and 46 of a power supply 47. Resistors 48 and 49 are respectively connected at points 43 and 44 at one side thereof while the other side of the resistors are interconnected as at 51. Point 51 is connected to terminal 52 of the transmitter 42. Power supply 47 and transmitter 42 are interconnected by leads 53 and 54. Transmitter 42 has connected thereto by coaxial cable 55 a dipole antenna 56.

In order to prevent damage to the gyroscope mechanism during the gun launching operation of the missile, provision is made for supporting the rotor while the extremely high acceleration forces accompanying such operation are present in the missile. During the launching operation the rotor comes to rest against a plurality supporting pins 57 mounted in one of the closures 13. The setback force acts on the rotor, shaft, and bearings to compress one of the springs 19 which in turn brings the rotor into contact with the pins 57. This supports the weight of the rotor and thereby avoids damage by the rotor to the bearings, pivot pins, ring, and shaft. This arrangement, also, prevents the rotor position with respect to the missile axis from being disturbed by the initial violent erratic motion of the missile during the launching thereof.

As is apparent in Fig. 2 of the drawings, the endwise movement of the rotor assembly is limited by the pins 57 mounted in both of the closures 13. When the acceleration forces have dissipated, the rotor assembly returns to its normal position.

During acceleration the inertia operated diaphragm puncturing means 36 initiates the flow of gas from container 35 through tube 34 to the turbine buckets 33 in the periphery of rotor 28. When the rotor, as aforesaid, moves back to its normal position the rotor is driven by the gas at high speed, thus acting as a gyroscope. In order to allow for the escape of the gas from casing 12 one or more ports 58 may be provided in the casing.

In operation, declination of the missile from the original launching angle changes the relative positions of the rotor 28 and the electrodes 37, the rotor axis being aligned with the missile axis at the time the rotor is set in operation, thereby to vary the capacitance between the electrodes and rotor to unbalance the bridge circuit in proportion to the change in the declination angle.

The fin structure of the missile is such as to cause the missile to rotate at a speed of approximately 600 R. P. M., for example. Thus, as the declination angle of the missile changes in response to the force of gravity thereon, the bridge circuit, which is initially balanced, develops in the output thereof an alternating signal voltage as the capacitive coupling of the electrodes with respect to the rotor alternately increases and decreases during successive revolutions of the missile, the amplitude of the alternating signal being proportional to the declination angle and the polarity of the signal being indicative of the instantaneous rotational position of the missile. Thus, assuming that the steering jet openings 100 for steering charge 127 on the missile are at zero degrees and the electrodes 37 and 38 are at 90° and 270° respectively, and assuming further that the electrode 37 is uppermost during positive half cycles of the alternating signal of the bridge, the steering jet will be on the starboard side of the missile when the signal reaches the peak of the positive half cycle.

The alternating signal is transmitted to the launching point by way of the telemetering link comprising apparatus 42, 55, 56, 61, and 59. The carrier of this telemetering link is utilized to transmit the bridge signal, the carrier for this purpose being either amplitude modulated or frequency modulated, preferably the latter, by suitable well known apparatus included in the transmitter. The signal received at the launching point is utilized to control firing of the steering charge in missile 10 by

5

transmitting a command signal, at a predetermined time, from transmitter 130 to the missile 10 wherein a receiver 125 is effective upon receiving the command signal to actuate steering charge 127. The instant of transmission from transmitter 130 is controlled by means of a control circuit 123 which includes a manually operable switch 124 and a pair of wiper contacts 82 and 84, of which contact 84 rotates and engages contact 82, it being apparent that engagement of contacts 82 and 84 closes the control circuit 123 when switch 124 is closed. In practice, when it is determined from the declination angle readings on cathode-ray tube 66 that the missile has attained the desired declination, switch 124 is closed and control circuit 123 is completed upon engagement of contacts 82 and 84 to actuate transmitter 130 to transmit the command signal, the instant of engagement of contacts 82 and 84 being adjustable as will be more fully described hereinafter. Of course, it is to be understood that receiver 125 and transmitter 130, instead of being separate units, may be combined in a transceiver unit.

Fig. 6 indicates in diagrammatic form a receiving circuit for the signals transmitted by the transmitter 42 of Fig. 5, the frequency modulation receiver 59 having a dipole antenna 61. Receiver 59 is energized by power supply 62 and the signal output of the receiver is carried by conductors 63 to the gunnery director 64 where these signals are integrated with other information within the gunnery director. The signals are passed to a cathode-ray tube assembly 65 where they are translated into a visual signal indicative of the instant declination angle of the missile 10, as will be hereinafter more fully described.

Fig. 7 indicates in diagrammatic perspective a cathode-ray tube 66 having a deflection coil 67 of the rotating magnet type to which is fed the signal received by receiver 59 after suitable demodulation therein, the deflection coil 67 being D. C. biased. The signal is fed to the coil 67 by slip rings 68 and brushes 69. The coil 67 is rotated at a speed of approximately 600 R. P. M. through reduction gears 71 and 72 by a variable speed motor 73.

Supported for rotation around the periphery of the face of tube 66 is a calibrated ring 74 for indicating the rotational angle of the missile. A pointer for indicating the zero angle position is indicated at 75 and extends from the inner periphery of ring 74 toward the center of the face of tube 66. The calibrations of ring 74 are indicated at 76 and marked to indicate degrees of angle of rotation of the missile. The outer periphery of ring 74 is formed with gear teeth 77 arranged to mesh with pinion 78 on shaft 79, the shaft having a manual adjusting knob 81 on one end thereof.

A contact point 82 is mounted on gear 71 for rotation therewith, and is in a predetermined position, i. e., is in the plane through reference line 83 and the axis of tube 66, when the deflection coil is in a position to deflect the beam along the reference line in response to the D. C. bias on the coil. A second contact 84 is mounted on a gear 85 for rotation therewith, the gear 85 being driven by idler pinion 86 and pinion 87 fixed to shaft 79. Shaft 79 is adjusted either manually, by knob 81, or automatically by the gunnery director 64 in any well-known manner.

In operation, the demodulated bridge signal received from director 64 is superimposed on the D. C. bias applied to the deflection coil. In the absence of the bridge signal which, as aforesaid, is caused by changes of the declination angle of the missile, a circle, which is the zero declination indication, is traced on the screen of tube 66. When the amplitude of the bridge signal varies in response to changes of declination of the missile, such for example, as when the rotor of the gyroscope moves its lower side relative to the missile in the direction of flight of the missile, the trace on the screen of the tube 66 moves toward the center thereof. A reverse tilt of the rotor will cause the trace on the screen to move toward the periphery thereof. Thus, as the capacitance

6

between electrode 37 and the rotor increases to the maximum value during the positive half cycle of the bridge output signal, the trace on the tube moves toward the periphery of the tube, and as the capacitance between electrode 38 and the rotor increases to the maximum value during the negative half cycle of the bridge output signal, the trace on the tube moves toward the center thereof whereby a resultant cardioid-shaped trace is produced on the tube.

The deflection coil 67, as aforesaid, is driven by motor 73 at a speed of approximately 600 R. P. M. which is the approximate speed of rotation of the missile. Due to the lack of synchronism of rotation of the missile and coil 67 the cardioid trace will slowly rotate on the screen of the tube. The speed of the motor 73 is adjusted to bring the rotation of the coil 67 into perfect synchronism with that of the missile whereupon the rotation of the trace is stopped. A further adjustment is made to bring the innermost portion of the trace into alignment with the reference mark 83 on the face of tube 66. This adjustment will serve to position contact 82 in order that upon engagement of contacts 82 and 84, command steering signals may be transmitted via transmitter 130 at the proper instant between the gunnery director 64 and the missile 10, wherein receiver 125 is effective in response to the command signal to actuate steering charge 127 as hereinbefore described.

The gunnery director 64 utilizes the demodulated bridge output signal to compute the declination angle and computes the desired possible rotational positions of the missile in which desired changes in course may be effected and continuously adjusts the position of contact 84 in order that the steering charge may be fired in the desired rotational position when the desired declination angle is reached. As the declination angle increases, the amplitude of the bridge output signal increases whereby the minimum point on the cardioid trace moves inwardly on the screen of the tube and thus visually indicates the declination angle continuously during the flight of the missile.

Contacts 82 and 84 are connected in a circuit in series with the command firing circuit 123 within the director 64 which controls the distance from a target at which the steering is to be initiated. Pointer 88 of ring 77, which indicates the calculated rotational positions in which changes of course of the missile 10 may be effected, continues to move over the tube face as contact 84 also is moved through the action of shaft 79 which is driven by suitable mechanism (not shown) contained in the director 64, the mechanism being influenced by information of the relative positions of the target and the missile received by the director.

In a modified form of the invention as disclosed in Figs. 8 and 9 of the drawings, four condenser elements 89, 91, 92 and 93 are secured to casing 12 equidistantly around the grounded rotor 28. These condenser elements or electrodes have a conformation similar to that of the elements 37 and 38. This arrangement is particularly desirable for use in a very slowly rotating body which is undergoing simultaneous yawing in two directions during the flight thereof.

Condenser elements 89 and 91 are arranged at diametrically opposite points in casing 12 while elements 92 and 93 are positioned diametrically opposite each other and are spaced 90° from elements 89 and 91. Condenser elements 89 and 91 are incorporated in bridge circuit 94, while condenser elements 92 and 93 are incorporated in bridge circuit 95.

Each of the bridge circuits receives voltage from a respective half of the output coil of power transformer 96, the coil being grounded at the center thereof. Power from transformer 96 enters the bridge circuits 94 and 95 at points 97 and 98 respectively. One end of each of a pair of resistors 99 and 101 is connected at point 97, while one end of each of a pair of resistors 102 and 103

is connected at point 98. The other ends of the resistors 99 and 101 are bridged by primary coil 104 of a transformer 105, while the other end of resistors 102 and 103 are bridged by the primary coil 106 of transformer 107. Transformers 105 and 107 are provided with secondary windings 108 and 109 respectively. Secondary windings 108 and 109 have their output leads connected to an F. M. transmitter 110 having means for converting the amplitude variations of the bridge outputs to frequency variations whereby frequencies individual to each bridge circuit 94 and 95 may be transmitted by way of the telemetering link generally designated 120 and which are indicative of the varying capacitance in the circuits caused by movement of grounded rotor 28 with respect to condenser elements 89, 91, 92 and 93. Signals transmitted by transmitter 110 are picked up at a remote point by receiver 111 which includes appropriate apparatus for demodulating the signals. These demodulated signals are passed through gunnery director 112 to a conventional cathode-ray tube assembly 113, the signals generated by bridge circuit 94 influencing the horizontal beam deflections of the tube, while the signals generated by circuit 95 influence the vertical beam deflections of the tube whereby the electron beam 121 is caused to move along the dashed line path 122 at a rate sufficiently slow to be capable of being followed by the eye of the operator who may thus visually ascertain the rotational position of the missile by noting the angular position of the beam. Otherwise the circuits of Figs. 8 and 9 operate in a similar manner to those of Figs. 5 and 6.

While the device of the present invention has been described and illustrated as being employed in a gun-fired rotating missile or shell, it is contemplated that the device may have other applications such, for example, as in any moving body where it is desirable to be informed at a remote position of the rotational position and deviations in the angle of the body during the travel thereof.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A differential gyroscope for a rotating missile comprising, a tubular casing fixed within said missile and rotatable therewith, a shaft mounted for rotation in said casing along the axis of rotation of said missile, a rotor mounted on said shaft and rotatable therewith, means for driving said rotor, said mounting for said rotor providing for angular movement of the rotor with respect to the shaft, a plurality of electrodes fixed to said casing and insulated therefrom, said electrodes being adjacent the periphery of said rotor and arranged in predetermined spaced relation around said periphery, an initially balanced bridge circuit, said electrodes and said rotor co-operating to form a plurality of variable capacitors in said bridge circuit whereby the capacity of the capacitors is varied and the bridge is unbalanced in accordance with changes in the relative positions of the electrodes and the rotor, and a circuit connected to the bridge circuit and arranged for transmitting a signal which varies in accordance with said variations of capacity of the bridge circuit.

2. Telemetering apparatus for use with gun-launched rotating missiles comprising, a casing fixedly mounted within said missile and having the normal axis thereof coincident to the rotating axis of the missile, a shaft mounted for rotation within said casing and on the axis thereof, a rotor mounted on said shaft for rotation therewith and constructed and arranged to have limited free angular motion with respect to said shaft, a pair of sup-

porting members mounted in the ends of said casing and having respective axial bores therein, a pair of bearing members for said shaft and mounted in said bores for yieldable movement in both directions along the axis of said casing, a plurality of pins extending from the inner walls of said supporting members and arranged to support said rotor as the bearing members yield to set back force during the launching of said missile, gas propelling means arranged to be initiated by said setback force for rotating said rotor as the setback force is reduced, an initially balanced bridge circuit, capacitor plates arranged in said bridge circuit and comprising said plates and said rotor and fixed to said casing adjacent said rotor whereby the capacitance of said circuit is varied and the bridge is unbalanced as the angle of the rotor varies with respect to the axis of said missile in response to variations in the declination angle of the missile in flight, and transmitting means in said missile influenced by said unbalance of the bridge circuit for transmitting signals proportional to said capacity variations.

3. A device for producing a visual indication of a signal which varies in value in accordance with the changes in angle of a rotating missile with respect to an initial position of the axis of rotation thereof comprising, in combination, a cathode ray tube, a coil arranged about said tube so as to control deflection of the electron beam of the tube in accordance with the degree of energization of the coil, said coil being supported for rotation about the axis of the tube, means for rotating the coil at approximately the speed of rotation of the missile, means for biasing the coil so as to produce a circular trace on the screen of said tube, means for applying said signal to the coil whereby said circular trace is changed to a cardioid trace which slowly rotates in accordance with the difference in the speeds of rotation of the coil and missile, and means for adjusting the speed of rotation of the coil sufficiently to bring the rotating coil into synchronism with the missile thereby to stop the cardioid trace on the screen whereby the radial deviations from said circular trace at the minimum of said cardioid trace may be observed as a measure of said changes in angle of the missile.

4. A system for firing the steering charge of a rotating missile having the steering charge in one side thereof comprising, in combination, means in the missile for generating and transmitting a signal which varies in magnitude in accordance with changes in declination angle of the missile, means at the launching point for receiving said transmitted signal, a cathode ray tube, a coil arranged about said tube so as to control deflection of the electron beam of the tube in accordance with the degree of energization of the coil, said coil being supported for rotation about the axis of the tube, means for rotating the coil at approximately the speed of rotation of the missile, means for biasing the coil so as to produce a circular trace on the screen of said tube, means for applying said signal to the coil whereby said circular trace is changed to a cardioid trace which slowly rotates in accordance with the difference in the speeds of rotation of the coil and missile, means for adjusting the speed of rotation of the coil sufficient to bring the coil into synchronism with the missile and the cardioid trace to a stop with the maximum inward deviation thereof in line with the vertical through the screen of the tube, a first contact member fixed to said coil for rotation therewith, and a second contact member mounted for rotatable adjustment about the axis of the tube and for momentarily contacting said first contact member during each rotation of the first contact member, said first and second contact members being included in a circuit for controlling firing of said steering charge and including a switch which renders the closing circuit effective to fire the charge as the contacts engage after the switch has been closed, said second contact being adjustable to different angular positions about the axis of the tube whereby the steering charge may be fired at

any desired rotational position of the missile when the declination angle reaches a predetermined value.

5. Apparatus for telemetering signals indicative of angular changes in the course of movement of a launched rotating body moving along a course comprising, in combination, a normally balanced bridge network carried by said body and rotatable therewith, variable impedance means in operative circuit relationship in said bridge network and movably mounted in said body for movement transverse to the axis of rotation of said body, said impedance means being movably operable in response to changes in angle from said course by said body to vary the impedance thereof and cause an unbalance in said bridge network whereby output signals are produced therein proportional to said changes in angle, acceleration-sensitive means operatively associated with said variable impedance means and responsive to the setback force developed upon launching of the moving body to render said variable impedance means effectively invariable until the setback force is dissipated, a transmitting circuit carried by said body and connected to be modulated by said output signals for producing and transmitting intelligence signals correlative to said changes in angle, and circuit means at a control station remote from the moving body and including receiving means for receiving said intelligence signals and intelligence translating means for reproducing indicia representative of said changes in angle.

6. The apparatus of claim 5, wherein said translating means comprises a cathode ray tube, a rotatable coil arranged about said tube so as to control deflection of the electron beam of the tube in accordance with the degree of energization of the coil, means for rotating the coil in synchronism with the speed of rotation of said rotating body, means for biasing said coil so as to produce a circular trace on the screen of said tube, and means for applying the received intelligence signals to said coil whereby said circular trace is changed to a cardioid trace in which the radial deviations from said circular trace at the minimum of said cardioid trace is a measure of said changes in angle.

7. The apparatus of claim 5, wherein said bridge network comprises a pair of normally balanced bridge circuits each having a pair of electrodes individual thereto, said variable impedance means including said electrodes and a rotor capacitively cooperating with all of said electrodes, said rotor being arranged for rotation about an axis coincident with the axis of rotation of said body to provide gyro action and mounted for movement transverse to said axis of rotation under influence of changes in angle from said given course for causing an unbalance in said bridge circuits whereby output signals are produced respectively by said bridge circuits proportional to said changes in angle; wherein said transmitting circuit is operably responsive to the output signals of said pair of bridge circuits to transmit a pair of intelligence signals simultaneously; and wherein said translating means comprises a cathode ray tube having vertical and horizontal beam deflection systems, the vertical deflection system being operably responsive to one of said intelligence signals while the horizontal beam deflection system is responsive to the other of said intelligence signals whereby a narrow concentrated moving beam indicative of said changes in angle is visually indicated on the screen of the tube.

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