United States Patent

Müller

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[54] FLIGHT CONTROL CIRCUIT FOR MISSILE SPINNING ABOUT ITS LONGITUDINAL AXIS

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **F41g 7/00**, F42b 15/02, G06f 15/50

[58] **Field of Search** 244/3.11, 3.15, 3.19, 3.20

[56] **References Cited**

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[57] **ABSTRACT**

A flight control circuit is provided for a missile spinning about its longitudinal axis and provided with at least one control member influencing its trajectory. The missile is stabilized about at least one of its pitch and yaw axes by at least one gyroscope having a gyro rotor shaft operatively associated with at least one position pickup indicating the position of the rotor shaft. Each position pickup is mounted rigidly on the missile frame in a plane containing the longitudinal axis of the missile and which plane also included the line of action of the control member. Each position pickup is connected directly to actuating means for the control member.

8 Claims, 4 Drawing Figures

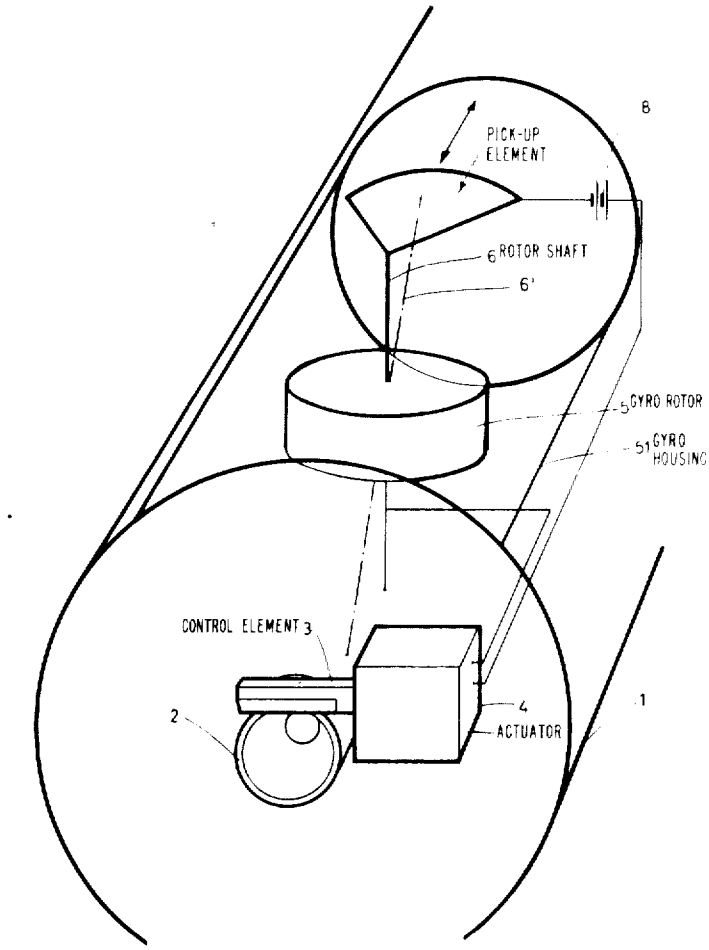


Fig. 2

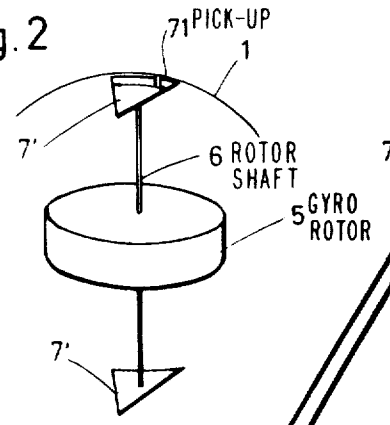


Fig. 1

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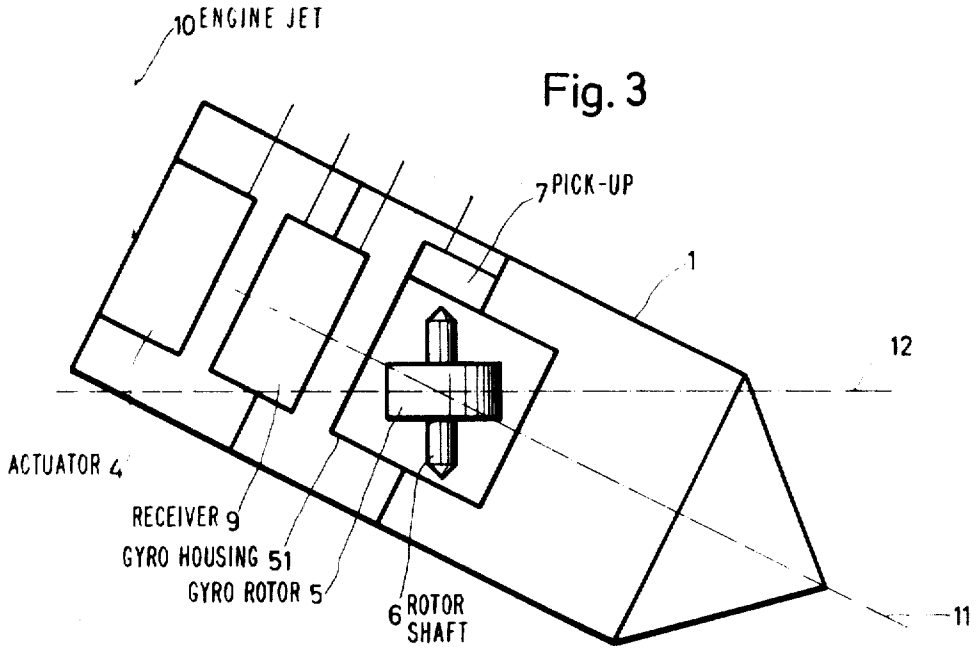


Fig. 3

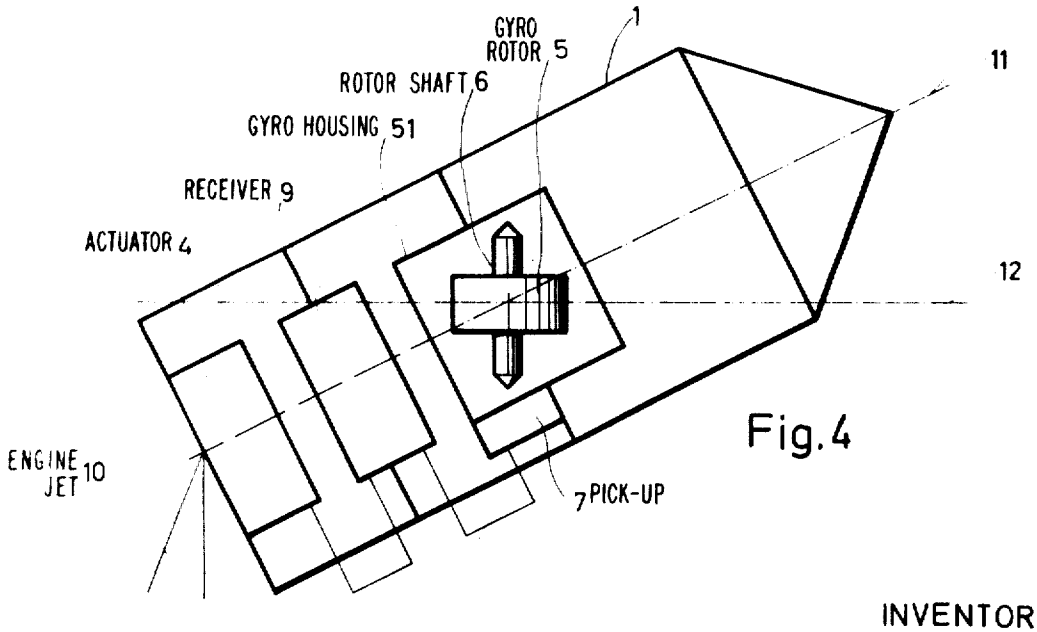


Fig. 4

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FLIGHT CONTROL CIRCUIT FOR MISSILE SPINNING ABOUT ITS LONGITUDINAL AXIS

BACKGROUND OF THE INVENTION

In the art of missiles, the term "flight control circuit" denotes the aggregate of those components which are necessary in the missile to maintain the missile automatically in a trajectory determined, for example, by the launching direction. A "flight control circuit" is also called an "internal control circuit." In contrast to this term, a "guide control circuit," also called an "external control circuit," operates to influence a missile to follow any desired trajectory at the will of a manual or automatic controller.

So-called tactical missiles, for ranges within which the missile can be visually observed, either by the unaided eye or by optical aiding means, which missiles spin about their longitudinal axis and which usually have, for their control, only one control member influencing their trajectory, as, for example, a jet rudder, a pivotable thrust nozzle, or a fixed control nozzle, often have only a guide or external circuit. Through this guide control or external control circuit, the missile is maintained in the desired flight position and guided by remote control from a directing station separate from the missile.

The absence of a flight control circuit independent of this guide control circuit, that is, the absence of the so-called internal control circuit, is felt to be particularly disadvantageous when the missile has a low initial speed. Due to this low initial speed or velocity, the missile is very sensitive to external influences with respect to the maintenance of this trajectory, and may be caused to veer from its original firing direction, for example by gusts of wind. When using the missile over only a short distance, such changes of direction of the missile from the launching direction aimed at a target are difficult or impossible to correct by the guide control circuit within the short flight time, because the guide control circuit determines the guiding or correction signals only from an off-position of the missile from the reference line. That is, the guide control circuit does not perceive rotations of the missile about its center of gravity and preceding the off-positions, and hence reacts very sluggishly. Moreover, for system-caused reasons, the guide control circuit is usually ready for use only after a certain minimum flight time.

If, after launching, such missiles are tracked by an infrared position finder, in order to obtain, from the off-position values determined by the position finder, the guiding signals to be transmitted to the missile, a relatively small deviation of the missile from its firing position leads already to the loss of guidability, since the pickup range of the infrared position finder, of about $\pm 3°$, is very narrow. After the missile has broken out of the pickup range of the infrared position finder, guiding the missile is no longer possible.

SUMMARY OF THE INVENTION

This invention relates to a flight control circuit for a missile spinning about this longitudinal axis and provided with at least one control member influencing the trajectory, the missile being stabilized about one or both of its pitch and yaw axes by means of a gyroscope, with each gyro rotor shaft being operatively associated with at least one position pickup indicating the position of the shaft. More particularly, the invention is directed to a novel flight control circuit utilizing already existing control components of the missile, such as a position gyroscope of the guide control circuit, and which flight control circuit is able to maintain the missile in the flight direction given by the launching immediately after its launching and when the guide or external control circuit is still inoperative, even at low initial speeds of a missile.

Based upon already existing guidance components, in accordance with the invention, the position pickups of a position gyroscope are rigidly connected with the missile frame in a plane containing the longitudinal axis of the missile, and which plane also includes the line of action of the control member. The position pickups are directly connected to a device actuating the control member.

In accordance with the preferred embodiment of the invention, each position pickup comprises an element which, upon rotation of the missile about its longitudinal axis, enters into operative connection with one end of the associated gyro rotor shaft. The duration of maintenance of this operative connection, referred to one revolution of the missile, is directly proportional to the inclination of the gyro rotor shaft relative to its theoretical position. That is, the duration of maintenance of the operative connection is the longer the greater the inclination of the gyro rotor shaft.

By this rigid correlation between the position pickup and the control member of the missile, there is insured, in an astonishingly simple manner that the missile receives, for example, a thrust vector signal correcting its trajectory precisely in a spin or angular position about its longitudinal axis in which an electric signal of a certain duration is produced by means of a gyroscope associated with the corresponding stabilization plane and by way of the element of the position pickup.

Preferably, the element is a triangular contact element which, upon contact with the gyro rotor shaft, closes a circuit including the actuating device for the missile control member. This contact element may be rigidly connected either with the missile frame, so that the gyro rotor shaft sweeps the element as a pickup, or, in accordance with another embodiment of the invention, each of such contact elements may be connected with each gyro rotor shaft end or alternatively with the two bearings of the gyro rotor shaft, with a pickup rigidly connected with the missile frame sweeping the contact elements.

By means of this arrangement, an electric signal, of a duration determined by the inclination of the gyro rotor shaft, is produced in a simple manner directly by closing a circuit, and is supplied to the actuating device of the control member. Therefore, the control member immerses, for example, into the engine jet of the missile, or respectively deflects the latter otherwise, exactly for the duration of the maintenance of the operative connection between the contact element and the gyro rotor shaft. In other embodiments of the invention, the use of position pickups operating, for example, inductively or photoelectrically, is possible in place of a direct electric contact element.

In the following, reference to the control member will be to a jet rudder which, during the time indicated by the position pickup, immerses into the engine jet of the thrust nozzle. However, in place of a jet rudder, a pivotable nozzle deflecting the engine jet, or a control nozzle secured to the missile and thus revolving about the longitudinal axis of the missile, may be used. There also may be used an aerodynamically active spoiler which, actuated in a certain spin position of the missile, guides the missile in a direction corresponding to this spin position.

In accordance with the preferred application of the invention, the flight or internal control circuit is used in connection with a missile guided by remote control from a directing station and through a guide or external control circuit. Preferably, the flight control circuit, or internal control circuit, is always connected only when the guide control circuit, or external control circuit, of the missile is not yet or no longer in operation. In principle, however, simultaneous operation of both control circuits is possible, the guide signals then being superimposed on the signals produced by the flight control circuit in a known manner.

Preferably, the flight control circuit of the invention bring about control of the missile immediately after launching of the latter. It is not until the first guide command is given to the missile through the guide control circuit that the flight control circuit is switched off. Thereby, it is possible to bring the missile into a near target, in direct firing, without taking the guide control circuit into operation, the launching direction of the missile being the same as the target direction, and which launching direction is maintained against external influences by means of the flight control circuit.

In accordance with another embodiment of the flight control circuit, an intentional change of the trajectory is possible by displacement of the position pickups, connected with the

missile frame, longitudinally of the missile. The commands causing such a displacement can be made available, for example, by transmission from a directing station or from a program storage secured on board the missile. In this way, a very simple guiding of the missile by almost exclusively mechanical means is possible with the aid of the flight control circuit of the invention.

An object of the invention is to provide an improved flight control circuit for a missile spinning about its longitudinal axis and provided with at least one control member influencing its trajectory.

Another object of the invention is to provide such a flight control circuit utilizing already existing guidance components on the missile.

A further object of the invention is to provide such a flight control circuit for a missile which is stabilized about at least one of the pitch and yaw axes by at least one gyroscope having a rotor whose shaft is operatively associated with at least one position pickup indicating the position of the rotor shaft.

Another object of the invention is to provide such a flight control circuit in which the position pickups of a position gyroscope are rigidly connected with the missile frame in a plane containing the longitudinal axis of the missile and also including the line of action of the control member.

A further object of the invention is to provide such a flight control circuit in which the position pickups are directly connected to a device actuating the control member.

Another object of the invention is to provide such a flight control circuit in which the duration of a position control circuit, referred to one revolution of the missile about its longitudinal axis, is directly proportional to the inclination of the gyro rotor shaft relative to its theoretical position.

Another object of the invention is to provide such a flight control circuit which is operative either only before and after a guide control circuit is active or which is operative simultaneously with a guide control circuit.

A further object of the invention is to provide such a flight control circuit including position pickups connected with the missile frame for displacement longitudinally of the missile responsive to external of internal command signals.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

In the drawings:

FIG. 1 diagrammatically illustrates the arrangement of a gyro rotor and a position pickup in a flight control circuit embodying the invention, as incorporated in a missile frame or casing provided with a single jet rudder;

FIG. 2, diagrammatically illustrates another embodiment of the position pickup; and

FIGS. 3 and 4, diagrammatically illustrate the mode of operation of the flight control circuit upon deviation of the missile about the pitch axis or the yaw axis.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, a missile air frame or casing 1, designated only in FIG. 1, has at one end a nozzle 2 for the discharge of the engine jet. A single jet rudder 3 is able to immerse or dip into the engine jet, in a known manner, when it is moved by way of an actuating device 4 which has not been shown in detail but which is well known to those skilled in the art. A gyroscope, which is illustrated in a simplified manner a comprising essentially only a rotor 5 and a gyroscope housing 51, is so suspended in missile airframe or casing 1 that, in the theoretical position of the missile, the gyro rotor shaft 6 is perpendicular to the pitch axis of the missile. That is, gyro rotor shaft 6, in such theoretical position, lies in the circular cross section plane of the gyroscope housing and of the missile air frame or casing 1.

Gyroscope housing 51 is rigidly connected with missile casing or frame 1 so that, in the subsequent consideration of the operation of the flight control circuit, it is immaterial whether the gyro rotor 5 moves relative to gyro housing 51 or relative to missile frame or casing 1. A triangular contact element 7 is cooperable with gyro rotor shaft 1, and is so arranged, for example on the inner surface of gyroscope housing 51, and hence also of missile frame or casing 1, that gyro rotor shaft 6, when in its theoretical position, touches the triangular contact or segment 7 only at the acute angle corner of the triangle or is just barely spaced from this corner.

The actuating means or device 4 for jet rudder 3 is included in an electric circuit which has been indicated only in principle, and this electric circuit is energized from a source of potential 8 by engagement of rotor shaft 6 and contact element 7.

During flight, missile air frame or casing 1 continuously spins about its longitudinal axis, while gyro rotor 5, and thus its shaft 6, maintain a position which is stationary in space. During this spinning of missile airframe 1, therefore, contact element 7 describes a circular path about gyro rotor 5, jet rudder 3, present with contact element 7 in the same longitudinal plane of the missile, also moving in a circle about the longitudinal axis of the missile. If missile frame 1 is in the theoretical or correct position in relation to its pitch axis, then, during spinning of the missile frame, with every sweeping of contact element 7 past one end of rotor shaft 6, the electric circuit is either closed for a very short time or is not closed at all. Thus, actuating device 4 is unable to impart, to jet rudder 3, a movement immersing or dipping the jet rudder into the engine jet.

If, on the other hand, missile frame 1 executes a movement about its pitch axis, then gyro rotor shaft 6, which remains stationary in space, migrates, relative to missile frame 1, into the position marked 6'. With every rotation of the missile frame about the longitudinal axis, therefore, the energizing circuit or device 4 is closed for a certain duration as contact element 7 sweeps by the upper end of gyro rotor shaft 6' so that, during this time, jet rudder 3 is immersed or dipped into the engine jet through actuating device 4. As the contact element 7 sweeps by the lower end of the gyro rotor shaft 6' no contact occurs between the contact element and the rotor shaft so that, in this spin position of the missile, no thrust vector variation influencing its direction can take place. The greater the change of position of missile frame 1 relative to its pitch axis, the further gyro rotor shaft will migrate from its theoretical position in relation to missile frame 1 and the longer will be the time during which actuating device 4 is switched on with the energizing circuit closed, since the path of the contact element 7 swept by gyro rotor shaft 6 becomes longer and longer.

In the other embodiment of the position pickup, as shown in FIG. 2, two contact elements 7' are secured to respective opposite ends of gyro rotor shaft 6. Contact elements 7' cooperate with a pin type pickup 71 rigidly connected with missile frame 1 so as to revolve, with the missile frame, about gyroscope 5. Pickup 71 closes the energizing circuit for actuating means 4 in the same manner as in the embodiment of the invention shown in FIG. 1.

FIG. 3, illustrates missile frame or casing 1 in which gyroscope 5, with its gyro rotor shaft 6, is arranged. Contact element 7, forming the position pickup, is electrically connected with actuating device 4, for the jet rudder, through the medium of an onboard receiver 9 not shown in detail, and which is part of a guide control circuit, which is also not illustrated. With the illustrated deviation of longitudinal axis 11 of the missile from the theoretical axis 12, which in the plan view represents the yaw axis and in side elevation represents the pitch axis of the missile, the schematically indicated engine jet 10 of the missile is so deflected, by means of position pickup 7 and actuating device 4 through the jet rudder, that the longitudinal axis of the missile is brought back into the direction of the theoretical axis 12. In other words, the missile is restored to its correct orientation.

FIG. 4 illustrates, in principle, the same operation of the flight control circuit except that now longitudinal axis 11 of the missile has rotated, relative to the theoretical axis 12 in precisely the opposite direction. Thus, engine jet 10 is deflected in the opposite direction in order to bring the missile back into its theoretically correct orientation. At such a direction of the missile, position pickup 7 gives a command to actuating means 4 controlling the jet rudder, in a spin position advanced by 180° relative to that shown in FIG. 3, so that again an actuation of the jet rudder, correctly correlated with the missile direction as to angle, occurs.

If, by means of the flight control circuit, a missile is to be stabilized relative to its yaw axis as well as to its pitch axis, two separate gyroscopes must be provided each having an individual position pickup associated therewith. These pickups, for example, act jointly on the actuating means 4 for a single jet rudder. The arrangement of the gyroscopes provided for the pitch axis and for the yaw axis can be seen from FIGS. 3 and 4, where the gyroscope 5 shown in these figures, when regarded as a side elevational view, stabilizes the missile relative to pitch movements and, when regarded as a top plan view, stabilizes the missile relative to the yaw movements. That is, corresponding signals are furnished to actuating means 4 through the individual position pickups 7.

Instead of a single jet rudder, there may be provided, for example, two jet rudders mutually displaced by 180°. Each jet rudder then has assigned to it its own position pickup which, referred to the missile airframe or casing, must lie in the same plane in which lies the line of action of the associated jet or correlated jet rudder. Such an arrangement of, for example, two jet rudders, may be necessary when high transverse accelerations are to be exerted on the missile so that, with each revolution about its longitudinal axis, two thrust vector commands can be imparted to it successively in respective spin positions.

If a separate gyroscope is provided for the pitch axis and for the yaw axis, each gyroscope may have its own jet rudder correlated to it. With such an arrangement, the jet rudders then preferably are displaced angularly by 90° relative to each other so that both jet rudders can become operative simultaneously

In the event the missile is to be brought on to a target over short distances in direct firing, that is, when the launching direction coincides with a nonvarying target direction, it makes sense not to let the guide control circuit of the missile become operative. In order that the distance to be traveled in direct firing can be freely selected, the flight control circuit therefore is not switched off until a first guiding signal, influencing the guide control circuit arrives at the missile. Thereby it is insured that the missile can fly over a freely selected distance, or respectively, a freely selected flight time, exclusively under the control of its flight control circuit which maintains the launching direction of the missile.

In accordance with a further embodiment of the flight control circuit, the contact element 7, shown in FIG. 1 is displacable in the longitudinal direction of missile air frame or casing 1, as indicated by the arrow, so that, in this manner any desired thrust vector commands can be given to the missile. When the contact element is displaced by a driving device, which has not been shown, in accordance with guiding signals emitted by a directing station separate from the missile or by a program storage mounted in the missile, then the flight control circuit acts, at the same time, also as a guide control circuit.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A flight control circuit, for a missile constantly spinning about its longitudinal axis during flight and provided with at least one control member influencing its trajectory, the missile having a frame and being stabilized about at least one of its pitch and yaw axes by at least one gyroscope, mounted in the frame so as to be stationary in space, and having a rotor whose shaft is operatively associated with at least one position pickup indicating the position of the rotor shaft relative to the missile frame, to sense deviations of the missile from a preselected trajectory: said flight control circuit comprising, in combination, means connecting each position pickup to the missile frame and fixed in a plane containing the longitudinal axis of the missile and which plane also includes the line of action of said control member, for cooperation with said rotor shaft during said spinning of the missile; actuating means for said control member; and means connecting each position pickup directly to said actuating means to operate said control member in accordance with sensed deviations of the missile relative to a preselected missile trajectory; each position pickup effecting actuation of its associated control member during a time period proportional to the magnitude of a sensed deviation of the missile from the preselected missile trajectory.

2. A flight control circuit for a missile, as claimed in claim 1, in which each position pickup comprises an element which, during each rotation of the missile about its longitudinal axis, enters into operative connection with one end of the associated gyro rotor shaft; the duration of the maintenance of this operative connection, referred to one rotation of the missile about its longitudinal axis, varying directly with the magnitude of the inclination of the associated gyro rotor shaft relative to the rotor shaft position when the missile has such preselected trajectory.

3. A flight control circuit for a missile, as claimed in claim 2, in which each element is a triangular contact element; an energizing circuit for said actuating means including a source of potential, said triangular contact element, and said gyro rotor shaft; said triangular contact element closing said energizing circuit upon engagement with the associated gyro rotor shaft.

4. A flight control circuit for a missile, as claimed in claim 3, in which said contact element is mounted on the missile frame for displacement longitudinally of the missile frame in said plane in accordance with an external guiding signal to change the trajectory of the missile.

5. A flight control circuit for a missile, as claimed in claim 3, in which each triangular contact element has its apex facing said gyro rotor shaft; the apex of each contact element, when the missile has such preselected trajectory, contacting the associated gyro rotor shaft momentarily during each rotation of the missile; each contact element being displaced from the plane of relative rotation of its associated gyro rotor shaft when the missile deviates in a first direction from the preselected trajectory, and having an increasing time of contact with its associated gyro rotor shaft when the missile deviates in a second and opposite direction from its preselected trajectory.

6. A flight control circuit for a missile, as claimed in claim 2, including a pair of triangular contact elements each secured to a respective opposite end of a gyro rotor shaft; a pickup maintained connected with the missile frame and cooperable with said triangular contact elements; an energizing circuit for said actuating means including a source of potential, said pickup, said contact elements and said gyro rotor shaft; each of said triangular contact elements closing said energizing circuit upon contact with said pickup.

7. A flight control circuit for a missile, as claimed in claim 1, in which said flight control circuit is part of a missile guided by remote control from a control station through a guide control circuit.

8. A flight control circuit for a missile, as claimed in claim 7, in which said flight control circuit is switched off responsive to receipt, at the missile, of the first guiding signal from the guide control circuit.

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