Sept. 11, 1962 W. E. BENNETT ETAL 3,053,099

ROLL STABILIZATION FREE GYRO SYSTEM

Filed April 25, 1960 5 Sheets-Sheet 1

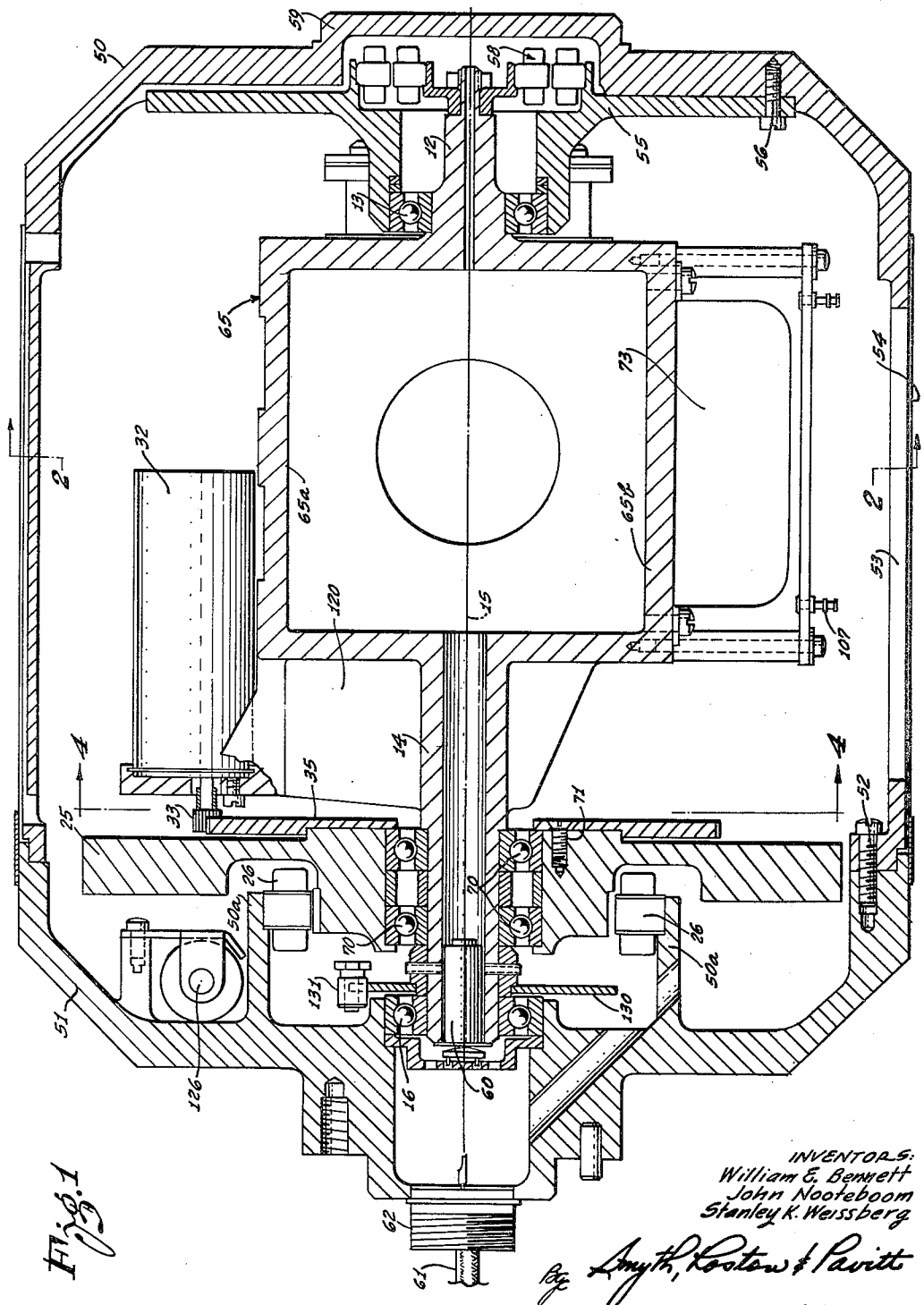


Fig. 1

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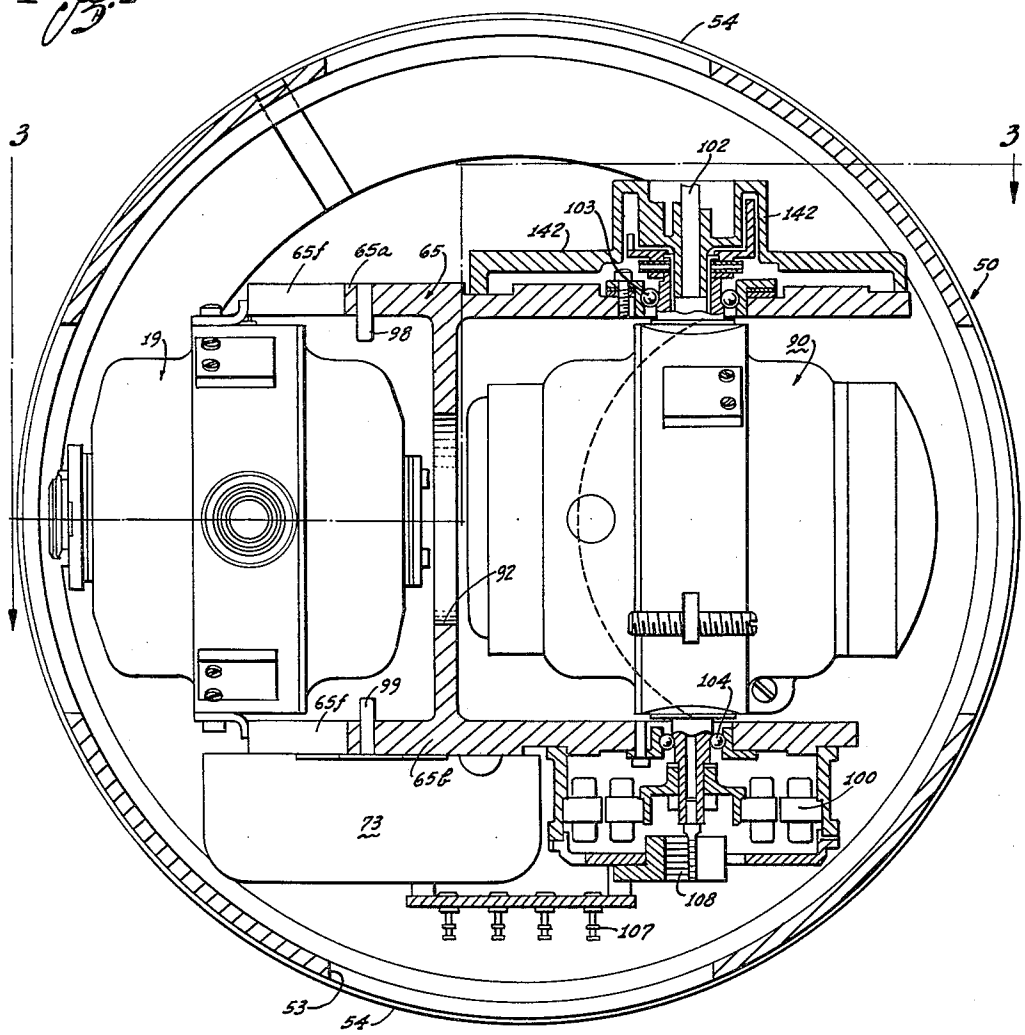
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Fig. 2



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ROLL STABILIZATION FREE GYRO SYSTEM

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Fig. 3

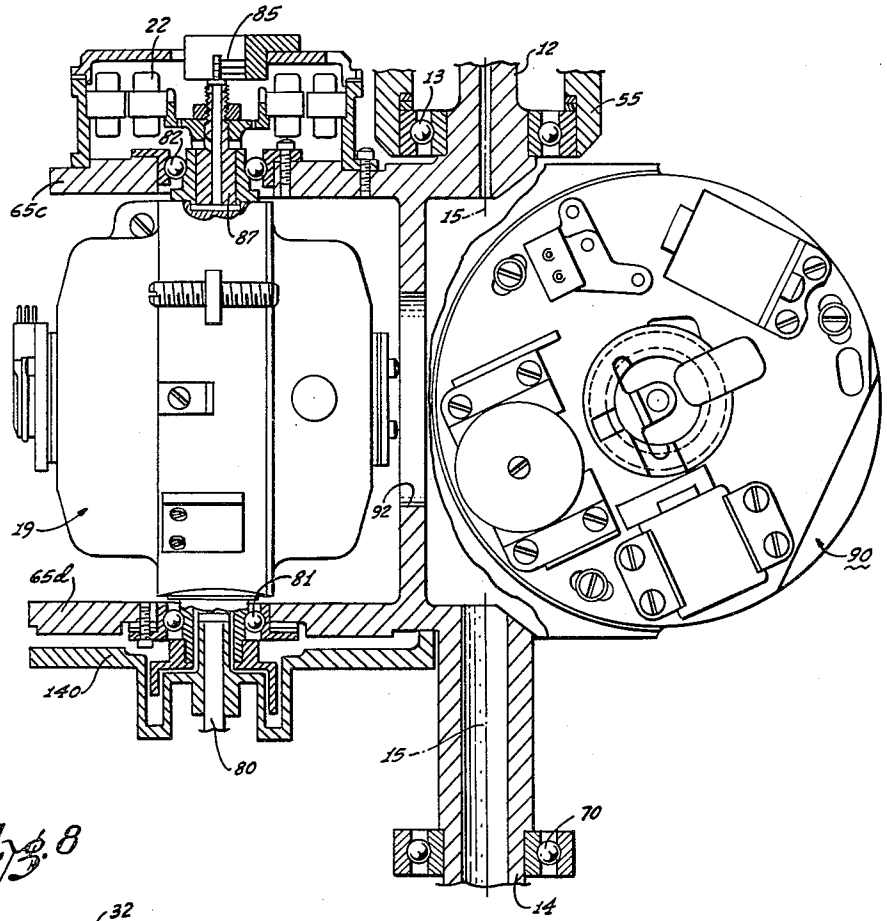
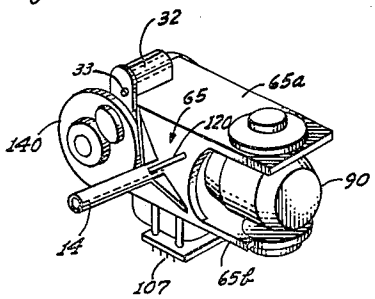


Fig. 8



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ROLL STABILIZATION FREE GYRO SYSTEM

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Fig. 4

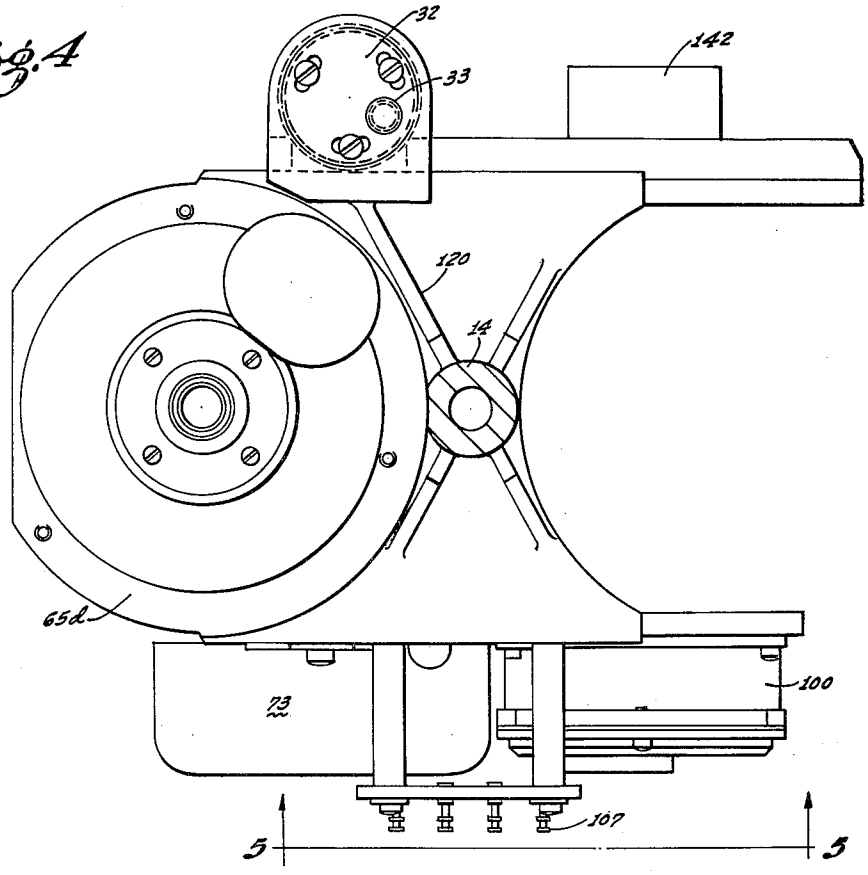
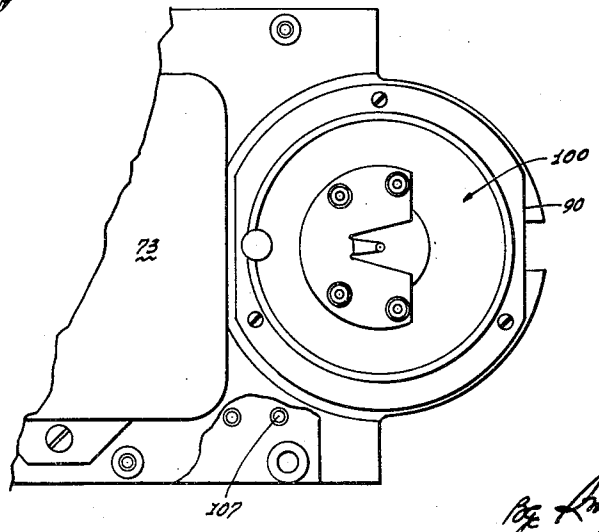


Fig. 5



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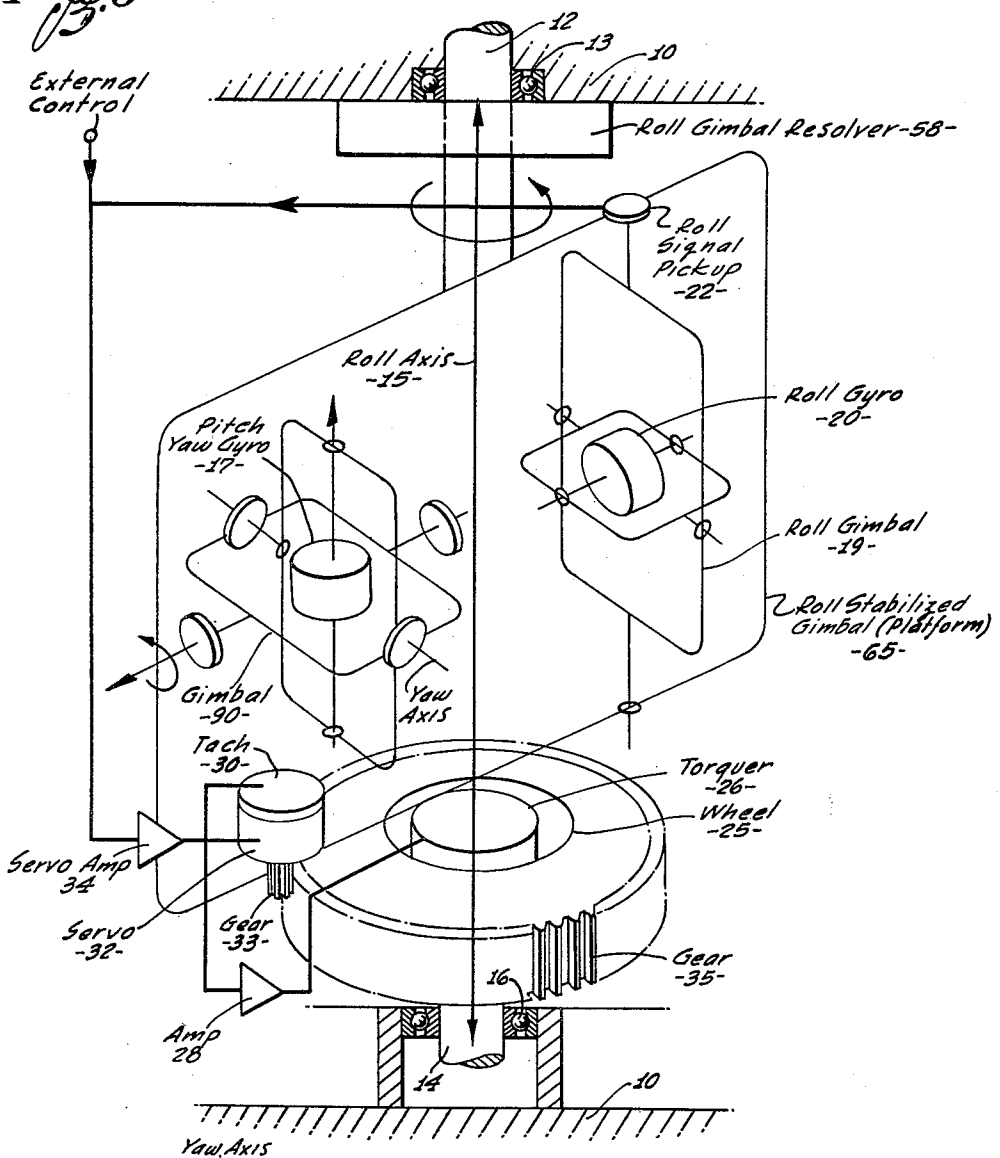
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ROLL STABILIZATION FREE GYRO SYSTEM

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Fig. 6



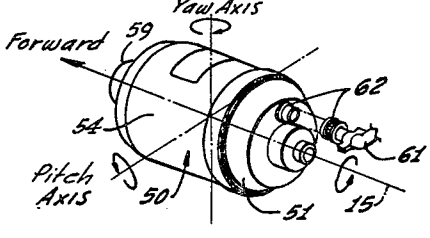


Fig. 7

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3,053,099

ROLL STABILIZATION FREE GYRO SYSTEM

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Filed Apr. 25, 1960, Ser. No. 24,507
12 Claims. (Cl. 74—5.4)

This invention relates to inertial navigation apparatus and, more particularly, to gyroscopic means for maintaining a stable platform in a moving vehicle. Many rockets are spin-stabilized and the present invention has particular application to such vehicles.

Free gyros have heretofore been utilized for determining the attitude of a missile when the missile is rotating at relatively low speeds. These gyros provide the attitude information without stabilizing a platform. Due, however, to the spinning, the gyroscope drift rate is high, and due to the limited freedom of the gyro gimbals, the reference is easily lost. When the missile is spinning at a relatively high speed, such as 20 cycles per second, the drift is so great that free gyros are effectively inoperable. Stabilized platforms have not been utilized in high spinning vehicles because of the tremendous power requirements required to stabilize the platform. The faster the missile spins, the less torque is available from a given rotor for stabilizing the platform. Moreover, the larger the motor utilized to stabilize the platform, the greater is its weight and inertia and, accordingly, the greater is the required torque. For these reasons, stabilized platforms for fast spinning missiles have heretofore been impractical and suitable means for accurately providing missile attitude information has been unavailable.

In a specific illustrative embodiment of this invention, a stabilized platform is provided for a high speed spinning missile utilizing relatively small motors and power requirements. A roll servo is provided which stabilizes the roll platform by reacting against an inertial fly-wheel. The inertial fly-wheel is maintained effectively stationary about its rotational axis with respect to three dimensional space by driving it at a speed equal to but in a direction opposite to the missile spinning motion.

The roll servo system essentially operates under substantially static conditions requiring minimum power, with the torques required to overcome bearing frictional losses due to the high rotational velocity being supplied to the fly-wheel by a relatively low power air gap torquer. Both the roll servo and the air gap torquer are relatively low power motors. The system operates under substantially static conditions because the roll servo reacts against the stationary fly-wheel instead of the spinning missile airframe. The instantaneous rotating speed of the fly-wheel changes quite rapidly due to accelerations of the missile but the speed restores relatively slowly because a low power torquer is utilized. The fly-wheel, accordingly, restores slowly to its effective stationary position in space.

The fly-wheel has a dual function in that it dampens the reaction of the roll servo as well as serving as an effectively static reaction member for the roll servo. By damping the roll servo, oscillations and rapid movements of the platform are avoided.

Further features of this invention pertain to the provision of a two degree-of-freedom gyro as the roll sensing element to avoid a drift of the system due to any wobble motion of the missile as it spins about its roll axis.

Further advantages and features of this invention will become apparent upon consideration of the following description when read in conjunction with the drawing wherein:

FIGURE 1 is a sectional view through the gyro system

of this invention depicting the fly-wheel and coupling to the roll servomotor;

FIGURE 2 is a sectional view taken along lines 2—2 of FIGURE 1 illustrating the roll gyro and the pitch-yaw gyro;

FIGURE 3 is a sectional view taken along lines 3—3 of FIGURE 2 showing the roll gyro and its bearing support means on the roll gimbal;

FIGURE 4 is a sectional view taken along lines 4—4 of FIGURE 1 depicting the tachometer and gear coupling to the fly-wheel;

FIGURE 5 is a partial side view taken along lines 5—5 of FIGURE 4 illustrating the pitch-yaw gyro and synchro pickoff;

FIGURE 6 is a functional representation of the gyro system of this invention illustrating the functional arrange of the various components of the system;

FIGURE 7 is a perspective view of the gyro system of this invention; and

FIGURE 8 is a perspective view of the roll gimbal structure forming the stabilized platform in the gyro system of this invention.

Referring first to FIGURE 6, the gyro system of this invention is mounted on a frame **10** of a spinning vehicle or missile. The spinning motion of the missile and the frame **10** therewith is about the roll axis **15** of the missile at an illustrative speed of 20 revolutions per second.

In the functional representation illustrated in FIGURE 6, the main shafts **12** and **14** of the gyro system are respectively rotatably mounted by bearings **13** and **16** on the frame **10** of the missile. Actually, as shown more particularly in FIGURES 1 and 2, the shafts **12** and **14** are rotatably mounted in a gyro housing **50** which is attached to the frame **10** and, therefore, rotatable with the missile. The housing **50**, which may be hermetically sealed, is substantially cylindrical in shape having illustrative dimensions of an eight inch diameter and an overall length of ten inches. The shape and external appearance of the housing **50** is shown particularly in FIGURE 7. The weight of the gyro system, including the housing **50** and the various components enclosed thereby, is quite small, illustratively, less than 20 pounds. The size and weight of the gyro system is, accordingly, very suitable to missile applications.

The housing **50** includes a front plate **51** which is attached to the main portion of the housing **50** by fastening means or screws **52** (FIGURE 1). The main portion of the housing **50** also has a number of access openings **53** which are covered after the various components are assembled in the housing **50** by a cylindrical sleeve **54** which may be soldered onto the housing **50**. The housing **50**, including the front plate **51** and the sleeve **54**, forms a rigid, hermetically sealed structure which is attached or affixed to the frame **10** of the spinning missile. The housing **50**, therefore, rotates about the roll axis **15**, illustrated in FIGURES 1, 3 and 7 as well as FIGURE 6, together with the frame **10** of the missile. The two shafts **12** and **14** mentioned above, are aligned along the roll axis **15** at opposite ends of the housing **50** and are respectively supported by the bearings **13** and **16** on the housing **50**. Actually, as shown particularly in FIGURE 1, the bearings **13** are supported by a resolver support plate **55** which is attached to the housing **50** by fastening means or screws **56** (FIGURE 1). In addition to the bearings **13**, the plate **55** also supports a roll gimbal resolver **58**, which may be a conventional type and which develops a signal indicative of the angular position of the shafts **12** and **14** with respect to the housing **50**. The roll gimbal resolver **58**, which ts into a cylindrical seat **59** at one end of the housing **50**, is illustrated functionally in FIGURE 6.

At the other end of the housing **50** in FIGURE 1, the

bearings 16 are supported by the front plate 51 and, in turn, rotatably support the end of the hollow shaft 14. A slip ring assembly 60 is provided at the end of the shaft 14 for establishing electrical connections between the various components mounted with the shafts 12 and 14 and a cable 61 which is attached to the end of the front plate 51 by a conventional type connector assembly 62 (FIGURES 1 and 7). As an illustration of the electrical connections through the slip ring assembly 60, the roll position signals from the roll gimbal resolver 58, mentioned above, are coupled to the cable 61 and all power required by the various components of the gyro system is also introduced through the cable 61 and the assembly 60.

The two shafts 12 and 14 supported at opposite ends of the housing 50 are integral parts of a roll gimbal structure 65 upon which most of the components in the housing 50 are supported. The roll gimbal structure 65 is caged in the housing 50 by a caging mechanism shown only partially at 126 in FIGURE 1. The caging mechanism may be conventional and includes a cam 130 attached to the shaft 14 and a cam follower 131. An external signal may be introduced through the cable 61 and assembly 60 to rotate the gimbal structure 65 by means of the cam 130 and follower 131 to a predetermined angular position. The particular caging mechanism for operating the cam 130, as indicated above, may be of conventional type and forms no part of this invention.

As illustrated in FIGURE 1 and in FIGURE 8, the roll gimbal structure 65 has a hollow bracket shape with an upper section 65*a* and a lower section 65*b*. A servomotor 32 is supported partially by the upper section 65*a* of the structure 65 and partially by a web 120 which is integral with the shaft 14. The gimbal structure 65 includes a number of webs 120 which strengthen the structure and serve to prevent flexure between the elongate shaft 14 and the rest of the gimbal structure 65. When the gimbal structure is uncaged or free to rotate, the reaction of the servomotor 32 against a flywheel 25 determines the roll position of the gimbal structure 65 and, in particular, it tends to maintain the structure 65 at a fixed roll attitude so as to function as a stabilized platform.

The flywheel 25 is rotatably supported by sets of bearing 70 (FIGURE 1) on the shaft 14 and is mechanically coupled by a gear linkage including a flywheel gear 35 and a servomotor spur gear 33 to the rotor, not shown, of the servomotor 32. The flywheel gear 35 is attached to the flywheel 25 by fastening means or screws 71, and the gear 33 is coupled through the rest of the gear linkage forming part of the servomotor package to the servomotor rotor shaft, not shown. The gear reduction between the rotor and the flywheel 25 may, illustratively, be 150 to 1.

Assuming for the moment that the flywheel 25 is stationary in space, a torque developed by the servomotor 32 serves to rotate the gimbal structure 65 attached thereto about the roll axis 15. The servomotor 32, in this manner, reacts against the stationary flywheel 25 to rotate the structure 65. Actually, the torque generated by the servomotor 32 tends to rotate the flywheel 25 and the gimbal structure 65 in opposite directions because relative motion of the flywheel 25 and the gimbal structure 65 depends upon their relative moments of inertia. Illustratively, as is further hereinafter described, the flywheel 25 may have one-half the moment of inertia of the structure 65 together with the various components supported thereby so that the flywheel 25 rotates through twice the angular distance of the gimbal structure 65 due to any particular servomotor torque.

The servomotor 32 is driven by an electrical signal supplied thereto from a servo amplifier 34 (FIGURE 6). The amplifier 34 is part of an amplifier section 73 (FIGURES 4 and 5) supported at the bottom of the lower section 65*b* of the gimbal structure 65. The upper and lower sections 65*a* and 65*b* of the structure 65 form a sandwich support enclosing two gyroscopes 20 and 17 therebetween. The gyro 20 is a two-degree of freedom roll gyro for developing a signal for energizing the servomotor 32 and, therefore, for controlling the roll position of the roll gimbal structure 65. The roll signal developed by the gyroscope 20 is provided through the servo amplifier 34 to control the torque delivered by the servomotor 32.

The gyroscope 20 is supported in a two-degree of freedom roll gimbal 19 (FIGURES 2, 3, 4 and 6) on the gimbal structure 65. As shown particularly in FIGURE 3, the gimbal 19 is mounted on a roll gyro shaft 80 which is rotatably supported by two sets of bearings 81 and 82 on vertical sections 65*c* and 65*d* of the gimbal structure 65: A slip ring assembly 87 establishes electrical connections from the roll gyroscope 20 (FIGURE 6) through brushes 85 to terminals 107 shown in FIGURE 2 adjacent the amplifier section 73. The terminals 107 are utilized as terminal connectors for electrical connections between the various components supported on the gimbal structure 65. The roll pickoff 22 (FIGURE 3) which may be a synchro resolver is utilized to develop the roll signal and introduce it to the servo amplifier 34 in the amplifier section 73. As described above, the amplified signal from the servo amplifier 34 is introduced to the servomotor 32 for varying the torque delivered thereby.

The servomotor 32 may have a maximum torque output of 250 gram-centimeters and the maximum available torque between the flywheel 25 and the gimbal structure 65 may be 500 gram-centimeters due to the gear ratio therebetween. The gear ratio of the gearing linkage including the flywheel gear 35 and the spur gear 33, as indicated above, may be 150 to 1, with the servomotor 32 including a gear box, not shown, in addition to the gears 33 and 35. Assuming steady state non-acceleration conditions, with the missile rotating at a steady speed of 20 cycles per second, the housing 50 rotates in one direction together with the spinning missile, and the flywheel 25 and the gimbal structure 65 rotate with respect to the housing 50 in the opposite direction at the same speed. In other words, the flywheel 25 and structure 65 are maintained roll stationary in three dimensional space as the housing 50 rotates by rotating the flywheel 25 and the structure 65 in the opposite direction with respect to the housing 50 but at an equal speed. The gimbal structure 65 is rotated together with the flywheel 25 so that it provides for a stationary platform in space.

The flywheel 25 is driven by means of an air gap torquer 26 (FIGURES 1 and 6) which is concentrically positioned with the flywheel 25 about the roll axis 15. The air gap torquer 26 is supported on a cylindrical extension 50*a* of the housing 50 and is, in turn, driven by a tachometer 30 (FIGURE 6). The servomotor package includes a tachometer 30 which develops a signal indicative of the speed of the servomotor 32 and the torque delivered by the servomotor 32. The tachometer signal from the tachometer 30 is coupled to the air gap torquer 26 through an amplifier 28 which is also included as part of the amplifier section 73. The air gap torquer 26 provides for a constant driving force as long as there are no accelerations to drive the flywheel 25 at a continuous speed of 20 revolutions per second. The constant driving force, as is hereinafter described, is required to overcome ordinary bearing friction. If the bearing friction and losses due to viscosity of the fluid medium in which the flywheel 25 and structure 65 rotate, etc., are ignored, the flywheel 25 rotates at a continuous speed of 20 revolutions per second, with respect to the cylindrical extension 50a (FIGURE 1) of the housing 50 without requiring any torque from the torquer 26. In other words, once the flywheel 25 and structure 65 are brought up to speed and steady state non-acceleration conditions exist, a torque is not exerted by the servomotor 32 and the torquer 26 does not apply a torque to the flywheel 25.

Due to the normal frictional losses, the torquer **26** provides a small continuous drive to the flywheel **25** to maintain it stationary in space. If such a torque is not provided, the bearing friction gradually speeds up the flywheel **25** until it rotates together with the housing **50**.

If the flywheel **25** is maintained roll-stationary in space, the full torque of the servomotor **32** is available for stabilizing the platform or gimbal structure **65**. The torquer **26** may be set to provide a predetermined small torque to overcome normal bearing friction when the servomotor is not developing a torque. Any rotation of the flywheel **25** about the roll axis **15** reduces the available torque because the servomotor **32** must first compensate for the movement of its reaction member, the flywheel **25**. It is the reserve torque of the servomotor which determines the stabilization characteristic of the platform. If the flywheel **25** is stationary, the servomotor **32** reacts against the stationary flywheel **25** so that an effectively static or non-spinning stabilization arrangement is achieved.

As long as the roll gimbal structure **65** is not accelerated so as to increase bearing friction and the missile spinning rate remains the same, the roll signal produced by the roll gyroscope **20** does not vary the torque delivered by the servomotor **32**. When the portion of the vehicle or missile carrying the housing **50** is accelerated either due to stage separation or about its roll axis **15**, the flywheel **25** and the gimbal structure **65** are accelerated and a roll signal is developed. Any change of the roll attitude of the platform or structure **65** either due to accelerations or frictional effects, develops a roll signal which is provided to the servomotor **32**. The servomotor **32** develops a torque for returning the structure **65** to its normal position by reacting against the flywheel **25** and at the same time it generates a tachometer signal for returning the flywheel **25** to its normal or stationary position in space. The torque generated by the air gap torquer **26** corrects both for the acceleration which rotates the flywheel **25** as well as the platform **65** and for the effect of the servomotor **32** reacting against the flywheel **25**. The torquer **26**, therefore, requires reserve torque facility to bring the flywheel **25** back to standstill after a random acceleration. The reserve torque required to stabilize the flywheel **25** is twenty times that available from the torquer **26** so that the flywheel **25** is returned slowly to standstill after a fast speed-up due to the random acceleration. A relatively small torquer **26** as well as servomotor **32** may, accordingly, be utilized.

The greater the mass of the flywheel **25**, the less variation occurs in its speed due to any acceleration. However, the illustrative moment of inertia of the flywheel **25** of one-half that of the gimbal structure **65** is selected because of a number of other considerations. For example, the larger the weight of the flywheel **25**, the greater is the weight of the housing package. In some applications, the weight factor is an important consideration. Moreover, the flywheel **25** has a dual function in that it functions as a damping device for the servomotor **32**. The gimbal structure **65**, therefore, does not move rapidly responsive to rapid changes of torque delivered by the servomotor **32** because of the damping provided by the flywheel **25**. The smaller the moments of inertia of the flywheel **25**, the greater the damping because a greater portion of the servomotor torque is expended in rotating the flywheel **25**. The moment of inertia of the flywheel **25**, accordingly, is a compromise of these factors and at the illustrative value, is one-half that of the roll gimbal structure **65** and its supported components.

The gyro system of this invention is suitable for applications in which the housing **50** may be subjected to accelerations as high as 100-G. For example, as indicated above, the gyro system of this invention may be utilized as part of a multi-stage rocket and when the different stages separate, very high loads or accelerations are transmitted to the housing **50** which tend to brake the gimbal structure **65** and the flywheel **25**. Any acceleration which tends to change the roll position of the gimbal structure **65** changes the roll signal generated by the roll gyroscope **20** to energize the servomotor **32** to maintain the attitude of the structure **65**. Both the braking load and the torque developed by the servomotor cause the flywheel **25** to rotate in space in a direction opposite to the direction of rotation of the housing **50**. The tachometer signal, however, gradually returns the flywheel **25** to its standstill position. The servomotor **32** reacts relatively fast to keep the platform or structure **65** stabilized and the flywheel **25** returns slowly to its standstill position.

Functionally, the operation is quite similar to the slow charging of a battery with small amounts of energy so that it can provide a large amount of energy during a brief interval. The flywheel **25** functions as the energy storage device releasing it in bursts upon random accelerations.

As described above, when the gyro system returns to a steady state condition, the output of the air gap torquer **26** is equal to the friction of the bearings for maintaining the flywheel **25** and the gimbal structure **65** stationary in space. Due to the constant bearing friction, the flywheel **25** tends to speed up and use up the torque of the servomotor **32**. The air gap torquer **26**, however, maintains the flywheel **25** at standstill to maintain the torque of the servomotor **32** available for stabilizing the platform or structure **65**.

A two degree of freedom roll gyroscope **20** is utilized instead of a single degree of freedom gyroscope to remove any components due to any wobble of the missile about the roll axis **15**. If a single degree of freedom gyroscope is used, a drift factor is introduced by kinematic rectification so that the platform **65** gradually rotates in space.

The stabilized platform or structure **65** supports, as indicated above, a pitch-yaw gyroscope **17** in addition to the roll gyroscope **20**. The pitch-yaw gyroscope **17** is supported, as indicated particularly in FIGURE 2, between the two horizontal sections **65***a* and **65***b* of the housing **65**. The pitch-yaw gimbal **90** which supports the gyroscope **17** is mounted on a shaft **102** which is pivotally supported in the bearings **103** and **104**. The upper end of the shaft **102** is supported in a housing extension **142** of the upper bracket **65***a*. A pitch-yaw pickoff **100**, which may be a synchro resolver, is utilized to generate the pitch-yaw signals and couple them through brushes **108** to the terminals **107**. The terminals **107** may be coupled to an amplifier, not shown, in the amplifier section **73** and the amplified pitch-yaw signal may be provided through the slip ring assembly **60** in FIGURE 1 to the cable **61**. The various components on the gimbal **90** shown in FIGURE 2 are part of the caging mechanism for the gimbal **90**. The caging mechanism may be conventional.

In this manner, pitch and yaw signals are provided from a roll stabilized platform **65** indicating the attitude of the missile. In addition, as described above, the roll gimbal resolver **58** provides signals indicative of the roll of the missile. The platform **65** is accurately roll-stabilized even though the missile is spinning at a high rate by utilizing relatively small and light components.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. For example, the particular disclosed pickoff means or caging equipment is merely illustrative. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

We claim:

1. In a spinning vehicle, a rotatable platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction flywheel pivoted to rotate about the axis of rotation of the spinning vehicle, a servomotor

mounted on said platform and coupled to said flywheel for angularly positioning said platform with respect to said flywheel, and gyroscopic means mounted on said platform and coupled to said servomotor for detecting any change in the angular position of said platform about said axis and for controlling said servomotor in accordance therewith to return said platform to its original position.

2. In a spinning vehicle, a rotatable platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction flywheel pivoted to rotate about the axis of rotation of the spinning vehicle, a servomotor mounted on said platform and coupled to said flywheel for angularly positioning said platform with respect to said flywheel, gyroscopic means mounted on said platform and coupled to said servomotor for detecting any change in the angular position of said platform about said axis and for controlling said servomotor in accordance therewith to return said platform to its original position, means coupled to said servomotor for generating a signal indicative of the speed of said servomotor, and a torquer coupled to said generating means and to said flywheel for torquing said flywheel in accordance with the generated signal from said generating means whereby said flywheel is returned to a substantially stationary position about said axis after any movement of said flywheel therefrom.

3. In a spinning vehicle subject to accelerations, a stabilized platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction member for said platform, means mounted on said platform for providing a signal indicative of an angular change of position of said platform, and means coupled to said platform and to said reaction member and responsive to said signal from said providing means for exerting a torque between said platform and said reaction member tending to rotate them in opposite directions.

4. In a spinning vehicle, a stabilized roll-free gyro system, including, a roll gyro gimbal having a roll axis about which it is pivoted, a rotatable reaction member for said gyro gimbal, torquing means coupled to said reaction member for returning said reaction member to a predetermined roll position after any displacement therefrom, and means mounted on said gyro gimbal for detecting any displacement in the roll position of said gyro gimbal and for energizing said torquing means in accordance therewith.

5. In a spinning vehicle, a substantially static reaction system, including, a normally non-rotating pivoted inertial member rotatable about the spinning axis of the vehicle, torquing means coupled to said member and effectively responsive to any torque which rotates said member for stabilizing said member about the spinning axis by slowly reducing the rotation of said member to standstill, a platform stabilized about the spinning axis of the vehicle, and a servomotor coupled between said member and said platform for stabilizing said platform by reacting against said member.

6. In a spinning vehicle, a substantially static reaction system, including, a normally non-rotating pivoted inertial member rotatable about the spinning axis of the vehicle, torquing means coupled to said member and effectively responsive to any torque which rotates said member for stabilizing said member about the spinning axis by slowly reducing the rotation of said member to standstill, a platform stabilized about the spinning axis of the vehicle, a servomotor coupled between said member and said platform for stabilizing said platform by reacting against said member, means coupled to said servomotor and said torquing means for developing a signal indicative of the stabilizing torque developed by said servomotor and for introducing the signal to said torquing means, and gyroscopic means mounted on said platform and electrically coupled to said servomotor for detecting any change in angular position of said platform about the spinning axis of the vehicle and for developing a control signal in accordance therewith for introduction to said servomotor.

7. In a spinning vehicle, a substantially static reaction system, including, a normally non-rotating pivoted inertial member rotatable about the spinning axis of the vehicle, torquing means coupled to said member and effectively responsive to any torque which rotates said member for stabilizing said member about the spinning axis by slowly reducing the rotation of said member to standstill, a platform stabilized about the spinning axis of the vehicle, a servomotor coupled between said member and said platform for stabilizing said platform by reacting against said member, and means coupled to said servomotor and said torquing means for developing a signal indicative of the stabilizing torque developed by said servomotor and for introducing the signal to said torquing means.

8. In a spinning vehicle, a rotatable platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction flywheel pivoted to rotate about the axis of rotation of the spinning vehicle, a servomotor mounted on said platform having a rotor, a gear train coupled between said rotor and said flywheel so that any torque generated by said servomotor tends to rotate said platform and said flywheel in opposite directions, and gyroscopic means mounted on said platform and coupled to said servomotor for detecting any change in the angular position of said platform about said axis and for controlling said servomotor in accordance therewith.

9. In a spinning vehicle, a rotatable platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction flywheel pivoted to rotate about the axis of rotation of the spinning vehicle, a servomotor mounted on said platform having a rotor, a gear train coupled between said rotor and said flywheel so that any torque generated by said servomotor tends to rotate said platform and said flywheel in opposite directions, gyroscopic means mounted on said platform and coupled to said servomotor for detecting any change in the angular position of said platform about said axis and for controlling said servomotor in accordance therewith, and torquing means coupled to said flywheel for returning said flywheel to a stationary position after being rotated by the reaction of said servomotor generating a torque to rotate said platform.

10. In a spinning vehicle, a rotatable platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction flywheel pivoted to rotate about the axis of rotation of the spinning vehicle, a servomotor mounted on said platform having a rotor, a gear train coupled between said rotor and said flywheel so that any torque generated by said servomotor tends to rotate said platform and said flywheel in opposite directions, gyroscopic means mounted on said platform and coupled to said servomotor for detecting any change in the angular position of said platform about said axis and for controlling said servomotor in accordance therewith, said flywheel having a moment of inertia less than the moment of inertia of said platform together with the servomotor and gyroscopic means supported thereby so as to dampen the rotational movements of said platform, and torquing means coupled to said flywheel for returning said flywheel to a stationary position after being rotated by the reaction of said servomotor generating a torque to rotate said platform.

11. In a spinning vehicle, a rotatable platform pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction flywheel pivoted to rotate about the axis of rotation of the spinning vehicle, a servomotor mounted on said platform and coupled to said flywheel for angularly positioning said platform with respect to said flywheel, and means for detecting any change in the angular position of said platform about said axis and for controlling said servomotor in accordance therewith to return said platform to its original position.

12. In a spinning vehicle subject to accelerations, a

stabilized member pivoted to rotate about the axis of rotation of the spinning vehicle, a rotatable reaction member for said stabilized member, means for providing a signal indicative of an angular change of position of said stabilized member, and means responsive to said signal from said providing means for exerting a torque between said stabilized member and said reaction member tending to rotate them in opposite directions.

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