Oct. 5, 1971 R. E. BAUMAN ET AL 3,610,096

SPIN AND FIN STABILIZED ROCKET

Filed Jan. 22, 1969 2 Sheets-Sheet 1

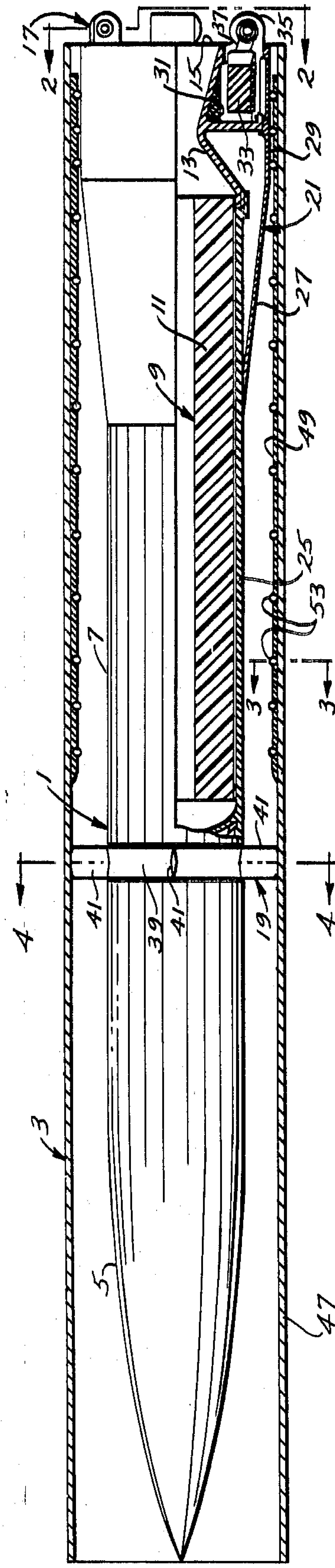

FIG. 1

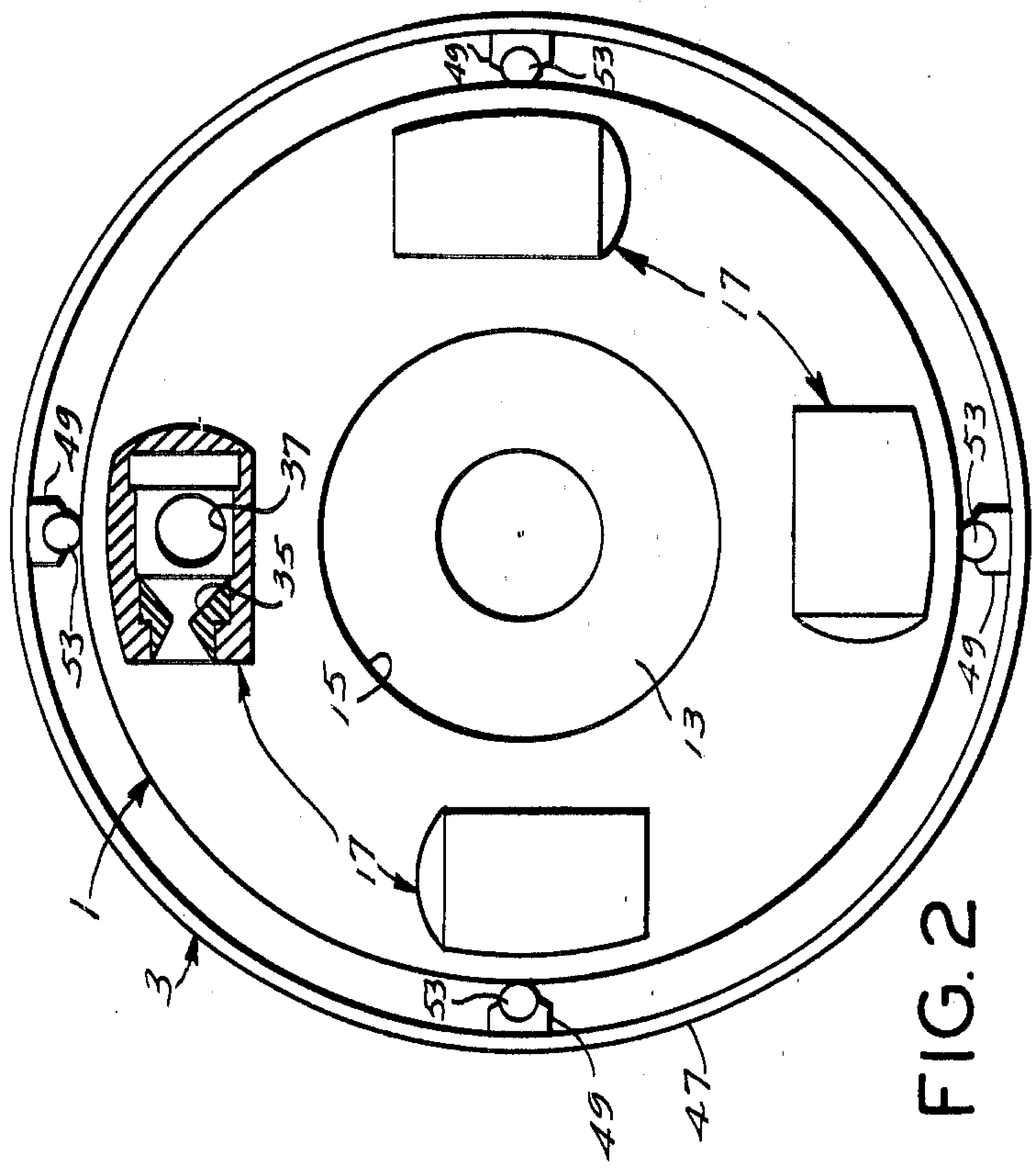

FIG. 2

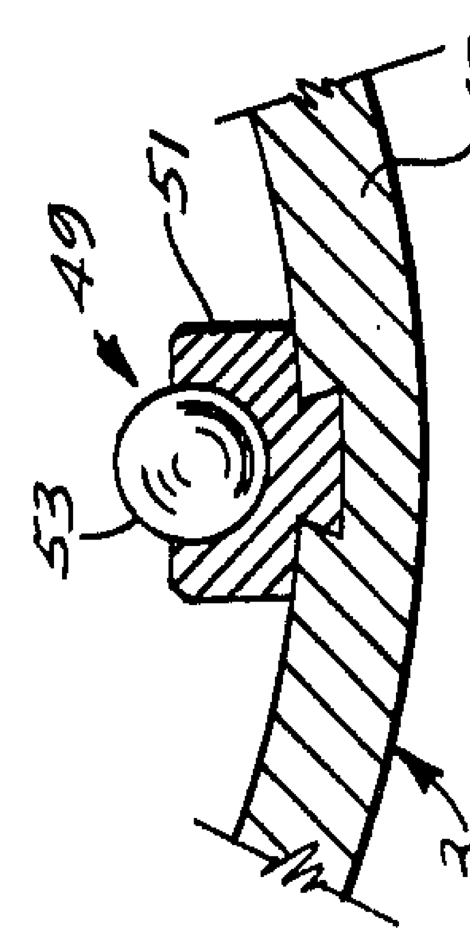

FIG. 3

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SPIN AND FIN STABILIZED ROCKET

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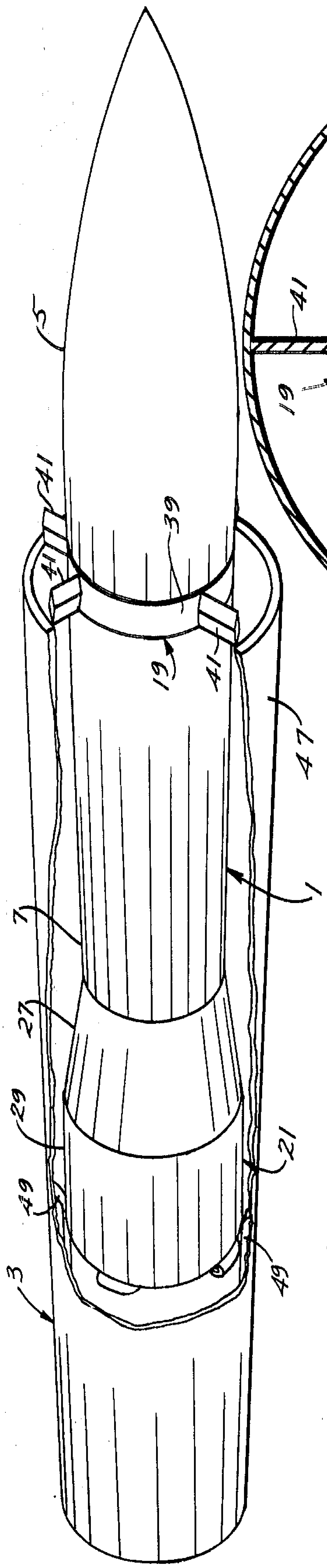

FIG. 5

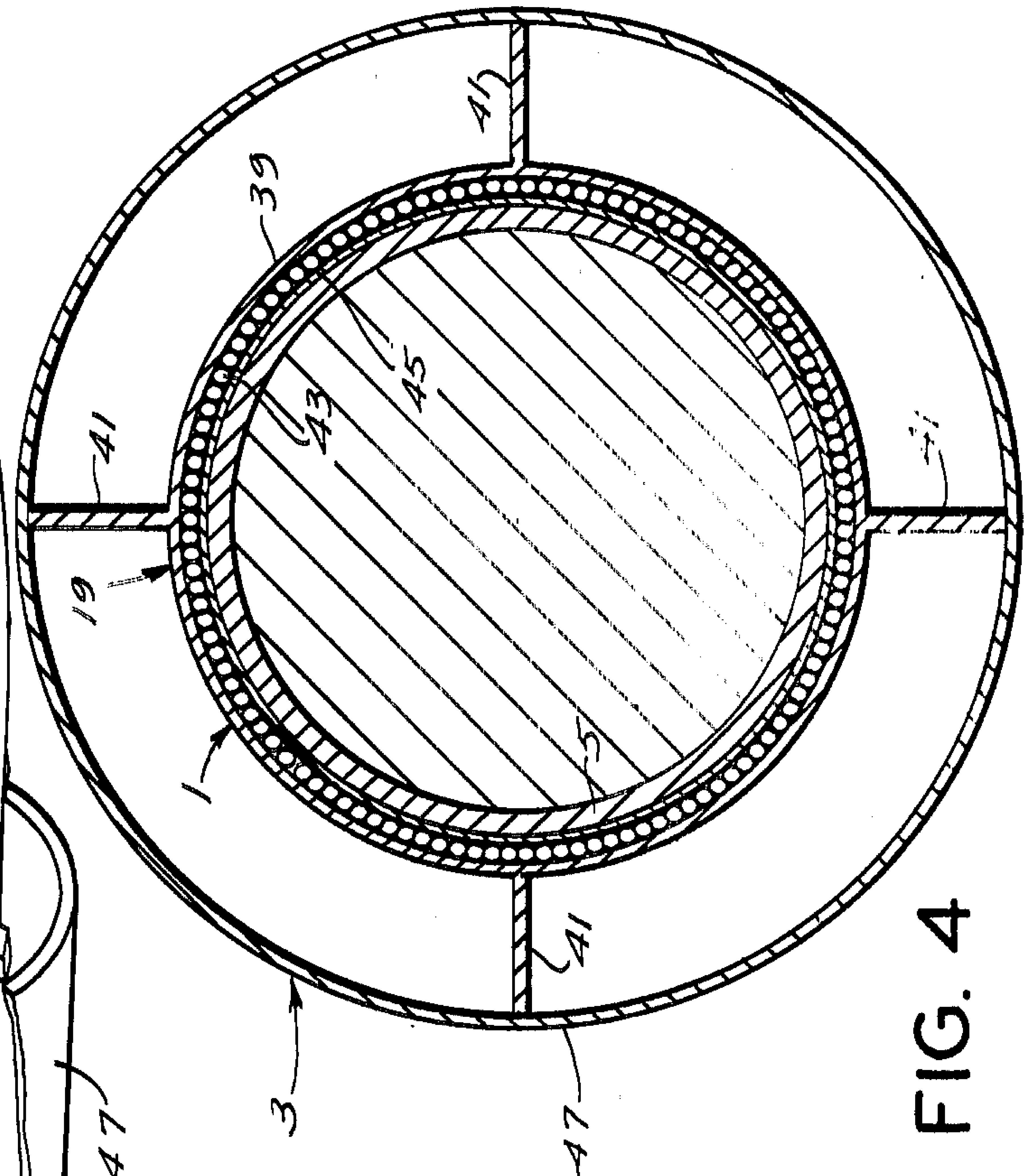

FIG. 4

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SPIN AND FIN STABILIZED ROCKET

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U.S. Cl. 89—1.808 13 Claims

ABSTRACT OF THE DISCLOSURE

A rocket weapon system in which the rocket is spin stabilized along its flight path by rotation of the rocket about its longitudinal axis and is aerodynamically stabilized by a forward fin ring and a rearward flared skirt. The rocket is spun-up in a launch tube having plural bearing supports at one end for supporting the rearward end of the rocket, while the forward end of the rocket is supported by fins on the fin ring, the latter being rotationally free of the rocket body. After spin-up, a boost propellant is ignited to propel the rocket from the tube without tip-off and the usual debris (sabot fragments) associated with the launch of such weapons.

BACKGROUND OF THE INVENTION

This invention relates to a weapons system, and more particularly to a weapons system of the rocket projectile type.

Unguided rocket projectiles of the prior art, for use in air-to-air, air-to-ground, ground-to-ground, or ground-to-air modes, have been seriously deficient in delivery accuracy. For example, in conventional fin stabilized projectile systems, the weapon is guided along its flight path solely by the aerodynamic forces exerted by the moving stream of air over the weapon and its guidance fins. While this type of aerodynamic stabilization tends to maintain the projectile along a predetermined flight path to its target, it does not compensate for thrust and/or mass misalignment of the projectile itself. That is, common manufacturing difficulties in mass producing such weapons commonly produce off-center thrust forces caused by either nozzle misalignment or uneven burning of the propellant grain, and mass or center of gravity misalignments of the entire projectile. These deficiencies cause the projectile to deviate substantially from its intended flight path.

To overcome the above problems associated with fin stabilization, the prior art has developed spin stabilized projectiles which cancel thrust and/or center of mass misalignments by rotating the projectile about its longitudinal axis during flight. This tends to equalize such misalignments about the axis of the projectile, thereby producing a canceling effect and enabling the projectile to follow its intended flight path. Such spin stabilized projectiles cannot, of course, utilize fins for guidance and stabilization because of the tendency of the fins, when exposed to a moving air stream, to reduce rotation of the weapon. Thus, the advantages gained in a fin stabilized weapon system are lost.

Yet another problem commonly associated with weapons of the rocket projectile type is that of tip-off caused when the projectile leaves its launcher. It is well known that one of the contributing causes of delivery inaccuracy of a rocket projectile is the initial angular deflections and rates imparted to the projectile as it emerges from the launcher. That is, in the time interval just prior to separation of the projectile from the launcher, the rearward or aft end of the projectile is still supported by the launcher after the center of mass of the projectile has passed the forward end of the launcher, and is no longer supported thereby. Thus, the center of mass starts to fall under the influence of gravitational forces imparting a nose-down angular acceleration on the projectile. If the projectile is spinning, a transverse angular rate will be developed because of gyroscopic torques. In the past, attempts have been made to provide the projectile with shoes or sabots which support the projectile on the launching rail or in the launch tube, such shoes or sabots being so constructed so as to simultaneously disengage from the fore and aft rails or the fore and aft portions of the launch tube to allow the projectile to be in a free flight condition as it emerges from the launcher. While such devices have generally proven acceptable for preventing undesirable tip-off, their use has been limited to fin stabilized projectiles. In addition, such shoes or sabots disengage from the rocket after launch and cause debris, or they remain with the rocket and are aerodynamically inefficient. In most cases, because of their aerodynamic inefficiency, such shoes or sabots are caused to disengage from the projectile after it leaves its launcher. In high-speed, air launched projectiles, the debris caused by the falling shoe or sabot may cause considerable damage to the aircraft launching the projectile, to other aircraft in the immediate vicinity, and to inhabitants and structures on the ground beneath the aircraft.

SUMMARY OF THE INVENTION

Accordingly, among the several objects of the present invention may be noted the provision of a rocket projectile having substantially improved delivery accuracy; the provision of such a projectile having the accuracy characteristics of spin stabilized projectiles at low spin rates, thus minimizing design and manufacturing problems associated with high spin; the provision of a projectile of the class described further incorporating aerodynamic stabilization; the provision of a projectile and launcher in which tip-off errors during the launch phase are eliminated; the provision of a projectile and launcher of the class described in which debris normally caused by sabot devices is eliminated; and the provision of a weapons system which is characterized by simplicity of construction, low cost, and ease of operation and use.

In general, a projectile constructed in accordance with the present invention comprises an elongate body having a forward portion and a rearward portion. Propulsion means are carried by the rearward portion for propelling the projectile along a flight path to a target, and means are provided for rotating the projectile about its longitudinal axis for stabilizing the projectile during flight. In addition, rotationally free aerodynamic fin means are provided on the body, the fin means serving to support the projectile in its launcher prior to launch. Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal view, partly in section, of the rocket projectile and launcher of this invention;

FIG. 2 is an end view taken on line 2—2 of FIG. 1;

FIG. 3 is a section taken on line 3—3 of FIG. 1;

FIG. 4 is a section taken on line 4—4 of FIG. 1; and

FIG. 5 is a perspective of the projectile as it emerges from the launcher.

Corresponding reference characters indicate coresponding parts throughout the several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly to FIG. 1, the present weapon system is shown to comprise a rocket projectile **1** within a launcher **3**. The projectile **1** is generally comprised of an elongate body having a forward portion **5** and a rearward portion **7**, the forward portion carrying a warhead and fuse (not shown) of conventional construction and the rearward portion carrying a propulsion means **9**. The propulsion means **9** comprises a rocket boost propellant grain **11** and an exhaust nozzle **13** terminating in a rearward opening **15**. Means **17** for rotating the projectile about its longitudinal axis are positioned about the rearward opening **15**. The projectile **1** is supported in the launcher **3** by front and rear support means **19** and **21**, respectively, which also serve to aerodynamically stabilize the missile during flight, as will appear hereinafter.

More specifically, the forward portion **5** of the rocket projectile **1** is of aerodynamically streamlined configuration and is adapted to contain the warhead and fuse. The rearward body portion **7** of the projectile comprises a propulsion motor case and insulation **25** containing the annular propellant grain **11**. The rear support **21** comprises a flared skirt joining the rearward body portion **7** just aft of its midpoint and having an outwardly angularly flaring portion **27** and an integral longitudinally extending portion **29**, the latter comprising the rear support for the projectile. The exhaust nozzle **13** is of the converging-diverging type and is affixed to its forward end to the rearward end of the motor case **25** and terminates at its rearward end at the nozzle opening **15**.

Within the confines of the diverging portion of the nozzle **13** are the four spin motors **17**. These motors are each comprised of a combustion chamber **31** containing a propellant grain **33**. A converging-diverging nozzle **35** is in communication with the combustion chamber **31** via a passage **37** extending generally longitudinally from the nozzle to the combustion chamber. The longitudinal axes of the spin motor nozzles **35** extend transversely to the longitudinal axis of the projectile **1** for producing tangential thrust forces which rotate the projectile **1** about its longitudinal axis in a clockwise direction, as viewed in FIG. 2.

The front projectile support is provided by the fin ring **19** which, as best shown in FIGS. 1 and 4, comprises a ring or band **39** having four radially extending integral fins **41** spaced at 90° intervals around its outer surface. The fin ring **19** is journaled for relative rotation on the rocket projectile **1** between the forward and rearward body portions thereof by means of a bearing assembly **43** interposed between the ring **39** and an inner race **45** carried by the projectile. The fins **41** and the flared skirt **21** are aerodynamically configured to stabilize the projectile during flight. In addition, and as will be more fully set forth hereinafter, these fins and the rearward portion **29** of the flared skirt **21** support and guide the projectile during the launch phase of its flight.

Referring now to FIGS. 1 and 3, the launcher **3** is comprised of a cylindrical thin-walled, open-ended, tube **47** having plural supports **49** spaced about its inner periphery extending from near the rear end of the tube to near the center of the tube. As shown in FIG. 3, each of the supports is comprised of an elongate retainer **51** having a dove-tail connection with the interior of the tube **47**. A plurality of ball bearings **53** are retained at equal intervals along the length of the retainer with their upper surfaces extending above the upper surface of the retainer. The supports **49** are spaced at 90° intervals around the inner periphery of the launch tube **47** for supporting the aft end of the rocket projectile at its longitudinally extending skirt portion **29**. Thus, the effect of the four supports **49** is to decrease the effective internal diameter of the launch tube throughout the extent of the supports. As will be seen, the bearings **53** provide a low-friction support for both longitudinal and rotational movement of the projectile.

The supports **49** and the relative dimensions of the launch tube **47** and projectile **1** are such as to eliminate tip-off during launch. That is, the distance between the rearward edge of the fins **41** and the forward exit end of the launch tube **47** is equal to the distance between the rearward edge of the projectile skirt **21** and the forward edge of the supports **49**. In addition, the radial extent or height of the support retainers **51** and bearings **53** is such as to provide sufficient clearance to prevent projectile contact with the launch tube envelope after the skirt **21** clears the supports **49**. This clearance, or the difference between the internal fore and aft diameters of the launch tube, is such as to avoid contact under substantially all launch conditions and is sufficient to allow for all perturbations considered to influence projectile-launcher relative displacements, such as projectile mass assymetries, thrust misalignment, initial body angular rates, airloads on the projectile, and launch platform angular and linear rates and accelerations.

Operation is as follows:

The weapons system of the present invention will be described in connection with an air-to-ground unguided rocket projectile, although it should be understood that the weapon may be used in other modes, e.g., in air-to-air, ground-to-ground, and ground-to-air modes, with either unguided or guided capabilities. In an air-to-ground configuration, the launch tube **47** may be utilized as both a protective shipping container for the projectile **1** and as a launcher, or only as a reusable launcher. The launch tube **47** is either movably or rigidly mounted on an aircraft of either the rotary or fixed wing type. In one embodiment for 105 mm. rocket projectiles, the tube **47** is approximately 48.5 inches in length with fore and aft internal diameters of 6.12 and 5.6 inches, respectively.

In operation, the aircraft aims the weapon in a conventional manner by either moving the launch tube relative to the aircraft to aim it at the target or by aiming the entire aircraft and launch tube at the target. When it is desired to launch the projectile **1**, a conventional electrically-ignited squib is activated to ignite the solid propellant spin motors **17**. The tangentially directed thrust forces produced by the propellant gases issuing from the nozzles **35** of the spin motors cause the projectile **1** to rotate about its longitudinal axis. A low-friction spin support is provided at the forward end of the projectile by the fin ring bearing assembly **43**, whereby the fin ring **39** and the fins **41** remain relatively stationary while the projectile body rotates therein, and at the rearward end of the projectile by the longitudinally extending skirt portion **29** riding on the bearings **53**. After reaching its designed spin rate of, for example, 200 revolutions per second, the boost motor propellant grain **11** is electrically ignited to accelerate the projectile in a longitudinal direction. Since the distance between the trailing edge of the fins **41** and the forward exit end of the launch tube **47** is equal to the distance between the rearward end of the longitudinally extending skirt **29** of the projectile **1** and the forward end of the projectile supports **49**, fins **41** pass the forward end of the launch tube at the same time that the rearward end of the projectile passes the forward end of the supports **49** and moves into the larger internal diameter portion of the launch tube. This condition is illustrated in FIG. 5. The projectile is thus in the free flight phase of launch while it is partially contained within the launcher envelope. Since the fore and aft projectile supports simultaneously release from the launch tube, and since the clearance in the forward section of the launch tube is sufficient to prevent projectile contact under substantially all launch conditions, tip-off errors normally associated with tube launched projectiles are eliminated.

As the missile proceeds along its flight path toward its intended target, it is stabilized aerodynamically by the rotationally free fin ring **19** at its forward end, which tends to remain stationary because of the aerodynamic forces exerted upon it by the moving air stream, and the flared skirt **21** at its rearward end. The projectile is also spin stabilized to reduce the tendency of the missile longitudinal axis to rotate as aerodynamic torques are introduced around the missile center of mass. The aerodynamic torques occur when an angle of attack disturbance causes a net lifting force on the missile body. The point of application of the net force is known as the aerodynamic center of pressure and this point is, in general, not coincident with the missile center of mass. The relative separation distance between the center of pressure and center of mass combined with the net lifting force gives rise to a torque about the mass center which tends to rotate the body axis in a direction which is dependent upon whether the force is located fore or aft of the mass center. Besides providing spin stabilization, the spin imparted to the missile by the spin motors **17** also reduces flight path deviation caused by radial center of mass and/or thrust asymmetries. This combination of aerodynamic and spin stabilization offers a gross improvement in delivery accuracy over that obtained with either aerodynamically stabilized or spin stabilized conventional unguided rocket weapons. Since tip-off is eliminated and the rocket supports, i.e., fins **41** and skirt **21**, remain as an integral, aerodynamically useful, part of the projectile during its flight, high delivery accuracy is achieved without producing the debris normally associated with tube launched projectiles.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results obtained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A fin and spin stabilized projectile, which comprises:

an elongated cylindrical body having a forward and a rearward portion, said rearward portion having a larger circumference than said forward portion for substantially the length of said rearward portion along a part comprising an integrally constructed, flared, aerodynamic skirt, said skirt comprising a first projectile support during launch;

propulsion means carried by said rearward portion for propelling said projectile along a flight path to a target;

means, carried by said projectile, for rotating said projectile about its longitudinal axis for spin stabilizing said projectile during flight; and

a plurality of symmetrically arranged and rotationally free aerodynamic fin means carried by said projectile for guiding said projectile along a flight path to a target, said fin means comprising a second projectile support during launch.

2. A projectile as set forth in claim **1** wherein said plurality of fin means is carried by said forward body portion and constitutes a forward projectile support.

3. A projectile as set forth in claim **2** wherein said plurality of fin means comprises a ring surrounding said projectile body with four aerodynamic fins spaced 90 degrees about said ring and extending radially outwardly therefrom, said ring being journaled to said body for rotation relative thereto.

4. A projectile as set forth in claim **3** wherein said flared skirt comprises an angularly flaring portion and a longitudinally extending portion, the latter constituting said rearward support.

5. A projectile as set forth in claim **1** wherein said propulsion means comprises a solid propellant rocket motor and said means for rotating comprises a solid propellant spin motor having a generally tangentially directed exhaust nozzle.

6. A combination fin and spin stabilized projectile and launcher therefor, which comprises:

an elongated projectile body having a forward and a rearward portion, said rearward portion comprising an integrally constructed, flared, aerodynamic skirt, said skirt comprising a first projectile support during launch;

propulsion means carried by said rearward portion for propelling said projectile along a flight path to a target;

means for rotating said projectile about its longitudinal axis for spin stabilizing said projectile during flight;

a plurality of symmetrically arranged and rotationally free aerodynamic fin means carried by said projectile for guiding said projectile along a flight path to a target, said fin means comprising a second projectile support during launch;

an open ended projectile bearing tube; and

a plurality of supports spaced about the inner periphery of said tube so as to define first and second tube sections delineated by first and second internal diameters such that said first projectile support rests in said first internal diameter and said second projectile support rests in said second internal diameter.

7. The combination as set forth in claim **6** wherein the internal diameters of said first and second tube sections are substantially equal to the diameters of said rearward portion and said fin means of said projectile, respectively.

8. The combination as set forth in claim **7** wherein said plurality of spaced supports each comprise a longitudinally elongated retainer secured to the inner wall of said tube, and bearings carried by said retainer for providing a low-friction longitudinal and rotational projectile support.

9. The combination as set forth in claim **8** wherein the distance between the rearward edge of said fin means and the forward end of said tube is equal to the distance between the rearward end of the projectile skirt and the forward end of said longitudinally extending supports.

10. A rocket system, which comprises:

a smooth bore, projectile bearing tube;

a plurality of supports spaced about an inner periphery of and attached to said tube, said supports and smooth bore tube defining first and second tube sections delineated by first and second internal diameters;

a projectile carried by said tube prior to launch;

a first self-contained projectile support consisting of a portion of projectile body, said body comprising an elongated cylindrical structure with forward and rearward integral portions, said rearward portion having a larger circumference than said forward portion for substantially the length of said rearward portion, said rearward portion comprising said first projectile support;

a second self-contained projectile support comprising a plurality of symmetrically arranged and rotationally free aerodynamic fins carried by said forward portion of said projectile body, said projectile adapted to be carried by said tube such that said first projectile support rests in said first tube internal diameter and said second projectile support rests in said second tube internal diameter.

11. The rocket system of claim **10** wherein said plurality of spaced supports individually comprises a longitudinally elongated retainer secured to the inner wall of said tube along said first tube section, and bearings carried by said retainer for providing a low friction longitudinal and rotational projecting support.

12. The rocket system as set forth in claim **10** wherein the internal diameters of said first and second tube sections are substantially equal to the diameters of said rearward portions and said aerodynamic projectile fins, respectively.

13. The rocket system as set forth in claim **12** wherein the distance between the rearward edge of said projectile fins and the forward end of said tube is equal to the distance between the rearward end of said projectile skirt and the forward end of said longitudinally extending supports.

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SAMUEL W. ENGLE, Primary Examiner

U.S. Cl. X.R.

42—76 R; 89—1.816, 14 R; 244—3.23

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,610,096 Dated October 5, 1971

Inventor(s) Robert E. Bauman and James R. Christenson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 67, change "projecting" to ---projectile---.

Signed and sealed this 21st day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents