Dec. 11, 1962 F. K. FELDMANN ET AL 3,067,682

GYRO PULL ROCKET

Filed Feb. 18, 1960 4 Sheets-Sheet 1

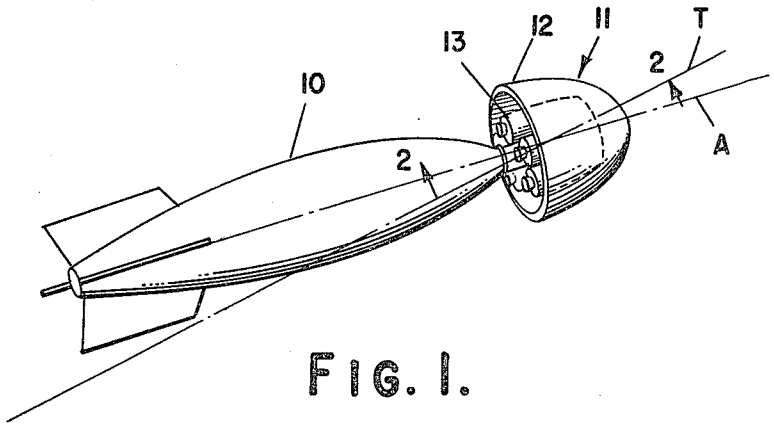


FIG. 1.

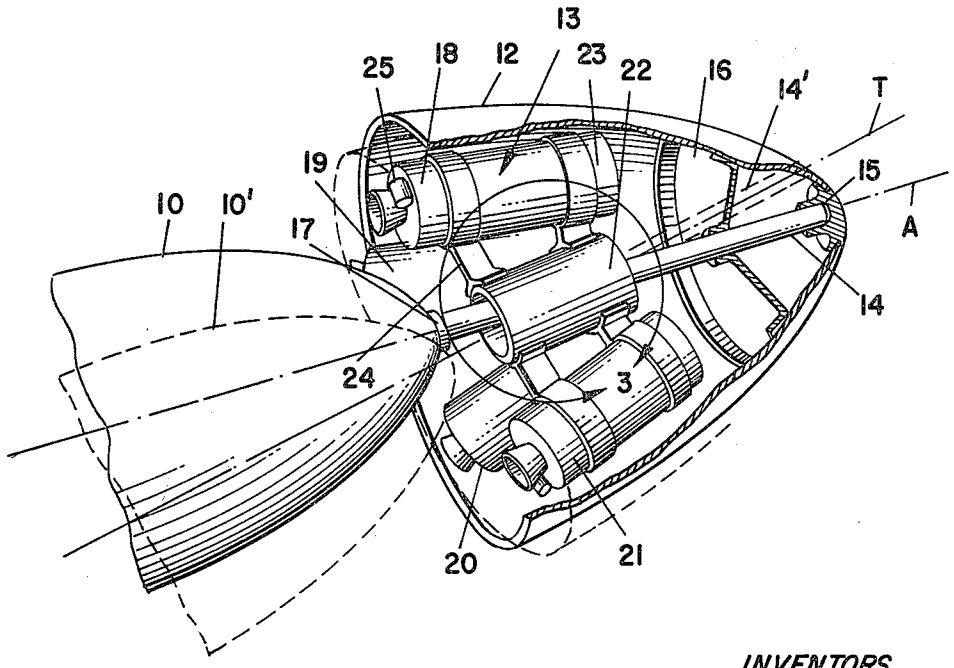


FIG. 2.

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GYRO PULL ROCKET

Filed Feb. 18, 1960 4 Sheets-Sheet 2

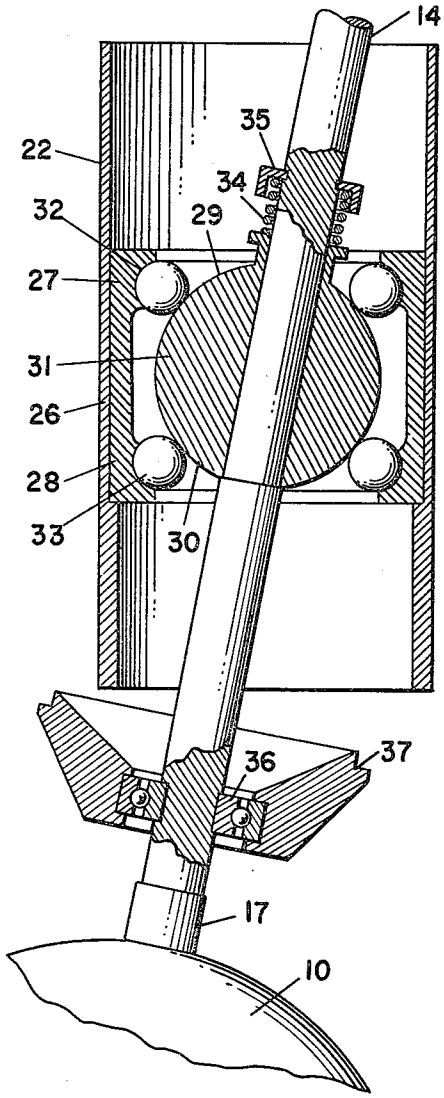


FIG. 3.

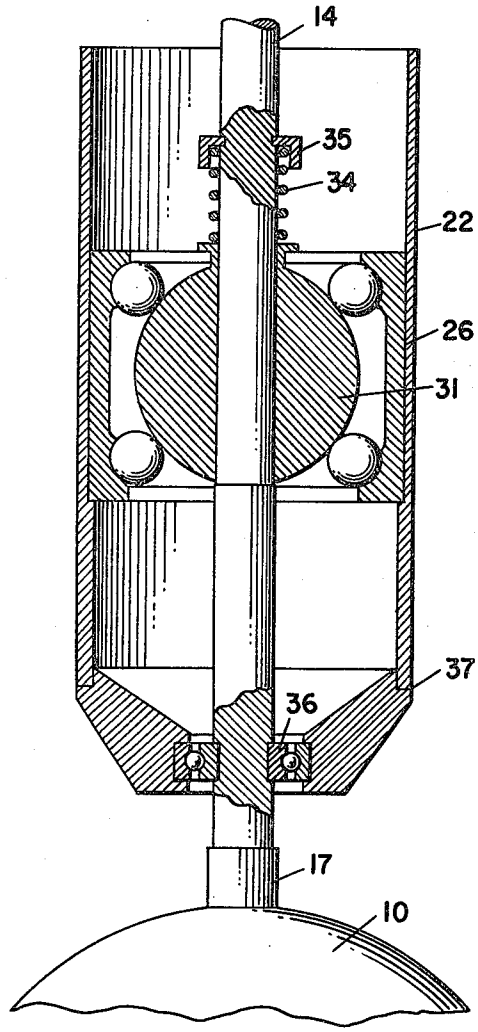


FIG. 4.

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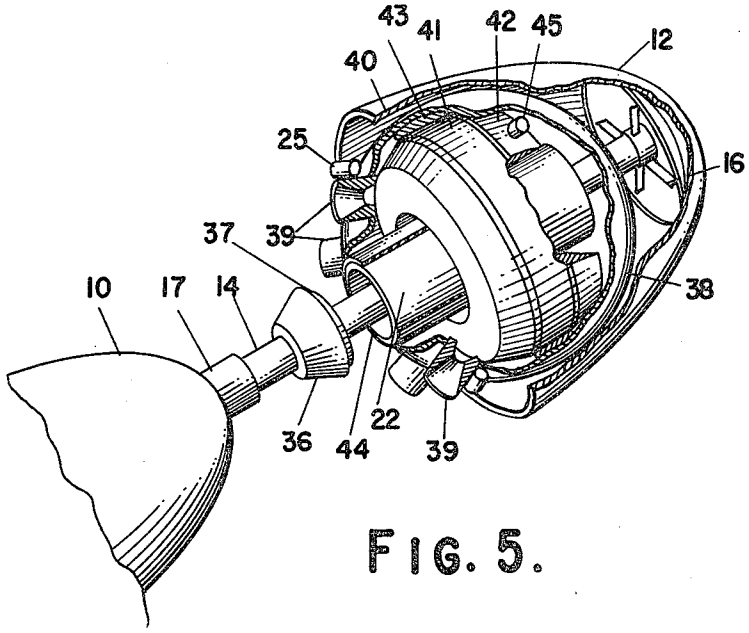


FIG. 5.

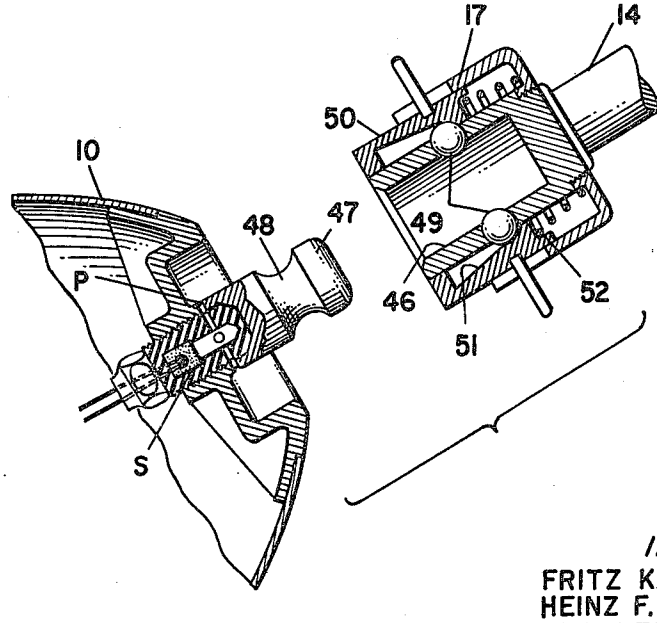


FIG. 6.

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GYRO PULL ROCKET

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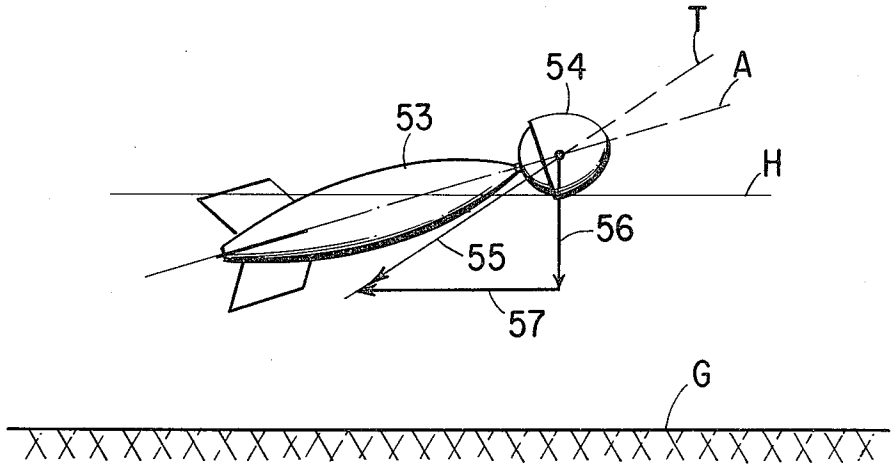


FIG. 7

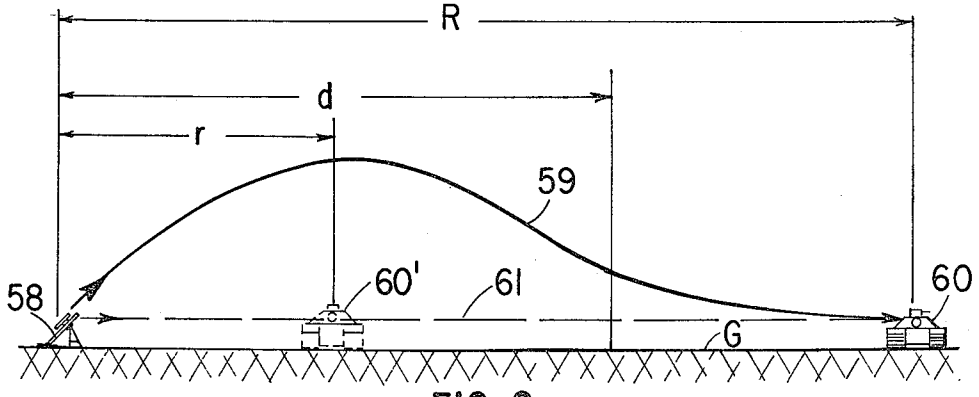


FIG. 8

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3,067,682

GYRO PULL ROCKET

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8 Claims. (Cl. 102—49)

This invention relates generally to rocket propelled missiles and more particularly to improved booster rockets in conjunction with either ballistic or self-powered pay loads.

Present day booster rockets are generally of the pusher type in which a payload is launched with the aid of the booster until the booster fuel is exhausted. At this time the booster stage is separated from the pay load. More recently, it has been proposed to employ boosters for controlling the range of a ballistic missile by separating the booster from the pay load when a certain condition is established regardless of whether or not the booster fuel has been used up. In this way, the pay load itself follows a ballistic trajectory after separation from the booster with a predetermined velocity so that accurate ranging can be achieved.

Present day booster rockets however, are subject to many problems, one of the more serious of which is thrust misalignment. Particularly is this the case in solid propellant rockets in which unsymmetrical physical conditions in the rocket motor during burning can result in dispersion of the missile. Therefore, when a solid propellant booster rocket is employed, any thrust misalignment can result in large position errors. In addition, the application of thrust of push boosters is generally behind the center of gravity of the pay load so that directional stability is often times difficult to maintain. Thus while some speed control may be realized by the use of push boosters for ballistic type missiles, accurate direction control is not always achieved.

Directional errors as a result of aerodynamic disturbances or other external disturbing forces on the missile and booster is also a serious problem. Heretofore relatively sophisticated solutions such as jet vanes, reaction controls, specialized launchers, and aerodynamic control surfaces have been proposed but their degree of success is usually proportional to their complexity and thus contribute to inherent high cost and low reliability.

Some further problems encountered with the use of boosters generally include difficulty in separating the booster from the pay load. To provide some stability, the push type booster is connected at several circumferentially spaced points which must all be separated at once. Failure to achieve simultaneous separation at all points may contribute to altitude and velocity errors at the end of boost. Additionally, in the event the pay load itself constitutes flares or the like which are to be parachuted at a given altitude, the separated booster when at the rear of the pay load is in a position to become entangled with the chutes.

With all of the foregoing in mind, it is a primary object of the present invention to provide an improved booster rocket in which most of the above noted difficulties are overcome to the end that both direction and speed control for accurate ranging of ballistic missiles at the end of boost can be achieved.

More particularly, it is an object to provide an improved booster rocket in which any thrust eccentricities or misalignments are substantially eliminated and the effects of external atmospheric disturbances to the direction of flight are substantially reduced.

Another important object is to provide an improved

booster rocket which is adaptable for connection to many different types of missiles and in which the connection itself need constitute only a single element to the end that separation for terminating the applied thrust is greatly facilitated and to the further end that once separated, the booster itself will not be in a position to interfere with any subsequent operation of the pay load.

Still another object is to provide a booster rocket in which substantially rectilinear flight paths for the pay load connected to the rocket can be realized with the resultant advantage that minimum hit ranges of line-of-sight controlled ground to ground missiles can be reduced to substantially zero.

Briefly, these as well as many further objects and advantages of this invention are attained by providing a booster rocket designed to pull, rather than push, the pay load. The pull rocket is positioned on the forward end of the missile and includes a thrust generating motor surrounded by a shroud structure preferably in the shape of a paraboloid or cone having an open end. An elongated stem co-inciding with the longitudinal axis of the pay load extends into the open end and supports the shroud in axial alignment with the pay load. This stem constitutes the sole connection between the pull booster and pay load. The thrust generating motor may constitute for example, a series of rocket nozzles arranged in a circular array about the elongated stem within the shroud but in spaced relationship thereto. A universal bearing rotatably mounts the nozzles to the elongated stem. For the case where the external configuration of the thrust motor is spherical or nearly spherical, that is, an external shape which essentially prevents the existence of disturbing aerodynamic moments, the shroud itself may be eliminated.

By the foregoing arrangement, the circular array of nozzles may be spun at gyroscopic speed so that the net thrust developed by the nozzles is stabilized in the direction of the axis of rotation of the nozzles. This high speed of rotation also cancels any thrust misalignments by averaging the same over 360 degrees. Because of the universal bearing mounting, the axis of the shroud stem and pay load can form an angle with the direction of thrust. The particular thrust direction however will always be constant as a consequence of the gyroscopic stability imparted thereto. Because the stem constitutes the sole connection of the pulling arrangement for towing the missile, release of the thrust generating system from the missile at the desired instant of time is greatly facilitated. Thus both direction and speed control of a pay load may be achieved by the gyroscopic pull rocket. In addition, the actual direction of thrust may be initially adjusted to provide a vertical thrust component substantially equal to the weight of the pull rocket and missile combined so that the entire system can be made to follow a horizontal path at a constant altitude above the ground.

A better understanding of the invention will be had by referring to one embodiment thereof as illustrated in the accompanying drawings, in which:

FIGURE 1 is a perspective view of the pull rocket of this invention towing a pay load.

FIGURE 2 is an enlarged cut-a-way perspective view of the pull rocket taken generally in the direction of the arrows 2—2 of FIGURE 1 showing one type of thrust generating system;

FIGURE 3 is a cross section of the universal bearing for the rocket motors within the circular arrow 3 of FIGURE 2;

FIGURE 4 is another view similar to FIGURE 3 showing the bearing means in caged position;

FIGURE 5 is a cut-a-way perspective view similar to

'IGURE 2 showing a modified type of thrust generating ıeans;

FIGURE 6 shows one type of releasable connection ıeans;

FIGURE 7 is an elevational view of a pay load and he pull rocket of this invention, useful in explaining one f its applications; and

FIGURE 8 is a diagrammatic view useful in explaining ome further advantages of the invention.

Referring first to FIGURE 1 there is illustrated a typical ay load **10** which may be a ballistic missile incorporating warhead to which an initial boost phase is to be imarted. Secured to the nose portion of the pay load **10** ; a pull rocket **11** including a shroud **12** surrounding a ırust generating means **13**.

In the particular illustration of FIGURE 1, the longituinal axis of the pay load **10** and shroud **12** is designated . The axis line T on the other hand represents the ırust axis for the means **13** and it will be noted that this ırust axis forms an acute angle with the shroud axis A.

Referring particularly to FIGURE 2, it will be evident ıat the shroud **12** is exteriorly shaped generally to corre-ɔond to a paraboloid. This shape may vary however epending upon aerodynamic requirements in accordance ith whether or not the contemplated flight speed is sub-ɔnic or super-sonic. A single elongated stem **14** co-ıciding with the axis of the paraboloid shape has one ıd secured to the interior nose portion of the shroud ; at **15** and to the interior wall by a suitable annular late or spider structure **16**. The stem **14** is thus held in ɔ-axial relationship with respect to the shroud. The ther end of the stem **14** terminates in a releasable connection **17** to the nose of the pay load **10**.

The particular thrust generating means **13** illustrated in IGURE 2, comprises a series of rocket motors **18**, **19**, **0**, and **21**, for example, each provided with rocket ozzles disposed in a circular array about the stem **14**. hese motors are secured to a universal bearing housing **2** by forward brackets **23** and rear brackets **24**. The niversal bearing housing **22** is shown in alignment with ıe thrust axis T and this axis corresponds to the axis f the circular array of the various motors. When the ıroud and stem are in the dotted line position, the axis co-incides with the axis A.

Each of the motors includes a small spin rocket such s indicated at **25** for the motor **18**. These spin rockets re arranged to direct their thrust tangentially to the ırcular array. The small spin rockets upon firing will ıus cause the entire array to rotate with the universal earing housing **22** about an axis co-inciding with the xis T.

The universal bearing incorporated within the housing **2** is shown in FIGURES 3 and 4 wherein the angle ɔrmed by the housing axis with the stem **14**, in FIGURE is preserved in FIGURE 3. As shown, the interior alls of the housing **22** support a bearing structure **26** ıcluding upper and lower annular bearing races **27** and **8** respectively. Co-operating with these bearing races re upper and lower annular spherical bearing surfaces **29** nd **30** on the upper and lower ends of a central core **31** idably surrounding the central portion of the stem **14**. uitable upper and lower ball bearings **32** and **33** comlete the bearing assembly. By this construction the stem **4** can effect universal movements within given limits ith respect to the bearing housing **22** to which the motors ıemselves are rigidly secured.

Caging and uncaging of the casing and bearing structre, is achieved by making the central core **31**, bearings, ısing, and motors secured thereto all capable of limited ngitudinal movement as a unit along the central por-ɔn of the stem. Upward movement is limited by a ɔmpression spring **34** disposed between the upper end f the core **31** and a flange stop **35** fixed to the stem. he lower end of the stem on the other hand includes a ıging bearing **36** rigidly secured to the stem and including an annular seat **37** receiving the lower end of the casing **22** when the structure is in caged position.

Thus, with particular reference to FIGURE 4, the stem and shroud axis is aligned with the thrust axis of the circular array of motors. Prior to launching of a missile, the components are in the position illustrated in FIGURE 4, and held in this caged position by the compression spring **34** and annular seat.

The operation of the caging mechanism is as follows: With the various component parts in the position shown in FIGURE 4, the desired direction of thrust is determined and the axis of the missile, stem, and bearing housing **22** aligned in this direction. This may be accomplished on the launcher by proper adjustment of the launching frame itself. Once the desired direction of thrust has been established, the small spin rockets such as the rocket **25** of FIGURE 2 may be ignited to cause the circular array of motors to rotate at high speed about the stem axis. The caging bearings **36** will maintain the axis of the bearing housing **22** and the axis of rotation of the motors in alignment with the stem axis so that the universal bearing surfaces **29** and **30** are locked against any tilting but will permit the desired rotation to take place.

The rocket motors are spun to a speed sufficient to develop a gyroscopic action. When the main rocket motors are fired, the thrust developed will overcome the force exerted by the compression spring **34** and the central bearing core **31** and housing will move upwardly along the stem from the position shown in FIGURE 4 to compress the spring **34**. The lower end of the housing will thus be free of the caging bearing as shown in FIGURE 3 so that the stem may then move in a universal sense within the bearing housing. The uncaging of the motors is accordingly achieved automatically and in response to the development of thrust.

FIGURE 5 illustrates a modified thrust developing means which may be substituted for the motors **13** of FIGURE 2. In FIGURE 5, the shroud, supporting stem, releasable connection, bearing means and caging assembly are identical to those shown in FIGURES 2, 3, and 4 and are designated by the same numerals.

Instead of a plurality of separate motors secured to the bearing housing, however, there is provided a single rocket motor casing **38** of generally spherical shape provided with individual rocket nozzles **39** disposed in a circular array about the central axis of rotation of the bearing housing and casing. Within the annular hollow interior of the casing **38** there are provided rings **40**, **41**, and **42** of solid propellant grain positioned between outer and inner annular plastic liners **43** and **44**. By employing more than one ring, a larger burning area of the grain is exposed for more rapid combustion.

Suitable spin-up motors **25** as in FIGURES 2, 3, and 4 may be employed to impart gyroscopic rotational speed to the casing **38**. Ignition of the rings of propellant can be achieved by a centrifugal switch and exploding cartridge structure responsive to the rotation of the casing by the spin rockets and secured within the casing itself as shown at **45**.

In FIGURE 6 a preferred design of the releasably connection **17** for the stem is shown in detail. A releasable connection is provided whenever the pull rocket is employed for purely ballistic type missiles for range control and the principal requirement is that the booster be released in response to a given signal at a given instance of time with minimum reaction on the pay load.

In the releasable connection **17** illustrated in FIGURE 6, there is provided a coupling cavity **46** for receiving a projection **47** from the nose of the missile **10**. The projection **47** includes an annular groove **48** receiving balls **49** partially projecting into the cavity **46**. An annular piston **50** in turn is positioned between the exterior of the cavity walls and interior of the connection **17** for sliding movement. Piston **50** includes annular sloping interior walls **51** defining ball receiving areas. A spring

52 urges the piston 50 in a rearward direction to lock the balls 49 in the groove 48 when the connection is attached. A small squib S is disposed in the interior of the rear portion of the projection and communicates with lateral ports P passing to the underside of the piston 50 when the connection is attached.

In operation, explosion of the squib S at the instant of time separation is desired is accomplished by an accelerometer on the missile or other transducer responsive to a physical condition of flight. Alternatively, the squib may be exploded from a ground command signal. The resulting expanding gases pass from the ports P to move the annular piston 50 upwardly against spring 52. The balls 49 can then fall into the space 51 thus freeing the coupling cavity 46 from the projection 47.

The continued thrust of the booster will then simply pull the stem 14 and coupling 17 from the nose projection 47 of the missile with minimum reaction on the missile, leaving the missile free for ballistic flight. The payload will then follow a conventional ballistic trajectory to its target. Thus, critical launch angles need not be computed since the ballistic portion of the trajectory only extends from the moment of release of the pay load by the pull rocket.

The rapid spinning achieving the gyroscopic stability of the thrust direction is one of the primary features of the instant invention and results in many useful applications of the pull rocket in addition to the foregoing described use with ballistic missiles. The ability to maintain a constant thrust direction can enable rectilinear flight paths of a missile to be achieved. For example, in FIGURE 7 there is shown a payload 53 being towed above the ground G by a pull rocket 54 such as described in FIGURES 2, 3, and 4. In this instance, the angle of thrust T with respect to the horizontal has been computed such that the thrust vector 55 provides a vertical component 56 exactly cancelling the weight of the payload 53 and pull rocket 54. The horizontal component 57 will provide the desired forward motion of the pay load so that the entire assembly will move in a horizontal path such as indicated by the line H.

The uses for straight line flight paths are many. As one example, a smoke screen curtain can be drawn over an extremely large area from a single pay load made to follow a rectilinear path at constant altitude. The stability afforded by the constant thrust direction will insure the desired straight line flight path.

FIGURE 8 illustrates another application of the pull rocket wherein the minimum hit range of a line of sight ground to ground missile can be substantially reduced to zero.

In FIGURE 8, there is illustrated a ground to ground missile launcher 58 which would normally launch a missile along a conventional flight path indicated at 59 to strike a target 60. The path 59 represents the conventional path that the missile must follow in order to become properly airborne and before conventional aerodynamic control thereof can be realized. It will be noted that the initial trajectory follows a parabolic path. There is thus a distance D within which the missile cannot be employed for kill purposes. The useful ranges of the missile therefore fall between the maximum range R and the minimum range D.

By providing a pull booster of the type described in FIGURE 7 on the missile launched at 58, however, a perfectly rectilinear flight path as shown by the dashed line 61 can be achieved throughout the entire range. Therefore, if a target were in the dotted line position 60' a direct hit could be scored. In fact, the entire path can be made at a constant altitude starting directly from the launcher so that the minimum distance heretofore decreasing the usefullness of ground to ground missiles can be substantially reduced to zero.

It will be understood of course that in addition to the principal feature of gyroscopic stabilization of thrust direction, the spinning of the thrust generating means achieves several other useful purposes. As already mentioned, thrust misalignments are cancelled as a consequence of the spinning operation. Further, in the event an extremely large pull rocket should be made employing liquid type fuel engines, the centrifugal forces established could be used for pumping the fuel thus eliminating the need for any fuel pumps.

By maintaining the axis of the shroud substantially in alignment with the pay load axis, the rotating rocket nozzles and motor are protected from adverse aerodynamic effects. Thus, the spinning structure is shielded from lateral aerodynamic forces which might cause precession and thus alter the direction of thrust. If a spherical type casing is employed as the thrust generating means such as shown in FIGURE 5, a shroud would not be an essential part of the structure.

Because of the fact that the pull rocket actually pulls the pay load, only a single connection at 17 is necessary. This feature renders the pull rocket adaptable to many different shaped missiles. Moreover, stability is achieved since the connection is in tension rather than compression and the pulling force is foreward of the center of gravity of the pay load. In addition, the continued thrust of the "booster upon separation will cause it to rapidly pull away from the pay load once the connection has been released so that the booster can in no way interfere with subsequent operation of the pay load. Thus the pull rocket would be well suited for launching and dropping parachuted flares and the like.

From all of the foregoing, it will be seen that the present invention provides a greatly improved rocket booster. While the word rocket has been employed throughout as describing the thrust generating means, the word as used in this connection is meant to include any type of thrust generating motor including liquid fuel engines, jets, and the like. Further, only two types of motors and nozzles have been shown as the thrust generating means, it should be understood that any annular type of construction which will provide thrust and enable rapid spinning of the thrust generating means about a central axis would be equivalent.

The invention is accordingly not to be thought of as limited to the particular embodiments chosen merely for illustrative purposes nor is it to be thought of as limited to the few applications set forth merely as exemplary.

What is claimed is:

1. A pull rocket comprising, in combination: a shroud structure generally in the shape of a paraboloid having an enlarged opening at its rear end; an elongated stem centrally positioned within said shroud and having one end portion coupled to said shroud, the other end of said stem terminating in connecting means adjacent to the open end of said shroud for connection to a pay load; thrust developing means positioned in an annular array about said stem within said shroud and in spaced relation to the interior wall of said shroud; and a universal bearing mounting said thrust developing means to said stem for rotation thereabout in such a manner that the axis of said stem can tilt with respect to the axis of rotation of said thrust developing means, whereby the thrust direction of said thrust developing means can assume an acute angle with respect to the axis of said stem and pay load.

2. The subject matter of claim 1, in which said thrust developing means includes a series of rocket nozzles disposed in a circular array, the axis of said circular array defining the direction of net thrust developed by said nozzles; and spin rocket means secured to said thrust developing means to generate a thrust tangent to said circular array whereby said series of rocket nozzles can be spun at a speed about the axis of said circular array sufficient to provide gyroscopic stabilization of said direction of thrust.

3. The subject matter of claim 1, in which said connecting means between said stem and said pay load includes a coupling structure having overlapping portions; and means responsive to a control signal for moving said portions out of overlapping relationship, whereby said pay load may be separated form said pull rocket at a given instant of time.

4. The subject matter of claim 2, including caging means for holding the axis of rotation of said thrust developing means in co-axial alignment with the axis of said stem during spinning of said rocket nozzles, said caging means including an annular caging bearing fixed to the lower portion of said stem, said mounting means being slidably mounted on said stem and including a lower portion receivable in said annular bearing when in its lowermost position along said stem and when the axis of said stem is co-axial with the axis of said mounting means, thrust developed by said thrust developing means moving said mounting means along said stem to a position free of engagement with said caging bearing to uncage said mounting means form said stem.

5. The subject matter of claim 2, in which said thrust developing means includes a plurality of individual rocket motors respectively connected to said rocket nozzles disposed in an annular array and connected to said mounting means.

6. The subject matter of claim 2, in which said thrust developing means includes a single spherically shaped motor casing with a diametric opening incorporating said mounting means and through which said stem passes, said nozzles being connected to exterior portions of said spherical casing to define said annular array and communicating with a single annular combustion chamber within said casing.

7. A pull rocket comprising: a supporting means adapted to be connected at one end to the nose portion of a pay load in axial alignment with the longitudinal axis of said pay load; a thrust developing means; mounting means for rotatably mounting said thrust developing means to said supporting means, said mounting means including a universal bearing such that said supporting means and pay load may tilt with respect to the direction of thrust of said thrust developing means; and means for rotating said thrust developing means to maintain said direction of thrust constant by gyroscopic action.

8. The subject matter of claim 7, including a shroud structure surrounding said thrust developing means.

References Cited in the file of this patent

UNITED STATES PATENTS

395,881	Cunningham	Jan. 8, 1889
1,376,316	Chilowsky	Apr. 26, 1921
1,748,697	Maier-Behring	Feb. 25, 1930
2,145,508	Denoix	Jan. 31, 1939
2,555,080	Goddard	May 29, 1951
2,792,758	Bach et al.	May 21, 1957
2,849,955	Smathers	Sept. 2, 1958
2,879,668	Mleczko	Mar. 31, 1959
2,884,859	Alexander et al.	May 5, 1959
2,945,442	Adelman et al.	July 19, 1960
3,001,739	Faget et al.	Sept. 26, 1961