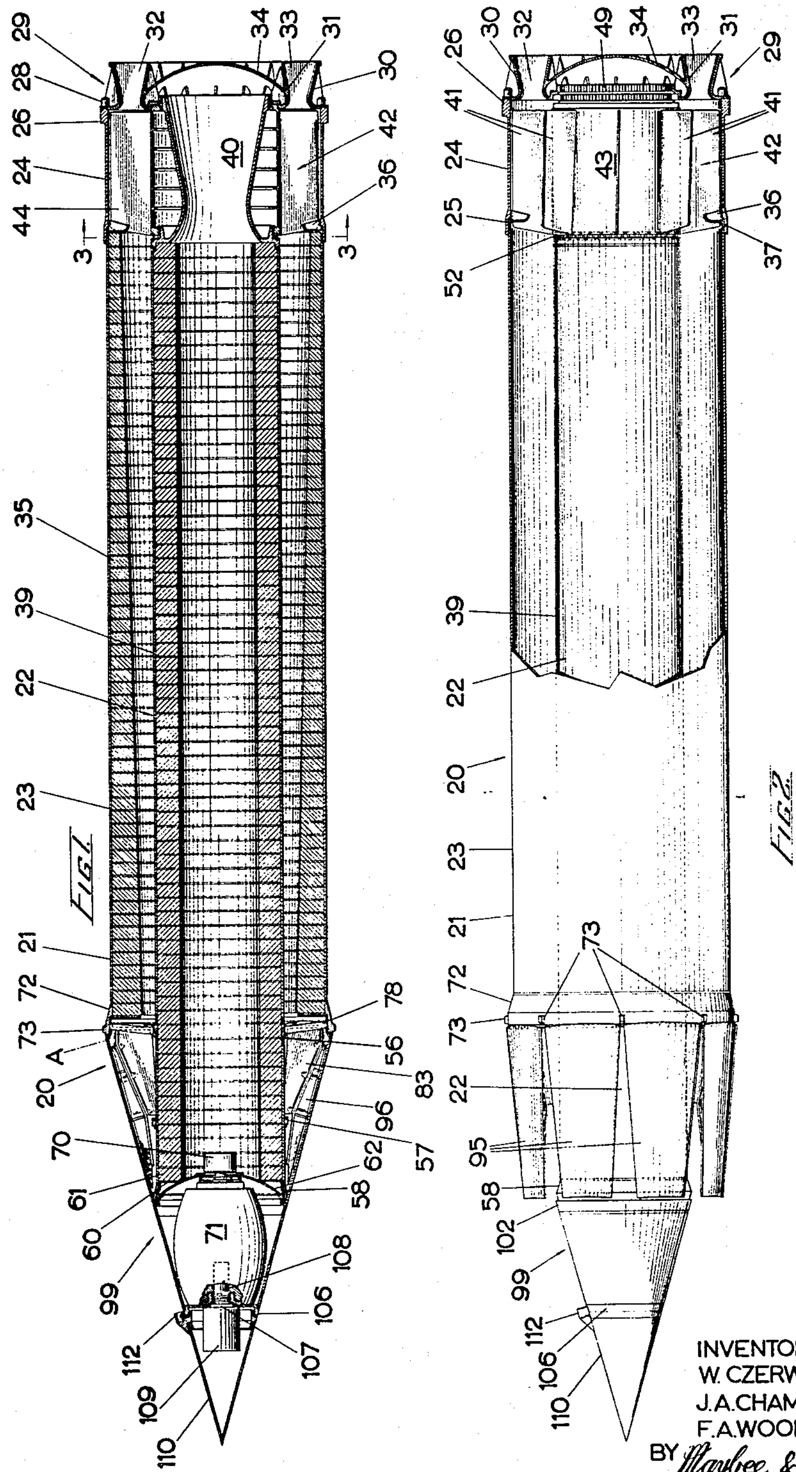
Jan. 26, 1965 W. CZERWINSKI ETAL 3,167,016

ROCKET PROPELLED MISSILE

Filed July 30, 1956 7 Sheets-Sheet 1



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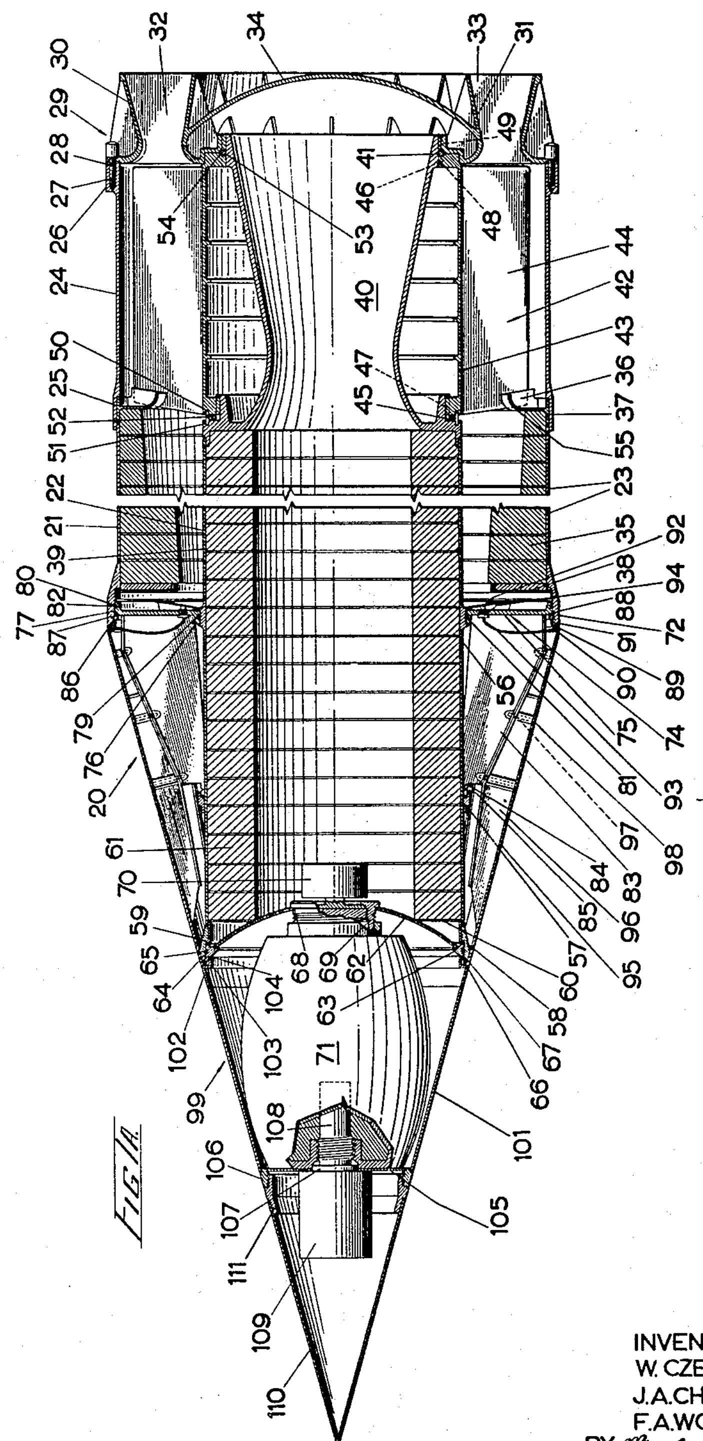

FIG. 1A.

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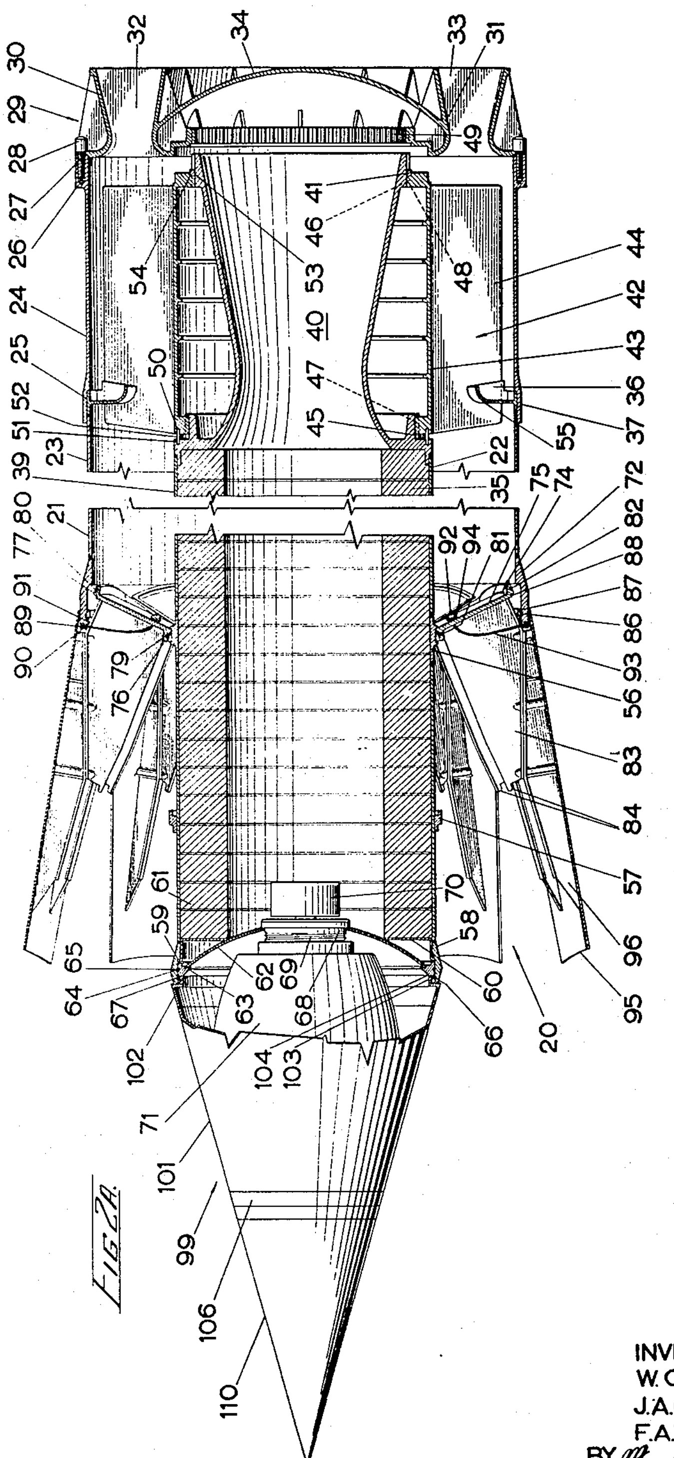

FIG. 2A.

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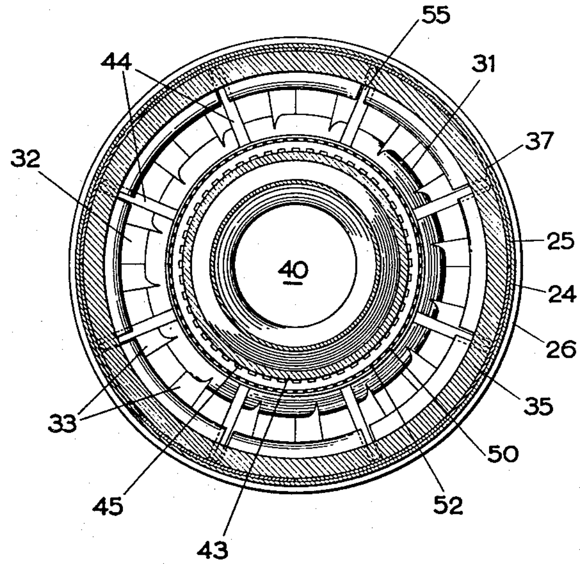

FIG. 3.

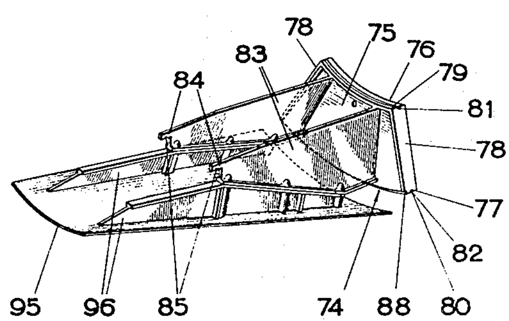

FIG. 5.

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Filed July 30, 1956 7 Sheets-Sheet 5

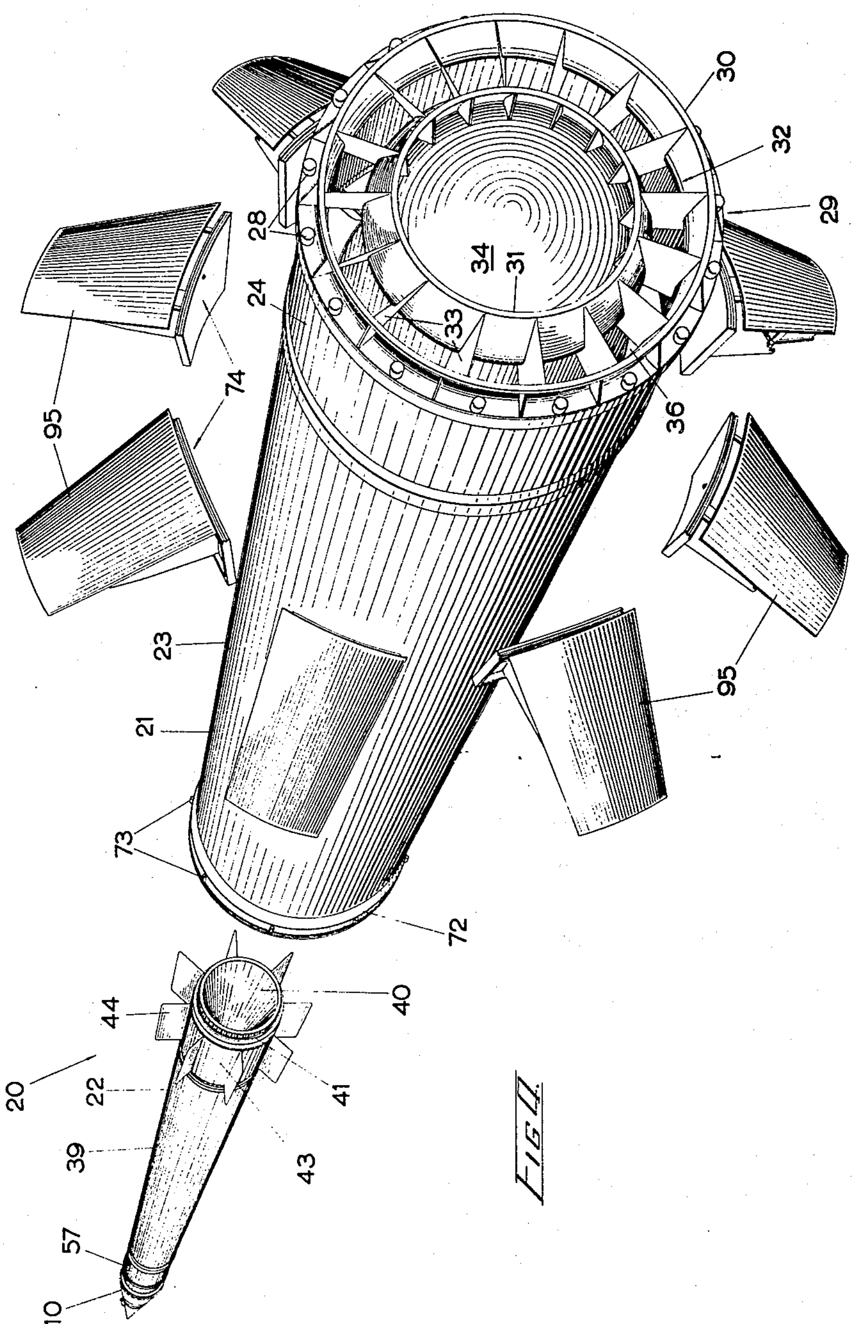

FIG. 11

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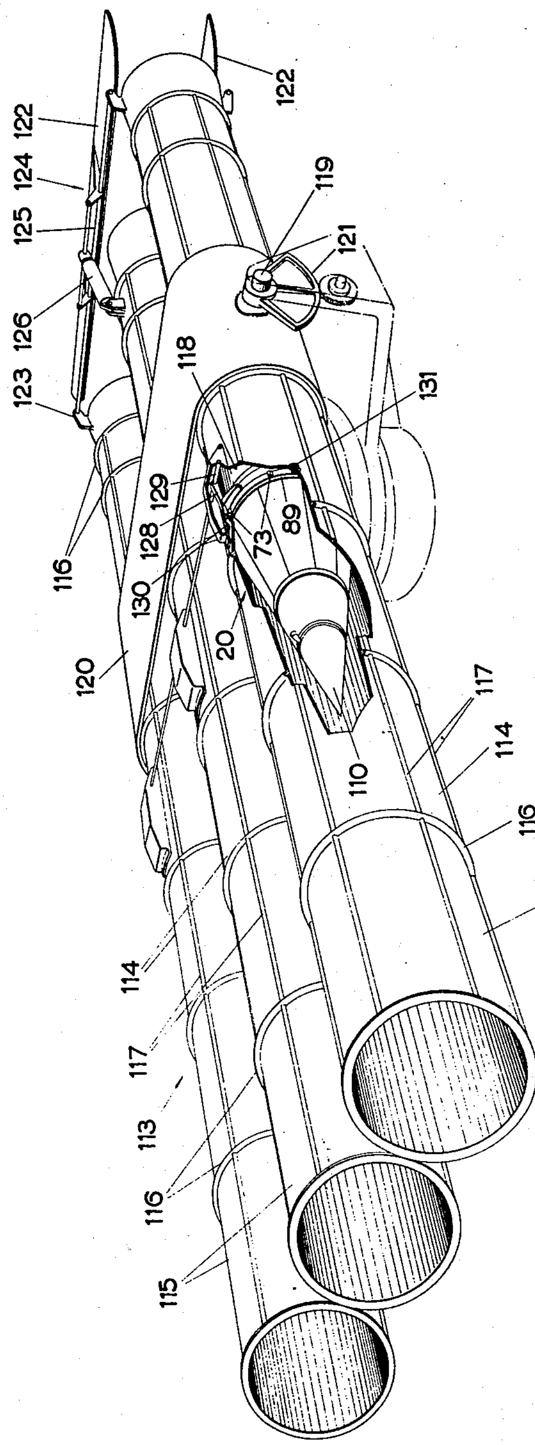

FIG. 6

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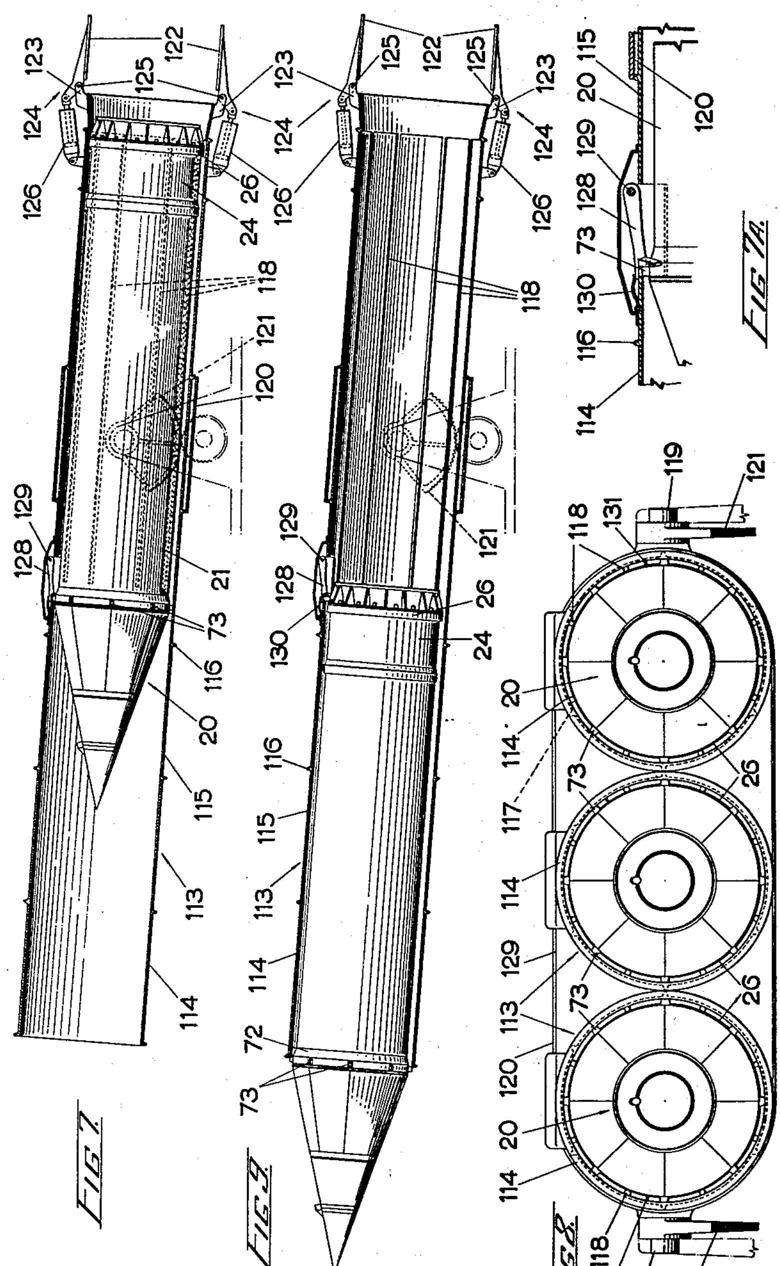

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3,167,016
ROCKET PROPELLED MISSILE

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Filed July 30, 1956, Ser. No. 600,859
8 Claims. (Cl. 102—49)

This invention relates to missiles and more particularly to an unguided two stage missile propelled by the efflux of gases generated by a rocket motor.

In the past, surface installations either on land or on the sea, have been defended against air launched attacks by the use of various specialized devices, the most common being projectiles propelled through the rifled barrel of a gun directed at the target. Other devices include unguided rocket projectiles, fired either singly or in salvo, and electronically guided missiles which are directed to the vicinity of the target by external aerodynamic control surfaces.

Unguided projectiles have the characteristic of low single shot probability of kill, which has been partially overcome by firing high velocity projectiles fitted with proximity fuses, at a high rate from radar directed guns or projectors. However, in view of the advent of fast modern aircraft which can take extreme evasive action, and of electronically controlled glide bombs and improved aerial torpedoes, it becomes necessary to increase substantially the warhead effectiveness of unguided missiles and to reduce their time of flight if an acceptable kill probability is to be maintained.

Homing guided missile systems have been used with a considerable degree of success. The guided missile overcomes the disadvantage of a long time of flight by continuously correcting its path in relation to the target so that the latter's evasive action becomes substantially meaningless. However, such a weapon with its large amount of electronic guidance equipment requires a long period of time to develop and is very expensive to manufacture.

The subject invention embodies an unguided two stage rocket propelled anti-aircraft missile which will achieve an exceptionally high single shot probability of kill. The missile described herein has a warhead weighing in the order of 150 lbs. and travels with a mean velocity of 6,000 ft./sec. over an effective range of up to 6,000 yds. This warhead is about eight times as large as a conventional anti-aircraft shell, and its velocity is about three times as high as that of a conventional anti-aircraft shell. These features make it possible to achieve an acceptable probability of kill against any of the targets previously mentioned, against which conventional defensive armament becomes ineffective. In addition, the rocket of the invention has the special features of spin stabilization, which eliminates the necessity of external fins on the outer casing, and thus simplifies ground handling; furthermore it has a simple mechanical construction combined with a minimum of delicate electronic or mechanical systems, thus reducing the cost as compared to that of a conventional guided missile.

It is obvious that such a missile will have to be aimed in much the same way as a gun and will require a fire control system of similar accuracy. A launching device therefore is provided: it is directed by an automatic electronic fire control system which will not be described herein since it is not part of the invention.

It is an object of the invention to provide a two stage rocket propelled missile having spin stabilization and then, on separation, fin stabilization.

It is another object of the invention to provide a simple

but effective mechanical arrangement whereby the two stages are separated when the propellant charge in the first stage is exhausted.

Another object of the invention is to provide structure associated with both the launcher and the missile which ensures that all parts of the missile leave the guiding surfaces of the launcher at one time in order to minimize misguide due to movement of the launcher during firing.

The foregoing and other objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, in which like reference numerals indicate corresponding parts throughout the several views, and in which:

FIGURE 1 is a longitudinal cross-sectional view of a missile constructed in accordance with the invention;

FIGURE 1A is an enlarged longitudinal cross-sectional view of the fore and aft portions of the missile of FIGURE 1;

FIGURE 2 is a longitudinal, part-elevational and part-sectional view of the missile at the initiation of separation of the first and second stage rockets;

FIGURE 2A is an enlarged longitudinal, part-elevational and part-sectional view of the fore and aft portions of the missile at the initiation of the separation of the first and second stage rockets;

FIGURE 3 is a transverse sectional view of the missile taken on the line 3—3 of FIGURE 1;

FIGURE 4 is a perspective view of the first and second stage rockets of the missile immediately after separation;

FIGURE 5 is a perspective view of a head segment with its associated fairing segment;

FIGURE 6 is a perspective view of a launcher for the missile, one of the barrels of the launcher being broken away to show a missile in firing position in the barrel;

FIGURE 7 is a longitudinal sectional view through a barrel of the launcher showing a missile in firing position;

FIGURE 7A is a detail of FIGURE 7 on a larger scale and showing a stop for the missile;

FIGURE 8 is an end elevational view of the launcher of FIGURE 6; and

FIGURE 9 is a view similar to FIGURE 7 but showing the missile emerging from the barrel.

Referring particularly to FIGURES 1, 2, 1A and 2A a missile **20** comprises a first stage **21**, and a second stage **22** coaxially disposed within and substantially encased by the first stage. The first stage includes an outer shell or casing **23** of cylindrical cross-section, to the aft portion of which is welded or otherwise secured a housing **24** of similar cylindrical cross-section. The housing is, in the vicinity of its attachment to the shell **23**, of slightly larger diameter than the shell **23** and has machined a recess **25** in its inner cylindrical surface adjacent its forward edge. The aft portion of the housing is of greater diameter than the forward portion, to provide a rear supporting ring **26** the main function of which will become apparent later. The ring **26** is provided with tapped holes **27** into which bolts **28** are inserted to attach a nozzle assembly **29** comprising an outer ring **30** and an inner ring **31**, the space therebetween constituting an annular convergent-divergent nozzle **32** in which are disposed deflector vanes **33**. The vanes **33** deflect the exhaust gases through an angle of approximately 20° from the axis to impart an angular velocity or spin to the rocket. The vanes are so arranged that the thrust is directed toward the centre of gravity of the missile in order to minimize the effects of malalignment due to thrust deviations around the nozzle. The vanes **33** are fast to the rings **30** and **31** and the vanes and the rings together with a spherical segment **34** which encloses the space within the inner ring **31** constitute a rigid unit.

The propellant charge for the first stage rocket comprises a multiplicity of precast rings or grains **35** which are manufactured from some suitable rapid burning rocket fuel. It will be noted that the inner diameters of the rings of propellant **35** gradually increase from fore to aft where, at the final ring, the grain assembly is held in position by a segmented rear grain support **36** having flanges **37** whereby it is rotatably mounted in the recess **25**. A forward grain support **38** serves mainly to retain the propellant charge in position during loading and storage.

The inner wall of the first stage rocket is formed by a slender cylindrical shell **39** which also provides the outer casing of the second stage rocket **22**. The second stage rocket is coaxially disposed within the first stage rocket and terminates at its aft and in a convergent-divergent nozzle **40** of circular cross-section which is welded to the shell **39**. The discharge portion of the nozzle **40** mates at its outer edge with the inner ring **31** of the nozzle **32** and, together with a split retaining ring **41**, forms a gas-tight joint between the nozzles **32** and **40**.

A fin wrapper **42** is constituted by a body portion **43** to which are attached integral fins **44** arranged in a slight spiral. The fin wrapper is fastened to the nozzle **40** in torque transmitting relationship by means of fore and aft splines **45** and **46** machined externally on the outer surface of the nozzle **40**; the splines are complementary to and register with splines **47** and **48** respectively, which are machined internally at the ends of the body portion **43**. The splines **46** also engage splines **49** machined on the inner ring **31** of the first stage nozzle assembly **29** to provide a torque transmitting connection between the two stages. A groove **50** machined in the forward face of the body portion **43** mates with a groove **51** machined in the nozzle **40**, the two mating grooves being adapted to receive a corrugated wire spring **52**. Grooves **53** and **54** machined in the splines **46** and **48** respectively, receive the split retaining ring **41**. Notches **55** provided between the segments of the first stage rear grain support **36** allow the passage of the fins **44** on separation of the two stages.

Near the forward end of the shell **39** (see FIGURES 1A and 2A) is a break in which a retaining ring **56** is welded in place. Somewhat forwardly of the ring **56** a stepped ring **57** is welded to the exterior of the shell **39** for a purpose that will become apparent hereafter. The extreme forward end of the shell **39** terminates in a forward tube collar **58** which is provided with an integral collet **59** in which is held a forward grain support **60**. The grain support **60** positions the second stage propellant charge, which charge is constituted by rings or grains **61**. To the outer periphery of a dished annular sealing plate **62** is welded an outer collar **63** having a groove **64** which receives a seal **65**. A groove **66** machined in the forward tube collar **58** receives a split retaining ring **67** which holds in position the outer collar **63** and hence the sealing plate **62**. An inner collar **69** extends through the hole **68** in the centre of the sealing plate and it is welded to the sealing plate. From the aft side of the collar **69** projects an igniter **70** for the second stage grain; a warhead **71** is attached to the other side of the collar **69** by means of screw threads.

Referring again to the first stage (see FIGURES 1 and 1A) there is welded to the forward end of the shell **23** a forward ring **72** having, integral with its outer surface, eight winglets **73**. Spanning the annular space between the forward ring **72** and the retaining ring **56** are eight head segments generally indicated at **74** (see FIGURES 1A and 5); they are annularly arranged about the retaining ring. Each of the head segments **74** comprises a web **75** having inner and outer arcuate flange segments **76** and **77** respectively, and radially disposed edges **78** which abut the edges of adjacent webs to form gas tight joints. Sealing grooves **79** and **80** are machined in the inner and outer flange segments respectively to receive O-ring seals

81 and **82** respectively. To the forward faces of each of the webs **75** are attached two integral ribs **83** having toe portions **84** which are restrained by the stepped ring **57**. A notch **85** on each of the toe portions provides an area of high local stress concentration when suitable loads are applied to the ribs **83**. A split retaining ring **86** fits into a groove **87** machined on the forward part of the inner surface of the forward ring **72** and mates with a recess **88** in the forward edges of the annulus constituted by the arcuate flange segments **77**; an igniter ring **89** abuts the end of the ring **72**. The igniter ring **89**, which has high electrical conductivity, is held securely in a mounting ring **90** of U-cross-section and which is made of some heat resistant plastic material having good electrical insulating characteristics. The igniter ring **89** is attached to the end of the ring **72** by means of an integral flanged collar **91** which fits within the forward inner surface of the ring **72** and abuts the split retaining ring **86**. Electrical contact between the ring **89** and igniters **92** adjacent the first ring of propellant is made by means of eight leads **93**, each one of which is connected to a terminal post **94** on the respective eight head segments **74** and makes contact with the igniters. The igniters **70** and **92** will not be described in detail since they are of known construction.

Low shock, high heat release, closureless igniters preferably are used for reliability. This type of igniter sprays molten magnesium and aluminum powder intimately into the forward disk of propellant; it is readily available in fully developed form and is known to perform well.

Fairing segments **95**, (see FIGURES 2, 2A and 5) when assembled, constitute a fairing which extends from the forward ring **72** to the forward tube collar **58**. Each of the fairing segments is provided with a pair of stiffening ribs **96**, the inner edges of which abut the outer edges of the opposed ribs **83** of the webs **75**; in the ribs **96** are holes **97** through which pass bolts **98** to fasten the fairing segments to the ribs **83**.

A warhead assembly **99** (see FIGURE 1A) comprises the warhead **71** having a fragmentable casing which contains a high explosive. The warhead **71** is fastened by screw means to the collar **69** and is contained within a warhead fairing **101** shaped in the form of a truncated cone. Secured to the aft edge of the fairing is a sleeve **102**; the sleeve includes a face **104** which abuts the ends of the fairing segments **95**, and a flange **103** which is encompassed by the split retaining ring **67**. The forward end of the fairing **101** is closed by a plate **105** fast to the fairing and having a threaded flange **106**. A hole **107** in the plate **105** allows the plug end **108** of a fuse **109** to be screwed into the warhead **71**. By the assembly of the collar **69**, the warhead **71**, the fairing **101** and the fuse **109**, this portion of the warhead assembly is secured to the second stage rocket **22**. A conical tip fairing **110** has at its base a threaded sleeve **111** for attachment to the flange **106**. A miniature radar antenna **112** (see FIGURES 1 and 2) receives signals from the ground control station which are transmitted to the fuse **109** to explode the warhead at the most advantageous position with respect to the target. The fuse **109**, the warhead **71** and the igniters **70** and **92** will not be described in detail since they are well-known to those skilled in the art.

In order to ensure that the missile **20** is properly launched, there is provided a launcher unit **113** (see FIGURES 6, 7, 7A, 8 and 9) comprising three separate launching barrels **114** capable of firing three missiles simultaneously or in a prescribed sequence. Each barrel consists of a hollow steel cylinder **115** to the exterior of which are integral stiffening rings **116** which provide circular stability, and also axial flutes **117**. In the interior of each barrel (see FIGURES 7 and 9) eight integral missile guide rails **118** are positioned equiangularly around the inner surface. In order to achieve dimensional accuracy, it is proposed that the barrels should be manufactured as centrifugal steel castings. This type of construction not only results in a product having acceptable dimensional tolerances but also permits the inclusion of all the exterior reinforcements and the interior guide rails 118.

The three barrels 114 are joined together to form the launcher unit 113 by welding the abutting flutes 117 of adjoining barrels; this eliminates distortion during welding. The unit 113 is supported on trunnions 119 of a torque box structure 120 consisting of steel plate of appropriate thickness welded to two suitably positioned stiffening rings. Geared elevating arcs 121 are welded to the torque box 120 below each of the trunnions 119. End caps 122 are hingedly mounted on brackets 123; each end cap may be swung from open to closed position by a rod and crank mechanism 124 welded to a common hinge pin 125 and actuated by a hydraulic jack 126. The end caps may be closed to protect empty or loaded barrels against the weather or, when a rocket has misfired, the caps may be closed and the missile ejected by compressed air introduced into the barrel between the missile and the caps. A cutout in the wall of each cylinder 115 (see FIGURES 7 and 7A) receives a missile stop 128 hingedly mounted on a pin 129 and urged inwardly by a leaf spring 130. A spring loaded contact pin 131 positioned immediately forward of one of the missile guide rails 118 is connected to the automatic electronic fire control and delivers an electrical impulse to the igniter ring 89 when it is desired to launch a missile. The trunnions 119 are mounted on a carriage (not shown) which contains suitable azimuth and elevation gearing to position the launcher unit 113 for firing.

Assembly

Because of the specific configuration of the two stages of the missile, one arranged within the other, and because of the novel means necessary to effect complete separation, a special sequence of assembly operations is required. The first step includes the filling of the second stage shell 39 with its propellant 61, held in position by the grain support 60; then the dished sealing plate 62 together with its outer collar 63 and its inner collar 69 and the igniter 70 are partially inserted into the forward end of the second stage. The seal 65 then is fitted into the groove 64 provided in the collar 63 and the whole subassembly is completely inserted leaving the groove 66 unobstructed. The split retaining ring 67 finally is placed in the groove 66 to complete this subassembly.

The second step in the assembly of the missile is begun by attaching the rear grain support 36 to the casing 23 of the first stage 21 and filling the casing with the propellant 35. The inner sealing ring 81 then is positioned around the retaining ring 56 and the eight head segments 74 are then installed with the aid of an assembly ring A. It should be noted that the toe portion 84 of each segment must fit under the stepped ring 57; also, each segment 74 must bear on the retaining ring 56 with the groove 79 registering with the sealing ring 81. The outer seal 82 is placed over the head segment assembly to fit into the groove 80 and the previously described second stage sub-assembly is inserted into the first stage sub-assembly and it is pushed as far aft within the first stage sub-assembly as permissible in order to facilitate the installation of the split retaining ring 86 in the groove 87. After the ring 86 has been fitted, the second stage sub-assembly is brought forward until the recess 88 in the web 75 of the head segments 74 abuts the split retaining ring 86.

The third step in the assembly of the missile relates to the nozzle section (see FIGURES 1A and 2A). The corrugated wire spring 52 is located in the machined groove 51, and the splines 47 and 48 on the body portion 43 of the fin wrapper 42 are pushed over the nozzle splines 45 and 46, insuring that the fins 44 slide into the notches 55 of the rear grain support 36. The fin wrapper 42 is pushed far enough forward to depress the corrugated spring 52 and expose the groove 53 in the aft portion of the nozzle 40 whereupon the split retaining ring 41 is installed and the fin wrapper 42 is freed in order to let the face of the groove 54 abut the ring 41. The first stage nozzle system 29 is then positioned at the end of the housing 24 with the inner ring 31 mating with the nozzle 40; the nozzle 29 then is bolted to the housing 24.

The fourth and final step involves the assembly of the extreme forward portion of the missile. The warhead 71 is screwed onto the collar 69 after which the warhead fairing 101 is fitted into place with the flange 103 of the sleeve 102 being a push fit over the split retaining ring 67; by screwing the fuse 109 into the warhead 71, the fairing 101 is held firmly in position. The tip fairing 110 is assembled by screwing the threaded portion of the sleeve 111 onto the flange 106. Then to complete the assembly, the igniter ring 89 is fitted into position, the leads 93 fastened on the face of the webs 75 and the fairing segments 95 placed in position with the bolts 98 fastening them to the ribs 83.

Operation

In operation, the end caps 122 of each launching barrel 114 are opened and remain open during firing. The forward end of the missile 20 is inserted in the barrel and the missile is pushed forward until one of the winglets 73 engages the missile stop 128, at which stage the pin 131 makes contact with the igniter ring 89 (see FIGURES 6, 7 and 7A). The fore part of the missile is supported on the inner surface of the cylinder 115 by the winglets 73 while the aft part is supported by the rear ring 26 of the housing 24 on the eight missile guide rails 118. It is intended that the launcher be aimed by radar control in which case the command for firing will be automatic, delivering an electrical impulse to the pin 131. The current will flow through the igniter ring 89 and the leads 93 to each of the contacts on the webs 75 of the head segments 74 to initiate combustion of the first of the grains of propellant 35. The hot gases thus formed will, in passing down the diverging passage between the propellant 35 and the shell 39, ignite the accelerating compound between the discs of propellant. An inhibitor is provided on the cylindrical surfaces of the discs so that the burning takes place on the faces to provide a large constant area burning surface. The gases generated travel radially inwards and then turn through 90° to pass axially down the diverging passage. The passage is rearwardly divergent in order to accommodate the increasing volume of gas as it progresses rearwardly. In order to prevent breaking up of the propellant under the high axial accelerations encountered, the discs are bonded to the shell 23 and are also supported by the rear grain support 36.

The gases, as they pass rearwardly enter the nozzle system 29 and are ejected to atmosphere through the annular nozzle 32 to produce a thrust on the missile. At the same time, the gases react on the vanes 33 to impart a spin to the missile, which spin acts as the stabilizing force while the missile is in flight. The rotational forces on the first stage rocket are transferred to the second stage by means of the splined connection between the inner ring 31 of the nozzle 32 and the aft portion of the nozzle 40. Because of the high pressure generated by the gas as it is formed in the first stage, high collapsing stresses will be imposed on the shell 39 of the second stage. Therefore, the shell must be of sufficient thickness to withstand the high load; it should not be overlooked however that the second stage grain will aid in withstanding this radial compressive stress. If it is considered that an increased shell thickness would seriously affect design criteria, the second stage may be pressurized immediately prior to use.

As the missile progresses down the launcher, it is supported, as stated above, by the winglets 73 bearing on the inner surface of the cylinder 115 and by the rear ring 26 bearing on the guide rails 118. However, the relationship between the distance from the winglets to the rear ring and the total length of the launcher barrel relative to the length of the guide rails is such that at the instant the winglets emerge from the launcher, the rear ring ceases to bear on the guide rails (see FIGURE 9). This has the effect of completely freeing the entire missile from the launcher at one instant, thus eliminating ballistic dispersion due to tip offs, transverse acceleration and static unbalance.

The second stage igniter **70** is activated at the same instant as the first stage is fired. However, by means of a time delay fuse, the second stage propellant is not ignited until a predetermined period of time after the firing of the first stage. This period of time is calculated to coincide with the burn-out time of the first stage propellant. When the pressure in the second stage reaches a predetermined value (called "the separation pressure"), the axial force acting on the spherical segment **34** which encloses the second stage nozzle **40**, pushes the whole outer shell **23** aft with sufficient force to break the toe portions **84** of the ribs **83** at the notches **85** (see FIGURE 5). The relative movement of the outer shell and the inner shell will cause a swinging movement or radial dispersion of the head segments **74** and of the fairing segments **95** attached to them (see FIGURES 2 and 2A). The dispersal speed will be augmented by the centrifugal force caused by the rotational velocity of the missile, as well as by the aerodynamic lift acting on the fairing segments. During separation, the eight fins **44** at the aft end of the second stage will pass freely through the notches **55** in the rear grain support. If any difference exists between the relative velocities of the two stages at the instant of separation the rear grain support in free to rotate in the recess **25** in order to obviate any ill effects due to the difference in relative velocities. Moreover, during separation, the head segments **74** with their associated fairing segments **95** will break away as shown in FIGURE 4.

At the instant of separation, the first stage becomes, in effect, a second launcher. Because of the high angular velocity imparted to the first stage by reason of the gases discharging through the inclined vanes **33**, the first stage has a high order of gyro stability and is maintained in a straight path during separation. The second stage is held concentric with the outer shell **23** by the fins **44** at the rear and also by the high gas pressure between the shells **23** and **39**. The fins **44** of the second stage are slightly helical so that the second stage retains the angular velocity imparted to it by the first stage and consequently retains a certain amount of gyro stability. However, because of the high length to diameter ratio of the second stage an additional amount of fin stabilization is required and the fins are provided mainly for this purpose.

After separation, the second stage carrying the warhead **71** continues on its path toward the target. It is not required, nor is it even desirable, that the warhead be exploded by impact with the target and for this reason some form of fusing is provided which will automatically explode the warhead at its optimum position in relation to the target. In the embodiment of the invention described herein, it is proposed to use what is known as a "Command Fuse." In this type of fuse, a radar range finder at the launching base constantly measures the distance between the target and the missile and, at the optimum distance, sends out a signal which is received by the antenna **112** and which triggers the fuse. However, it will be understood that other types of fusing may prove advantageous for certain applications, e.g. an infra-red fuse operated by heat generated by the target, a Doppler radar fuse, an accelerometer-type distance measuring fuse, or an electronic self-contained distance measuring fuse.

It is to be understood that the form of the invention herein shown and described is to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of the parts may be resorted to without departing from the spirit of the invention and the scope of the subjoined claims.

What we claim as our invention is:

1. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the second stage motor so that an annular passage for products of combustion is provided between the propellant and the second stage motor, and an annular nozzle at the aft end of the shells to discharge to atmosphere the products of combustion emanating from the passage.

2. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the second stage motor so that an annular passage for products of combustion is provided between the propellant and the second stage motor, a solid propellant bonded to the inner face of the cylindrical shell of the second stage motor, the said propellant being of annular cross-section to provide a central passage for the products of combustion thereof, igniting means for the propellant of the second stage motor, and nozzles at the aft end of the passages to discharge to atmosphere the products of combustion emanating therefrom.

3. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the second stage motor so that an annular passage for products of combustion is provided between the propellant and the second stage motor, an annular nozzle at the aft end of the annular passage, a solid propellant bonded to the inner face of the cylindrical shell of the second stage motor, the said propellant being of annular cross-section to provide a central passage for the products of combustion thereof, igniting means for the propellant of the second stage motor, and a nozzle at the aft end of the passage of the second stage motor to discharge to atmosphere the products of combustion emanating therefrom.

4. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the sec-

ond stage motor so that an annular passage for products of combustion is provided between the propellant and the second stage motor, and nozzle means at the aft end of the first stage motor shell to discharge to atmosphere the products of combustion emanating from the passage.

5. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the second stage motor so that an annular passage for products of combustion is provided between the propellant and the second stage motor, nozzle means at the aft end of the first stage motor and communicating with the passage for the ejection of the products of combustion of the propellant of the first stage motor to propel the missile and to impart to the missile a rotary motion and thus to provide it with gyroscopic stability, and fin means at the aft end of the shell of the second stage motor to provide aerodynamic stability thereto after separation from the first stage motor.

6. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the second stage motor so that an annular passage for the products of combustion is provided between the propellant and the second stage motor, an annular nozzle at the aft end of the first stage motor and communicating with the passage for the ejection of the products of combustion of said propellant, a series of vanes angularly disposed within the annular nozzle to impart to the missile a rotary motion to provide it with gyroscopic stability before separation of the motors, a nozzle at the aft end of the shell of the second stage motor, and fin means associated with said last named nozzle to provide aerodynamic stability to the second stage motor after separation thereof from the first stage motor.

7. A rocket propelled missile comprising a first stage rocket motor including a cylindrical shell, a second stage rocket motor including a cylindrical shell coaxially disposed within and substantially encased by the first stage motor, the cylindrical shell of the second stage motor being spaced from the cylindrical shell of the first stage motor to define therewith an annular chamber, a solid propellant in the annular chamber and bonded to the inner face of the cylindrical shell of the first stage motor, igniting means for the propellant, the solid propellant being of annular cross-section and its internal diameter being greater than the external diameter of the shell of the second stage motor so that an annular passage for products of combustion is provided between the propellant and the second stage motor, an annular nozzle at the aft end of the annular passage for discharging the products of combustion of the first stage motor to atmosphere, a series of vanes angularly disposed within the nozzle to impart to the missile a rotory motion and thus to provide it with gyroscopic stability before separation of the motors, a nozzle at the aft end of the second stage motor for discharging its products of combustion to atmosphere, and a group of fins equiangularly arranged on the nozzle of the second stage motor to provide the second stage motor with aerodynamic stability after separation of the motors.

8. A missile as claimed in claim 7, in which the fins are helical in shape with their helix axis coinciding with the longitudinal axis of the second stage motor.

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