Jan. 2, 1962 J. F. GANAHL 3,015,231

MISSILE FLIGHT SIMULATION SYSTEM

Filed Sept. 8, 1958 3 Sheets-Sheet 1

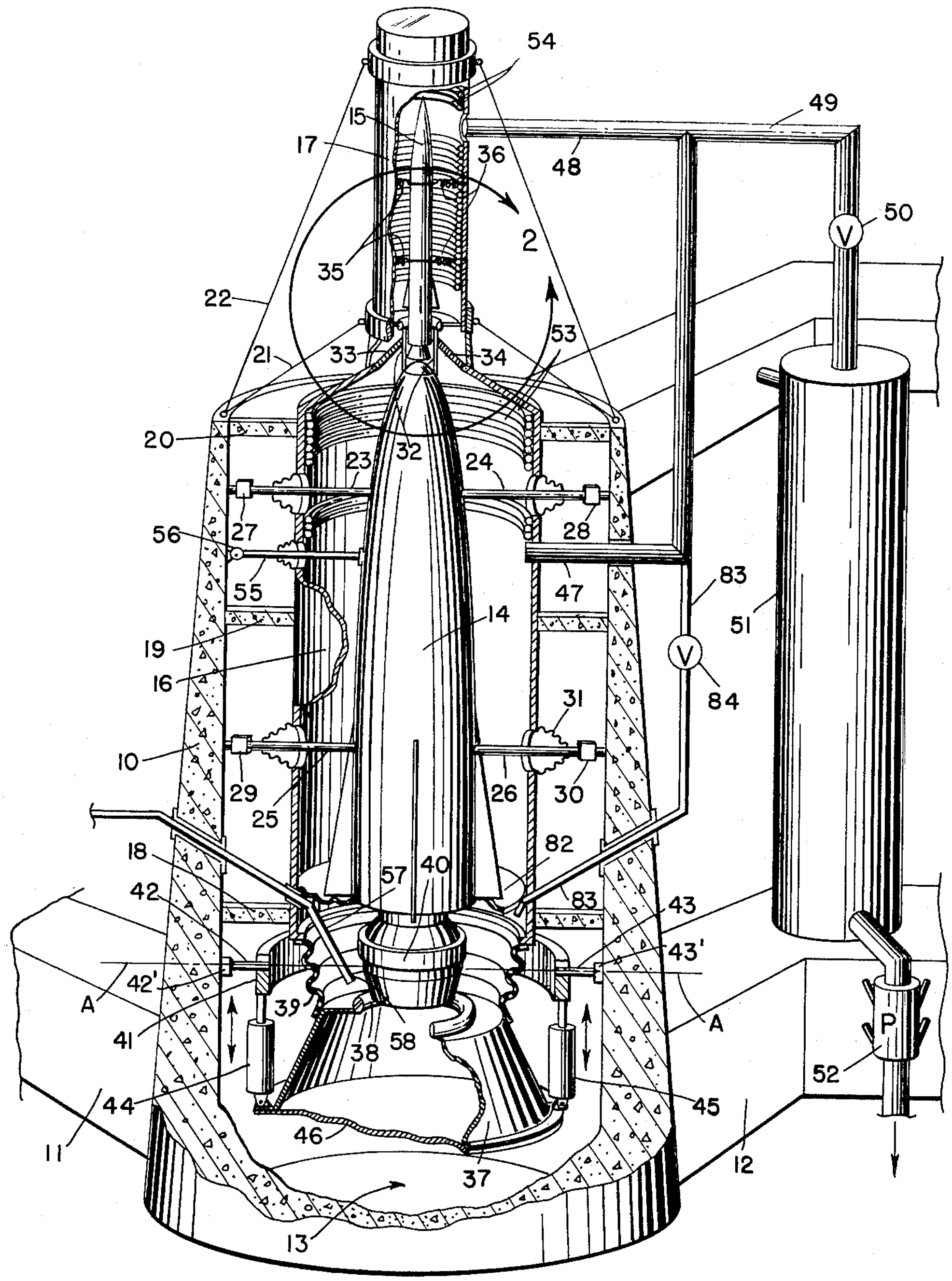


FIG. I

INVENTOR.
JOSEPH F. GANAHL
BY Elliott & Pastoriza
ATTORNEYS

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J. F. GANAHL
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MISSILE FLIGHT SIMULATION SYSTEM
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3 Sheets-Sheet 2

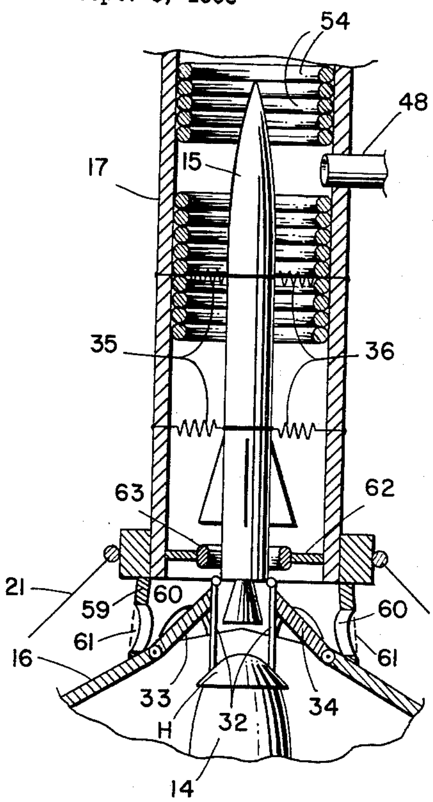


FIG. 2

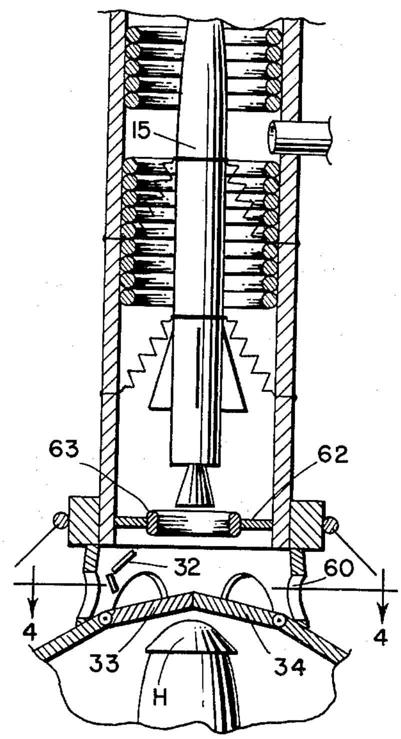


FIG. 3

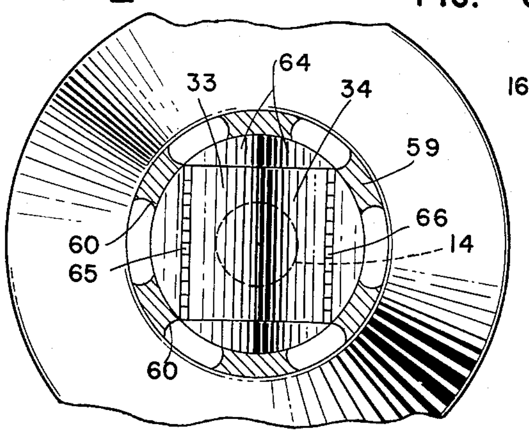


FIG. 4

*INVENTOR.*
JOSEPH F. GANAHL
*BY* Elliott & Pastoriza
ATTORNEYS

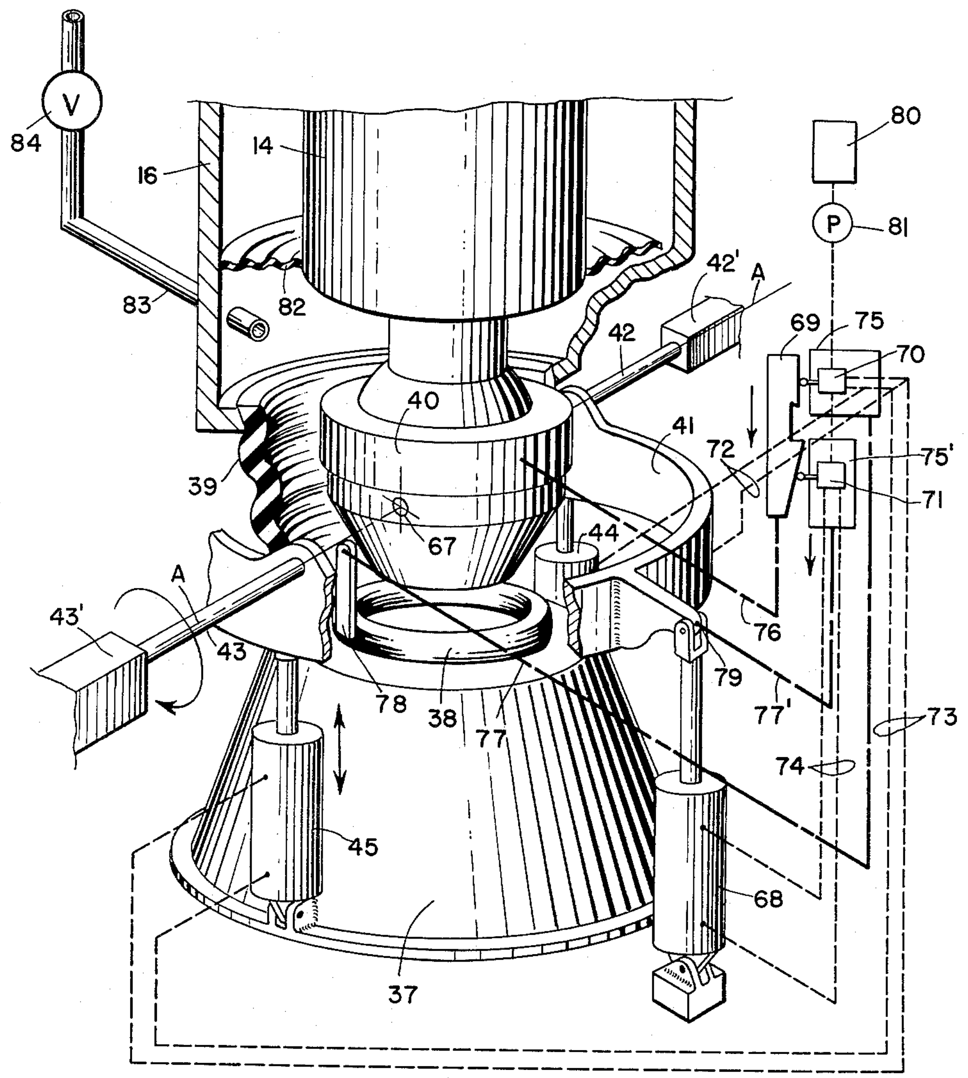


FIG. 5

INVENTOR.
JOSEPH F. GANAHL
BY Elliott & Pastoriza
ATTORNEYS

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3,015,231

# MISSILE FLIGHT SIMULATION SYSTEM

Joseph F. Ganahl, Santa Ana, Calif., assignor to Aeroscience, Inc., a corporation of California

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11 Claims. (Cl. 73—116)

This invention relates generally to testing and measuring systems and more particularly to a novel testing facility for simulating high altitude and other flight conditions to enable substantially complete studies of missiles or other flight vehicle systems to be made while on the ground.

It is common practice to test and measure certain parameters of missile propulsion systems such as thrust, combustion temperatures, general reliability of fuel metering pumps, valving, and the like while the missile is on the ground. Such tests are very valuable not only because the missile propulsion system is captive and thus repeated tests may be run on the same apparatus but also because of the greatly increased data that can be obtained over that normally received by telemetering systems in actual flight testing.

The foregoing advantages could also be realized for an entire missile assembly if flight conditions could be properly simulated on the ground. Thus, if a complete flight simulation system is established for a captive missile, most of the data now presently obtainable only after several test firings could be readily provided with a vast saving in both time and expense. Not only would costly flight testing be avoided but the increased precision of data obtainable as well as the ability to conduct a complete failure analysis on the structure under test would enable design and evolution of improved missile systems to progress far more rapidly than is presently possible.

Bearing the foregoing in mind, it is a primary object of the present invention to provide a complete missile flight simulation system for enabling a missile propulsion system as well as an entire multiple stage missile to be tested under substantially the same environmental conditions to which it would be subject in actual flight.

More particularly, it is an object to provide a test facility enabling study and check-out of the following factors:

First, the overall missile system compatability and reliability. This study includes the provision of data, for example, on the propulsion system performance under high altitude conditions; the starting capabilities of the propulsion system under high altitude conditions; the effectiveness of thrust direction control; the effect of exhaust on other missile components; and, the precision of shutdown of the propulsion system.

Second, the missile flight stability. This study includes the provision of data, for example, on the ability of the structure to withstand environmental conditions such as temperature, radiation, rapid atmospheric pressure changes, and the like; the effectiveness of the missile staging and separation structure and operation thereof; the guidance and control system under shock and impact; and the communication system under flight conditions.

Briefly, these and other objects and advantages of this invention are attained by providing a basic shroud structure arranged to completely envelop a missile propulsion system with the exception of an end opening in axial alignment with the direction of the missile exhaust. The dimensioning of this end opening is designed with respect to the exhaust configuration in such a manner that the jet action of the exhaust will serve to create and maintain a partial vacuum within the shroud. By this arrangement, pressures simulating altitudes up to 100,000 feet can be maintained within the shroud and thus the



behavior of the propulsion system under such environmental conditions can be closely studied without the necessity of actual test flights.

In a preferred embodiment of the invention, the shroud is arranged to enclose a complete missile system which may include multi-stages arranged to be successively fired at pre-assigned time intervals. The integrated system compatibility and reliability can thus be studied and checked out under altitude conditions.

In accordance with a further feature of the invention, an auxiliary vacuum tank may be placed in communication with the interior of the shroud for enabling a partial vacuum to be attained more easily with more rapid attainment of equilibrium conditions of the jet exhaust. The normally open end of the shroud may be closed by a membrane so that the vacuum tank can also be employed to simulate the starting of engines under high altitude conditions.

Other features of the missile flight simulation system include suitable means within the shroud for heating or refrigerating the missile; subjecting the missile to vibrations or impacts while under test; disrupting the flow of gases from the engine nozzle to simulate back flow conditions and enable the effect of exhaust gases on other missile components to be studied; and various other environmental control devices, to the end that the complete missile assembly may be tested without actually leaving the ground.

A better understanding of the preferred embodiments of the invention as well as various additional features and advantages will be had by referring to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cutaway perspective view illustrating one embodiment of a missile flight simulation system in accordance with the present invention;

FIGURE 2 is an enlarged cross sectional view of the interstage coupling portion enclosed within the circular arrow 2 of FIGURE 1;

FIGURE 3 is a view similar to FIGURE 2 illustrating the relative position of the missile stages after firing of the second stage;

FIGURE 4 is a fragmentary cross section taken in the direction of the arrows 4—4 of FIGURE 3; and,

FIGURE 5 is an enlarged cutaway perspective view, partly diagrammatic, of the lower portion of the missile flight simulation system looking from the right hand rear end of the drawing of FIGURE 1.

Referring first to the overall view of FIGURE 1, there is shown a support structure in the form of a concrete emplacement **10** including laterally extending supporting legs **11** and **12**. The emplacement **10** is provided with a bottom opening **13** positioned over a vertically clear area such as adjacent to the edge of a building or mountain. Within the emplacement **10** there is shown a missile system comprising a first stage missile **14** and second stage missile **15**. As shown, these first and second stages are surrounded by primary and secondary shrouds **16** and **17**. The primary shroud **16** is in turn secured rigidly to the inner walls of the emplacement **10** as by lateral members **18**, **19**, and **20** shown between the left hand wall of the emplacement **10** and the left hand portion of the shroud. Similar members may be secured between the other side of the shroud and emplacement wall. The secondary shroud **17** may be secured as by suitable guy wires such as **21** and **22**. The arrangement is such that exhaust gases from the first stage missile **14** will pass out of the lower end of the shroud and through the lower opening **13** of the concrete emplacement **10** to the free atmosphere.

The first stage missile **14** itself is supported within the primary shroud **16** by support means in the form of rods

23, 24, 25, and 26. These rods pass through openings in the shroud to connect directly to the inner wall of the emplacement 10 and include measuring devices, such as strain gauge balances, for example, indicated schematically by the boxes 27, 28, 29, and 30 respectively. To maintain an air tight seal between the interior and exterior portions of the shroud adjacent the openings through which the various rods extend, there may be provided flexible bellows such as indicated at 31 for the rod 26. By this arrangement, movement of the missile body 14 will not be impeded by the presence of the shroud and yet such movement of the missile may be indicated by measuring the strains in the various rods with the measuring devices 27 through 30. Typically, these measuring devices may be used to indicate lateral or sidewise movements of the missile as well as thrust. By providing supporting rods 23 and 24 at the upper portion of the missile body 14 and supporting rods 25 and 26 adjacent the lower portion of the missile, bending moments established in the missile may also be indicated by comparison of the various readings obtained on the measuring devices 27 through 30.

Referring now to the upper nose portion of the first stage missile 14, there is shown an interstage coupling means including exploding bolts 32 extending past a pair of deflection plates 33 and 34 and connecting to the second stage missile 15. When the second stage missile is fired and separated from the first stage missile 14, it is retained within the secondary shroud 17 by resilient springs 35 and 36 as will become clearer when the operation of the complete system is described.

Referring now to the lower portion of the primary shroud 16, there is provided a conically shaped exhaust cowling 37 including at its upper end an erosion ring 38 defining an end opening for the shroud through which exhaust gases pass. The exhaust cowling 37 and erosion ring 38 are coupled to the remaining portion of the primary shroud by means of a flexible annular bellows 39. The spacing and dimensioning of the end opening defined by the erosion ring 38 from the missile engine 40 is such that the momentum of the exhaust gases passing through the erosion ring draws out the air from the shroud thus establishing a partial vacuum within the shroud. By this inducer action, the energy in the exhaust blast itself serves to maintain a considerably reduced pressure within the shroud.

While the erosion ring 38 in the foregoing description and in the drawings has been shown as circular, it is to be understood that it may assume other geometrical shapes in conformance with the general cross sectional configuration of the exhaust blast from the missile propulsion system. Such configuration is important to maintain the desired reduced pressure within the shroud.

In propulsion systems in which the thrust vector can be changed as in a "jetevator" engine or a conventional nozzled engine employing deflector plates for altering the thrust direction, it is important that the erosion ring 38 remain substantially axially aligned with the thrust direction to maintain the desired reduced pressure. To this end, the invention contemplates suitable tilt and extension means for enabling the exhaust cowling 37 and erosion ring 38 to follow changes in the thrust direction. Tilting may be achieved by a tilt yoke 41 mounted for tilting movement about an axis A—A as by pivot pins 42 and 43. These pins in turn may be journaled in suitable bearings 42′ and 43′ secured to opposite sides of the inner walls of the concrete emplacement 10. Extension and retraction of the erosion ring and exhaust cowling in order to vary the distance between the end opening and the engine are effected by a pair of hydraulic cylinders 44 and 45 disposed between the outer peripheral edge of the cowling 37 and the lower ends of the tilt yoke 41 as shown.

When it is desired to simulate a high altitude starting condition for the propulsion system under test, or more quickly attain altitude pressure in the shroud, the partial vacuum within the primary shroud must be initially provided by means other than the exhaust gases from the engine itself. For this purpose, there may be provided an airtight membrane 46 covering the extreme lower peripheral portion of the cowling 37. Suitable exhaust lines such as indicated at 47 and 48 extend from the primary and secondary shrouds respectively to a common conduit 49. The conduit 49 includes a valve 50 connecting to an auxiliary vacuum tank 51. The tank 51 may be exhausted of air as by a pump 52. By proper control of the valve 50, the reduced pressure within the shrouds may be provided prior to any firing of the engine to simulate any particular altitude. When the engine is fired, the initial burst of exhaust gases will simply burn away the membrane 46 and the resulting gaseous discharge past the erosion ring 38 will then maintain the partial vacuum initially provided within the shroud by the auxiliary tank 51. Another means of aiding the establishment of a partial vacuum would be to add an annular ring of individual auxiliary jets about the exhaust nozzle to assist the ejector action of the principal jet blast past the erosion ring.

To simulate other atmospheric conditions in addition to reduced air pressure, both the primary and secondary shrouds 16 and 17 may be provided with heating and refrigeration coils passing annularly about the interior walls of the shrouds respectively as indicated at 53 and 54. By this arrangement, a desired temperature can be maintained within the shrouds or altered as desired to simulate different environmental conditions for instruments within the missile stages and for the propulsion system.

Still further conditions may be simulated such as sudden wind gusts or the like. For example, a physical vibration or shaking may be imparted to the first stage 14 of the missile as by a small force rod 55 shown passing from the left center portion of the missile through the primary shroud 16 to a suitable vibrating or shaking device 56 secured to the inside emplacement wall. A vibration or shaking mechanism of this type may also be employed to simulate a flutter condition and thus the stability of the missile can be studied. While not shown in FIGURE 1, similar devices could be incorporated in the secondary shroud structure 17 for imparting impacts or lateral loads to the second stage missile 15. Tests such as the foregoing are valuable in evaluating the effectiveness of the missile guidance system by observing the ability of the system to return the missile to its desired course after a forced deviation therefrom.

To provide additional data on the propulsion system there may be provided an air or rocket blast tube 57 shown entering the emplacement 10 and shroud 16 adjacent the engine 40 of the first stage of the missile 14. This blast tube terminates in one or more nozzles such as nozzle 58 adjacent the erosion ring 38 and by controlled blasts of air or other gas, the vacuum forming jet action of the exhaust gases from the engine can be modified resulting in a back flow of exhaust gases into the shroud about the engine. Alternatively, the spacing of the erosion ring from the engine exhaust opening may be varied to achieve such back flow. By such testing, some of the possible causes of unexplained missile explosions shortly after take-off may be determined and remedial apparatus tested.

Referring now to FIGURES 2, 3, and 4, the interstage coupling mechanism between the first stage missile 14 and second stage missile 15 and the primary and secondary shrouds is shown in greater detail. Between the upper end of the primary shroud 16 and the lower end of the secondary shroud 17 immediately below the connection of the guy wire 21 there is provided an annular wall 59 having a plurality of lateral openings 60 closed off by a plastic foam or membrane indicated by the dotted lines 61. Thus, the interior of the primary and secondary shrouds are in communication with each other but sealed from the exterior surroundings. When the second stage missile 15 is to be launched, the explosive bolts 32 which may constitute spacer struts disintegrate as shown in FIGURE 3 and the thrust from the second stage engine will cause the missile body 15 to rise to the position shown in FIGURE 3. In this position, the restraining forces of the springs 35 and 36 counterbalance the thrust force. The timing between the separation and firing of the second stage is adjusted to avoid excessive negative *g* loads acting on the second stage. Simultaneously with the destruction of the explosive bolts and the movement of the missile body 15 the deflection plates 33 and 34 will fall by gravity to a closed position as illustrated in FIGURE 3. The exhaust blast from the second stage missile 15 will then be deflected through the openings 60, the hot gases themselves burning away the plastic foam 61 thus providing egress for the exhaust through the openings. The partial vacuum within the secondary shroud 17 is maintained by the provision of apertured floor 62 supporting an erosion ring 63 at the inside lower portion of the secondary shroud adjacent the exhaust nozzle of the missile.

In the plan view of FIGURE 4, it will be noted that the deflection plates 33 and 34 are arranged to close a rectangular opening formed in a floor plate 64 adjacent the nose of the first stage missile 14. By this arrangement, the first stage missile is protected from the exhaust blast of the second stage. Further protection from heat is afforded by an insulating cover H for the nose of the first stage.

Referring now to FIGURE 5, the tilt and extension mechanism for the exhaust cowling 37 on the lower portion of the primary shroud 16 of FIGURE 1 will be described in detail. As shown in FIGURE 5, the motor tilt axis passes through the point 67. Tilting of the motor about this axis will change the thrust direction. In order to follow this direction change to maintain the end opening as defined by the erosion ring 38 in substantial axial alignment with the direction of thrust, it is preferable although not necessary to mount the tilt yoke 41 so that its axis A—A coincides with the tile axis of the motor.

The actual tilting of the yoke to tilt the exhaust cowling 37 is effected by a hydraulic tilt cylinder and piston indicated at 68 secured between the tilt yoke and a stationary point on the emplacement wall. This tilt cylinder in co-operation with the extension and retraction cylinders 44 and 45 is arranged to move the exhaust cowling 37 to track movements of the engine 40. One arrangement for effecting this tracking is indicated schematically in FIGURE 5 as comprising a cam plate 69 and pilot control valves 70 and 71. As shown by the dashed lines 72 and 73, the pilot control valve 70 is in communication with the extension hydraulic cylinders 44 and 45 so that the linear distance between the erosion ring 38 and the engine 40 is under control of this valve. The pilot valve 71 in turn is connected as indicated by the dashed lines 74 to the tilt cylinder 68. The valves 70 and 71 are mounted for movement upon sliding carriages 75 and 75′ respectively.

A mechanical linkage indicated by the dashed-dot lines 76 extends between the motor 40 and the cam plate 69 so that the cam plate 69 will move in response to tilting movement of the motor. The carriages 75 and 75′, on the other hand, are mechanically connected as indicated by the dashed-dot lines 77 and 77′ respectively to an extension 78 on the erosion ring 38 lying on the axis A—A, and to the tilt yoke 41 as at 79 so that the carriage 75 will follow extension and retraction movements of the erosion ring and cowling, and carriage 75′ will follow tilting movements of the tilt yoke. A reservoir 80 together with a pressure pump 81 is arranged to supply hydraulic fluid under pressure through the pilot control valves 70 and 71 to the various cylinders.

The cam surface of the cam plate 69 in the particular system chosen for illustrative purposes has a straight portion resting against the stem for valve 70 and an inclined portion resting against the stem for the valve 71 such that movement of the plate up or down as viewed in FIGURE 5 will vary the fluid pressure in each of the pairs of lines passing to the cylinder for controlling the direction and degree of movement of the corresponding pistons of these cylinders.

In the operation of the tilt and extension mechanism, assume that the jetevator motor 40 tilts in a clockwise direction as viewed from the left hand journal bearing 43′ in FIGURE 5. This tilting motion of the motor will be communicated through the mechanical linkage 76 to the cam plate 69 causing the same to be moved downward. Downward movement of the cam plate 69 will not move the stem for the valve 70 since the camming surface in the example chosen is flat and, therefore, the extension and retraction cylinders 44 and 45 will remain stationary and the linear distance between the erosion ring 38 and the engine nozzle will remain constant. Since the tilt yoke axis A—A corresponds with the axis about which the motor 40 tilts, there is no necessity of varying the linear distance with tilting movement of the motor. On the other hand, if the tilt axis for the motor 40 were different from the tilt yoke axis A—A, then a suitably programmed cam surface on the upper portion of the cam plate 69 would be provided to cause the extension and retraction cylinders 44 and 45 to adjust the distance between the erosion ring 38 and the nozzle of the engine in a manner to maintain optimum conditions for maintaining the partial vacuum within the shroud 16 upon tilting movement of the motor.

The downward movement of the cam plate 69 will result in an inward movement of the stem for the valve 71 as a consequence of the inclined portion of the camming surface. Inward movement of the valve stem will result in greater fluid pressure in the upper one of the hydraulic lines 74 connected to the tilt cylinder 68 than in the lower line whereby the piston in the cylinder 68 will move downwardly to tilt the yoke in a manner to follow the tilting of the motor 40. As the yoke itself is tilted, this movement will be communicated through the mechanical linkage 77′ to the carriage 75′ to move the same downwardly and thus the valve 71 will track the cam plate 69 until the valve stem is in a position corresponding to its initial position. At this time no further operation of the cylinder 68 will take place.

If the initial tilting of the motor 40 is in the opposite or counter clockwise direction as viewed from the journal bearing 43′, the cam plate 69 will be moved upwardly resulting in an outward movement of the stem for the valve 71. This movement of the valve stem in the opposite direction will then result in a greater fluid pressure in the lower of the pair of hydraulic lines 74 resulting in an upward movement of the piston for the cylinder 68 to tilt the yoke 41 in the corresponding direction. This latter movement is then, as before, communicated to the carriage 75′ for the pilot valve 71 through the mechanical linkage line 77′ and this carriage is moved upward until the valve stem assumes its initial position at which time the pressure above and below the piston in the cylinder 68 is again equalized.

Preferably, a mechanical override for actuating the extension and retraction cylinders 44 and 45 is provided so that the linear distance between the erosion ring 38 and the nozzle of the engine 40 can be varied while observing the exhaust blast until an optimum or "tuned" condition is realized wherein maximum jet action in maintaining the partial vacuum within the shroud 16 is achieved. In some instances, variations in the jet blast itself can be predetermined and the flat portion on the cam plate 69 upon which the stem for the pilot valve 70 rests can be modified or suitably programmed to actuate the pilot valve 70 in a manner to maintain optimum spacing between the erosion ring and the nozzle whereby a completely automatic system is provided. While not shown in the drawing, the actual extension and retraction of the cowling is effected through a gear system coupled between the cylinder pistons and the cowling to insure uniform action by the pistons and avoid binding.

In addition to the above described tilt and extension system there is also shown in FIGURE 5 an isolating diaphragm 82 disposed between the lower end portion of the primary shroud 16 and the first stage missile 14. This diaphragm is preferably removable but is inserted to enable the pressure in the environment of the engine to be different from that in the environment of the remaining portion of the missile. To vary the pressure surrounding the engine portion beneath the diaphragm 82, there may be provided an additional exhaust conduit 83 extending through a control valve 84 and connecting into the common exhaust line 49 to the tank 51 as shown in FIGURE 1.

With the foregoing description in mind, the operation of the entire system will now be described.

Referring once again to the overall view of FIGURE 1, the two stage missile system may be placed within the shrouds by removing the lower exhaust cowling 37, for example, and simply raising the structure into position. The lower cowling 37 may then be repositioned and the various supporting rods 23, 24, 25, and 26 secured to the sides of the missile as shown. The springs 35 and 36 in the upper secondary shroud 17 may similarly be connected to the second stage of the missile. The initial placement of the two stage missile system within the shrouds may be effected through the top of the shrouds if the desired or the shrouds themselves may be longitudinally split and arranged to be opened for receiving the missile. The particular manner in which the missiles are initially positioned and connected within the shrouds forms no part of the present invention and is, therefore, not shown in detail.

If one of the factors to be measured and tested is high altitude starting of the missile propulsion system, the covering diaphragm 46 is next positioned about the lower end of the exhaust cowling 37 and the shroud structures evacuated by means of the vacuum tank 51 and pump 52. The pressure is reduced to a value corresponding to the particular altitude at which it is desired to test engine starting. The first stage propulsion system is then fired and the initial blast as described heretofore will simply blow out the temporary membrane 46, the subsequent momentum of the high velocity exhaust gases from the engine 40 serving to maintain the partial vacuum created within the shroud as a consequence of the jetting action past the erosion ring 38. Various parameters indicative of the performance of the propulsion system can then be measured under the high altitude conditions simulated within the shroud.

In the event that the propulsion system under test includes means for varying the thrust vector such as is the case with the engine 40 described in FIGURES 1 and 5, the hydraulic servo system enabling the exhaust cowling 37 and erosion ring 38 to maintain a proper spacing from the exhaust and follow the thrust direction is actuated as described heretofore.

From the foregoing it will be evident that the propulsion system efficiency at any desired simulated altitude can be readily observed. Moreover, the engine thrust as well as side and bending forces on the missile body can be indicated by the various strain gauge balance systems incorporated in the blocks 27 through 30.

To observe the effects of back flow of gases about the engine portion of the missile, air or rocket jet blasts from the nozzle 58 at the end of the controlled line 57 can be directed adjacent the erosion ring 38 to destroy the partial vacuum within the shroud. Other propulsion system conditions can also be studied independently of the main portion of the missile body as a consequence of the provision of the isolating diaphragm 82 and separate



evacuating exhaust line 83. In addition, the shutdown precision and burnout of the propulsion system in the first stage prior to launching of the second stage can all be observed and recorded under altitude conditions.

One of the major problems in actual test flights of multiple stage missiles is the obtaining of accurate data relating to the launching and separation of the second stage from the first stage. With the apparatus of the present invention, such launching and separation can be very carefully observed as a consequence of the captive arrangement for the second stage within the secondary shroud 17. Moreover, much of the data obtained with respect to the first stage can also be obtained with respect to the propulsion system of the second stage. Any defect or weak points in the interstage coupling system can also be analyzed.

Finally, the desired study and measurements of the overall missile system can be made under various temperature conditions as a consequence of the provision of the refrigeration and heating coils 53 and 54 in the respective shrouds. Also the effects of shocks and impacts imparted by the impact rod 55 to simulate wind gusts and the like can be studied as described heretofore. As also mentioned heretofore, this arrangement provides a check on the guidance system of the missile.

It will be evident that repeated tests can be run on the same missile structures and thus the precision of the obtained data is greatly increased.

Many other features and advantages as well as additions to the simulating system of the present invention will occur to those skilled in the art. For example, further shrouds could be added to enable three or more stage missile assemblies to be studied. Moreover, additional air blast manifolds may be provided adjacent the missile body to simulate secondary flow along the skin of the missile to enable boundary layer conditions to be studied. This same arrangement will enable studies to be made of flow into the engine compartment, base pressure, and jet interaction in the jet blast wake. The overall missile flight simulation system is, therefore, not to be thought of as limited to the particular embodiment set forth merely for illustrative purposes.

What is claimed is:

1. A flight simulation system for testing a missile engine, comprising, in combination: a fixed support connected to said engine; a shroud dimensioned to surround said engine, said shroud including flexible wall means terminating in an exhaust cowling, said exhaust cowling having an exhaust exit opening; extension and tilt means connected to said cowling for varying the distance and angular alignment of said opening with respect to the exhaust of said engine; and control means responsive to changes in the thrust of said engine connected to said extension and tilt means for maintaining said opening at a desired spacing from and in axial alignment wth the exhaust gases from said engine whereby exhaust gases passing through said opening and out said cowling maintain a partial vacuum in said shroud to simulate a given altitude.

2. The subject matter of claim 1, including gas pressure supply means passing within said shroud and positioned upon actuation to disrupt the flow of said exhaust gases through said opening to destroy said partial vacuum and simulate back flow of gases.

3. A flight simulation system for testing a complete missile comprising, in combination: a fixed support structure; a shroud rigidly secured to said fixed support structure; mounting means extending from said fixed support structure to pass within said shroud for supporting said missile within said shroud; flexible air tight means connected between said mounting means and the point where it passes into said shroud to maintain said shroud air tight at said point while permitting relative movement between said mounting means and said shroud; and strain measuring means secured to said mounting means for in-

dicating reactions of said missile when mounted within said shroud, said shroud having an end opening in axial alignment with the direction of thrust of said missile when mounted within said shroud and positioned such that exhaust gases from said missile will pass through said opening to maintain a partial vacuum in said shroud whereby a high altitude environment is provided for said missile.

4. The subject matter of claim 3, including an auxiliary vacuum tank; a control valve connected between said tank and said shroud; and a pump for maintaining a desired reduced pressure in said tank whereby the partial vacuum within said shroud may be controlled by said control valve.

5. The subject matter of claim 4, including refrigeration and heating means within said shroud for subjecting said missile to environmental temperatures simulating actual temperatures to which the missile would be subject when in flight.

6. The subject matter of claim 5, including means for subjecting said missile to vibration when mounted within said shroud to simulate aerodynamic pressures.

7. The subject matter of claim 6, including air tight isolating means adapted to be secured between said missile and the inner walls of said shroud in a position to isolate the atmospheric environment of the engine of said missile from the atmospheric environment of the remaining portion of said missile; and gas pressure supply means passing within said shroud to the atmospheric environment of said engine and positioned to disrupt the flow of exhaust gases through said opening to destroy said partial vacuum and simulate back flow of gases.

8. A flight simulation system for testing at least a two-stage missile assembly, comprising, in combination: a fixed supporting structure; a primary shroud secured to said fixed supporting structure; a secondary shroud forming an extension of said primary shroud; means for mounting the first stage of said two-stage missile within said primary shroud, said second stage extending within said secondary shroud; and means resiliently connecting said second stage to said secondary shroud, whereby movement of said second stage within said secondary shroud upon firing of said second stage is resiliently restrained by said resilient means.



9. The subject matter of claim 8, in which said primary shroud includes an end opening in substantially axial alignment with the direction of exhaust gases from said first stage when mounted in said primary shroud, said opening being so dimensioned and positioned with respect to said exhaust gases that a partial vacuum is established and maintained within said primary and secondary shrouds as a consequence of said exhaust gases passing through said end opening.

10. The subject matter of claim 9, including an annular wall having a plurality of openings positioned between said primary and secondary shrouds; means temporarily sealing said openings closed; and normally open deflection plates mounted within said annular wall and adapted to close upon firing and separation of said second stage from said first stage to shield said first stage from exhaust gases from said second stage, and deflect said gases through said openings, said secondary shroud including an end opening through which said exhaust gases pass to maintain a partial vacuum in said secondary shroud.

11. A flight simulation system for testing a missile engine, comprising, in combination: a fixed support for connection to said engine; a shroud dimensioned to surround said engine, said shroud including flexible wall means terminating in an exhaust cowling having an exhaust exit opening; extension and tilt means connected to said exhaust cowling for positioning said exhaust exit opening at a desired spacing from and in a desired alignment with exhaust gases from said engine when mounted within said shroud, the dimensioning of said cowling and exhaust opening and its spacing from said engine being such that exhaust gases will pass through said exit opening in a manner to maintain a partial vacuum within said shroud.

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