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REVERSE FLOW AFT INLET RAMJET SYSTEM

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NOTICE

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REVERSE FLOW AFT INLET RAMJET SYSTEM

ABSTRACT OF THE DISCLOSURE

A combined rocket/ramjet for propelling a missile including a missile payload module and an integral rocket/ramjet engine system strapped on the missile payload module, and incorporating a liquid or solid fuel rocket engine and a ramjet engine having a combustion chamber common with the rocket engine, an exhaust nozzle, and multiple aft-mounted air inlets movable between a retracted position during rocket boost flight and an extended, pop-out position to receive and direct ram air in a reverse flow direction into the combustion chamber during ramjet flight.

REFERENCE TO RELATED APPLICATIONS

This is a division of application Serial No. 431,180, filed January 7, 1974.

BACKGROUND OF THE DISCLOSURE

This invention relates generally to integral rocket/ramjets and, in particular, to ramjets having multiple, aft-mounted air inlets and used to propel missiles.

One problem involved with the aforementioned ramjets is that the aft-mounted air inlets thereof permanently protrude outside the missile body envelope and thus make internal bomb bay stowage very difficult. On the other hand, the new and improved ramjet system of the present invention eliminates the foregoing problem principally by making the aft-mounted air inlets thereof retractable into a completely recessed position when not in use by novel and yet simplified means to be hereinafter further disclosed in the following summary and detailed description thereof.

SUMMARY OF THE INVENTION

The present invention consists principally in a novel air-launched ramjet-powered missile, or a combined rocket and ramjet propulsion unit that may be uniquely strapped on, or to a missile payload module and which may include a liquid or solid fuel component or rocket engine and a ramjet engine integrated therewith and incorporating a combustion chamber immediately downstream of, and receiving the discharge from the liquid or solid fuel component or rocket engine. In unique combination with and forming an integral part of the ramjet engine are a plurality of aft-mounted, air inlets housed within the exhaust nozzle structure of the combined unit and adjustable between a first, retracted and recessed position completely out of the air stream and disposed within the engine casing during the boost/launch operation to be effected either by means of the air launch thereof, or by operation of the rocket engine, and a second, extended or pop-out position to receive ram air thereinto during the cruising operation of the ramjet engine.

A common air injector tube, in communication with each of the aforementioned air inlets, uniquely and yet in a relatively simplified manner directs the incoming ram air in a reverse flow direction to thereby promote the more efficient mixing, reaction and combustion of fuel therewith in the said common combustion chamber.

Other objects and inherent advantages of the invention will readily appear hereinafter in connection with the following disclosure, taken with the accompanying drawings; in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a longitudinal or axial view, partly schematic, sectioned and broken-away, illustrating the unique reverse-flow aft mounted, multiple inlets of the invention as applied to a convergent-divergent nozzle and with the use of an end burning grain;

Figure 1a is a detailed fragmentary, and partly schematic and sectional view more clearly depicting the aft mounted, multiple inlets of Figure 1;

Figure 2 is a second longitudinal or axial view, partly broken-away, schematic and sectioned, showing the new and improved multiple air inlets of the invention as applied to a plug nozzle;

Figure 3 is another longitudinal or axial view, partly schematic, broken-away and sectioned, showing a modified, single flap inlet-form of the invention, again, as applied to a convergent-divergent nozzle;

Figure 4 is still another longitudinal or axial view, partly schematic, sectioned and broken-away, of a further modified, submerged inlet form of the invention, as may be applied to either a convergent-divergent, or plug nozzle; and

Figure 5 is another longitudinal or axial view, partly broken-away, schematic and sectioned, representing a still further modified form of the present invention, as applied to, or used particularly with a liquid fuel.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring generally to the drawings and, in particular, to Figures 1 and 1a thereof, the new and improved ramjet missile propulsion system of the present invention is indicated generally at 10 as being strapped on, or, in other words, releasably attached to a missile payload module at 11, as by means of the bolts at 13, and includes a main engine casing 12, and an end-burning, solid fuel grain 14 disposed in the forward end of the casing 12 and having implanted at the aft end thereof an igniter 15. A combustion chamber 16 receives the discharge from the end burning grain 14, and the unique aft-mounted, multiple air inlet means of the present invention is indicated generally at 18. A convergent-divergent nozzle 17 completes the principal components of the overall system. It is noted that, in the simplest and most basic form of the invention, the aforementioned end-burning grain 14 is, as noted hereinbefore, a "fuel" grain which may be composed of a single composition to be used only during ramjet flight, after the combined missile and ramjet-propulsion system of the invention has been air launched from a supersonic aircraft. However, the said grain 14 could, as an alternative, be comprised of a solid "propellant" grain having a first, relatively fast-burning composition portion at the area, indicated generally at 14a and a second, relatively slow-burning composition portion, indicated generally at 14b. In this manner, the inventive ramjet propulsion system 10 could be combined and made integral with a rocket engine portion that would provide the necessary boost/launching phase of operation, in place of the air launch thereof from a supersonic aircraft.

The inventive multiple air inlet means 18, which may be mounted in the throat area 17a of the nozzle 17, consists of a plurality of retractable air inlet elements, as indicated at 19, 20, 21 and 22 in Figure 1a, which are mounted in suitable supporting passages formed at 90° angles to each other and extending through the said nozzle-throat area 17a. In accordance with the novel teachings of the present invention, said inlet elements 18 are uniquely slidably mounted in the aforementioned supporting passages for the novel adjustment thereof, as taught by the present invention, between extended, pop-out and recessed positions to be further described. Each of the said inlet elements 19 to 22 comprise a first, relatively enlarged, inlet head-portion on the outer end thereof, as is indicated respectively at 19a, 20a, 21a and 22a in Figure 1a, and a second, relatively elongated, inlet head-supporting portion respectively indicated at 19b, 20b, 21b and 22b, which slidably and adjustably engage in the previously mentioned passages specifically provided therefor in and through the said nozzle throat area 17a. These passages may, it is noted, be offset somewhat relative to their opposite number in order to provide sufficient space for allowing said air inlet elements 19 to 22 to be moved to their completely retracted position.

The aforementioned air inlet elements 19 to 22, the retractable and extendable nature of which constitute the principal feature of the present invention, may be normally stowed in an inner recessed and compact position within the nozzle throat area 17a by providing suitably configured recesses in the outer wall structure of the nozzle 17, as is indicated respectively at 19c, 20c, 21c and 22c (Figure 1a), within which recesses may be adjustably positioned in a relatively snug-fit and recessed relation the relatively enlarged, inlet head-portions 19a, 20a, 21a and 22a corresponding thereto. In this connection, when the present system is either air-launched, or, alternatively, the combined rocket/ramjet arrangement thereof is being used, in which event the rocket engine comprising the propellant portion 14a would be operated to boost and launch the missile payload module 11 and connecting propulsion unit 12 to the required or desired ramjet-cruising speed, the above-described multiple air inlet elements 19-22, inclusive, are in their inner, retracted, closed, recessed and compact position, as is shown in the dotted line configuration thereof in both Figures 1 and 1a.

Thus, if the grain 14 represents a solid propellant grain, as stated before, composition, as when the combined rocket-ramjet form is being operated, ignition of the first, relatively fast-burning composition portion 14a by the igniter 15 would produce hot gases discharged into the combustion chamber 16 for the exhaustion thereof out of the exhaust nozzle 17, as indicated by the arrow "A", and, in this manner, the rocket boost/launching phase of operation would result. Of course, during this time, the aft inlet elements 19-22 would be in their retracted position, as noted before. Thereafter, the air inlet elements 19 to 22 would be moved, as by any well-known remotely-controlled means such as explosive squibs (not shown), to their extended, pop-out position to receive and direct ram air into the combustion chamber 16 and thus provide the ramjet operation. Similarily, where the air-launched form of the invention is being contemplated, then, the end burning grain 14 would be comprised of a suitable solid "fuel", rather than a propellant, and would be mixed with the incoming ram air in the same combustion chamber 16 to thereby provide the propulsion needed for ramjet-cruising operation.

The above-described extension of the air inlet elements 19-22, inclusive, to their pop-out position, illustrated in the solid line depiction thereof in Figure 1, for example, of course, disposes their inlet head-portions at the aforementioned 90° angle and therefore in equal spaced apart relation to each other, and naturally facing forward or upwind, as is seen for the air inlet element 19 in Figure 1. In this manner, incoming ram air, as seen at the arrow "B", would enter the air inlet entrance openings, as at 19d (Figure 1), from whence it would be directed initially for a short distance to the rear in a substantially horizontal direction and immediately thereafter turned and forced inwardly towards the missile longitudinal axis, as is denoted for example by the arrow "C". Finally and again in accordance with the novel teachings of the present invention, the incoming ram air from each of the air inlet elements 19 to 22 would be further turned and specifically and positively forced in a reverse flow direction (arrow "D") into the combustion chamber 16 by way of another important teaching of the present invention; namely, the single, uniquely-oriented and simplified air injector tube at 23, which is common to, and communicates with the inner, air passage-opening of each of the inventive, retractable air inlet elements 19-22. It is noted that the tube 23 is open only at its forward end, its aft end being completely closed by a back plate at 24. Because of its reverse flow, the incoming ram air better mixes and reacts with the burning end surface of the grain 14 to thereby create a much more efficient combustion therewith. The hot gas products being thus formed in the combustion chamber 16 are exhausted around the air injector tube 23 and out through the exhaust nozzle 17 to thereby produce the necessary propulsion for ramjet flight.

To properly support the above-noted air injector tube 23, the latter may be mounted to the exhaust nozzle 17, by means of a plurality of four supporting struts, one of which being indicated at 24a in Figure 1. These struts, as at 24a, are made hollow in form and, in this simplified manner, not only provide the mounting means for the tube 23 but, in addition, actually, in the present instance, provide the previously-mentioned passages within which the inventive air inlets, as at 19, are slidably positioned and guided in their inward and outward movements.

With specific reference to Figure 2, the inventive ramjet-missile propulsion system is indicated generally at 25 as comprising a missile payload 26 and a combined end burning, solid grain 27 and ramjet engine 28 respectfully positioned in the forward and aft-end portions of a casing 29. Again, if desired, the end burning grain 27 could be composed of both relatively fast and relatively slow-burning "propellant" grain portions to thereby form a rocket engine integral with the ramjet engine 28. Alternatively, the end burning grain 27 could be a solid "fuel" grain, as when the propulsion system 25 would be air launched. The Figure 2 arrangement is somewhat modified over that of Figure 1 by incorporating a plug-type of exhaust nozzle at 30, as distinguished from the convergent-divergent nozzle 17 of Figure 1, which plug nozzle 30 incorporates preferably a plurality of four supporting struts, as at 31, that both mount the nozzle 30 to the engine casing 29 and which are made hollow in configuration to thereby form open, guide passages within which the inventive multiple aft-mounted, ram air-inlets, as at 32, may be slidably engaged for their unique adjustment between retracted, recessed and extended, pop-out positions, the latter position being depicted in solid in the aforementioned Figure 2.

Integrally formed to a forward end portion of the plug nozzle 17 and having a passage 33 (Figure 2) disposed in open communication between the ramjet-combustion chamber 35 and the interiorily-disposed air passage, as at 34 for the inlet element 32, of each of the said air inlet elements, is the air injector tube 36. The said air inlet elements, as at 32, each incorporate an outer ram air-receiving, entrance opening-containing and inlet head portion, as at 32a, that faces in an upstream direction to receive ram air thereinto from the direction indicated by the arrow "E", and an inner, inlet head-supporting portion, as at 32b, that is slidably mounted and guided in the guide passages disposed in, and formed by the hollow supporting struts, as at 31.

When in their extended or pop-out position, as noted hereinbefore, each of the said air inlets, as at 32, would receive ram air, from the direction of the arrow "E", into their inlet head-portions, as at 32a, from whence the incoming ram air would thereafter be directed inwardly, downwardly and initially to the rear by built-in air passageways in each of the said aft inlets, in the direction indicated generally by the arrow "F", and, subsequently, be turned by the arcuate and inwardly-curved configuration-portion 30a of the inner hollow wall surface of the plug nozzle 30 into the forward or reverse flow direction indicated by the arrow "G". To specifically provide for the said reverse flow, in addition to the rearwardly curved configuration-portion 30a of the plug nozzle 30, the previously-described, air injector tube 36 is utilized to thereby receive the collective, reverse flow of the incoming ram air, as indicated at the arrow "G", for each of the multiple aft inlets. Finally, the ram air so collected is specifically and positively introduced through the upstream opening of the said injector tube 36 in the said reverse flow direction of the arrow "G" into the combustion chamber 35, as is indicated at the arrows "I".

Upon the introduction of the above-noted ram air into the combustion chamber 35, the end burning grain 27 would be ignited by well-known igniter means (not shown) and the hot gases being produced by the thorough mixture therewith of the incoming and reverse flowing-ram air would thereafter by exhausted around the injector tube 36 and plug nozzle 30 for the discharge thereof out of the rear exhaust nozzle opening of the combined propulsion unit 26. This, of course, provides the propulsion needed for ramjet-cruising flight.

Referring particularly to Figure 3, it is clearly seen that the basic concept of the present invention of an aft-mounted air inlet means for providing the ram air required for ramjet-cruise operation has been embodied in an overall engine unit casing that, once again may be comprised of a missile payload preferably incorporated in a separatable module 38 and, in this instance, combined with an integral rocket/ramjet-propulsion unit indicated generally at 39 as comprising a rocket engine 40 and a ramjet engine 41. In this further modified arrangement, the rocket engine 40 incorporates both a first, relatively slow-burning, propellant-sustainer grain 43 located in the main engine casing immediately downstream or aft of the missile payload module 38 and a second, relatively fast-burning, solid propellant-boost grain 44 disposed further aft and in axial or longitudinal alignment with the first-named grain 43. Both sustainer and booster grains 44, 45 are of the radial-burning configuration and also may be composed of different compositions to achieve the different burning rates specified above.

Continuous or substantially continuous combustion chambers 45 and 46, separated by a partition 39a, are respectively provided for the boost, and sustainer grains 43 and 44. A straight end portion of an air injector tube 47 projects into the combustion chamber 45, which tube 47 also incorporates an opposite tube-end portion 47a that is curved outwardly towards and is appropriately integrated with, or otherwise mounted to one side 42a of a convergent-divergent nozzle 42. The nozzle-side 42a, which contains an opening, located generally at the area indicated at 47b, and which is suitably aligned with the outer end opening of the tube 47, is made of a uniquely hollow configuration and is accordingly comprised of a relatively thin-walled surface of an arcuate-shape and which has been appropriately inwardly curved, as is indicated generally at 48, for thereby specifically and precisely interfitting and exactly matching a complementarily-curved, inner side 49a of a single, two-position flap inlet member 49 that may be pivoted about a pivot at 49b between a first, extended and ram air-receiving position, as depicted in the aforementioned Figure 3, and a second, retracted, recessed and compact position completely out of the airstream and in snug-fit and meshing relation with and against the previously-described arcuate-shaped, outer wall surface 42a of the nozzle 42. Naturally, in the latter position, the outer opening, also indicated generally at 47b, of the air passage extending through the air injector tube 47 is closed to the atmosphere and thus no ram air would be admitted into the ramjet engine 41. Of course, this is the position of the said flap member 49 when the rocket engine 40 is being operated for the rocket boost/launching phase of overall engine operation.

The above-mentioned rocket boost/launch operation would naturally be initiated by the use of an igniter (not shown since this is a well-known device and the details thereof are not important to the present invention) to ignite and thereby burn the radial burning-boost, propellant grain 44. The hot gas products thereof are naturally discharged into the first combustion chamber 45 and thereafter exhausted around the injector tube 47 and out through the nozzle 42 to produce the rocket boost/launching phase of operation. A temporary partition could be used at 39a to block flow between the combustion chambers 45 and 46 until the boost grain 44 is completely or practically completely consumed, at which time, the temperature in the chamber 45 would be high enough to vaporize the preselected material out of which the partition 39a would have been constructed.

After the boost grain 44 has completely burned off and thus rocket engine operation is finished, with the partition 39a now being destroyed, the flap member 49 would be opened, again by any well-known and already-available remotely controlled means (not shown) and, simultaneously therewith, burning of the sustainer grain 43 would commence to thereby begin ramjet flight. To this end, the opening of the flap member 49, which would then act as an air scoop, would cause ram air to enter the air injector tube 47 and because of the specific configuration and orientation thereof, to flow in a reverse flow direction through the said tube 47 into the combustion chamber 46 (by way of the combustion chamber 45 now opened therewith by the destruction of the partition 39a), where the mixture thereof and the production of additional hot gas products with the now-burning sustainer grain 43 occurs for the exhaustion of the latter around the tube 47 and out of the nozzle 42. In this manner, the continual production of the thrust necessary for the aforementioned ramjet flight is effected.

In Figure 4, a still further modified form of the invention is indicated generally at 50 as comprising a combined rocket/ramjet-propulsion unit, to the forward end of which may be mounted a missile payload 51, and which includes an exhaust nozzle section 53, a rocket engine, indicated generally at 52 as again having boost, and sustainer grains 55 and 56 mounted in axial alignment with each other, and a ramjet engine 54 incorporating a novel and alternate type of ram air inlet means comprising at least one pair of ram air inlet passages, 58 and 59, that are uniquely submerged or, in other words, entirely built into the casing of the combined unit to thereby form and provide the basic recessed and thus compact configuration concept taught by the present invention for the new and improved aft mounted-ram air inlet means thereof.

The aforementioned ram air inlet passages 58 and 59 each contain a first, straight, inwardly-inclined and rearwardly-directed air entrance-opening-passage portion, respectively delineated by the arrows at "M" and "Q", and a second arcuate passage portion at the arrows "N" and "R" that are inwardly and forwardly curved to specifically direct any incoming ram air passing therethrough in the inventive upstream or reverse flow direction. A forwardly-directed protuberance, intermediately-disposed, as seen at 60, in the path of the incoming ram air from both of the inlets 58 and 59 acts to positively turn and force the air in the said reverse flow direction.

To ensure that the incoming ram air being turned in the second arcuate-passage portions, indicated at the arrows "N" and "R", is led into the second, ramjet-combustion chamber at 57, once more, an air injector tube at 61 is utilized, which air injector tube 61 is made integral with the same interiorily-disposed casing wall surfaces, as at 62 and 63, within which is formed the passages of the air inlets 58 and 59. Naturally, the air passage incorporated in the injector tube 61 is arranged in a continuous and open communication with the innermost openings of the passages of the air inlets 58, 59. The further path of the previously-turned incoming ram air is indicated by the arrows "O" and "P".

In a manner quite similar to that of the inventive form of Figure 3, for example, when it is desired to begin operation of the combined unit of Figure 4, the boost grain 55 may be ignited by known igniter means (not shown) to initiate combustion and thus the burning thereof to produce hot gases therefrom in a first combustion chamber at 64. As before, an expendable partition may be employed at 65 to divide and separate the two combustion chambers 57 and 64 and, of course, the boost and sustainer grains 55, 57 until the total or almost total consumption of the boost grain 55 has caused an increase in the temperature of the hot gas products in the chamber 64 sufficient to destroy the selected material of the said partition 65. As previously explained, the hot gas products in the combustion 64 are exhausted to the rear around the injector tube 61 for expulsion from the nozzle section 53 to thereby produce the initial, rocket boost/launch thrust required.

After exhausting and producing the necessary thrust required for rocket boost operations from the consumption of the boost grain 55, which may be selected from a relatively fast burning composition, as desired, a speed suitable for ramjet operation having thereby been obtained, the operation of the ram jet engine 54 then commences for the cruising phase of engine operation. This occurs from the opening of a flap or vane element, indicated respectively and schematically at 66 and 67 for each of the inlets 58 and 59, which flap elements 66 and 67 may be suitably hingedly mounted for pivoting between open and closed positions. To open them, any appropriate and well-known remotely-controlled means (not shown) may be used, or, alternatively, they may be designed to automatically open under the action of the dynamic pressure of the surrounding air which would become automatically operative to open the said flap elements 66, 67 when the pressure in the combustion chamber 64 has decreased a sufficient amount, as a result of the complete burning off of the boost grain 55. Upon opening of the flap elements 66 and 67, ram air admitted thereinto is directed in a reverse flow direction, as noted hereinbefore, by the inwardly and forwardly-oriented, curvature of the air inlet passages 58, 59 and, in particular, by the specific disposition of the air injector tube 61 where it is introduced into and thoroughly mixed in the combustion chamber 57 with the hot gas products being simultaneously produced from the burning of the sustainer grain 56. Of course, as noted hereinbefore, the partition 65 would, at this time, have been destroyed. This mixture of ram air and sustainer grain-hot gases naturally produces the thrust required for ramjet-cruising operation by the exhaustion thereof to the rear around the injector tube 61 and out through the exhaust nozzle section 53.

The unique retractable aft mounted, ram air inlet means of the present invention has equal application to a combined rocket/ramjet-propulsion unit in which a liquid fueled rocket engine is utilized in place of the previously-described solid fuel arrangement. In this connection, such a liquid fuel system is indicated generally at the reference numeral 68 in Figure 5 as including a missile payload module 69 that may be releasably attached on the forward end of a combined rocket/ramjet-propulsion unit indicated generally at 70. The latter may comprise a rocket engine-portion-liquid fuel containing-tank 71, a ramjet engine-portion 72, and a single combustion chamber 73 that is common to both the rocket engine-portion 71 and ramjet engine-portion 72. The exhaust nozzle section is denoted generally at 74 and the exhaust flow therefrom at the arrows "S". Contained within the ramjet engine-portion 72 is a unique and somewhat modified form of a combined aft mounted-retractable air inlet and injector tube-incorporating means comprising and incorporating the basic concept of the present invention and which is indicated generally at 75.

The above-mentioned combined retractable air inlet and injector tube-incorporating means 75 may preferably comprise an integral housing member or structure, indicated generally at 76 and which may incorporate a first, ram air-inlet-supporting housing portion at 77 and a second, air injector tube-containing-housing portion 78 that is integrally formed to and with the first-named housing portion 77 and which extends into the common combustion chamber 73. The first, ram air-inlet-supporting housing portion 77, which may preferably be comprised of and formed from supporting wall surfaces interiorily disposed in and integrated with the casing of the combined unit 70, incorporates a plurality of the inventive retractable air inlet elements, as at 79 and 80, which, as in the other forms of the invention, are extendable from an inner, recessed and compact position and an outer, pop-out position, as is illustrated in the aforementioned Figure 5.

When the Air inlet elements 79, 80 are in their pop-out position of Figure 5, the incoming ram air naturally initially enters the air entrance openings at 79a and 80a, as is further denoted by the arrows "T" and "U", where it is turned inwardly and then in a forward or reverse flow direction, as is respectively illustrated at the arrows "V" and "W". At this point, the incoming ram air is introduced into the housing portion 78 containing a modified air injector tube and which has been previously described as being integrally formed with the housing structure 77 of the air inlet elements 79 and 80. The air injector tube-passage is in a naturally open and continuous communication with the air inlet element-passages 79, 80. The aforementioned air injector tube contained within the housing 78 has been modified to be specifically adapted to and accommodates the liquid fuel form of the present invention, as will be further described hereinafter.

The modification referred to above for the air injector tube-containing housing 78 includes the formation therein of a plurality of air passage-openings, as indicated generally at 81, that are disposed along the outer circumference thereof and which communicate with the common ram-air-receiving passage naturally formed in and along the longitudinal axis of the tube 78. It is this longitudinal passage that would be, and is in open communication between the air passages of the inlet elements 79, 80, at the aft and thereof, and the combustion chamber 73 at the forward end thereof. In this manner, of course, the incoming ram air is introduced into the combustion chamber 73 both through the forward end of the tube 78 and, by means of the communicating openings 81, throughout the said chamber.

In its most basic form, as is specifically illustrated in the aforementioned Figure 5, the combined unit 68 thereof could be air launched from a supersonic aircraft to thereby achieve the necessary or desired speed for ramjet operation. Thereafter, the ramjet engine 72 could be placed into immediate operation to propel it and the missile payload module 69 attached therewith at the specified cruising operation by extending the retractable air inlet elements, as at 79 and 80 to their outer, pop-out position for the capture of ram air thereby and its introduction in the inventive reverse flow direction by and through means of the air injector tube-containing housing 78 and its plurality of air passages, as at 81, into the combustion chamber 73 where it would be mixed, ignited and thus produce hot gas products with liquid fuel being fed from the liquid fuel-containing tank 71.

The above-referred to liquid fuel would have been fed or injected into the incoming ram air within each of the plurality of air passage openings 81 by way of the fuel injection manifold 84 and the fuel injectors, as at 85, extending between the manifold 84 and each of the air openings 81. Of course, to feed this liquid fuel from the tank 71 to the manifold 84, fuel feed lines 82 and 83 and a fuel pump and control valve, as at 86 and 87, may be utilized. In this connection, in place of the initial air launching step, a built-in source of oxygen, for example, may be carried for introducing oxygen into the combustion chamber 73 for its mixture with the liquid fuel from the tank 71 to thereby produce the initial rocket boost/launching operation required to bring the ramjet engine 72 up to the desired speed range, after which ramjet flight would be initiated for cruising operations, as noted before.

Thus, a new and improved strap-on ramjet system for propelling missiles or aircraft has been developed by the present invention in which aft-mounted, pop-out ram air-inlets have been utilized together with a reverse flow combustion process that promotes greater combustion efficiency in a much cleaner and more compack package facilitating the internal bomb bay stowage thereof.

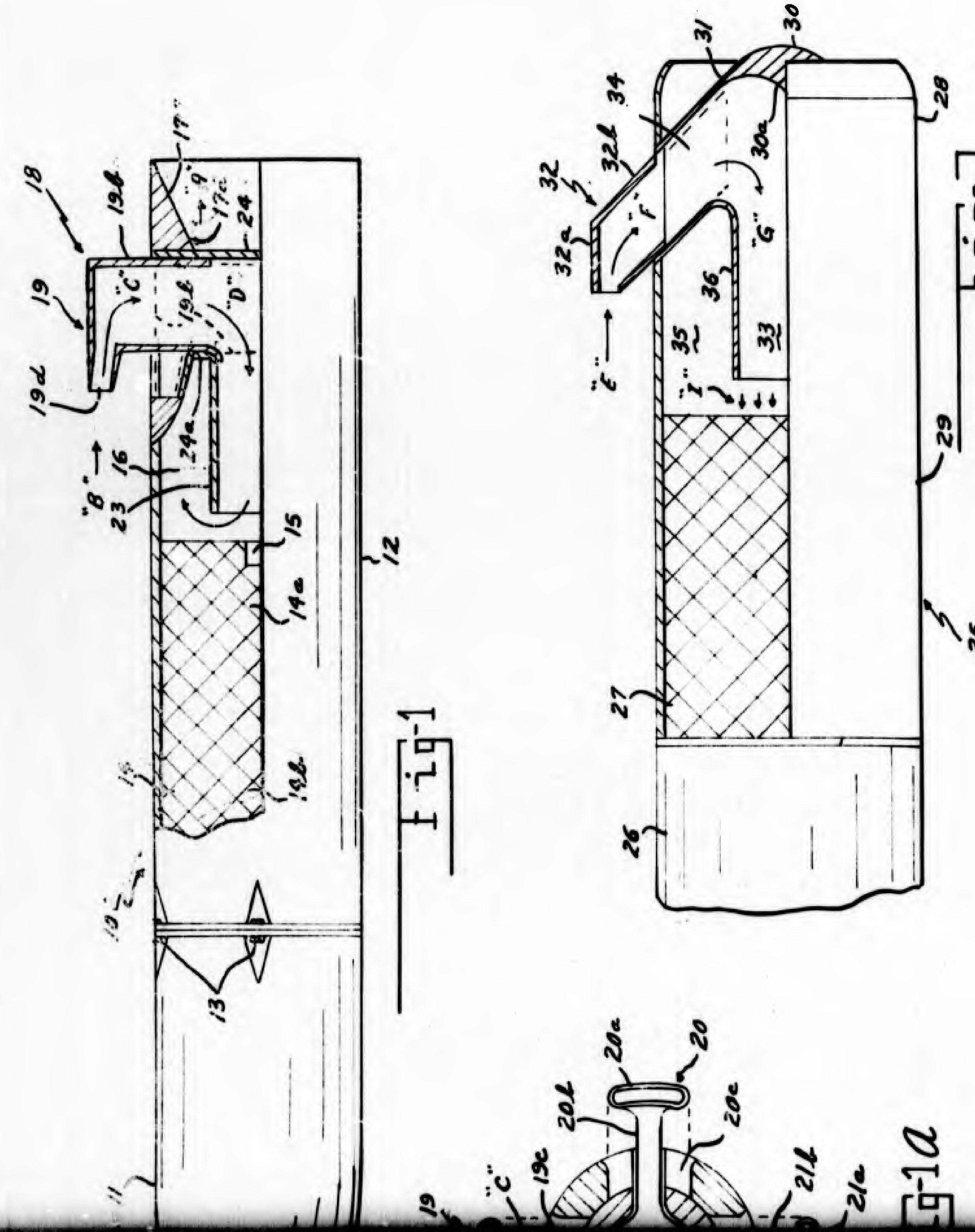

Fig-1

Fig-2

Fig-1a

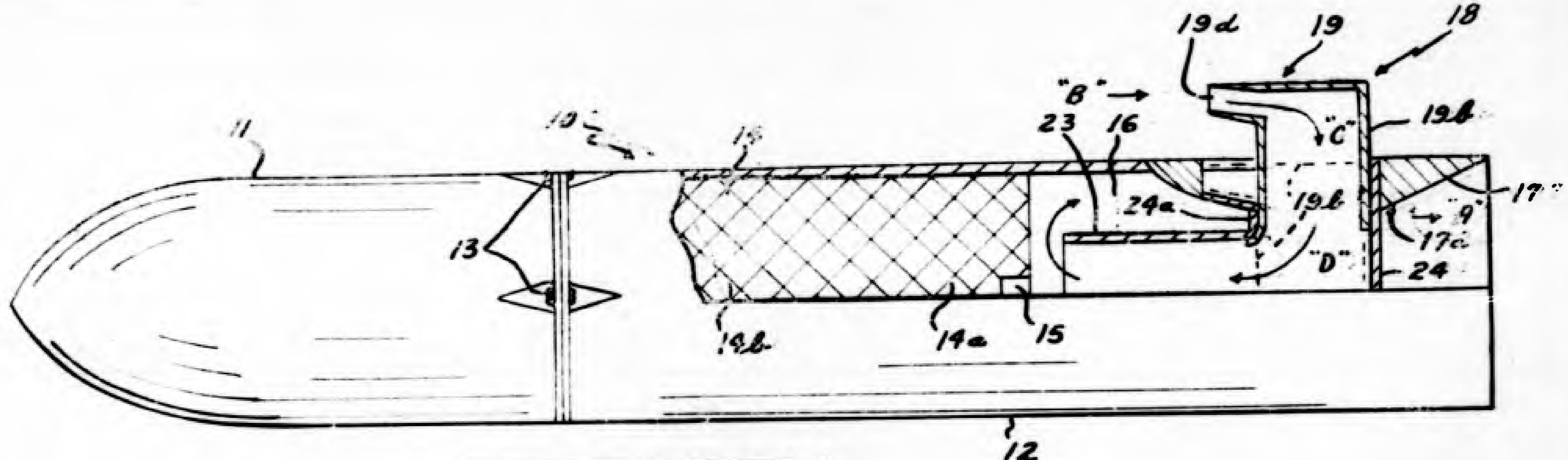

Fig-1

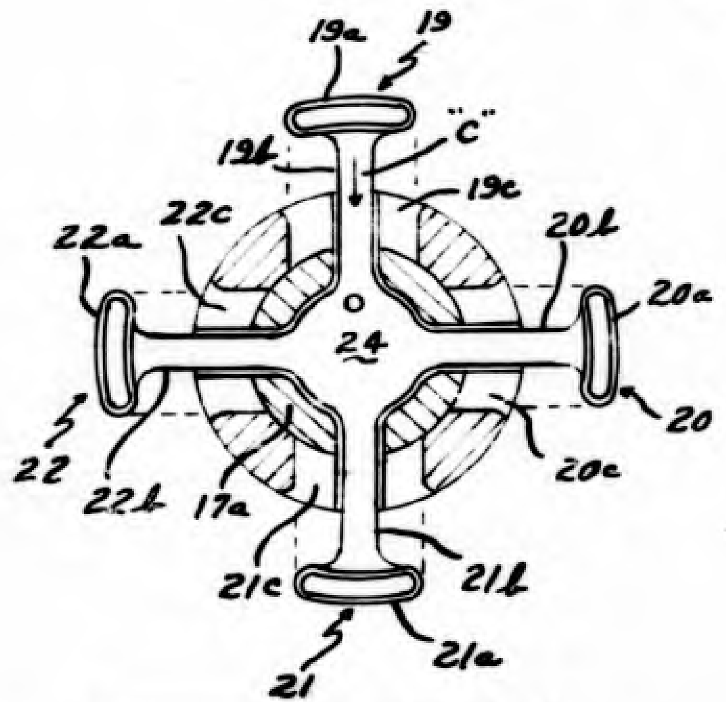

Fig-1a

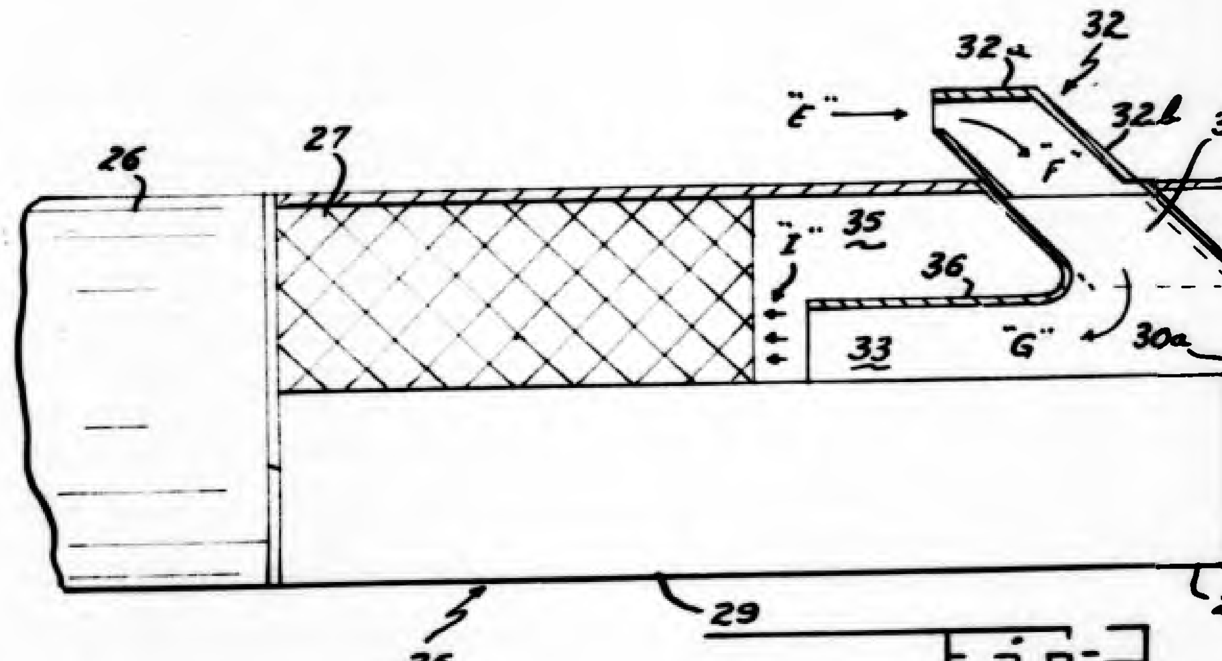

Fig-2

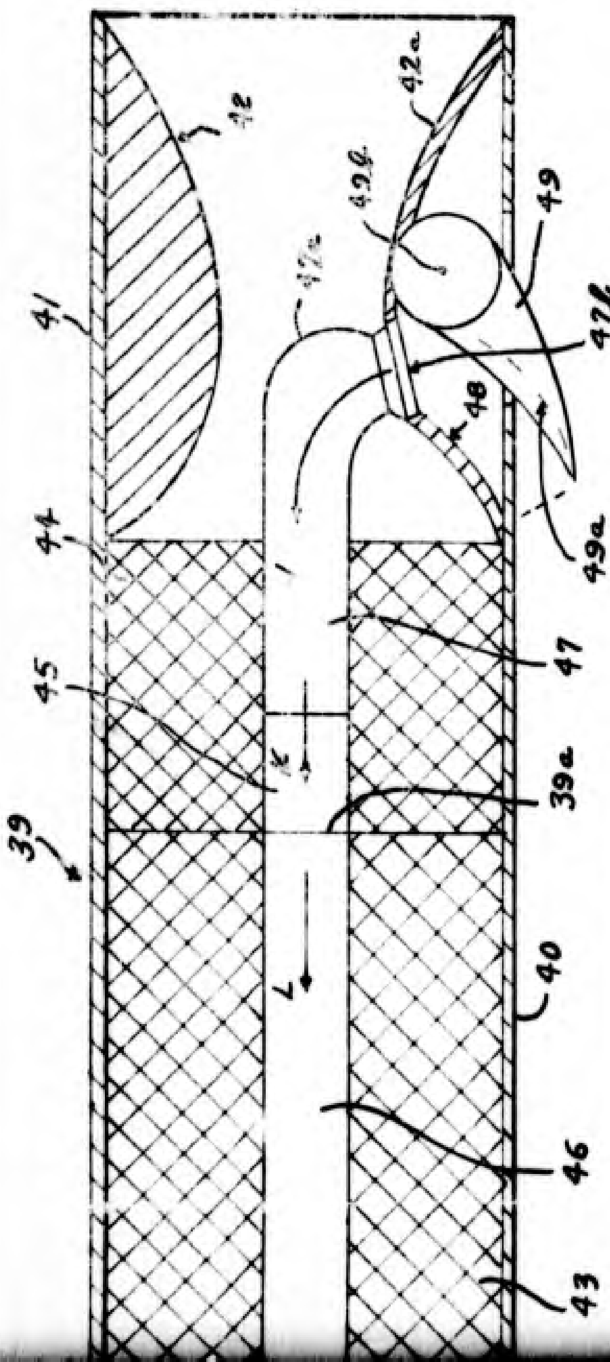
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Fig-3

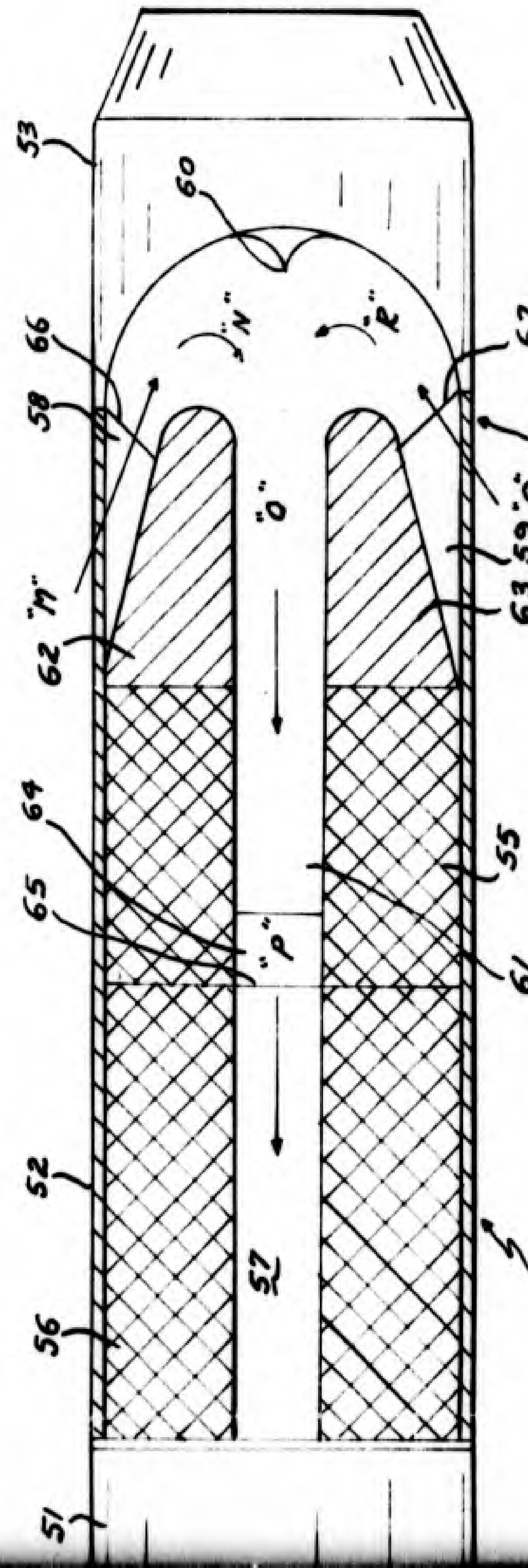
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Fig-4

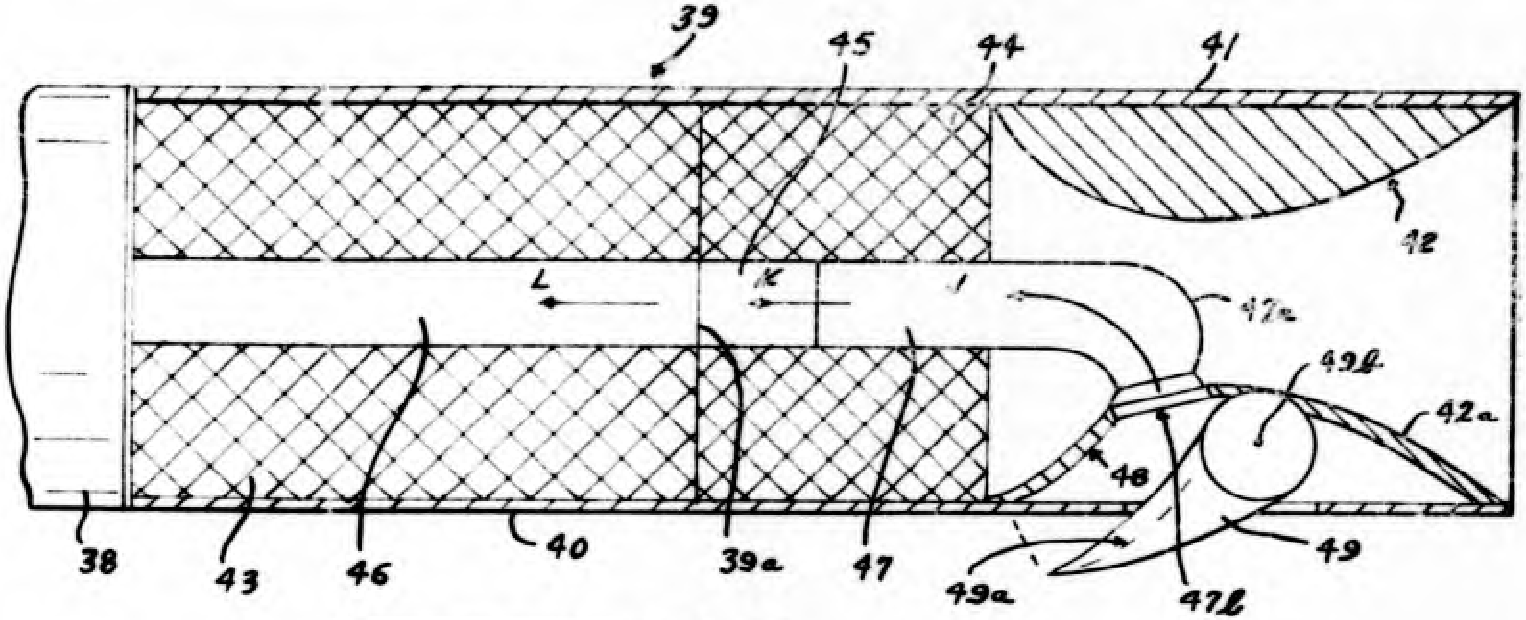
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Fig-3

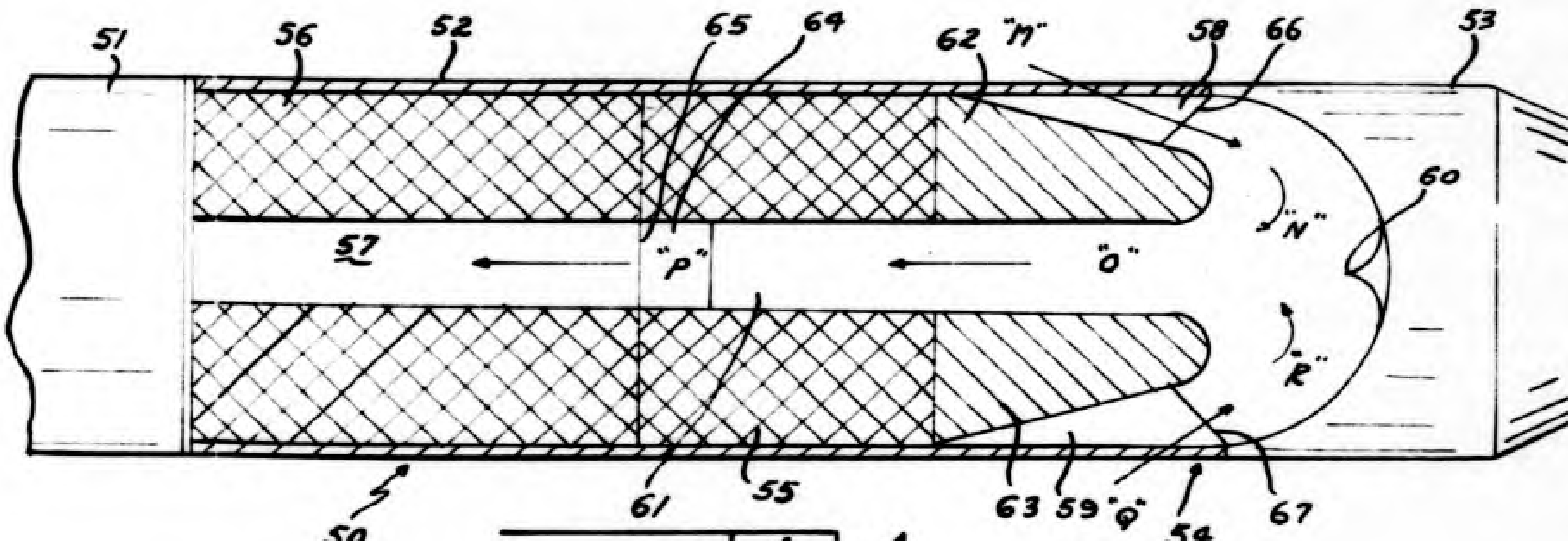
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Fig-4

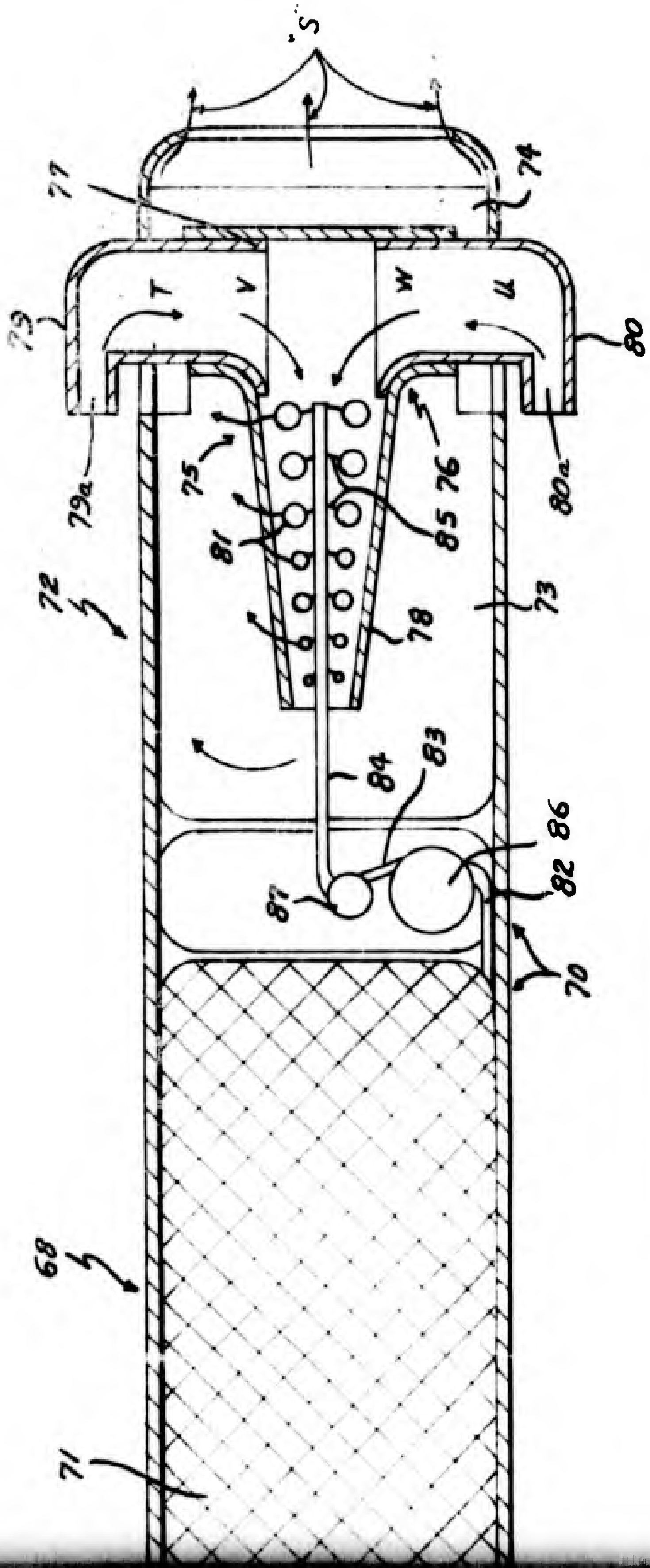
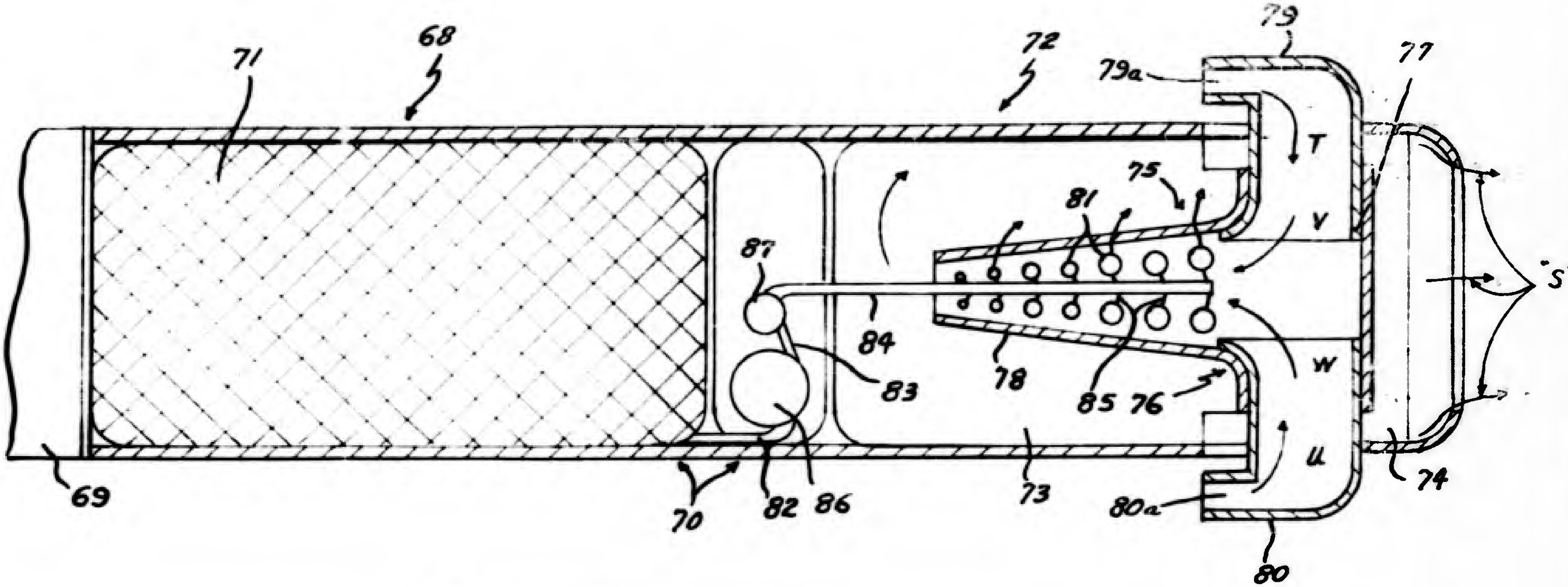


Fig-5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T
75
81
V
87
84
S
83
78
W
85 76
69
70
82
86
73
80a
U
74
80

Fig-5