

May 24, 1960

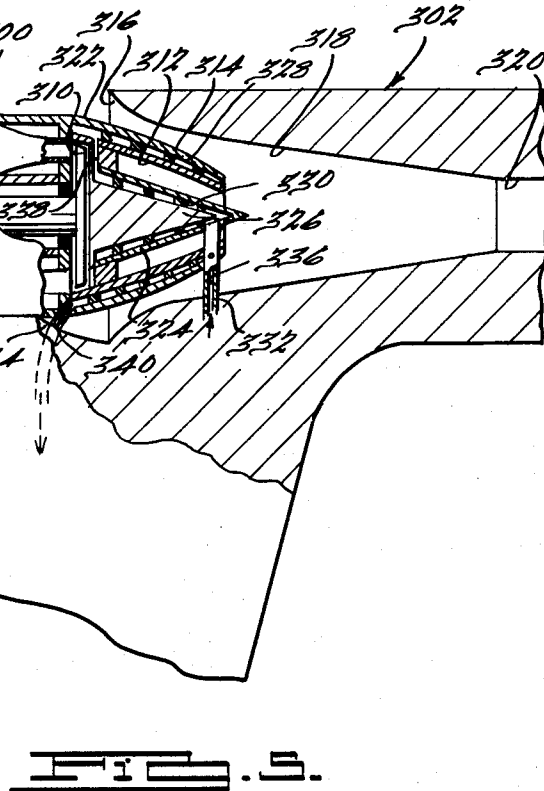
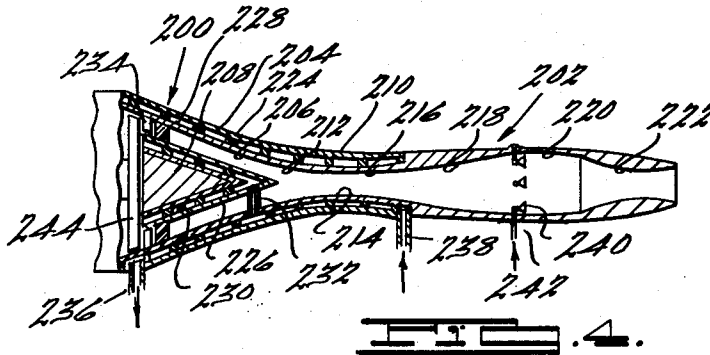
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2,937,494

SERIES TYPE MULTIPLE THERMAL JET PROPULSION SYSTEM

Filed Sept. 13, 1955

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SERIES TYPE MULTIPLE THERMAL JET PROPULSION SYSTEM

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Filed Sept. 13, 1955, Ser. No. 533,988

12 Claims. (Cl. 60—35.6)

This invention relates to jet propulsion power plants and, more particularly, to a series type multiple thermal jet propulsion system. This application is a continuation-in-part of the applicant's copending application, Serial No. 50,271, filed September 21, 1948, now Patent Number 2,721,444, issued October 25, 1955, for Series Type Multiple Ram Jet Propulsion System.

Thermal jet propulsion power plants may be divided into the turbo jet, pulse jet, ram jet and rocket types. The turbo jet presently enjoys wider use than the other types because in the turbo jet plant some form of rotary compressor is utilized to initially pressurize the air entering the combustion chamber, to thereby materially increase the velocity of the products of combustion at relatively low air speeds. The pulse jet and the rocket types are relatively short-lived in the present state of development. In the ram jet, which is a continuous firing unit operating with a continuous flow of air to produce a continuous propulsion thrust, air is rammed from the ambient atmosphere into the combustion chamber by the velocity of the unit and without the benefit of mechanical compression and also without the use of valves or other moving parts. Such units are also known as athodyds. As used herein, throughout the specification and claims, the term "ram jet" is intended to refer to a power plant of the athodyd type. With the turbo jet, pulse jet and rocket types of propulsion, sufficient velocity can be developed at the outlet nozzle to effect take-off of aircraft, for example, while in the ram jet, insufficient jet velocity has thus far been developed for this purpose.

Turbo jet power plants present much greater cooling problems than the other types and it has been necessary to constantly force extra air through them, resulting in considerable unburned oxygen at the exhaust. Heretofore, additional thrust has been obtained by providing an after-burner of the ram jet type at the outlet of a turbo jet plant, such after-burner receiving the entire exhaust of the turbo jet with no separate source of air being provided, so that combustion in the after-burner is supported entirely by excess oxygen from the exhaust of the turbo jet.

The present invention contemplates the provision of a novel jet propulsion power plant utilizing two or more thermal jet units wherein the outlet of the first unit communicates with the inlet of the second unit and wherein cooling means is provided in heat exchange relationship with respect to the outlet of the first unit so as to increase the density and the mass of the hot gases in the first unit without decreasing the velocity thereof, thereby enabling the charging rate and the pressure in the second unit to be increased and increasing the efficiency of both units. The size of the second or subsequent units or stages is not limited by the size and characteristics of the first or earlier stages.

An object of the present invention is to overcome disadvantages in prior jet propulsion plants of the indicated character and to provide an improved thermal jet propulsion power plant system which facilitates a higher

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ratio of jet velocity to air speed, at relatively low air speeds, than has heretofore been obtainable with power plants of this character.

Another object of the invention is to provide an improved thermal jet type power plant comprising two or more thermal jet units arranged in tandem, with the jet issuing from the nozzle of the first unit into the combustion chamber of the succeeding unit to increase the efficiency of both units.

Another object of the invention is to provide a novel thermal jet type propulsion power plant of the character described in which air drawn into the trailing unit or units is caused to enter the latter at an accelerated rate.

Another object of the invention is to provide an improved series type multiple thermal jet propulsion system that is economical to manufacture and assembly, durable, efficient and reliable in operation.

The above as well as other objects and advantages of the present invention will become apparent from the following description, the appended claims and the accompanying drawing wherein:

Figure 1 is a side elevational view, with portions in section, of a jet propulsion plant embodying the present invention;

Fig. 2 is an enlarged view of a portion of the power plant illustrated in Fig. 1;

Fig. 3 is a sectional elevational view of another embodiment of the invention;

Fig. 4 is a fragmentary sectional side elevational view of another embodiment of the invention; and

Fig. 5 is a side elevational view, with portions in section of still another embodiment of the invention.

Referring to the drawing and more particularly to Figs. 1 and 2 thereof, one embodiment of the invention is shown as comprising two longitudinally aligned ram jet propulsion units, generally designated 10 and 11. The unit 10 includes a diffuser section 12 having an inlet opening 13 which, when mounted on an aircraft, faces in the direction of motion of the aircraft. The unit 10 also includes a combustion chamber 14, a constricted throat portion 15 and a divergent portion 16 which might, if the unit 10 were used alone, be opened to discharge directly to the atmosphere. The unit 10 is used as an injector to accelerate the gases entering the second unit 11, however, and in order to increase the density of the hot gases in the first unit without decreasing the velocity thereof, a cooling section, generally designated 17, is provided which includes a substantially straight section 17A for reversing the diverging tendency of the gases and a section 17B which converges sufficiently to offset the decrease in volume and maintain the velocity of the gases. In this embodiment of the invention, the cooling section is cooled by a jacket structure trough which fuel is passed, and the cooling section discharges into the trailing unit 11.

The unit 11 is substantially larger than the unit 10 in the embodiment of the invention illustrated, and is preferably formed as a single unit having an inlet opening 18 at its forward end which leads into a convergent wall 19A spacedly surrounding the rear cooling and discharge portions of the front unit 10, around which air from the inlet 18 is thus admitted. The outlet of the cooling section of the forward unit 10 terminates in forwardly spaced relationship with respect to a constricted throat portion 19B provided in the trailing unit 11, and the hot gases flow through the throat portion 19B to a divergent, pressure increasing diffuser section 20 and from there past burners 36 to a combustion chamber 21 and a discharge nozzle opening 22.

The thickened wall of the unit 11 intermediate the opening 18 and the throat portion 19B is provided with a reduced peripheral portion having an external thread 23

for receiving the internally threaded end of a hollow smooth cylindrical casing or shell 24 thereon, the outer periphery of the shell being flush with the outer periphery of the supporting thickened wall of the unit 11 so that a streamlined and unbroken surface is provided thereby. The rear end of the shell fits tightly upon the thickened rear wall of the unit 11 and the last-mentioned thickened wall provides a continuation of the unbroken streamlined surface. The shell 24 also bridges the reduced intermediate portions of the rear unit 11 to provide an annular fuel feeding and inlet cooling chamber 37 through which the fuel is delivered to the burners 36.

The cooling section 17 of the unit 10 is defined by double walls 27 and 27A between which are disposed two spaced helical ribs 25 and 26 of like pitch, the ribs 25 and 26 extending for substantially the entire length of the cooling section 17 and co-acting with the frusto-conical walls 27 and 27A to thereby define alternate spiral passages 28 and 29 between the walls 27 and 27A. The passages 28 and 29 are thus in intimate heat conductive relationship with the sections 17A and 17B.

The first ram jet unit 10 is supported within the rear ram jet unit 11 with the outlet of the cooling section 17 of the front unit terminating forwardly of the throat portion 19B of the second unit. A plurality of radially arranged, spaced streamlined struts 30 are provided which include reduced bosses 31 at the outer ends which secure the struts within the wall of the unit 11 forwardly of the throat portion 19, the struts also being tightly connected, as by welding, to the outer wall 27 at their inner ends. The spaces between the struts 30 permit communication of the throat portion 19B of the unit 11 with the atmosphere through the opening 18. The unit 10 is also supported by the unit 11 at a point rearwardly of the throat 15 by a plurality of radially arranged, spaced, streamlined struts 32 which have reduced diameter externally threaded bosses 33 at their inner ends received within a series of threaded apertures formed in the wall of the unit 10, the outer ends of the struts 32 being fixed to the periphery of the wall of the unit 11. The spaces between the struts 32 also permit the passage of air from the ambient atmosphere to the interior of the unit 11 by way of the spaces between the struts 30.

A series of radially arranged fuel burners 34 are mounted within the combustion chamber 14 of the unit 10 and connected by conduits 35 with a suitable fuel supply (not shown) externally of the system. In a similar manner, the combustion chamber 21 of the unit 11 has mounted therein a series of radially arranged fuel burners 36 (only one being shown in Fig. 1) but instead of being supplied directly from the fuel source, the burners 36 are supplied from the chamber 37 located between the outer periphery of the wall of the unit 11 and the inner periphery of the shell 24, the burners 36 communicating with the chamber 37 through conduits or pipes 38. Fuel is supplied to the chamber 37 by suitable conduits (not shown) which may be connected to a series of radially spaced tapped ports 39 formed in the wall of the unit 11 adjacent the opening 18. The ports 39 register with passageways 40 formed in the struts 32, the passageways 40 discharging into the helical spiral passageways 28 and 29 previously referred to. One passageway 40 communicates with the helical passageway 28 and the other communicates with the helical passageway 29. The outlet of the passageway 29 communicates with the chamber 37 by way of a passageway 42 formed in one of the struts 30 and the outlet of passageway 28 communicates with chamber 37 by way of a passageway 43 in another of the struts 30. In this manner, fuel flowing through the relatively long passageways 28 and 29 acts as a cooling agent for dissipating some of the heat of the combustion gases emerging from the section 17 of the unit 10.

Assuming that the propulsion plant is mounted on an aircraft, for example, the unit 10 will operate as a conventional ram jet. Air is rammed into the opening 13 and

its velocity drops and its pressure increases in the diffuser section 12. At the burners 34 the high pressure air is mixed with the fuel supplied by conduits 35 and burned in the combustion chamber 14. The gases resulting therefrom are expanded and accelerated to pass at considerable velocity through the throat portion 15 and then through the cooling section 17 to emerge therefrom as a jet having a high velocity. Instead of utilizing the thrust of the jet issuing from the section 17 solely as a means for deriving propulsion, the ram jet type of propulsion plant is improved by the present invention in accordance with which the jet issuing from the section 17 passes into the second unit 11. The high speed gases leaving the front unit create a low pressure area forwardly of the throat portion 19B of the second unit, thus inducing the air from the surrounding atmosphere entering the opening 18 to accelerate in its passage to the throat 19B where it continues to accelerate as it mixes with the high speed gases emanating from the front unit until the mixture reaches the diffuser section 20 of the rear unit in which the burned gases and the air are nearly at the same velocity. As the latter mixture approaches the combustion chamber 21 its velocity decreases and its pressure increases, the pressure reaching a maximum value at the burners 36 where the fuel from the conduits 38 is injected into the mixture and burned by the burners 36. The resulting burned gases are expanded and accelerated through the nozzle 22 attaining a maximum velocity as they issue as a jet from the nozzle.

It will be apparent that by the novel arrangement hereof the jet of the first unit is utilized not merely for thrust purposes as in conventional power plants but for increasing the entrance velocity of the atmospheric air to the second combustion chamber which, of course, not only increases the velocity of the jet issuing from the nozzle 22 of the second unit but also aids in total combustion within the second combustion chamber.

It will be understood that other stages may be used in addition to the two stages shown whereby the use of one stage to increase the velocity of the next stage will increase the maximum pressure of the latter stage and thereby increase the overall efficiency of the plant.

While the increased entrance velocity will increase the entrance temperature, a net gain will be obtained nevertheless because as more stages are utilized the higher will be the maximum pressure in the last stage.

The length of the throat portion 19B must be great enough so that the air and the burned gases will be moving at substantially the same velocity when they reach the diffuser section 20. The cross sectional area of the throat 19B is only varied throughout its length sufficiently to compensate for variations of volume of the mixture due to temperature change and variations of the velocity of the burned gases and air as they approach a common velocity. The air will increase in volume at about the same rate that the burned gases decrease in volume during the transfer of heat in mixing so that the total volume will remain approximately the same. Similarly the increase in velocity of the air is offset by a decrease in velocity of the burned gases so that the cross sectional area between the two sections will be approximately constant.

Another embodiment of the invention is illustrated in Fig. 3 and is comprised of a rocket propulsion unit, generally designated 100, and a ram jet propulsion unit, generally designated 102, the units 100 and 102 being substantially coaxially aligned and being shown in installed relationship with respect to a schematically illustrated wing section 104. The rocket unit 100 includes a combustion chamber 106, a constricted throat portion 108 and a divergent portion 110 which might, if the unit 100 is used alone, be opened to discharge directly to the atmosphere. The unit 100 is used as an injector to accelerate the gases entering the ram jet unit 102 and, in order to increase the density of the hot gases emanating

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from the rocket unit without decreasing the velocity thereof, a cooling section 112 is provided which includes a substantially straight section 114 for reversing the diverging tendency of the gases and a section 116 which converges sufficiently to offset the decrease in volume and maintain the velocity of the gases. In this embodiment of the invention, the cooling section is cooled by a jacket structure through which coolant flows, the coolant being recycled. It will be understood, however, that, if desired, fuel could be utilized as the coolant, the fuel being discharged to a suitable reservoir for the ram jet unit.

The ram jet unit 102 is substantially larger than the rocket unit 100, and includes an inlet opening 118 at its forward end which leads into a convergent section 120. The outlet of the rocket unit terminates in forwardly spaced relationship with respect to the convergent section 120 and the convergent section 120 merges with a throat section 122, the hot gases flowing through the throat section 122 through a divergent pressure increasing diffuser section 124 and from there past burners 126 to a combustion chamber 128 which corresponds to the combustion chamber 21 in the embodiment of the invention illustrated in Figs. 1 and 2. The products of combustion then flow outwardly through a discharge nozzle in the manner previously described.

The rocket unit 100 includes spaced walls 130 and 132 between which spaced helical ribs 134 and 136 are disposed, the ribs extending for substantially the entire length of the rocket unit and co-acting with the walls 130 and 132 to define spiral passageways 138 and 140. The passageway 138 is separated from the passageway 140 by an intermediate wall 142 which extends annularly around the rocket unit 100 intermediate the walls 130 and 132.

The cooling portion of the rocket unit 100 is supported within the forward portion of the ram jet unit 102 so that the outlet of the cooling section 112 of the rocket unit terminates forwardly of the throat portion 122 of the ram jet unit. A plurality of radially extending angularly spaced streamlined struts 144 are provided which are fixed to the rocket and ram jet units in any desired or conventional manner so as to support the cooling section 112, while the forward portion of the rocket is supported on a mounting section 146 carried by the wing structure 104. The spaces between the struts 144 permit communication of the throat portion 122 of the ram jet unit with the ambient atmosphere through the inlet opening 118.

Fuel is supplied to the combustion chamber 106 through a conduit 148 while an oxidizer is supplied to the combustion chamber through a conduit 150. The series of radially arranged fuel burners 126 mounted in the combustion chamber are supplied with fuel through conduits 152 which communicate with a suitable fuel supply (not shown) externally of the system.

Coolant is supplied to the section 138 of the cooling system through a conduit 154 and is returned from the section 138 through an outlet conduit 156 while the chamber 140 of the cooling section is supplied with coolant through a conduit 158, the coolant flowing outwardly from the section 140 through an outlet conduit 160.

The coolant flowing through the sections 138 and 140 defined by the helically extending ribs 134 and 136 serves to cool and dissipate some of the heat from the combustion gases emerging from the combustion chamber of the rocket. With such a construction, the cooling means increase the density and the mass of the hot gases emerging from the rocket without decreasing the velocity of the gases, thereby enabling the charging rate and the pressure on the ram jet to be increased, and materially increasing the efficiency of both units.

Assuming that the propulsion plant is mounted on an aircraft, the rocket unit 100 operates as a conventional

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rocket. Fuel and an oxidizer are supplied through the conduits 148 and 150, respectively, and the products of combustion are accelerated and pass at considerable velocity through the throat portion 108 and then through the cooling section 112 so as to emerge from the outlet nozzle as a jet having a high velocity. Instead of utilizing the thrust of the rocket issuing from the cooling section 112 solely as a means of deriving propulsion the efficiency of the power plant is improved by the present invention in accordance with which the jet issuing from the cooling section 112 passes into the ram jet unit 102. The high speed gases leaving the rocket unit create a low pressure area forwardly of the throat portion 122 of the ram jet unit, thus inducing the air from the ambient atmosphere entering the opening 118 to accelerate in its passage to the throat portion 122 where it continues to accelerate as it mixes with the high speed gases emanating from the rocket until the mixture reaches the diffuser section 124 of the ram jet unit in which the burned gases and the air are substantially the same velocity. As the latter mixture approaches the combustion chamber 128, its velocity decreases and its pressure increases, the pressure reaching a maximum value at the burners 126 where fuel from the conduits 152 is injected into the mixture and burned. The resultant burned gases are expanded and accelerated through the outlet nozzle of the ram jet unit attaining a maximum velocity as they issue as a jet from the outlet nozzle of the ram jet unit.

It will be apparent that by the novel arrangement of this embodiment of the invention, the jet of the rocket unit is utilized not merely for thrust propulsion but is also utilized for increasing the entrance velocity of the atmospheric air to the combustion chamber of the ram jet unit which, of course not only increases the velocity of the jet issuing from the outlet nozzle of the ram jet unit but also aids in total combustion within the combustion chamber of the ram jet unit.

The length of the throat portion 122 of the ram jet unit is preferably great enough so that the air and the products of combustion of the rocket will be moving at substantially the same velocity when they reach the combustion chamber 128. The cross sectional area of the throat portion 122 is only varied throughout its length sufficiently to compensate for variations of volume of the mixture due to temperature changes and variations of the velocity of the products of combustion and entering air as they approach a common velocity. The entering air will increase in volume at approximately the same rate that the burned gases decrease in volume during the transfer of heat in mixing so that the total volume will remain approximately the same. Similarly, the increase in the velocity of the air is offset by a decrease in the velocity of the burned gases so that the cross sectional area will be approximately constant.

Another embodiment of the invention is illustrated in Fig. 4 and is comprised of a turbo jet propulsion unit, generally designated 200, and an after-burner, generally designated 202, the turbo jet 200 and the after-burner 202 being substantially coaxially aligned. The turbo jet unit 200 includes an exhaust section 204 which defines an annular outlet nozzle 206, an exhaust cone 208 being disposed in the central portion of the outlet nozzle in the conventional manner. In order to reduce the temperature of the gases issuing from the exhaust nozzle 206 into the after-burner 202, a cooling section 210 is provided which includes a converging section 212, a throat section 214 and a diverging section 216, the sections 206 and 212 converging sufficiently to offset the decrease in volume and maintain the velocity of the gases. The cooling section 210 may be cooled by a jacket structure through which the fuel is passed and such cooling section discharges into the inlet of the after-burner 202.

The after-burner 202 includes a diverging section 218, a combustion chamber 220 and an outlet nozzle portion 222. The diverging section 218 serves as a pressure in-

creasing diffuser section and the gases flow from the diffuser section through the combustion chamber 220 and discharge from the outlet nozzle 222.

The walls 224 and 226 of the unit 200 and the cone 208, respectively, define spiral passageways 228 and 230, the passageway 228 also extending through the cooling section 210 while the passageway 230 terminates adjacent the apex of the cone 208.

The cone 208 is supported within the exhaust nozzle 206 of the turbo jet unit 200 by a plurality of radially extending struts 232 and 234, the opposite ends of which are fixed to the walls 224 and 226. The spaces between the struts 232 and 234 permit the passage of the hot gases through the exhaust nozzle 206 of the turbo jet unit. The struts 232 and 234 define fluid passageways through which coolant flows from the spiral passageway 228 into the spiral passageway 230 and from the spiral passageway 230 into an outlet conduit 236 which communicates with the passageway 230. The coolant is supplied to the spiral passageway 228 through an inlet conduit 238, the conduit 238 being connected to a suitable source of supply (not shown).

A plurality of burners 240 are mounted in the combustion chamber 220, the burners 240 being supplied with fuel through suitable conduits 242 which communicate with the fuel reservoir.

Assuming that the propulsion plant is mounted on an aircraft, for example, the unit 200 operates as a conventional turbo jet. After the hot gases pass through the turbine blades 244, the gases flow through the outlet nozzle 206 and the cooling section 210. The gases flowing through the outlet nozzle 206 contain substantial amounts of unburned oxygen, and the gases issuing from the discharge nozzle 206 flow through the cooling section 210 directly into the after-burner 202. As the gases flow through the diffuser section 218, the velocity decreases and the pressure increases, the pressure reaching a maximum value at the burners 240 where fuel is sprayed into the gases and burned. The resulting products of combustion are expanded and accelerate through the nozzle 222, attaining a maximum velocity as they issue as a jet from the nozzle 222.

The cooling means which is in heat exchange relationship with respect to the outlet of the turbo jet unit increases the density of the hot gases discharged from the turbo jet unit without decreasing the velocity thereof, thereby materially increasing the efficiency of both the turbo jet unit as a pump and the after burner as a jet unit. Since the cooling between the turbo jet unit and the ram jet unit increases the mass of the gases without decreasing the velocity thereof, the charging rate and the pressure in the after-burner are materially increased with the result that the pressure ratio and the efficiency of the after-burner is increased.

Another embodiment of the invention is illustrated in Fig. 5, this embodiment of the invention including a turbo jet unit 300 and a ram jet unit 302, the turbo jet 300 and the ram jet 302 being substantially coaxially aligned. The turbo jet unit 300 includes a diffuser section 304, a compressor section 306, a combustion section 308, a turbine section 310 and an outlet nozzle 312. The turbo jet 300 functions as an injector to accelerate the gases entering the ram jet unit 302, and in order to reduce the temperature of the gases delivered from the turbo jet unit into the ram jet unit, a cooling section 314 is incorporated in the exhaust section of the turbo jet. In accordance with the present invention, the outlet nozzle 312 of the turbo jet unit converges sufficiently to offset the decrease in volume of the hot gases passing there-through and maintain the velocity of such gases. The cooling section includes a jacket structure through which fuel is passed and the gases are discharged from the cooling section into the inlet of the ram jet unit 302.

The ram jet unit 302 includes an inlet opening 316 which leads into a convergent section 318 spacedly

surrounding the rear cooling and discharge portions of the turbo jet unit 300 around which air from the inlet 316 is admitted. The air from the inlet 316 and gases from the turbo jet unit are lead through a throat section 320 to either a converging or diverging pressure increasing diffuser section, combustion chamber and discharge nozzle in the manner previously described. The wall 322 of the discharge section of the turbo jet and the wall 324 of the discharge cone 326 of the turbo jet define longitudinally extending helical passageways 328 and 330, respectively, through which fuel or other suitable coolant flows to cool the gases flowing through the discharge nozzle 312. The turbo jet unit 300 is supported within the ram jet unit with the outlet of the turbo jet unit terminating forwardly of the throat 320 of the ram jet unit, the rear section of the turbo jet unit being supported by a plurality of angularly spaced radially extending streamlined struts, such as 332 and 334. The struts 332 define fluid conduits 336 through which the coolant flows into the passageways 328 and 330. The coolant flows through the passageways 328 and 330, and the coolant leaves the passageway 330 through a conduit 338 and flows into the passageway 328. The coolant then flows from passageway 328 through an outlet conduit 340 defined by the strut 334. The conduits 336 and 340 may be connected to a suitable reservoir or may be included in the fuel supply line through which the fuel is supplied to the ram jet unit 302.

Assuming that the propulsion plant is mounted on an aircraft, for example, the unit 300 will operate as a conventional turbo jet unit. Air is rammed into the diffuser section 304 and flows through the compressor section 306 into the combustion chamber 308 where fuel is mixed with the high pressure air and burned. The products of combustion then flow through the turbine section 310 where sufficient energy is extracted from the hot gases to drive the compressor section 306. The gases then flow through the exhaust nozzle 312 and emerge therefrom as a jet having a relatively high velocity. The cooling means which is in heat exchange relationship with respect to the outlet of the turbo jet unit increases the density of the hot gases without decreasing the velocity thereof. Since the cooling means also increases the mass of the gases without decreasing the velocity thereof, the charging rate and pressure in the ram jet unit are increased. The gases emerging from the turbo jet unit create a low pressure area forwardly of the throat portion 320 of the ram jet unit, thus inducing the air from the ambient atmosphere entering the inlet opening 316 to accelerate in its passage to the throat portion 320 where it continues to accelerate as it mixes with the high speed gases emanating from the turbo jet unit. When the mixture reaches the diffuser section of the ram jet unit the burned gases and the air are nearly at the same velocity and as the mixture approaches the combustion chamber of the ram jet unit the velocity decreases and the pressure increases in the manner previously described so that the pressure reaches a maximum value at the burners of the ram jet unit. Fuel is then added in the combustion chamber of the ram jet unit in the manner previously described, and the resulting burned gases are expanded and accelerated through the outlet nozzle of the ram jet unit so as to attain a maximum velocity as they issue as a jet from the ram jet unit.

While preferred embodiments of the invention have been shown and described, it will be understood that various changes and modifications may be made without departing from the spirit of the invention.

What is claimed is:

1. A series type multiple thermal jet propulsion system comprising, in combination, a forward thermal jet propulsion unit, a trailing thermal jet propulsion unit, said forward unit including a body having a combustion chamber section and a converging outlet nozzle section to the rear of and communicating with said combustion

chamber section, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet nozzle section and effective to accelerate the gases emanating from said combustion chamber section, said trailing unit including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet nozzle section communicating with said combustion chamber section of said trailing unit, said outlet nozzle section of said forward unit communicating with the inlet section of the trailing unit, and cooling means in heat exchange relationship with respect to the outlet nozzle section of said forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet nozzle section of said forward unit after the gases have passed through said expansion section of said forward unit, said outlet nozzle section of said forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet nozzle section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

2. A series type multiple thermal jet propulsion system comprising, in combination, a forward thermal jet propulsion unit, a trailing thermal jet propulsion unit, each of said units including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet section communicating with said combustion chamber section, said outlet section of the forward unit being in the form of a converging nozzle and communicating with the inlet section of the trailing unit, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet section of the forward unit and effective to accelerate the gases emanating from said combustion chamber section of the forward unit, and cooling means in heat exchange relationship with respect to the outlet section of the forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet section of the forward unit after the gases have passed through said expansion section of the forward unit, said outlet section of the forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

3. In a series type multiple thermal jet propulsion system, the combination including a forward thermal jet propulsion unit, a trailing thermal jet propulsion unit, each of said units including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet section communicating with said combustion chamber section, said outlet section of the forward unit being in the form of a converging nozzle and communicating with the inlet section of the trailing unit, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet section of the forward unit and effective to accelerate the gases emanating from said combustion chamber section of the forward unit, said body of said trailing unit also including forwardly opening portions communicating the inlet section thereof directly with the atmosphere, and cooling means in heat exchange relationship with respect to the outlet section of the forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet section of the forward unit after the gases have passed through said expansion section of the forward unit, said

outlet section of the forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

4. A series type multiple thermal jet propulsion system comprising, in combination, a pair of thermal jet propulsion units disposed in substantially tandem relationship, each of said units including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet section communicating with said combustion chamber section, said outlet section of the forward unit being in the form of a converging nozzle and communicating with the inlet section of the trailing unit, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet section of the forward unit and effective to accelerate the gases emanating from said combustion chamber section of the forward unit, and cooling means in heat exchange relationship with respect to the outlet section of the forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet section of the forward unit after the gases have passed through said expansion section of the forward unit, said outlet section of the forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet section for the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

5. A system as defined in claim 4 wherein the second unit is a ram jet unit, the inlet section of said second unit communicating with the atmosphere as well as with said outlet section of the first unit.

6. A series type multiple thermal jet propulsion system comprising, in combination, a turbo jet unit, a ram jet disposed in tandem relationship with respect to said turbo jet unit, each of said units including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet section communicating with said combustion chamber section, said outlet section of the turbo jet unit being in the form of a converging nozzle and communicating with the inlet section of the ram jet unit, said turbo jet body also including an expansion section interposed between said combustion chamber section and said outlet section of the turbo jet unit and effective to accelerate the gases emanating from said combustion chamber section of the turbo jet unit, and cooling means in heat exchange relationship with respect to the outlet section of the turbo jet unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet section of the turbo jet unit after the gases have passed through said expansion section of the turbo jet unit, said outlet section of the turbo jet unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet section of the turbo jet unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

7. A series type multiple thermal jet propulsion system comprising, in combination, a forward thermal jet propulsion unit, a trailing thermal jet propulsion unit, said forward unit being in the form of a rocket and including a body having a combustion chamber section and a converging outlet nozzle section to the rear of and communicating with said combustion chamber section, said forward unit body also including an expansion section interposed between said combustion chamber section

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tion and said outlet nozzle section and effective to accelerate the gases emanating from said combustion chamber section, said trailing unit being in the form of a ram jet and including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet nozzle section communicating with said combustion chamber section, said outlet nozzle section of said forward unit communicating with the inlet section of the trailing unit, and cooling means in heat exchange relationship with respect to the outlet nozzle section of said forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet nozzle section of said forward unit after the gases have passed through said expansion section of said forward unit, said outlet nozzle section of said forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet nozzle section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

8. A series type multiple thermal jet propulsion system comprising, in combination, a forward thermal jet propulsion unit, a trailing thermal jet propulsion unit, said units being disposed in substantially coaxial tandem relationship, each of said units including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet section communicating with said combustion chamber section, said outlet section of the forward unit being in the form of a converging nozzle and communicating with the inlet section of the trailing unit, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet section of the forward unit and effective to accelerate the gases emanating from said combustion chamber section of the forward unit, and cooling means in heat exchange relationship with respect to the outlet section of the forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet section of the forward unit after the gases have passed through said expansion section of the forward unit, said outlet section of the forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

9. A system as defined in claim 8 wherein the forward unit is a turbo jet.

10. A system as defined in claim 8 wherein the forward unit is a turbo jet and the trailing unit is a ram jet, the inlet section of said ram jet communicating with the atmosphere as well as with the outlet section of the turbo jet.

11. A series type multiple thermal jet propulsion system comprising, in combination, a forward ram jet propulsion unit, a trailing ram jet propulsion unit, each of said units including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet section communicating with said combustion chamber section, said

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outlet section of the forward unit being in the form of a converging nozzle and communicating with the inlet section of the trailing unit, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet section of the forward unit and effective to accelerate the gases emanating from said combustion chamber section of the forward unit, said trailing ram jet unit also including means connecting the inlet section thereof directly with the atmosphere, and cooling means in heat exchange relationship with respect to the outlet section of the forward unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet section of the forward unit after the gases have passed through said expansion section of the forward unit, said outlet section of the forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

12. A series type multiple thermal jet propulsion system comprising, in combination, a forward thermal jet propulsion unit, a trailing thermal jet propulsion unit, said forward unit including a body having a combustion chamber section and a converging outlet nozzle section to the rear of and communicating with said combustion chamber section, said forward unit body also including an expansion section interposed between said combustion chamber section and said outlet nozzle section and effective to accelerate the gases emanating from said combustion chamber section, said trailing unit including a body having an inlet section, a combustion chamber section to the rear of and communicating with said inlet section, and an outlet nozzle section communicating with said combustion chamber section, said outlet nozzle section of said forward unit communicating with the inlet section of the trailing unit, cooling means in heat exchange relationship with respect to the outlet nozzle section of said forward unit, and cooling means in heat exchange relationship with respect to the inlet section of the trailing unit, said cooling means being effective to increase the mass velocity product per square inch of the gases flowing through said outlet nozzle section of said forward unit after the gases have passed through said expansion section of said forward unit, said outlet nozzle section of said forward unit having a cross-sectional area progressively decreasing as a function of the cooling capacity of said cooling means whereby the velocity of the gases flowing through said outlet nozzle section of the forward unit is maintained substantially constant while the volume of the gases decreases and the density of the gases increases.

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