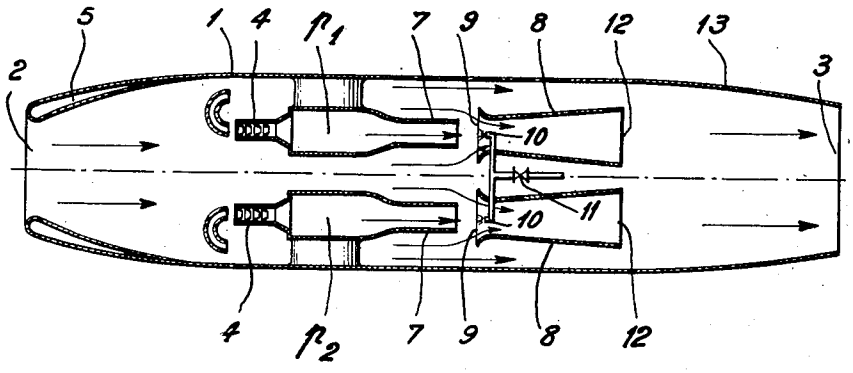
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COMPOSITE RAMJET-PULSEJET ENGINE

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Fig. 1



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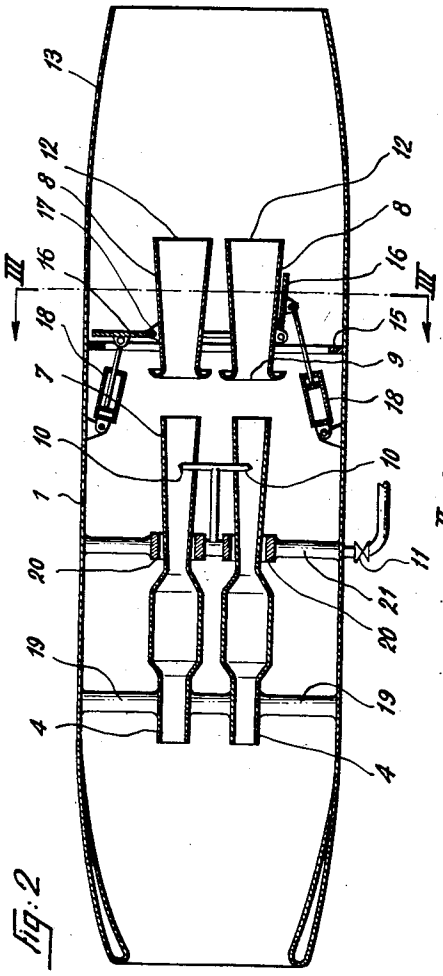


Fig. 2

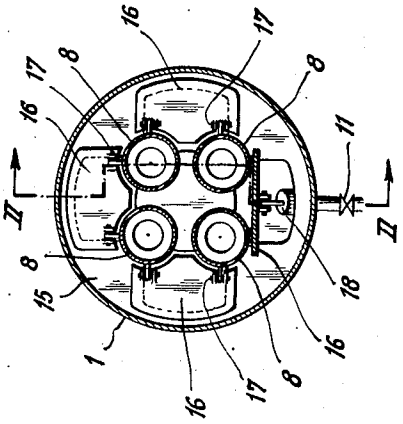


Fig. 3

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COMPOSITE RAMJET-PULSEJET ENGINE

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Application July 11, 1955, Serial No. 521,352

Claims priority, application France July 28, 1954

2 Claims. (Cl. 60—35.6)

The present invention relates to reaction propulsion units which comprise one or preferably a number of pulsatory combustion chambers, especially of the kind employed in pulse-jet units, arranged inside a cowling or casing similar to the casing of a ram-jet unit and comprising, at the front, a diffuser adapted to slow down the speed of the air for supply to the pulsatory chambers and, at the rear, a discharge nozzle.

Apparatus of this kind comprising various arrangements of the pulsatory chambers and/or of the casing, have already been described by the present applicants in U. S. patent applications Ser. No. 229,946, filed June 5, 1951, Ser. No. 340,832 filed March 6, 1953, and Ser. No. 350,072 filed April 21, 1953, now Patent No. 2,750,-733, dated June 19, 1956.

The apparatus in accordance with U. S. Patent application Ser. No. 229,946 is arranged in such a way that a part of the air which penetrates into the cowling passes freely towards the exhaust discharge nozzle, following a cycle similar to that of a normal ram-jet unit, this air being heated in the central part of the cowling by the heat which is produced during the operation of the pulse-jet units through the wall of these latter.

It has however been indicated that it is possible to provide in the ram-jet unit supplementary means for heating the air which follows the ram-jet cycle, for example fuel burners which can be momentarily put into action in order to obtain, in case of need, a supplementary thrust. Finally, it has also been stated that it is of special advantage to arrange after the exhaust pipe of each of the pulsatory chambers, an ejector or dilution nozzle into which passes a part of the air passing through the ram-jet unit, this air having its speed accelerated by each of the exhaust puffs from the corresponding pulsatory chamber, thereby enabling a substantial increase in thrust to be obtained together with an excellent efficiency.

The U. S. patent applications Ser. No. 340,832 and Ser. No. 350,072 also describe the arrangement of ejectors of this kind, with this special feature that all the air which does not take part in the combustion in the pulsatory chambers is forced back through these ejectors towards the rear part of the cowling which is separated from the front portion by means of a partition.

One of the objects of the present invention is the arrangement of means for introduction of fuel into the path of the flow passing out of one or a number of pulsatory chambers, that is to say either in the interior of one or a number of ejectors, or between the ejectors and the outlet orifices of the pulsatory chambers, or within the interior of these outlet orifices, the said means being adapted to be put into action at will so as to increase the temperature of the air and the thrust. With such as arrangement, which ensures a rapid and perfect combustion of the supplementary fuel by virtue of its excellent mixture with the air under the effect of the stirring and the turbulence produced by the successive puffs

of exhaust gases from the pulsatory chambers, it is of special advantage to adapt the reciprocal arrangement of the ejectors and of the cowling of the ram-jet system so that the ejectors deliver into the cowling at a substantial distance on the upstream side of its outlet orifice in order that the combustion may be completed before that orifice.

A further special feature which also forms an object of the present invention, and which may be applied either separately or in combination with that referred to above, is a movable or retractable partition device which enables the part of the cowling in which are located the intake orifices of the ejectors to be separated at low speeds of flight from the portion of the said cowling into which the ejectors discharge. A partition of this kind is of advantage in improving the thrust and the efficency at zero speed and at low speeds and also the cooling of the pulsatory combustion chambers at zero speed. On the other hand, it is an advantage to open the partition or to withdraw it when the speed of flight exceeds a certain value, and this may be effected by means of an automatic device actuated, for example, by the dynamic pressure derived from a sounder provided on the leading edge of the cowling or of a wing of the aircraft.

The description which follows below with respect to the attached drawings (which are given by way of example only and not in any sense by way of limitation) will make it quite clear how the invention may be carried into effect, the special features which may be brought out, either in the text or in the drawings, being understood to form a part of the said invention.

Fig. 1 shows a diagrammatic axial cross-section of one form of construction of a combined propulsion unit in accordance with the present invention.

Fig. 2 is a diagrammatic longitudinal cross-section of an alternative form of embodiment of a propulsion unit of this type.

Fig. 3 is a transverse cross-section following the line III—III of Fig. 2; in this Fig. 3, the broken line II—II is the outline of the plane of cross-section of Fig. 2.

In Fig. 1, there is shown at **1** a cowling or casing of a ram-jet unit, the air intake orifice of which is shown at **2** and the gas outlet orifice at **3**. In this cowling are arranged a certain number of pulse-jet units *p1*, *p2* . . . in such manner that the inlet orifices of these pulse-jet units, which are preferably of the type having valveless aerodynamic inlets, take in air on the downstream side of the inlet diffuser **5** of the ram-jet unit, that is to say in the zone in which the speed of the air is reduced. A part of the air passing into the ram-jet unit also serves to supply the pulsatory combustion in the pulse-jet units which are provided with fuel injectors arranged in the manner usual with machines of this kind. The remainder of the air passes over the pulse-jet units and is thus heated by the heat given off through the walls of the pulse-jets. The exhaust pipes **7** of the pulse-jet units deliver into ejectors which are freely open towards the front at **9** so as to permit of the admission of a part of the air which has passed over and around the pulse-jet units, the said ejectors having a divergent part **8** adapted to withstand the pressure which is produced by the meeting of each puff of exhaust gas with the air which fills the ejector, this enabling an increase in thrust to be obtained on the cowling to which the said ejectors are fixed.

In the front portion of each of the ejectors (or of some of these ejectors only) is arranged a fuel injector **10** by means of which fuel may be introduced into the ejector when it is desired to obtain a supplementary thrust. The ignition of the fuel is obtained automatical-

ly as soon as the supply valve **11** of the injectors is opened, by reason of the high temperature of the gases discharged from the pulse-jet units. The puffs of gas give rise to an agitation and a turbulence inside the ejectors which are favourable to a rapid and homogeneous diffusion of the atomised fuel, the combustion of which is very rapid and complete over a short length on the downstream side of the ejectors. The wake created by the ejectors in the flow of air which passes round them is furthermore well adapted to the stabilization of the flame without there being any need for special stabilising screens. Such screens could, however, be added if this deemed to be necessary.

The fuel injectors **10** may also be arranged on the upstream side of the ejectors, between the outlet orifices of the discharge nozzle 7 and the inlet orifices of the ejectors, or within the interior of the discharge nozzles **7**, or again inside the divergent section of the ejectors on the downstream side of the neck of the latter, although this latter arrangement is not quite so good. The injection of the supplementary fuel may be effected at low pressure and without vaporisation, and this enables the use of a high power pump to be dispensed with.

Although Fig. 1 shows the injectors **10** directed so as to discharge the fuel against the flow of air, which is a generally favourable arrangement, the said injectors may be arranged otherwise because of the diffusion resulting from the turbulence produced in the ejectors.

There is an advantage to be derived in separating the outlet orifices **12** of the ejectors from the outlet orifice **3** of the cowling by a distance which is great enough for the combustion to be completed before the said orifice. There is even an advantage in arranging the orifices **12** of the ejectors to precede sufficiently the commencement of the convergent portion **13** of the discharge nozzle of the ram-jet unit in order that this discharge nozzle may play its part in expanding the gases at uniform temperature.

In the form of embodiment shown in Figs. 2 and 3, the cowling **1** of the ram-jet unit is partitioned between the respective planes containing the intake orifices **9** of the ejectors and the outlet orifices **12** of the said ejectors. The partition comprises fixed parts **15** and movable parts **16** which may either completely close the passage of the air around the ejectors, as shown in the upper part of Fig. 2, so that all the air then passes through the interior of the ejectors, or open the air passage, as shown in the lower part of Fig. 2, a portion of the air then passing around the ejectors directly towards the discharge nozzle of the ram-jet unit. In the drawings, the movable parts **16** have been shown in the form of shutters hinged at **17** on the ejectors which are themselves held by the fixed parts **15** of the partition, the pivotal movement of the said movable parts being controlled by hydraulic jacks **18** supplied either through a manual control operated by

the pilot, or automatically as a function, for example, of the dynamic pressure of flight. At zero speed and at low speeds of flight, the parts **16** are put in the closed position, as indicated in the upper portion of Fig. 2. They are retracted at high speeds of flight at which the cycle of the ram-jet unit enables a large thrust to be obtained under its own power.

In Fig. 2, the fuel injectors **10** are formed by simple tubular members opening into the interior of the exhaust pipes **7** of the pulsatory chambers and injecting the fuel at low pressure at right angles to the axes of the said exhaust pipes.

There has also been shown in Fig. 2 an advantageous method of mounting of the pulsatory chambers. The air admission tubes **4** of these chambers (these tubes being freely open and arranged so as to form aerodynamic valveless inlets) are rigidly connected to radial arms **19** fixed on the cowling of the ram-jet unit and transmitting to this cowling the thrust generated by the pulsatory chambers. The exhaust nozzles **7** are carried by collars **20** connected to arms **21** fixed to the cowling. The play between each nozzle **7** and its collar **20** provides for the free expansion of the combustion chamber and of its discharge nozzle and, in addition, limits the transmission of heat to the arms **21**. One of these arms may serve to supply fuel to the injectors **10**.

What we claim is:

1. A composite jet propulsion engine comprising a ramjet nacelle having in succession a ramming air intake, an intermediate space of greater cross-section fed with air at reduced velocity and increased pressure which has traversed said ramming intake, and a jet propulsion nozzle; a plurality of pulsejet units extending inside said intermediate space, in spaced relationship with each other and with the wall of said nacelle, and having a combustion chamber adapted to heat the air flowing through said nacelle around said units and an exhaust pipe facing downstream toward said propulsion nozzle; an individual ejector tube coaxially associated with each pulsejet unit and having an inlet opening spaced from and facing toward the exhaust pipe of said unit and an outlet opening in a rear part of said ramjet nacelle, said ejector tubes being adapted to suck said heated air; and a transverse partition across said nacelle in a part thereof lying between the inlet openings and the outlets of said ejector tubes whereby said nacelle is divided into two compartments communicating with each other through said ejector tubes, at least a portion of said partition being retractable to provide direct communication between said compartments.

2. Engine as claimed in claim 1 wherein the partition extends across the intermediate space of the ramjet nacelle.

No references cited.