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LEAK RECOVERING DEVICE FOR PULSE JET UNITS

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Fig. 1

Fig. 2

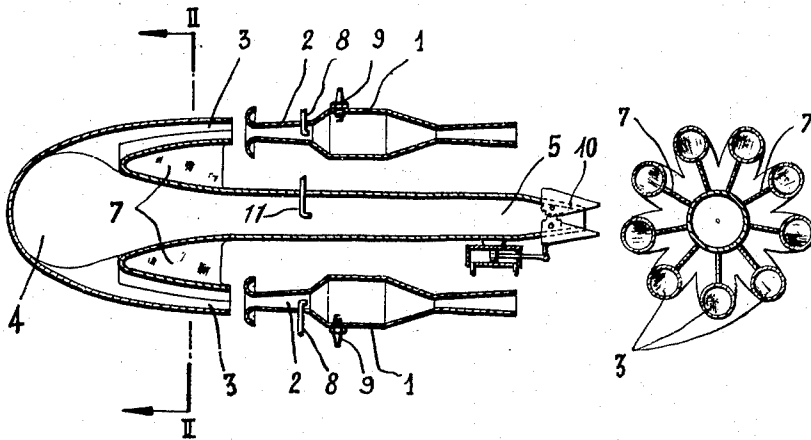
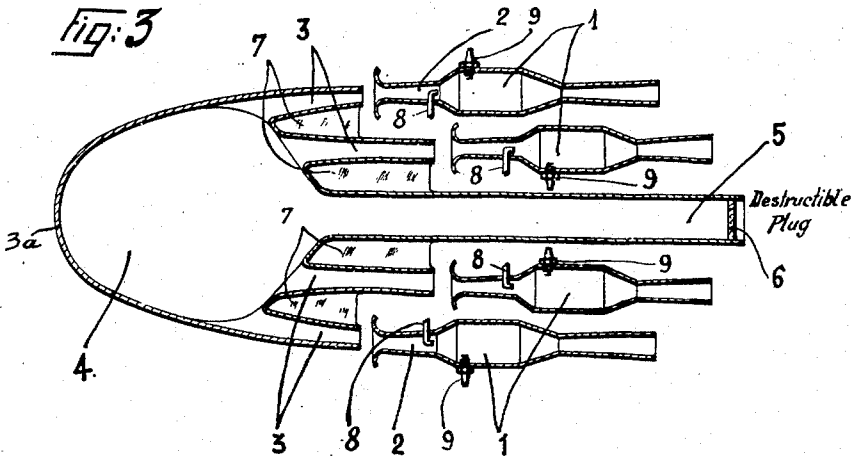


Fig. 3



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LEAK RECOVERING DEVICE FOR PULSE JET UNITS

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6 Claims. (Cl. 60—35.6)

Almost every kind of pulse-jet unit or pulsatory combustion chamber, having aerodynamically-operated inlet valves, suffers from the same disadvantage: an appreciable part of the gases which furnish the thrust escapes through the valve towards the front. This leakage gives rise to a counter-thrust and also hinders the admission of air necessary to the combustion.

In order to overcome these difficulties, it has already been proposed to canalize the escape of gas in a tubular member, co-axial with the air inlet valve of the pulse-jet unit and placed at a certain distance in front of the latter in order to leave sufficient space for the admission of air. In this way, the jet of gas discharged towards the front by the pulse-jet can be rapidly separated from the surrounding atmosphere from which must be drawn the inlet air necessary to the combustion of the charge. This pulsatory jet can be quite easily turned to advantage if the tubular member is long enough and comprises a divergent section immediately after its inlet opening. The tubular member is bent round towards the rear of the pulse-jet in such a way that the pulsatory jet produces a thrust on the tubular member which contributes to the propulsion exactly as if the escape jet had been directly discharged towards the rear. Furthermore, it has been found that the tubular member can draw in a large quantity of air, drawing-off at the same time a part of the kinetic energy of the leakage jet discharged through the pulse-jet inlet valve. This energy is however restored to some extent to the dilution air drawn in by the recovery pipe and the resulting efficiency is thus sufficient to ensure that the total thrust may be increased by the use of the recovery device. This phenomenon has already been described in greater detail in U. S. patent application Ser. No. 229,947, filed June 5, 1951.

Such an arrangement has, however, certain disadvantages:

(a) The jet of gas discharged from the tubular recovery member is liable to be slowed down by friction if it comes up against walls or members placed in the zone of its discharge path; this may lead to an increase in overall dimensions of the unit and thus reduce the possibilities of grouping together a number of pulse-jet units inside the same streamlined casing or cowl.

(b) The rate of dilution of a single tubular or recovery member cannot be regulated.

(c) The losses in energy of the gases in the bend, through which they must pass, increase proportionately as the bend in the tubular member becomes more acute, and this fact is likely to result in a too-great increase in the minimum overall dimensions of the unit.

The object of the present invention is to provide a leak recovering device for pulse jet units.

The device consists of a series of tubular members arranged at a certain distance in front of the inlet orifices of the pulse-jet units and co-axially mounted with respect to the latter, the said tubular members discharging into a common chamber which is extended towards the

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rear by a discharge pipe parallel to the exhaust pipes of the pulse-jets, in such a manner that the said discharge tube, which is fed by the gases resulting from back-flow through the inlet orifices of the pulse-jet units, contributes to the propulsive effect of these latter.

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

Fig. 1 is a diagrammatic longitudinal section of pulse-jet units provided with a recovery device in accordance with the invention.

Fig. 2 is a cross-section along the line II—II of Fig. 1.

Fig. 3 shows a modified form of embodiment of the invention.

In the drawings, 1 generally indicates a pulse jet unit or pulsatory combustion chamber provided with an aerodynamically-operating air inlet valve 2, i. e., a uni-directional tube so designed as to allow free flow towards the chamber 1 when a depression prevails in this chamber, before each explosion, hindering (although not preventing) back flow from the chamber 1 due to overpressure obtaining after each explosion. The combustion chambers 1 are provided with a fuel injector 8 and an ignition plug 9 used at the start.

In Figs. 1-2, the pulse jet units are disposed in annular formation: an odd number (nine) of units being distributed about a single ring. In the example of Fig. 3, two coaxial rings of pulse jet units are provided. At a certain distance in front of this orifice 2, and on the same axis as the latter, there is arranged a tubular member 3 of slightly divergent form and having a bent portion 3a which is intended to direct towards the rear of the unit, parallel to the axis of the pulse-jet, the gases which escape towards the front through the orifice 2 and which are collected by the tubular member 3.

The tubular members 3 which collect the leak gas of the pulse-jet units 1, are joined together. These tubular members, which are constructed integrally with reinforcement struts 7, are joined to each other and discharge into a common chamber 4 which is prolonged towards the rear, co-axially with the ring or rings of pulse-jet units, by a discharge pipe 5, parallel to the latter. By reason of the large volume of the chamber 4 and the normally asynchronous operation of the pulse-jet units, there is obtained in the discharge tube 5 an almost steady uniform output which can be regulated by means of a single variable-area nozzle 10 of conventional design. In addition, advantage can be taken in this way of the known fact that for equal kinetic energy, the propulsive effect of a steady flow is greater than that of a pulsatory flow.

Since the junction of the tubular members 3 is effected before the zone in which the jets of gas are turned around, the losses in power are reduced as a consequence of the diminution of the surface swept by these jets of gas. The regulator nozzle provided at the rear results in the maintenance of a slight pressure in the common chamber 4, the effect of which is to slow down the gas flow before it is turned round, which facilitates the flow round the bend. The divergence of the tubular members 3 results, in effect, in the transformation into potential energy of a portion of the energy of the collected escape jets without excessive loss.

The recovery device which has just been described does not increase the overall size of a group of pulse-jet units. In addition, its front portion 3a is given a streamlined form which reduces the air resistance.

It should be noted that, by means of this device, the problem of starting up groups of pulse-jet units is much

simplified. Instead of being obliged to inject compressed air into all the pulse-jet units, it may be sufficient to start up by injecting one or two pulse-jet units of a ring assembly; the gases from the chamber 4, which penetrate into each of the other pulse-jet units, possess sufficient energy to start them up. In order to facilitate starting up, it may be advantageous to provide on the common exit tube 5 from this chamber, some kind of temporary closure device intended to increase the quantity of gas available for starting up. This device could, for example, consist of a capsule 6 which is automatically destroyed at a predetermined pressure or temperature.

It is also possible to utilize the common exhaust tube 5 to obtain an exhaust reheat under steady flow conditions by means of an afterburner 11.

It will be well understood that modifications can be made to the various embodiments of the invention which have been described, in particular by the substitution of equivalent technical means, without thereby departing from the spirit or scope of the present invention.

What we claim is:

1. The combination, with a group of pulse-jet units having air inlet orifices facing towards the front of said units and of the kind in which a back flow of leak gas through said orifices towards the front of said units occurs at each explosion therein, of a leak gas recovery device comprising tubular members having intake ends substantially coaxial with and arranged at a distance in front of said air inlet orifices, a common chamber communicating with said tubular members for collecting the leak gas issuing from said orifices and flowing through said members, a discharge pipe communicating with said chamber and having an outlet opening facing towards the rear of said group of pulse-jet units, for discharging the gas collected in said chamber in a rearward direction, thereby contributing to the effect of propulsion of the pulse-jet units, and a destructible plug obturating said discharge pipe.

2. The combination, with a group of pulse-jet units having air inlet orifices facing towards the front of said units and of the kind in which a back flow of leak gas through said orifices towards the front of said units occurs at each explosion therein, of a leak gas recovery device comprising tubular members having intake ends substantially coaxial with and arranged at a distance in front of said air inlet orifices, a common chamber communicating with said tubular members for collecting the leak gas issuing from said orifices and flowing through said members, a discharge pipe communicating with said chamber and having an outlet opening facing towards the rear of said group of pulse-jet units, for discharging the gas collected in said chamber in a rearward direction, thereby contributing to the effect of propulsion of the pulse-jet units, and exhaust reheat means in said discharge pipe.

3. The combination, with a group of pulse-jet units having air inlet orifices facing towards the front of said units and of the kind in which a back flow of leak gas through said orifices towards the front of said units occurs at each explosion therein, of a leak gas recovery device comprising tubular members having intake ends substantially coaxial with and arranged at a distance in front of said air inlet orifices, a common chamber communicating with said tubular members for collecting the leak gas issuing from said orifices and flowing through said members, a discharge pipe communicating with said chamber and having an outlet opening facing towards the rear of said group of pulse-jet units, for discharging the gas collected in said chamber in a rearward direction, thereby contributing to the effect of propulsion of the pulse-jet units, and a variable-area nozzle at the rear end of said discharge pipe.

4. A jet propulsion plant comprising a plurality of pulse-jet units in the form of uninterrupted ducts extending in a generally fore-and-aft direction and having each an air intake portion opening towards the front of said plant, an intermediate combustion space and a gas exhaust portion opening towards the rear of said plant, whereby combustion gases generated at each explosion in said combustion space flow both rearwardly through said exhaust portion and forwardly through said intake portion to issue from both ends of said ducts, a plurality of tubular members extending forwardly of the intake portions of said ducts and spaced therefrom to allow free passage of ambient air thereinto, each tubular member having an orifice facing towards the intake portion of the respective duct and substantially coaxial therewith, a common chamber communicating with said tubular members for collecting the combustion gases issuing from said intake portions and entering said tubular members, and a discharge pipe communicating with said chamber and having an outlet facing towards the rear of said plant in substantial parallel relationship with said exhaust portions of said ducts.

5. Plant as claimed in claim 4, wherein the tubular members are of divergent shape from the orifice thereof to the common chamber.

6. Plant as claimed in claim 4, wherein the tubular members are smoothly connected with the common chamber.

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