March 4, 1958 J. BERTIN ET AL 2,825,202

PIPES TRAVERSED BY PULSATING FLOW GASES

Filed June 5, 1951

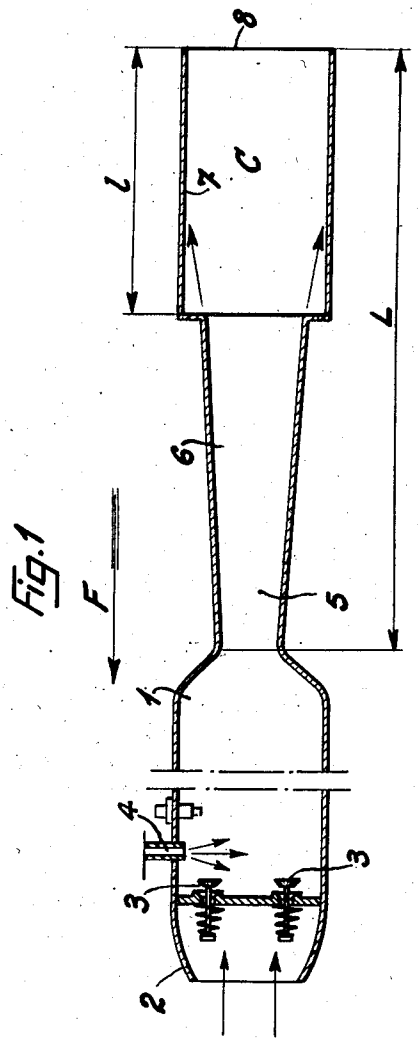


Fig.1

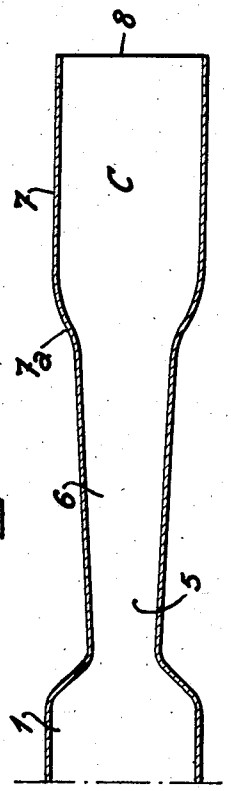


Fig.2

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United States Patent Office 2,825,202 Patented Mar. 4, 1958

2,825,202

PIPES TRAVERSED BY PULSATING FLOW GASES

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Application June 5, 1951, Serial No. 229,948

Claims priority, application France June 19, 1950

3 Claims. (Cl. 60—35.6)

The exhaust pipes of explosion engines or internal combustion engines are traversed by a pulsating flow of gas. In pulse-jet units, the same applies as regards the rear tube which forms the propulsion jet.

The present invention relates to an improvement in such tubes traversed by a pulsating flow gas which when applied to the exhaust pipes of an ordinary engine enables the filling or the scavenging inside the cylinder or cylinders of the said engine to be improved and which, when applied to a pulse-jet unit (which is the most important case), enables not only a satisfactory filling or scavenging of the combustion or explosion chamber to be obtained, but also a marked improvement of the propulsion output and of the thrust.

According to this invention, there is provided for the pulsating flow, a convergent-divergent nozzle similar to a de Laval nozzle, opening downstream into an elongated chamber of a section which is relatively large with respect to that of the neck of the nozzle.

This chamber may be constituted by a cylindrical or slightly conical pipe, which may or may not be preceded by a divergent portion connecting the surface of the nozzle to that of the pipe.

The description which follows, considered in conjunction with the accompanying drawings, given simply by way of example, will enable the manner in which the invention is carried into effect to be readily understood, the details which are apparent from the description and the drawing obviously forming part of the said invention.

Figures 1 and 2 are diagrammatic sectional views showing two embodiments of the invention as applied to a pulse-jet unit.

Referring to the drawing, **1** is the explosion or combustion chamber of a pulse-jet unit adapted to propel a movable craft in the direction of the arrow F. Atmospheric air is admitted periodically into this chamber between the successive explosions or combustions by any suitable device which in itself does not form the subject of the invention. An air-admitting device has been shown diagrammatically and simply by way of example in the drawings, which comprises a diffuser **2** and a plate carrying valves **3** which are opened automatically between the explosions or combustions by the pressure of the air prevailing in the diffuser **2** and are closed by the pressure in the chamber **1** at the time of the explosions or combustions.

Any other arrangement could be employed and especially a device of known type which does not comprise any mechanical valve but which offers a resistance to the passage of air which is smaller in the filling direction than in the opposite direction. The liquid fuel is admitted into the chamber by an injector **4** and the explosion or the combustion is determined by a spark plug, a burner, a hot element, etc. The generated gases are discharged from the chamber at high velocity at the rear in order to form the intermittent propulsion jet.

This discharge is effected, according to the invention, through a converging section **5** followed by a diverging section **6**, the whole constituting a nozzle similar to a de Laval nozzle. The divergent section **6** opens into a large-section pipe **7** which is entirely open at the rear at **8**.

In the embodiment shown in Figure 1, the pipe **7** is cylindrical, the surface thereof forming a sudden enlargement of the section **6** of the nozzle.

The pipe **7** constitutes a sound tube which has a natural frequency of vibration.

If this natural frequency of the pipe is tuned experimentally to the frequency of the pulse-jet unit for a given normal rate of operation of the latter, for example, by suitably regulating the length *l* of the cylinder **7**, a considerable increase in the thrust is obtained with constant consumption of fuel, as has been proved by the tests carried out by the applicants. This improved output results from a better utilization of the discontinuous kinetic energy of the hot gases escaping from the chamber **1**. Instead of these gases escaping directly to atmosphere through a simple tube, as is the case with the usual devices, the arrangement described makes it possible for them to act on a supply of fresh air which, after the previous exhaust, has entered the rear chamber **7**. A major part of the kinetic energy of the hot gases is transmitted to the fresh air with an efficiency which is all the better as the gases and the air are in stratified layers and not simply dilution and friction occur. The arrangement thus permits a transfer of amounts of momentum between the gases and the fresh air with constant kinetic energy, this explaining the improvement of the propulsion output which is observed.

Moreover, the arrangement makes it possible to extend the time of expulsion of the burnt gases over the most important fraction of the period of the pulse-jet unit and consequently to increase the thrust.

It is desirable that the section **6** of the exhaust nozzle be gradually divergent, at least in the part near the neck.

Moreover, the following ratios have given excellent results:

The area of the cross section of the cylindrical part **7** being greater than three times the area of the cross section of the neck of the nozzle **5**, **6**, the length *l* of the cylinder **7** is greater than a quarter of the length L between the neck of the nozzle and the rear opening **8** of the tube **7**.

The volume of the tube **7** obviously plays an important part and it is the cylinder which contains the greatest volume for a given cross-section. However, other considerations may be involved in the selection of the shape to be given to the chamber **7** and make it preferable to choose a shape different from that of a cylinder.

The applicants have obtained good results with the embodiment shown in Figure 2, in which the tube **7** comprises a first conical part **7***a* united to the outlet of the nozzle **6** and a cylindrical part **7**.

Another important advantage which it is possible to obtain with the invention is the improvement in the filling or scavenging of the explosion or combustion chamber **1** with fresh air. This result is obtained by the production, at the outlet of the nozzle **6**, of a divergent stream which is produced naturally in the case of Figure 1, or caused by the shape of the wall **7***a* in the case of Figure 2. Upon completion of the ejection phase of the gases, this divergent stream acting on the atmosphere causes a lowering of static pressure upstream, that is to say, in the chamber **1**, which facilitates the filling with the fresh air entering this chamber by way of the device **2**, **3**.

For this reason, the arrangement described may be applied to any pipe capable of serving for the pulsating flow of a gas. As already described, it would be possible, for example, by means of parts similar to those numbered **5**, **6** and **7**, to adapt it to the exhaust pipe of one or more cylinders of an explosion engine or an in-

ternal combustion engine, more especially the exhaust pipe of a two-stroke engine cylinder, whether or not the gas jet is finally used to produce a propulsive reaction.

It is obvious that it is possible to modify the pipes which have just been described, more especially by substituting equivalent technical means, without thereby departing from the scope of the invention.

What we claim is:

1. The combination with a pulse jet engine of the type comprising a convergent-divergent pipe designed for expanding and imparting velocity to pulses of combustion gas flowing therethrough, of an exhaust tube extending downstream of said convergent-divergent pipe and directly connected thereto at one end of said tube, the other end thereof being freely open to the atmosphere, and facing toward the rear of the engine, said tube having a substantially uniform cross-section which is substantially greater than the maximum cross-section of the divergent portion of said pipe.

2. The combination of claim 1 wherein the convergent-divergent pipe and the exhaust tube have walls smoothly blending with each other.

3. The combination of claim 1 wherein the cross-section of the exhaust tube is greater than three times

the minimum cross-section of the convergent-divergent pipe and the length of the exhaust tube is greater than one-third of the length of the divergent portion of the pipe.

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